Final Environmental Impact Statement

Koa Ridge Makai & Waiawa Development

Waipi‘o and Waiawa, O‘ahu, Hawai‘i

April 2009
APPENDICES

Prepared for:
Castle & Cooke Homes Hawai‘i, Inc.

Prepared by:
Helber Hastert & Fee, Planners

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AECOS No. 1186

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November 18, 2008

Stream biological and water quality impacts assessment for the Koa Ridge Makai and Castle & Cooke Waiawa development in central Oʻahu.

November 18, 2008 *AECOS* No. 1186

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Executive Summary

This report is a technical document prepared for the EIS for a proposed 766-acre (310-ha) Koa Ridge Makai and Castle & Cooke Waiawa urban development. Koa Ridge Makai is proposed for the interfluve between Kīpapa Gulch and Pānakauahi Gulch, bordered on the east by the H-2 Interstate and the south by Ka Uka Blvd. Castle & Cooke Waiawa will be located off Ka Uka Blvd. across H-2 on the interfluve east of Pānakauahi Gulch.

Field observational surveys were undertaken at all locations along streams and gullies anticipated to be directly or indirectly impacted by the project storm water drainage systems. Observations on stream biota and water quality were made, as was a thorough review of pertinent literature.

The development will require storm water drainage systems to discharge into adjacent gulches of Kīpapa and Pānakauahi. Treatment of runoff will be accomplished using detention basins proposed in some cases for gulch bottom locations. Detention basins will be designed to maintain the flow of runoff into area streams at predevelopment peak flows, in some cases by capturing storm runoff from upstream of the project because land to treat runoff from Koa Ridge Makai is not obtainable. This approach provides flood mitigation for flow areas impacted by the development. In addition, so-called "storm water treatment facilities"—smaller detention basins or structures designed to detain runoff from typical storms for an extended period of time—will be constructed for each of the project drainage areas in accordance with standard requirements imposed by the City & County of Honolulu. Because of an association between most pollutants and particulate matter in urban runoff, the storm water quality facilities are anticipated to mitigate much of the adverse impact on stream water quality associated with urbanization.

Water quality in Kīpapa Stream (Waikele Stream branch adjacent to the project site) and Waikele downstream from the project has been monitored by various programs for over three decades. The earliest data set by U.S. Geological Survey showed a decrease in nutrient (compounds of nitrogen and phosphorus that promote algae and plant growth) concentrations in the stream water after 1985, an improvement of unknown cause. Nutrient values obtained since 1984 continue to exceed State of Hawaiʻi water quality standards in the lower reach of Waikele Stream, but are within the standards in Kīpapa Stream. Samples collected and analyzed for this report come from isolated pools in the stream bed and are thus not representative of water quality of flowing water. The results are generally consistent with expectations for stagnant water and useful for characterizing conditions under which the extant aquatic fauna must live.

During periods of high surface runoff into Kīpapa Stream (freshets) marked increases in suspended solids (sediment and organic matter carried by the stream) occur. Both the Waikele and Waiawa stream systems—which Kīpapa and Pānakauahi are, respectively, branches of—are listed as impaired with respect to water quality by the State Department of Health (HDOH). Waikele Stream is listed as not meeting state standards for total nitrogen and turbidity; Waiawa is listed for not meeting the nutrient standards (nitrate + nitrite, total nitrogen, total phosphorus), turbidity, and "trash." Both stream systems are currently completing development of Total Maximum Daily Load (TMDL) calculations to guide allocation of pollutant loadings between point-sources regulated by National Pollutant Discharge Elimination System (NPDES) permits, natural runoff from undeveloped lands, and non-point sources from developed lands. Dedicated storm water drainage systems come under the City & County of Honolulu (C&C) Separate Storm Sewer NPDES Permit, and the discharge into state waters is subject to the permit compliance requirements and eventually could be subjected to more specific, HDOH requirements for pollutant reduction under a TMDL program. Presently, C&C standards require that storm drainage systems incorporate best management practices that address both runoff quantity (flood control) and water quality, requirements that will be met by the Koa Ridge development.

The project area streams are depauparate in native aquatic fauna and no aquatic species protected by state or federal statute would be impacted adversely by the project. The development is located on interfluves elevated above gulch bottoms and does not require stream channel modifications. Physical alterations to bed or banks of streams known to serve as migratory pathways for native amphidromous species will be limited to minor protective hardening as required to prevent erosion at detention basin and drain line outlets.

Consideration is given to federal jurisdictional issues related to planned construction within the gulches. Although no wetlands occur in the project area, natural drainage ways present are jurisdictional, with the possible exception of a gulch off Pānakauahi Gulch where a proposed detention basin for Castle & Cooke Waiawa would be built, and that portion of the unnamed gulch above the outlet of Mililani Mauka Drain Line 2, where a maintenance road for proposed Drainage Basin 2 would be built. Although proposed drainage basins mostly avoid jurisdictional waters (DB-3 is an exception), each has a connection point within the ordinary high water mark that may require a federal permit to construct.

Introduction

This report describes the results of literature research and field surveys of streams and gulches in central Oʻahu potentially impacted by the proposed 766-acre (310-ha) Koa Ridge Makai and Castle & Cooke Waiawa Development. The majority of the development (Koa Ridge Makai) is proposed for the interfluve between Kīpapa Gulch and Pānakauahi Gulch, extending from Ka Uka Blvd. in the south to around the 720-ft (219-m) elevation in the north. This project area is bordered on the east by the H-2 Interstate (Fig. 1). However, a portion of the project called Castle & Cooke Waiawa would be located off Ka Uka Blvd. across H-2 on the interfluve to the east of Pānakauahi Gulch (Helber Hastert & Fee, 2008).

Although no part of the proposed development would be located in gulch areas, four detention basins (DB) are proposed for scattered gulch locations to mitigate run-off from the proposed suburban environment planned to replace existing and past agricultural land use (see Figure 1 for locations of the four detention basins). Proposed detention basins will mitigate flood hazard and water quality impacts by achieving a net decrease or no increase in peak flow runoff to area streams. However, constraints exist with respect to placement of the basins in relation to project storm water collection points. Some of the basins are positioned to service run-off flows from developed lands not part of Koa Ridge. That is, three of the basins are planned to intercept runoff from drains servicing Mililani Mauka suburban lands. This approach is innovative and provides potential mitigation for flow areas impacted by the Koa Ridge development, but does so by treating nonpoint-source run-off originating in a suburban development upstream of Koa Ridge and for which minimal mitigative measures are presently in place.

In addition to describing the affected fluvial and stream environments, this report assesses the impacts of the construction of various drainage features on these environments and assesses federal stream and wetland jurisdictional issues.

Methods

The "stream" survey areas lie along Kīpapa Gulch and some smaller gulches that feed into Kīpapa Gulch. Kīpapa Gulch is deeply incised into the central plain of Oʻahu and joins Waikele Gulch downstream of the Koa Ridge Development. Various points along the gulches (including Pānakauahi Gulch) were visited on September 3 and October 8 by *AECOS* biologists Eric Guinther and Susan Burr, and by biologists S. Burr and Chad Linebaugh (Kīpapa Gulch) on September 5 and 9, 2008. The surveys consisted of walking the gulch bottoms from the uppermost point of a proposed maintenance roadway for catchment basin DB-2 to the lowermost catch-

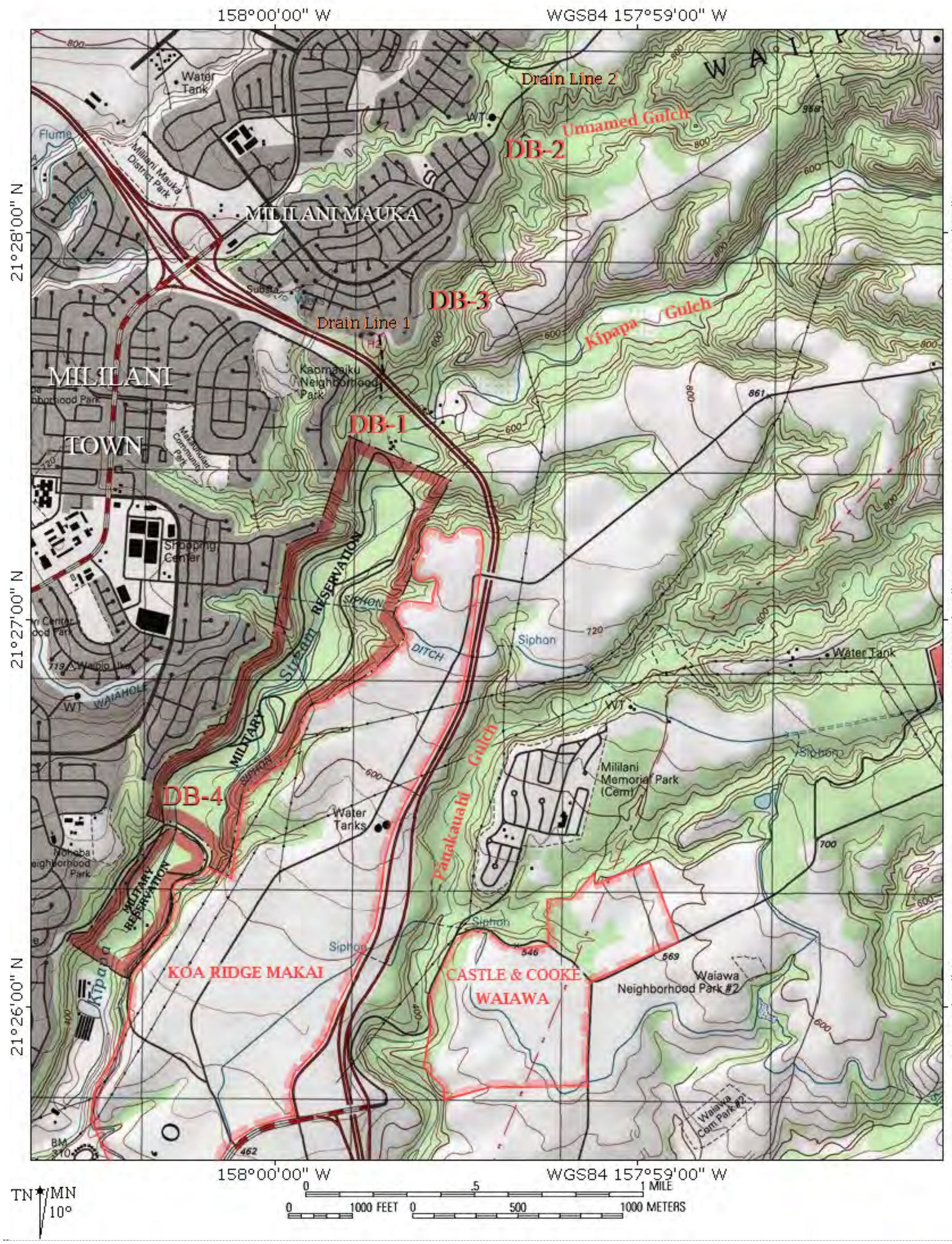

Figure 1. Topographic map of a portion of central O‘ahu showing the location of various features discussed in the text in relation to the proposed Koa Ridge Makai and Waiawa Development.

ment basin (DB-4) located about 0.9 mi (1.4 km) upstream of the Kamehameha Highway (State Rte. 99) bridge and the outlet for drain Line 1 in Kīpapa Gulch directly downstream from the bridge. Much of lower Kīpapa Stream to the confluence with Waikele Stream was investigated.

Biological observations in Waikele, Kīpapa, and nearby Waikakalaua streams are provided in several reports consulted for this study: *AECOS* (1989, 1992a, 2000), Archer (1985), Brasher (1991), Englund (1993), and Henderson (2003). Pertinent water quality data were obtained from AECOS (1992b), Brasher (1991), Oceanit & AECOS (2002), and Hoover (2002).

Koa Ridge Project and Watershed Descriptions

Waikele Stream[1] (Fig. 2; State Perennial Stream ID No. 3-4-10) drains the second largest watershed (30,984 ac; Commission on Water Resources Management or CWRM No. 3064) on the Island of Oʻahu. Only the Kiʻikiʻi Stream system (at 37,426 ac) has a larger watershed, draining the central plain of Oʻahu to the north. Waikele Stream drains that portion of the plain between the now highly eroded Waiʻanae and Koʻolau volcanic shields where these slope southward towards Pearl Harbor, discharging into West Loch. Waikele Stream includes tributaries that drain both the eastern slope of the Waiʻanae mountain and the leeward or western slope of the Koʻolau mountain. The principal tributaries draining the Koʻolau or eastern side are Kīpapa and Waikakalaua (State ID No.s 3-4-10.01 and 3-4-10.02, respectively). The Waianae side is drained by upper Waikele Stream from at least a half dozen small tributaries with origins on the steep face of the ridgeline between 2900 ft high Puʻu Kumakaliʻi and 2728 ft Puʻu Kanehoa. The headwaters are mostly on military lands associated with Schofield Barracks (U.S. Army) and forest reserves. The streams in this area are all intermittently flowing, until the main channel descends into the deeper gulch of Waikakalaua Stream, which brings perennial flow to the system. Waikele Stream is perennial (although interrupted) downstream of this confluence, occupying a steep-sided gulch incised into the Central Oʻahu Plain. The bottom of the gulch is a Military Reservation. The more even ground beyond the margins of the gulch was formerly in agriculture—pineapple (*Ananas comosus*) and sugar cane (*Saccharum officinarum*)—but is now mostly fallow, with Mililani Town located along the eastern side.

The Koa Ridge Makai development is proposed for an area within what has been designated "SubBasin 4" (Oceanit & *AECOS*, 2002) of the Waikele Watershed. This subwatershed covers an area of 5.72 mi² (11.8% of the entire watershed) with land

[1] Much of this description comes from the website "Waikele Stream System" at URL: http://www.aecos.com/CPIE/WaikeleStr.html authored by E. Guinther and the report Oceanit & AECOS (2002).

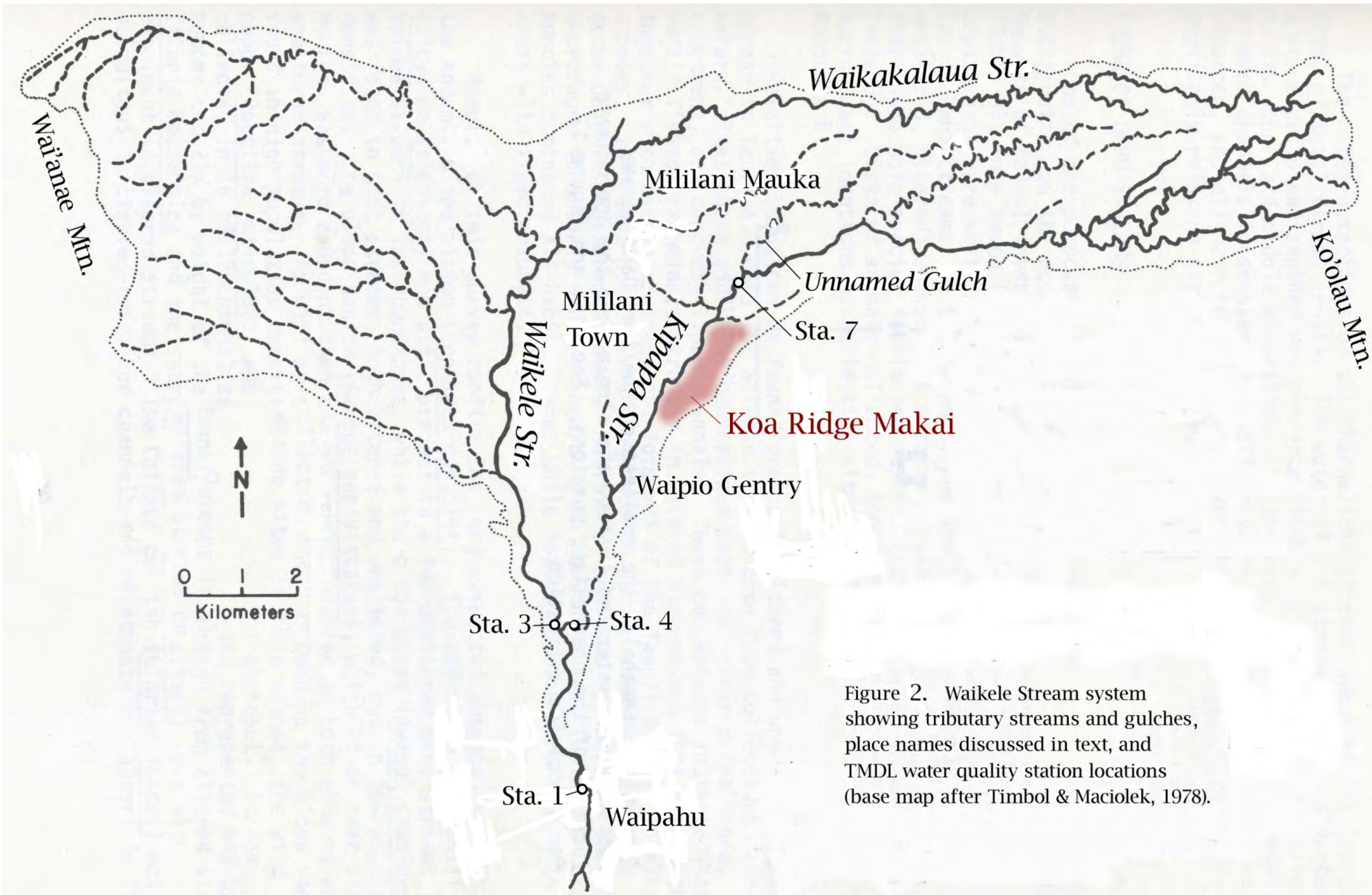

Figure 2. Waikele Stream system showing tributary streams and gulches, place names discussed in text, and TMDL water quality station locations (base map after Timbol & Maciolek, 1978).

use percentages (estimated in 2002) of 32% agriculture, 32% residential, 21% forest, 13% roads, and 2% business/light industrial. Included is a large proportion of Mililani Town south and west of H-2. Koa Ridge Makai would transform the agricultural portion to paved roads and residential and commercial properties (i.e., classified residential). Forested land is located within Kīpapa Gulch and would be impacted very little by the development plans. The low end (outlet) of SubBasin 4 is indicated by "Sta. 4" in Fig. 2.

Upstream of SubBasin 4 is "SubBasin 7" (Oceanit & *AECOS*, 2002) encompassing the entire watershed of Kīpapa Gulch upslope of the H-2 viaduct. Although no part of the Koa Ridge Makai development would be built in this subwatershed, two of the proposed catchment basins (DB-2 and DB-3) could be, so information on this subwatershed is addressed herein. SubBasin 7 includes roughly the eastern half of Mililani Mauka in its area of 10.93 mi[2]. Land use percentages are 65% forest, 27% agriculture, 6% residential, and just over 1% roadways. Much of the area designated agriculture in this analysis is former sugar cane and pineapple fields that are now fallow and gulch areas that are "forested." Active agriculture is practiced within Kīpapa Gulch, mostly upstream of the H-2 viaduct and on much of the land north of Ka Uka Blvd. to the H-2 viaduct (formerly pineapple cultivation; now diversified agriculture or truck farming). The low end of SubBasin 7 is indicated by "Sta. 7" in Fig. 2.

Figure 3 depicts the Waikele watershed showing current land uses as well as designations (Class 1, Class 2, Estuarine) of the various main and tributary streams (Waikakalaua Stream is missing from the map) according to the State of Hawaii, Department of Health water quality regulations at HAR §11-54-03 (HDOH, 2004).

The Castle & Cooke Waiawa project area is located within a different watershed: the 17,401-ac (7,042-ha) Waiawa watershed (CWRM No. 3061). This watershed is the third largest on the Island of Oʻahu (Geographic Decision Systems International and Dashiell, 1994). Most of this watershed consists of Pearl City, Pacific Palisades, and former agriculture parcels in the lower part and forested lands of the Koʻolau in the uplands. The relative areas by State land use districts are: 8,436 ac (3,414 ha; 48%) conservation, 4,904 ac (1,985 ha; 28%) agriculture, and 4,060 ac (1643 ha; 23%) urban (Geographic Decision Systems International and Dashiell, 1994). However, much of the former agriculture land is slated for urbanization by Waiawa Ridge Development, LLC.

[2] Although not obvious by reference to the topographic maps or the TMDL report, SubBasin 7 receives runoff from nearly all of Mililani Mauka Phase II, and SubBasin 4 from most of the remainder of Mililani Mauka (Phase I), in total 988 acres or 1.54 sq. mi².

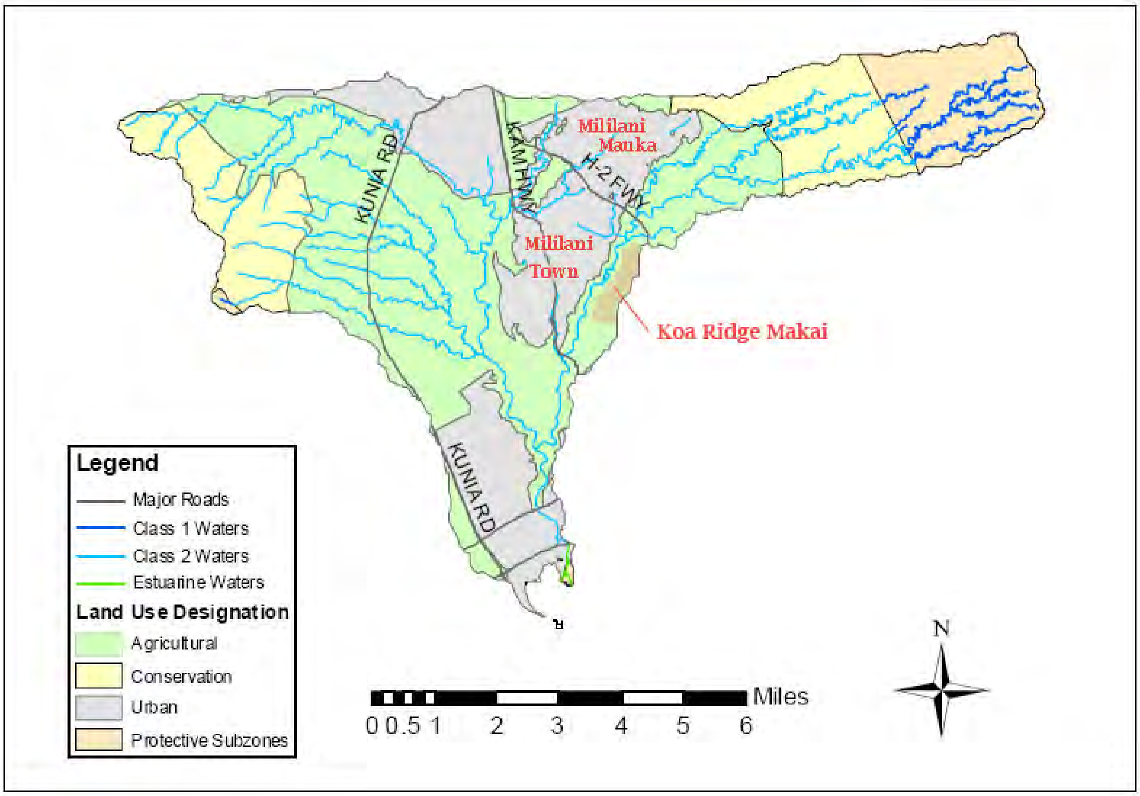

Figure 3. Stream classification and land uses, Waikele Stream and its watershed (modified from Henderson, 2003).

Stream Descriptions

Upper Kīpapa Stream

Kīpapa Stream arises on the crest of the Koʻolau from several tributaries draining the western slopes behind windward Oʻahu's Waiahole Valley. There are actually many tributaries within the ahupuaʻa of Waipiʻo that flow mostly westward or west-southwest onto the central plain east and south of Mililani Town, becoming the major landscape feature known as Kīpapa Gulch just before crossing under H-2. The gulch turns eventually southward and joins the equally large Waikele Gulch with Waikele Stream. Elevation at the confluence of the streams is about 80 ft (24 m) above sea level.

As noted above, the upper reaches of Kīpapa Stream, with numerous tributaries in narrow, steep-sided gulches draining forested lands, comprises SubBasin 7 in the Hawaii Department of Health TMDL study (Oceanit & *AECOS*, 2002). This subwatershed ends at TMDL Sta. 7, located along Kīpapa Stream at the 450 ft (137

m) elevation, just upstream of the H-2 viaduct crossing. The following description by Ron England (ETI, 1993) evokes a useful image of the uppermost reaches of these central Koʻolau streams:

> The stream[s] begin as a series of steep hanging valleys that coalesce at approximately 518 m [1700 ft] elevation into sinuate, rock and cobble channel. The channel follows an extremely convoluted course through a catchment composed of heavily forested razorback ridges, until emerging into the benchlands of central Oahu...
>
> ... In its far upper reaches the Kipapa Stream consists of scattered pools connected by subsurface flow that emerges occasionally in areas of bedrock exposure. Beginning at approximately 381 m [1250 ft] elevation permanent flow appears, consisting of shallow riffle/runs connecting long, deep pools

The riparian vegetation along the upper reach of Kīpapa is described (Englund, 1993) as dominated by guava (*Psidium cattleianum*), ʻōhiʻa (*Metrosideros polymorpha*), and koa (*Acacia koa*) with a thick understory of ferns. At somewhat lower elevation (244 m or 800 ft), ʻōhiʻa, guava, ginger (*Hedychium coronarium*), ti (*Cordyline fruticosa*), kukui, and Christmasberry predominate. Mass wasting (hillslope landslides) was evident on the steep slopes, potentially contributing to substantial inputs of soil and rock during storms.

The Englund report suggests Kīpapa Stream is interrupted (flowing only part of the time) from about the 700-ft (210-m) elevation to and beyond the confluence with Waikele Stream "owing to agricultural and domestic withdrawals". This would seem to be more a phenomenon resulting from drought conditions, perhaps influenced by groundwater withdrawals, as there are no stream diversions in upper Kīpapa. Some crop-farming occurs along the floor of the gulch above the TMDL Station 7 (mostly papaya and banana). Former agricultural lands now developed for housing as Mililani Mauka contributes storm water runoff to the gulch just above and just below the water quality sampling point at the bottom of Sub-basin 7.

Unnamed Gulch (21° 27’48” N – 157°59’30” W)

The upper-most detention basin, DB-2, is located at the bottom of a side gulch that branches off of Kīpapa Gulch a short distance upstream of the H-2 viaduct. This gulch branches several times upslope, forming an anastomizing pattern of erosion features that arise from a process known as drainage piracy. Over geological time, run-off has concentrated in several different channels at different times, the channels "competing" for run-off from branch flows by headward erosion. This same process allowed Kīpapa Stream to capture flows that may have once been part of this small watershed. An intermittent stream indicated on the USGS map (Waipahu Quadrangle) for this gulch is shown as arising from a ridge at about the 1600-ft (490-m) elevation between the drainages of Kīpapa and Waikakalaua streams. However, this latter stream feeds via another gulch to Kīpapa Stream, and the unnamed gulch is shown with an intermittent stream arising in a saddle at the 1140-ft (350-m) elevation (described in more detail below).

The following detailed description of this "unnamed" gulch is taken from AECOS (1992, p. 9)[3]:

> This unnamed feature is a gulch with several branches extending nearly 6.4 km (4 miles) (linear distance) from the mouth at Kipapa Gulch to the canyon head. The lower one-third of this [fluvial] feature is a broad, flat bottomed gulch with steep sides rising some 60 m (200 ft) to the plateau-like topography of the central Oʻahu pineapple fields. This segment begins at the junction with Kipapa Stream around the 150-m (500-ft) elevation and extends to about the 250-m (800-ft) level. The floor and lower parts of the valley slopes support a nearly closed canopy of Christmasberry (*Schinus terebinthifolius*), mango (*Mangifera indica*), albizia ([*Falcateria moluccana*]), and guava (*Psidium guajava*). Open areas, mostly on the margins of the gulch, are dominated by grasses. The upper slopes show much evidence of erosion, mostly from ground slumping.
>
> Evidence of water flow can be found in some places on the valley floor. Sticks piled against the upstream face of large tree trunks indicate that a broad sheet of water flows along the bottom of the gulch on occasion. However, no boulder-filled or rock-bottomed channel is present. Vegetation, mostly a closed canopy of trees, covers the valley floor… Near the point where the gulch opens onto Kipapa, the unnamed "stream" crosses an unimproved road. Although it is difficult to distinguish a channel, water does collect here in the tire ruts, probably from seepage….
>
> [Upstream, t]he gulch narrows and the "stream" meanders considerably through the middle segment which begins around the 250-m (800-ft) elevation. The canyon walls rise between 60 and 90 m (200 and 300 ft) to the ridge tops on either side, with a tendency to be less steep than in the segment downstream. These ridges are mostly covered with eucalyptus (*Eucalyptus robusta* and perhaps others) and the valley floor is dominated by guava and kukui (*Aleurites moluccana*), but areas of native forest including ʻohiʻa (*Metrosideros polymorpha*), koa (*Acacia koa*), hapuʻu (*Cibotium*), ʻieʻie (*Freycinetia arborea*), and kopiko (*Psychotria* sp.) are increasingly evident upstream.

[3] Much of this area was revisited on September 3, 2008 for the present report.

> As in the lowermost segment, signs of surface water or water flow in the middle segment are spotty. In some areas, a distinct channel up to one meter wide and one-quarter to one-half meter deep is evident. In other areas, the bottom of the gulch is a broad area of undisturbed "level" soil and dense vegetation. In a few areas, water and/or wet soil is exposed in pig wallows. The valley floor is dominated at the lower end by strawberry guava (*Psidium cattleianum*), common guava, and occasional kukui. Moving up the canyon, the forest of the valley floor is increasingly dominated by guava and kukui. Shampoo ginger (*Zingiber zerumbet*) dominates the herbaceous layer, along with basketgrass (*Oplismenus hirtellus*) and, in some areas, thimbleberry (*Rubus rosaefolius*).
>
> The upper portion parallels, and is one ridge south of, Waikakalaua Stream. The very uppermost part of the valley was incompletely explored because this gulch demonstrates a curious erosion pattern known as stream capture or stream piracy. At the 350-m (1140-ft) elevation, another unnamed stream which arises at around the 550-m (1800-ft) elevation and also eventually feeds into Kipapa Stream has captured the flow from the subject gulch by lateral excavation. That is, this other drainage system has cut through the separating ridge to "capture" the intermittent headwaters flow from the surveyed, unnamed gulch. With respect to water flow, the surveyed gulch effectively ends at the 350-m (1140-ft) elevation.
>
> The process of stream piracy has occurred recently in a geological sense. At the point where the water flow from the headwaters is diverted, the preference for flow to the gulch to the south is only just evident. At very high peak flows some water might even spill over into the surveyed gulch, although this thought is only speculation. The upper reach (at least where examined) is confined within a narrow, steep sided canyon. The floor is littered with angular boulders, indicating perhaps a predominance of erosion over sediment deposition (unlike the situation in the valley floor below 350 m or 1140 ft). The headwaters of the stream are indicated as occurring around 490 m (1600 ft), not very far above the capture point, [t]hus the absence of rounded boulders…

The unnamed gulch receives a significant storm water runoff (Drainline 2; see Fig. 1) from suburban Mililani Mauka. This drain[4] arises in what has been called the "South Gully" on the upslope side of Lehiwa Drive, collecting run-off from all of Mililani Mauka Phase II (ECI, 1992). Storm water runoff is conducted via an 8 to 12 x 10 ft box culvert to an outlet at the bottom of the unnamed gulch (Fig. 4). Storm water is now redirected south to Kīpapa Gulch to alleviate potential flooding of "Waipio Acres," a subdivision on the north side of Mililani Town.

[4] Construction of this large box drain ("Drainline 2") and other Mililani Mauka drainage system structures were the basis for the *AECOS* (1992) study.

Above the point at which this drainage from Mililani Mauka contributes to runoff flow, the unnamed gulch bottom is more or less flat, with vague signs of water flow; that is, a stream bed is not present (Fig. 5; also Fig. 6 in AECOS, 1992). The course of flow is poorly incised where the gulch is widest across the bottom, with more than one channel evident in some places. Where the gulch is narrow, a channel is incised a foot or less. The channel is covered with leaf litter, indicating very infrequent flows and minimal scouring. This description matches what was observed in 1992 (AECOS, 1992).

Figure 4. Drainage outlet (Mililani Mauka Drainline 2) into unnamed gulch upslope of proposed catchment basin (DB-2).

However, downstream from the point where Mililani Mauka Drainline 2 discharges into the gulch, the vaguely defined water course (AECOS, 1992) is today recognizable as having a stream bed, with some rounding of boulders and banks with debris lines. In places, the soil is eroded away to bedrock (Fig. 6). This change indicates that the Mililani Mauka drain constitutes a significant contributor to run-off flow in the gulch and follows from change in storm peak flow predicted by Engineering Consultants Inc (ECI, 1992) (Q_{100}) to be carried by the gulch before and after installation of the drain from about 800 cfs to nearly 3000 cfs. Also evident along the gulch bottom downstream from the drain outlet is a considerable amount of discarded flotsam: plastic bottles, toys, metal debris, etc. reflecting street litter carried with the flow into the gulch.

Figure 5. View of water course along bottom of gulch upslope of proposed DB-2.

Figure 6. View of water course along bottom of gulch a short distance downslope of proposed DB-2.

Potential "Unnamed Gulch" Jurisdictional Issues — No wetlands as defined by the U.S. Army Corps of Engineers (ACOE, 1987) are found in the unnamed gulch within the section explored (essentially from the mouth to the 800-ft or 240-m elevation). The stream present in this gulch is an intermittent stream from the outlet of Mililani Mauka Drain Line 2 (Fig. 4) down to the mouth of the gulch. Intermittent streams that discharge to perennial streams are jurisdictional. A definable stream is not present upslope of the proposed Detention Basin DB-2, and therefore this gully (all of the unnamed gulch above the outlet of Mililani Mauka, Drain Line 2) does not appear to be jurisdictional.

Figure 7. View into project site (plateau across Kīpapa Gulch), looking east from Noholoa Neighborhood Park in Mililani Town.

Kīpapa Gulch

Kīpapa Gulch downslope from the unnamed gulch (essentially from the H-2 viaduct, south) is noteworthy for its size and steep margins. Koa Ridge Makai lies along the east side of Kīpapa Gulch, some 250 ft higher than the floor of the gulch (Fig. 7, above), and presently drains mostly to Kīpapa Gulch. Development will result in some reallocation of runoff, resulting in two major drainage systems (ParEn, 2008). Drainage Area No. 1 (south; 362 ac), with a calculated peak discharge volume of 1,840 cfs, will discharge in the southwest corner of the parcel (Figs. 8 and 9). Storm water from the drainage area will flow into a storm water quality treatment facility before being discharged into Kīpapa Stream via Drain Line No. 1 (DL-1). The water quality treatment facility could include some combination of grassed swales, extended detention basin, or flow through-based (hydro-dynamic separator) system designed to satisfy the City's storm water quality requirements (ParEn, 2008). Runoff collected within Drainage Area No. 2 (north; 203 ac), with a peak discharge of 970 cfs, will be directed

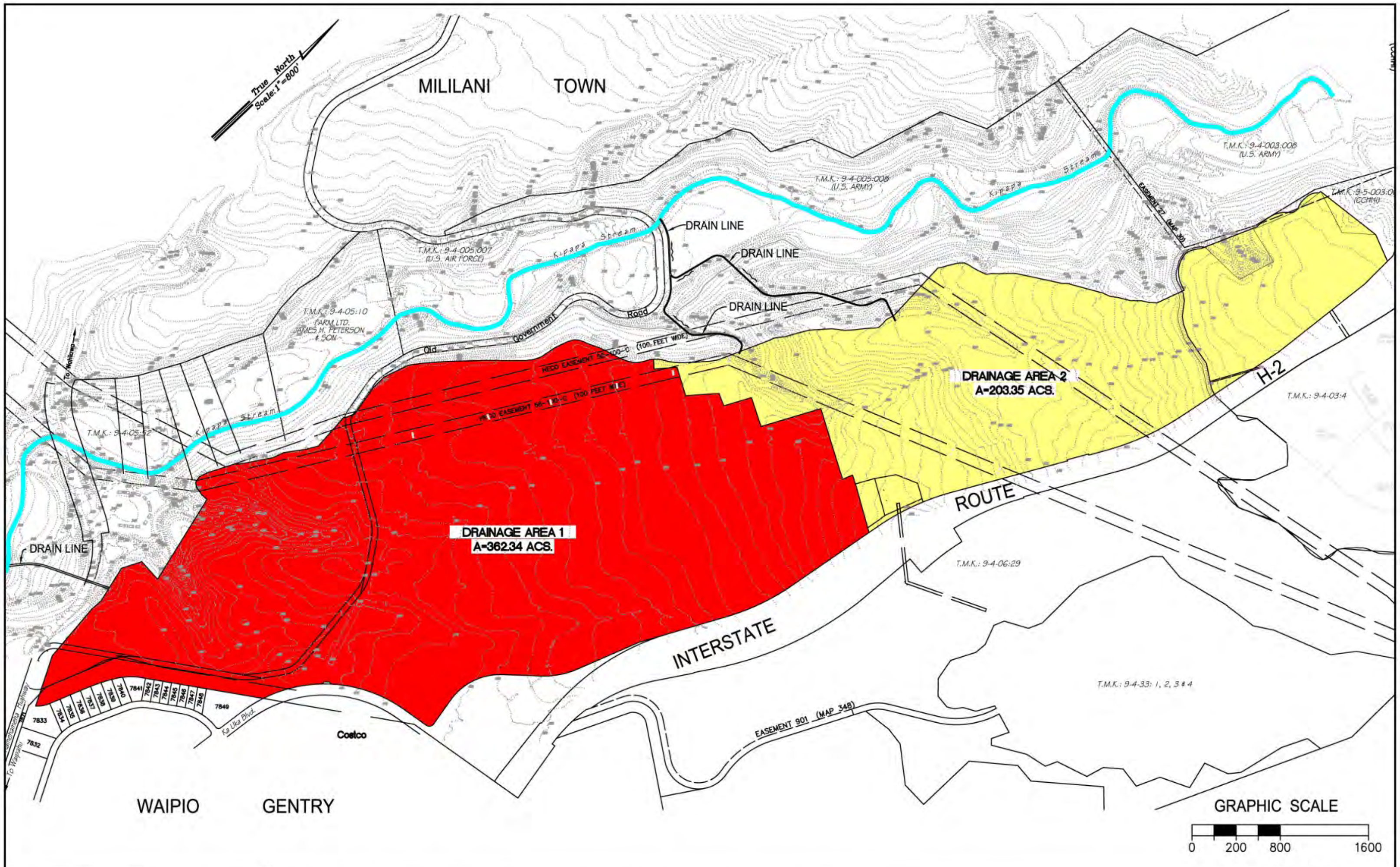

Figure 8. KOA RIDGE MAKAI PROPOSED DRAINAGE AREAS

ParEn, Inc. dba Park Engineering Engineers, Surveyors, Planners

after ParEn, 2008

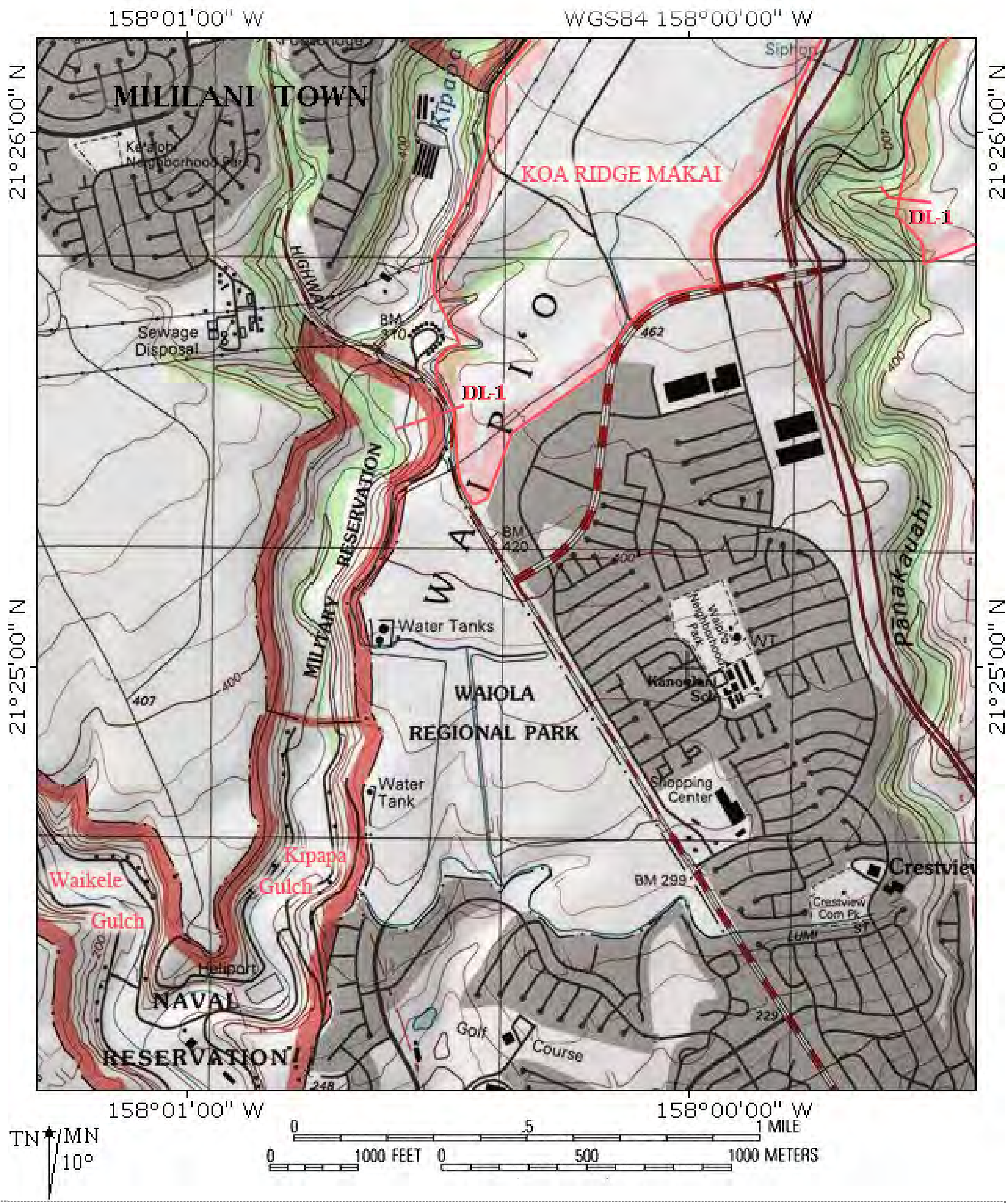

Figure 9. Lower (south) end of Koa Ridge Makai parcel showing location of Drain Line No. 1 (DL-1) for Koa Ridge Makai project and (upper right) DL-1 for Castle & Cooke Waiawa project.

into an existing (natural) gully located roughly midway along the west side of Koa Ridge Makai (Fig. 8). The flow from this gully would be directed into DB-4, if the latter is built (see below). In any event, a storm water quality treatment facility would be constructed as described for Drainage Area No. 1 to meet the City & County storm water quality requirements.

Proposed offsite drainage improvements include three detention basins within Kīpapa Gulch itself (DB-1, DB-2, and DB-3 or DB-4); the locations of these basins are shown in Fig. 1. Two of the basins are proposed for a side gulch off Kīpapa, referred to herein as the “unnamed gulch”. Detention Basin 4 (DB-4), also proposed for Kīpapa Gulch and indicated in Fig. 1, is presently regarded as an alternative in the event that the proposed site for DB-3 is not available. The three basins (DB-1, DB-2, and DB-3) will detain flows generated from fully developed subdivisions of Mililani Mauka[5]. Anticipated basin volumes and peak design discharge rates are provided in Table 1 from ParEn (2008).

Table 1. Design specifications for the Koa Ridge Makai detention basins (after ParEn, 2008).

PROPOSED BASIN	VOLUME	PEAK DISCHARGE* INFLOW	OUTFLOW
DB-1	40 ac-ft (49,340 m^3)	1,960 cfs	1,490 cfs
DB-2	35 ac-ft (43,172 m^3)	3,110 cfs	2,500 cfs
DB-3	10 ac-ft (12,335 m^3)	2,890 cfs	2,830 cfs
DB-4	35 ac-ft (43,172 m^3)	970 cfs	640 cfs

* Design peak discharge: 100-year 24-hour storm.

<u>Potential Kīpapa Gulch Jurisdictional Issues</u> — No wetlands as defined by the U.S. Army Corps of Engineers (ACOE, 1987) are found in Kīpapa Gulch within the section of the gulch explored in 2008: essentially from the mouth of unnamed gulch (around the 510 ft or 155 m elevation) to the confluence with Waikele Stream (see Fig. 7) at about the 80 ft (24 m) elevation. The stream present in the section of this gulch explored is an interrupted stream,[6] a type of perennial stream and jurisdictional within its high water banks. This stream is designated a Class 2 Inland Water by HDOH (2004). Given the very considerable incised channel at the bottom of the gulch, the ordinary high water mark (OHM; jurisdictional boundary) for this stream can be expected to coincide closely with the upper edge of the stream bank throughout the reach.

[5] DB-4, proposed for a location above the stream’s right bank, would take storm run-off from the Koa Ridge Makai, Drain Line 2.

[6] Streams that are perennial (constant flowing) in the wetter highlands, but seasonally dry in the lowlands are called interrupted streams (Timbol & Maciolek, 1978). These streams are treated as perennial streams because the entire waterway is important to native amphidromous species (see text, page 39) that populate the perennial reach.

Pānakauahi Gulch

Pānakauahi Gulch parallels Kīpapa Gulch to the east (Fig. 1), although the stream drains a much smaller basin area. Outflows carried by Pānakauahi discharge to Waiawa Stream in the vicinity of the H-1/H-2 Interchange; Waiawa Stream discharges into Middle Loch of Pearl Harbor. Thus, although Pānakauahi is the watershed adjacent to Kīpapa in the project area, their discharge points within Pearl Harbor are far apart. Koa Ridge Makai is separated from Pānakauahi Gulch by H-2 and no site runoff from the development will be directed eastward to Pānakauahi Gulch (ParEn, 2007). The Castle & Cooke Waiawa development is located across the gulch from H-2, and run-off from this development will be directed into Pānakauahi Gulch.

Two drainage areas are recognized within the development (ParEn, 2007). The upper, Drainage Area 2, will collect runoff in street drains and direct them to the swale separating the development parcel from Mililani Memorial Park. An extended detention basin is being considered for this swale, which connects hydrologically to Pānakauahi Gulch via a culvert under Mililani Memorial Park Road. Drainage Area 1 will likewise collect runoff via street drains and discharge into Pānakauahi Gulch after passing through a water treatment facility. Because space is limited in this area, the water treatment facility would likely be a hydrodynamic separator, a flow-through system with a much smaller foot-print than that of a detention basin (ParEn, 2007).

<u>Potential Pānakauahi Gulch Jurisdictional Issues</u> — No wetlands as defined by the U.S. Army Corps of Engineers (ACOE, 1987) are found in the unnamed side gulch within the section explored: essentially from an existing culvert at Mililani Memorial Park Road up along the gulch bottom for a distance of approximately 1600 ft (500 m). This gulch is a drainage swale lacking characteristics of a stream (not likely to be jurisdictional). Pānakauahi Gulch, at least downstream from the culvert under Mililani Memorial Park Road, has characteristics of an intermittent tributary stream. No wetlands are present in this gulch adjacent to the Koa Ridge Waiawa parcel, although the normally dry stream bed here is likely to be jurisdictional and a Class 2 Inland waters given the presence of a stream bed and banks.

Stream Water Quality

Water Quality Data

Water quality of stream flow in the Waikele/Kīpapa system is well documented from several studies that span over 30 years of data collection. Many of these studies and site specific sampling efforts are summarized in the technical report for the Waikele Stream TMDL (Oceanit & AECOS, 2002). For example, some 20-years of water quality data collected by U.S. Geological Survey (USGS) at a station on lower Waikele Stream are summarized by Hoover (2002, cited in Oceanit & AECOS, 2002). For reasons not well explained in the report, an improvement in water quality occurred in 1985, so only post-1984 data were considered in the presented summaries, as in our Table 2. Further, the "baseline data" (storm flow data excluded[7]) were summarized as arithmetic means, and not geometric means as would be appropriate for nutrient data (HDOH, 1978), in particular if used to compare with Hawaiʻi water quality standards. HDOH collected water quality measurements at six of the TMDL study (Oceanit & *AECOS*, 2002) stations each month between November 2001 and June 2002. All but one of these sampling events was a non-storm event: that is, six represent basal flow water quality data at each of the sampled stations. The data for three of these stations (Sta. 7 – upper Kīpapa; Sta. 4 – Lower Kīpapa, and Sta. 1 – Lower Waikele) are given in Table 2, and station locations are shown in Fig. 2, above.

Table 2. "Baseline" nutrient concentrations from USGS National Stream Water Quality Accounting Network (NASQAN) data for lower Waikele Stream for the period 1985-1996 and monthly monitoring by HDOH from November 2001 to June 2002 (from Oceanit & *AECOS*, 2002).

	(n)	NH_3 (µgN/l)	NO_2+NO_3 (µgN/l)	TN (µgN/l)	PO_4 (µgP/l)	TP (µgP/l)
USGS NASQAN						
Median	*~40*	30	1197	1397	140	160
Mean	*~40*	37	1176	1434	138	164
Std. Dev.		*±22*	*±384*	*±629*	*±45*	*±42*
HDOH* TMDL						
Upper Kīpapa	*7*	16	13	87	---	26
Lower Kīpapa	*7*	5	23	157	---	9
Lower Waikele	*7*	26	713	1483	---	197

* HDOH data are geometric means

Suffice it to say, the nutrient values are high relative to water quality standards, particularly at the Lower Waikele station. While excluding certain data points (notably samples collected at higher flows) and calculating arithmetic means invalidates strict comparison with the state water quality standards, a correct

[7] It is not clear why these are called "baseline" water quality data. They are represented to be values collected during basal flow periods (non-storm influenced flow). The correct terminology is probably basal flow water quality, since "baseline" implies an unbiased collection of samples collected under average conditions for a specified time period.

summarization of the data would not significantly improve the nutrient results. The state criteria for nitrate plus nitrite (NO_3 + NO_2) are sample data geometric mean not-to-exceed (GMNTE) 70 and 30 µgN/l for wet and dry seasons, respectively; for total nitrogen (TN) the GMNTE criteria are 250 and 180 µgN/l; and for total phosphorus (TP) the GMNTE criteria are 50 and 30 µgP/l.

The upper and lower Kīpapa stations (HDOH data) demonstrate much lower nutrient concentration values. Although again not strictly valid for comparison with the state standards (all 8 sampling events should have been averaged), the basal flow data are under the various GMNTE criteria.

Only a minimal number of water quality samples were collected as part of the field effort for our survey for the reason that most areas investigated had no water, or at most, pools of standing water. Kīpapa and Waikele streams were visited at their point of confluence on October 8, 2008. Waikele was a dry stream bed; Kīpapa Stream upstream of the road bridge (downstream of HDOH bioassessment station) consisted of several large pools, with no visible moving water. Samples and measurements were collected from six separate locations in Kīpapa Gulch on September 5, 2008. Station locations are in the vicinity of the proposed drainage basins and drain lines described in the text (see Figs. 1 and 9) and to be interpreted as follows: DDB3 is a short distance downstream of DB-3; UDL1 is a short distance upstream of DL-1, and so forth. Sampling and analytical results are shown in Table 3. The water sampled was, for the most part, confined to pools, and these appeared to be isolated, although a slow flow could be occurring beneath the stream bed between pools. Because of the lack of or very sluggish flow, results can be expected to deviate from values that would be obtained under “normal” flow conditions.

We can note that parameters such as temperature, DO, and oxygen saturation are somewhat time dependent (temperature increases, DO decreases into the afternoon) as well as location dependent. Conductivity, on the other hand, increases downstream as is typically the case. Most of the other parameters show no particular pattern, indicating that some of the pools have been independent of connecting flow for awhile. For example, the pool at Sta. UDL1 is extreme for TSS, turbidity, ammonia, TN and TP. These values suggest eutrophication in this pool, where nutrients have been taken up by a phytoplankton population. On the other hand, the pool at UDB4 is high in ammonia, nitrate + nitrite, and low for turbidity and TSS. Inorganic nutrients in this pool are not being utilized by phytoplankton, perhaps due to shading or slow but steady flushing of the water. With respect to nutrients, these pools have generally lower concentrations than is the case for the long term (basal flow) water quality data for Waikele Stream given in Table 2, above.

Table 3. Kīpapa Stream samples from September 5, 2008.

Station	Time	Temp. (°C)	DO (mg/l)	DO (% Sat.)	pH -	Cond. (μmhos/cm)
Sta. DDB3	1240	26.0	4.63	57	6.57	90
Sta. DDB1	1100	29.5	7.78	102	7.83	84
Sta. UDB4	1455	24.8	3.96	48	7.39	220
Sta. DDB4	1430	28.8	4.79	62	7.50	183
Sta. UDL1	1248	31.7	3.42	47	7.11	227
Sta. DDL1	1203	22.3	1.35	16	7.09	182

Station	TSS (mg/l)	Turb. (ntu)	Ammonia (μg N/l)	Nitrate +nitrite (μg N/l)	Total N (μg N/l)	Total P (μg P/l)
Sta. DDB3	5.3	15.0	8	43	156	10
Sta. DDB1	2.3	4.82	6	21	333	24
Sta. UDB4	1.3	1.34	68	152	435	28
Sta. DDB4	3.7	3.26	19	28	473	25
Sta. UDL1	8.8	7.78	74	17	1020	102
Sta. DDL1	2.0	1.68	69	87	413	22

Station numbers reference the Drainage Basin proposed locations, with U = "upstream of" and D = "downstream of" and are arranged from highest to lowest elevation.

Urban Runoff Quality

Pollutants found in storm water associated with various land uses (forested, agriculture, industrial, urban) have been studied for decades. In addition to the long term survey of water quality of Waikele Stream (USGS, cited in Hoover, 2002), another study by the USGS (Yamane and Lum, 1985) monitored water quality in stormwater runoff from two different parts of Mililani Town: a 291-ac (118-ha; Basin A) high density residential basin and a 139-ac (56-ha; Basin B) medium density residential basin. Both basins drained to Kīpapa Gulch, but only during rainfall induced runoff events. These data are summarized in Table 4.

Table 4. Mililani Urban Runoff Study (Yamane & Lum, 1985).

		NO_2+NO_3 (μgN/l)	TN* (μgN/l)	TP (μgP/l)	TSS (mg/l)
Basin A	Median	210	1410	340	204
	Range	40-700	840-4200	80-1400	11-3000
Basin B	Median	100	1500	170	96
	Range	100-300	490-1700	120-270	3-759

* Calculated from TN = TKN + NO_2 + NO_3; range is that of the TKN values.

The high TSS values in Table 4 are explained by the fact that these are storm water samples, the TSS representing particulates picked up by runoff. The other significant component is organic matter, also presumably mostly particulates. Soluble nitrogen in the form of nitrates are also moderately high, but still low in comparison with the basal stream flow numbers shown in Table 2. Sources of these chemicals in the runoff from urban Mililani are leaf litter, fertilizers, and animal wastes.

The TMDL Study for the Waikele Stream system (Oceanit & AECOS, 2002) obtained water quality data from various locations, collected during storm runoff conditions (top 10% of stream flows during the year). Table 5 presents values from selected station locations, arranged from upstream of Koa Ridge Makai property (Sta. 7) in downstream order. These stations are shown in Fig. 2, located at the bottom of the subbasins described above in this report.

Table 5. Storm water quality for Waikele and Kīpapa streams (after Oceanit & *AECOS*, 2002).

Station	*(n)*	TSS (mg/l)	Turb. (ntu)	Nitrate +nitrite (μgN/l)	Total N (μgN/l)	Total P (μgP/l)
Sta. 7 Upper Kīpapa	*7*	121	165	94	913	262
Sta. 4 Lower Kīpapa	*7*	77	110	100	1121	253
Sta. 1 Waikele at USGS gauge	*46*	155	148	405	1702	508

NOTE: Values are geometric means calculated on *(n)* number of samples.

With respect to TN and TP, these values are in line with mean values reported by USGS at Sta. 1 for the period 1985-1996 (see Table 2). The nitrate + nitrite values are an order of magnitude lower. Because nitrates are highly soluble, they tend to infiltrate into ground water, appearing in the stream as spring fed flow (Hoover, 2002). Storm flows are predominantly fed by runoff, with typically lower amounts of nitrates (Oceanit & AECOS, 2001). Thus, the basal flow reflects more the contribution from springs than from storm runoff, whereas the values in Table 5 are stream freshet water quality characteristics, and compare more closely with values reported by Yamane & Lum (1985) for storm water runoff from Mililani (Table 4). The only pattern evident in the Table 5 data is an increase in nutrient content (especially nitrate + nitrite) in the downstream direction.

Various studies on Oʻahu have looked at toxic compounds in streams that can be attributed to runoff from urban environments. Insecticides used for the treatment for termites under houses and mosquito control (examples are Chlordane and DDT) have appeared in stream sediments and even marine sediments off stream mouths. Uses of these long-lived chlorinated compounds have been banned for decades and new projects like Koa Ridge Makai are not a potential source. A recent study involving watersheds on Oʻahu (Ala Wai and Kāneʻohe) has demonstrated an association between certain metals as particulates associated with runoff from urban watersheds (lead, zinc, copper, barium and cobalt), agricultural lands (arsenic, cadmium, uranium), and native minerals in the watershed (nickel, vanadium, and chromium; DeCarlo, Beltran, & Tomlinson, 2004).

Stream Biota

The aquatic biota of Waikele, Kīpapa, and Waikakalaua streams has been surveyed many times in recent decades. These surveys have been summarized by Henderson (2003, p. 8), in part:

> A 1991 survey reported introduced fishes, such as topminnows (*Poecilia* spp.) and dojo (*Misgurnus anguillicaudatus*), in the middle reaches of the Waikakalaua Tributary and ʻo'opu nakea (*Awaous guamensis)* at approximately 1380 feet elevation (Dames & Moore as cited in AECOS 1992). In 1993, Environmental Technologies International (ETI [Englund, 1993]) documented ʻo'opu naniha (*Stenogobius hawaiiensis)* and ʻo'opu nakea juveniles as well as various size classes of ʻo'opu ʻakupa (*Eleotris sandwicensis)* and aholehole (*Kuhlia sandvicensis)* below the Farrington Highway Bridge. ʻOpae oeha'a were also observed in the lower reaches of Waikele Stream, and many life stages of ʻoʻopu nakea were found in the lower, middle and upper reaches (Kipapa Tributary) of Waikele Stream ([Englund] 1993). ʻopae kalaʻole (*Atyoida bisulcata*) were reported in Kipapa Stream in a 1996 study related to the Air Force POL pipeline

> (EA Engineering, Science, and Technology). In a 1997-1998 survey of the lower and middle reaches of Waikele Stream, declining numbers of adult *A. guamensis* and *S. hawaiiensis* were reported (Englund and Filbert 1999). Contrary to the 1993 ETI study, post-larvae of these species were not detected. Topminnows and bristlenose catfish (*Ancistrus* cf. *temminckii*) were abundant during this sampling effort, and the introduced shrimp, *Neocaridina denticulata sinensis*, were documented in large numbers….

The HDOH (Henderson, 2003) study involved 5 stream sampling stations selected to "roughly correspond to a DOH Clean Water Branch water quality sampling location and/or [be] representative of a larger section of the stream with respect to habitat, biological community and expected response to human degradation". Three of these—upper Kīpapa (700-ft elev.), Lower Kīpapa (120-ft elev.), and Lower Waikele (40-ft elev.)—are of particular relevance herein, although all are distant (up and down stream) from the Koa Ridge Makai project site. The HDOH surveys are especially useful because they apply "…a quantitative, multi-metric approach to evaluating the habitat and biotic conditions..." That is, various metrics are utilized to quantify observations so that stream habitat and biota can be rated to compare with other stream systems in the Hawaiian Islands.

Unnamed Gulch

Detention Basin No. 2 (DB-2) is proposed for a location in Unnamed Gulch a short distance downstream from the Mililani Mauka Drainline 2 outlet. With the exception of one or two pig wallows, no standing or flowing water was observed in the unnamed gulch upstream of the outlet of the outlet structure. In the vicinity of the outlet, several pools were present. These may have been feed by outflow from the drain or local rainfall. Some pools showed growth of a green alga (*Oedogonium* or *Spyrogyra*) and supported small populations of a physid snail (*Physa virgata*), a thiarid snail (*Melanoides tuberculata*), and an unidentified chironomid (fly) larva. No fishes were observed in the small pools, but the presence of this minimal aquatic fauna (snails, at least) suggests the pools are semi-permanent.

Stream conditions are more or less similar along this gulch from the proposed location for DB-2 to the confluence with the much larger Kīpapa Gulch. Detention Basin No. 3 (DB-3) would be located along the gulch bottom starting at about 500 ft (150 m) from Kīpapa Stream to a point approximately 1500 ft (450 m) up the gulch. No water flow was observed in this part of the gulch, although there was ample evidence of flows in the past (mud and debris marks up to 3 ft or 1 m off the ground, dried mud in the bed with dried algae). The dry stream bed is incised into the floor of the gulch as much as 10 ft (3 m) in places, with boulders embedded in silt deposits in the bed. Several pools are present in the area of proposed DB-3.

One of the largest (40 x 6 ft, 1 ft deep) was a milky white color derived from a white bedrock eroding in the stream bed. A water sample was collected from this pool (see DDB3 in Table 3). Aquatic fauna here consisted of a physid snail, an unidentified leech, and a green filamentous alga.

Because aquatic habitat is all but absent from the unnamed gulch, no earlier surveys in the larger watershed include this particular gulch area.

Kīpapa Stream

Detention Basin No. 1 (DB-1) is proposed for a location above the right bank[8] of Kīpapa Stream just downstream of the H-2 Kīpapa Gulch viaduct. This basin would receive runoff from Mililani Mauka via an existing drain (Drain Line No. 1). Nearby Kīpapa Stream was flowing slowly at this location, and harbors a green alga, a physid snail, and Mexican molly (*Poecilia mexicana*). The fish and snail are abundant here. A water quality sample was obtained at this point in the stream (labeled Sta. DDB1).

A large pool is present under the H-2 viaduct a short distance upstream of the location proposed for DB-1. This pool is about 3 ft (1 m) deep and both small-mouth bass (*Micropterus dolomieu*) and *ʻoʻopu nakea* (*Awaous guamensis*) were observed present. No poeciliids were observed in the pool, but armored catfish (*Ancistrus* cf. *temminckii*) and bullfrog (*Rana catsebeiana*) were seen in small numbers.

A stream bed of large boulders and slow flowing water (Fig. 10) is present upstream and beyond the confluence with the outlet from the unnamed gulch (at the 500-ft or 150-m elevation). A green alga, pond snail (*Physa* sp.) and Mexican short-fin molly are generally abundant in this reach. The HDOH (Henderson, 2003) study of a station at the 700-ft (210-m) elevation generated a Hawaii Stream Visual Assessment Protocol (HSVAP) score of 1.7 (max = 2.0), or a high rating, and a Hawaii Stream Bioassessment Protocol (HSBP) Habitat score of 161.5 (81%), defined as "supporting" of aquatic life.

Further downstream is the location of proposed optional detention basin DB-4, at about the 350-ft (107-m) elevation. Castle & Cooke proposes to build a box culvert here, draining Koa Ridge Makai (Drainage Area 2 in Fig. 8) into Kīpapa Stream upstream of an old roadway bridge. If DB-4 is built, this storm drain will discharge

[8] The terms "left" and "right" bank always refer to the side of a stream or river as seen facing downstream. This form of description is superior to a compass direction, because the latter will change dramatically with each meander of the stream and can be dependent upon map scale.

flows into it. The drainline and basin are downslope of a small swale that is a natural drainage point on the Koa Ridge Makai interfluve.

Figure 10. Kīpapa Stream in the general vicinity of proposed DB-1 showing shaded and unshaded reaches, boulder strewn bed, and part of a pool habitat.

Upstream of the area proposed for DB-4, Kīpapa Stream is a wide, boulder strewn bed, with (at the time of the survey) a few isolated pools of water. Several existing drain pipes occur above the right (west) bank. Erosion of the stream banks is particularly evident where the channel narrows or debris dams have built up.

Kīpapa Stream channel in the vicinity of DB-4 is some 45 ft (15 m) across and incised 18 ft (6 m) into the gulch floor. The streambed consists of boulders, cobble, and gravel. Finer sediments are not as prominent as observed further upstream around DB-1. At the time of the survey, several large, isolated pools were present, with no obvious water flow moving between them. A water sample (DDB4) was collected from one of these pools for analysis.

Thiarid snail, armored catfish, and toad (*Bufo marianus*) tadpoles are abundant in the pools. Green algae (*Chara* and another filamentous species) are abundant in the pools. Mexican molly is common, particularly in the shallow margin areas, as are guppies (*Poecilia reticulata*). The physid snail seen upstream was not observed here, but an occasional bass was observed in the deep parts of the pools, and one, 4-in (10-cm) long ʻoʻopu nakea was seen in a pool. An introduced atyid shrimp (*Neocaridina denticulata sinensis*) was observed (this species increases in abundance downstream from this area) as was the Pacific prawn, *Macrobrachium lar*.

The September 2008 stream survey extended to and beyond a proposed Koa Ridge Drainline No. 1 (DL-1) planned for a discharge point on Kīpapa Stream approximately 1600 ft (0.49 km) downstream of the Kamehameha Highway bridge. Here, the stream bed is about 60 ft (20 m) across and the banks are not particularly steep. The streambed consists of boulders and rocks and is not as embedded as at Basin 1. When surveyed, stream flow was not observed and only a few small pools were present in the streambed. In these pools was an abundance of green algae (same as observed in pools further upstream), thiarid snail, armored catfish, Mexican molly, guppy, and toad tadpoles. The physid snail was common. A single *ʻoʻopu nakea* was seen along with a red-eared slider (*Trachemys scripta elegans*). *Neocaridina* shrimp were abundant and Pacific prawn, common.

Further downstream from proposed DL-1 discharge point we encountered a large pool that was mostly dried up. *Neocaridina* were plentiful here. Dragonflies (one *Anax* and several *Pantala*) and damselflies (*Ischnura posita and I. ramburi*) were abundant, skimming the surface of the pools.

The HDOH reference station for Lower Kīpapa was located within the former Waikele Naval Ammunition Depot not far upstream from the confluence of Kīpapa and Waikele streams. This station should be representative of the lower reach of Kīpapa in the project vicinity. The HSVAP score here was 1.3 (out of 2.0) or "medium" habitat. The HSBP habitat score was 107 or 54% of the statewide reference ("partially supporting"); and the HSBP biological metrics was 15 (27% of the reference streams) for an "impaired" rating (Henderson, 2003). Only alien aquatic fauna were recovered from the stream.

Waikakalaua Stream

Waikakalaua Stream generally parallels Kīpapa Stream, draining the same slope of the Koʻolau further north, eventually joining Waikele Stream north of the confluence with Kīpapa. This stream was surveyed by Brasher (1991) from the H-2 freeway overpass to approximately the 1520-ft (460-m) elevation and the report referenced here as a source of information on a nearby stream with similar flows and ecology. Observations on water quality (DO and pH) and biota were made at a the total of 12 sites. Invertebrates noted included a native freshwater sponge (*Heteromyenia baileyi*), a thiarid snail (*Melanoides* sp.), and several aquatic insects (*Cheumatopsyche analis*, *Hydroptila arctis*, *Pantala flavescens*, chironomids, and culicids). Both *Rana* frogs and *Bufo* toads were present. Fishes observed were guppy, swordtail (*Xiphophorus helleri*), dojo (*Misgurnus anguillicaudatus*), and ‘o‘opu nakea. Only the dragonfly (*P. flavescens*) and the goby (‘o‘opu) fish are native (indigenous) species. The fauna of Waikakalaua is the same as that reported for Kīpapa/lower Waiklele. HDOH (Henderson, 2003) ratings for this stream were basically the same as those recorded for Kīpapa (comparing upper Waikakalaua with upper Kīpapa, and lower Waikakalaua with lower Kīpapa).

Waikele Stream

Waikele Stream above project influence—that is above the confluence with Kīpapa Stream—is perennial up to the confluence with Waikakalaua (although this reach has low flow or becomes isolated pools in the dry season), and intermittent above that. No HDOH bioassessment sites were located on Waikele Stream above the confluence with Kīpapa (except those on the Waikakalaua branch). HDOH (Henderson, 2003) ratings for lower Waikele Stream, sampled below the Waipahu Street bridge, were: HSVAP – 1.2 (medium), HSBP habitat – 60% (partially supporting); and HSBP biota – 31% (impaired)

Pānakauahi Gulch

No previous studies of biota inhabiting Pānakauahi Gulch were found. This gulch contains an intermittent stream and is essentially a dry stream bed most of the time, so it is unlikely that an aquatic biota study has been done. The stream is shown (USGS, Topographic Map) arising at around the 1380-ft (420-m) elevation. It seems unlikely that any reach of the stream is perennial flowing, although isolated pools remaining after freshet flows may be present along the upper reach.

Table 6. Checklist of aquatic fauna observed or previously reported from Waikele and Kīpapa streams.

Species	Common name	Status	QC Code	ABUNDANCE
ALGAE				
CHLOROPHYTA	green algae			
Indet. chlorophyte		---	10	C
CHARACEAE				
Chara sp.	stonewart alga	---	20	O
INVERTEBRATES				
PORIFERA	(sponges)			
Heteromyenia baileyi (Bowerbank)		**end**	11^{0}	P

Table 6 (continued).

Species	Common name	Status	QC Code	ABUNDANCE
ANNELIDA, HIRUDINEA	(worms)			
indet.	leech	---	10	U
MOLLUSCA, GASTROPODA, MESOGASTROPODA	(mollusks)			
THIARIDAE				
Mellanoides tuberculata (Müller)	melanid snail	nat	10 11[0,1,3]	C - A
MOLLUSCA, GASTROPODA, PULMONATA				
LYMNAEIDAE				
Lymnaea producta (Mighels)	pond snail	**end**	11[1]	C
PLANORBIDAE				
Planorba duryi Wetherby	ramshorn snail	nat	10	R
PHYSIDAE				
Physa virgata (Gould)	pond snail	nat	20	C
MOLLUSCA, BIVALVIA				
CORBICULIDAE				
Corbicula fluminea Müller	Asiatic flume clam	nat	10 11[1,2,3]	†
ARTHROPODA, CRUSTACEA, DECAPODA	(insects)			
ATYIDAE				
idina denticulata sinensis (de Haan)	Taiwan blue shrimp	nat	10 11[3,4]	A
CAMBARIDAE				
Procambarus clarki (Girard)	American crayfish	nat	10 11[1,3,4]	E
PALAEMONIDAE				
Macrobrachium grandimanus (Randall)	*ʻopae ʻoehaʻa*	**end**	11[1,4]	O
Macrobrachium lar (de Haan)	Pacific prawn	nat	10 11[1,4]	O
ARTHROPODA, INSECTA	(insects)			
DIPTERA, CHIRONOMIDAE				
indet.	larvae	nat	10 11[0]	U
DIPTERA, CULICIDAE	(mosquitoes)			
indet.		nat	11[0]	P
HEMIPTERA, VELIIDAE				
Microvelia vagans White	water strider	**end**	11[2,3]	C
ODONATA, ANISOPTERA	(dragonflies)			
AESCHNIDAE				
Anax junius (Drury)	green darner, adult	**ind**	10 11[3]	R
Anax junius (Drury)	green darner, nymph	**ind**	11[3]	O
LIBELLULIDAE				
Crocothemis servilia Drury	scarlet skimmer, adult	nat.	10 11[3]	C
Orthemis ferruginea (Fabricius)	adult	nat.	10 11[1,3]	C
Pantala flavescens (Fabricius)	globe skimmer, adult	nat.	10 11[0,1,3]	U
ODONATA, ZYGOPTERA	(damselflies)			
COENAGRIONIDAE				
Ischnura posita (Hagen)		nat.	10	R
Ischnura ramburi (Selys-Longchamps)	Rambur's damselfly	nat.	10	O
TRICHOPTERA	(caddisflies)			
HYDROPSYCHIDAE				
Cheumatopsyche analis Banks		nat	11[0]	P
Cheumatopsyche pettiti (Banks)		nat	11[1]	P
HYDROPTILIDAE				
Hydroptila arctia Ross		nat	11[0]	P

Table 6 (continued).

Species	Common name	Status	QC Code	ABUNDANCE
VERTEBRATES				
VERTEBRATA, PISCES	(fishes)			
CENTRARCHIDAE				
Micropterus dolomieui Lacepède	smallmouth bass	nat	10	O
CICHLIDAE				
Tilapia sp.	tilapia	nat	11[1]	A
CLARIIDAE				
Clarius fuscus (Lacepède)	Chinese catfish	nat	11[4]	P
COBITIDAE				
Misgurnus anguillicaudatus (Cantor)	dojo	nat	11[0,4]	P
ELEOTRIDAE				
Eleotris sandwicensis (Vaillant & Sauvage)	*ʻoʻopu ʻakupa*	**end**	11[2]	P
GOBIIDAE				
Awaous stamineus (Eydouxi & Souleyet)	*ʻoʻopu nakea*	**ind**	10 11[0,1,2,4]	O
Stenogobius hawaiiensis Watson	*ʻoʻopu naniha*	**ind**	11[2]	P
KUHLIIDAE				
Kuhlia sandvicensis (Steindachner)	*aholehole*	**end**	11[3]	O
LORICARIIDAE				
Ancistrus cf. *temminckii*	bristle-nosed catfish	nat	11[1,3,4]	C
Hypostomus sp. *watwata* group	suckermouth	nat.	10	O
POECILIIDAE				
Gambusia affinis (Baird & Girard)	Mosquitofish	nat	10 11[3,4]	U
Poecilia mexicana (Steindachner)	Mexican mollie	nat	10 11[1,3,4]	A
Poecilia reticulata Peters	guppy, rainbow fish	nat	10 11[1,0,3,4]	C
Xiphophorus helleri Heckel	green swordtail	nat	11[0,1,3,4]	P
VERTEBRATA, AMPHIBIA	(frogs & toads)			
BUFONIDAE				
Bufo marinus (L.)	marine toad, tadpole	nat	10 11[0,1]	A
RANIDAE				
Rana catesbeiana Shaw	bullfrog, tadpole	nat	10 11[0,1]	U
VERTEBRATA, REPTILIA, TESTUDINES	(frogs & toads)			
EMYDIDAE				
Trachemys scripta elegans (Wied)	red-eared slider	nat	10	R
VERTEBRATA, AVIA	(birds)			
ARDEIDAE				
Nyctocorax nytocorax hoactli	black-crowned night heron	**ind**	10 11[3]	R

KEY TO SYMBOLS USED:

Status:

nat. – naturalized; an introduced or exotic species.
ind. - indigenous. A native species also found elsewhere in the Pacific.
end. - endemic - A native species found only in the Hawaiian Islands.

QC Code:

10 - Observed in the field by *AECOS* aquatic biologist in 2008.
11 – Previously reported by others ([0] Brasher, 1991; [1] Englund, 1993; [2] Englund & Filbert, 1999; [3] AECOS, 2000; [4] Henderson, 2002).
20 – Collected in 2008; identified in the laboratory; specimen(s) not saved.
† - observed only as skeletal material or sign.

Table 6 (continued)

Reported abundance categories:

R – Rare - only one or two individuals seen.
U - Uncommon - several to a dozen individuals observed.
C - Common - Seen everywhere, although generally not in large numbers.
A - Abundant - found in large numbers and widely distributed.
P – Present - noted as occurring, but quantitative information lacking.

Project Impacts Assessment

General Environmental Concerns

Urban/Suburban housing developments raise a number of environmental concerns. The present assessment is limited to impacts on stream and gulch systems arising from both direct impacts of construction within the fluvial gulches affected by the project and indirect impacts resulting from run-off from project areas on aquatic environments at and downstream of the project areas. Impacts on aquatic environments from land developments are generally a consequence of changes in the nature of runoff from the land. Changes can involve physical and chemical properties (water quality) of the runoff reaching aquatic environments, or changes in the distribution of flow (water quantity) delivered to aquatic systems. Lotic (flowing water) ecosystems in particular can be sensitive to both kinds of impacts. Limnetic (open water) ecosystems are mostly sensitive to physical and chemical characteristics of land runoff.

Land development—changing the nature of the land from forest, grassland, or agriculture to urban or suburban use—alters the way the land surface deals with rainfall inputs. Urban and suburban lands have a greater proportion of impermeable surfaces than other land categories. These surfaces (paved roads, parking lots, structure roofs) decrease the amount of rain that is infiltrated, capturing it and directing it through drainage structures as runoff flow. Excess runoff is eventually directed to natural drainage areas (gulches, streams), but the amount arriving from any given size of storm is greater from developed land than from undeveloped land; and the runoff occurs more rapidly on developed land.

While capturing and directing more of the rainfall to a stream may or may not have impacts on groundwater resources, the impact on stream ecology is primarily caused by changes in the distribution of flow with time. Rain falling on a forest will move slowly into the stream drainage and the groundwater as recharge[9]; rain falling on land with impermeable surfaces moves quickly (and is helped by the man-made drainage system) to the streams, resulting in a sharp rise in the flow to maximum (called the peak flow) for a particular event. It is the change in peak flow characteristics that determines the potential adverse water quantity impacts of land development on stream ecology. Hawaiian streams are naturally flashy, by which is meant flows rise considerably for short periods of time called freshets fed by runoff from high local rainfall events. The change in flow regime resulting from

[9] For Kīpapa Stream, it has been estimated that only 18.5% of annual rainfall becomes direct surface runoff (Hirashima, 1971). The majority is infiltrated, although may show up later as springs discharging into this or other streams. In fact, this capture of rain water by the watershed contributes to the stream's perennial flow between storms.

urbanization is not just a matter of exacerbating this flashy nature, but also one of reducing groundwater available for basal flow between freshet episodes.
Changes in the nature of land uses also effect changes in the quality of runoff. In general, naturally vegetated surfaces not only infiltrate a greater proportion of rainfall, but tend to give up little in the way of soil particles and organic matter. Disturbed ground erodes easily and provides no filtration for particulates moving across its surface. Land development results in the addition of various chemicals that can be picked up and moved into aquatic environments: particularly fertilizer and pesticides from agriculture operations, heavy metals, petroleum residues, cast-off materials (man-made debris) from roads, yards, and light industrial sites. Unshaded surfaces can increase water temperature by giving up heat to shallow runoff flows.

The pollutants associated with urban runoff are generally well known (see, for examples, Sartor & Boyd, 1972; Laws, 1981), and have even been studied specifically in the project vicinity (Yamane & Lum, 1985; Hoover, 2002) as well as elsewhere on O‘ahu (DeCarlo, Beltran, & Tomlinson, 2004). The latter study supports a known association between trace metal content and particulates (suspended solids) in runoff and stream flow. A similar association has been demonstrated for organic toxicants and particulates (e.g., see Izuka, et al., 1993).

Regulatory Aspects

303(d) list — The Clean Water Act, Section 303(d) (CWA § 303(d)) requires states to submit a list of water quality-limited segments (waters that do not meet state water quality standards) and a priority ranking of these listed waters based upon the severity of pollution and uses of the waters. This list is known as the §303(d) list. “The §303(d) list leads to action” (HDOH, 2008a). For each water body on the §303(d) list, a pollution budget or Total Maximum Daily Load (TMDL) must be developed to bring that water body into compliance with water quality standards.

Waikele Stream, to which Kīpapa Stream is tributary, and Waiawa Stream, to which Pānakauahi Gulch is tributary, are both on the State of Hawai‘i, §303(d) list. The entire Waikele Stream system has been found not to meet the total nitrogen (TN) criteria during the wet and dry seasons and the turbidity criterion during the wet season (HDOH, 2008a). The stream system is listed as categories 3 and 5[10]. Waikele Stream is given a “high” TMDL priority code for “initiating TMDL development

[10] Category 3: insufficient available data and/or information to make a use support determination; Category 5: available data and/or information indicate at least one designated use is not being supported or is threatened, and a TMDL is needed.

within the current monitoring and assessment cycle (through April 15, 2008), based on the prioritization criteria described in the HDOH report and on current and projected resource availability for completing the TMDL development process." HDOH notes that TMDL development is in progress for Waikele Stream (HDOH, 2008a).

The entire Waiawa Stream system has been found not to meet the trash criteria during wet and dry seasons. Waiawa Stream is on the list as not meeting TN, nitrate+nitrite (NO_3+NO_2), total phosphorus (TP), and turbidity criteria during the dry season and the turbidity criterion during the wet season, based upon a "visual listing from 2001-2004" (HDOH, 2008a). The stream system is also listed as categories 3 and 5 (see footnote below). Waiawa Stream is also given a "high" TMDL priority code for "initiating TMDL development within the current monitoring and assessment cycle (through April 15, 2008), based on the prioritization criteria described in the HDOH report and on current and projected resource availability for completing the TMDL development process." The listing notes that TMDL development is in progress for Waiawa Stream (HDOH, 2008a).

<u>TMDL</u> — A TMDL is a calculation of "the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of that amount to the pollutant's sources (USEPA, 2008). A TMDL is typically quantified with the following equation:

$$\text{TMDL} = \text{WLA} + \text{LA} + \text{MOS}$$

WLA (Waste Load Allocation) is the portion of the maximum pollutant load[11] that is delivered from point sources, that is, discharges regulated under National Pollutant Discharge Elimination System (NPDES) permits. LA (Load Allocation) is the portion of the maximum pollutant load that is delivered from non-point sources. MOS (Margin of Safety) accounts for errors, limitations, and uncertainty in computing the load allocations.

According to DOH, "the primary objectives of …TMDLs are to stimulate and guide action that will control sources of excessive" pollutants, "and to improve the water quality of the streams so that the designated and existing uses of waterbodies … will be protected and sustained" (HDOH, 2008c).

Prior to TMDL establishment in a water body, the HDOH encourages land owners and project managers to properly apply "suitable best management practices in all

[11] The term "load" refers to an amount over time; it is a function of the concentration times the volume or flow. A high concentration in a trickle may have the same load ass a low concentration in a flood.

phases of the project" and adhere "to any applicable ordinances, standards, and permit conditions" and, in this case, to "specify how the proposed project would contribute to reducing the polluted discharge and runoff entering the receiving waters, including plans for additional pollutant load reduction practices in future management of the surrounding lands and drainage/discharge systems" (HDOH, 2008b). After the TMDL is established, HDOH will require all CWA permit holders to comply with allocations (WLA) as set by the TMDL.

Although storm runoff is considered a non-point source of stream pollutants, the City and County of Honolulu is an NPDES permit holder for its municipal storm drain system (Separate Storm Sewer System NPDES Permit No. HI0021229). Under TMDL, the contribution from permit holders is an allocated waste load (WLA); that is, one subject to regulation by HDOH through the permit process. Although preliminary TMDL calculations have been completed for Waikele Stream (Oceanit & *AECOS*, 2002), these are not considered by HDOH as final or even applicable at this point in time. The TMDL report concludes that given the difficulty of characterizing storm flow water quality in Hawaiian streams, actual regulation of waste load allocations is perhaps better "…expressed as implementable best management plans (BMPs) and not as numeric limits" (Oceanit & *AECOS*, 2002, p. 6-1). However, HDOH is moving ahead to eventually place numerical limits on all discharges subject to a permit review process. Since the TMDL process is still underway in the subject watersheds and the likelihood of quantifiable reduction of select pollutants from storm drains only a remote possibility, best management practices sanctioned by the City and County of Honolulu (as permit holder for these drainage systems; see C & C, 2000) is the only practicable compliance approach.

Mitigating Adverse Impacts on Stream Systems

Engineering measures can be applied to mitigate potential adverse impacts on aquatic environments resulting after conversion of the land from an undisturbed state (or in this case, agricultural use) to urban use. Various types of basins, called settling, infiltration, retention, detention, or debris basins can be constructed to receive storm runoff from urban lands or freshet flows in streams. Detention and retention basins are now required for new developments on O‘ahu (C & C 2000), although this is a fairly recent requirement, and fitting basins into an already developed landscape can be difficult. These basins may be constructed in or adjacent to, or remote from natural aquatic environments. Retention or settling basins (sometimes called water quality basins) reduce the velocity of the water flow and retain some of it to allow settleable material to sink to the bottom. Retention basins typically incorporate a body of water or a wetland in the design. A debris basin is usually constructed on a stream above the urban areas to collect large rocks and tree branches and trunks that might clog downstream culverts, causing flooding by overflow.

Detention basins typically are intended to hold back high flow rates, by holding back water entering in excess of the discharge escaping through a pipe made purposely small. Runoff water is typically held for less than 24 hours. Thus, small amounts of runoff pass freely through the basin. The basin must be of sufficient size to store the runoff from large storms, and in such cases, the peak flow of the run-off is simply stored and released over time. A detention basin is very effective at reducing peak flows, and may remove some of the debris and sediment carried by the runoff before it reaches the discharge. Typically, the water is not retained long enough (less than 24 hours) to effect changes in the fine sediment loading or in chemical pollutants carried by the runoff. But the fact that all types of basins need regular maintenance in the form of sediment and debris removal attests to a degree of cleaning of the runoff before it is released to a stream. Furthermore the design can incorporate a certain amount of debris removal, particularly refuse that gets swept into street drains.

Increasing the detention time can effect even greater improvements in water quality; the basin becomes an extended detention type (New Jersey DEP, 2008). Typically, extended detention basins, while remaining dry between storms, are constructed to hold back runoff from smaller storms for a longer period of time than the detention basin. A vegetated swale may be incorporated in the design. This longer detention results in greater settlement of suspended solids and thus overall greater removal of pollutant loads carried by urban runoff. Even greater reduction in fine solids and nutrients can be achieved using retention or wet-detention basins, but these structures are difficult to maintain and subject to undesirable liabilities (drowning hazard, mosquito breeding).

Specific Mitigations Proposed

Koa Ridge Makai — In order to mitigate increases in storm water runoff from the Koa Ridge Makai development, offsite detention basin are proposed in drainage basins upstream of the project site. These basins will attenuate the peak discharge into Kīpapa Stream so the net impact of the Koa Ridge Makai development will be no increase in Kīpapa Stream discharge at the points where contribution from the project occur as a result of development (ParEn, 2008).

In effect, it is proposed that detention basins located in Kīpapa Gulch—adjacent to, but not in or incorporating Kīpapa Stream flow—pull peak flow off storm water presently being contributed to Kīpapa Stream by developed (and some undeveloped) lands upstream of Koa Ridge Makai. Thus, implementation of basins DB-1, DB-2, DB-3 as described (see Table 1) will reduce peak flow in Kīpapa Stream at a point immediately downstream of the Koa Ridge Makai, Drain Line 1 (DL-1) outlet to 19,411 cfs under design storm conditions, a reduction of 165 cfs compared with existing circumstances (ParEn, 2008). Construction of DB-4 in place of DB-3 will result in an even greater reduction to 19,315 cfs. This approach accomplishes the desired result from a strictly hydrological or engineering perspective of no net increase in storm flood flow. From an environmental perspective, the approach can provide subtle but additional benefits by reducing erosion within the gulch downstream of each proposed detention basin, reducing stream sediment loading. Reduction of erosion would seem especially beneficial for the unnamed gulch (to be protected by DB-2), the floor of which did not support an eroding stream bed prior to the construction of the Mililani Mauka Drain Line 2. Since construction of the Mililani Mauka main drain lines, some local neighborhoods now have small detention basins of the sort described herein as "water quality treatment facilities," intended to treat storm water from small storms. Otherwise, the Mililani Mauka storm runoff system is not subject to detention to the extent proposed for the Koa Ridge Makai project.

Drain lines from the project will incorporate "storm water quality treatment" basins or structures to satisfy the Storm Drainage Standard (C & C, 2000) prior to discharge into Kīpapa Stream (ParEn, 2008). These basins or structures are intended to treat the far more numerous, smaller storms anticipated to generate runoff and not the flood control (peak flow reduction) achieved by the large detention basins sited within Kīpapa Gulch.

<u>Castle & Cooke Waiawa</u> — For the Castle & Cooke Waiawa, upper drainage area (Area 2), a detention basin is proposed that will be of sufficient capacity to capture peak flow equivalent to that generated by the entire Castle & Cooke Waiawa developed area (ParEn, 2007). That is, because a suitable area for a detention basin to service Drainage Area 1 is not available, the amount of peak runoff anticipated for this lower area will be detained from the runoff from Area 2 on top of or in addition to the amount captured from Drainage Area 2. The storage volume of the proposed 8.5-ac (3.4-ha) detention basin will provide for the capture of 30 to 50 acre-feet from a 100-year 24-hour peak discharge.

Just as proposed for detention basins in Kīpapa Gulch to pull peak flow off storm water carried by Kīpapa Stream upstream of the Koa Ridge Makai project, the proposed detention basin for Castle & Cooke Waiawa will capture, temporarily, a sufficient volume of the flood surge draining the upper half of the project area to effect a net reduction below the outlet of the drain line from the lower half of the development. This "tradeoff" will achieve the desired amelioration of flood hazard by attenuating peak discharge to predevelopment conditions downstream of the project area. The tradeoff accomplishes the desired result from a strictly hydrological or engineering perspective. From an environmental perspective, the approach can provide subtle but additional benefits by reducing erosion (thereby reducing stream sediment loading) and enhancing infiltration.

Essentially, the upper drainage basin will be over-sized for its drainage area. Since it is to be located in a gulch lacking a true stream, maintaining peak runoff at present levels is especially important. Lacking a rocky stream bed, soil along the bottom of the gulch is easily eroded. A larger detention basin could retain the flood water for a longer period and, having a greater basal area, infiltrate more of the detained water into the aquifer further upslope than would be the case with two separate basins for each drainage area of the project.

The outlet location for the drain line (Drainage Area 1; Fig. 9) is proposed for a location on Pānakauahi Gulch immediately upstream of a sharp horseshoe bend in the gulch. This bend is the result of a thick, highly resistant bed of lava forming a cliff along the right bank. Directing the storm flow from the drain line into the stream at this point will not enhance erosion of soil on the right bank because of this massive natural rock that occurs there (Fig. 11).

Figure 11 The right bank of the dry stream in Pānakauhi Gulch at the location proposed for a drainage outlet is naturally hardened (massive basalt formation) greatly reducing soil erosion potential.

A storm water quality treatment facility is proposed (ParEn, 2007) for the lower drainage area, by which is meant a small detention basin or, owing to limited available space, a hydrodynamic separator as described elsewhere above. These basins are designed to retain water from small storms, effecting minimal flood protection but enhancing removal of some particulates and debris from street runoff by detaining runoff for up to several days. Downstream flood prevention (peak flow detention) for Pānakauahi and Waiawa downstream of Drainage Area 1 will be accomplished by the Drainage Area 2 detention basin as described above.

Impacts on Stream Biota

Some native faunal elements in Hawaiian streams are protected by statute. Hawaiʻi Administrative Rules (HAR) §13-95 regulates the taking of *āholehole*, while HAR §13-100 and §188-43 regulate the taking of all ʻ*oʻopu* in Hawaiian waters (DLNR, 2007). No federally endangered or threatened aquatic species (Federal Register, 2005; USFWS, 2005) were encountered during our 2008 or any of the earlier Waikele/Kīpapa Stream surveys discussed above, and none is anticipated to utilize stream habitats in the project area. The project will not have any adverse impacts on aquatic species protected by state or federal statutes.

Water Quality — Assessing impacts on stream biota from non-point source pollution is difficult because impacts may be subtle and can have indirect consequences. For example, demonstrating that certain metals are more characteristic of runoff from Oʻahu urban settings than rural ones (DeCarlo, Beltran, & Tomlinson, 2004) describes only the potential for pollutant loading of stream and nearshore sediments. The actual adverse impacts of these potentially harmful chemicals on aquatic biota can only be surmised as occurring or possible. Native stream biota may be more or less sensitive to these and other pollutants, and adverse impacts to native populations may hinge on the sensitivity of food resources rather than direct impacts on, say fishes, mollusks, or crustaceans. In any event, preventing harmful substances applied purposefully or accidentally to exposed urban surfaces from entering streams becomes difficult if not impossible, once these substances are entrained in runoff flows. It is more effective to prevent or reduce contamination of substances having an adverse biological impact of aquatic biota at the source.

On the assumption that reversion of lands to forest instead of housing is not an option, the detention and extended detention (water quality) basins proposed for Koa Ridge remain the best approach for mitigating changes in the nature of pollutants anticipated as land use changes from one of agriculture to one of housing. Although many pollution reducing measures, such as directing drainage into grassy swales instead of concrete drains, are only practical in rural and agricultural settings, the water quality treatment basins and structures proposed for Koa Ridge Makai and Waiawa are the urban equivalent of the grassy swale for small storms. These treatment facilities are likely to be effective in preventing increases in stream water temperature occurring when small storms generate runoff from daylight exposed impermeable surfaces such as roads and parking areas.

Litter — Trash (litter) carried by runoff from the urban environment can have adverse impacts on stream biota, and even greater adverse impacts on nearshore waters where the stream discharges at the coast. Greater human density and commerce (as characterize an urban setting) can only result in greater amounts of litter entering a stream system to be transported to nearshore environments. Consequently, direct deposit of trash into stream beds is a significant problem in Hawaiʻi in both urban and rural areas (Fig. 12). Construction of treatment basins between land drainage systems and a stream offer an opportunity to remove much of the litter from the system.

Figure 12. Not all litter carried by streams to the ocean comes from runoff. A significant amount is garbage and litter deposited directly in the stream bed as here in Kīpapa Stream.

Channel Modifications — Most of the biota extant in the affected streams (Waikele and Waiawa stream systems) is non-native, consisting of species introduced to Hawaiian fresh waters in the last 50 to 100 years. Native species numbers have severely declined over this period, for a variety of reasons, most significant of which is alteration of stream habitats (Timbol & Maciolek, 1978). Although alteration of stream habitats can take many forms, including the direct and indirect impacts of peak flow alterations, channel modification is perhaps most significant.

The impact that channel modifications can have on native stream biota relates to the anadromous nature of the native macrofauna. A channelized section that causes difficulty to a species migrating upstream to habitats in the uplands, can result in the depletion of that species from the system, despite a complete absence of adverse impacts to the uplands habitat of the species. Without free access along the entire length of a stream, the amphidromous populations cannot persist in the upper reaches. It is not necessary for the stream to flow year round. Migration between the uplands and the sea occurs during freshets that flush eggs downstream and provide enough flow for juveniles to move upstream, sometimes in stages between freshets.

Englund (1993) explored locations on Kīpapa Stream at elevations (above 1250 ft or 380 m) where water flow is perennial and reported *'o'opu nakea* as present. This native goby is amphidromous: during its life cycle, each fish migrates to and from the sea. Migration seaward entails only hatchlings. The larval stages develop in marine waters and, as post-larvae called *hinana*, ascend freshwater streams to populate these and grow to adults. Thus, populations of *'o'opu nakea* in the upper reaches of Kīpapa are utilizing aquatic habitat in Kīpapa and Waikele gulches to complete this migration, and a number of individuals were observed "trapped" in pools within the gulch. Presumably, these fish will continue their upstream migration as flow is re-established in the wet season.

Waikele Stream system (Fig. 2) has seen channel modifications along the lowermost reach in Waipahu and a revetment bank in the Schofield area. In a 1978 inventory of O'ahu streams, Timbol & Maciolek gave a total length of Waikele and its tributaries, including Kīpapa, at 195 km (121 mi) with 5.2 km (3.2 mi) channelized. These values are little changed today. Modifications that exist within the Waikele Stream system include short sections of box culvert in the Waipahu area, but mostly revetment banks and channel realignment. Thus, this stream system is relatively free of channel modifications and the values given by Timbol & Maciolek (1978) amount to only 2.7% of the length of the stream and its tributary channels.

The Koa Ridge Makai project does not involve channel modifications to Kīpapa Stream, with the exception that some bank areas may be hardened to prevent erosion associated with outlets from detention basins and drain lines. These minor alterations to the stream bed and banks will not have an adverse impact on stream biota (native or non-native). Detention basins proposed for this project are located above the banks and would not adversely impact migratory patterns of the native aquatic fauna. No aquatic fauna exists to be impacted by Castle & Cooke Waiawa or

DB-3 in the unnamed gulch of Kīpapa, the latter proposed to include within its structure the actual (intermittent) stream bed.

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B | Infrastructure Reports

Infrastructure Report

For the

KOA RIDGE

Makai

Development

Waipio, Ewa, Oahu, Hawaii

Castle & Cooke Homes Hawaii, Inc.
100 Kahelu Avenue
Mililani, Hawaii 96789

Prepared by:
ParEn, Inc.
dba Park Engineering
711 Kapiolani Boulevard, Suite 1500
Honolulu, Hawaii 96813

November 2008

Infrastructure Report

For the

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Waipio, Ewa, Oahu, Hawaii

Castle & Cooke Homes Hawaii, Inc.
100 Kahelu Avenue
Mililani, Hawaii 96789

KEITH S. UEMURA
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HAWAII, U.S.A.

THIS WORK WAS PREPARED BY
ME OR UNDER MY SUPERVISION

ParEn, Inc.
dba PARK ENGINEERING

LICENSE EXPIRATION 4-30-2010

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November 2008

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FIGURES

TABLES

APPENDICES

1 DESCRIPTION OF PROJECT

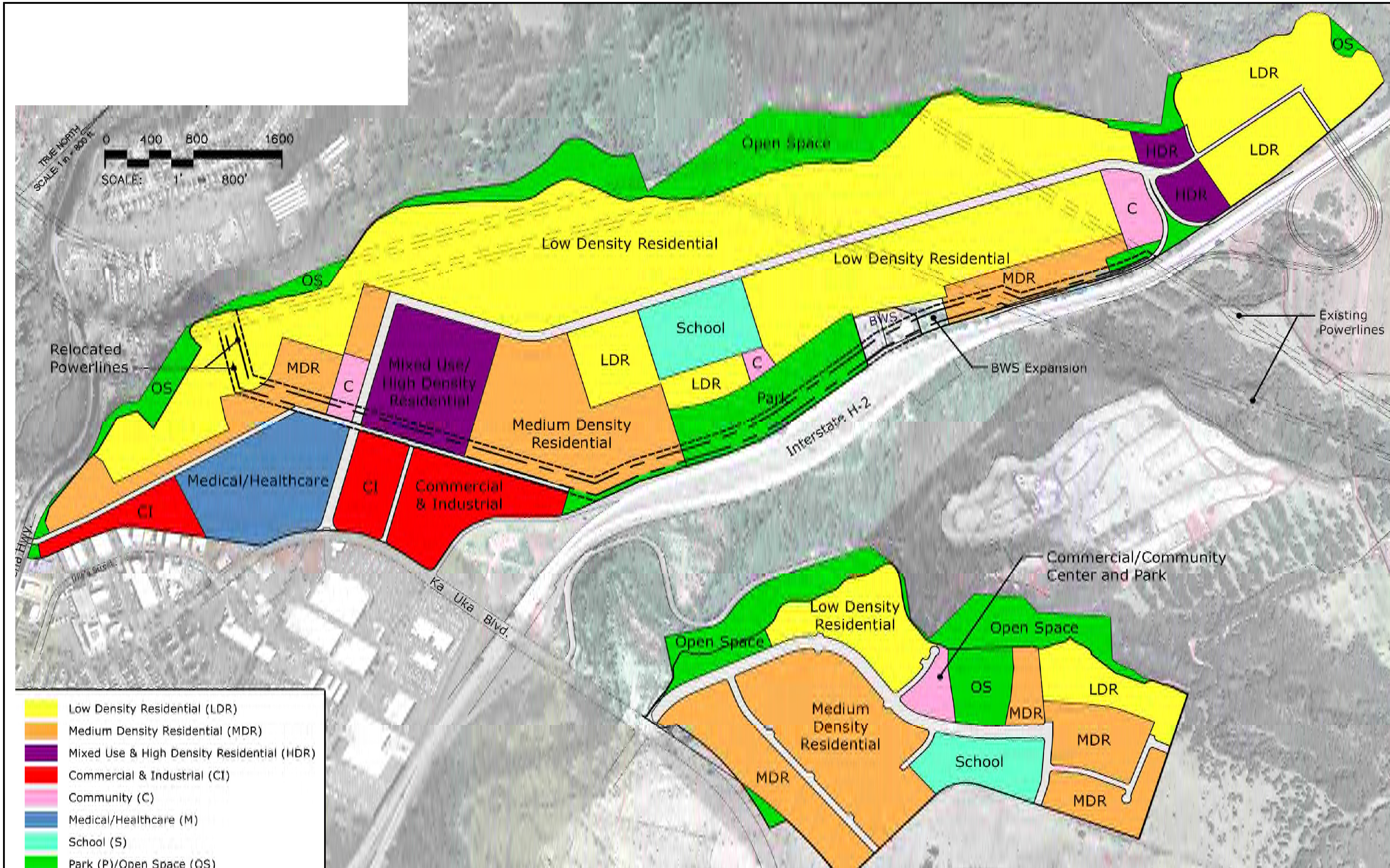
Koa Ridge is a master planned community in Central Oahu proposed by Castle and Cooke Homes Hawaii, Inc. The development will feature a medical/health care component supported by a mix of land uses including commercial, residential, community and open space. A mixed-use village center is proposed as the focal point of the 575 acre development. A total of 3,500 residential units including community-support facilities such as parks, an elementary school, retail, neighborhood business, light industrial, and hotel are planned. Natural gullies and other peripheral areas will be kept as open space.

A summary of the proposed land uses is provided in Table 1-1. The corresponding Land Use Map is included as Figure 1-1.

TABLE 1-1
SUMMARY OF PROPOSED LAND USES

Land Use	Acres	Quantity	Units
Residential			
Single Family	174	1,016	Each
Medium Density Multi-Family	83	1,637	Each
High Density Multi-Family	32	847	Each
Commercial			
Retail	31	315,100	Sq. Ft.
Office	5	50,700	Sq. Ft.
Light Industrial	18	352,000	Sq. Ft.
Hotel	5	150	Rooms
Koa Ridge Medical Center *	28		
Medical Office Building		150,000	Sq. Ft.
Ambulatory Care		18,750	Sq. Ft.
Skilled Nursing Facility		150	Beds
Hospital		120	Beds
Medical Service Building		10,000	Sq. Ft.
Parks	35		
Elementary School	12		
TOTAL	**423**		

* For planning purposes only. A definitive program fro the medical center has not been established.



KOA RIDGE
MAKAI
INFRASTRUCTURE REPORT

LAND USE MAP

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FIGURE 1-1

2 PROJECT LOCATION

The Koa Ridge project site is located in Central Oahu just west of the Interstate H-2 freeway. It is bordered to the north and east by Interstate H-2 Freeway, to the south by Ka Uka Blvd. and Gentry Business Park, and to the west by Kipapa Gulch and Kamehameha highway (See Figure 2-1 – Location Map).

3 TOPOGRAPHY

Topography at the project location ranges from elevation 435 to 730 feet MSL. Terrain at the site is gently sloped with an average slope of approximately 3%.

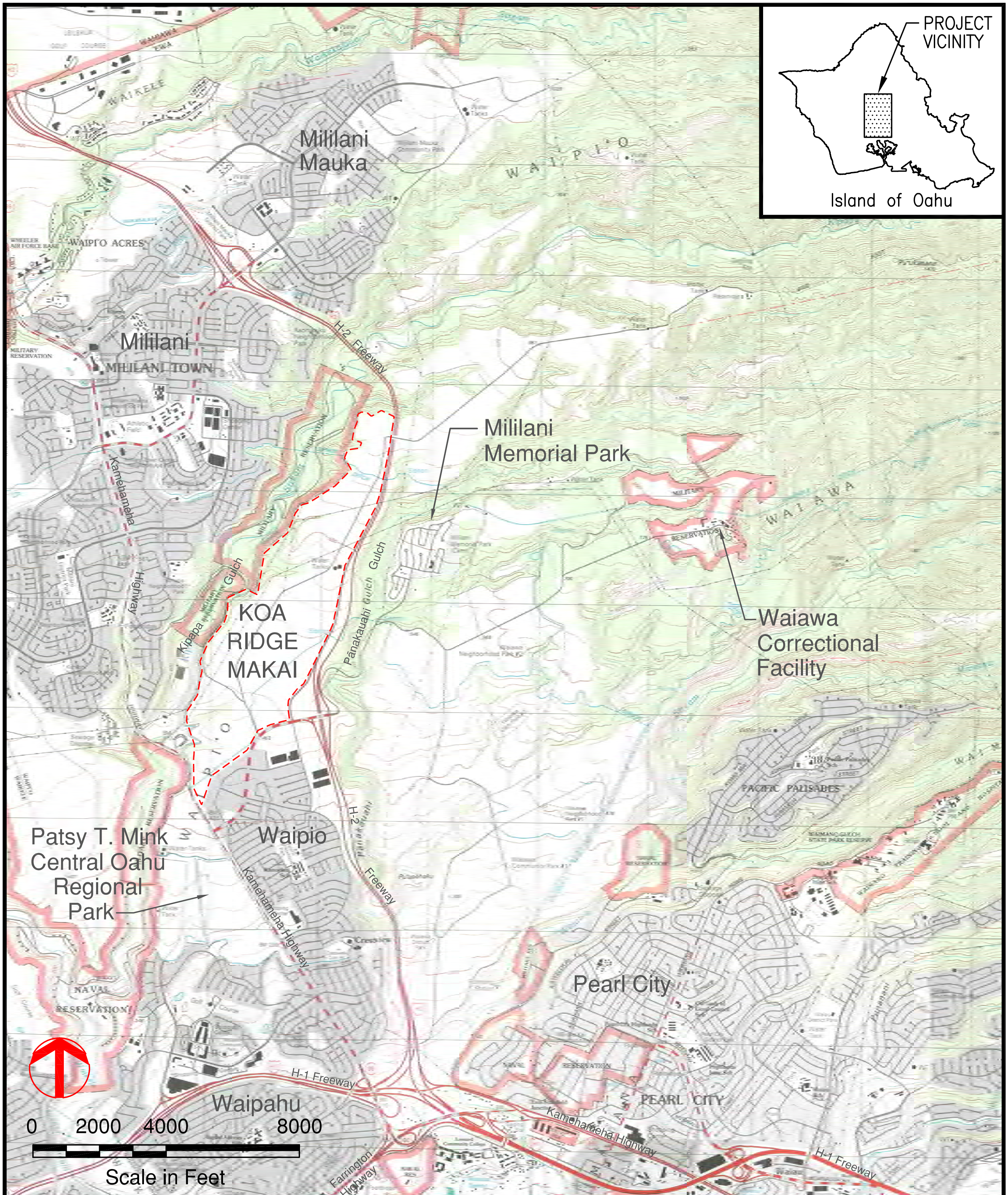
4 SEWER SYSTEM

4.1. EXISTING SEWER SYSTEM

Currently, there are no sewer system improvements within the project site. There are existing 8-inch, 10-inch and 12-inch sewer lines within the adjacent developments of Waipio Gentry and Waipio Industrial Subdivision. The nearest sewer line to the project site is an 8-inch vitrified clay pipe within Ka Uka Boulevard at the entry to the project site. These small diameter sewer lines are intended for localized sewer collection and do not have sufficient capacity to service the projected wastewater flows from the proposed project.

4.2. PROJECTED SEWER DEMAND

It is estimated that the proposed project will generate a peak wastewater flow of 5.14 million gallons per day (MGD). Flow computations are based on the "Design Standards of the Department of Wastewater Management", Volume 1, City and County of Honolulu, State of Hawaii, dated July 1993 with an average daily per capita flow of 80 gallons per day. Average daily wastewater generation is based on the City standard population densities associated with the various land uses. Schools and parks are the only exception with a per capita flow rate of 25 gallons per day. The following densities are used for the category of land use:



KOA RIDGE
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INFRASTRUCTURE REPORT

LOCATION MAP

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FIGURE 2-1

ParEn Inc.

SEWER: KOA RIDGE

DISTRICT: WAIPIO

REFERENCE MAPS:

BY: TSW

TABLE 4-1
KOA RIDGE DEVELOPMENT
COMPUTATION OF WASTEWATER FLOW

Normal Infilt: 5 (gpcd) [USE 5 OR 35]

Wet Infilt: 1250 (gpad) [USE 1250 OR 2750]

LAND USE		TRIB. AREA		TRIB. POPULATION			FLOW	AVE.	MAX	MAX	NORM DESIGN AVE		DESIGN	WET	DESIGN
		Increment	Total	Units	Increment	Total	gpcd	FLOW (mgd)	FLOW FACT.	FLOW (mgd)	INFIL (mgd)	FLOW (mgd)	HRLY FLOW (mgd)	INFILT. (mgd)	PEAK FLOW (mgd)
KOA RIDGE MAKAI															
SINGLE-FAMILY		174.00	174.00	1,016	4,064	4,064	80	0.3251	3.78	1.2281	0.0203	0.3454	1.2484	0.2175	1.4659
MEDIUM DENSITY MULTI-FAMILY		83.00	257.00	1,637	4,584	8,648	80	0.6918	3.25	2.2469	0.0432	0.7350	2.2901	0.3213	2.6114
HIGH DENSITY MULTI-FAMILY		32.00	289.00	847	2,372	11,019	80	0.8815	3.09	2.7276	0.0551	0.9366	2.7827	0.3613	3.1439
COMMERCIAL-RETAIL		31.00	320.00		4,340	15,359	80	1.2287	2.90	3.5576	0.0768	1.3055	3.6344	0.4000	4.0344
OFFICE (NEIGHBORHOOD BUS.)		5.00	325.00		200	15,559	80	1.2447	2.89	3.5946	0.0778	1.3225	3.6724	0.4063	4.0786
LIGHT INDUSTRIAL		18.00	343.00		1,800	17,359	80	1.3887	2.83	3.9236	0.0868	1.4755	4.0104	0.4288	4.4391
HOTEL		5.00	348.00		2,000	19,359	80	1.5487	2.76	4.2812	0.0968	1.6455	4.3780	0.4350	4.8130
PAC. HEALTH CTR-1		28.00	376.00		845	20,204	80	1.6163	2.74	4.4301	0.1010	1.7174	4.5311	0.4700	5.0011
PARK		35.00	411.00	700.00	219	20,423	80	1.6339	2.73	4.4685	0.1021	1.7360	4.5706	0.5138	5.0843
ELEMENTARY SCHOOL		12.00	423.00	800.00	250	20,673	80	1.6539	2.73	4.5122	0.1034	1.7572	4.6155	0.5288	5.1443

** ASSUMPTIONS PARKS LESS THAN 2 ACRES WILL NOT HAVE SEWER FLOW, 800 STUDENTS FOR ELEM. SCHOOL @ 25 GPCD, 20 PERSONS / ACRE / PARK @ 25 GPCD

DESIGN CRITERIA POPULATION (GENERATING 25 GPCD) CONVERTED TO AN EQUIVALIENT POPULATION (GENERATING 80 GPCD) BY MULTIPLYING UNIT/POP BY 0.3125

TABLE 4-2 WASTEWATER GENERATION BY LAND USE TYPE		
Land Use	**Quantity**	**Units**
Residential Single Family	4	Capita per unit
Residential Multi-Family	2.8	Capita per unit
Community Business	140	Capita per acre
Neighborhood Business	40	Capita per acre
Resort	400	Capita per acre
General Industry	100	Capita per acre
Schools - Elementary	800*	Capita/facility
Parks	20*	Capita per acre

* Per capita flow rate of 25 gallons per day.

Wastewater demands for the medical/health care facilities are calculated based on the following flow rates provided in Table 4-3:

TABLE 4-3 WASTEWATER GENERATION FOR MEDICAL USES		
Land Use	**Quantity**	**Units**
Medical Office Building	0.16	Gallons/SF/day
Ambulatory Care	0.16	Gallons/SF/day
Skilled Nursing Facility	100.00	Gallons/bed/day
Hospital	200.00	Gallons/bed/day
Medical Service Building	0.16	Gallons/SF/day

A summary of the wastewater computation is presented in Table 4-1.

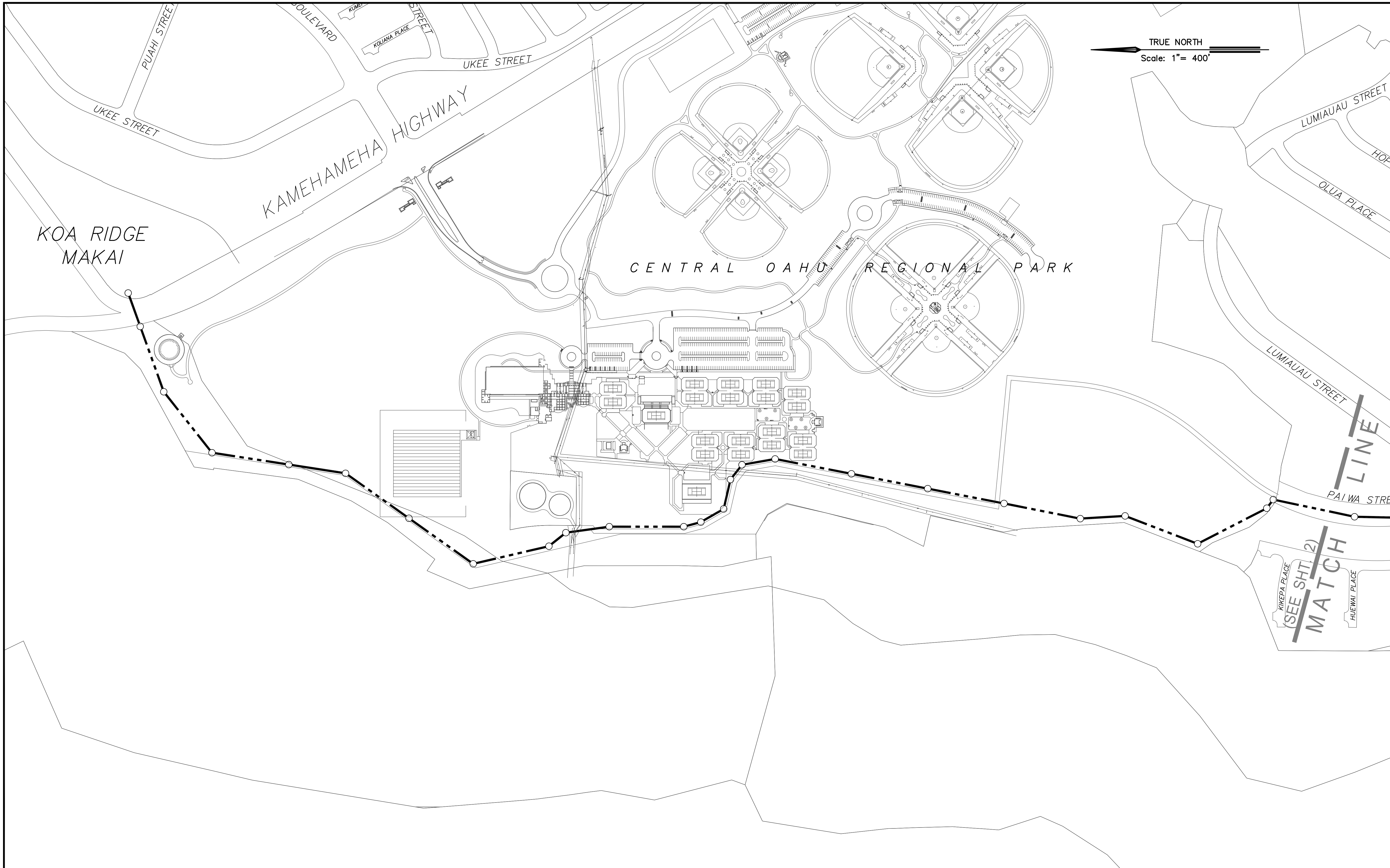
4.3. PROPOSED SEWER SYSTEM IMPROVEMENTS

The sewer system will be designed in accordance with the "Design Standards of the Department of Wastewater Management", Volume 1, City and County of Honolulu, State of Hawaii, dated July 1993. It will be designed to carry the peak flows of this development. The City's policy is that peak flows for new pipelines not exceed 85% of full pipe capacity. This allows the City to have a reserve capacity in new pipelines of up to 15%.

The onsite wastewater collection system will essentially follow the proposed public roadway system and will be conveyed by gravity to the proposed 36-inch offsite sewer system (See Figure 4-1 - Proposed Sewer System). The point of connection to the offsite sewer line is in the vicinity of the proposed access road connection to Kamehameha Highway shown on Figure 1-1.

The 36-inch offsite sewer line is a trunk sewer intended to convey the flows from the project site to the Waipahu Wastewater Pump Station, a distance of approximately 19,000 lineal feet. The alignment for the offsite sewer line is described below:

- The offsite sewer line will connect to the onsite sewer system of Koa Ridge and cross under Kamehameha Highway and into Central Oahu Regional Park (CORP).
- The line will continue south through CORP along the Kipapa Gulch perimeter until the north end of Paiwa Street.
- It continues south along Paiwa Street, crosses under the H-1 freeway into the former Waikele Shopping Center's employee parking lot parcel. This parcel is between Paiwa Street to the west, existing subdivisions to the east, Koaki Street to the south and H-1 to the north.
- From there it continues south through the parking lot until Koaki Street in the Waipahu Industrial Park (A&B Industrial Phase IA).
- It goes through the Waipahu Industrial Park along Koaki Street, Kopake Street and to Mokuola Street.
- The line heads south on Mokuola Street and turns east on Moloalo Street just before Farrington Highway.
- At the end of Moloalo Street, the line veers into Farrington Highway and continues east until Waipahu Depot Road.
- At Waipahu Depot Road the line heads south again and terminates at the Waipahu Wastewater Pump Station (WWPS).



KOA RIDGE
MAKAI
INFRASTRUCTURE REPORT

PROPOSED SEWER SYSTEM

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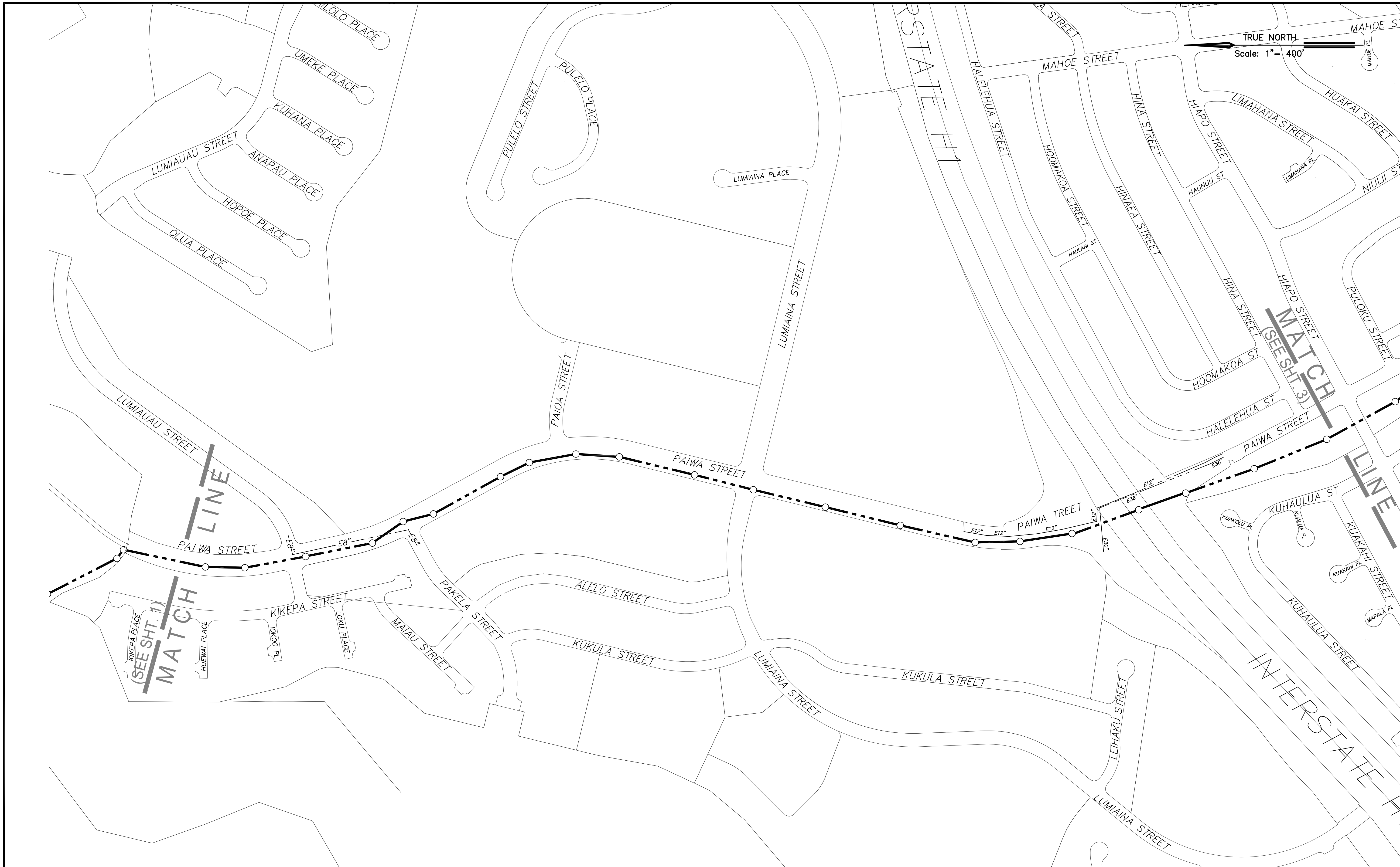
FIGURE 4-1 (SHT. 1 OF 3)



MAKAI
INFRASTRUCTURE REPORT

PROPOSED SEWER SYSTEM

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FIGURE 4-1 (SHT. 2 OF 3)

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INFRASTRUCTURE REPORT

PROPOSED SEWER SYSTEM

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FIGURE 4-1 (SHT. 3 OF 3)

A majority of the offsite sewer line will be installed using conventional open trench methods. This method is best suited for portions of the alignment that are shallower and have minimal obstructions to laying out the pipe segments. However, at locations where conventional methods are impractical or will result in significant impacts, microtunneling will be utilized for installation of the pipe line. Although microtunneling minimizes surface disruptions, large jacking and receiving pits will need to be excavated at intervals to provide access for the tunneling head and pipe segments.

Microtunneling is proposed for the section along Farrington Highway to Waipahu WWPS. Poor soil conditions within this corridor necessitate stabilization of the soil supporting the pipe using a method called jet grouting. Jet grout columns spaced at intervals providing end support to pipe segments are drilled to depths sufficient to bear into firm soil. In this way, the jet grout columns perform in a manner similar to pile foundations.

Construction of the project will be divided into five phases due to the magnitude and considerable length of the sewer line. Phase 1 of the project is from Waipahu WWPS to the intersection of Mokuola Street and Farrington Highway. Phase 2 continues from that intersection to Koaki Street at the bottom of the Waikele Employees Parking Lot parcel. Phase 3 continues through the parking lot parcel to a manhole makai of the H-1 freeway. Phase 4 crosses under the H-1 freeway and up to the top of Paiwa Street. And finally, Phase 5 extends from Paiwa Street, through CORP and under Kamehameha Highway to the bottom of the Koa Ridge project site.

Wastewater pumped from the Waipahu WWPS is discharged into the trunk sewer on Geiger Road and continues on for treatment at the Honouliuli Wastewater Treatment Facility (WWTF). Capacity at Waipahu WWPS was recently upgraded to 38 million gallons per day (mgd) at peak flow. The treatment plant currently processes an average flow of 27 to 29 mgd at the primary treatment level, which is being expanded to 38 mgd. Secondary treatment capacity at the plant is 13 mgd. Treated effluent is either disposed of through the deep ocean outfall or is further treated at the Honouliuli Reclamation Facility for industrial or irrigation reuse. The tertiary treatment for reuse water is capable of producing 12 mgd.

Honouliuli WWTF is a regional facility that treats wastewater from the West Mamala Bay communities of Aiea, Pearl City, Waipio, Waipahu, Mililani, Ewa, Kapolei and Makakilo. Developments within the basin area all compete for sewer capacity within the existing collection system and treatment facility infrastructure. Approval of sewer connection applications are based on available capacity and are awarded on a first come, first served basis.

5 DRAINAGE SYSTEM

5.1. EXISTING DRAINAGE CONDITIONS

The project site is comprised of ten existing drainage areas. All areas either sheet flow towards Kipapa Gulch or collect in localized gullies that drain into Kipapa Stream (See Figure 5-1 - Existing Drainage Areas). Under existing conditions, the 100-year peak discharge for Kipapa Stream at a point downstream of the project site is 19,576 cubic feet per second (cfs). This flow corresponds to a drainage basin measuring 9,181 acres and extends to the top of the Koolau Mountain Range and includes the project site.

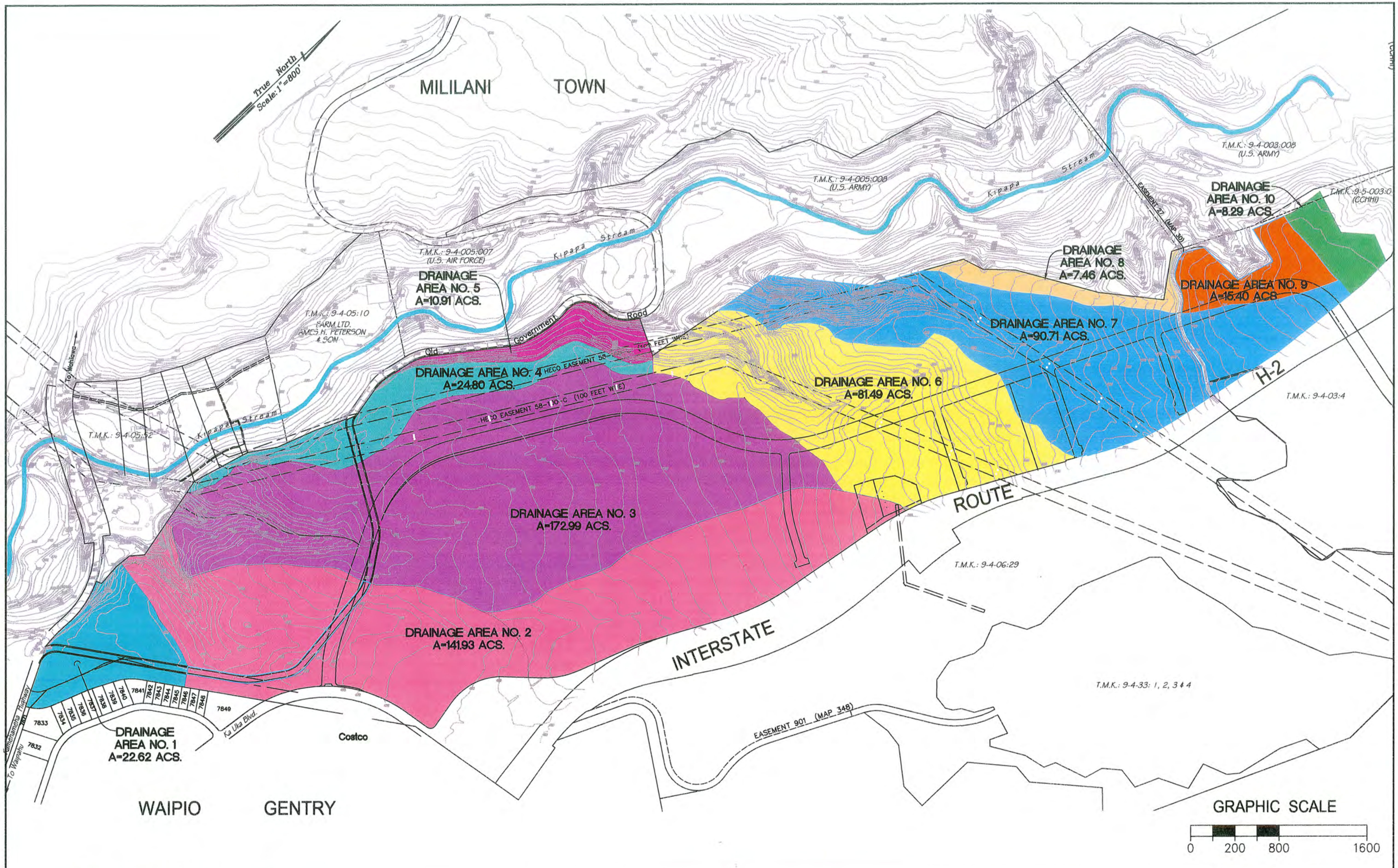
Existing conditions at the site can be characterized as active diversified agricultural land to the south and fallow agricultural land to the north. The fallow agricultural lands to the north were once cultivated in pineapple but is now heavily overgrown with tall grass and wooded in low-lying areas leading to gulches.

5.2. PROPOSED DRAINAGE CONDITIONS

Development of the project site will result in reallocation of drainage areas from the pre-developed condition. It is anticipated that the site will be developed into two major drainage areas. The general drainage patterns for the site will still flow from north to south, following the underlying terrain of the site. (See Figure 5-2: Proposed Drainage System). Runoff from both drainage areas will be conveyed to Kipapa Stream through culverts and outlet structures located on United States Army (Army) property. Drainage Area 1 is approximately 362 acres and Drainage Area 2 roughly 203 acres.

Site characteristics will be consistent with typical urbanized residential development. Impervious area will increase with the construction of roadways, driveways, sidewalks and other improvements resulting in a higher runoff coefficient.

In order to mitigate any downstream increases in stormwater runoff from the project site, offsite detention basins are being proposed in the drainage basins upstream of the Koa Ridge site. These basins will be sited on lands between Mililani and the project site which are owned by Castle and Cooke, Inc. or the Army. Detention basins function by using the storage volume to dampen the peak flow rates into the basin by controlling the rate of outflow leaving the basin. This is accomplished by appropriate sizing of the outlet works from the basin to restrict flow to a desired rate. These basins will attenuate the peak discharge from a 100-Year storm event into Kipapa Stream so the net impact of the project will be no increase or potentially a decrease in Kipapa Stream discharge at the point of contribution from the site. Upstream reductions in



KOA RIDGE
MAKAI
INFRASTRUCTURE REPORT

EXISTING DRAINAGE AREAS

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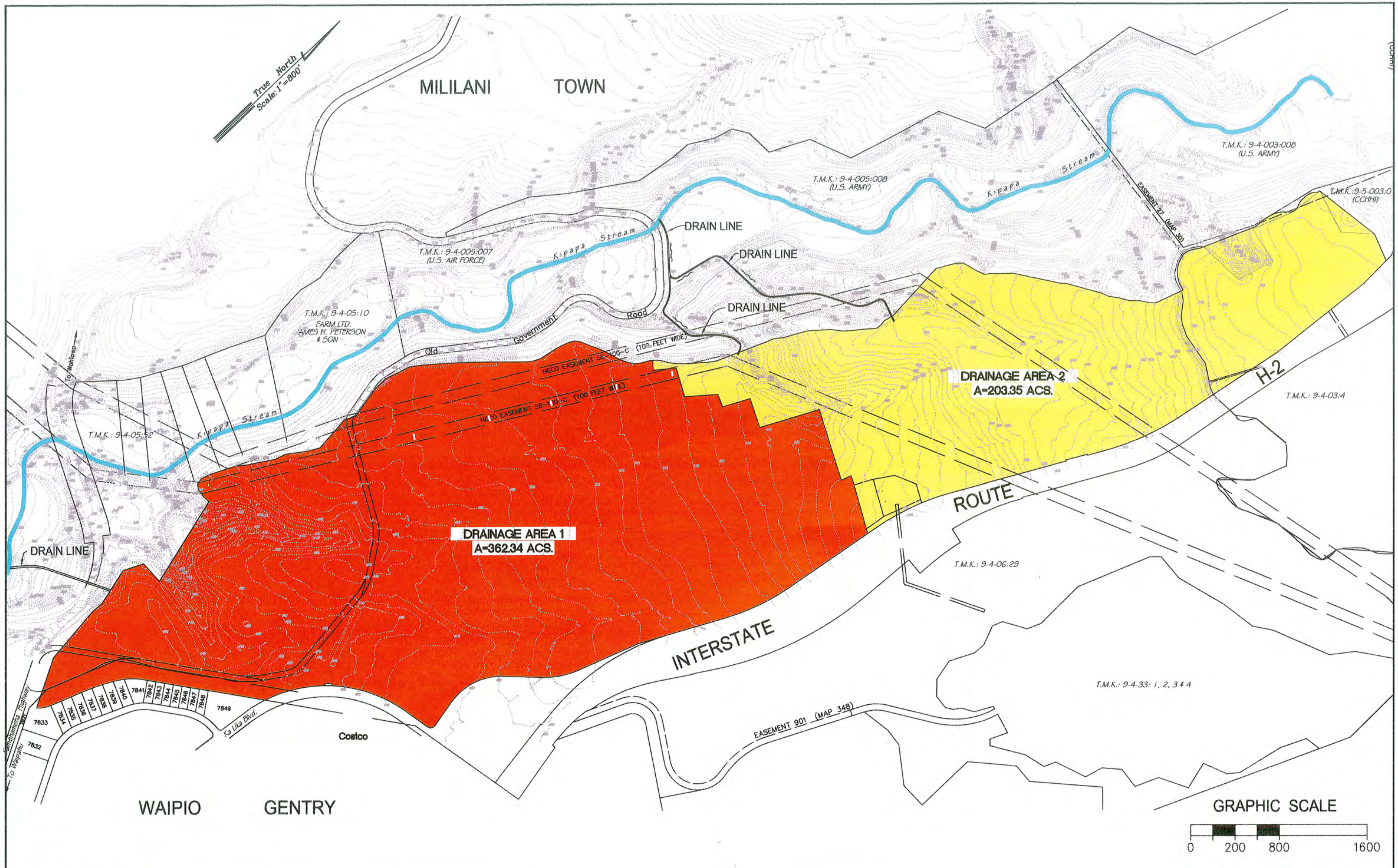
FIGURE 5-1



KOA RIDGE
MAKAI
INFRASTRUCTURE REPORT

PROPOSED DRAINAGE AREAS

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FIGURE 5-2

stream flow allow for the unattenuated flows from the developed project site to combine with Kipapa Stream without increasing the risk of flooding downstream.

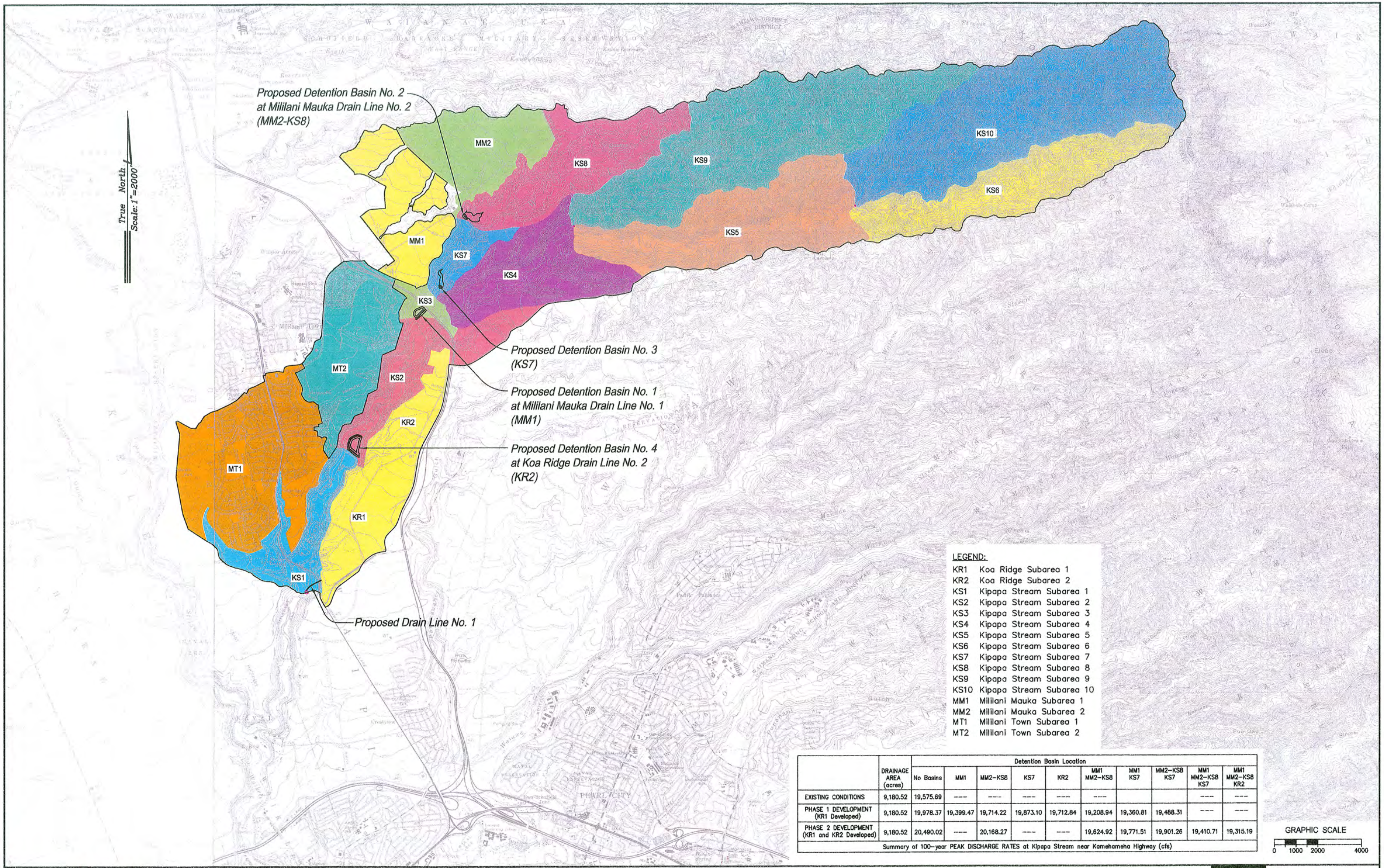
5.3. PROPOSED DRAINAGE IMPROVEMENTS

Stormwater runoff from developed areas will be collected by onsite drainage systems located within the internal roadways. Drainage improvements for the project will be designed in accordance with the "Rules Relating to Storm Drainage Standards", Department of Planning and Permitting, City and County of Honolulu, Honolulu, Hawaii, dated January 2000.

It is anticipated that each drainage area will have its own outlet. Runoff from Drainage Area No. 1 will be conveyed through drainage piping to the southwest corner of the parcel adjacent to Kamehameha Highway (See Figure 5-2 – Proposed Drainage Map). A water quality treatment facility, which could either be a detention based or a flow through based system to remove sediments and pollutants from storm runoff, will be sited in this vicinity to satisfy the water quality requirements of the Storm Drainage Standard prior to discharge into Kipapa Stream. Detention based system employ basins to hold back storm runoff for several days to allow sediments to settle out. Flow through based systems can be either grassed swales of appropriate length and geometry or proprietary, chambered systems that utilize baffling to hydraulically remove sediments from storm runoff. Anticipated peak discharge rate from Drainage Area No. 1 is approximately 1,840 cfs.

Runoff from Drainage Area No. 2 will also be collected and conveyed via drainage piping to the vicinity of the natural gully located approximately at the midpoint of the parcel (See Figure 5-2 – Proposed Drainage Map). Peak discharge for this drainage area into Kipapa Stream is 970 cfs. Collected stormwater will be treated to satisfy the City's storm water quality requirements. The treated runoff will then be discharged into Kipapa Stream through a box culvert and outlet works located on Army property.

Offsite drainage improvements will consist of three detention basins located in the upper reaches of the Kipapa Stream drainage basin, all of which are on lands owned by Castle and Cooke, Inc. Basin 4, which is the only basin located on Army property, is included as an alternative location in the event the site for Basin 3 is not suitable for development as a basin. These basins will detain flows generated from the fully developed subdivisions of Mililani Mauka and from the undeveloped tributary areas of Kipapa Stream. Figure 5-3 identifies the location of proposed offsite drainage basins and corresponding drainage areas. Of the three offsite basins on Castle and Cooke property, only Basin 1 is in an area that is actively being farmed. Construction of this basin may result in the relocation of a farm dwelling and removal of a limited area of cultivated land.



	DRAINAGE AREA (acres)	Detention Basin Location									
		No Basins	MM1	MM2–KS8	KS7	KR2	MM1 MM2–KS8	MM1 KS7	MM2–KS8 KS7	MM1 MM2–KS8 KS7	MM1 MM2–KS8 KR2
EXISTING CONDITIONS	9,180.52	19,575.69	---	---	---	---	---			---	---
PHASE 1 DEVELOPMENT (KR1 Developed)	9,180.52	19,978.37	19,399.47	19,714.22	19,873.10	19,712.84	19,208.94	19,360.81	19,488.31	---	---
PHASE 2 DEVELOPMENT (KR1 and KR2 Developed)	9,180.52	20,490.02	---	20,168.27	---	---	19,624.92	19,771.51	19,901.26	19,410.71	19,315.19

Summary of 100-year PEAK DISCHARGE RATES at Kipapa Stream near Kamehameha Highway (cfs)

KOA RIDGE
MAKAI
INFRASTRUCTURE REPORT

OFFSITE DETENTION BASINS

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FIGURE 5-3

Basins will have impounded volumes less than 50 acre-feet with maximum downstream berm heights of 25 feet such that these basins will not be subject to the requirements of the Hawaii Dam and Reservoir Safety Act of 2007. Berms will be constructed from compacted soil with typical fill slopes of 3 horizontal to 1 vertical. Each basin will require access during construction as well as permanent access for maintenance. Generally, access for the area is from the eastern edge of Mililani Town through an existing dirt road that provides access to Kipapa Gulch farmers. Access road will be roughly 20 feet wide and will likely be of crushed rock construction.

As the basins will be constructed in close proximity to Kipapa Stream and its tributaries, permits from various agencies will be required. The following is a list of potential permits:

- Federal: United States Army Corp of Engineers; Environmental Protection Agency; National Marine Fisheries Service Essential Fish Habitat and Endangered Species
- State: Coastal Zone Management; Department of Health Clean Water Branch; Department of Land and Natural Resources Aquatic Resources, Office of Conservation & Coastal Lands; State Historic Preservation
- Other: Interested Native Hawaiian groups or other ethnic/cultural groups.

Anticipated basin area and volume and peak discharge rates are provided in Table 5-1 below.

TABLE 5-1
Basin Size and Peak Design Discharge Rates

BASIN NUMBER	DRAINAGE BASIN ID	DISTURBED AREA (Acre)	VOLUME (Acre-feet)	PEAK INFLOW (cfs)	PEAK OUTFLOW (cfs)
1	MM1	1.11	40	1,960	1,490
2	MM2-KS8	1.40	35	3,110	2,500
3	KS7	0.43	10	2,890	2,830
4	KR2	2.16	35	970	640

Preliminary flood routing results demonstrate that for full development of Koa Ridge Makai, implementation of Basins 1, 2, and 3 will result in a 100-year peak discharge of 19,411 cfs at a point immediately downstream of the project site on Kipapa Stream. This represents a flow reduction of 165 cfs compared to the existing conditions. If Basin 4 is constructed in place of Basin 3, the peak discharge is 19,315 cfs which corresponds to a 261 cfs reduction in peak discharge.

6 WATER SYSTEM

6.1. EXISTING POTABLE WATER SYSTEM

There is no potable water infrastructure currently available to service the Koa Ridge Makai project site. However, the Honolulu Board of Water Supply (BWS) operates a well and reservoir facility within the project area. The BWS Waipio Heights III wells and 595 reservoirs are located in TMK: 9-4-006:014 & 015 along Interstate Route H-2 within the Koa Ridge Makai plateau. The facility houses two deep well pumps, two 1.5 million gallon (MG) reservoirs, control building, instrument house, and a granular activated carbon (GAC) treatment system. As part of the BWS 595 water system, the wells and reservoirs are designated to provide potable water to the area south of Ka Uka Boulevard.

Other existing BWS wells in the project vicinity include the Mililani III wells, located across Kipapa Gulch in Mililani Town, and the Waipio Heights II wells, situated to the south near the intersection of Ka Uka Boulevard and Kamehameha Highway. Although these wells are located in the vicinity of Koa Ridge Makai, they provide potable water to different service areas and are not expected to contribute to water service at Koa Ridge Makai.

6.2. PROJECTED POTABLE WATER SYSTEM IMPROVEMENTS

It is estimated that the proposed Koa Ridge Makai development would generate an average daily water demand of 2.0 million gallons per day (MGD). Two water service zones are proposed to serve the development: a 595-ft system and an 820-ft system. The Koa Ridge 595 system would serve the development areas north of Ka Uka Boulevard to an elevation of 495 feet above mean sea level (MSL). The Koa Ridge 820 system would serve the development areas from elevation 495 to 720 feet above MSL. Refer to Tables 1 and 2 for the projected potable water demand from the proposed Koa Ridge Makai development for each water service zone.

6.3. PROPOSED POTABLE WATER IMPROVEMENTS

The proposed Koa Ridge 595 system would ultimately be connected to the BWS Waipio Heights 595 system. The proposed Koa Ridge 595 well and reservoir complex will be located on lands immediately north of the existing BWS Waipio Heights III well site. The new site will function as an expansion of the existing facility, capable of servicing both the existing Waipio Heights 595 service zone (south of Ka Uka Boulevard) and the Koa Ridge Makai 595 service zone. The new site will encompass approximately 1.7 acres. The proposed potable water system infrastructure improvements will include construction of two additional wells, each with pumps rated at 1,200 gallons per minute (GPM), and a new 1.5 MG reservoir. Refer to Figure 6-1 for the location of proposed well and reservoir facilities.

The proposed Koa Ridge 820 well site will be located to the northeast of the Koa Ridge Makai project site, mauka of Interstate Route H-2. The proposed well site will require approximately 1.7 acres. This site will include three wells, each rated at 1,200 GPM, and a 1.5 MG reservoir.

Although a standby well is available at the Waipio Heights III facility, the two water service zones would be hydraulically interconnected so that the upper (820) service zone is capable of providing standby capacity for the lower (595) service zone, when needed.

The proposed wells and reservoirs will be designed in accordance with the BWS standards. A summary of the proposed facilities for each service zone is presented below:

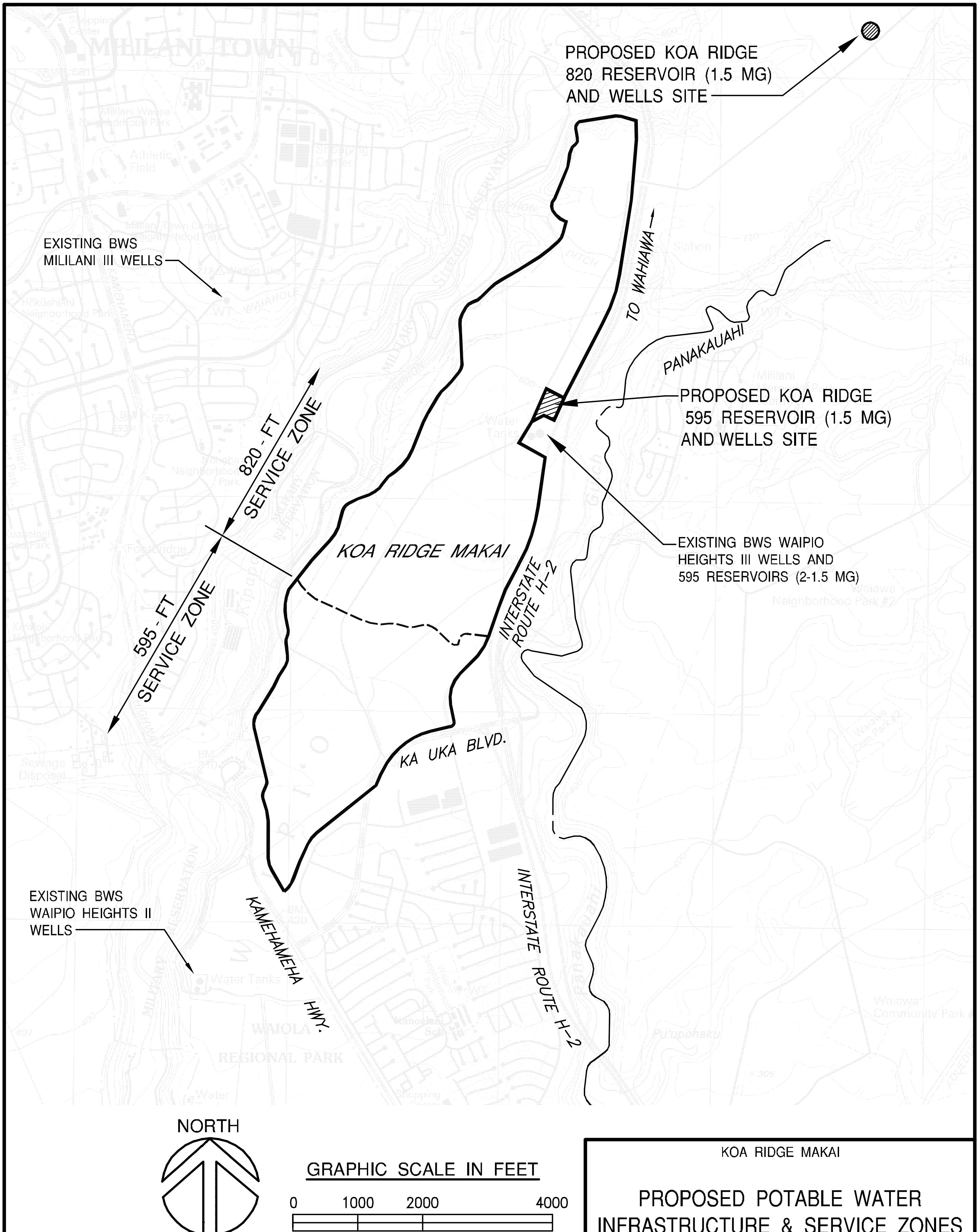
Parameter	595 Service Zone	820 Service Zone
Reservoir Capacity (MG)	1.5	1.5
Well Pump Capacity (GPM)	1,200	1,200
Number of Wells	2	3

The potable water transmission mains will be designed in accordance with BWS standards. The transmission mains will be sited within the proposed roadways of the Koa Ridge Makai development, or within easements with an all-weather road provided.

6.4. PROBABLE IMPACTS ON GROUNDWATER RESOURCES

Water source availability and probable impacts to groundwater resources were addressed by Water Resource Associates in their report entitled *Groundwater Resources and Supply for Koa Ridge Makai Development*, August 2008. The report is summarized in this section.

The proposed potable water facilities for Koa Ridge Makai will require permits for water use, well construction, and pump installation from the Commission of Water Resource Management, State Department of Land and Natural Resources. The Commission on Water Resource Management regulates groundwater use in the designated water management areas in the State of Hawaii.



KOA RIDGE MAKAI

PROPOSED POTABLE WATER INFRASTRUCTURE & SERVICE ZONES

FIGURE 6-1

TABLE 6-1
Koa Ridge Makai Water Demand
595 Water Service Zone

Land Use	Koa Ridge		595' Water Zone			Unit Demand		Average Daily Demand (GPD)	Maximum Daily Demand (GPD)	Peak Hour Demand (GPD)
	Acres	No. of Units	Percentage	Acres	No. of Units	GPD/ Acre	GPD/ Unit			
Residential										
Single Family	174	1,016	10%	17	102	---	500	50,800	76,200	152,400
Medium Density Multi-Family	83	1,637	50%	42	819	---	400	327,400	491,100	982,200
High Density Multi-Family	32	847	90%	29	762	---	400	304,920	457,380	914,760
Commercial										
Retail	31	---	80%	25	---	3,000	---	74,400	111,600	223,200
Office	5	---	100%	5	---	3,000	---	15,000	22,500	45,000
Light Industrial	18	---	100%	18	---	4,000	---	72,000	108,000	216,000
Hotel	5	150	100%	5	150	---	350	52,500	78,750	157,500
Health care	28	---	100%	28	---	3,000	---	84,000	126,000	252,000
Parks	35	---	20%	7	---	4,000	---	28,000	42,000	84,000
Elementary School	12	---	0%	0	---	4,000	---	0	0	0
Total (Rounded)	**423**	**3,650**	**---**	**176**	**1,832**	**---**	**---**	**1,009,000**	**1,514,000**	**3,027,000**

TABLE 6-2
Koa Ridge Makai Water Demand
820 Water Service Zone

Land Use	Koa Ridge		820' Water Zone			Unit Demand		Average Daily Demand (GPD)	Maximum Daily Demand (GPD)	Peak Hour Demand (GPD)
	Acres	No. of Units	Percentage	Acres	No. of Units	GPD/ Acre	GPD/ Unit			
Residential										
Single Family	174	1,016	90%	157	914	---	500	457,200	685,800	1,371,600
Medium Density Multi-Family	83	1,637	50%	42	819	---	400	327,400	491,100	982,200
High Density Multi-Family	32	847	10%	3	85	---	400	33,880	50,820	101,640
Commercial										
Retail	31	---	20%	6	---	3,000	---	18,600	27,900	55,800
Office	5	---	0%	0	---	3,000	---	0	0	0
Light Industrial	18	---	0%	0	---	4,000	---	0	0	0
Hotel	5	150	0%	0	0	---	350	0	0	0
Health care	28	---	0%	0	---	2,200	---	0	0	0
Parks	35	---	80%	28	---	4,000	---	112,000	168,000	336,000
Elementary School	12	---	100%	12	---	4,000	---	48,000	72,000	144,000
Total (Rounded)	**423**	**3,650**	**---**	**248**	**1,818**	**---**	**---**	**997,000**	**1,496,000**	**2,991,000**

The proposed Koa Ridge Makai development is not expected to have an adverse impact on the potable quality of the underlying Waipahu-Waiawa Aquifer. The State Commission on Water Resource Management (CWRM) established a sustainable yield of 104 MGD for the Waipahu-Waiawa Aquifer, and as of June 2006, the unused allocation amounted to 19.144 MGD. An average withdrawal of 2.006 MGD is anticipated for the Koa Ridge Makai development. This projected withdrawal rate for Koa Ridge Makai is within the unallocated sustainable yield.

The two proposed well sites, located 1.6 miles apart, are not expected to have any adverse impact on the salinity of the existing upgradient or downgradient wells due to localized upconing or thinning of the basal lens. Further, with the exception of Waipio Heights III, the other wells withdrawing from the Waipahu-Waiawa Aquifer are located a mile or more from the two wells sites proposed for the project.

The Waipahu-Waiawa Aquifer has been impacted by the past use of herbicides and pesticides on former pineapple lands. The Department of Health's (DOH's) Groundwater Contamination Map of 2005 documented the presence of agricultural herbicides and pesticides in this aquifer system. In conformance with the DOH's regulations for the development of new potable water sources, water from the proposed wells will be analyzed for the various water quality parameters. In the event herbicides and/or pesticides are present in the analyses, water treatment units such as GAC filtration will be incorporated.

7 ELECTRICAL SYSTEM

7.1. SUMMARY

This report is prepared to discuss and summarize the electric and communications systems required for implementation of the anticipated urban land use of the area designated as the Castle & Cooke Koa Ridge Makai Development.

Electric and communications improvements necessary to support the requirements of the Koa Ridge Makai Development, based on the Koa Ridge Land Use Program and Absorption Schedule provided by Castle & Cooke Homes Hawaii on 31 July 2008, can be served from the existing utility systems, with some offsite work required. In general, the offsite improvements necessary to serve this development are ongoing activities for the respective utility companies and should not create an undue hardship for them. Furthermore, the project will require that the electric and communications utility systems be constructed and maintained according to approved utility standards.

Hawaiian Electric Company ("HECO") plans to add transformers at their "Waipio" Substation to serve the development initially, and ultimately anticipates extending the existing 46 kilo-volt (kV) lines that cross Koa Ridge Makai to a proposed substation site in the project to serve this development and other future loads. In addition, both Hawaiian Telcom ("HTCO") and Oceanic Time Warner Cable ("OCEANIC") anticipate requiring office sites in Koa Ridge Makai, and must extend their trunking facilities from Ka Uka Boulevard and from Kamehameha Highway, respectively, to serve this project.

Onsite facilities for the utility systems will have minimal impact on the environment. Noise, aesthetic considerations, safety hazards, and loading impact will be within normally applied guidelines.

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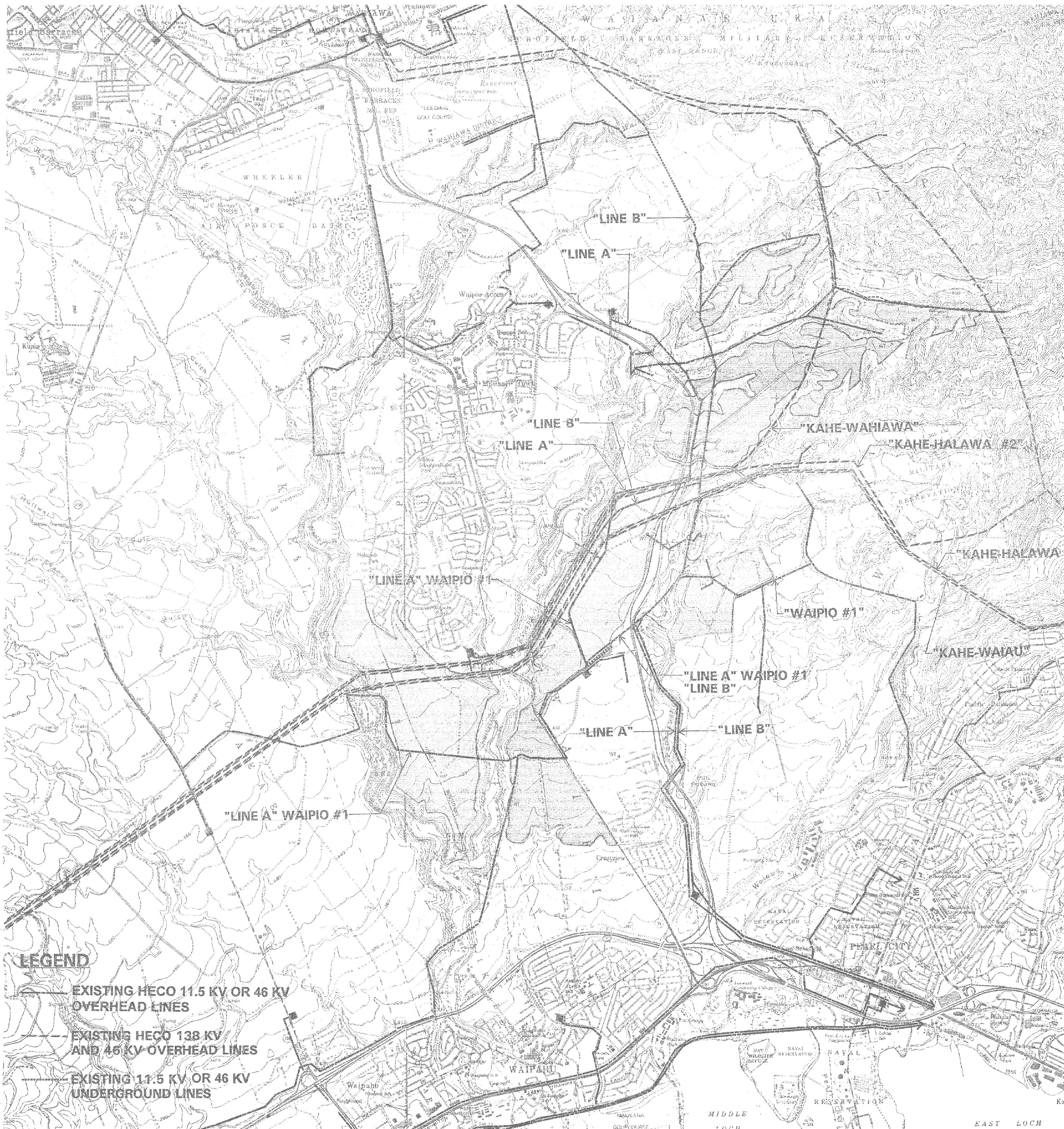
7.2. EXISTING CONDITIONS

Electric power is generated by Hawaiian Electric Company ("HECO") and is transmitted across O'ahu via overhead and underground lines that are energized at 138 kilo-volts (kV), and distributed from 46-25 kV and 46-12kV substations via overhead and underground cables, presently energized at 25/12.47/4 kV, that are owned and maintained by HECO. As of 2006, HECO's current available generation capacity is approximately 1,669 megawatts (MW) and the present peak coincident demand for electricity on O'ahu is approximately 1,327 MW.

HECO's existing "Waipio" Substation, which is located in the Gentry Business Park and is situated adjacent to Ka Uka Boulevard, steps-down the 46 kV sub-transmission voltage to 12.47 kV for distribution, and serves the Gentry Busines Park and various existing facilities along Kamehameha Highway via an underground duct system that runs along the project frontage of Ka Uka Boulevard, between Moaniani Street and Ukee Street. (See Figure 7-1: Existing Electrical).

Hawaiian Electric Company also completed construction of a tap to the existing 46 kV "Line B" circuit on the east side of the "Waipio" Interchange, and has extended this feeder to their "Waipio" Substation (which is situated on the west-side of the interchange). The cables for this feeder are aerial across the interchange and then underground along Ka Uka Boulevard, from Moaniani Street to the substation.



KOA RIDGE MAKAI INFRASTRUCTURE REPORT	EXISTING ELECTRICAL	ParEn, Inc. dba Park Engineering Engineers, Surveyors, Planners FIGURE 7-1

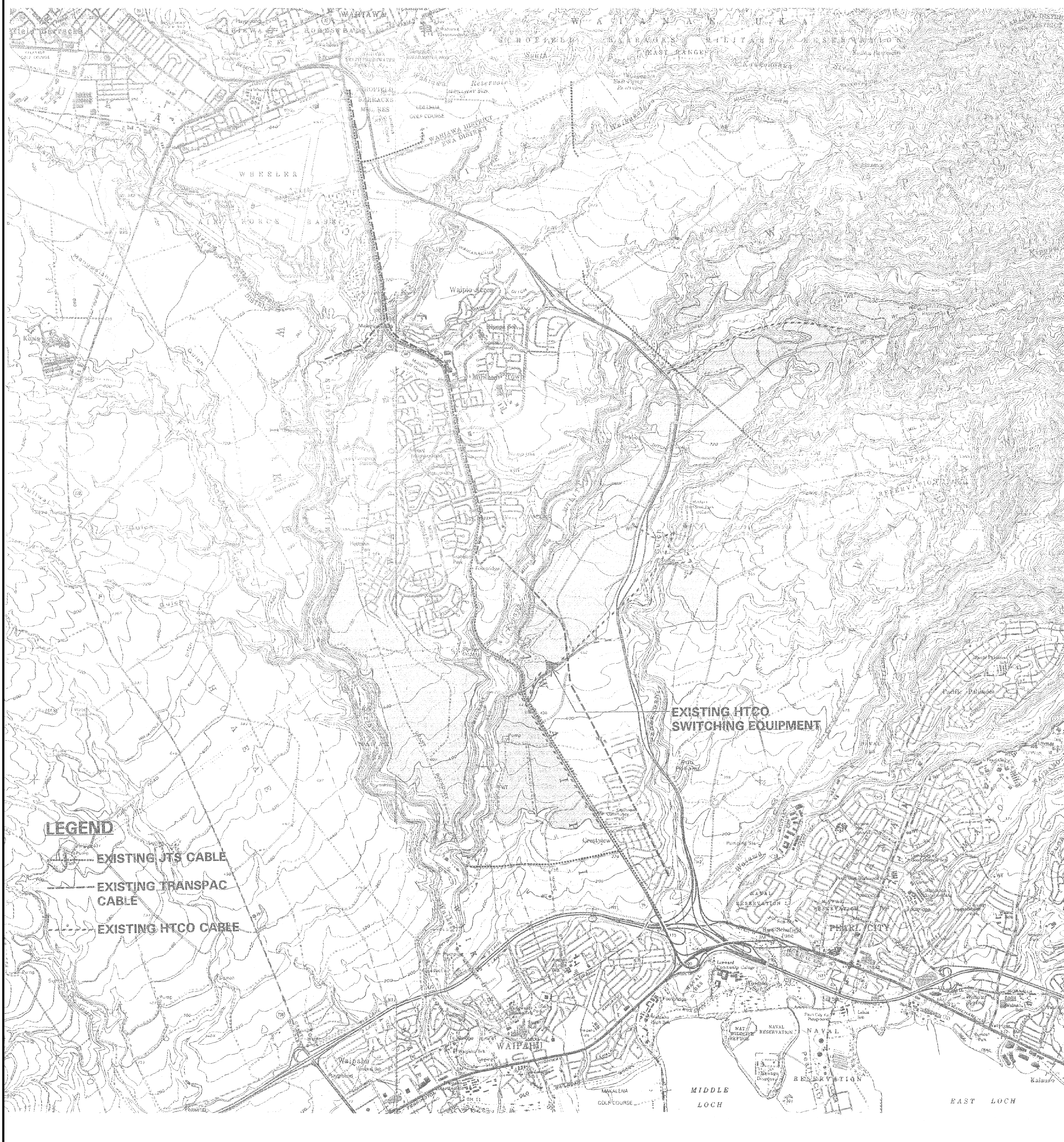
Hawaiian Telcom ("HTCO") is the local area telephone provider, and presently serves this area from their "Waipio" Remote Office, which is located along Kamehameha Highway, at the upper corner of the Waikele Development. In addition, HTCO has installed a "pair-gain" (switching equipment) unit within an easement along Ka Uka Boulevard, adjacent to where it intersects the Old Government Road that was also used to access the Mililani Memorial Park. Trunking cables are routed from the "Waipio" Remote Office to the "pair-gain" unit and from that "pair-gain" unit, HTCO has underground facilities along Ka Uka Boulevard thru which distribution cables are extended to serve the Gentry Business Park, and portions of Waipio By Gentry. (See Figure 7-2: Existing Communication).

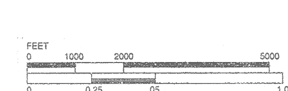
Oceanic Time Warner Cable ("OCEANIC") is the local area CATV provider, and has an agreement with HTCO for use of the joint utility poles along Kamehameha Highway, on which it has attached aerial cables to support their facilities in this area. OCEANIC also leases space in the HTCO ductline along Ka Uka Boulevard to extend cables to serve the Gentry Business Park and parts of Waipio By Gentry.

A joint pole line consisting of HECO 46 kV ("Line A") and 11.5 KV (the "Waipio #1" circuit) overhead lines and HTCO cables follows Ka Uka Boulevard across the project frontage, from the vicinity of the Old Government Road to the "Waipio" Interchange. The HTCO cables cross the "H-2" freeway underground, while the HECO lines span over the interchange. From the Old Government Road to Kamehameha Highway, HECO's 46 kV "Line A" and 11.5 kV "Waipio #1" circuits, and Time Warner Telecom of Hawaii and HTCO cables cross the project overhead following the alignment of the old Mililani Memorial Park access road. Furthermore, HTCO's direct buried "Transpac" cable traverses the western end of the site in the vicinity of the Old Government Road, and continues on to Wahiawa following Kamehameha Highway..

In addition, the project is traversed by three major pole lines, each carrying one HECO 138 kV transmission feeder (designated as the "Waiau-CEIP", "Kahe-Halawa #1", and "Kahe-Halawa #2" circuits, respectively), another transmission pole line carrying both HECO 138 kV "Kahe-Wahiawa" and 46 kV "Line A" circuits, a pole line for a parallel spur of HECO's 46 KV "Line A" and 11.5 kV "Waipio #1" circuits, and a second HECO 46 kV pole line ("Line B"). And, a joint pole line supporting a HECO 11.5 kV circuit and HTCO cables spans across the "H-2" freeway from the east to provide service to the BWS Waipio Heights Well No. 3.

Street lighting has been provided along Ka Uka Boulevard. And, traffic signal systems have been installed at both the Moaniani Street and the Ukee Street intersections with Ka Uka Boulevard.





KOA RIDGE
MAKAI
INFRASTRUCTURE REPORT

EXISTING COMMUNICATION

ParEn, Inc.
dba Park Engineering
Engineers, Surveyors, Planners

FIGURE 7-2

7.3. FUTURE DEVELOPMENT PLANS

HECO plans to relocate the two 46 kV pole lines that span the “Waipio” Interchange onto a single pole line that will follow the Ka Uka Boulevard alignment until the Moaniani Street intersection. Beyond that intersection, one feeder will be spliced to the existing overhead line that continues along the mauka side of Ka Uka Boulevard to their “Waipio” substation, and the second feeder would be connected to the existing underground cables that go to that same substation. At that time, it may also be possible to relocate the segment of the pole line adjacent to the Moaniani intersection which presently clips the eastern tip of the Koa Ridge Makai site, to the Ka Uka Boulevard right-of-way.

In the future, HECO anticipates extending a third 46 kV line from Wahiawa to their “Waipio” Substation. The corridor for this line has not yet been determined.

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7.4. PROPOSED DEVELOPMENT

7.4.1. ELECTRICAL SYSTEM

Onsite segments of the existing pole lines where the HECO 138 kV (“Waiau-CEIP”, “Kahe-Halawa #1”, and “Kahe-Halawa #2”) circuits, 46 kV “Line A” and “Line B”, and 11.5 kV “Waipio #1” overhead lines take-off to span the “H-2” freeway and Kipapa Gulch, and the existing pole lines that are beyond the project site may remain. However, those segments of the HECO 46 kV “Line A” and “Line B” and 11.5 kV “Waipio #1” circuits that traverse the project will be relocated underground along the roadways within the development; the portions of the pole lines that are beyond the project will remain overhead. In addition, electric service to the BWS Waipio Heights Well No. 3 site will be reconnected from the overhead lines spanning the “H-2” freeway to new HECO cables routed in the duct system that will be provided with this project.

Also, the existing 138 kV pole lines will be relocated to accommodate the project, but will remain overhead. (See Figure 1-1: Land Use Map). Easements for the 138kV lines, typically about 75'-0" wide, will be required along the entire route for each pole line, with supplemental easements necessary for anchor guying and at the transitions where the direction of the line must change to follow the alignment. HECO will design and construct the pole line, but must receive approval from the Public Utilities Commission prior to ordering the required equipment and proceeding with construction. Therefore, the necessary approvals and equipment procurement processing should be completed prior to project inception to allow HECO sufficient time to relocate the 138kV power lines to accommodate the development schedule.

Landscaping and allowable uses within the easement(s) are attached in the Appendix. (See HECO Comments on the Power Line Relocation Plan, Planting Trees Near HECO Facilities Guidelines, and HECO DV Recommended Plant Listing).

The projected peak demand for this project is forecasted to be approximately 42.1 MW. (See Table 7-1: Koa Ridge Makai Forecasted Electric Loads). HECO anticipates that its generation system will be adequate to carry the project's electrical demand since the annual load growth for the project is anticipated to be gradual. However, based on the forecasted loading, HECO plans to add transformers at their "Waipio" Substation to serve the initial loads, and will also require that a new substation be constructed to ultimately serve the project. A site of about 22,500 square foot is anticipated for the substation installation. In addition, the existing 46 kV lines crossing the development must be extended to the substation site. The necessary land acquisition and equipment procurement processing should be initiated at project inception so that a substation can be in place and ready to serve the project loads as facilities thereat are completed.

The existing and proposed substations will step-down the incoming 46 kV sub-transmission voltage to 12.47 kV, as required by HECO for distribution throughout the project. The distribution feeders from these substations will be extended to each development parcel and connected to service transformers located adjacent to project facilities via switching vaults provided along the distribution feeder routes. The switching vaults will protect the distribution feeders, and allows for isolation of damaged cables and redundancy to protect the development against prolonged outages resulting from the failure of any one section of the underground electrical system. The service transformers will step-down the 12.47 kV distribution voltage to the utilization voltage(s) required by the project facilities.

The electrical system within the project will be an underground facility with the exception of the substation, the overhead transmission and sub-transmission lines and structures, switching vaults and service transformers. Cables and ducts will be suitable for underground applications and therefore, are tolernat of both wet and dry conditions. Providing a network of underground ducts and handholes would facilitate the cable installation, and HECO would cable the underground duct system, if it is constructed in compliance with their standards. Thus, plans should be submitted to HECO during the design development of the project to verify their requirements.

TABLE 7-1
KOA RIDGE MAKAI
FORECASTED ELECTRIC LOAD (PEAK)

Description	Quantity	Unit	KW/Unit	Forecasted Load (KW)
PRELIMINARY DEVELOPMENT PLAN				
Park Site	2	EA	150.0	300.0
Single Family Res.	1,016	EA	6.0	6,096.0
Multi-Family Res.	1,637	EA	4.5	7,366.5
Multi-Family Res. (High Density)	847	EA	4.0	3,388.0
Recreation Center	3	EA	500.0	1,500.0
Neighborhood Commercial	315,100	SF	0.020	6,302.0
Office Building	50,700	SF	0.015	760.5
Light Industrial	352,000	SF	0.010	3,520.0
Hotel	150	RMS	4.0	600.00
Healthcare Facility	28	AC	341.07	9,550.0
Elementary School	1	EA	950.0	950.0
Church Site	2	EA	300.0	600.0
Roadway Lighting	81,000	LF	0.0015	121.5
Sewer Lift Station	0	EA	50.0	0.0
595’ Water Pump Station	2	EA	150.0	300.0
820’ Water Pump Station	3	EA	250.0	750.0
Forecasted Electric Loads (Peak)				42,104.5

Notes:

1. Load forecasts are based on the Koa Ridge Makai Land Use Program and Absorption Schedule provided by Castle & Cooke Homes Hawaii, Inc., dated 31 July 2007.
2. Electrical requirements for the Healthcare Facility were provided by Architects Hawaii for the Koa Ridge Medical Center, dated 30 September 2008.
3. Electrical requirements for off-site roadway improvements, if required, are not available and therefore, they are not included.

7.4.2. **COMMUNICATIONS**

The existing offsite HTCO overhead lines along Panakauahi Gulch may remain. However, those segments of the existing HTCO lines that traverse the project will be relocated underground along the roadways within the development; the portions of the pole lines that are beyond the project will remain overhead. Furthermore, the overhead HTCO and Time Warner Telecom lines along the old Memorial Park access road between Kamehameha Highway and Ka Uka Boulevard will be relocated underground. In addition, telephone service to the BWS Waipio Heights Well No. 3 site will be reconnected from the overhead lines spanning the “H-2” freeway to new HTCO cables routed in the duct system that will be provided with this project. Also, HTCO's direct buried “Transpac” cable which crosses the site and continues on to Wahiawa will be relocated as necessary to accommodate the development.

The existing telephone switching equipment located along Ka Uka Boulevard will remain, and trunking facilities must be extended along Ka Uka Boulevard to a site, approximately 16,000 square feet, within Koa Ridge Makai that HTCO requires to construct a “Remote Office” to serve this project.

OCEANIC facilities do not exist on the site and must be extended along Ka Uka Boulevard from OCEANIC trunking facilities located along Kamehameha Highway to a site within Koa Ridge Makai, approximately 1,200 square feet, that OCEANIC will require to construct an office (“Hub Facility”) to serve this project.

The necessary land acquisition and equipment procurement processing should be initiated at project inception so that the “Remote Office” and “Hub Facility” are in place and ready to serve the project as project facilities are completed.

HTCO cross-connect pedestals and OCEANIC power supply pedestals will be provided by HTCO and OCEANIC, respectively, in easements situated at various locations throughout each of the development parcels to facilitate providing and maintaining telephone and cable television services to the project facilities. The communications systems will be underground facilities with the only exceptions being the switching equipment enclosures and office structures, and the cross-connect and power supply pedestals. Cables and ducts will be suitable for underground applications and therefore, are tolerant of both wet and dry conditions. Providing a network of underground ducts and handholes will facilitate the cable installations, and if it is constructed in compliance with their standards, HTCO and OCEANIC will cable the underground duct systems and make all the necessary arrangements for serving each facility's communications requirements. Therefore, during the design development of the subdivision, plans should be submitted to HTCO and OCEANIC to verify their requirements.

7.4.3. STREET LIGHTING

A street lighting system complying with the recommendations of the Illuminating Engineering Society of North America and the Standards of the City and County of Honolulu should be provided for the project roadways.

7.4.4. TRAFFIC SIGNALS

A traffic study should be conducted prior to design development to determine the improvements required along Ka Uka Boulevard and on whether traffic signal systems at project roadway intersections are warranted.

7.5. POTENTIAL IMPACTS AND MITIGATION MEASURES

Most of the facilities provided by Hawaiian Electric Company, Hawaiian Telcom and Oceanic Time Warner Cable to serve this project will be placed underground and therefore, should have minimal negative impact on the surrounding communities. The electric and communication distribution systems will be constructed and maintained according to approved utility standards and construction methods, and will be planned to coincide with the project development. Furthermore, the improvements necessary to accommodate this project are ongoing activities for the respective utility companies and the utility companies are mandated by their respective tariff rules and licenses to exercise reasonable diligence and care in maintaining their lines and structures to be able to provide continuous service to their customers.

7.6. ELECTRICAL LOAD FORECASTS

Forecast of the anticipated maximum electrical demands for the proposed project is shown in Table 7-1: Koa Ridge Makai Forecasted Electric Loads.

The electric loads for this project have been forecasted based on empirical units used by the local utilities for similar facilities multiplied by the facilities' area or the number of units shown in the Koa Ridge Makai Land Use Program and Absorption Schedule provided by Castle & Cooke Homes Hawaii on 31 July 2008.

These demand units, used by the local utility company to forecast the electrical loads for proposed facilities, are derived from their records of the electrical consumptions for other similar facilities

Ground Water Resources and Supply for
Koa Ridge Makai Development

Appendix A

Koa Ridge Makai
Infrastructure Report

GROUNDWATER RESOURCES AND SUPPLY
For
KOA RIDGE MAKAI DEVELOPMENT
Central Oahu, Hawaii

Prepared for:

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Mililani, Hawaii 96789

Prepared by:

Water Resource Associates
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GROUNDWATER RESOURCES AND SUPPLY
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August 2008

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For
KOA RIDGE MAKAI DEVELOPMENT
Central Oahu, Hawaii

INTRODUCTION

Castle and Cooke Homes Hawaii, Inc. plans to develop a master-planned community in Central Oahu, called the Koa Ridge Makai Development. The planned development embraces an elongated parcel of land that lies north of Ka Uka Boulevard between the H-2 Freeway to the east and Kipapa Gulch to the west (see Map 1). The Koa Ridge Makai Development, which will be built on 575 acres of gently sloping former agricultural (pineapple) land with elevations ranging from 440 to 720 feet, will consist of a residential community with mixed uses, including medical/health care facilities, school, commercial spaces, church, open spaces, and parks.

This report, prepared in support of an Environmental Impact Statement, discusses the groundwater resources, the project water requirements, and the availability of water to meet those requirements. The report also discusses the potential impacts and mitigation measures of the project relating to the underlying aquifer, groundwater occurrence, sustainable yield, proposed water supply, and existing wells.

At full build-out, over an estimated 10-year period, the Koa Ridge Makai Development will include a community of an estimated 3,500 single-family and multi-family residential units with plans for other uses, including health-care facilities, parks, elementary school, and commercial facilities.

REGIONAL HYDROGEOLOGIC SETTING

GEOLOGY

The Koa Ridge Makai Development is situated on gentle upland slopes of deeply weathered basaltic lava flows which erupted from the Koolau Mountain Range. During the shield-building period of Koolau Volcano, innumerable lava flows from the Koolau Range flowed 10 miles westward across central Oahu toward the Waianae Mountain Range. Eventually, these Koolau lava flows accumulated and banked up against the older, eroded Waianae Range, forming the uplands of central Oahu. The accumulation of these Koolau lavas, with their high permeability, set the stage for the occurrence of the prime basal aquifer of central Oahu. The Koolau lava flows throughout central Oahu are deeply weathered and typically exhibit a horizon consisting of about 20 ft. of soils/subsoils residually weathered in situ, 120 ft. of saprolite (highly to moderately weathered basalt in which original texture remains evident), and unweathered basalt below the saprolite.

GROUNDWATER OCCURRENCE

The central portion of the Koolau Range and its adjacent slopes, receives an average rainfall of 100 to over 200 inches per year. This area is the principal source of recharge to the great aquifers of central Oahu. Rainfall over the Koolau Range percolates readily into the ground and sustains groundwater at high levels in the dike intruded lavas associated with the Koolau Range. Beneath the central Oahu section of the the Koolau Range, dike-confined groundwater bodies occur at various levels approaching a maximum of about 880 feet above sea level east of Wahiawa.

An overview of the types of groundwater occurrence on Oahu is shown in Map 2, a 30+ years old map that remains conceptually valid.

Beneath the Wahiawa plateau, high-level groundwater (referred to as the Schofield high-level body in Map 2, but now designated as the Wahiawa Aquifer) occurs at an elevation of approximately 280 feet above sea level. This body of high-level water covers an area of about 69 square miles and is bounded on the north and south by natural "dams" of low permeability geologic formations or structures which are inferred entirely from hydrologic evidence of differential water levels in several wells. The cross-sectional width of the southern dam is about a mile across based upon two closely-spaced wells, but the width of the northern dam is less well known due to the lack of closely-spaced wells.

The southern boundary of the Wahiawa Aquifer (which alone, comprises the Central Hydrologic Sector) is bordered in large part by the extensive basal water body of central Oahu (referred to as the "Honolulu-Pearl Harbor basal water body" in Map 2), but now modified to embrace a smaller regional area called the Pearl Harbor Hydrologic Sector (see Map 3).

As shown in Map 3, the proposed Koa Ridge Makai Development is located within the Waipahu-Waiawa Aquifer, the largest of the three contiguous basal aquifers that comprise the Pearl Harbor Hydrologic Sector.

GROUNDWATER LEVELS AND MOVEMENT

In the Waipahu-Waiawa Aquifer, the principal movement of groundwater is from the water-rich, high rainfall areas of the Koolau Range and its leeward slopes, southwestward toward Pearl Harbor and the Ewa coastal plain. In the Koolau Range of central Oahu, groundwater spills and leaks from bodies of high-level water, confined as high as 880 ft. above sea level by volcanic dikes in the rift zone, into both the Wahiawa Aquifer (280 ft. high-level water) and the Waipahu-Waiawa Aquifer (20+ ft. basal water) (see Maps 2 and 3). Some Wahiawa Aquifer water moves northward into the basal aquifers of the North Hydrologic Sector, but most of it moves southward into the Waipahu-Waiawa and Ewa-Kunia Aquifers (according to Dale and Takasaki (1976). Recharge to the Waipahu-Waiawa Aquifer, in which the Koa Ridge Makai Development is located, originates from rainfall occurring in both the

Wahiawa and the Waipahu-Waiawa Aquifers (see Map 3). Consequently, as shown in Map 3, groundwater movement in the Waipahu-Waiawa Aquifer is predominantly southwestward from the Koolau Range. Ultimately, groundwater in the Waipahu-Waiawa Aquifer discharges into Pearl Harbor and the Ewa coast. The Ewa-Kunia Aquifer, which borders the Waipahu-Waiawa Aquifer's western boundary and is one of the three aquifers that comprise the Pearl Harbor Hydrologic Sector, consists of basal water primarily in Waianae, rather than Koolau basalts, and is recharged by rainfall in the Waianae Mountain Range and by groundwater flow from the Wahiawa Aquifer. The Waipahu-Waiawa Aquifer's southeastern boundary with the adjacent Waimalu Aquifer is presumed to be a non-flow boundary, i.e., no groundwater recharges or discharges across the boundary.

HYDROLOGIC SECTORS, AQUIFERS, AND SUSTAINABLE YIELDS

The State Commission on Water Resource Management (CWRM) has divided Oahu into six major hydrologic sectors, each containing one or more aquifer systems, and has adopted sustainable yields for each aquifer system (see Map 4). The Koa Ridge Makai Development is located within the Waipahu-Waiawa Aquifer of the Pearl Harbor Sector (see Maps 4 and 5). As shown in Maps 3 and 4, this hydrologic sector includes three basal water aquifers that discharge into Pearl Harbor and the ocean along the Ewa-Pearl Harbor coast. The Waipahu-Waiawa and Waimalu Aquifers are located in Koolau basalts, whereas the Ewa-Kunia Aquifer is located in Waianae basalts.

On March 3, 1993, the CWRM designated the former Waipahu and Waiawa Aquifers as one aquifer (Waipahu-Waiawa) to allow for more flexibility in regulating the pumpage in the Pearl Harbor Sector. At the same time and for the same reason, the former Ewa and Kunia Aquifers were also combined into one aquifer (Ewa-Kunia). Subsequently, a small portion of the Ewa-Kunia Aquifer was subdivided and named the Makaiwa Aquifer (shown in Map 4, but not in Map 3), because of significant groundwater level differences, but no sustainable yield has been established for it.

The sustainable yields of the three major basal aquifers of the Pearl Harbor Sector currently (2007) total 165 mgd (see Map 4). On March 15, 2000, the CWRM revised and adopted a sustainable yield of 104 mgd for the Waipahu-Waiawa Aquifer and later on March 15, 2002 it revised and adopted a sustainable yield of 16 mgd for the Ewa-Kunia Aquifer. The sustainable yield of the Waimalu System remains at 45 mgd.

WATER MANAGEMENT AREAS

Except for the Waianae Sector, the CRWM has designated all hydrologic sectors of Oahu as Water Management Areas. As such, the term “water management area” is synonymous with the term “aquifer” and all well drilling and development and groundwater use (except for small individual domestic uses) in the Pearl Harbor Sector are regulated by the CWRM by means of permits for well construction, pump installation, and water use. The drilling and outfitting of any new well in the Waipahu-Waiawa Aquifer requires all three permits. The CWRM issues these permits on the basis that a new well will not have an adverse impact on any existing well or conflict with any other legal use and that the use permitted will not cause the total allocated use to exceed the sustainable yield of the aquifer system in which the new well is located.

THE WAIPAHU–WAIAWA AQUIFER SYSTEM

AQUIFER BOUNDARIES

The proposed Koa Ridge Makai Development is located in the Waipahu-Waiawa Aquifer, largest of the three basal aquifers which comprise the Pearl Harbor Sector (see Maps 1 and 5). This aquifer and all others on Oahu, except those in the Waianae Sector, have been designated for groundwater regulation by the CWRM. The Waipahu-Waiawa Aquifer includes an area of 60.7 square miles and is bounded to the north by the Wahiawa Aquifer, to the east by the crest of the Koolau Range, to the southeast by the Waimalu Aquifer, and to the west by the Ewa-Kunia Aquifer (see Maps 3 and 4).

WATER LEVELS AND GROUNDWATER MOVEMENT

The Waipahu-Waiawa Aquifer consists of an extensive, thick basal lens that is recharged by rainfall over the aquifer and by the inflow of groundwater from the Wahiawa Aquifer. Keeping in mind that water-level measurements have been made at different times and using different instruments, the water level in the Waipahu-Waiawa Aquifer ranges from about 16 ft. above sea level near the Pearl Harbor coast to about 23 ft. above sea level in the Mililani Mauka area. In the Koa Ridge Makai area, the basal water table occurs approximately 21 ft. above sea level.

Groundwater within the aquifer moves principally from the water-rich areas of the Koolau Range towards the southwest, eventually turning south to discharge into Pearl Harbor and the ocean in the coastal stretch between Ewa and Pearl Harbor (see Map 3). A significant amount of groundwater also moves southward from the Wahiawa high-level aquifer into the Waipahu-Waiawa basal aquifer. According to Dale and Takasaki, 1976, roughly 100 mgd of groundwater is estimated to flow from the Wahiawa Aquifer into both the Waipahu-Waiawa and Ewa-Kunia Aquifers.

VERTICAL INFILTRATION RATE OF RAINFALL

The subsurface strata of soil, saprolite, and basalt lava flows in the project area is similar to that of the entire Pearl Harbor Sector where numerous groundwater hydrology studies have been conducted.

Eyre (1987) estimated that the average vertical infiltration rate of rainfall, downward through soil-saprolite, is 15 feet per year. This value is considered to be a gross average, because during dry periods infiltration may cease completely and during a rainstorm event in which three inches of rainfall may occur in a few hours, the rate may be considerably more than the average rate. Eyre’s estimate was based upon soil boring data collected in a pineapple field located in the Mililani area, where rainfall averages about 100 inches a year.

The vertical infiltration rate through unsaturated permeable basalts underlying the soil-saprolite strata is considerably greater. Eyre (1987) estimated an average infiltration rate of 350 to 400 feet per year for permeable Koolau basalts, based upon a statistical analysis of 22 years (1937-1958) of monthly rainfall and water level data in the Schofield area.

SUSTAINABLE YIELD

Sustainable yield, as used in Hawaii and by the CWRM, is the amount of groundwater that can be developed overall from an aquifer on a long-term basis without affecting the aquifer's utility or its potable quality with respect to salt-water intrusion. The term sustainable yield was originally developed for basal aquifers, but is also applied to high-level aquifers because they are often interrelated with the sustainable yield of down-gradient basal aquifers. The CWRM has used the concept of sustainable yield to establish sustainable yield values for nearly all aquifers in the State. In designated water management areas, the CWRM uses the sustainable yield it has established for aquifers, such as the Waipahu-Waiawa Aquifer, to manage and regulate the uses and withdrawals of water from the aquifer. Once adopted, the CWRM may later revise the sustainable yield of an aquifer.

In March 2000 the CWRM, responding to the loss of sugar and pineapple cultivation in the Pearl Harbor Sector, conducted a re-evaluation of the sustainable yield of the Waipahu-Waiawa Aquifer and adopted a value of 104 mgd, based on a hydrologic water budget analysis. Also, with plantation closure various water use permits of former Oahu Sugar Co. wells were revoked, providing the Waipahu-Waiawa Aquifer with some 20 mgd of unallocated sustainable yield. A sustainable yield value of 104 mgd and an unallocated sustainable yield of 20.108 mgd for the Waipahu-Waiawa Aquifer, as of July 2005, are reported in Table 6-6 of the CWRM's public review draft, *Water Resources Protection Plan*, *2007*.

EXISTING WELLS AND WATER USE

Over 100 wells have been drilled in the Waipahu-Waiawa Aquifer, many in clusters of two and three, such as Honolulu Board of Water Supply (BWS) municipal sources and a few in batteries of 5 to 10 wells at former plantation irrigation sources such as EP18. A few major well sources consist of a shaft-type development such as the U.S. Navy's Waiawa Shaft. There are approximately 28 major well sources (some are not in production) located in the Waipahu-Waiawa Aquifer and they are geographically well-distributed, as shown in Map 6. The majority of these sources are owned by the BWS and all of them yield potable water (less than 250 mg/L chlorides) except for EP18. A summary of the data on these existing major wells are presented in Table 1.

The existing well sources of particular interest in this report are the BWS's Waipio Heights I, II, and III and Waipahu I, II, and III sources which are located generally and hydrologically downgradient of the new wells proposed for the Koa Ridge Makai Development. The potential impact of the proposed wells on these existing wells is discussed later in this report.

Table 1. EXISTING MAJOR WELL SOURCES, WAIPAHU-WAIAWA AQUIFER

Well Source	State Well No.	Owner or User	Ground Elev. (ft)	Well Depth (ft)	Head (ft)	Chloride (mg/L)	Water Use Permit No.	Permitted Use (mgd)
EP 15, 16	2202-21	Hon. BWS	150	156	22-24	125 – 184	581	7.661
EP 18	2102-02, 04 to 22, 2202-03 to 20	D.R.Horton/Schuler	44 – 50	303 – 481	12-19	141 – 635	534	7.969
Hoaeae	2301-34 to 39	Hon. BWS	123 – 133	194 – 276	17	97 – 196	092	6.61
Kunia I	2302-01 to 04	Hon. BWS	201 – 206	338 – 427	23	97 – 176	093	5.000
Kunia II	2402-01 to 03	Hon. BWS	417 – 430	575 – 610	17-24	85 – 146	582	2.71
Kunia III	2401-04 to 06	Hon. BWS	315 – 317	452 – 460	--	76 – 80	602	3.050
Manana	2458-05	Hon. BWS	137	277	14	126	625	0.1
Mililani I	2800-01 to 04	Hon. BWS	757 – 762	1008 – 1022	21	16 – 23	114	2.98
Mililani II	2859-01, 02	Hon. BWS	835	995, 985	18	16 – 20	074	1.9
Mililani III	2600-03, 04	Hon. BWS	664, 665	814, 815	23	20	139	1.250
Mililani IV	2858-01 to 03	Hon. BWS	960	1160	23	17	595	2.022
Pearl City Shaft	2458-01	Hon. BWS	111	151	19	50 – 52	624	1.22
Pearl City I	2458-03, 04	Hon. BWS	120	150, 140	18	32 - 208	482	0.7
Pearl City II	2457-01 to 03	Hon. BWS	267 – 272	398 – 423	18	26 – 149	483	1.8
Pearl City III	2557-03	Hon. BWS	620	750	15	18 – 20	073	0.5
Waiawa Shaft	2558-10	U.S. Navy	150	170	--	--	111	14.977
Waiawa 595-1, 2	2658-03, 2659-04	Gentry	591, 598	761, 738	19-21	20	None	0
Waiawa 785-1, 2	2658-04, 05	Gentry	764, 771	896, 901	19-21	20, 22	None	0
Waiawa G.C.-1, 2	2658-07, 08	Gentry	--	--	--	--	692,693	0.982
Waipahu I	2400-01 to 04	Hon. BWS	200	355 – 386	17-24	38 – 113	058	6
Waipahu II	2400-05, 06, 08, 14	Hon. BWS	206 – 211	340 – 344	15-20	44 – 60	597	2.1
Waipahu III	2400-09 to 13	Hon. BWS	312 – 318	453 – 458	19	32 – 38	808	3.029
Waipahu IV	2301-44 to 47	Hon. BWS	131 – 136	271 – 276	15-18	54 – 60	588	3.000
Waipio Hts	2459-19, 20	Hon. BWS	202	337	18	61 – 172	107	0.63
Waipio Hts I	2459-23, 24	Hon. BWS	200	315, 325	15	148 – 208	470	0.68
Waipio Hts II	2500-01, 02	Hon. BWS	416, 419	546, 570	17	28 – 38	587	1
Waipio Hts III	2659-02, 03	Hon. BWS	571, 572	710, 700	17-22	18 – 19	067	0.85
Waipahu WP 1	2301-01 to 10	Waikele Golf, LLC	21 – 31	400 – 498	20-23	82 – 186	623	0.95

Note: Waiawa 595-1, 2 and Waiawa 785-1, 2 Wells drilled, but not in production.
Waiawa G.C. source not drilled, but permitted.

Source of Data: CWRM

Existing (2006) Water Use. The existing water use or withdrawal from the Waipahu-Waiawa Aquifer currently (2006) averages 50.404 mgd. Of this amount, the BWS pumped 68%, or 34.230 mgd for municipal use, and the U.S. Navy pumped 25%, or 12.555 mgd for potable use (see Figure 1). The remaining 7% (3.619 mgd) was pumped by various other well owners for such purposes as business and irrigation (golf courses, landscaping, and agriculture). During the past eight years (1999-2006), annual water use from the Waipahu-Waiawa Aquifer has ranged from a low of 43.46 mgd to a high of 54.87 mgd (see Table 2).

Permitted Water Use. As of June 20, 2006, the CWRM has issued water use permits for a total of 84.856 mgd or 81.59% of the 104 mgd sustainable yield it has established for the Waipahu-Waiawa Aquifer. Thus, the remaining balance of 19.144 mgd represents the unallocated amount of groundwater available in the Waipahu-Waiawa Aquifer to meet the water requirements of the Koa Ridge Makai Development. The water requirements, water availability, and proposed new wells and reservoir site for the Koa Ridge Makai Development are discussed later in this report.

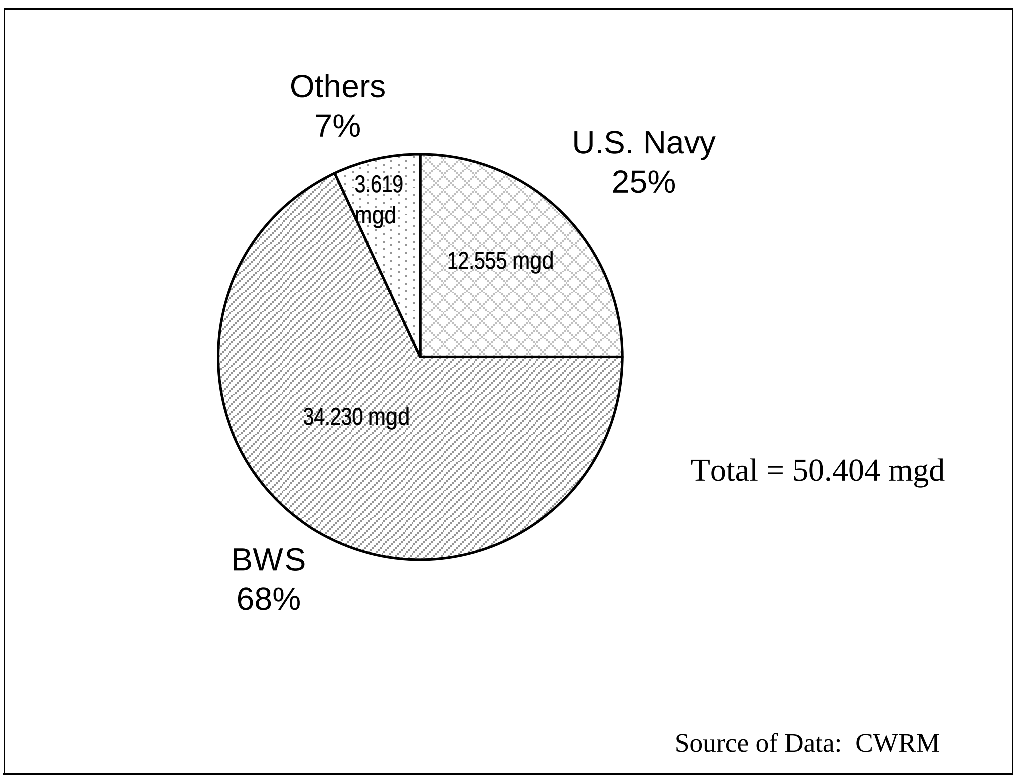


Figure 1. EXISTING (2006) WATER USE, WAIPAHU-WAIAWA AQUIFER SYSTEM

Table 2. REPORTED WATER USE IN THE WAIPAHU-WAIAWA AQUIFER SYSTEM

	Total Aquifer Use (mgd)	BWS Use (mgd)	Navy Use (mgd)	Other (mgd)
1999	50.925	29.789	17.122	4.014
2000	54.873	32.610	17.362	4.901
2001	52.432	30.884	17.187	4.361
2002	46.444	30.573	12.228	3.643
2003	43.457	28.587	11.423	3.447
2004	49.101	32.990	12.694	3.421
2005	51.455	34.672	13.055	3.733
2006	50.404	34.230	12.555	3.619

Source of Data: CWRM

DEEP MONITOR WELLS

The 60.7 square-mile Waipahu-Waiawa Aquifer, being the largest in the Pearl Harbor Sector, is the principal source of groundwater for central Oahu and the Ewa coastal plain. Approximately 100 wells have been drilled in the aquifer and much groundwater data has become available over the years.

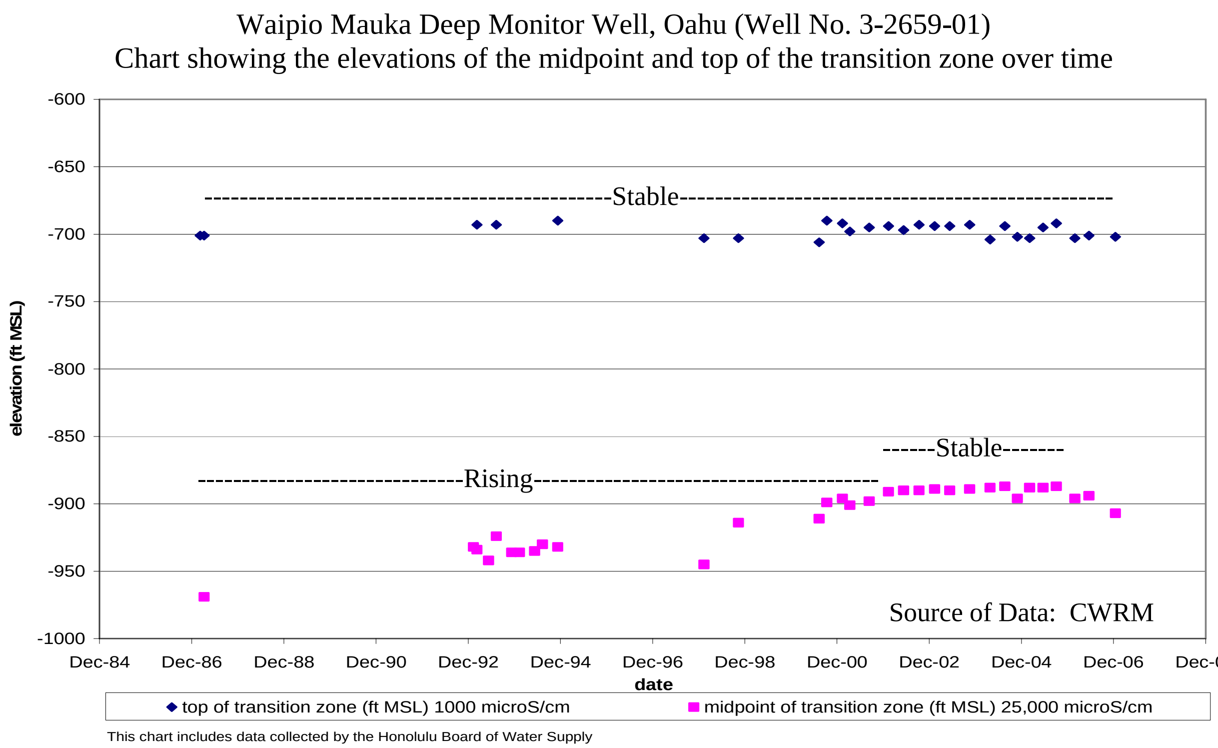
In recent years, a total of eight deep monitor wells have been drilled in the aquifer to study the thickness of the basal lens and underlying transition zone over time. As shown in Table 3, six such monitor wells have been drilled by the BWS and two by the State (CWRM). These deep monitor wells are scattered throughout the lower half of the aquifer as shown in Map 6 and data is normally collected on a quarterly basis.

Of particular interest are the monitor wells *Waipio Mauka*, *Lower Waiawa*, and *Waipahu 241* located approximately more or less downgradient of the new wells proposed for the Koa Ridge Makai Development. These three monitor wells will provide baseline data that should be useful in evaluating the effects, if any, of new well sources for the Koa Ridge Makai Development. As shown in Map 6, the *Waipio Mauka* monitor well lies a half mile from the proposed new well source to be located adjacent to the Waipio Heights III facility. The *Lower Waiawa* monitor well (next to the BWS' Waipio Heights I facility) lies approximately 2.5 miles downgradient, and the *Waipahu 241* monitor well (near Pearl Harbor) lies approximately 3.5 miles downgradient of the proposed well at Waipio Heights III facility. Records since January 1987 show that the top of the transition zone in the *Waipio Mauka* and *Waipahu 241* wells has been fairly stable over the past 15 to 20 years (see Figure 2). During the same period, the midpoint of the transition zone in the *Waipahu 241* well has also been stable; but anomalously, the midpoint in the more inland situated *Waipio Mauka* well rose about 80 ft. from early 1987 to early 2001, before stabilizing (see Figure 2). The reason for the rise of the midpoint in the *Waipio Mauka* well is conjectural, but may somehow be related to the well-known major change in aquifer condition—the cessation of heavy pumping of former sugarcane irrigation wells during the 1990s.

As can be seen in Figure 2, since 2004 the midpoint of the transition zone in both the *Waipahu 241*and *Waipio Mauka* wells have begun to show a deepening trend, which normally suggests a possible thickening of the basal lens. However, the dynamics of the transition zone underlying Hawaii's basalt aquifers have not been well-studied. It is noted that the total annual withdrawals from the Waipahu-Waiawa Aquifer have been steady at approximately 50 mgd from 1999-2006 (see Table 2).

Table 3. DEEP MONITOR WELLS LOCATED IN THE WAIPAHU-WAIAWA AQUIFER SYSTEM

Well Name	Well No.	Owner
Kunia T-41	2201-10	BWS
Lower Waiawa	2459-26	BWS
Manana	2458-06	BWS
Poliwai Gulch	2602-02	BWS
Waimano Gulch	2557-04	BWS
Waiola	2500-03	BWS
Waipahu 241	2300-18	State
Waipio Mauka	2659-01	State



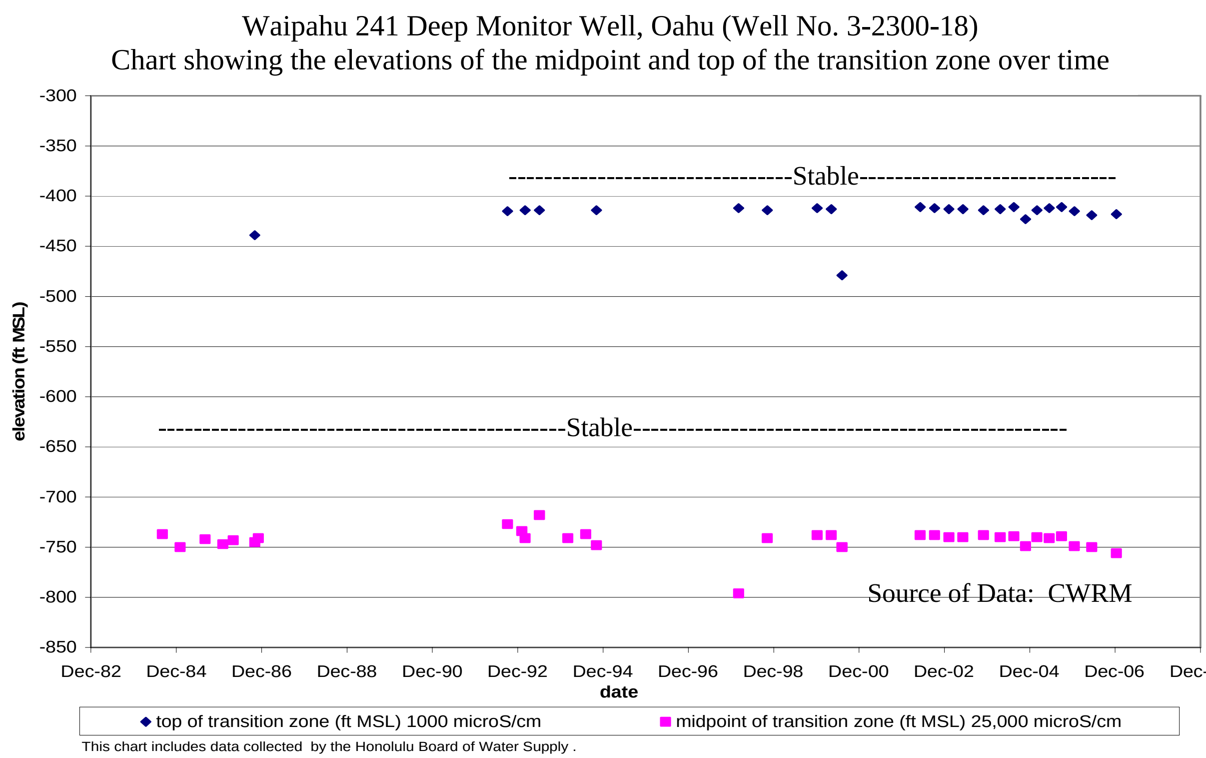


Figure 2. WAIPIO MAUKA AND WAIPAHU 241 MONITOR WELLS SHOWING STABILITY OF TRANSITION ZONE

POTABLE WATER REQUIREMENTS

GENERAL

The potable water requirements of Koa Ridge Makai Development have been estimated by Engineering Concepts, Inc., using the following standards of the Honolulu Board of Water Supply:

A. Unit Consumption Factors

Land Use	Average Daily Demand
Single Family	500 gpd/unit
Multi-Family	400 gpd/unit
Park/Open Spaces	4,000 gpd/unit
Community/Rec. Center	4,000 gpd/acre
Commercial	3,000 gpd/acre

B. Maximum and Peak Demand Factors

1. Maximum Daily Demand = 1.5 x Average Day
2. Peak Hour Demand = 3.0 x Average Day

C. Fire Flow Requirement

1. Single Family = 1,000 gpm for 1 hour
2. Multi-Family = 1,500 gpm for 1 hour
3. Schools/Neighborhood Businesses = 2,000 gpm for 2 hours

Based on the above criteria and the estimated land uses shown in Table 4, the Koa Ridge Makai Development will have the following water requirements:

Average Daily Demand:	2,006,000 gpd
Maximum Daily Demand:	3,009,000 gpd
Peak Daily Demand:	6,018,000 gpd

The average daily demand of 2,006,000 gpd for the proposed development is based on 3,500 single and multi-family residential units plus other community and commercial land uses, altogether covering a total area of 423 acres (see Table 4).

Table 4. POTABLE WATER REQUIREMENTS FOR
KOA RIDGE MAKAI DEVELOPMENT

Land Use	Acres	No. of Units	Unit Demand		Ave. Daily Demand (gpd)	Max. Daily Demand (gpd)	Peak Hr. Demand (gpd)
			Gpd/unit	gpd/unit			
Residential							
Single Family	174	1,016	---	500	508,000	762,000	1,524,000
Med. Density Multi-Family	83	1,637	---	400	654,800	982,200	1,964,400
High Density Multi-Family	32	847	---	400	338,800	508,200	1,016,400
Commercial							
Retail	31	---	3,000	---	93,000	139,500	279,000
Office	5	---	3,000	---	15,000	22,500	45,000
Light Industrial	18	---	4,000	---	72,000	108,000	216,000
Hotel	5	150	---	350	52,500	78,750	157,500
Healthcare	28	---	3,000	---	84,000	126,000	252,000
Parks	35	---	4,000	---	140,000	210,000	420,000
Elementary School	12	---	4,000	---	48,000	72,000	144,000
TOTAL (Rounded)	423	3,650	---	---	2,006,000	3,009,000	6,018,000

Source of Data: Engineering Concepts, Inc., July 2008

595-FOOT SERVICE ZONE

The water requirements of the Koa Ridge Development will be met in two service zones—a 595-ft. Service Zone and an 820-ft. Service Zone. As shown in Table 5, the 595-ft. Service Zone will have the following water requirements:

Average Daily Demand:	1,009,000 gpd
Maximum Daily Demand:	1,514,000 gpd
Peak Daily Demand:	3,027,000 gpd

The average daily demand of 1.009 mgd for the 595-ft. Service Zone is based upon 1,683 single-family and multi-family residential units plus other community and commercial land uses, altogether covering an estimated 176 acres.

820-FOOT SERVICE ZONE

As shown in Table 6, the 820-ft. Service Zone will have the following water requirements:

Average Daily Demand:	997,000 gpd
Maximum Daily Demand:	1,496,000 gpd
Peak Daily Demand:	2,991,000 gpd

The average daily demand of 0.997 mgd for the 820-ft. Service Zone is based upon 1,818 single-family and multi-family residential units plus other community and commercial land uses, altogether covering an estimated 248 acres.

Table 5. WATER DEMAND – 595-FOOT SERVICE ZONE

Land Use	595-Ft. Service Zone		Unit Demand		Ave. Daily Demand (gpd)	Max. Daily Demand (gpd)	Peak Hour Demand (gpd)
	Acres	Units	gpd/acre	gpd/unit			
Residential							
Single Family	17	102	---	500	50,800	76,200	152,400
Medium Density Multi-Family	42	819	---	400	327,400	491,100	982,200
High Density Multi-Family	29	762	---	400	304,920	457,380	914,760
Commercial							
Retail	25	---	3,000	---	74,400	111,600	223,200
Office	5	---	3,000	---	15,000	22,500	45,000
Light Industrial	18	---	4,000	---	72,000	108,000	216,000
Hotel	5	150	---	350	52,500	78,750	157,500
Healthcare	28	---	3,000	---	84,000	126,000	252,000
Parks	7	---	4,000	---	28,000	42,000	84,000
TOTAL (Rounded)	176	1,832	---	---	1,009,000	1,514,000	3,027,000

Source of Data: Engineering Concepts, Inc., July 2008

Table 6. WATER DEMAND – 820-FOOT SERVICE ZONE

Land Use	820-Ft. Service Zone		Unit Demand		Ave. Daily Demand (gpd)	Max. Daily Demand (gpd)	Peak Hour Demand (gpd)
	Acres	Units	gpd/acre	gpd/unit			
Residential							
Single Family	157	914	---	500	457,200	685,800	1,371,600
Medium Density Multi-Family	42	819	---	400	327,400	491,100	982,200
High Density Multi-Family	3	85	---	400	33,880	50,820	101,640
Commercial							
Retail	6	---	3,000	---	18,600	27,900	55,800
Parks	28	---	4,000	---	112,000	168,000	336,000
Elementary School	12	---	4,000	---	48,000	72,000	144,000
TOTAL (Rounded)	248	1,818	---	---	997,000	1,496,000	2,991,000

Source of Data: Engineering Concepts, Inc., July 2008

AVAILABILITY OF GROUNDWATER

Groundwater from the underlying Waipahu-Waiawa Aquifer is readily available to meet the potable water requirements of the proposed Koa Ridge Makai Development, from both a hydrological and regulatory standpoint. The development is located in an area that receives an average annual rainfall of just under 50 inches (see Map 3). Existing wells which have records that demonstrate the robust nature and large sustainable yield of the Waipahu-Waiawa Aquifer include the BWS' Mililani I, II, IV (Year 2006 use, 4.90 mgd) located 1 to 2 miles from the project area; the BWS' Waipio Heights III (Year 2006 use, 1.29 mgd) located nearby; and the Navy's Waiawa Shaft (Year 2006 use, 12.55 mgd) located 2.5 miles to the south (see Map 6). Currently, four wells (Waiawa 595-1, 2 and Waiawa 785-1, 2) have been drilled and tested, but have no pumps installed in them. These four wells are planned for future municipal use.

Because the wells proposed for the Koa Ridge Makai Development are located in a designated water management area, permits for groundwater use, well construction, and pump installation will be required by the CWRM. As previously mentioned, the CWRM regulates groundwater use by first establishing the sustainable yield and then allocating water use by permits within the limit of sustainable yield. In issuing water use permits, the CWRM uses various criteria, including: (1) water availability for allocation at the time an application is filed, i.e., total allocations including the requested amount of water use will not exceed the aquifer's sustainable yield, (2) the requested use will not interfere with other legally permitted uses, and (3) the requested use will not adversely impact the quality and permitted use of existing wells. On March 15, 2000, the CWRM revised downward the sustainable yield of the Waipahu-Waiawa Aquifer System to 104 mgd, based upon a re-evaluation of the Pearl Harbor Hydrologic Sector.

As of June 20, 2007, permits for a total water use of 84.856 mgd have been issued, leaving a balance of 19.144 mgd of unallocated water use in the Waipahu-Waiawa Aquifer. The Koa Ridge Makai Development's potable water requirement of 2.006 mgd, can be readily met from this 19.144 mgd of unallocated water use (see Figure 3).

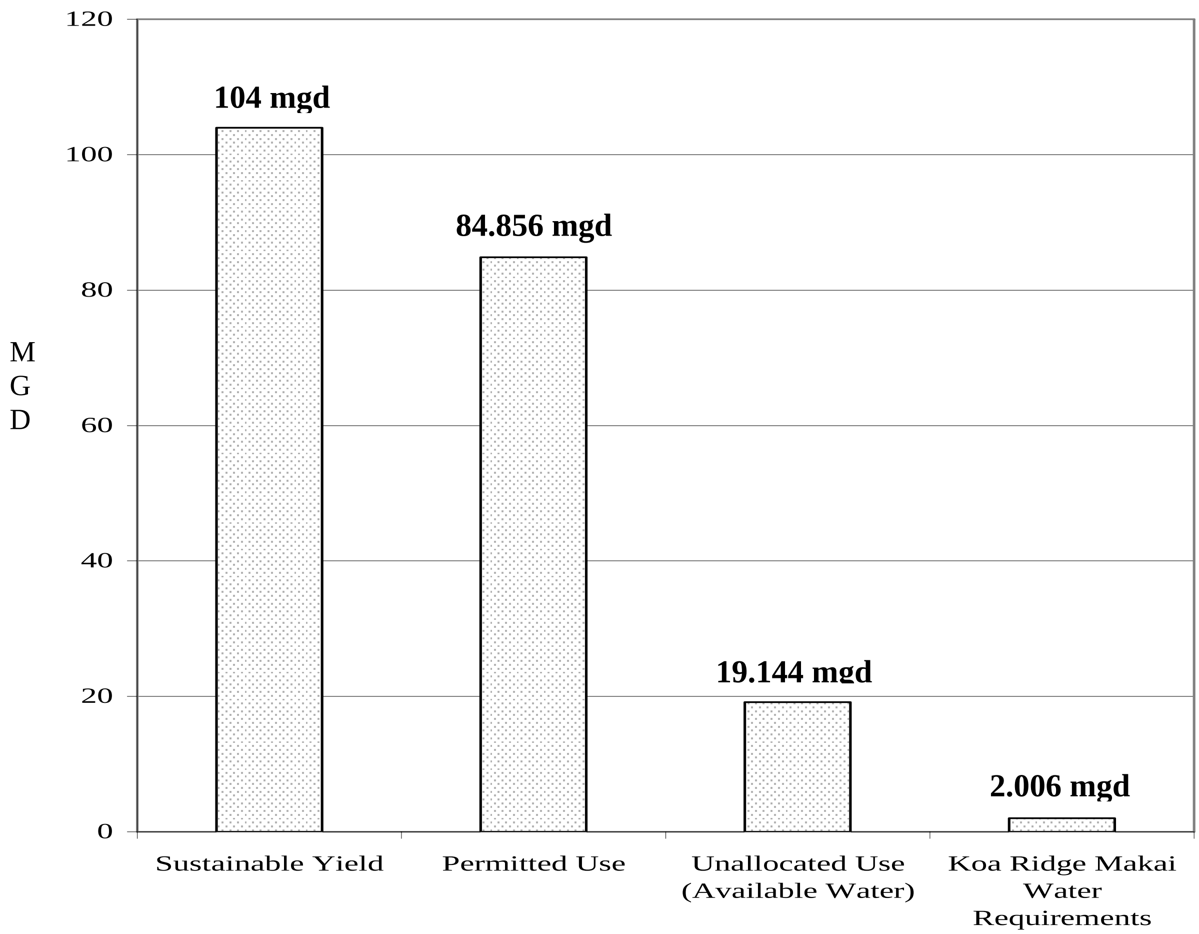


Figure 3. AVAILABILITY OF GROUNDWATER IN THE WAIPAHU-WAIAWA AQUIFER AS OF JUNE 20, 2007

PROPOSED POTABLE WATER SUPPLY

Since no municipal water supply is available to serve the project, new water systems must be constructed to meet the potable water requirements of the Koa Ridge Makai Development. New wells, along with storage reservoirs and transmission/distribution pipelines will be needed to serve the proposed development in two pressure zones—one below the 595-foot elevation and the other below the 820-foot elevation (see Tables 5 and 6, Map 7). Castle and Cooke Homes Hawaii, Inc. will be responsible for the following phases of water development:

1. Prepare and submit a water master plan to BWS for approval.

2. Prepare and submit applications for water use, well construction, and pump installation permits for approval by the CWRM.

3. Prepare plans and specifications to construct two new well sources and other component parts of the water systems, subject to BWS review, approval, and oversight.

4. Dedicate water systems to the BWS.

PROPOSED WELL SOURCES

The 595-ft. service zone will be served by a new well source consisting of two 790 gpm wells located at an elevation of 575 ft. at a site adjacent to the existing BWS' Waipio Heights III well and reservoir site. The requirement for a standby well will be jointly worked out with the BWS. The 820-ft. service zone will be served by a second well source consisting of three 780 gpm wells (includes one standby) located at an elevation of 800 ft. at a site situated 1.6 miles away and approximately 0.7 mile east of the H-2 Freeway. The location of these two proposed well sites are shown in Map 7 and the dimensions and other parameters of the wells are shown in Table 7.

Table 7. DESCRIPTION OF PROPOSED WELLS

Well Parameters	Service Pressure Zones	
	595-foot	820-foot
Number of Wells	2	3*
Ground Elevation (ft.)	575	800
Total Depth (ft.)	705	930
Casing, Outside Diameter (in.)	16	18
Solid Casing Depth (ft.)	605	830
Open Hole Length (ft.)	100	100
Open Hole Diameter (in.)	15	17
Well Pump Capacity (gpm)	790	780
Estimated Chlorides (mg/L)	20	20
Estimated Temperature (°F)	70	70
Estimated Head (ft.)	19	20
Service Zone Pump Capacity, w/o Standby (gpm)	1,580	1,560

* Includes one standby well

PROPOSED RESERVOIRS

The Koa Ridge Makai Development will also require a 1.5 MG (million gallons) storage reservoir at each of the two proposed well sites, based on the following BWS criteria:

1. Meet maximum day consumption. Reservoir full at beginning of the 24-hour period with no source impact to the reservoir.

2. Meet maximum day rate plus fire flow for duration of fire. Reservoir ¾ full at start of fire, with credit for incoming flow from pumps, one maximum size pump out of service.

3. Minimum reservoir size shall be 100,000 gallons. Reservoir size shall be as specified in the Water System Standards, Section 105.10 – RESERVOIR, Subsection A – Size: "Size of reservoir shall be designed to store sufficient water to insure a reliable supply of water, maintain adequate pressures and an economical water system. Unless otherwise approved, standard sizes shall be 0.1 MG, 0.2 MG, 0.25 MG, 0.30 MG, 0.50 MG, and 1.0 MG; thereafter, sizes shall be in multiples of 0.5 MG."

Using criteria 1 and 3 above and the "maximum daily demand" shown in Tables 5 and 6 as the equivalent of "maximum day consumption" in criteria 1, the reservoir capacity required at each of the two well sites is 1.5 MG.

PROBABLE IMPACTS ON GROUNDWATER RESOURCES

The Koa Ridge Makai Development is underlain by the Waipahu-Waiawa Aquifer at a depth ranging from 400 to 700 feet. However, the proposed residential use of the former agricultural parcel is not expected to have any adverse impact on either the sustainable yield or the potable quality of the underlying aquifer, based on the long-term use of similarly developed lands in central Oahu. The probable impacts of the proposed project on groundwater resources are discussed below.

IMPACTS ON WATER SUPPLY

The Koa Ridge Makai Development, at full build-out, will require an average 2.006 mgd of potable water that will be provided by two new well sources tapping the underlying Waipahu-Waiawa basal aquifer. The CWRM's current (2007) sustainable yield for the aquifer is 104 mgd, of which 84.856 mgd have been allocated as of June 20, 2007, leaving a balance of 19.144 mgd of water supply available for future allocation. Thus, the project's potable water requirements of 2.006 mgd represents only 1.9% of the aquifer's sustainable yield and only 10.5% of the 19.144 mgd currently available for allocation.

IMPACTS ON GROUNDWATER RECHARGE AND SUSTAINABLE YIELD

In March 2000, the CWRM lowered the sustainable yield of the Waipahu-Waiawa Aquifer to 104 mgd as a result of a major change in the Pearl Harbor Sector's land use caused by the cessation of sugarcane and pineapple cultivation and irrigation. The methodology used in the reevaluation of aquifer sustainable yields was based on a rainfall isohyet protocol (hydrologic water budget analysis), according to a memo from Ernest Lau, Deputy Director of CWRM, dated April 8, 2003 to Dede Mamiya of the Land Division of the Department of Land and Natural Resources. Thus, the aquifer's 104 mgd sustainable yield (which was adopted in

March 2000) was reevaluated and established at a time when the Koa Ridge Makai parcel was known to consist of fallow pineapple fields.

The proposed Koa Ridge Makai Development lies below the 50-inch rainfall isohyet, similar to other nearby suburban areas (see Map 8). It is generally accepted by Hawaii hydrologists that areas in Hawaii receiving less than an average 50 inches of rainfall a year do not contribute a significant amount of groundwater recharge from net rainfall infiltration. This is due to evapotranspiration equaling or exceeding the amount of rainfall in areas with less than 50 inches (see Figure 4). Consequently, the proposed Koa Ridge Makai Development is expected to have no adverse impact on groundwater recharge or sustainable yield. Nevertheless, some reduction in recharge may occur as a result of an increase in impervious surfaces due to land development. Mitigation measures for loss of recharge are discussed later in this report.

Groundwater recharge studies in Hawaii have been problematic due to the general lack of evapotranspiration data and a scarcity of pan evaporation data as well. Early investigators associated with the sugar and pineapple industry eventually recognized a one-to-one relationship between evapotranspiration (for areas where water is constantly available) and pan evaporation. Later, in the 1960s, others began to recognize that there was a relationship between pan evaporation and rainfall, a readily available climatic data. Takasaki, 1959, developed data showing a relationship between median annual pan evaporation and median annual rainfall in the Hawaiian Islands for areas where cumulative annual wind movement is less than 20,000 miles. Assuming evapotranspiration to be equal to pan evaporation, Takasaki's data showed that median annual evapotranspiration would equal or exceed median annual rainfall for areas receiving less than 50 inches of rainfall a year. Thus, deep percolation of rainfall, i.e., groundwater recharge, would equal zero for areas receiving less than 50 inches of annual rainfall (see Figure 4).

IMPACTS ON EXISTING WELLS

The proposed Koa Ridge Makai Development's potable water requirements will be met from five new wells (one standby), two of which are to be located at a new well and reservoir site adjacent to the BWS' Waipio Heights III source to serve the 595-ft. service zone and three (one standby) of which are to be located at a new well and reservoir site to serve the 820-ft. service zone. The proposed sites are situated 1.6 miles apart as shown in Map 7.

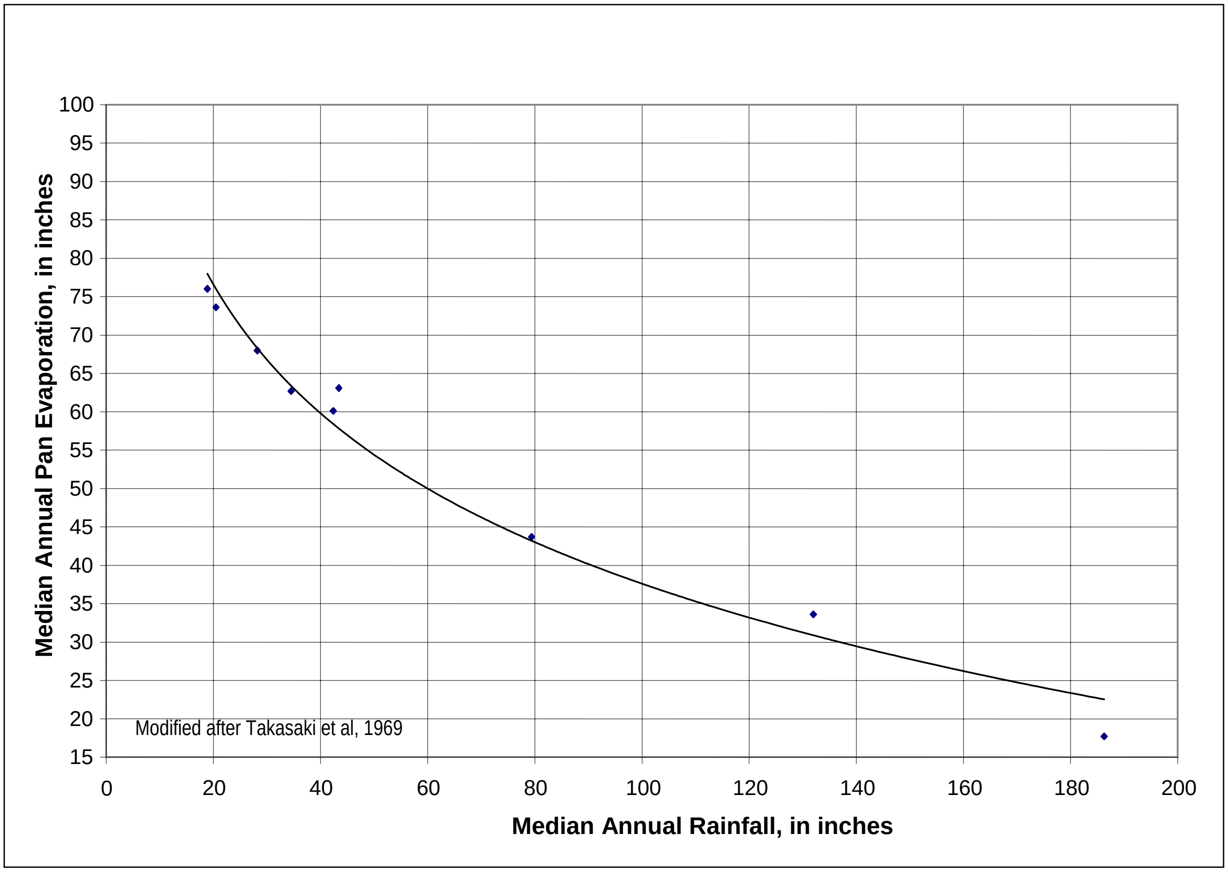


Figure 4. MEDIAN ANNUAL PAN EVAPORATION VS. MEDIAN ANNUAL RAINFALL IN THE HAWAIIAN ISLANDS

At full build-out of the Koa Ridge Makai Development, the proposed wells will withdraw an overall average of 2.006 mgd, but with maximum individual withdrawal rates of approximately 0.75 mgd based on a pump capacity of 790 gpm and a 16-hour-per-day pumping schedule.

The proposed wells are located more than a mile from existing wells, except for the BWS' Waipio Heights III source (see Maps 6 and 7). Any effect on existing wells, particularly those downgradient of the proposed wells, is expected to be undetectable for a number of years, and minimal if at all. This expectation is largely based on: (1) the robust nature of the Waipahu-Waiawa Aquifer, (2) the mile or more distances, (3) the modest withdrawal rates of the proposed wells, and (4) the fact that the total permitted use of water from the Waipahu-Waiawa Aquifer is significantly less (only 81.6%) than its sustainable yield. It is anticipated that no adverse impact on the overall Waipahu-Waiawa Aquifer or existing wells will occur as a result of the proposed withdrawal of 2.006 mgd by the Koa Ridge Makai Development.

It is recognized, however, that there is a need for baseline monitoring and collecting more definitive data. Consequently, the BWS and CWRM have constructed eight deep monitor wells scattered throughout the Waipahu-Waiawa Aquifer to probe the potable basal lens and underlying transition zone. All of these deep monitor wells are expected to provide important baseline records on aquifer conditions and data related to any long-term effects of aquifer withdrawals on downgradient wells. Apparently with this in mind, two deep monitor wells (*Lower Waiawa* and *Waipahu 241*) have been located near the Waipio Heights II source (see Map 6).

As discussed earlier in this report under the section, Deep Monitor Wells, the transition zone in the *Waipahu 241* monitor well (near Pearl Harbor) and the *Waipio Mauka* monitor well have remained fairly stable over the past 15-20 years. During the past three years, these two monitor wells have shown an apparent improvement (downward trend) in the position of the midpoint of the transition zone. (see Map 6 and Figure 2).

IMPACTS ON WATER QUALITY

The proposed Koa Ridge Makai Development is not expected to have any adverse impact on the potable quality of the underlying Waipahu-Waiawa Aquifer. This is based, first, on the long-term suburban use of similar lands in central Oahu, and secondly, on the design goals of the Koa Ridge Makai Development to utilize low-impact and smart-growth policies, the latest environmental guidelines, and best management practices relating to suburban development and water resource utilization. The average withdrawal of 2.006 mgd required for the project at full build out from two new sources located 1.6 miles apart is not expected to have any adverse impact on the salinity of existing upgradient as well as downgradient well sources due to localized upcoming or thinning of the basal lens. Excepting Waipio Heights III, most existing wells are located a mile or more distance from the project's two new well sources (see Maps 6 and 7).

The Waipahu-Waiawa Aquifer, however, has been affected by the past use of herbicides and pesticides on former pineapple lands. Based on the Hawaii Department of Health's Groundwater Contamination Maps for 2005, agricultural herbicides and pesticides continue to be present in a number of wells. The proposed Koa Ridge Makai wells, when they are drilled, will be tested for various water quality parameters as required by the Hawaii Department of Health for new potable water sources. The laboratory results will be evaluated at that time to assess the need for water treatment.

MITIGATION MEASURES

With regard to mitigation measures to lessen the impact of urban land-use activities on water resources, the proposed Koa Ridge Makai Development will have design goals that encourage water conservation efforts, such as: (1) low-flow water fixtures (toilets, shower heads, front-load washers, etc.), (2) drought-tolerant and low water-use landscaping, and (3) water-efficient irrigation systems that utilize drip irrigation and electronic controls (moisture sensors) where feasible.

With regard to the impact of the proposed project on aquifer recharge, it has been noted that the project lands receive less than 50 inches of annual rainfall (see Map 8); and, as a result, the proposed development is expected to have no significant impact on aquifer recharge, as discussed earlier in this report. However, urban land use may result in some loss of recharge as a result of impervious surfaces (concrete, pavement, etc.) causing increased runoff and less groundwater infiltration. Mitigation measures for loss of recharge will include, if feasible, the utilization of retention/detention basins, etc., to minimize erosion and allow groundwater infiltration of runoff.

With regard to the mitigation of any impact of the project's proposed wells on existing wells, the project design goals are to cooperate, assist, and participate where feasible in the study of groundwater conditions in the project wells and downgradient wells as may be requested or required by the CWRM and the BWS.

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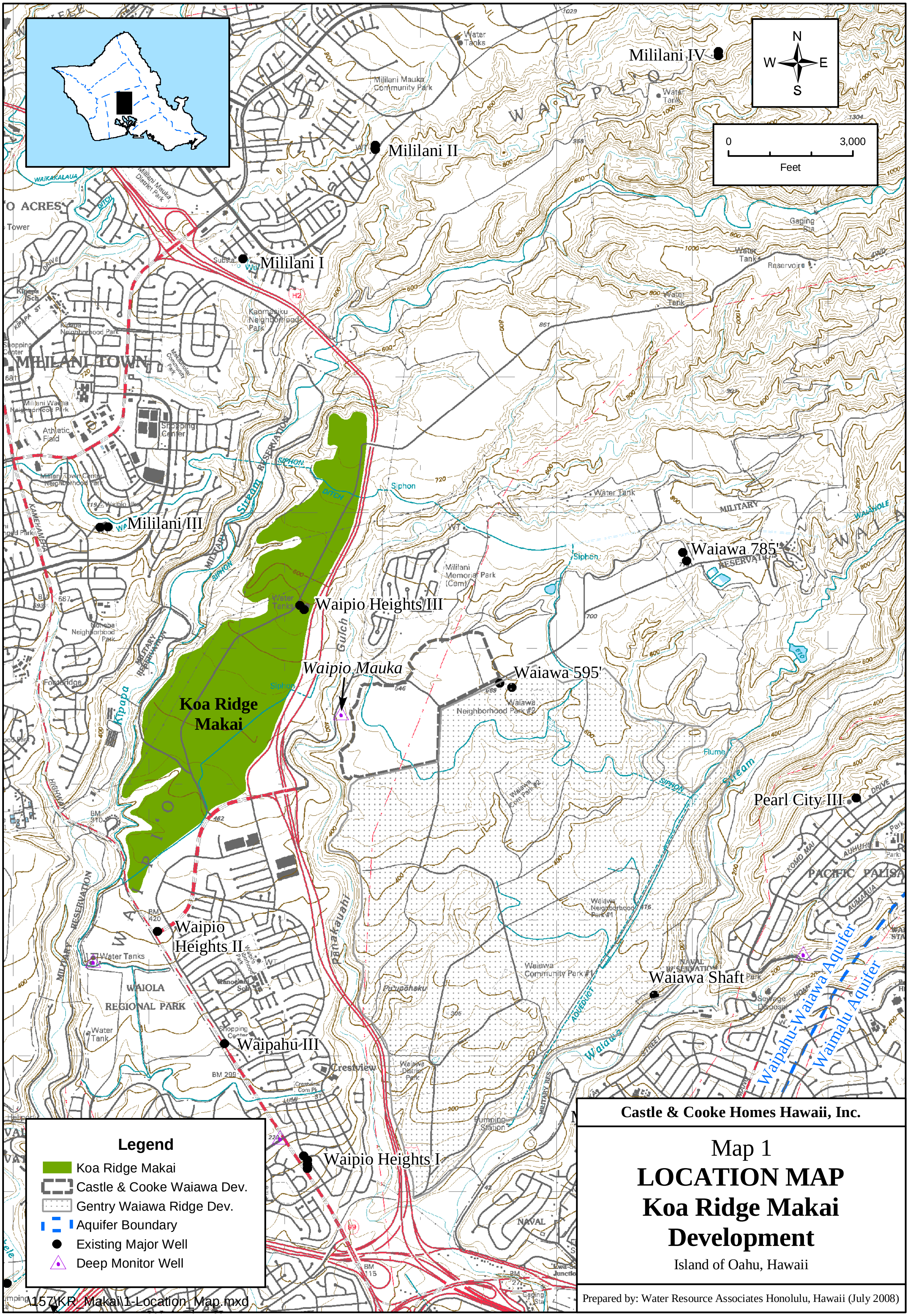
Castle & Cooke Homes Hawaii, Inc.
Map 1
LOCATION MAP
Koa Ridge Makai
Development
Island of Oahu, Hawaii
Prepared by: Water Resource Associates Honolulu, Hawaii (July 2008)
Legend
Koa Ridge Makai
Castle & Cooke Waiawa Dev.
Gentry Waiawa Ridge Dev.
Aquifer Boundary
Existing Major Well
Deep Monitor Well
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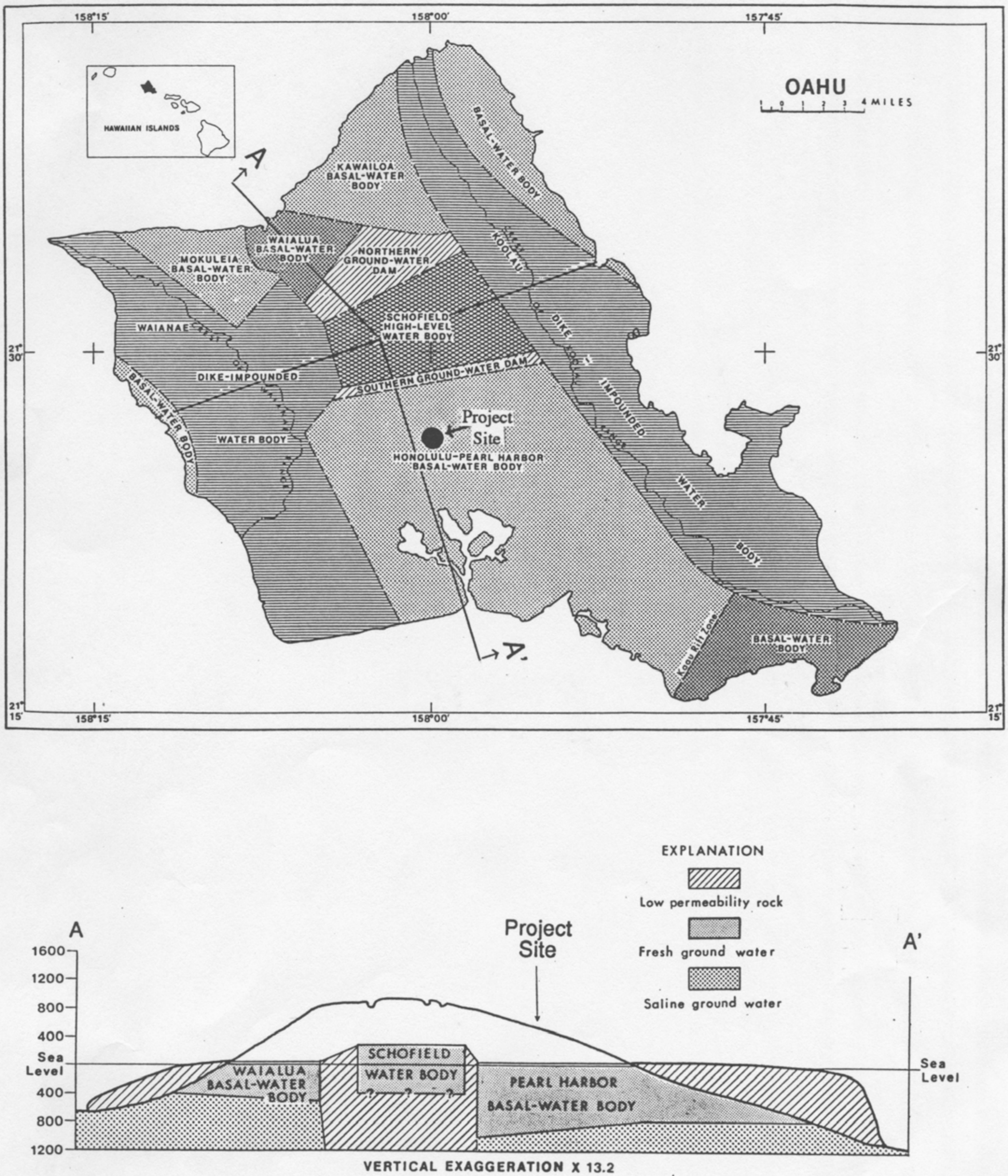
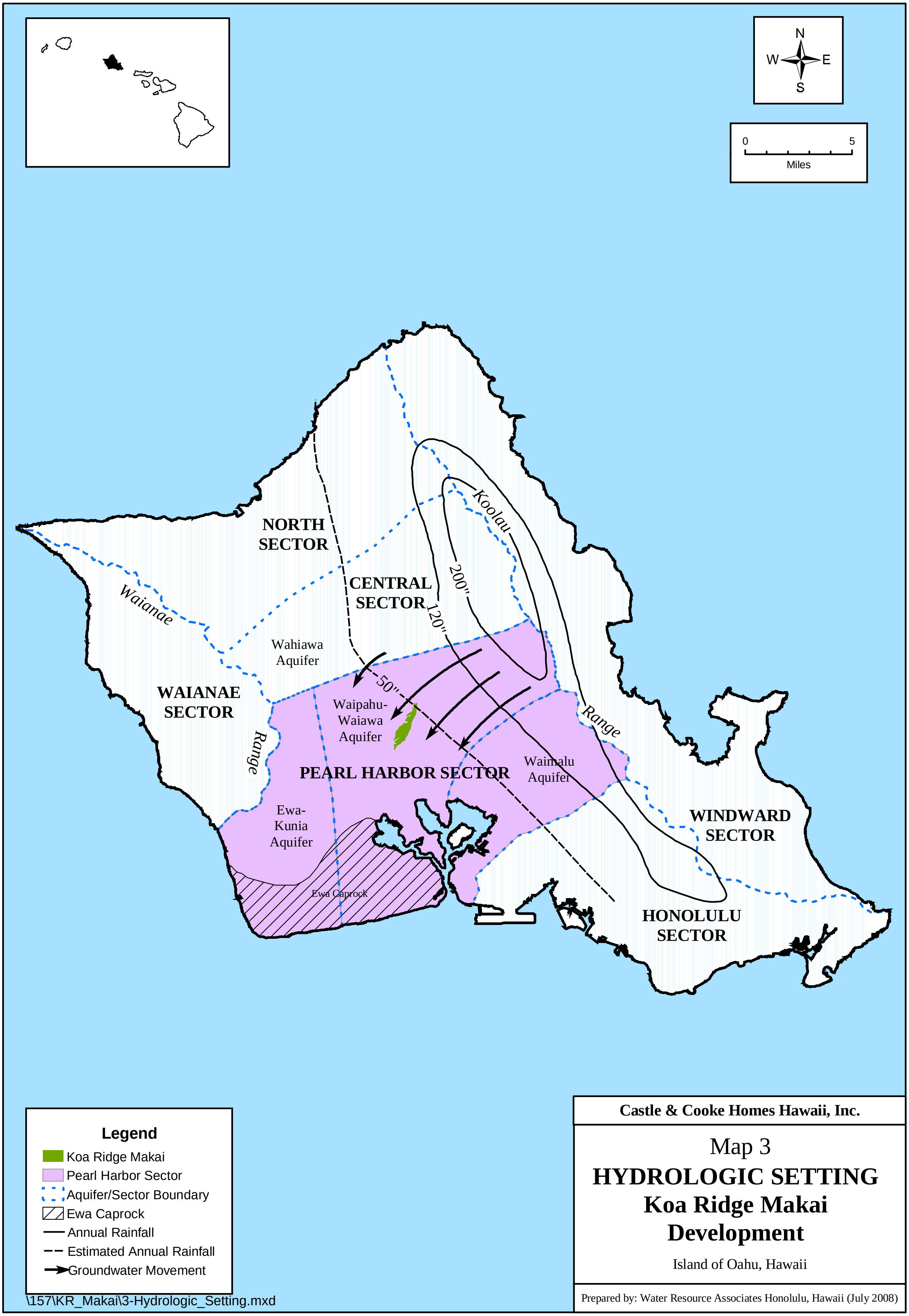
Feet
Koa Ridge
Makai
Mililani IV
Mililani II
Mililani I
Mililani III
Waipio Heights III
Waipio Mauka
Waiawa 595'
Waiawa 785'
Pearl City III
Waiawa Shaft
Waipio
Heights II
Waipahu III
Waipio Heights I
Waipahu-Waiawa Aquifer
Waimalu Aquifer
MILILANI TOWN
WAIOLA
REGIONAL PARK
PACIFIC PALISA
157\KR_Makai\1-Location_Map.mxd



Map 2. GROUNDWATER OCCURRENCE ON OAHU
(Modified after Dale & Takasaki, 1976)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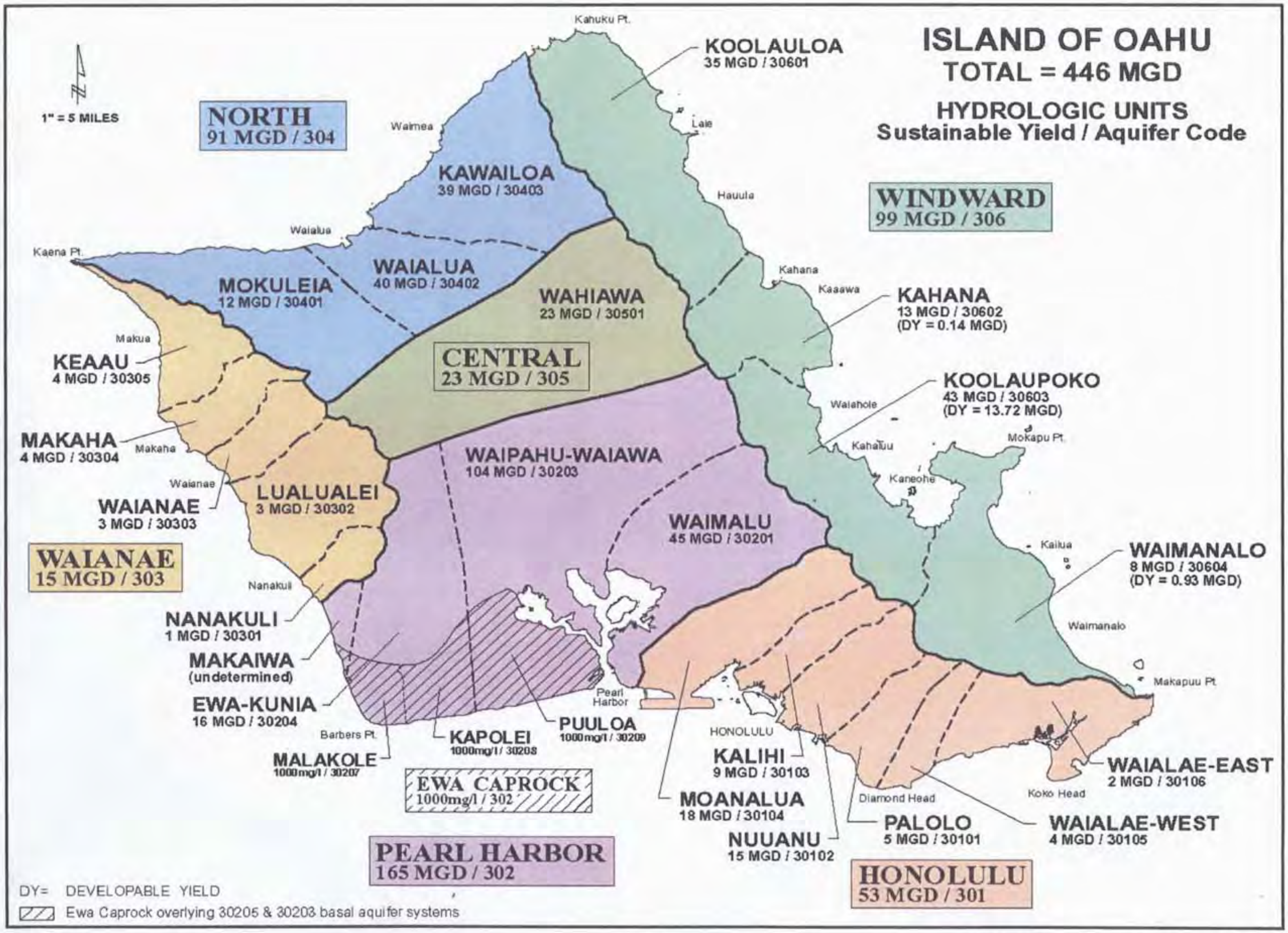
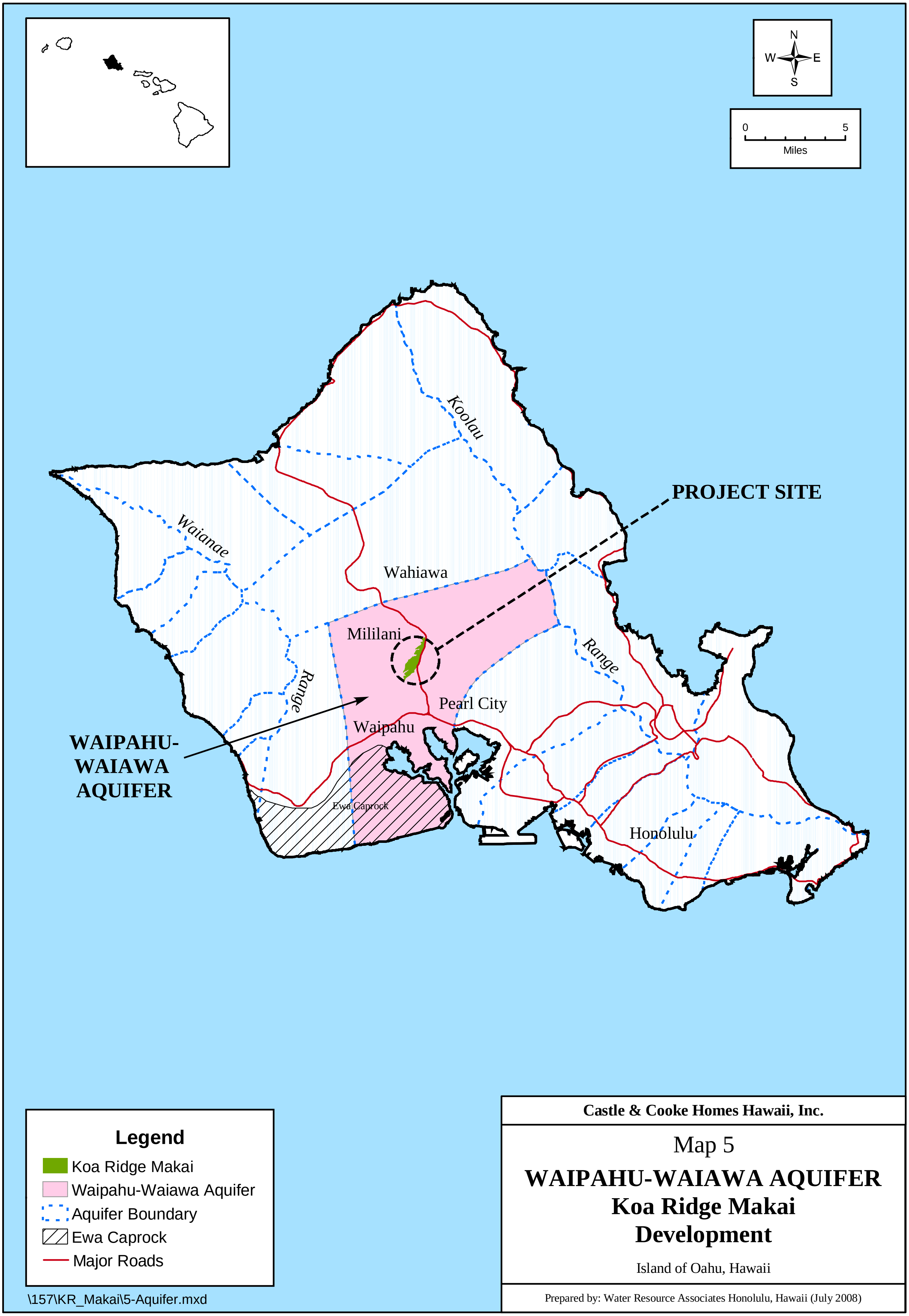
NORTH SECTOR
CENTRAL SECTOR
WAIANAE SECTOR
PEARL HARBOR SECTOR
WINDWARD SECTOR
HONOLULU SECTOR
Wahiawa Aquifer
Waipahu-Waiawa Aquifer
Waimalu Aquifer
Ewa-Kunia Aquifer
Ewa Caprock
Waianae Range
Koolau Range
200"
120"
50"
Legend
Koa Ridge Makai
Pearl Harbor Sector
Aquifer/Sector Boundary
Ewa Caprock
Annual Rainfall
Estimated Annual Rainfall
Groundwater Movement
\157\KR_Makai\3-Hydrologic_Setting.mxd
Castle & Cooke Homes Hawaii, Inc.
Map 3
HYDROLOGIC SETTING
Koa Ridge Makai
Development
Island of Oahu, Hawaii
Prepared by: Water Resource Associates Honolulu, Hawaii (July 2008)

Map 4. HYDROLOGIC SECTORS, AQUIFERS, & SUSTAINABLE YIELD



03/31/2000

Map Projection: Universal Transverse Mercator



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Pearl City
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WAIPAHU-
WAIAWA
AQUIFER
Ewa Caprock
Honolulu
Legend
Koa Ridge Makai
Waipahu-Waiawa Aquifer
Aquifer Boundary
Ewa Caprock
Major Roads
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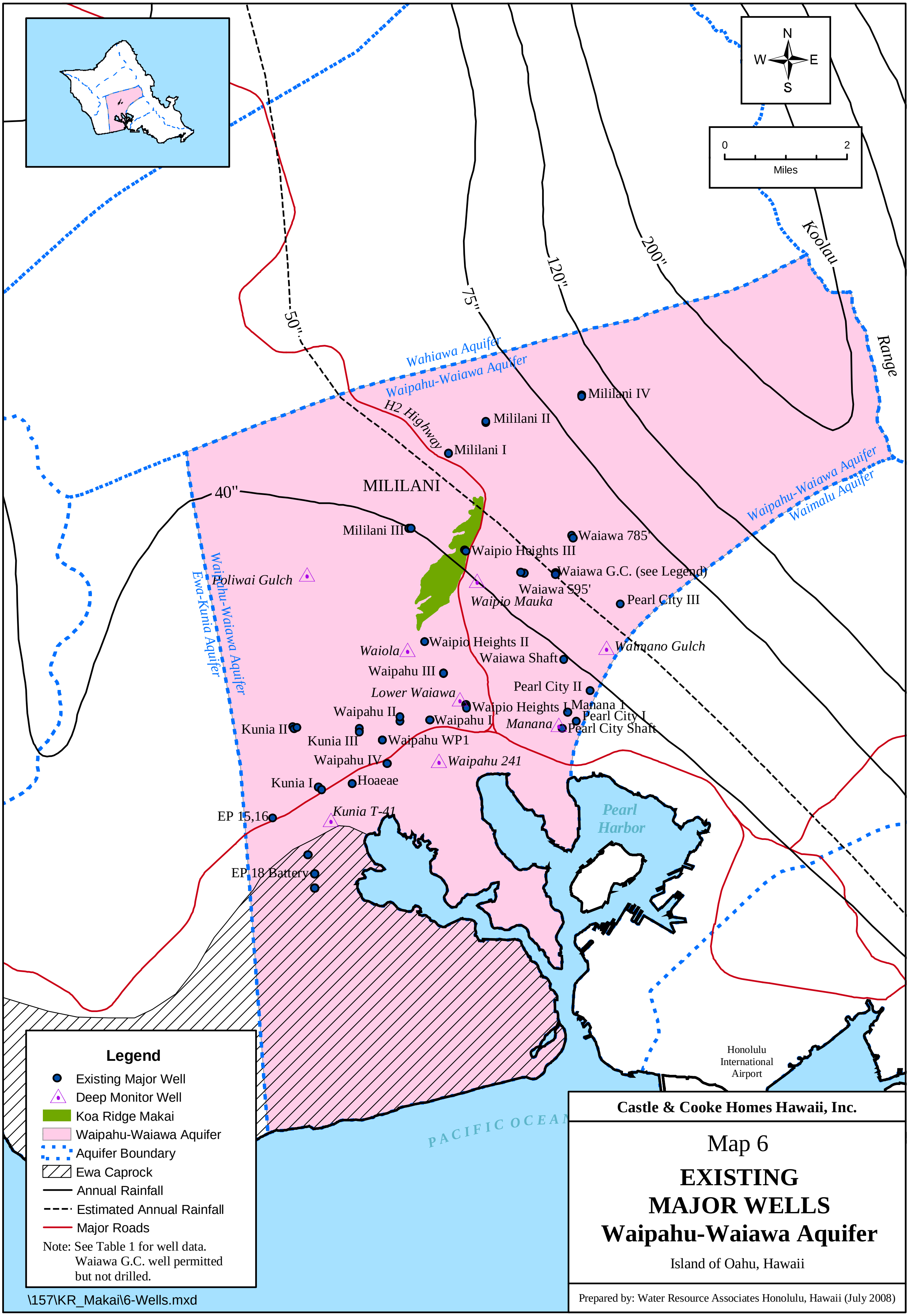
Castle & Cooke Homes Hawaii, Inc.
Map 5
WAIPAHU-WAIAWA AQUIFER
Koa Ridge Makai
Development
Island of Oahu, Hawaii
Prepared by: Water Resource Associates Honolulu, Hawaii (July 2008)



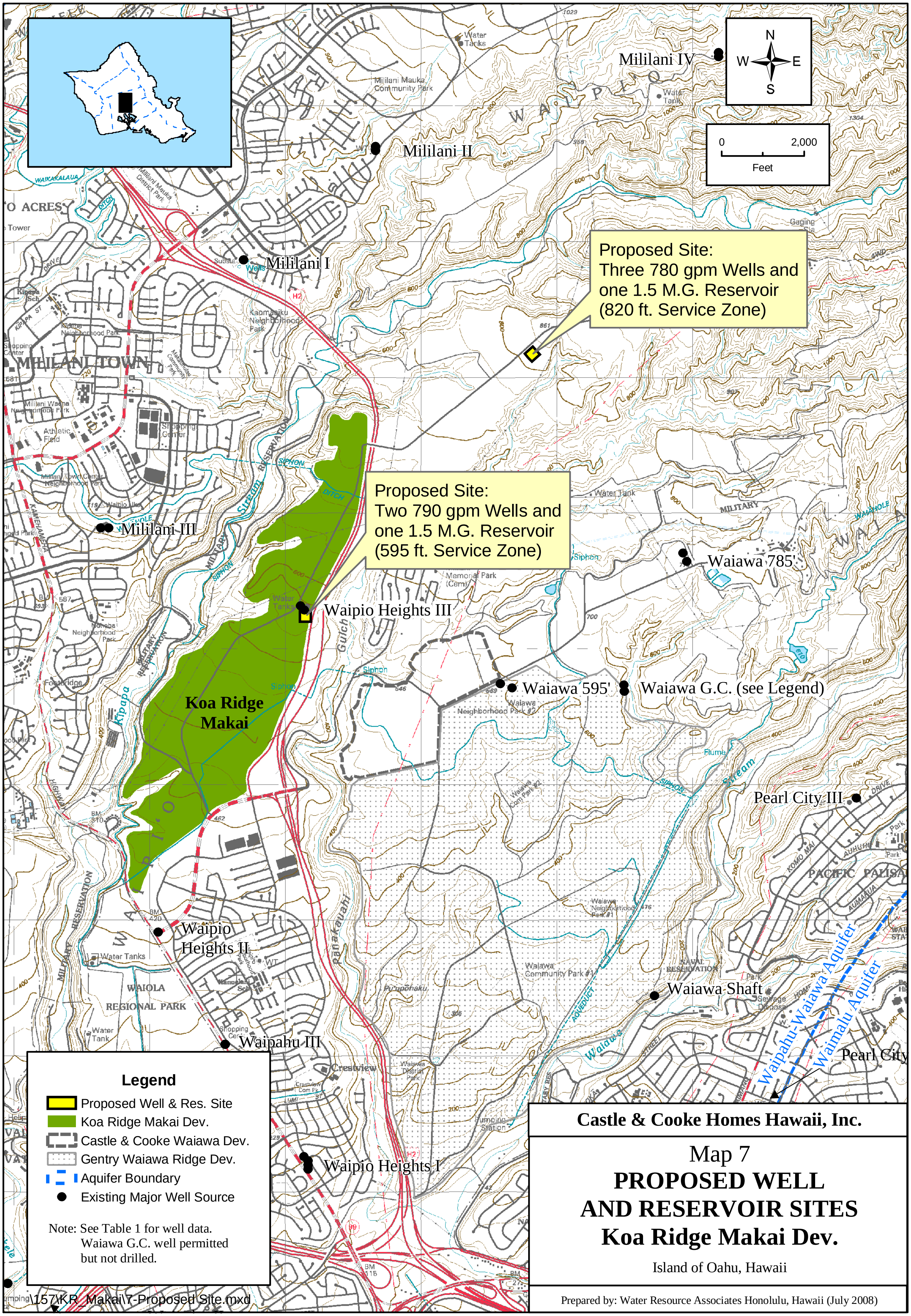
Castle & Cooke Homes Hawaii, Inc.

Map 6

EXISTING
MAJOR WELLS
Waipahu-Waiawa Aquifer

Island of Oahu, Hawaii

Prepared by: Water Resource Associates Honolulu, Hawaii (July 2008)



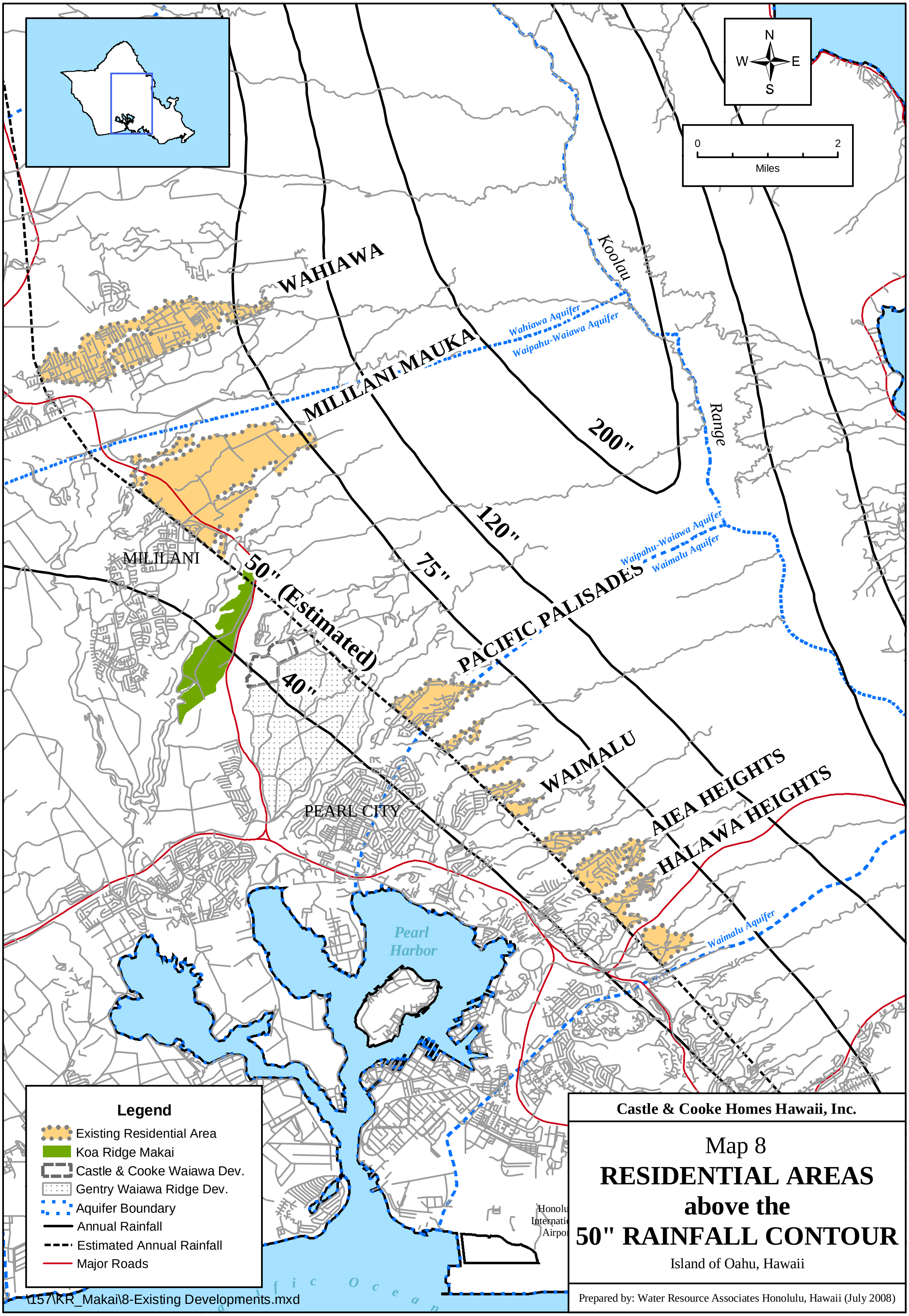
Castle & Cooke Homes Hawaii, Inc.

Map 7

PROPOSED WELL AND RESERVOIR SITES Koa Ridge Makai Dev.

Island of Oahu, Hawaii

Prepared by: Water Resource Associates Honolulu, Hawaii (July 2008)



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MILILANI MAUKA
MILILANI
PACIFIC PALISADES
WAIMALU
AIEA HEIGHTS
HALAWA HEIGHTS
PEARL CITY
Pearl Harbor
Koolau Range
Wahiawa Aquifer
Waipahu-Waiawa Aquifer
Waimalu Aquifer
200"
120"
75"
50" (Estimated)
40"
Legend
Existing Residential Area
Koa Ridge Makai
Castle & Cooke Waiawa Dev.
Gentry Waiawa Ridge Dev.
Aquifer Boundary
Annual Rainfall
Estimated Annual Rainfall
Major Roads
\157\KR_Makai\8-Existing Developments.mxd
Castle & Cooke Homes Hawaii, Inc.
Map 8
RESIDENTIAL AREAS
above the
50" RAINFALL CONTOUR
Island of Oahu, Hawaii
Prepared by: Water Resource Associates Honolulu, Hawaii (July 2008)

HECO Comments on the Power Line
Relocation (email dated 27-Oct-2008)

Appendix B

Koa Ridge Makai
Infrastructure Report

From: Ikeda, Lisa Y. M. [mailto:lisa.ikeda@heco.com]
Sent: Monday, October 27, 2008 9:04 AM
To: Ronald NS Ho & Associates (FD)
Cc: Lum, Mike; Lum, Jimmy; Shimabukuro, Ruby
Subject: RE: Koa Ridge Makai Master Plan (PN 27168)

Hi Gary,

Below are HECO's initial comments/concerns to the attached Draft Preferred Plan for Koa Ridge.

1. HECO will require a minimum 50 ft wide easement for each double circuit 138kV pole line. The minimum separation between the two 50 ft wide easements still needs to be determined per the new 2002 NESC code. This will not be determined until the preliminary design stage when pole locations and span lengths are roughly identified. However, per the G.O.6 code which requires that the pole lines be separated by the height of the tallest pole, assuming a 120 ft pole, the maximum pole line separation would be approximately 70 ft, i.e. pole lines centered within each 50 ft wide easement and 70 ft between easements.
2. The new double circuit steel poles will be approximately 120 ft in height (see attached deadend and tangent pole configurations). I have also attached a photo of an overhead to underground riser pole.
3. The new double circuit steel poles will be spaced approximately 500 ft apart.
4. HECO will allow passive parks, roadways, sidewalks, and plantings (per tree planting guidelines attached) within our easements, but no buildings or structures will be allowed. Special requests can be submitted and will be evaluated on a case by case basis. Any encroachment into our easement will require an Easement Encroachment Agreement.
5. HECO has concerns with the lines crossing a proposed hotel, community center, church, and residential use as shown on the draft plan, open space is acceptable.
6. HECO has concerns with the lines crossing over the BWS wells, open space is acceptable.
7. For the relocation of 138kV lines, PUC approval will be required, estimated at a 9 to 12 month duration after application is filed.
8. For the relocation and construction of 138kV lines, SDOT and City approvals may be required.

Should you have any other questions or comments, please let me know.

Thanks,
Lisa

From: Ronald NS Ho & Associates (JW) [mailto:postmaster@rnsha.com]
Sent: Friday, October 24, 2008 7:45 AM
To: Lum, Jimmy
Subject: Koa Ridge Makai Master Plan (PN 27168)

Jimmy –

Reference is made to the Van Meter Williams Pollack Draft Preferred Plan for Koa Ridge. Please advise if HECO has any comments or concerns on the conceptual alignment for proposed relocation of the 138kV transmission pole lines. Also, what are the allowable uses that HECO would accept within the power line easement? And, lastly, in addition to the PUC and HECO, of course, what other approvals would be required, if any, for the relocation of the 138kV lines?

gary

Planting Trees Near HECO Facilities Guideline

Appendix C

Koa Ridge Makai Infrastructure Report

Planting Trees Near HECO Facilities
Guidelines

Guidelines For Planting Trees Near Overhead Lines

Tall trees that can contact the wires, poles or equipment should not be planted near overhead lines. Trees contacting overhead electric lines can cause electric service outages and expose children, the public, tree workers and electric company crews to hazards from electric shock. Trees and shrubs can also block physical and visual access to poles and equipment for inspection, maintenance and repair. Tall trees must be continuously pruned rendering them unsightly and increasing the cost of electricity.

A planning guide to help select the right trees for planting near overhead lines is as follows:

- Trees that mature at height below 20' may be planted under lines;
- Trees that mature at heights 20' to 30' should be planted at least 10' horizontally from overhead lines;
- Taller, columnar trees (e.g. palms, Formosa koa (*Acacia confusa*), vertical wiliwli (*Erythrina variegate 'fastigiata'*) can be planted as close as 15' horizontally from overhead lines;
- Taller trees with spreading crowns that mature at heights greater than 30' should be planted at least 30' horizontally from overhead lines.

It is important to recognize that the above is not definitive, but should be used as a planning guide. Each tree species and site is unique and should be addressed individually. A tree that is not appropriate on one site may be acceptable on another. Prior to planting, contact your local electric company if you have any questions regarding the correct type of tree to plant.

Guidelines For Planting Trees Near Underground Lines

Large trees and/or trees with invasive roots must not be planted over or near underground lines. Invasive roots can infiltrate electrical conduits and create electrical service outages and hazards of electrical shock. The weight of large trees over underground lines can crush the electrical conduit resulting in electrical service outages and increased environmental damage and cost when repairing the line. Future maintenance and/or excavation of the underground lines can result in damage or death of trees planted too close to the lines. Irrigation water can transport salt from fertilizers and corrode underground line connections resulting in electric service outages.

A planting guide to help select the right tree for planting near underground lines is as follows:

- Always locate all underground utilities prior to performing any digging by contacting your utility companies;
- Do not plant any trees or shrubs directly over underground electric lines;

- As a rule, plant the tree or shrub far away from the underground line so that the tree or shrub crown, at maturity, does not extend over the underground line.

The following trees may be planted as close as five (5) feet from an underground line:

Areca palm	*Chrysalidocarpus lutescens*
Dwarf Date palm	*Phoenix roebelenii*
Dragon tree	*Dracaena marginata*
MacArthur palm	*Ptychosperma macarthurii*
Ma'o	*Gossypium tomentosum*
Ho-awa	*Pittosporum hosmeri*
Kolea	*Myrsine lessertiana*
Awa	*Piper methysticum*
Tree Jasmine	*Posoqueria latifolia*
Kolomana	*Cassia suratensis*
Bottle palm	*Mascarena lagenicaulis*
Blue Latan palm	*Lantania loddigesii*
Manila palm	*Veitchia merrillii*
Thrinax palm	*Thrinax parviflora*
Crepe Myrtle	*Lagerstroemia indica*
Alahe`e	*Canthium odoratum*
Winim palm	*Veitchia winin*
Oleander	*Nerium oleander*
Yellow Jasmine	*Jasminum mesnyi*
Naupaka	*Scaevola sericea*
Panax	*Polyscias guilfoylei*

The following trees may be planted as close as seven (7) feet from an underground line:

Candle bush	*Senna alata*
Plumeria	*Plumeria rubra*
Tiare	*Gardenia taitensis*
Traveler's tree	*Ravenala madagascariensis*
Silver bush	*Sophora tomentosa*
Dwarf Poinciana	*Caesalpinia pulcherrima*
Yellow Bells	*Stenolobium stans*
Jathropha	*Jathropha integerrima*
Golden Dewdrop	*Duranta erecta*
Nanu	*Gardenia brighamii*
Noni	*Morinda citrifolia*
Mamane	*Sophora chrysophylla*
Papa Kepau	*Pisonia sandwicensis*
Aulu	*Pisonia umbellifera*
Keahi	*Nesoluma polynesicum*
Rhodesian Wisteria	*Bolusanthus speciosus*
Bottle Brush	*Callistemon citrinus*

Kou	*Cordia subcordata*
Allspice	*Pimenta dioica*
Palmer's Tecoma	*Tabebuia palmeri*
Lechoso	*Stemmadenia litoralis*
Olopua	*Nestegis sandwicensis*
Lama	*Diospyros sandwicensis*
Podocarpus	*Podocarpus gracilior*
Loulu palm	*Prichardia hillebrandii*
Joannis palm	*Veitchia joannis*
Montgomery palm	*Veitchia montgomeryana*
Mock Orange	*Murraya paniculata*

The following trees may be planted as close as ten (10) feet from an underground line:

Cotoneaster	*Cotoneaster pannosa*
Coconut	*Cocos nucifera*
Partridge Wood	*Andira inermis*
Carob	*Ceratonia siliqua*
Koki'o	*Hibiscus drynarioides*
Silver Buttonwood	*Conocarpus erectus*
St. Thomas tree	*Bauhinia monandra*
Silver Trumpet	*Tabebuia aurea*
False olive	*Cassine orientalis*
Calabash Tree	*Crescentia cujete*
Ohia Lehua	*Metrosideros polymorpha*
Fern tree	*Filicium decipiens*

Large tree species like Monkeypod, Albizia, Eucalyptus, and Banyan will require an onsite investigation by a HECO System Arborist to determine a safe planting distance from any underground electrical facilities. In some instances, a mitigation measure such as a root barrier cloth may be used to reduce the planting distance from the underground facilities. As a guide, the recommended planting distance will be the estimated radius to the drip line from the trunk of the tree at maturity.

It is important to recognize that the above lists are not definitive, but should be used as a planning guide. Each tree species and site is unique and should be addressed individually. A tree that is not appropriate on one site may be acceptable on another. Prior to planting, contact your local electric company if you have any questions regarding the correct type of tree to plant.

HECO DV Recommended Plant Listing

Trees recommended for Dry Sites

Bottlebrush	*Callistemon rigidus*	20'	6	R/YR	I	Tolerates many conditions including salt and drought.
Buttonwood	*Concocarpus erectus*	30'	2-6	I	I	Tree has beautiful silvery foliage. Full sun and well drained soil preferred. Will tolerate many conditions including salt.
Geiger Tree	*Cordia sebestena*	30'	2-6	O-R/YR	I	Grows well in dry areas. Moderate salt tolerance. Used as street tree in Honolulu.
Madagascar Olive	*Noronhia emarginata*	30'	2	I	P-E	Excellent street tree with non-aggressive root system. Tolerant of many conditions.
Red Plumeria	*Plumeria rubra*	25'	6	R/YR	BR/YR	Tolerant of many conditions except wet soils. Thrives on neglect. Mature width 15'-20'.
Pomegranate	*Punica granatum*	20'	6	R/YR	R-E/YR	Small bushy tree at maturity tolerates many conditions except salt.
Beach Heliotrope	*Tournefortia argentea*	25'	6	I	I	Coastal tree with a mature width of 25'. Slow growing.

Form	Flower (Color/Flowering Season)	Fruit (Color/Fruiting Season)
1 = Pyramidal 2 = Full Crown 3 = Fountain 4 = Weeping 5 = Columnar 6 = Spreading 7 = Vase-Shaped 8 = Multistemmed	Color: R = Red Y = Yellow O = Orange B = Blue W = White Br = Brown I = Inconspicuous Flowering Season SP = Spring S = Summer F = Fall W = Winter YR = Year Round	Color: R = Red Y = Yellow O = Orange B = Blue W = White Br = Brown L = Legume I = Inconspicuous E = Edible Fruiting Season SP = Spring S = Summer F = Fall W = Winter YR = Year Round

HECO DV Recommended Plant Listing

Trees Recommended for Wet Sites

Surinam Cherry	*Eugenia uniflora*	25'	6-8	W	Y-R/E	Tolerates many different soil conditions. No salt tolerance.
Tahitian gardenia	*Gardenia taitensis*	20'	6-8	W/YR	I	Tolerates many different soil conditions, prefers rich organic. No salt tolerance.
Lignum vitae	*Guaiacum officinale*	25'+	2-6	B/S-F	O-Y/F	Wonderful upright small tree with compact growth. Tolerant of many conditions. Moderate salt and drought tolerance. Great street tree.
Rose Flower	*Jatropha integerrima*	20'	6	R/YR	I	Grows best in full sun and in organic well drained soils.
Mock Orange	*Murraya paniculata*	25'	6-8	W/SP	R/SP	Tolerant of many soil conditions, prefers fertile well drained sites. Moderate drought and salt tolerance.
Ochrosia	*Ochrosia elliptica*	20'	2-6	W	R	Slow growing tree, tolerant of many conditions. Good salt tolerance.

Form	Flower (Color/Flowering Season)	Fruit (Color/Fruiting Season)
1 = Pyramidal 2 = Full Crown 3 = Fountain 4 = Weeping 5 = Columnar 6 = Spreading 7 = Vase-Shaped 8 = Multistemmed	<u>Color:</u> R = Red Y = Yellow O = Orange B = Blue W = White Br = Brown I = Inconspicuous <u>Flowering Season</u> SP = Spring S = Summer F = Fall W = Winter YR = Year Round	<u>Color:</u> R = Red Y = Yellow O = Orange B = Blue W = White Br = Brown L = Legume I = Inconspicuous E = Edible <u>Fruiting Season</u> SP = Spring S = Summer F = Fall W = Winter YR = Year Round

HECO DV Recommended Plant Listing

Native Plants for Dry and Wet Sites
(Available Only As Seedlings)

Kokio keokeo	*Hibiscus arnottianus 'Shy Girl'*	25'	6	W/YR	I	Flower is fragrant. Native to mesic and wet areas of Oahu. Slow growing.
*Alahe'e	*Canthium odoratum*	18'	6	W	I	Occurs in dry and wet forests and can handle a wide variety of soil conditions. No salt tolerance.
*A'ali'I	*Dodonea viscosa*	25'	6	I	Y-R	Pioneer species in dry areas. Will tolerate various conditions. Prefers well drained soils.
*Nehe	*Lipochaeta succulenta*	6'	6	Y/YR	I	Spreading understory costal shrub. Possible erosion control plant.
*Kului	*Nototrichium sandwicensis*	15'	6	I	I	Does well in dry coastal areas with well drained soils
*Pohinahina	*Vitex rotundifolia*	5'	6	B	I	Spreading shrub that roots at nodes. Possible erosion control. Prefers coastal habitats.

Form	**Flower (Color/Flowering Season)**	**Fruit (Color/Fruiting Season)**
1 = Pyramidal 2 = Full Crown 3 = Fountain 4 = Weeping 5 = Columnar 6 = Spreading 7 = Vase-Shaped 8 = Multistemmed	Color: R = Red Y = Yellow O = Orange B = Blue W = White Br = Brown I = Inconspicuous Flowering Season SP = Spring S = Summer F = Fall W = Winter YR = Year Round	Color: R = Red Y = Yellow O = Orange B = Blue W = White Br = Brown L = Legume I = Inconspicuous E = Edible Fruiting Season SP = Spring S = Summer F = Fall W = Winter YR = Year Round

HECO DV Recommended Plant Listing

Palms and Other Monocots

Areca Palm	*Chrysalidocarpus lutescens*	30'	3	I	I	Grows best in well drained soils with plenty of water. Very popular palm in private landscapes. Clumping.
*Bottle Palm	*Hyophorbe lagenicaulis*	15'	3	I	I	Tolerant of many site conditions. Prefers full sun and can withstand drought.
*Triangle Palm	*Neodypsis decaryi*	25'	3/7	I	I	Requires full sun and good drainage. Extremely drought tolerant.
*Dwarf Date Palm	*Phoenix roebelenii*	10'	3	I	E	Slow growing. Tolerant of many sites. Requires full sun.
Loulu Palm	*Pritchardia martii*	20'	3	I	I	Very slow growing. Native to the Koolau mountains. Prefers moist sites with good drainage. Only seedlins available.
Fiji Fan Palm	*Pritchardia thurstonii*	20'	3	I	I	Tolerant of dry conditions. Needs to receive water to maintain proper health.
Manila Palm	*Veitchia Merrillii*	25'	3	I	I	Grows well in a wide range of conditions. Does best with full sun and ample water.
*Pony Tail Palm	*Beaucarnia recurvata*	25'	3	I	I	Xerophyte. Trunk is swollen at base. Extremely drought tolerant.
*Money Tree	*Dracaena marginata*	25'	3	I	I	Tolerant of many conditions, including salt.

Form	Flower (Color/Flowering Season)	Fruit (Color/Fruiting Season)
1 = Pyramidal 2 = Full Crown 3 = Fountain 4 = Weeping 5 = Columnar 6 = Spreading 7 = Vase-Shaped 8 = Multistemmed	<u>Color:</u> R = Red Y = Yellow O = Orange B = Blue W = White Br = Brown I = Inconspicuous <u>Flowering Season</u> SP = Spring S = Summer F = Fall W = Winter YR = Year Round	<u>Color:</u> R = Red Y = Yellow O = Orange B = Blue W = White Br = Brown L = Legume I = Inconspicuous E = Edible <u>Fruiting Season</u> SP = Spring S = Summer F = Fall W = Winter YR = Year Round

HECO DV Recommended Plant Listing

Appendix D

Koa Ridge Makai
Infrastructure Report

Hawaiian Electric
Company, Inc.

Hawaii Electric
Light Company, Inc.

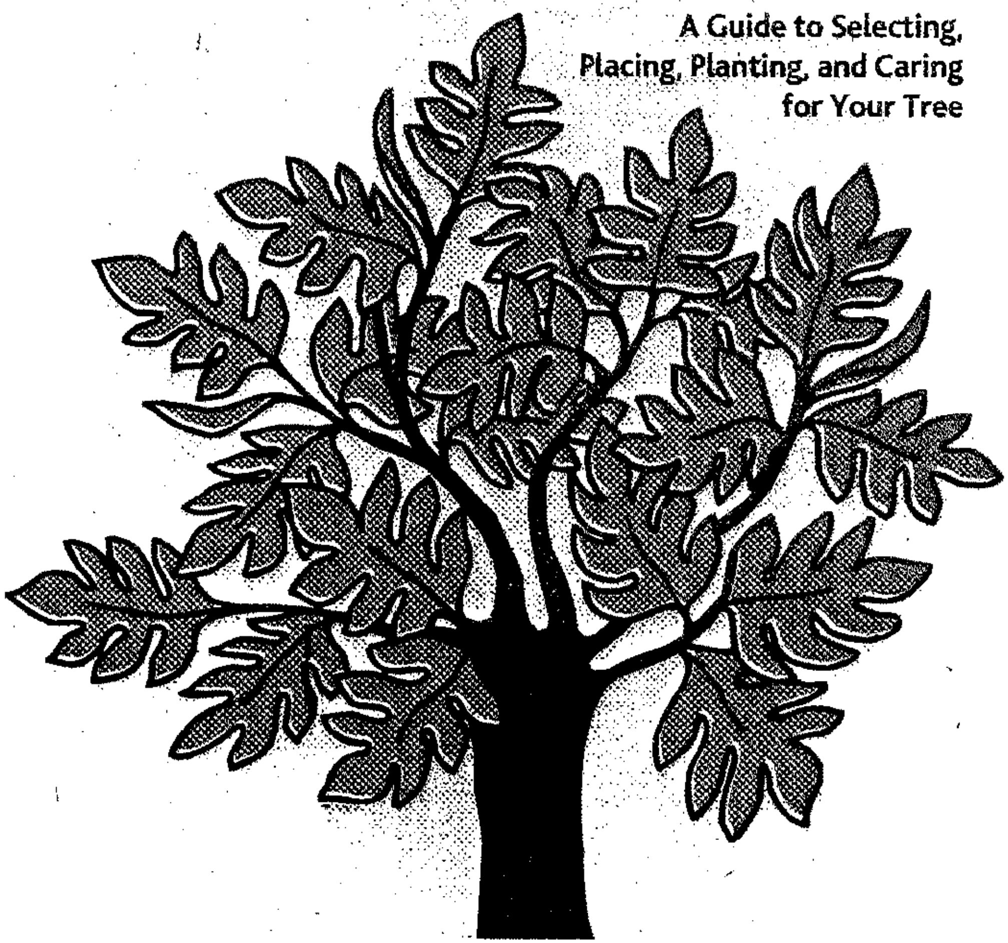
Maui Electric
Company, Ltd.

KAULUNANI

CTAHR · Cooperative Extension Service · Oahu · Urban Garden Center

THE RIGHT TREE *for* THE RIGHT PLACE

A Guide to Selecting,
Placing, Planting, and Caring
for Your Tree



Printed on Recycled Paper

The Benefits of Trees

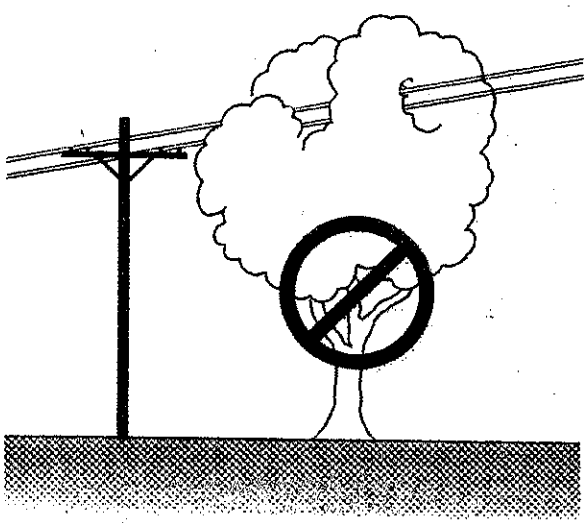
Trees may be the most important feature of our landscapes. They provide beauty and enjoyment through their many forms, colors, flowers, and fruits.

Along with the shade and beauty they provide are the many less visible benefits that make trees valuable assets. They enhance our environment by producing oxygen, storing carbon, cooling streets, preventing erosion, and filtering noise and pollutants. They can block wind and screen undesirable views. Attractive trees and landscaping add to a property's real estate value.

Perhaps the most impressive benefit of trees is the dollars saved on utility bills. Research has shown that properly located trees can reduce air conditioning costs in homes and office buildings by 30 percent or more.

Too often, we take trees for granted and don't properly plan and plant. Not matching the right tree to the site can prevent the desired aesthetic and environmental benefits and result in unexpected liabilities and costs.

Selecting the RIGHT TREE for the RIGHT PLACE will help you get the long-term benefits, beauty, and satisfaction from the trees you plant.



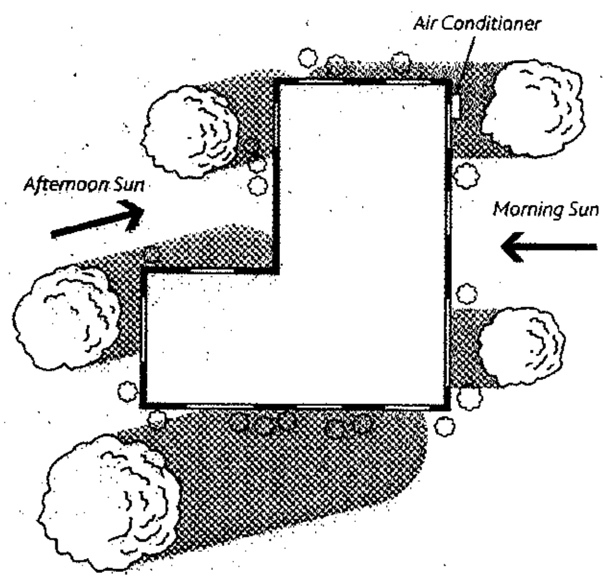
Don't plant trees that grow higher than 30 feet under utility lines as they could cause power outages and create

Selecting the Right Tree

Planning ahead is the most important step you can take to ensure that the time and money you invest in planting a new tree are well spent. The key to successful landscaping is to plant the right tree in the right place.

What will the tree look like when it is mature? Above all, find out how tall and what shape your tree will be when it is fully grown to make sure that it fits the space and purpose you have for the tree.

The checklist on the following pages will guide you in the selection of the right tree. Use this guide along with a good resource, such as your favorite local nursery or plant book, to prepare a list of trees that will meet your needs. Then go through each successive item in this guide and eliminate trees that do not conform to site restrictions or conditions. If the guide is followed carefully, the final list should provide you with the best trees for your specific landscape.



Plan your residential landscape: Save money on utility bills by planting a large tree to shade the air conditioner. Other trees are carefully located to shade windows from morning and afternoon sun. Shrubs planted on all sides of the house help reduce the temperature of the soil and the walls. Be sure to prune

The Checklist

1. What do you want the tree to do?

(Pick one or more.)

☐ Shade	☐ Focal point for yard
☐ Windscreen	☐ Grow fast
☐ Visual screen	☐ Grow slow
☐ Accent	☐ Grow tall
☐ Colorful fruit	☐ Stay small
☐ Flowers	☐ Other ______________

2. How much space does the tree have to grow?

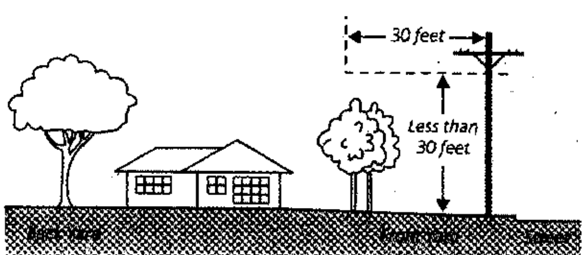
Are there any obstacles overhead, to the side, at ground level, or even underground?

☐ No power lines overhead

If you are planting near power distribution lines that run through residential areas, the most important thing to remember is the 30-FOOT RULE: Trees and plants within 30 feet of power lines should not grow higher than 30 feet tall when fully grown. Consult your nursery or landscape professional for trees whose mature height does not exceed 30 feet.

☐ No buildings in close proximity

Don't plant trees that can grow large enough to contact buildings or block signs. Trees that grow over roofs and rain gutters can create maintenance problems and damage buildings.



For sites within 30 feet of power lines, select trees and plants that grow to less than 30 feet. You don't want your shade trees

☐ No underground utilities

Do not dig or plant until you identify all nearby underground utility lines, including cable, sewer, and power lines.

Do not plant trees on top of underground lines.

Do not plant trees with aggressive roots near underground utilities where their roots can damage the facilities.

☐ No swimming pools near site

If trees will be near a pool, select trees that do not drop leaves that will fall or blow into the pool.

☐ No plants or other landscape features that may suffer in the shade of a large tree

Ensure that large trees will not grow over and shade out smaller trees, shrubs, and groundcovers.

☐ No obstruction of scenic views

Ensure that the tree will not grow to block a desirable view for you or your neighbors.

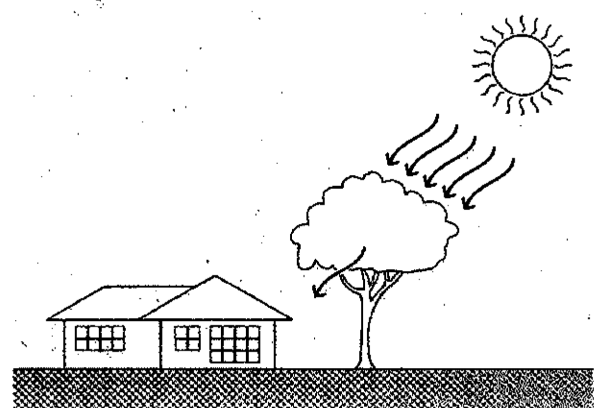
☐ No nearby driveways/roadways/sidewalks

Select trees that have a high, clear trunk or that can be practically pruned so as not to obstruct safe travel.

Do not plant large trees near driveways, roadways, curbs, and sidewalks where their roots may cause damage.

☐ No nearby walls to undermine

Do not plant large trees near walls. Their roots may cause damage to them.



Tree shade is better than Venetian blinds, plastic coatings, or reflective glass surfaces at cooling your home on hot, sunny days. Shading walls and windows can reduce air conditioning

❑ No nearby property boundaries

Do not plant trees where roots can invade and damage neighboring properties.

❑ Other considerations...

It's important to identify and avoid any obstacles that could restrict the canopy and root growth of your tree, or could be damaged by any part of your tree. Also, identify any situation where your tree could create a safety hazard or nuisance.

If obstacles are near the site, how far away from the planting site are they? They must be far enough so that the top, canopy, or roots of the tree do not interfere with these obstacles when the tree is at its mature size and maximum growth range. It's important to note that roots can extend two to three times beyond the canopy. With most trees, however, the roots with the greatest potential to cause damage are generally found within the area under the canopy.

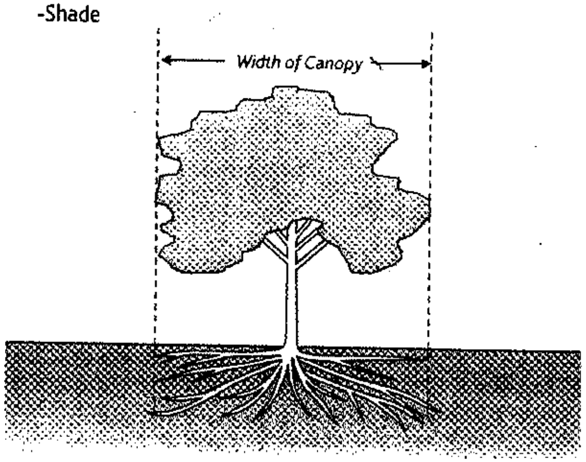
3. How are the planting conditions at the site?

Select a tree that will thrive or at least tolerate the growing conditions of the planned site.

❑ Quality of sunlight

Is there sufficient sunlight to ensure proper growth?

-Direct all day
-Filtered through overhead obstacles
-Shade



Roots can extend 2 to3 times beyond the canopy, although, with most trees, the roots with the greatest potential to cause

❑ Sufficient natural water

Natural availability of water may limit the selection of trees suitable for the site, without artificial irrigation.

-Dry
-Wet
-Moderate

❑ Quality of soil

The type of soil on site may limit your selection of plants to tolerant species.

-Heavy clay
-Sand
-Nice topsoil

❑ Depth of the soil

Make sure the soil is deep enough to support the tree's root system. Most of the tree's roots are confined to the top two feet of the soil layer. A large tree may be inappropriate for shallow or unstable soil.

❑ Exposure to salt spray.

If the planting site is near the beach, make certain that the tree you select is salt tolerant.

❑ Strong winds

If the site is windy, are the trees sensitive to or damaged by strong winds?

4. Will the tree grow well in your neighborhood?

One easy way to answer this question is to take a look around your neighborhood. See how others have used trees in their landscaping design and find out what kinds of trees are growing well. Your local plant nursery can also suggest appropriate trees for your climate and soil conditions.

5. How much maintenance does the tree require?

-Is the tree low maintenance?
-Does the tree drop lots of leaves and/or fruit?
-What kind of maintenance can you reasonably provide?

If cleanup is a concern, don't plant trees that shed.

How to Plant the Tree

Digging the Hole: The hole should be dug as large as practical, but at least twice the width of the root ball. If the soil is very dense and hard, the hole should be three to five times the width of the root ball. The hole should not be dug too deep.

The hole should be slightly shallow so the top of the root ball is one to two inches above the level of the surrounding soil. The bottom of the hole should not be filled with soft soil or with gravel to support and raise the tree.

Removing the tree from the container: Before planting, the tree must be carefully removed from the container. In many instances, the tree will have been kept in the container for an extended period of time causing the roots to grow into a dense, circling mass packed into the container.

In these instances, the root mass should be sliced vertically around the root ball, in three to four places with a sharp knife, to allow you to separate the roots and cause them to grow out.

Roots that grow across and around the ball will not provide adequate support for the tree and will eventually girdle and strangle the tree.

Setting the tree: Use care when handling the tree to minimize damage to the tiny fibrous roots and the stem. Handle the tree by the root ball, not grabbing the trunk or branches. After the tree is set in the hole, check the height of the root ball to ensure that it is not too low. Remove tags and labels so they do not girdle the tree.

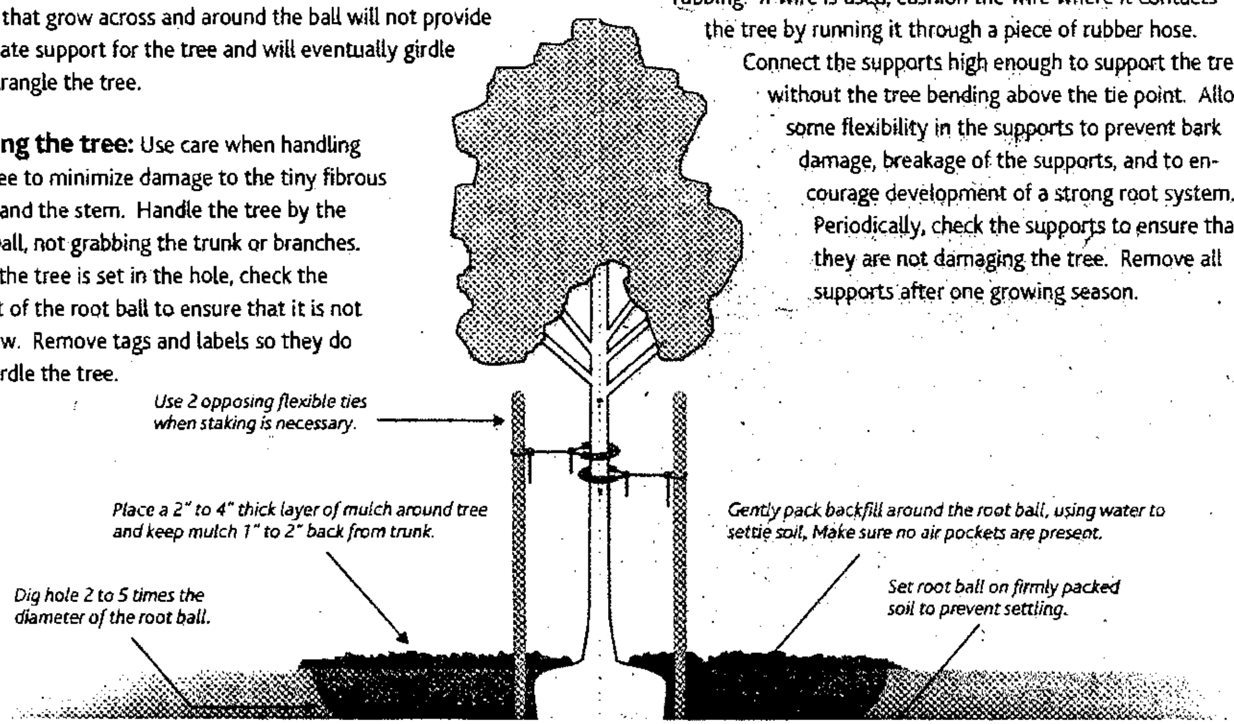
Backfilling the hole: In most cases, it is better to backfill the hole with soil from the site. Research has shown that soil amendments (compost or sand) do not assist in tree establishment and growth. Do not fertilize the tree until at least one growing season after planting.

Work the soil around the ball and firm it in to ensure that no air pockets are present. Do not pack the soil! Water thoroughly while backfilling to help eliminate air pockets. Ensure that the top of the root ball is slightly above the level of the surrounding soil. Do not plant the tree too deep!

It may be beneficial to create a small berm (mound of soil) around the perimeter of the hole to retain water. If the soil is very dense, leave some breaks in the berm so that excess water can drain.

Staking: Do not stake trees unless absolutely necessary to support or to protect the tree from damage. If staking is required, place two opposing stakes to provide the desired support or protection.

Support the tree by using soft flexible material, such as strips of rubber inner tube, that will not damage the tree bark from rubbing. If wire is used, cushion the wire where it contacts the tree by running it through a piece of rubber hose. Connect the supports high enough to support the tree without the tree bending above the tie point. Allow some flexibility in the supports to prevent bark damage, breakage of the supports, and to encourage development of a strong root system. Periodically, check the supports to ensure that they are not damaging the tree. Remove all supports after one growing season.



Caring for the Tree

Mulch: After proper selection and planting, the single best thing you can do for any tree, just planted or older, is to mulch. Organic mulch can be purchased at most garden supply stores or from mulch suppliers. You can also create mulch from your own compost pile.

Mulch retains moisture, protects trees from damage from lawn mowers and weeders, moderates soil temperatures, provides a natural interchange of nutrients, controls weeds, and eliminates competition for space, nutrients, and moisture from grass. Mulch zones should encircle the tree from the trunk to a distance of at least three feet.

Larger trees should be mulched from the trunk to a distance of approximately one foot for each inch of trunk diameter. If it is impractical to mulch the prescribed distance for larger trees, the mulch zone should be as large as possible, but at least twelve feet in radius from the trunk.

Water: Water management is based on the size and type of plant, air temperature, humidity, amount of sunlight, wind, and soil type. The most important point is to select a tree that is appropriate and tolerant of the natural water levels of your neighborhood. However, during dry or hot and windy periods, especially with very light and sandy or heavy clay soils, additional watering is desirable.

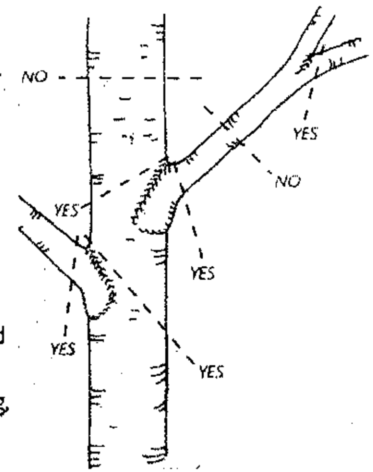
When watering is performed, it should be done in the early morning. This will minimize water loss from evaporation and will allow time for leaves and soil to dry, which helps prevent fungal problems. Watering should be performed infrequently and slowly so that it percolates deeply into the soil. This encourages good root structure and better root distribution. Water should be distributed evenly to as much of the root system as possible.

Fertilizer: Like watering, fertilizing should be kept to a minimum. A regular mulching program should maintain a good nutrient cycle, minimizing the need for supplemental fertilizer. However, on certain sites where certain nutrient requirements cannot be maintained or acquired, or construction or damage creates stress, fertilizer is beneficial.

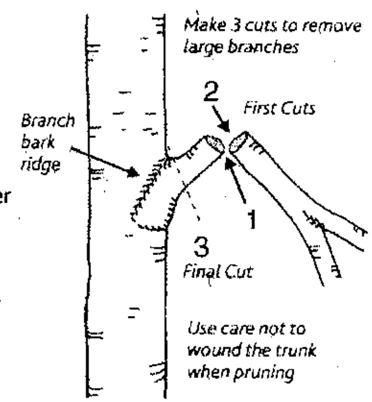
It is advisable to consult a certified arborist for fertilization recommendations for specific tree species and conditions.

Generally, a slow-release fertilizer, applied at rates according to label directions during times when moisture levels are high, is the most effective.

Pruning: Pruning should be performed to remove dead, damaged, diseased, and crossing limbs, to reduce crowding of branches, and to eliminate hazards. Pruning can also be performed to slow growth, to reduce wind resistance, to increase light penetration, to shape the canopy, and to prevent or enhance flowering and fruiting. Consult a landscape professional regarding pruning, especially if the tree is near power lines.



The key to pruning is to select the correct limbs for removal and to make the proper pruning cut, called "natural target pruning."



Always cut at nodes. Nodes are where branches meet other branches or the main trunk.

Do not remove more than one-third of the foliage at any single pruning.

Always make proper cuts. Proper pruning cuts use the branch bark ridge as a guide. Start the cut next to the top and beside the branch bark ridge. Do not cut the ridge. The final cut should be at an opposite and approximately equal angle to the bark branch ridge. This will remove the target limb without damaging the branch collar, which will enable the tree to effectively compartmentalize the wound and protect itself from rot and disease.

Do not paint cuts. Wound dressings do not help the tree and can actually cause harm by inhibiting wound closure and providing a warm, moist site for decay-causing organisms such as fungi.

Infrastructure Report

For the

Castle & Cooke Waiawa

Development

Waipio and Waiawa, Oahu, Hawaii

Castle & Cooke Homes Hawaii, Inc.
100 Kahelu Avenue
Mililani, Hawaii 96789

Prepared by:
ParEn, Inc.
dba Park Engineering
711 Kapiolani Boulevard, Suite 1500
Honolulu, Hawaii 96813

October 2007

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FIGURES

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1 DESCRIPTION OF PROJECT

Castle & Cooke Waiawa is a master planned community in Central Oahu proposed by Castle and Cooke Homes Hawaii, Inc. The major land use proposed is residential development, encompassing 138.07 acres of the 191.214 acre project site. A total of 1,500 residential units including community-support facilities such as parks, a school, a commercial site and drainage facilities are planned. Remaining areas will be kept as open space. (See Figure 1-1 – Land Use Map)

2 PROJECT LOCATION

The Castle & Cooke Waiawa Development project site is located in Central Oahu just north of the Interstate H-2 freeway in the vicinity of the Waipio (Ka Uka Boulevard) Interchange. It is bordered to the north by Panakauahi Gulch and the Mililani Memorial Park Cemetery and to the south and east by the proposed master planned community of Waiawa being developed by Waiawa Ridge Development, LLC (WRD).

This project will work in conjunction with the master planned development of Waiawa (See Figure 2-1 – Location Map) and has been incorporated into the infrastructure master plans for Waiawa. As such, primary offsite infrastructure such as roadways and utility transmission mains to the project site are being provided by WRD's Waiawa development or are being constructed in cooperation with their project.

3 TOPOGRAPHY

Topography at the project location ranges from elevation 450 to 600 feet MSL. Terrain at the site is gently sloped with an average slope of approximately 3%.

4 SEWER SYSTEM

4.1. EXISTING SEWER SYSTEM

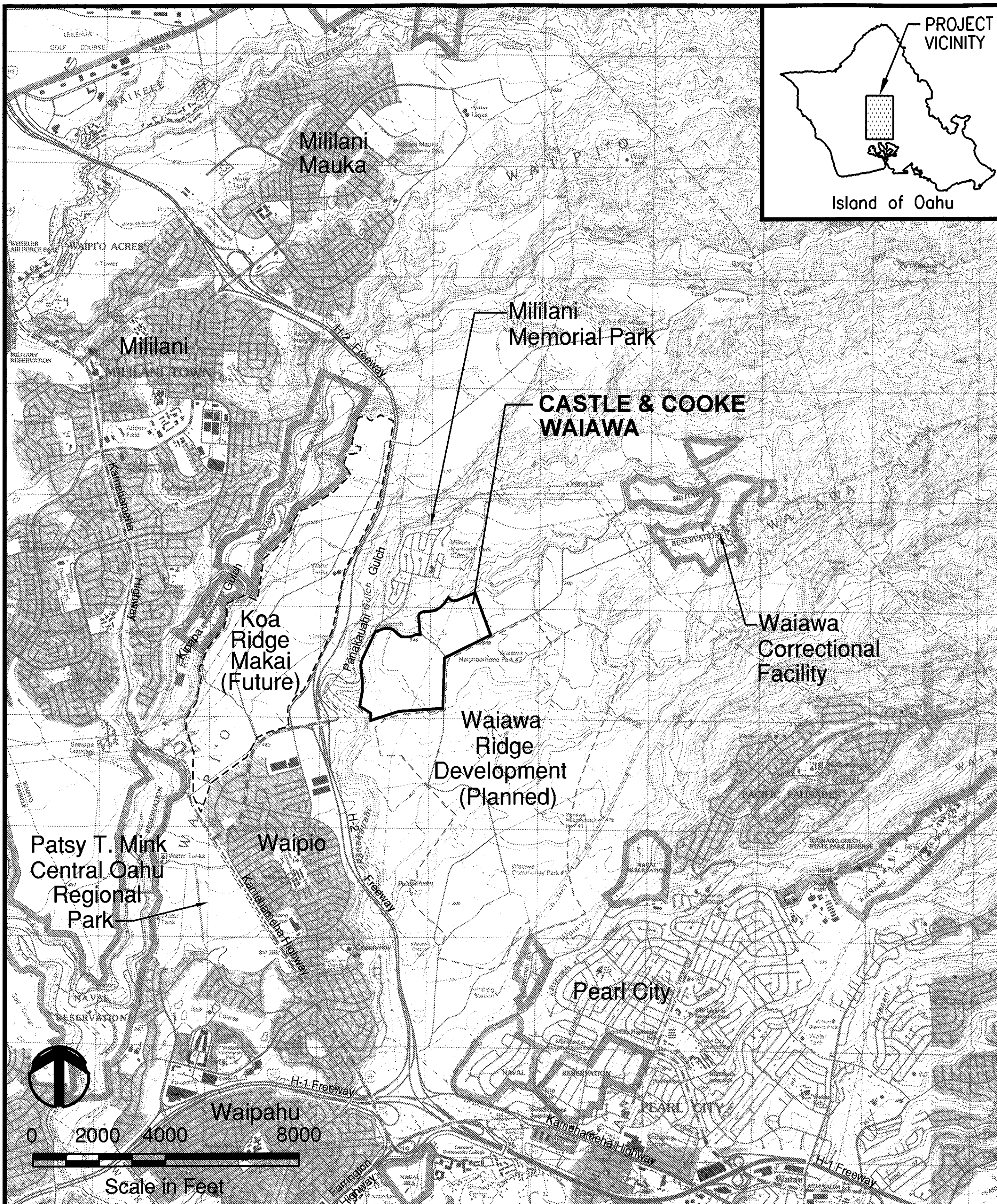
Currently, there are no sewer system improvements within or adjacent to the project site. However, offsite sewer improvements for the project will be constructed with the master planned development of Waiawa by WRD.

CASTLE & COOKE WAIAWA

LAND USE MAP

ParEn, Inc.
dba Park Engineering
Engineers, Surveyors, Planners

FIGURE 1-1



CASTLE & COOKE WAIAWA
LOCATION MAP

ParEn, Inc.
dba Park Engineering
Engineers, Surveyors, Planners

FIGURE 2-1

The proposed sewer improvements to be constructed with the Waiawa project will include a 12-inch sewer stub at the south-east corner of the Castle and Cooke Waiawa parcel. Sewer from the Waiawa project site will be conveyed via the proposed offsite sewer line through Pearl City which will terminate at the Pearl City Pump Station. Wastewater from the pump station ultimately is delivered to the Honouliuli Wastewater Treatment Plant for treatment and disposal.

4.2. PROJECTED SEWER DEMAND

It is estimated that the proposed project will generate a peak wastewater flow of 1.60 million gallons per day (MGD). Flows are based on the "Design Standards of the Department of Wastewater Management", Volume 1, City and County of Honolulu, State of Hawaii, dated July 1993 with an average daily per capita flow of 80 gallons per day. A summary of the wastewater computation is presented in Table 4-1.

Forecasted sewer flows from Castle and Cooke Waiawa's parcel are accounted for in their Revised Wastewater Master Plan for Waiawa by Gentry, dated September 2006.

4.3. PROPOSED SEWER SYSTEM IMPROVEMENTS

The sewer system will be designed in accordance with the "Design Standards of the Department of Wastewater Management", Volume 1, City and County of Honolulu, State of Hawaii, dated July 1993. It will be designed to carry the peak flows of this development. Forecasted sewer flows from Castle and Cooke Waiawa's parcel are accounted for in their Revised Wastewater Master Plan for Waiawa by Gentry, dated September 2006.

The onsite wastewater collection system will essentially follow the proposed public roadway system and will be conveyed by gravity to the proposed 12-inch sewer stub provided by the WRD's Waiawa development (See Figure 4-1 - Proposed Sewer System). A limited portion of the south-west corner of the site is lower than the sewer connection point and will need to be pumped to a discharge manhole prior to flowing by gravity. This pump station will likely be a packaged sewer pump station which will be privately owned and operated.

ParEn Inc.

SEWER: WAIAWA
DISTRICT: WAIPIO
REFERENCE MAPS:

TABLE 4-1
CASTLE & COOKE WAIAWA
COMPUTATION OF WASTEWATER FLOW

BY: TSW

Normal Infilt: 5 (gpcd) [USE 5 OR 35]
Wet Infilt: 1250 (gpad) [USE 1250 OR 2750]

LAND USE		TRIB. AREA		TRIB. POPULATION			FLOW	AVE.	MAX	MAX	NORM DESIGN AVE		DESIGN	WET	DESIGN	Pipe				Qreq
		Increment	Total	Units/Pop	Increment	Total	gpcd	FLOW (mgd)	FLOW FACT.	FLOW (mgd)	INFIL (mgd)	FLOW (mgd)	HRLY FLOW (mgd)	INFILT. (mgd)	PEAK FLOW (mgd)	Size (IN)	Slope (%)	Capacity (mgd)	Vel. (fps)	/Qall (%)
CASTLE & COOKE																				
SINGLE FAMILY		31.64	31.64	222	888	888	80	0.0710	5.00	0.3552	0.0044	0.0755	0.3596	0.0396	0.3992					
MULTI-FAMILY		64.53	96.17	1071	2,999	3,887	80	0.3109	3.81	1.1850	0.0194	0.3304	1.2045	0.1202	1.3247					
PARK		6.54	102.71	131	41	3,928	80	0.3142	3.80	1.1950	0.0196	0.3339	1.2147	0.1284	1.3431					
SCHOOL		8.00	110.71	800	250	4,178	80	0.3342	3.76	1.2555	0.0209	0.3551	1.2764	0.1384	1.4148					
COMM - NEIGBORHOOD BUS		3.02	113.73		121	4,299	80	0.3439	3.74	1.2845	0.0215	0.3654	1.3060	0.1422	1.4481	12	0.73	1.71	3.37	0.85
** ASSUMPTIONS PARKS LESS THAN 2 ACRES WILL NOT HAVE SEWER FLOW, 800 STUDENTS FOR ELEM. SCHOOL @ 25 GPCD, 20 PERSONS / ACRE / PARK @ 25 GPCD																				
DESIGN CRITERIA POPULATION (GENERATING 25 GPCD) CONVERTED TO AN EQUIVALIENT POPULATION (GENERATING 80 GPCD) BY MULTIPLYING UNIT/POP BY 0.3125																				
CASTLE & COOKE																				
PUMP STATION AREA																				
MULTI-FAMILY		12.60	12.60	207	580	580	80	0.0464	5.00	0.2318	0.0029	0.0493	0.2347	0.0158	0.2505	8	0.44	0.45	1.99	0.56
TOTAL			126.33	1500		4,878	80	0.3903	3.64	1.4212	0.0244	0.4146	1.4456	0.1579	1.6035	12	1.00	2.00	3.94	0.80

CASTLE & COOKE WAIAWA

PROPOSED SEWER SYSTEM

ParEn, Inc.
dba Park Engineering
Engineers, Surveyors, Planners

FIGURE 4-1

5 DRAINAGE SYSTEM

5.1. EXISTING DRAINAGE CONDITIONS

The project site is comprised of two existing drainage areas. Both areas sheet flow into existing Panakauahi Gulch (See Figure 5-1 - Existing Drainage Areas). Drainage Area No. 1 drains directly towards Panakauahi Stream while Drainage Area No. 2 flows into a small tributary before its confluence with Panakauahi Stream.

Existing conditions at the site can be characterized as fallow agricultural land and pasture. Much of it is heavily overgrown with tall grass and wooded in low-lying areas leading to gulches.

5.2. PROPOSED DRAINAGE CONDITIONS

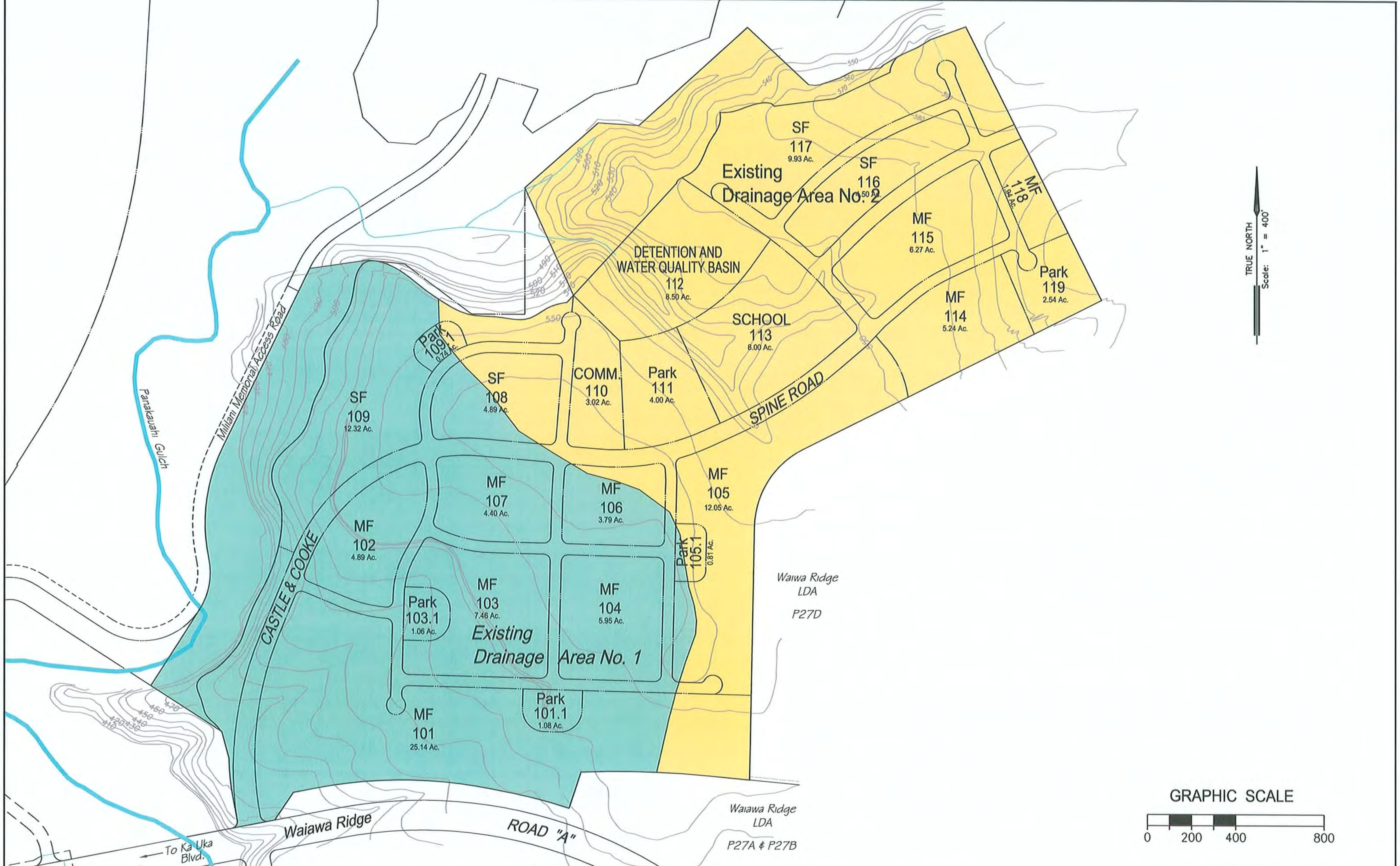
Development of the project site will result in some reallocation of drainage areas from the pre-developed condition. However, the general character of the site having two drainage areas will not change (See Figure 5-2: Proposed Drainage System).

Site characteristics will be consistent with typical residential development. Impervious area will increase with the construction of roadways, driveways, sidewalks and other improvements resulting in a higher runoff coefficient. In order to mitigate any increases in stormwater runoff, a detention basin is being proposed to attenuate peak discharge from the site to not exceed pre-developed conditions.

5.3. PROPOSED DRAINAGE IMPROVEMENTS

Stormwater runoff from developed areas will be collected by onsite drainage systems located within the internal roadways. Drainage improvements for the project will be designed in accordance with the "Rules Relating to Storm Drainage Standards", Department of Planning and Permitting, City and County of Honolulu, Honolulu, Hawaii, dated January 2000.

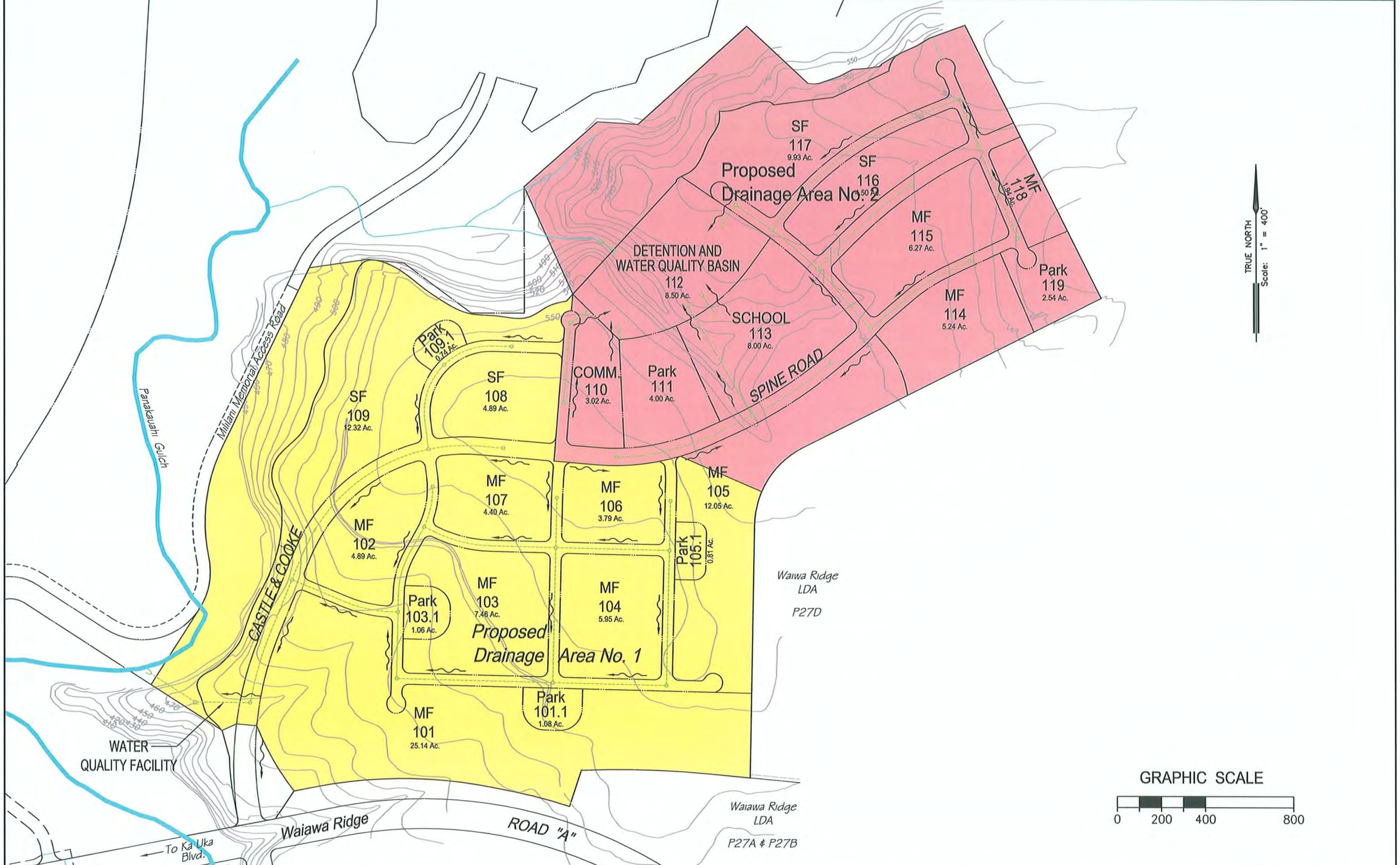
It is anticipated that each drainage area will have its own outlet. Runoff from Drainage Area No. 1 will be conveyed via drainage piping to the southwest corner of the parcel. A water quality treatment facility will be sited in this vicinity to satisfy the water quality requirements of the Storm Drainage Standard prior to discharge into Panakauahi Stream.



CASTLE & COOKE WAIAWA
EXISTING DRAINAGE AREAS

ParEn, Inc.
dba Park Engineering
Engineers, Surveyors, Planners

FIGURE 5-1



CASTLE & COOKE WAIAWA
PROPOSED DRAINAGE SYSTEM

ParEn, Inc.
dba Park Engineering
Engineers, Surveyors, Planners

FIGURE 5-2

Runoff from Drainage Area No. 2 will also be collected and conveyed via drainage piping to the vicinity of the natural depression which forms a tributary to Panakauahi Stream. A detention basin is proposed at this location to provide sufficient hydraulic detention for the entire developed site and also to satisfy the stormwater quality requirements for Drainage Area No. 2. It is anticipated that the required storage volume for the basin will range between 30 Acre-Feet to 50 Acre-Feet for a 100-year 24-hour peak discharge. The current acreage for the detention basin site measures 8.5 acres. Discharge from the detention basin will follow the natural drainage patterns, crossing under the Miliani Memorial Park Access Road through the existing box culverts before joining up with Panakauahi Stream flows.

6 WATER SYSTEM

6.1. EXISTING POTABLE WATER SYSTEM

The proposed project overlies the Waipahu-Waiawa Aquifier System, largest of the three aquifiers systems which comprise the Pearl Harbor sector. Currently no potable water facilities exist on either the Castle & Cooke Waiawa Development and the Waiawa Ridge Development, except for four non-developed wells on the lands of the WRD (named *Waiawa 595* and *Waiawa 785*). (See Figure 6-1).

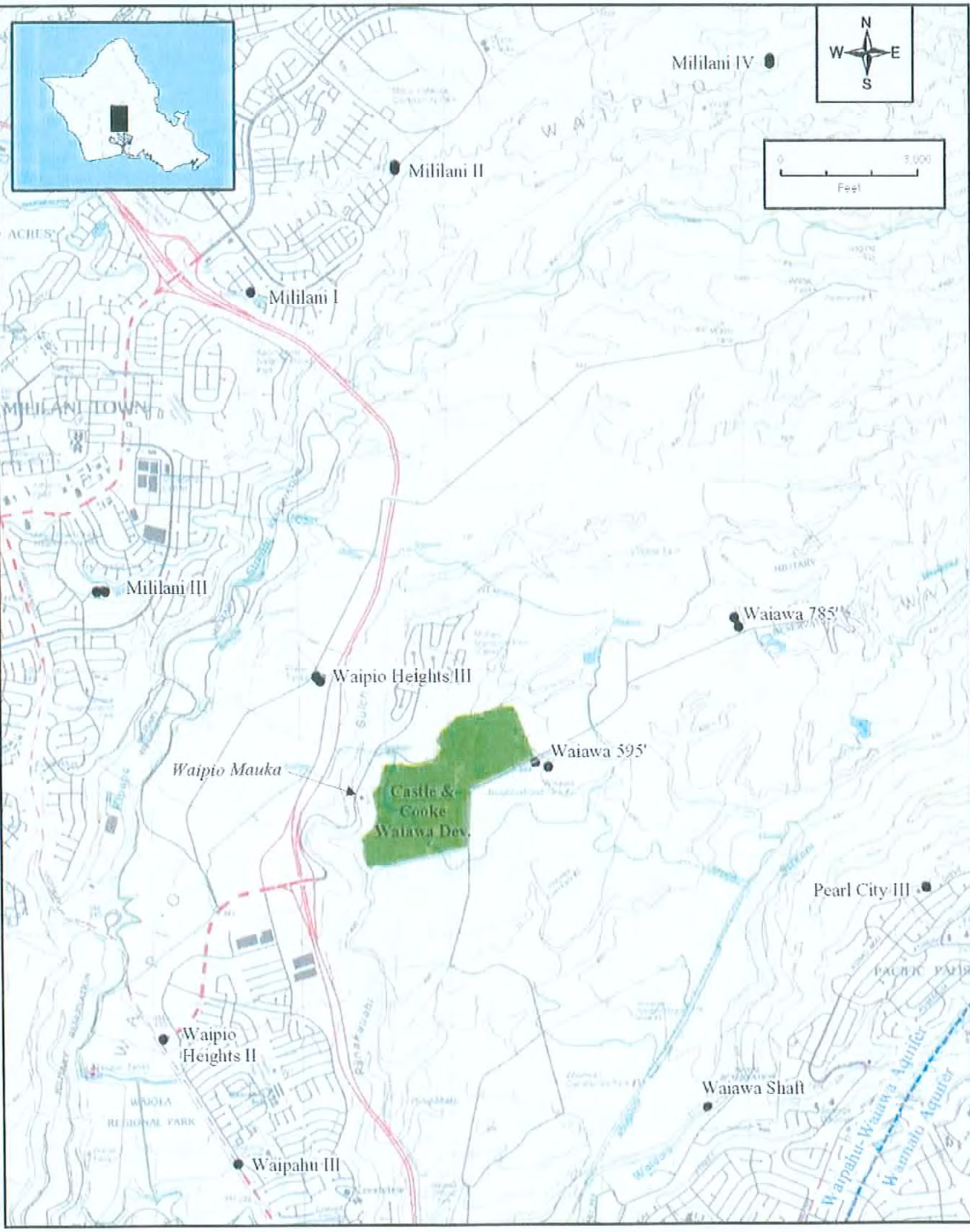
A municipal potable water system is located to the west to service the communities of Crest View and Waipio Gentry. Farther to the north and west is another municipal water system to service the community of Mililani Town and Mililani Mauka. The existing municipal potable water systems will not be integrated with the proposed Castle & Cooke Waiawa or the Waiawa Ridge Development.

Existing municipal wells near the Castle & Cooke Waiawa Development include *Waipio Heights II, Waipio Heights III, Waipahu III, Mililani I, Mililani II, Mililani III, Mililani IV, and Pearl City III.*

A Navy water well, the *Waiawa Shaft*, is located approximately two miles south of Castle & Cooke Waiawa. This potable water source provides the majority of the water demand for the Navy's Pearl Harbor Complex.

6.2. PROJECTED POTABLE WATER DEMAND

The projected average daily water demand for the Castle & Cooke Waiawa Development is estimated at 0.704 million gallons per day. The water demands were developed based on the Water System Standards of the City



Legend

- Castle & Cooke Waiawa Dev
- Gentry Waiawa
- Aquifer Boundary
- Existing Major Well
- Deep Monitor Well

SOURCE: GROUNDWATER RESOURCES AND SUPPLY FOR CASTLE & COOKE WAIAWA DEVELOPMENT, DATED JULY 2007

POTABLE WATER INFRASTRUCTURE REPORT
CASTLE & COOKE WAIAWA DEVELOPMENT

WELL LOCATIONS

FIGURE 6-1

and County of Honolulu Board of Water Supply. Estimated projected water demands are shown in Table 6-1.

6.3. PROPOSED POTABLE WATER IMPROVEMENTS

The Waiawa Castle and Cooke Development is situated in the Honolulu Board of Water Supply's 785 water service zone. The potable water system improvements will be coordinated with those of the Waiawa Ridge Development.

Water improvements for the Waiawa Ridge Development 785 water service zone are identified in the *Master Plan, Water System Study, Waiawa By Gentry*, Akinaka and Associates, November 2004. The improvements to service the Waiawa Ridge Development 785 water service zone include:

1. Storage Facility: 1.5 million gallon reservoir
2. Water Source: 3-1,250 gpm pumping units (wells)
3. Transmission Main: A 24- and 20-inch water line will convey water from the well/reservoir complex to consumers for both Waiawa Ridge Development and Castle & Cooke Waiawa Development

Regarding the proposed potable water infrastructure to service the Castle & Cooke Waiawa Development, the following potable water infrastructure includes (See Figure 6-2):

a. Storage Facility: The projected water demand would require 1.0 million gallons of storage. Depending on the scheduling of the Waiawa Ridge and Castle & Cooke Waiawa Developments, either a single 3.0 mg storage tank would be constructed or one 1.5 mg storage tank and one 1.0 mg storage tank.

b. Wells: One 1,250 gpm pumping (well) unit will be required for the Castle & Cooke Waiawa Development. This will result in a total of four pumping (well) units at the 785 well/reservoir site.

   i. Castle & Cooke Waiawa
   ii. Waiawa Ridge Development (Phase 1 & 2)
   iii. Standby

c. Transmission Main: The transmission main will be shared by both developments to convey water to both projects.

Table 6-1
Castle & Cooke Waiawa - Water Demand Computations

DOMESTIC WATER DEMANDS					
No. of Units	No. of Acres	Type	Average Daily Demand (*Water Standards 2002 - Oahu pg 111-3) (gal/unit)	(gal/acre)	Average Daily Demand (gallons)
222	31.64	Single Family	500		111,000
1278	77.13	Multi-Family	400		511,200
---	10.23	Park and Open Spaces		4,000	40,920
1	3.02	Commercial/ Neighborhood Business		3,000	9,060
1	8	School		4,000	32,000
1502	130.02			Total Average (gpd)	704,180
				(gpm)	489
				Max Daily (1.5 X Average Day) gpd	1,056,270
				(gpm)	734
				Peak (3.0 X Average Day) gpd	2,112,540
				(gpm)	1,467

*Board of Water Supply; City and County of Honolulu; Water System Standards 2002

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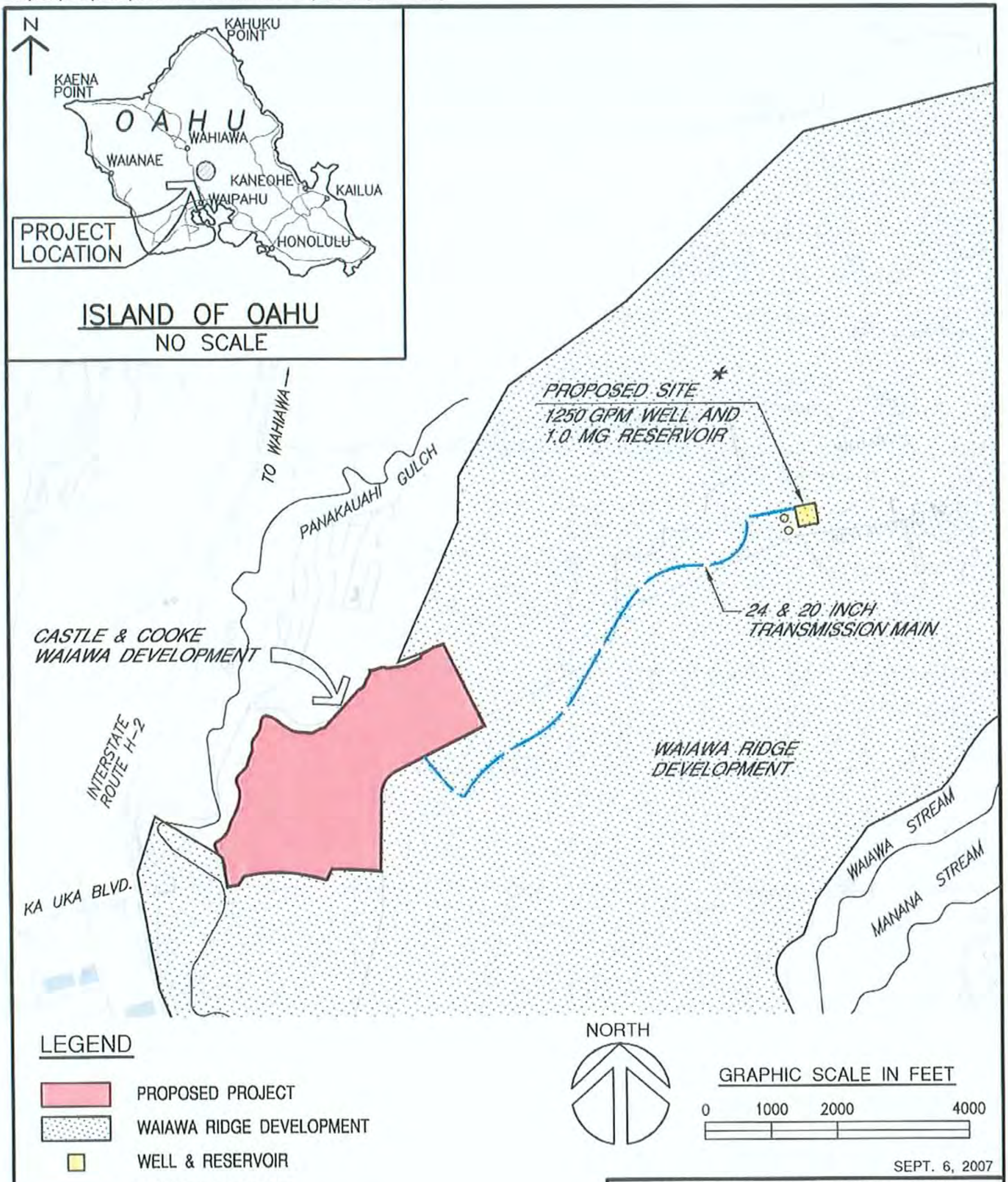

SEPT. 6, 2007

POTABLE WATER INFRASTRUCTURE REPORT
CASTLE & COOKE WAIAWA DEVELOPMENT

PROPOSED POTABLE WATER INFRASTRUCTURES

FIGURE 6-2

d. Distribution Mains: The distribution mains will be installed in the roadways of the project (See Figure 6-3) to distribute potable water to the various parcels.

6.4. PROBABLE IMPACTS ON GROUNDWATER RESOURCES

The following is a summary from the report by Water Resources Association, *Groundwater Resources and Supply for Castle and Cooke Waiawa Development,* July 2007, addressing the availability of the water source and probable impacts to the groundwater resources.

From a regulatory standpoint, groundwater resources are available to support the needs of the Castle & Cooke Waiawa Development. The sustainable yield for the Waipahu-Waiawa Aquifier is 104 mgd as established by the State Commission on Water Resource Management (CWRM). Currently, CWRM has issued permits for a total use of 84.856 mgd in the Waipahu-Waiawa Aquifier, leaving a balance of 19.144 mgd of unallocated water use. The Castle & Cooke Waiawa Development has an estimated potable water demand of 0.882* mgd which can be met with the 19.144 mgd of unallocated water.

Regarding impacts on the water resources a review of the results from the deep monitoring wells is presented. The records of monitor wells, *Waipio Mauka*, and *Waipahu 241* located approximately 1.7, and 4.3 miles down gradient of the Castle & Cooke Waiawa Development were reviewed. Records since January 1987 show that the top of the transition zone in the *Waipio Mauka* and *Waipahu 241* monitoring wells has been nearly stable over the past 15 to 20 years. Further, the midpoint of the transmission zone at the Waipio Mauka monitoring well rose about 80 feet from 1987 to early 2001.

*Report by Water Resources Association was prepared prior to final land master plan which currently calls for an estimated potable water demand of 0.704 mgd.

6.5. REFERENCES

1. Akinaka and Associates, Tom Nance Water Resources Engineering; Revision to Master Plan, Water System Study, Waiawa by Gentry; November 2004.

2. Water Resource Associates; Groundwater Resources and Supply for the Castle and Cooke Waiawa Development, Central Oahu, Hawaii; July 2007.

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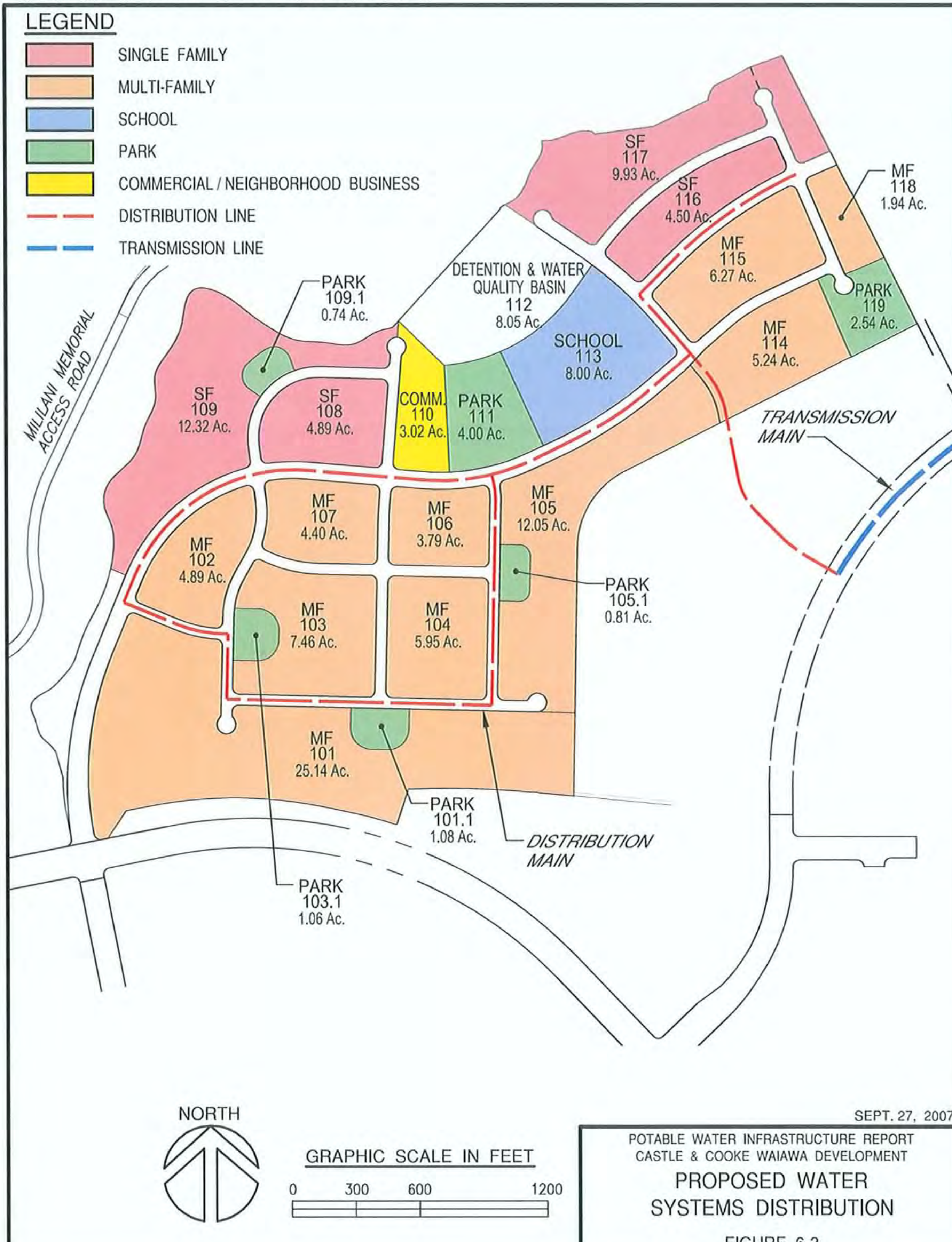
N:\CAD\DWG\2005\0518-WAIAWA RIDGE WTR MP\FIGURES\FIG 6-3.dwg



SEPT. 27, 2007

POTABLE WATER INFRASTRUCTURE REPORT
CASTLE & COOKE WAIAWA DEVELOPMENT

PROPOSED WATER SYSTEMS DISTRIBUTION

FIGURE 6-3

3. Board of Water Supply; City and County of Honolulu; Water System Standards; 2002.

7 ELECTRICAL SYSTEM

7.1. SUMMARY

Electrical and communications improvements necessary to support the requirements of the Castle & Cooke Waiawa Master Plan, dated 23 August 2007, can be served from the existing utility systems, with some offsite work required. In general, the offsite improvements necessary to serve this development are ongoing activities for the respective utility companies and should not create an undue hardship for them. Furthermore, this development will require that the electrical and communications utility systems be constructed and maintained according to approved utility standards.

Hawaiian Electric Company ("HECO") anticipates extending 46 kilo-volt (kV) lines to a substation site in the proposed Waiawa Ridge Development and providing a substation to serve both that development and this project. In addition Hawaiian Telcom ("HTCO") and Oceanic Time Warner Cable ("OCEANIC") must extend their facilities from Ka Uka Boulevard and Kamehameha Highway, respectively, to the proposed Waiawa Ridge Development, and service for this project is anticipated to come from the Waiawa Ridge Development.

Onsite facilities for the utility systems will have minimal impact on the environment. Noise, aesthetic considerations, safety hazards, and loading impact will be within normally applied guidelines.

7.2. EXISTING CONDITIONS

Electric power is generated by Hawaiian Electric Company ("HECO") and is transmitted across O'ahu via overhead and underground lines that are energized at 138 kilo-volts, and distributed from substations via overhead and underground cables, presently energized at 12.47 kilo-volts, that are owned and maintained by HECO. HECO's current available generation capacity is approximately 1,669 megawatts (MW). The present peak coincident demand for electricity on O'ahu is approximately 1,327 MW.

Hawaiian Telcom ("HTCO") is the local area telephone provider, and presently serves this area from their "Waipio" Remote Office. In addition, HTCO has installed a "pair-gain" (switching equipment) unit within an easement along Ka Uka Boulevard, adjacent to where it intersects the old Memorial Park access road. Trunking cables are routed from the Remote Office, which is located along Kamehameha Highway, to the "pair-gain" unit and from that "pair-gain" unit, HTCO has installed underground facilities along Ka Uka Boulevard, and underground distribution cables are extended to serve the Gentry Business Park, and portions of Waipio By Gentry.

Oceanic Time Warner Cable ("OCEANIC") is the local area CATV provider, and has an agreement with HTCO for use of the joint utility poles along Kamehameha Highway, on which it has attached aerial cables to support their facilities in this area.

The project site is essentially without utilities except for a joint pole line consisting of an existing HECO 11.5 kV overhead line ("Waipio #1" circuit) and a HTCO cable that traverse the northern end of the project site, and a private street lighting system owned by Mililani Memorial Park, along the access road to the Memorial Park. In addition, buried joint trunking cables owned by the Federal Government pass the project north of Mililani Memorial Park and are currently inactive according to HTCO, who had been using and maintaining those cables to provide telephone service to the Waiawa Correctional Center, Teen Challenge and to several farmers.

Existing offsite facilities include 46 kV and 11.5 kV ("Waipio #1" circuit) HECO overhead lines and structures, and HTCO overhead cables along Panakauahi Gulch, adjacent to the "H-2" freeway, and the forest reserve.

Furthermore, although no physical improvements have been constructed in the adjacent Waiawa Ridge Development at this time, it is assumed that the HECO, HTCO and OCEANIC facilities that are proposed to be provided in the initial phase(s) of that development, and that are necessary to service this project, will be operational prior to any onsite utility services being required. Included in these improvements will be HTCO switching equipment and a HECO substation.

7.3. FUTURE DEVELOPMENT PLANS

HECO plans to relocate the two 46 kV pole lines that span the Waipio Interchange onto a single pole line that will follow the Ka Uka Boulevard alignment until the Moaniani Street intersection. Beyond that intersection, one feeder will be spliced to the existing overhead line that continues along the northern side of Ka Uka Boulevard to their "Waipio" Substation, and the second feeder will be connected to existing underground cables that were installed to that substation.

In the future, HECO plans to extend a third 46 kV line from Wahiawa to their "Waipio" Substation. The corridor for this line has not yet been determined.

7.4. PROPOSED DEVELOPMENT

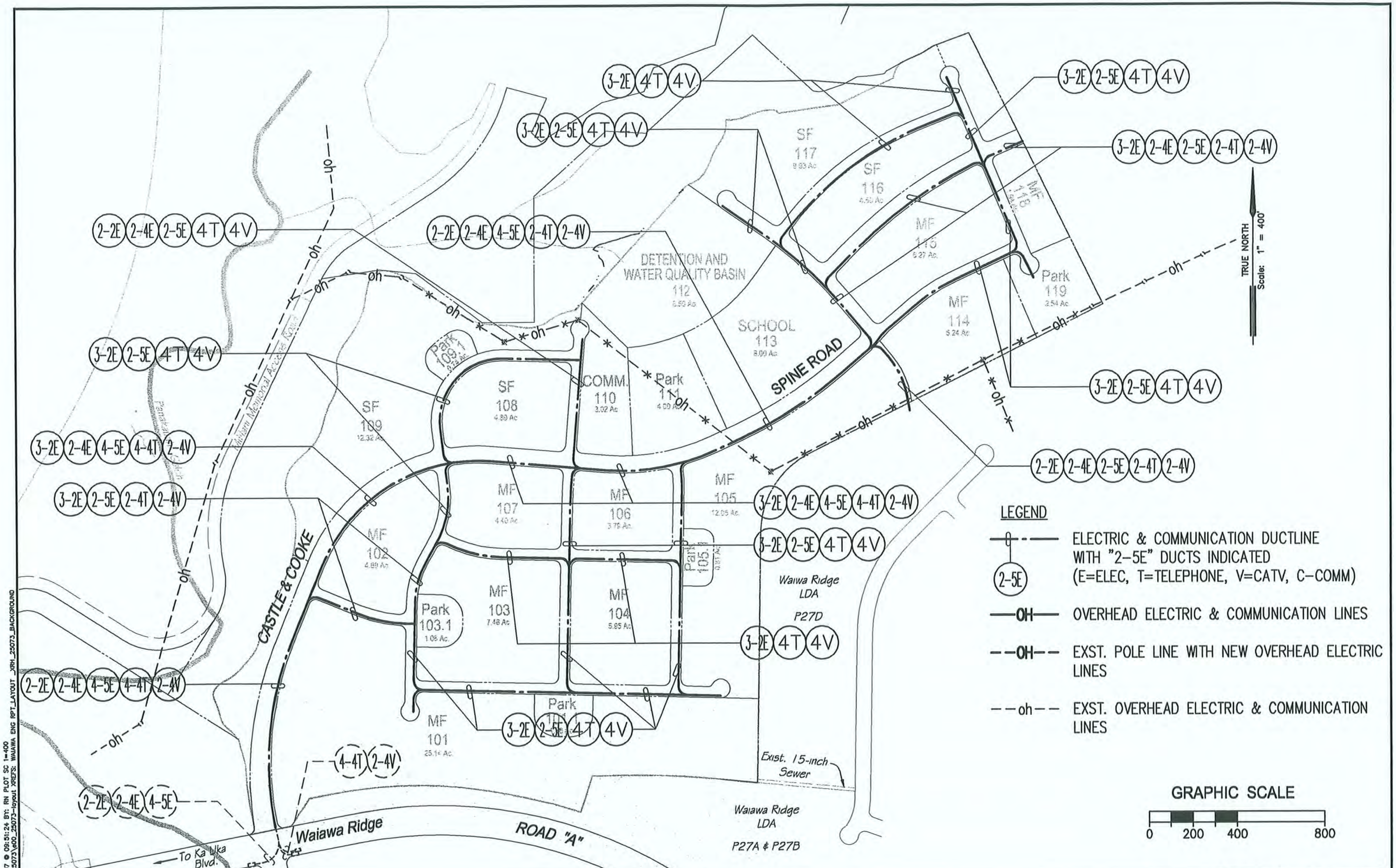
7.4.1. ELECTRICAL SYSTEM

Existing offsite HECO 46 kV and 11.5 kV overhead lines along Panakauahi Gulch and the forest reserve may remain. However, the segment of the existing HECO 11.5 kV ("Waipio #1" circuit) overhead line that traverse the northern end of the project will be relocated underground along the roadways within the development; those portions of the pole line beyond the development will remain overhead.

The "Proposed Electrical Systems" is shown in Figure 7-1. The projected peak demand for this project is forecasted to be approximately 7.8 MW. Based on the forecasted loading, HECO does not require that a new substation be constructed to serve this project. Instead, HECO intends to serve this project from their proposed "Waiawa Ridge Makai" Substation, which is scheduled to be constructed to coincide with the initial phase(s) of the Waiawa Ridge Development.

The proposed "Waiawa Ridge Makai" Substation will step-down the incoming 46 kV sub-transmission voltage to 12.47 kV, as required by HECO for distribution throughout the development. The distribution feeders from the substation will be extended to the project and connected to service transformers located adjacent to project facilities via switching vaults provided along the distribution feeder routes. The switching vaults will protect the distribution feeders, and allows for isolation of damaged cables and redundancy to protect the development against prolonged outages resulting from the failure of any one section of the underground electrical system. The service transformers will step-down the 12.47 kV distribution voltage to the utilization voltage required by the project facilities.

The electrical system will be an underground facility with the exception of the substation, the overhead transmission lines and structures, switching vaults and service transformers. Cables and ducts will be suitable for underground applications and therefore, are tolerant of both wet and dry conditions. Providing a network of underground ducts and handholes would facilitate the cable installation, and HECO would cable the underground duct system, if it is constructed in compliance with their standards. Thus, plans should be submitted to HECO during the design development of the project to verify their requirements.



CASTLE & COOKE WAIAWA

PROPOSED ELECTRICAL SYSTEMS

FIGURE 7-1

7.4.2. COMMUNICATIONS

The existing offsite HTCO overhead lines along Panakauahi Gulch may remain. However, the segment of HTCO overhead lines that traverse the northern end of the project will be relocated underground across the development along its roadways; those portions of the existing pole line beyond the development will remain overhead.

HTCO facilities must be extended into the project from the proposed switching equipment that HTCO will provide in the Waiawa Ridge Development.

Also, OCEANIC facilities do not exist on the site and must be extended from the OCEANIC trunking facilities that will be provided from Kamehameha Highway to the proposed Waiawa Ridge Development. The "Proposed Electrical Systems" is shown in Figure 7-1.
HTCO cross-connect pedestals and OCEANIC power supply pedestals will be provided by HTCO and OCEANIC, respectively, at various locations throughout each of the development parcels to facilitate furnishing and maintaining telephone and cable television services to the project facilities. The communications systems will be underground facilities with the only exceptions being the switching equipment enclosures, and the cross-connect and power supply pedestals. Cables and ducts will be suitable for underground applications and therefore, are tolerant of both wet and dry conditions. Providing a network of underground ducts and handholes will facilitate the cable installation, and if it is constructed in compliance with their standards, HTCO and OCEANIC would provide the respective cross-connect and power supply cabinets, cable the underground duct system, and make the necessary arrangements for serving each facility's communication requirements. Therefore, during the design development of the subdivision, plans should be submitted to HTCO and OCEANIC to verify their requirements.

7.4.3. STREET LIGHTING

A street lighting system complying with the recommendations of the Illuminating Engineering Society of North America and the Standards of the City and County of Honolulu should be provided for the project roadways.

7.4.4. TRAFFIC SIGNALS

A traffic study should be conducted prior to design development to determine the improvements required along Ka Uka Boulevard and on whether traffic signal systems at project roadway intersections are warranted.

7.5. POTENTIAL IMPACTS AND MITIGATION MEASURES

Essentially all of the facilities provided by Hawaiian Electric Company, Hawaiian Telcom and Oceanic Time Warner Cable to serve this development will be placed underground and therefore, should have minimal negative impact on the surrounding communities. The electric and communication distribution systems will be constructed and maintained according to approved utility standards and construction methods, and will be planned to coincide with the project development. Furthermore, the improvements necessary to accommodate this project are ongoing activities for the respective utility companies and the utility companies are mandated by their respective tariff rules and licenses to exercise reasonable diligence and care in maintaining their lines and structures to be able to provide continuous service to their customers.

7.6. ELECTRICAL LOAD FORECASTS

Forecast of the anticipated maximum electrical demands for the proposed project is included in Table 7-1.

The electric loads for this development have been forecasted based on empirical units used by the local utilities for similar facilities multiplied by the facilities' area or the number of units as shown in the Castle & Cooke Waiawa Master Plan dated 23 August 2007.

These demand units, used by the local utility company to forecast the electrical loads for proposed facilities, are derived from their records of the electrical consumptions for other similar facilities.

TABLE 7-1
CASTLE & COOKE WAIAWA
FORECASTED ELECTRIC LOAD (PEAK)

Description	Quantity	Unit	KW/Unit	Forecasted Load (KW)
PRELIMINARY DEVELOPMENT PLAN				
Park Site	1	EA	150.0	150.0
Single Family Res.	222	EA	4.0	888.0
Multi-Family Res.	1,278	EA	3.5	4,473.0
Recreation Center	1	EA	500.0	500.0
Neighborhood Commercial	3.02	AC	209.1	631.5
Elementary School		EA	650.0	650.0
Roadway Ltg.	16,600	LF	0.0013	21.6
Sewer Lift Station	1	EA	40.0	40.0
Water Pump Station	1	EA	400.0	400.0
Forecasted Electric Loads (Peak)				7,754.1

Notes:

1. Load forecasts are based on he Preliminary Waiawa Master Plan prepared by Castle & Cooke Homes Hawaii, Inc., dated 23 August 2007.
2. Electrical requirements for various off-site improvements to the water and sewer systems, if required, are not available and therefore, they are not included.
3. Electrical requirements for off-site roadway improvements, if required, are not available and therefore, they are not included.

C | Botanical Survey

BOTANICAL SURVEY OF THE KOA RIDGE MAKAI AND WAIAWA PROPOSED CONSTRUCTION AREAS, O‘AHU, HAWAI‘I

by

Art Whistler, Ph. D.
Isle Botanica
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Prepared for

Helber Hastert, and Fee
Planners
Honolulu, Hawai‘i

November 2008

INTRODUCTION

The study area comprises several proposed construction sites, staging areas, detention basins, and connecting roads in and around the proposed Koa Ridge Makai development just south of Mililani, Oʻahu, Hawaiʻi (Fig. 1). Going from south to north, the first site, called "DL 1," is in a former military facility located west of and contiguous with Kamehameha Highway. It comprises a dry riverbed, a paved road, and disturbed forest and scrub on the flat bottomland and extending up both sides of a narrow valley in the lower Kipapa Gulch. Bunkers built into the hill attest to its former use for ammunition storage. The second site, called "DB 4," is a proposed detention basin located in and around the Army's Kipapa Ammunition Storage Site. It comprises an area at the bottom of the gulch, a contiguous staging area along Kipapa Stream, the slope extending up to the Koa Ridge plateau, a road (most of it paved) leading from gulch up to the Koa Ridge plateau, and another staging area along the road. The third site, called "KR," is located just east of the H-2 Freeway along the north and south sides of an unpaved road that leads from the Koa Ridge plateau under the H-2 and eastward to a ranch. It comprises open fields used for grazing cattle, a wooded, S-shaped canyon, part of which is apparently used as a corral, and a narrow strip of land extending southward along the eastern side of the H-2. The fourth site, called "DB 1," is a proposed detention basin lying just west of the H-2 (and partially under it). It comprises a broad flat area (currently under cultivation), the contiguous slopes, and an access road leading to it from Maunaunalau Road. The fifth site, called "DB 3," is a proposed detention basin and associated features upstream and downstream from an overgrown unpaved access road northeast of DB 1. The sixth site, called "DB 2," is a proposed detention basin downslope from Mililani Mauka, along with connecting roads (one of which leads a considerable distance up the broad stream valley) and two proposed construction staging areas. The study site also includes a proposed sewer line route that extends southward from the site along paved city streets, ending up at the Waipahu Wastewater Pumping Station (Fig. 2). Additional information is contained in Hosaka (1937) on what the area was like 70 years ago.

The objectives of the current field study were to provide a general description of the vegetation types present at the six sites (particularly any sensitive types of vegetation that may harbor rare plant species), to make a checklist of all native and naturalized vascular plants found, and to search for threatened and endangered plant species.

METHODOLOGY

Before the fieldwork was carried out, a review of the literature was undertaken by the principal investigator. The main sources of information were a botanical survey done at the site in 1996 (Funk 1996) and two more recent ones carried out for the proposed development at Koa Ridge and Waiawa (Whistler 2007A, 2007B). The current status of any endangered species previously reported from the surrounding area was checked using the official database of threatened and endangered plant species (USFWS 2005). This list is identical to the State of Hawaiʻi list of threatened and endangered species. In addition, information about threatened and endangered plant species found in the area was extracted from the Hawaiʻi Natural Heritage Program database (Anon. 2005) of federally listed plant species (Fig. 3).

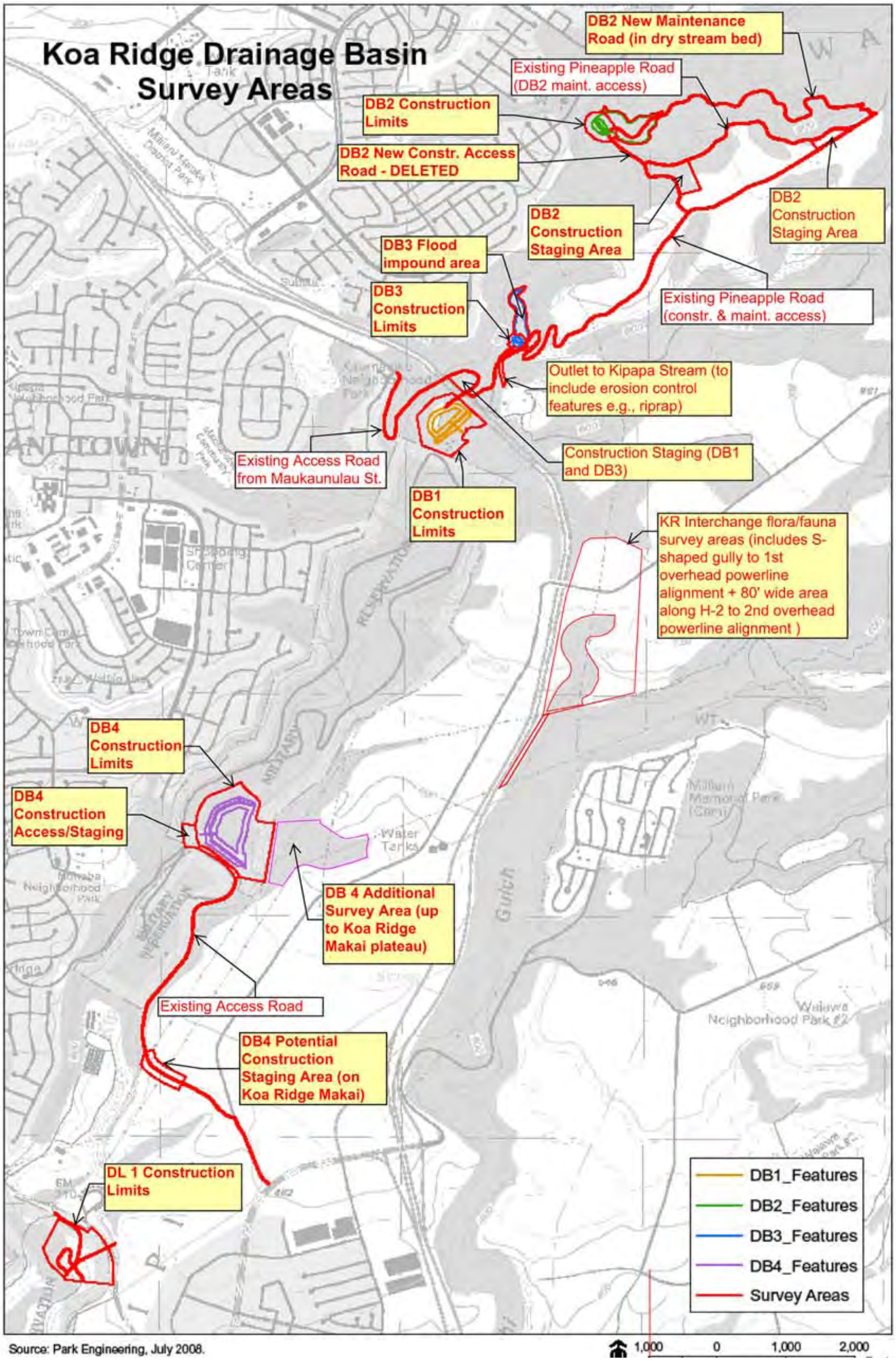

Fig. 1. Map of the Koa Ridge Makai area and the study sites.

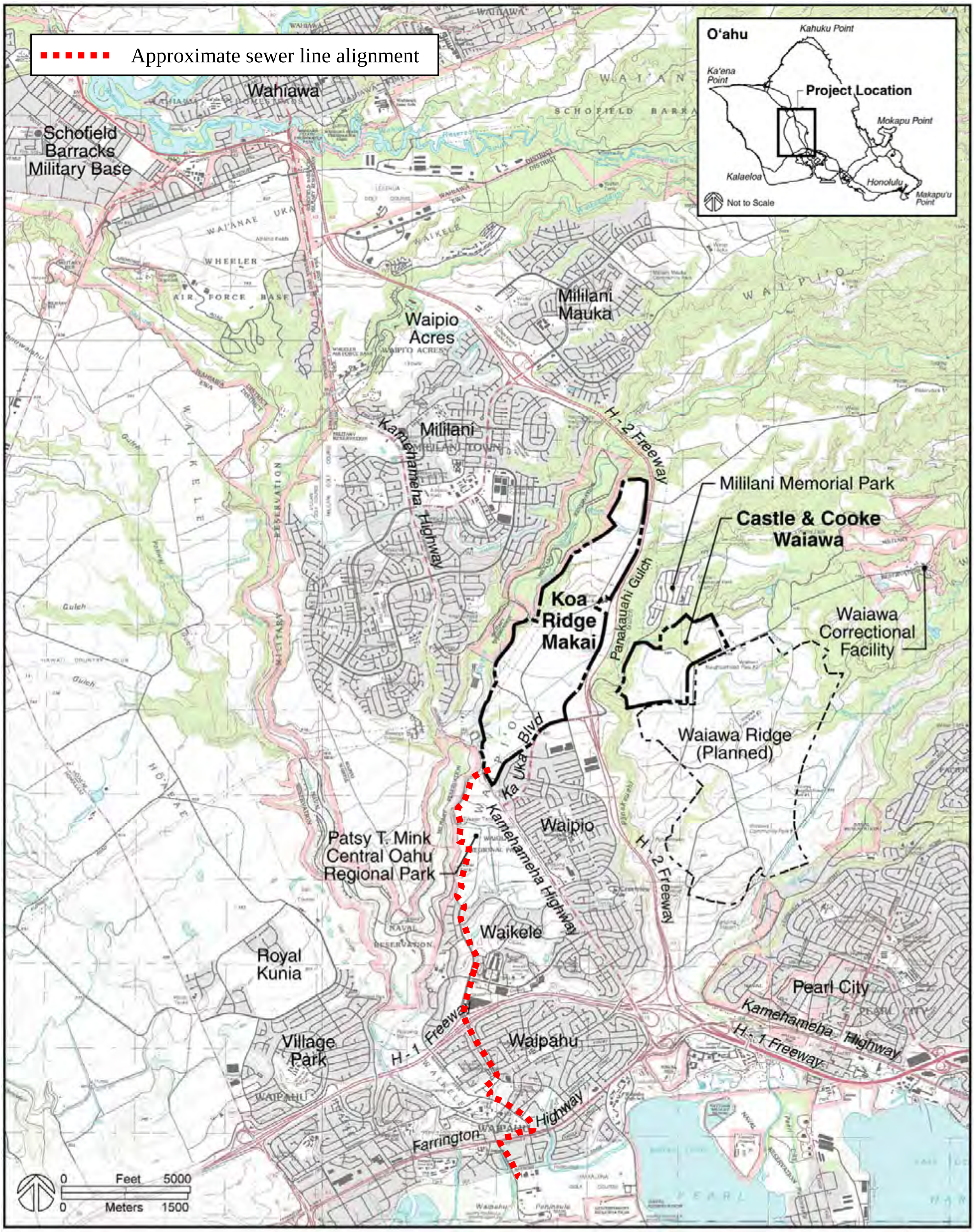

Fig. 2. Proposed sewer line route from Koa Ridge to Waipahu Wastewater Pumping Station.

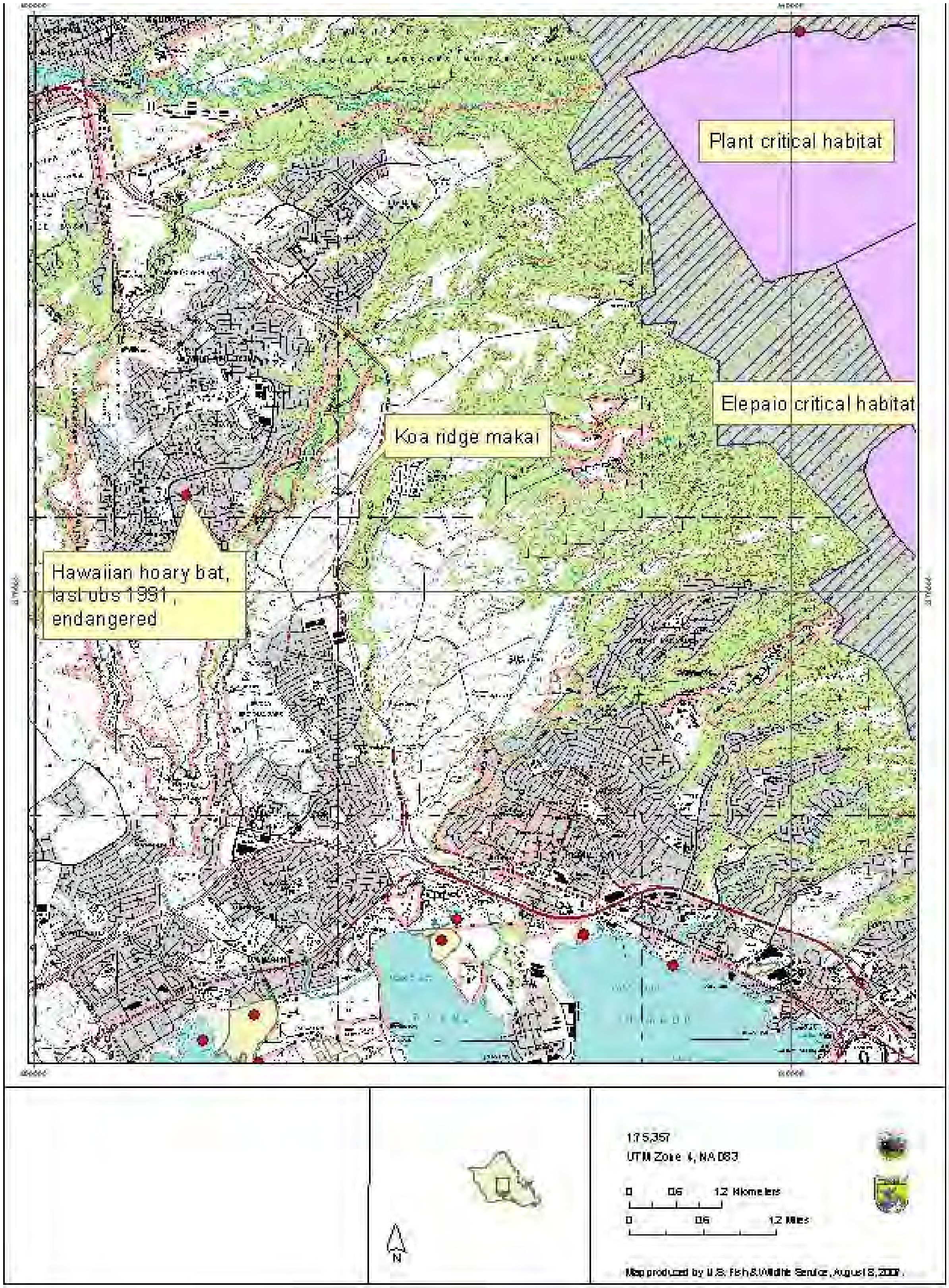

Fig. 3. Hawai‘i Natural Heritage Program database map
of federally listed plant species at the study area.

After the literature review, a botanical field survey was conducted at the study sites by a two-person botanical team consisting of the principal investigator and a field assistant over four days from 25 July to 7 September 2008. A "walk-through survey" was employed, and all plant species encountered were recorded, along with an indication of their frequency. Particular care was taken in areas where native species are most likely to be found (e.g., in gullies), but the whole area has been heavily disturbed for many decades, and in fact, no undisturbed vegetation was found at any of the sites. All species encountered were incorporated into a checklist for each type of vegetation and each area. All plants recorded were then put into a comprehensive checklist for the study site (see Table 2 in the Appendix). Notes were also taken on vegetation types present, indicating the dominance and frequency of the plant species comprising them. These notes were written up into the vegetation description below.

All species except one were identified during the fieldwork. The one that defied identification appears to be an escaped ornamental in the genus *Crassula* that has not previously been reported as naturalized. The survey was conducted during the dry part of the year, a year marked by a serious drought. If done later in the year during the rainy season or in a wetter year, it is likely that a few additional species, mostly herbaceous alien weeds, would have been recorded. However, few if any additional species that might be found would be native, and it is highly unlikely that any threatened or endangered species would be encountered, since none have previously been reported from the area. Consequently there is no need for any further field work in the wet season.

THE VEGETATION

Four basic types of vegetation can be recognized on the study sites: (1) Managed Land Vegetation; (2) Guinea Grass Grassland; (3) Alien-Dominated Forests; and (4) Riparian Vegetation. These are often indistinct from each other, since in reality they often blend together, but the categories are useful for descriptive purposes. The latter category can be divided into several types, based upon which species dominate the canopy and forest floor. All these vegetation types and their subtypes are classified as "disturbed vegetation," and native species are nearly absent. The four types and their subtypes are described below.

(1) Managed Land Vegetation

This comprises the vegetation on areas that are under periodic or frequent management, such as roadsides and roadways, pastures, and cultivated areas. Active pastureland is found at Site KR, where Guinea grass (*Panicum maximum*) dominates the periodically grazed fields (Fig. 4). The few scattered trees present here are all alien species. Roadside vegetation comprises mostly weedy alien herbaceous species that grow on abandoned unpaved roads and old, cracking pavement (Fig. 5). These species are able to survive in open sunny areas where, because of the pavement or vehicular damage, trees, shrubs, and Guinea grass are cut back or killed. Common roadway species include sensitive plant (*Mimosa pudica*), coat buttons (*Tridax procumbens*), prickly sida (*Sida spinosa*), *Sida ciliaris* (no common name), *Boerhavia coccinea* (no common name), Natal redtop (*Rhynchelytrum repens*), love grass (*Eragrostis tenella*), and goose grass (*Eleusine indica*). On roadsides and roadways that are not managed, Guinea grass typically takes over, crowding out most other herbaceous and woody species (Fig. 6). Tree saplings sometimes manage to grow though this dense cover, and eventually, if not further disturbed, may form a type of woodland described below in the third section.

The center of Site DB 1 is currently being cultivated (Fig. 7), mostly with papaya (*Carica papaya*) and a species of orange (*Citrus* sp.). Very few native species, especially endemic ones, are found on managed land. The few exceptions are the common ‘uhaloa (*Waltheria indica*), popolo (*Solanum americanum*), and kowali (*Ipomoea indica*), all of them indigenous rather than endemic (see the section on Flora).

The northern portion the proposed sewer line route runs through a sports complex and southward to Paiwa St., and from there continues several miles along paved city streets to the Waipahu Wastewater Pumping Station. The vegetation along this route is entirely managed land vegetation, most of it comprising lawns and street trees.

(2) Guinea Grass Grassland

This type of vegetation is dominated by Guinea grass (*Panicum maximum*). Most of it comprises land that were once under cultivation (pineapple). It also occurs on roadsides that are not managed. The guinea grass forms a nearly pure association, probably with over 98% of the biomass, since few other species are able to grow in the dense clumps of grass that may be up to 6 ft or more in height.

Pure stands of Guinea grass without trees are uncommon at the site, but when there are a few trees present, the vegetation is somewhat intermediate between an open forest (see below) and Guinea Grass Grassland (Fig. 8). The most common trees found here are koa haole (*Leucaena leucocephala*) and albizzia (*Paraserianthes falcataria*), and, to a lesser extent, Formosan koa (*Acacia confusa*). No native species were recorded in this type of vegetation, and the overall number of alien species is small, due to the pervasive nature of Guinea grass.

(3) Alien-Dominated Forest

This is the open forest dominated by alien tree species. It occurs mostly on the slopes and bottoms of gullies, but also on the Koa Ridge plateau and on the flat areas above some of the gullies. The forests at the study site might be classified together as the same “plant community,” since they have the same general form (woodlands or forests) and are dominated by alien trees. A woodland is an open forest with scattered trees in a grassland, whereas a forest has trees that are closer together and often form a closed canopy. At the study sites, this vegetation is heterogeneous, and at least six subtypes can be distinguished. If these were dominated by native species, they might be considered separate “associations” all belonging to the same large category—lowland forest community. They differ from each other, however, in species composition and probably in origin, and are treated here as types of Alien-Dominated Forest. It is, however, sometimes impossible to recognize boundaries since they often blend into each other.

One subtype is a forest dominated by albizzia (*Paraserianthes falcataria*), under which a dense matrix of Guinea grass (*Panicum maximum*) dominates the ground. Because of this, the line between Guinea Grass Grassland and this forest are not distinct. A good example of this subtype occurs on the slopes leading down from Mililani Mauka to the proposed detention basin at Site DB 2. This woodland is entirely dominated by a high canopy of albizzia, with few other trees present (Fig. 9). The forest floor is covered with guinea grass, which is so dense that few other species can survive there.

A second subtype of forest occurs in grasslands where albizzia is less common, and other species such as koa haole (*Leucaena leucocephala*), Christmas berry (*Schinus terebinthifolius*), African tulip tree (*Spathodea campanulata*), or silk oak (*Grevillea robusta*) may be common. The forest in Kipapa gulch (Fig. 10), near the stream, fits into this category. The overall dominant tree species in this somewhat open forest are African tulip tree, Chinese banyan (*Ficus microcarpa*), satin leaf (*Chrysophyllum oliviformis*), and koa haole. Beneath it is a dense cover of guinea grass, except in more shaded places, where rouge plant (*Rivina humilis*) can dominate.

A third subtype of forest is largely dominated by koa haole, as found on the slopes of Site DL 1. In this area, the ground cover is mostly scattered Guinea grass, probably inhibited by the dry soil of the slope (Fig. 11). Nearby at the same site, in the much wetter area by the stream, the ground cover can be dense (Fig. 12) and dominated by other herbaceous species, such as rouge plant, *Glycine wightii* (no common name), and the escaped ornamental white shrimp-plant (*Justicia betonica*). Such variation in ground cover under a nearly identical canopy makes it difficult to classify vegetation, especially when several different sites in somewhat different environmental conditions are studied together. Also complicating the picture in the study area is that koa haole forest is sometimes under a light canopy of albizzia.

A fourth subtype of Alien-dominated Forest if found along streams, particularly at Site DL 1 (Fig. 13). The dominant species here are Java plum (*Syzygium cumini*), koa haole, *Macaranga tanarius* (no common name), and monkeypod (*Samanea saman*), along with several other less common alien tree species. Java plum is characteristic of moist soil areas and often dominates stream sides in the lowlands of Hawaiʻi. The ground cover in the DL 1 forest is dominated by white shrimp plant, rouge plant, and basket grass (*Oplismenus hirtellus*). No native species were recorded in this type of forest.

A fifth subtype of forest is found in the moister portions of the site, especially in the canyon just south of Mililani Mauka. This forest, which covers the slopes and bottom of this wide canyon, particularly mauka (upstream) of the proposed detention basin of Site DB 2, is dominated by two alien tree species, Christmas berry and strawberry guava (*Psidium cattleianum*). These two species, particularly the latter one, form a dense, low forest (Fig. 13) that produces a dense shade on the forest floor. This shady habitat is unsuitable for Guinea grass, which is replaced by a light to moderate cover of herbaceous species, particularly the native fern blechnum (*Blechnum occidentale*), and alien species oak fern (*Christella parasitica*) and basket grass (*Oplismenus hirtellus*). The most common shrubs here include Koster's curse (*Clidemia hirta*), Hilo holly (*Ardisia crenata*), and shoebutton ardisia (*Ardisia elliptica*). Only a few native species are found in this type of forest. It sometimes thins out on the slopes, where patches of fernland dominated by ʻuluhe (*Dicranopteris linearis*) may take over.

A sixth subtype of forest differs from the others in that it is entirely dominated by species that have been planted. These plantation forests are found near Kipapa Gulch, the S-shaped canyon at Site KR, and on the flat area on the south side of the large canyon south of Mililani Mauka. These are often in monoculture, i.e., comprise a single species, but sometimes several species are planted together. The most common trees used for this purpose at the sites are swamp mahogany (*Eucalyptus robusta*), lemon-leafed gum (*Eucalyptus citriodora*), and ironwood (*Casuarina equisetifolia*). Forests of ironwood (Fig. 15) usually lack understory shrubs and herbs because of the dense layer of its needle-like leaves (actually, stems) that accumulate on the ground. Other forests may or may not have a diverse assemblage of shrubs and herbs on the forest floor.

Table 1. Native Vascular Plants Recorded at the Study Site

Species	Family	Common Name
	Endemic	
Acacia koa	Fabaceae	koa
Metrosideros polymorpha	Myrtaceae	‘ohi‘a lehua
	Indigenous	
Blechnum occidentale	Blechnaceae	blechnum
Cassytha filiformis	Cassythaceae	kauna‘oa pehu
Dicranopteris linearis	Gleicheniaceae	uluhe
Dodonaea viscosa	Sapindaceae	‘a‘ali‘i
Hibiscus tiliaceus	Malvaceae	beach hibiscus
Ipomoea indica	Convolvulaceae	koali-‘awa
Pleopeltis thunbergiana	Polypodiaceae	pakahakaha
Psilotum nudum	Psilotaceae	moa
Solanum americanum	Solanaceae	black nightshade, popolo
Sphenomeris chinensis	Lindsaeaceae	pala‘a
Waltheria indica	Sterculiaceae	‘uhaloa

(4) Riparian Vegetation

This comprises the forest occurring on the margins of streams and streambeds, as well as the herbaceous vegetation found in the stream channels themselves. No distinct riparian forest is present at any of the study sites, because the trees that line the stream channels are often the same ones that occur on the adjacent slopes, with the exception of Java plum (*Syzygium cumini*), which is most frequently found in wet soils and often dominates stream sides as noted above. Most of the streams at the sites were not running at the time of the survey, but some had pools of standing water (Fig. 16). The vegetation within the stream channels was sparse to dense, depending upon the stream. The plants present are mostly alien herbaceous species, some of them typical of wetlands, but most of them weeds found in many disturbed habitats. The most common species typically associated with wetlands include umbrella sedge (*Cyperus alternifolius*), *Pycreus polystachyos* (no common name), primrose willow (*Ludwigia octovalvis*), tarweed (*Cuphea carthagenensis*), *Ruellia graecizans* (no common name), false daisy (*Eclipta alba*), and seedlings of Java plum. Species present that are less commonly associated with wetlands include ageratum (*Ageratum conyzoides*), Guinea grass, owi (*Stachytarpheta dichotoma*), white shrimp plant (*Justicia betonica*), and wedelia (*Wedelia trilobata*). In some minor stream channels, particularly in Kipapa Gulch and the forest east of DB 2, California grass (*Brachiaria mutica*) forms dense monodominant grasslands (Fig. 17).

THE FLORA

One hundred seventy-four vascular plant species were recorded at the study site (see Table 2 in the Appendix). Only 13 of the 174 are native, eleven of them indigenous and two endemic (Table 1). Indigenous plants are species native to a region or place, but which are also found elsewhere. Endemic plants are species restricted to a single region or area, i.e., in the case of Hawaiʻi, they are found only in Hawaiʻi. In biodiversity terms, the endemic status is the more important of the two categories, since if a species belonging to it is endangered or threatened in Hawaiʻi, it would likewise be classified globally. Indigenous species, however, can be rare in Hawaiʻi, but may be common elsewhere in the Pacific. Over 90% of the native plants in Hawaiʻi are endemic, one of the highest rates in the world. The two endemic species found during the survey are koa (*Acacia koa*) and ʻohiʻa lehua (*Metrosideros polymorpha*), both of which are common in Hawaiʻi.

The majority of the 174 non-native species encountered during the survey are naturalized or weedy "alien" plants that were accidentally or intentionally introduced to Hawaiʻi, but which have now become established in the islands and can spread on their own. These can be divided into Polynesian introductions (plants brought in before the European era in Hawaiʻi), which are represented by an "X" in Table 2 in the Appendix, and modern introductions (plants arriving during the European era), which are represented in the table by a "X". Some of the introduced species, such as mango, are remnants of former cultivation (or are currently cultivated) rather than being naturalized and spreading on their own.

DISCUSSION AND CONCLUSIONS

Four types of vegetation can currently be found at the site: (1) Managed Land Vegetation; (2) Guinea Grass Grassland; (3) Alien-Dominated Forest; and (4) Riparian Vegetation. The Alien-Dominated Forest can be subdivided into six subtypes based on differences in species composition, but these are difficult to delineate since they often blend into each other. All four vegetation types are dominated by alien species, and virtually no undisturbed vegetation is found at the site. With the exception of streambeds, no wetlands or sensitive types of vegetation (or even native types of vegetation) were encountered during the survey.

A total of 174 plant species was recorded during the fieldwork. Only thirteen of these are native, and only two of them are endemic: koa (*Acacia koa*) and ʻohiʻa lehua (*Metrosideros polymorpha*). Both of these endemics are widespread and common in Hawaiʻi. Several other species were found along a steep trail leading from the DB 2 construction staging area and the detention basin, but this area was excluded from the study. Species found here include pukiawe (*Styphelia tameiameiae*), ʻulei (*Osteomeles anthyllidifolia*), and ʻohiʻa lehua, but all these are common species in Hawaiʻi. No federally listed threatened or endangered plant species have been recorded from the area (see Fig. 3), because of the highly disturbed nature of the vegetation present.

Two botanical factors can complicate proposed construction in Hawaiʻi. One is the presence of sensitive types of vegetation, the other is the presence of threatened or endangered plant species. Sensitive vegetation includes wetlands and native forest. No wetlands, which have characteristic flora, soil, and standing water characteristics, are present at the site. However, because of the presence of streams on the site, a permit from the U.S. Army Corps of Engineers will be required. Likewise, no native vegetation is present at the sites. Because these sites do not contain any threatened or endangered plant species, and no native vegetation is present, there is no botanical reason why development of these sites cannot take place as planned.

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APPENDIX

The following is a checklist of the vascular plants inventoried during the field studies on the Koa Ridge Makai study area. The plants are divided into three groups, Ferns (including fern allies), Monocots, and Dicots. Within these groups, the species are presented taxonomically by family, with each family and each species in the family in alphabetical order. The taxonomy and nomenclature of the ferns follow Palmer 2003 and the flowering plants (Monocots and Dicots) follow Wagner *et al*. (1999). In most cases, common English and/or Hawaiian names listed here have been taken from St. John (1973) or Porter (1972).

For each species, the following information is provided:

1. Scientific name with author citation.
2. Common English and/or Hawaiian name, when known.
3. Biogeographic status. The following symbols are used.
   - E = endemic (found only in Hawai‘i).
   - I = indigenous (native to Hawai‘i as well as other geographic areas).
   - P = Polynesian introduction (introduced to Hawai‘i by Polynesians before the advent of the Europeans).
   - X = Introduced or alien (not native, introduced to Hawai‘i, either accidentally or intentionally, after the advent of the Europeans).
4. Relative frequency (abundant, locally abundant, common, locally common, occasional, uncommon, rare).

Table 2. Plant Species Checklist

Species	Common Names	Status	Presence[1]				
FERNS AND FERN ALLIES							
BLECHNACEAE (Blechnum Family)							
Blechnum occidentale L.	blechnum	I	--	--	--	4	5
GLEICHENIACEAE (Gleichenia Family)							
Dicranopteris linearis (Burm.) Underw.	uluhe	I	--	--	--	--	5
HEMIONITIDACEAE (Gold Fern Family)							
Pityrogramma calomelanos (L.) Link	gold fern	X	--	--	--	4	5
LINDSAEACEAE (Lace Fern Family)							
Sphenomeris chinensis (L.) Maxon	pala‘a	I	--	--	--	--	5
NEPHROLEPIDACEAE (Sword Fern Family)							
Nephrolepis multiflora (Roxb.) Jarret ex Morton	hairy swordfern	X	--	--	--	--	5
POLYPODIACEAE (Common Fern Family)							
Phymatosorus grossus (Langsd. & Fisch.) Brownlie	laua‘e	X	--	--	--	4	--
Pleopeltis thunbergiana Kaulf.	pakahakaha	I	--	--	--	4	--
PSILOTACEAE (Psilotum Family)							
Psilotum nudum L.	moa	I	--	--	--	--	5

Species	Common Names	Status	Presence[1]				
THELYPTERIDACEAE (Downy Woodfern Family)							
Christella parasitica (L.) Leville	oak fern	X	--	--	3	4	5
MONOCOTS							
AGAVACEAE (Agave Family)							
Cordyline fruticosa (L.) A. Chev.	ti, ki	P	--	--	--	--	5
Dracaena fragrans (L.) Ker Gawler	fragrant dracaena	X	--	--	--	4	--
Sansevieria fasciata Cornu ex Gérome & Labroy	bowstring hemp	X	--	2	--	--	--
ARECACEAE (Palm Family)							
Archontophoenix alexandrae (F.v. Mueller) Wendl. & Drude	Alexandra palm	X	1	--	--	--	--
BROMELIACEAE							
Ananas comosus (L.) Merr.	pineapple	X	--	--	--	--	5
COMMELINACEAE (Spiderwort Family)							
Commelina diffusa N. L. Burm.	honohono	X	--	2	--	--	5
CYPERACEAE (Sedge Family)							
Cyperus alternifolius L.	umbrella plant	X	1	--	--	--	--
Cyperus gracilis R. Br.	McCoy grass	X	1	--	--	--	--
Fimbristylis dichotoma (L.) Vahl	tall fringe-rush	X	1	--	--	--	--
Pycreus polystachyos (Rottb.) P. Beauv.	----------	X	--	2	--	--	5
LILIACEAE (Lily Family)							
Asparagus setaceus (Kunth) Jessop	asparagus fern	X	--	2	--	--	5
MUSACEAE (Banana Family)							
Musa xparadisiaca L.	banana	P	--	--	--	4	--
POACEAE (Grass Family)							
Andropogon virginicus L.	broomsedge	X	--	--	--	--	5
Brachiaria mutica (Forssk.) Stapf	California grass	X	--	2	--	--	5
Cenchrus ciliaris L.	buffel grass	X	--	--	--	--	5
Cenchrus echinatus L.	sandbur	X	--	--	--	--	5
Chloris barbata (L.) Sw.	swollen fingergrass	X	1	2	--	--	--
Chrysopogon aciculatus (Retz.) Trin.	golden beardgrass	X	--	2	--	--	--
Digitaria insularis (L.) Mez ex Ekman	sour grass	X	--	--	3	--	--
Digitaria violascens Link	violet crabgrass	X	1	--	--	--	--
Eleusine indica (L.) Gaertn.	goose grass	X	--	2	--	--	--
Eragrostis tenella (L.) P. Beauv. ex Roem. & Schult.	love grass	X	1	--	--	--	--
Leptochloa uninervia (K. Presl) Hitchc. & Chase	----------	X	--	2	--	--	--
Melinus minutiflora P. Beauv.	molasses grass	X	--	--	3	--	5
Oplismenus hirtellus (L.) P. Beauv.	basket grass	X	1	2	--	4	5

Species	Common Names	Status	Presence[1]				
POACEAE (cont’d.)							
Panicum maximum Jacq.	Guinea grass	X	1	2	3	4	5
Paspalum conjugatum Bergius	t-grass	X	--	2	--	4	5
Pennisetum purpureum Schumach.	elephant grass	X	1	2	--	--	--
Rhynchelytrum repens (Willd.) C.E. Hubb.	Natal redtop	X	--	--	3	--	--
Sacciolepis indica (L.) Chase	Glenwood grass	X	1	2	--	--	--
DICOTS							
ACANTHACEAE (Acanthus Family)							
Asystasia gangetica (L.) T. Anderson	Chinese violet	X	--	2	--	4	5
Barleria repens C. Nees	pink ruellia	X	--	--	--	4	--
Dicliptera chinensis (L.) Juss.	dicliptera	X	1	--	--	--	--
Justicia betonica L.	white shrimp-plant	X	1	--	3	--	--
Ruellia graecizans Backer	----------	X	--	2	--	4	--
AMARANTHACEAE (Amaranth Family)							
Alternanthera pungens Kunth	khaki weed	X	1	--	--	--	--
Amaranthus viridis L.	slender amaranth	X	1	2	--	--	--
ANACARDIACEAE (Mango Family)							
Mangifera indica L.	mango	X	--	--	--	4	5
Schinus terebinthifolius Raddi	Christmas berry	X	1	2	3	4	5
APIACEAE (Carrot Family)							
Centella asiatica (L.) Urb.	Asiatic pennywort	X	--	--	--	4	--
Ciclospermum leptophyllum (Pers.) Sprague	fir-leafed celery	X	--	--	--	--	5
APOCYNACEAE (Periwinkle Family)							
Cascabela thevetia (L.) Lippold.	be-still tree	X	--	2	--	--	--
ARALIACEAE							
Schefflera actinophylla (Endl.) Harms	octopus tree	X	1	--	--	--	--
ASTERACEAE (Sunflower Family)							
Ageratum conyzoides L.	ageratum	X	1	2	3	4	5
Bidens alba (L.) DC.	beggar’s-tick	X	--	--	--	--	5
Bidens pilosa L.	beggar’s-tick	X	--	2	3	--	--
Calyptocarpus vialis Less.	hierba del cabello	X	--	2	3	--	5
Conyza bonariensis (L.) Cronq.	hairy horseweed	X	--	2	3	--	5
Crassocephalum crepidioides (Benth.) S. Moore	crassocephalum	X	--	2	--	4	--
Dyssodia tenuiloba A.P. de Candolle	Dahlberg daisy	X	--	2	--	--	--
Eclipta alba (L.) Hassk.	false daisy	X	1	--	--	--	--
Emilia fosbergii Nicolson	red pualele, emilia	X	--	--	--	4	5
Erechtites valerianifolia (Wolf) DC.	----------	X	--	2	--	--	--
Pluchea carolinensis (Jacq.) G. Don	pluchea	X	--	2	--	--	5
Synedrella nodiflora (L.) Gaertn.	synedrella	X	--	--	--	--	5
Tridax procumbens L.	coat buttons	X	--	--	3	--	5

Species	Common Names	Status	Presence[1]				
ASTERACEAE (cont'd.)							
Vernonia cinerea (L.) Less.	ironweed	X	1	--	3	--	5
Wedelia trilobata (L.) Hitchc.	wedelia	X	1	2	--	--	5
Youngia japonica (L.) DC.	Oriental hawksbeard	X	--	--	--	4	--
BIGNONIACEAE (Bignonia Family)							
Spathodea campanulata P. Beauv.	African tulip tree	X	1	2	3	4	5
BORAGINACEAE (Heliotrope Family)							
Heliotropium procumbens Mill.	weedy heliotrope	X	--	--	--	--	5
BRASSICACEAE (Mustard Family)							
Lepidium virginicum L.	wild peppergrass	X	--	2	--	--	5
BUDDLEIACEAE (Butterfly-bush Family)							
Buddleia asiatica Lour.	dogtail, heulo‘ilio	X	1	2	3	4	--
CACTACEAE (Cactus Family)							
Hylocereus undatus (Haw.) Britten & Rose	night-blooming cereus	X	--	--	--	4	--
Opuntia ficus-indica (L.) Mill.	prickly pear, panini	X	1	--	--	--	--
CARICACEAE (Papaya Family)							
Carica papaya L.	papaya	X	--	--	--	4	--
CARYOPHYLLACEAE (Carnation Family)							
Drymaria cordata (L.) Willd. ex R. & S.	drymaria	X	--	2	--	4	--
CASSYTHACEAE (Cassytha Family)							
Cassytha filiformis L.	kauna‘oa pehu	I	--	--	--	--	5
CASUARINACEAE (Ironwood Family)							
Casuarina equisetifolia L.	ironwood	X	--	2	3	--	5
CLUSIACEAE (Mangosteen Family)							
Clusia rosea Jacq.	autograph tree	X	1	2	--	--	--
CONVOLVULACEAE (Morning-Glory Family)							
Ipomoea cairica (L.) Sweet	koali	X?	--	2	--	--	--
Ipomoea indica (J. Burm.) Merr.	koali-‘awa	I	1	--	--	--	--
Ipomoea obscura (L.) Ker-Gawl.	bindweed	X	1	2	3	--	5
Merremia tuberosa (L.) Rendle	wood rose	X	1	--	--	--	--
CRASSULACEAE (Stonecrop Family)							
Crassula sp.	------	X	1	--	--	--	--
Kalanchoë pinnata (Lam.) Pers.	air plant	X	--	2	--	--	--
CUCURBITACEAE (Gourd Family)							
Coccinea grandis (L.) Voigt	ivy gourd	X	1	2	--	--	--
Momordica charantia L.	wild bittermelon	X	--	2	--	--	--
EUPHORBIACEAE (Spurge Family)							
Aleurites moluccana (L.) Willd.	candlenut, kukui	P	1	2	--	4	5
Chamaesyce hirta (L.) Millsp.	garden spurge	X	1	2	3	--	5
Chamaesyce hypericifolia (L.) Millsp.	graceful spurge	X	1	2	3	--	5

Chamaesyce hyssopifolia (L.) Small	----------	X	--	2	--	--	--

Species	Common Names	Status	Presence[1]				
EUPHORBIACEAE (cont'd.)							
Chamaesyce prostrata (Aiton) Small	prostrate spurge	X	1	--	--	--	--
Euphorbia heterophylla L.	kaliko	X	--	--	--	--	5
Macaranga tanarius (L.) Muell. Arg.	----------	X	1	2	3	4	--
Phyllanthus debilis Klein ex Willd.	phyllanthus weed	X	1	2	--	4	5
Ricinus communis L.	castor bean	X	1	2	--	--	--
FABACEAE (Pea Family)							
Acacia confusa Merr.	Formosan koa	X	1	2	3	4	5
Acacia koa A. Gray	koa	E	--	--	--	--	5
Canavalia cathartica Thouars	mauna-loa	X	1	2	--	--	--
Chamaecrista nictitans (L.) Moench	partridge pea, lau-ki	X	--	--	--	--	5
Crotalaria incana L.	fuzzy rattlepod	X	--	2	--	--	--
Crotalaria pallida Aiton	smooth rattlepod	X	--	2	--	--	5
Crotalaria retusa L.	rattlebox	X	--	--	--	--	5
Desmanthus pernambucanus (L.) Thellung	virgate mimosa	X	--	2	3	--	--
Desmodium incanum DC.	Spanish clover	X	--	--	--	4	5
Enterolobium cyclocarpum (Jacq.) Griesb.	earpod	X	--	2	--	--	--
Glycine wightii (Wight & Arn.) Verdc.	----------	X	1	2	--	4	--
Indigofera spicata Forssk.	creeping indigo	X	1	2	--	--	--
Leucaena leucocephala (Lam.) de Wit	koa haole	X	1	2	3	4	5
Macroptilium atropurpureum (DC) Urb.	wild bushbean	X	--	--	3	--	5
Medicago polymorpha L.	bur clover	X	--	2	--	--	--
Mimosa pudica L.	sensitive plant	X	--	2	3	--	5
Paraserianthes falcataria (L.) I. Nielsen	albizzia	X	1	2	3	4	5
Pithecellobium dulce (Roxb.) Benth.	'opiuma, Manila tamarind	X	1	2	--	--	--
Samanea saman (Jacq.) Merr.	monkeypod	X	1	2	--	--	--
Senna surattensis (N.L. Burm.) H. Irwin & Barneby	kolomona	X	1	--	--	--	--
LAMIACEAE (Mint Family)							
Hyptis pectinata (L.) Poir.	comb hyptis	X	1	2	--	--	--
LAURACEAE (Laurel Family)							
Persea americana Mill.	avocado	X	--	--	3	4	--
LYTHRACEAE (Loosestrife Family)							
Cuphea carthagenensis (Jacq.) Macbr.	tarweed	X	--	2	--	--	5
Cuphea hyssopifolia Kunth	false heather	X	1	--	--	4	--
MALVACEAE (Mallow Family)							
Hibiscus tiliaceus L.	beach hibiscus, hau	I	--	2	--	--	--
Malvastrum coromandelianum (L.) Garcke	false mallow	X	1	2	--	--	5
Sida ciliaris L.	----------	X	1	--	3	--	--
Sida rhombifolia L.	Cuba jute	X	--	--	--	--	5

Sida spinosa L.	prickly sida	X	1	2	--	--	5

Species	Common Names	Status	Presence[1]				
MELASTOMATACEAE (Melastoma Family)							
Clidemia hirta (L.) D. Don	Koster's curse	X	--	2	3	4	5
MELIACEAE (Mahogany Family)							
Melia azedarach L.	Chinaberry tree	X	1	2	3	--	5
MORACEAE (Mulberry Family)							
Ficus microcarpa L. f.	Chinese banyan	X	1	2	--	4	--
MYRSINACEAE (Myrsine Family)							
Ardisia crenata Sims	Hilo holly	X	--	--	--	4	5
Ardisia elliptica Thunb.	shoebutton ardisia	X	--	2	--	--	5
MYRTACEAE (Myrtle Family)							
Eucalyptus citriodora Hook.	lemon-scented gum	X	--	2	3	--	--
Eucalyptus robusta Sm.	swamp mahogany	X	--	2	3	--	5
Metrosideros polymorpha Gaud.	‘ohi‘a lehua	E	--	--	--	--	5
Psidium cattleianum Sabine	strawberry guava	X	--	--	--	4	5
Psidium guajava L.	guava	X	--	2	3	4	5
Syzygium cumini (L.) Skeels	Java plum	X	1	2	--	4	--
Syzygium jambos (L.) Alston	rose apple	X	--	--	3	4	--
NYCTAGINACEAE (Four-o'-Clock Family)							
Boerhavia coccinea Mill.	----------	X	1	2	3	--	--
Bougainvillea glabra Choisy	bougainvillea	X	1	--	--	--	--
ONAGRACEAE (Evening Primrose Family)							
Ludwigia octovalvis (Jacq.) Raven	primrose willow	X	1	2	--	--	--
OXALIDACEAE (Wood-Sorrel Family)							
Oxalis corniculata L.	wood sorrel	P	1	--	3	--	--
PASSIFLORACEAE (Passionflower Family)							
Passiflora edulis Sims	passionfruit	X	--	2	3	4	--
Passiflora suberosa L.	----------	X	1	2	--	4	5
PHYTOLACCACEAE (Pokeweed Family)							
Rivina humilis L.	rouge plant	X	1	2	--	4	--
PORTULACACEAE (Purslane Family)							
Portulaca oleracea L.	common purslane	X	--	2	--	--	--
Portulaca pilosa L.	‘ihi	X	--	2	--	--	--
Talinium paniculatum (Jacq.) Gaertn.	Jewels of Opar	X	--	2	--	--	--
PROTACEAE (Protea Family)							
Grevillea robusta A. Cunn. ex R. Br.	silk oak	X	1	2	3	4	--
ROSACEAE (Rose Family)							
Eriobotrya japonica (Thunb.) Lindley	loquat	X	--	--	--	4	--
RUBIACEAE (Coffee Family)							
Hedyotis corymbosa (L.) Lam.	----------	X	1	--	--	--	--
Morinda citrifolia L.	Indian mulberry, noni	P	--	--	--	4	--

Species	Common Names	Status	Presence[1]				
RUBIACEAE (cont'd.)							
Paederia scandens (Lour.) Merr.	maile pilau	X	--	2	--	--	--
Richardia brasiliensis Gomes	----------	X	--	--	3	--	--
Spermacoce assurgens Ruiz & Pav.	buttonweed	X	--	--	--	--	5
RUTACEAE (Citrus Family)							
Citrus sp.	orange	X	--	--	--	4	--
Murraya paniculata (L.) Jack.	mock orange	X	--	--	--	4	5
SAPINDACEAE (Soapberry Family)							
Dodonaea viscosa Jacq.	‘a‘ali‘i	I	--	2	--	--	--
Filicium decipiens (Wight & Arn.) Thw.	fern tree	X	--	2	--	--	--
SAPOTACEAE (Sapodilla Family)							
Chrysophyllum oliviforme L.	satinleaf	X	--	2	3	4	5
Sideroxylon persimile (W. Hemsley) T.D. Pennington	bumelia	X	1	2	3	4	5
SOLANACEAE (Nightshade Family)							
Cestrum nocturnum L.	night cestrum	X	--	--	--	4	--
Datura stramonium L.	Jimson weed	X	--	--	--	4	--
Solanum americanum Mill.	black nightshade, popolo	I?	1	2	--	--	--
Solanum mauritianum Scop.	pua nana honua	X	--	--	3	4	5
Solanum seaforthianum Andr.	blue potato-vine	X	--	2	--	4	--
STERCULIACEAE (Cacao Family)							
Waltheria indica L.	‘uhaloa	I	--	--	--	--	5
TILIACEAE (Linden Family)							
Heliocarpus popayanensis Kunth	moho	X	--	2	--	--	5
ULMACEAE (Elm Family)							
Trema orientalis (L.) Bl.	gunpowder tree	X	1	2	--	4	--
URTICACEAE (Nettle Family)							
Pilea microphylla (L.) Liebm.	rockweed	X	--	2	--	--	--
VERBENACEAE (Verbena Family)							
Citharexylum caudatum L.	fiddlewood	X	--	--	--	4	5
Lantana camara L.	lantana	X	--	--	3	--	5
Stachytarpheta dichotoma (Ruiz & Pav.) Vahl	owi	X	--	--	3	4	5
Stachytarpheta jamaicensis (L.) Vahl	Jamaica vervain, owi	X	--	--	3	--	5
Verbena litoralis Kunth	ha‘uoi	X	--	--	3	--	--

[1]The study sites as described here are as follows: 1= DL1 Kamehameha Highway site; 2=DB4 Kipapa Gulch and Koa Ridge Makai plateau; 3= KR Agriculture area and S-shaped gully; 4= DB1 construction area; and 5= DB2 and DB3 (two sites combined together) construction and impoundment areas.

Fig. 4. Pastureland at Site KR, with scattered alien trees and grazed Guinea grass.

Fig. 5. Roadway with scattered weeds at proposed access/staging area in Kipapa Gulch.

Fig. 6. Guinea grass overgrowing infrequently used unpaved road.

Fig. 7. Cultivation of papaya at Site DB 1.

Fig. 8. Guinea Grassland with scattered albizzia trees at DB 1.

Fig. 9. Albizia forest on the slopes above DB 2, below Mililani Mauka.

Fig. 10. Mixed species Alien-Dominated Forest in Kipapa Gulch.

Fig. 11. Koa Haole Scrub Forest with dry Guinea grass ground cover at Site DL 1.

Fig. 12. Koa Haole Scrub Forest with dense ground cover in wet soil cover at Site DL 1.

Fig. 13. Mixed species Alien-Dominated Forest along stream at Site DL 1.

Fig. 14. Forest dominated by Christmas berry and strawberry guava upstream from Site DB 2.

Fig. 15. Plantation forest dominated by ironwood at Site KR.

Fig. 16. Kipapa Gulch streambed with standing pools of water.

Fig. 17. Dense grassland of California grass in Kipapa Gulch.

Botanical Survey

of the

Castle and Cooke Koa Ridge Makai Parcel,

Mililani, O‘ahu

by

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Isle Botanica
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Report prepared for

Wilson Okamoto Corporation
Honolulu

September 2007

INTRODUCTION

The wedge-shaped study site (Fig. 1) is located in central Oʻahu near the town of Mililani, just north of Waipiʻo Gentry, west of H-2, and east of Kipapa Gulch (Fig. 1). It comprises about 571 acres of mostly flat land formerly used for growing pineapple. This practice has been abandoned for several years now, but at the time of the survey (July 2007) part of the site was in agriculture (corn, papayas, cabbage, etc.), part was fallow, and part was covered with grasslands and woodlands dominated by alien species. While most of the site is flat, gently sloping land, gullies and slopes are present in the area, particularly Kipapa Gulch, which, however, is mostly outside of the study site. The study site also includes a proposed sewer line corridor that extends southward from the site and down a paved city street (Paiwa) several miles to a bus staging area, but the southern portion of this corridor is paved and the vegetation along the corridor is almost non-existent.

The objectives of the current field study were to provide a general description of the vegetation types present at the site (particularly any sensitive types of vegetation that may harbor rare plant species), to make a checklist of all native and naturalized vascular plants found, and to search for threatened and endangered species.

METHODOLOGY

Before the fieldwork was carried out, a review of the literature was undertaken by the principal investigator. The main source of information was a botanical survey done at the site in 1996 (Funk 1996). The current status of any endangered species previously reported from the surrounding area was checked using the official database of threatened and endangered plant species (USFWS 2005). This list is identical to the State of Hawaiʻi list of threatened and endangered species. In addition, information about threatened and endangered plant species found in the area was extracted from the Hawaiʻi Natural Heritage Program database (Anon. 2005) of federally listed plant species (Fig. 2).

After the literature review, a botanical field survey was conducted at the study site by a two-person botanical team consisting of the principal investigator (Art Whistler) and a field assistant (Beate Neher) from 29 to 31 July. A "walk-through survey" was employed, and all plant species encountered were recorded, along with an indication of their frequency. Particular care was taken in areas where native species are most likely to be found (e.g., in gullies), but the whole the area was heavily disturbed. All species encountered were incorporated into a checklist for each type of vegetation and each area. All plants recorded were then put into a comprehensive checklist for the study site (see Appendix I). Notes were also taken on vegetation types present, indicating the dominance and frequency of the plant species comprising them. These notes were written up into the vegetation description below.

The survey was conducted during the dry part of the year, a year marked by a serious drought. If done later in the year during the rainy season or in a wetter year, it is likely that a few additional species, mostly herbaceous alien weeds, would have been recorded. It is very unlikely that more than a few additional native species would be found in such a survey, and even less likely any threatened or endangered species would, since none have previously been reported from the area.

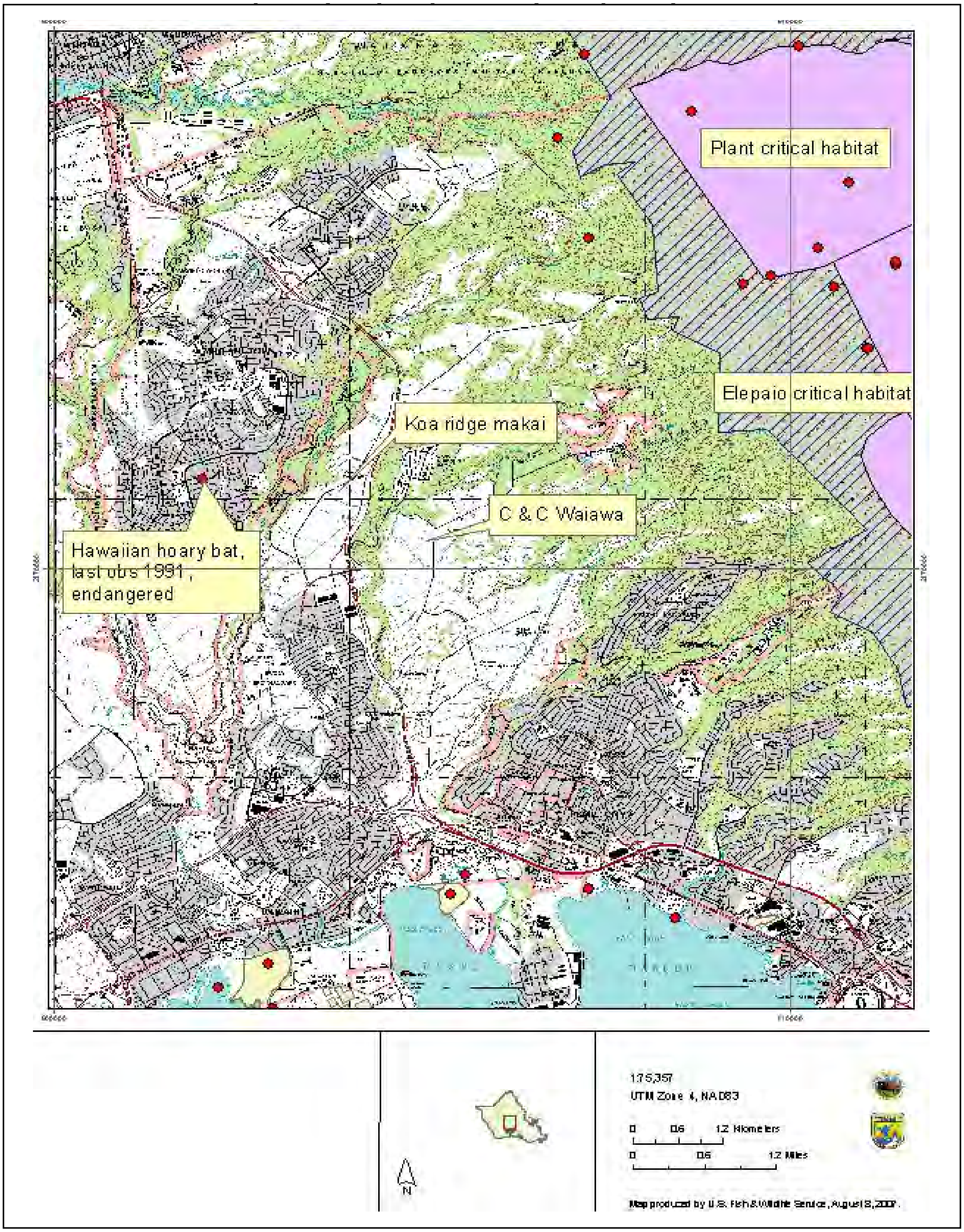

Fig. 2. Hawai‘i Natural Heritage Program database map of federally listed plant species at the Castle and Cooke Koa Ridge Makai study site.

THE VEGETATION

Three types of vegetation can be recognized at the Koa Ridge Makai study site (which includes the proposed pipeline corridor down Paiwa St.): (1) Managed Land Vegetation; (2) Guinea Grass Grassland; and (3) Alien-Dominated Forests. These are often not distinct from each other, since in reality they can blend together, but the categories are useful for descriptive purposes. The latter category can be divided into several types, based upon how close together the trees are (i.e., scattered trees comprise what is called a "woodland" and densely packed trees comprise a "forest"). All these vegetation types and their subtypes are classified as "disturbed vegetation," and are virtually devoid of any native species. The three types and their subtypes are described below.

(1) Managed Land Vegetation

This comprises the vegetation on areas that are under periodic or frequent management, such as roadsides and cultivated areas. Distinct roadside vegetation is not easily distinguished at the site, since most of the roads are dirt roads and there is no distinct zone between the dirt road and the crops or fallow land away from the road (Fig. 3). Most of the roadsides are dominated by Guinea grass (*Panicum maximum*). Cultivated or fallow lands comprise the dominant types of Managed Land Vegetation, particularly fallow land (Fig. 4). On cultivated land, crops, particularly corn, papayas, squash, zucchinis, bell peppers, cabbage, and green onions, are currently being grown. Pineapple is no longer cultivated, and the only place it was seen during the present survey was at the northern end of the study site, where it was residual in a ruderal area now overrun with weeds. The most common weeds include nutgrass (*Cyperus rotundus*), goosegrass (*Eleusine indica*), Guinea grass (*Panicum maximum*), dropseed (*Sporobolus diander*), fuzzy rattlepod (*Crotalaria incana*), and pink bindweed (*Ipomoea triloba*).

The area at the north end of the study site was somewhat intermediate between Managed Land Vegetation and Guinea Grass Grassland (Fig. 5). The presence of pineapples indicates that the area comprises only recently abandoned pineapple lands. It is no longer managed, but Guinea grass has not yet assumed dominance. Guinea grass shares dominance with sour grass (*Digitaria insularis*), mission grass (*Pennisetum polystachyon*), Koster's curse (*Clidemia hirta*), and an assortment of other alien weeds. These species are virtually absent from Guinea Grass grassland, and are likewise mostly absent from Managed Land Vegetation.

The proposed sewer line corridor is situated on highly disturbed land. The northern portion runs through a sports complex, and extends southward (Fig. 6) to a paved road (Paiwa St.), and from there it continues several miles south to a bus staging area. The later area is mostly paved, with the alien species oleander (*Nerium oleander*) and monkeypod (*Samanea saman*) dominating the disturbed landscape.

(2) Guinea Grass Grassland

This type of vegetation is dominated by Guinea grass (*Panicum maximum*). It occurs along the edges of the cultivated and fallow land on areas that may have once been cultivated, but not for a long time. The guinea grass forms a nearly pure association, probably with over 98% of the biomass, since few other species are able to grow in the dense clumps of grass that may be up to 6 ft or more in height. Unlike the nearby Waiawa area that was studied at the same time as the present survey (Whistler 2007), most of the Guinea grass was brown rather than green (Fig. 7), probably because of the drought that has recently been affecting the island. The Waiawa site presumably gets more rainfall, since it is closer to the Koʻolau Mountains, which would account for the green Guinea grass.

Pure stands of Guinea grass without trees are uncommon at the site, but when a few trees are present, the vegetation is somewhat intermediate between an alien tree woodland (see below) and Guinea Grass Grassland. The most common trees found in this grassland are koa haole (*Leucaena leucocephala*) and albizzia (*Paraserianthes falcataria*), and, to a lesser extent, Formosan koa (*Acacia confusa*). No native species were recorded in this type of vegetation.

(3) Alien-Dominated Forest

This is the woodland dominated by alien tree species. It occurs on the slopes and bottoms of gullies, and in several places around the periphery of the study site. The woodlands at the study site might be classified together as the same "plant community," since they have the same general form (woodlands or forests) and are dominated by alien trees. However, this vegetation is heterogeneous, and at least four kinds can be distinguished. If these were dominated by native species, they might be considered separate "associations" all belonging to the same large category—lowland forest community. They vary from each other, however, because they differ in species composition and probably in origin, and are treated here as types of Alien-Dominated Forest.

One type is a woodland dominated by albizzia (*Paraserianthes falcataria*), under which a dense matrix of Guinea grass dominates the ground. Because of this, the line between Guinea Grass Grassland and this woodland are not distinct. The best example of this woodland occurs on the northern portion of the study site (Fig. 8). Several other trees species occur here, especially Chinaberry tree (*Melia azedarach*), gunpowder tree (*Trema orientalis*), and African tulip tree (*Spathodea campanulata*), but none are as common as the large albizzia trees. Few ground cover species are able to survive in the dense ground cover created by the Guinea grass, and thus this type of woodland is low in species diversity, and in fact was found to be totally lacking in native species.

A second type of woodland found at the study site on the slopes of gullies and on some flat areas on the margin of the fallow and cultivated land that covers the center of the study site is typically dominated by koa haole (*Leucaena leucocephala*), sometimes in a dense association (Fig. 9). Other tree species are often found here, the most common of which are silk oak (*Grevillea robusta*), Chinaberry tree (*Melia azedarach*), Formosan koa (*Acacia confusa*), ironwood (*Casuarina equisetifolia*), and albizzia (*Paraserianthes falcataria*). This is a common type of woodland in Hawaiʻi that is entirely dominated by alien species, especially the koa haole.

A third type of vegetation present at the study site is a woodland entirely dominated by ironwood (*Casuarina equisetifolia*). This tree occurs in the forest type dominated by koa haole described above, but sometimes forms pure associations with no other tree species present. It produces a dense ground layer of "needles" (actually, pineneedle-like branchlets) that apparently prevent even ground cover species from growing under the pine-like trees.

A fourth type of woodland is found in gullies at the study site, where soil water is naturally more plentiful. This allows for a denser forest to grow here. The component species are mostly different from the ones inhabiting the drier areas (as noted in the forest type above dominated by koa haole). The dominant species are Java plum (*Syzygium cumini*), African tulip tree (*Spathodea campanulata*), and *Macaranga tanarius* (no common name), with lesser amounts of gunpowder tree (*Trema orientalis*), Chinese banyan (*Ficus microcarpa*), *Chrysophyllum* cf. *mexicanum* (no common name), and Koidzumi's firethorn (*Pyracantha* cf. *koidzumii*). Ironwood and koa haole are also found here, but in lesser amounts than in drier areas. The ground cover, like most of the rest of the area at the study site that is not currently being cultivated or fallowed, is dominated by Guinea grass. Other weeds, such as rouge plant (*Rivina humilis*) and Chinese violet (*Asystasia gangetica*) are common here, but uncommon or absent from the drier flat land areas of the study site.

At the time of the survey, there had been a recent fire on the south part of the sports complex. The trees were badly burned and the ground cover charred. However, the Guinea grass is fire resistant, and can be expected to soon dominate the area, along with the charred kiawe (*Prosopis pallida*) trees found in the area.

THE FLORA

One hundred twenty-nine plant species were recorded at the study site (see Appendix I). Only three of the 129 are native, all of them indigenous rather than endemic. Indigenous plants are species native to a region or place, but are also found elsewhere. Endemic plants are species restricted to a single region or area, i.e., in the case of Hawai‘i, they are found only in Hawai‘i. In biodiversity terms, the endemic status is the more important of the two categories, since if a species belonging to it is endangered or threatened in Hawai‘i, it would likewise be classified globally. Indigenous species, however, can be rare in Hawai‘i, but may be common elsewhere in the Pacific. Over 90% of the native plants in Hawai‘i are endemic, one of the highest rates in the world. The three species are pa‘u-o-Hi‘iaka (*Jacquemontia ovalifolia*), popolo (*Solanum americanum*), and ‘uhaloa (*Waltheria indica*). The latter two are typical of this area, but pa‘u-o-Hi‘iaka is a littoral plant almost entirely restricted to coastal habitats. Its seeds may have been carried stuck to heavy equipment that was previously used in coastal areas.

The majority of the 129 species encountered during the survey are naturalized or weedy "alien" plants that were accidentally or intentionally introduced to Hawai‘i, but which have now become established in the islands and can spread on their own. An earlier botanical survey by Funk (1996) included 123 species, but 49 of those were not found during the present survey. Some of these may have been misidentified (e.g., *Albizia lebbek* is on that checklist, but is probably an incorrect identification of *Paraserianthes falcataria*, which is not listed by Funk). Many of the others are weedy alien species associated with open crops, such as pineapple, but these areas have now largely reverted to grasslands covered with the all-pervasive Guinea grass (*Panicum maximum*) or are under cultivation with different crops (no pineapple cultivation was seen at the time of the survey). In addition to two of the three native species found during the present survey (excluding pa‘u-o-Hi‘iaka), Funk (1996) recorded ‘ilima (*Sida fallax*) and koa (*Acacia koa*). The former would be expected to be present, but may not have been obvious due to the dry season conditions and the dense growth of the Guinea grass. The koa, however, is out of place, but reference to it may have been based on cultivated individuals.

DISCUSSION

The study site was surveyed over a period of three days in July 2007. Three types of vegetation can currently be found at the site: (1) Managed Land Vegetation; (2) Guinea Grass Grasslands; and (3) Alien-Dominated Forest. The latter type can be subdivided into four types based on differences in species composition. All are dominated by alien species. No wetlands or sensitive types of vegetation (or even native types of vegetation) were encountered during the survey.

During the present survey, 129 plant species were recorded. A previous botanical survey (Funk 1996) recorded 123 species. Forty-nine of the species in the 1996 survey were not found during the present study. Several reasons may account for this, the main one perhaps being a change in habitat (from pineapple cultivation to other types of cultivation and the spread of grassland dominated by Guinea grass). This makes a total of 178 species recorded from the site. Only five of the 178 species are native: popolo (*Solanum americanum*), ‘uhaloa (*Waltheria indica*), pa‘u-o-Hi‘iaka (*Jacquemontia ovalifolia*), ‘ilima (*Sida fallax*), and koa (*Acacia koa*). The first four of these are wide-ranging and common indigenous species. Only the koa is endemic, but it was not found during the present survey, and is likely to have comprised cultivated individuals, since koa is not usually found in the habitats present at the study site. No federally listed threatened or endangered species have been recorded from the area (see Fig. 2), because of the highly disturbed nature of the vegetation present.

CONCLUSIONS

Two botanical factors can complicate proposed construction in Hawai‘i. One is the presence of sensitive types of vegetation, the other is the presence of endangered plant species. Sensitive vegetation includes wetlands and native forest. No wetlands or native forests are found in the area. Only three native species turned up in the survey, all of them wide-ranging species common in Hawai‘i. Two additional ones were recorded by Funk (1996), but one is a common indigenous species and the other is a common endemic that was probably cultivated rather than naturally growing there. No federally listed threatened or endangered species have been reported in the area, since the native vegetation has long since disappeared. Consequently, there are no botanical reasons why development of the parcel cannot take place. This includes the main parcel, and the pipeline corridor that runs southward through the park complex down Paiwa St. to a bus staging depot. All of the proposed construction is on very disturbed land.

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APPENDIX I. PLANT SPECIES CHECKLIST

The following is a checklist of the vascular plants inventoried during the botanical survey on the Koa Ridge Makai study area. The plants are divided into three groups: Ferns, Monocots, and Dicots. Within these groups, the species are presented taxonomically by family, with each family and each species in the family in alphabetical order. The taxonomy and nomenclature of the ferns follow Palmer 2003 and the flowering plants (Monocots and Dicots) follow Wagner *et al*. (1990). In most cases, common English and/or Hawaiian names listed here have been taken from St. John (1973) or Porter (1972).

For each species, the following information is provided:

1. Scientific name with author citation.
2. Common English and/or Hawaiian name, when known.
3. Biogeographic status. The following symbols are used.
   E = endemic (found only in Hawaiʻi).
   I = indigenous (native to Hawaiʻi as well as other geographic areas).
   P = Polynesian introduction (introduced to Hawaiʻi by Polynesians before the advent of the Europeans).
   X = Introduced or alien (not native, introduced to Hawaiʻi, either accidentally or intentionally, after the advent of the Europeans).
4. Relative frequency (abundant, locally abundant, common, occasional, uncommon, rare, or cultivated).

Species	Common Names	Status	Abundance
FERNS			
NEPHROLEPIDACEAE (Sword Fern Family)			
Nephrolepis multiflora (Roxb.)	hairy swordfern	X	locally abundant
MONOCOTS			
AGAVACEAE (Agave Family)			
Sansevieria fasciata Cornu ex Gérome & Labroy	bowstring hemp	X	occasional
Yucca gloriosa L.	Spanish bayonet	X	cultivated
ARACEAE (Arum Family)			
Colocasia esculenta (L.) Schott	taro, kalo	P	cultivated
BROMELIACEAE (Bromeliad Family)			
Ananas comosus (L.) Merr.	pineapple	X	cultivated
COMMELINACEAE (Spiderwort Family)			
Commelina diffusa N. L. Burm.	honohono	X	uncommon
CYPERACEAE (Sedge Family)			

Cyperus rotundus L.	nutgrass	X	common

Species	Common Names	Status	Abundance
LILIACEAE (Lily Family)			
Allium fistulosum L.	green onion	X	cultivated
MUSACEAE (Banana Family)			
Musa xparadisiaca L.	banana	P	cultivated
POACEAE (Grass Family)			
Cenchrus echinatus L.	sandbur	X	uncommon
Chloris barbata (L.) Sw.	swollen fingergrass	X	uncommon
Cynodon dactylon (L.) Pers.	Bermuda grass	X	occasional
Digitaria insularis (L.) Mez ex Ekman	sour grass	X	common
Eleusine indica (L.) Gaertn.	goose grass	X	common
Panicum maximum Jacq.	Guinea grass	X	abundant
Paspalum conjugatum Bergius	t-grass	X	occasional
Pennisetum polystachion (L.) Schult.	feathery pennisetum	X	locally abundant
Rhynchelytrum repens (Willd.) C.E. Hubb.	Natal redtop	X	uncommon
Sorghum sp.	sorghum	X	occasional
Sporobolus diander (Retz.) P. Beauv.	dropseed	X	common
Zea mays L.	corn	X	cultivated

DICOTS

AIZOACEAE (Carpetweed Family)			
Trianthema portulacastrum L.	----------	X	occasional
AMARANTHACEAE (Amaranth Family)			
Achyranthes aspera L.	----------	X	uncommon
Alternanthera pungens Kunth	khaki weed	X	uncommon
Amaranthus spinosus L.	spiny amaranth	X	occasional
Amaranthus viridis L.	slender amaranth	X	occasional
Gomphrena globosa L.	globe amaranth	X	cultivated
ANACARDIACEAE (Mango Family)			
Schinus terebinthifolius Raddi	Christmas berry	X	common
APOCYNACEAE (Dogbane Family)			
Nerium oleander L.	oleander	X	cultivated
Plumeria rubra L.	frangipani	X	cultivated
ARALIACEAE (Panax Family)			
Schefflera actinophylla (Endl.) Harms	octopus tree	X	occasional
ASTERACEAE (Sunflower Family)			
Ageratum conyzoides L.	ageratum	X	uncommon
Bidens alba (L.) DC.	beggar’s-tick	X	uncommon
Bidens pilosa L.	beggar’s-tick	X	uncommon

Species	Common Names	Status	Abundance
Calyptcarpus vialis Less.	hierba del cabello	X	common
Conyza bonariensis (L.) Cronq.	hairy horseweed	X	occasional
Eclipta alba (L.) Hassk.	false daisy	X	uncommon

Species	Common Names	Status	Abundance
ASTERACEAE (cont'd.)			
Emilia fosbergii Nicolson	red pualele, emilia	X	uncommon
Helianthus annus L.	sunflower	X	cultivated
Pluchea carolinensis (Jacq.) G. Don	pluchea	X	occasional
Sonchus oleraceus L.	sow thistle	X	uncommon
Synedrella nodiflora (L.) Gaertn.	synedrella	X	uncommon
Tridax procumbens L.	coat buttons	X	uncommon
Verbesina encelioides (Cav.) Benth. & Hook.	golden crownbeard	X	uncommon
BIGNONIACEAE (Bignonia Family)			
Spathodea campanulata P. Beauv.	African tulip tree	X	occasional
Tabebuia heterophylla (DC.) Britton	pink tecoma	X	cultivated
BORAGINACEAE (Heliotrope Family)			
Heliotropium procumbens Mill.	weedy heliotrope	X	occasional
BRASSICACEAE (Mustard Family)			
Brassica cf. *oleracea* L.	cabbage	X	cultivated
Brassica juncea (L.) Czern.	mustard greens	X	cultivated
BUDDLEIACEAE (Butterfly-bush Family)			
Buddleia asiatica Lour.	dogtail, heulo'ilio	X	occasional
CACTACEAE (Cactus Family)			
Hylocereus undatus (Haw.) Britten & Rose	night-blooming cereus	X	uncommon
Opuntia cf. *ficus-indica* (L.) Mill.	prickly pear, panini	X	uncommon
CARICACEAE (Papaya Family)			
Carica papaya L.	papaya	X	cultivated
CASUARINACEAE (Ironwood Family)			
Casuarina equisetifolia L.	ironwood	X	locally abundant
CONVOLVULACEAE (Morning-Glory Family)			
Ipomoea obscura (L.) Ker-Gawl.	bindweed	X	uncommon
Ipomoea triloba L.	pink bindweed	X	common
Jacquemontia ovalifolia (Choisy) H. Hall.	pa‘u-o-Hi‘i‘aka	I	uncommon
Merremia aegyptia (L.) Urb.	hairy merremia	X?	uncommon
CUCURBITACEAE (Gourd Family)			
Coccinea grandis (L.) Voigt	ivy gourd	X	occasional
Cucurbita pepo L.	zucchini	X	cultivated
Cucurbita cf. *maxima* Lamarck	squash	X	cultivated
Momordica charantia L.	wild bittermelon	X	uncommon

EUPHORBIACEAE (Spurge Family)			
Chamaesyce hirta (L.) Millsp.	garden spurge	X	occasional
Chamaesyce hypericifolia (L.) Millsp. Croizat & Degener	graceful spurge	X	occasional
Euphorbia lactea Haworth	milkstripe euphorbia	X	cultivated
Euphorbia tirucalli L.	pencil tree	X	cultivated

Species	Common Names	Status	Abundance
EUPHORBIACEAE (cont'd.)			
Macaranga tanarius (L.) Muell. Arg.	----------	X	occasional
Ricinus communis L.	castor bean	X	uncommon
Synadenium grantii J.D. Hooker	African milkbush	X	uncommon
FABACEAE (Pea Family)			
Acacia confusa Merr.	Formosan koa	X	common
Cajanus cajan (L.) Millsp.	pigeon pea	X	cultivated
Cassia x*nealii* Irwin and Barneby	rainbow shower	X	cultivated
Chamaecrista nictitans (L.) Moench	partridge pea, lau-ki	X	occasional
Crotalaria incana L.	fuzzy rattlepod	X	common
Crotalaria cf. *micans* Link	----------	X	occasional
Crotalaria pallida Aiton	smooth rattlepod	X	occasional
Desmanthus pernambucanus (L.) Thellung	virgate mimosa	X	occasional
Desmodium triflorum (L.) DC.	beggarweed	X	common
Glycine wightii (Wight & Arn.) Verdc.	----------	X	occasional
Indigofera spicata Forssk.	creeping indigo	X	occasional
Indigofera suffruticosa Mill.	indigo, ‘iniko	X	common
Leucaena leucocephala (Lam.) de Wit	koa haole	X	abundant
Macroptilium atropurpureum (DC) Urb.	wild bushbean	X	occasional
Macroptilium lathyroides (L.) Urb.	cow pea	X	uncommon
Paraserianthes falcataria (L.) I. Nielsen	albizzia	X	common
Pithecellobium dulce (Roxb.) Benth.	‘opiuma, Manila tamarind	X	occasional
Prosopis pallida (Humb. & Bonpl.ex Willd.) Kunth	kiawe, mesquite	X	uncommon
Samanea saman (Jacq.) Merr.	monkeypod	X	uncommon
Senna occidentalis (L.) Link	coffee senna	X	uncommon
LAMIACEAE (Mint Family)			
Leonotis nepetifolia (L.) R. Br.	orange lion's-ear	X	uncommon
MALVACEAE (Mallow Family)			
Abutilon grandifolium (Willd.) Sweet	hairy abutilon	X	uncommon
Hibiscus rosa-sinensis L.	hibiscus	X	cultivated
Malva parviflora L.	cheeseweed	X	uncommon
Malvastrum coromandelianum (L.) Garcke	false mallow	X	uncommon

Sida ciliaris L.	----------	X	uncommon
Sida spinosa L.	prickly sida	X	uncommon
Thespesia populnea (L.) Sol ex Corr.	milo	P	uncommon
MELASTOMATACEAE (Melastoma Family)			
Clidemia hirta (L.) D. Don	Koster’s curse	X	locally abundant
MELIACEAE (Mahogany Family)			
Melia azedarach L.	Chinaberry tree	X	occasional

Species	Common Names	Status	Abundance
MORACEAE (Mulberry Family)			
Artocarpus heterophyllus Lamarck	jackfruit	X	cultivated
MYRTACEAE (Myrtle Family)			
Melaleuca quinquenervia (Cav.) Blake	paperbark tree	X	uncommon
Psidium cattleianum Sabine	strawberry guava	X	uncommon
Psidium guajava L.	guava	X	occasional
Syzygium cumini (L.) Skeels	Java plum	X	occasional
NYCTAGINACEAE (Four-o’-Clock Family)			
Boerhavia coccinea Mill.	----------	X	occasional
OXALIDACEAE (Wood-Sorrel Family)			
Oxalis corniculata L.	wood sorrel	P?	occasional
PAPAVERACEAE (Poppy Family)			
Argemone mexicana L.	Mexican poppy	X	uncommon
PASSIFLORACEAE (Passionflower Family)			
Passiflora edulis Sims	passionfruit, liliko‘i	X	uncommon
Passiflora foetida L.	love-in-a-mist	X	uncommon
Passiflora suberosa L.	----------	X	uncommon
PHYTOLACCACEAE (Pokeweed Family)			
Rivina humilis L.	rouge plant	X	uncommon
PORTULACACEAE (Purslane Family)			
Portulaca oleracea L.	common purslane	X	occasional
Talinum paniculatum (Jacq.) Gaertn.	Jewels of Opar	X	uncommon
PROTACEAE (Protea Family)			
Grevillea robusta A. Cunn. ex R. Br.	silk oak	X	common
ROSACEAE (Rose Family)			
Pyracantha cf. *koidzumii* Rehder	Koidzumi’s firethorn	X	occasional
RUTACEAE (Citrus Family)			
Murraya koenigii (L.) Spreng.	curry leaf	X	cultivated
SAPOTACEAE (Sapodilla Family)			
Chrysophyllum oliviforme L.	satinleaf	X	uncommon
Chrysophyllum cf. *mexicanum* Brandegee	----------	X	common
SOLANACEAE (Nightshade Family)			

Capsicum annum L.	bell pepper	X	cultivated
Lycopersicon pimpinellifolium (Jusl.) Mill.	currant tomato	X	uncommon
Solanum americanum Mill.	black nightshade, popolo	I?	uncommon
Solanum mauritianum Scop.	pua nana honua	X	occasional
STERCULIACEAE (Cacao Family)			
Waltheria indica L.	‘uhaloa	I	uncommon
ULMACEAE (Elm Family)			
Trema orientalis (L.) Bl.	gunpowder tree	X	occasional

Species	Common Names	Status	Abundance
URTICACEAE (Nettle Family)			
Pilea microphylla (L.) Liebm.	rockweed	X	uncommon
VERBENACEAE (Verbena Family)			
Lantana camara L.	lantana	X	occasional
Stachytarpheta jamaicensis (L.) Vahl	Jamaica vervain, oi, owi	X	uncommon
Verbena litoralis Kunth	ha‘uoi	X	occasional

Fig. 3. Roadside of dirt road dominated by Guinea grass.

Fig. 4. Fallow land and cultivated areas (in the distance) and the Koa Ridge Makai study site.

Botanical Survey

of the

Castle and Cooke Waiawa Parcel,

Waipi‘o and Waiawa, O‘ahu

by

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Report prepared for

Wilson Okamoto Corporation
Honolulu

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INTRODUCTION

The study site is located in central O'ahu near the town of Mililani, and lies just south of the Mililani cemetery on the east side of H-2 (Fig. 1). It comprises 191 acres of former pineapple fields that have been abandoned since the mid 1990s. Also included in the study is a small parcel of land (less than an acre) contiguous with the southwest side of the main parcel, and a road corridor and reservoir (shown as a yellow dotted line in Fig. 1). After pineapple farming was abandoned, the area became overgrown with weeds, and no pineapples were seen growing in the area at the time of the survey (July 2007). A fire occurred in the area in 1998 (Funk 2002), which is a major reason that the fire-resistant Guinea grass now entirely dominates the open areas. The grasslands on the northern portion of the parcel are currently used as a pasture for cattle. While most of the site is flat, gently sloping land, gullies are present in the contiguous study area and along the route of the proposed road to the east of the study site, and some of these and the adjacent flatlands are covered with forests comprising trees planted by the State.

The objectives of the current field study were to provide a general description of the vegetation types present at the site (particularly any sensitive types of vegetation that may harbor rare plant species), to make a checklist of all native and naturalized vascular plants found, to search for threatened and endangered species; and to determine whether any threatened or endangered plant species or sensitive types of vegetation (plant communities) present would be adversely affected by the proposed action. .

METHODOLOGY

Before the fieldwork was carried out, a review of the literature was undertaken by the principal investigator. The main source of information was a botanical survey done at the site in 1996 (Funk 1996), as well as an addendum several years later (Funk 1999) and a follow-up letter (Funk 2002). The current status of the endangered species previously reported from the surrounding area was checked using the official database of threatened and endangered plant species (USFWS 2005). This list is identical to the State of Hawai'i list of threatened and endangered species. In addition, information about threatened and endangered plant species found in the area was extracted from the Hawai'i Natural Heritage Program database (Anon. 2005) of federally listed plant species (Fig. 2).

After the literature review, a botanical field survey was conducted at the study site by a two-person botanical team consisting of the principal investigator (Art Whistler) and a field assistant (Beate Neher) from 28 to 30 July. A "walk-through survey" was employed, and all plant species encountered were recorded, along with an indication of their frequency. Particular care was taken in areas where native species were most likely to be present (e.g., in gullies). The species encountered were incorporated into a checklist for each type of vegetation and each area. All plants recorded were put into a comprehensive checklist for the study site (see Appendix I). Notes were also taken on vegetation types present, indicating the dominance and frequency of the plant species found there. These were written up into the vegetation description below.

Nearly all of the species encountered during the fieldwork were familiar to the field team and were identified in the field. The few that defied immediate identification were collected and shown to Clyde Imada and other botanists at the Bishop Museum, who promptly identified them (Imada, pers. comm. 2007). Two of the species, *Chrysophyllum* cf. *mexicanum* and Koidzumi's

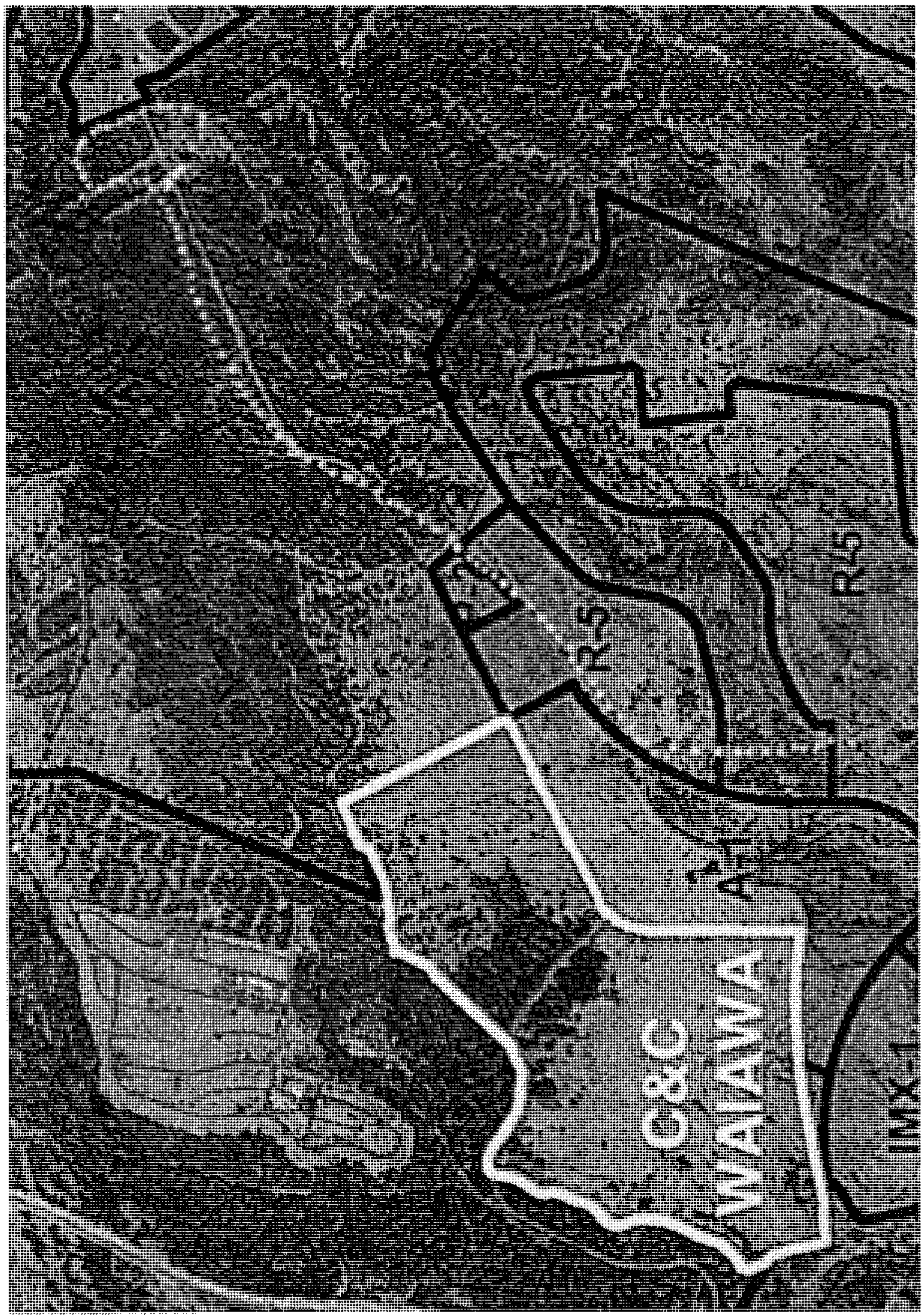

Fig. 1. The Castle and Cooke Waiawa study site, and proposed reservoir and road corridor.

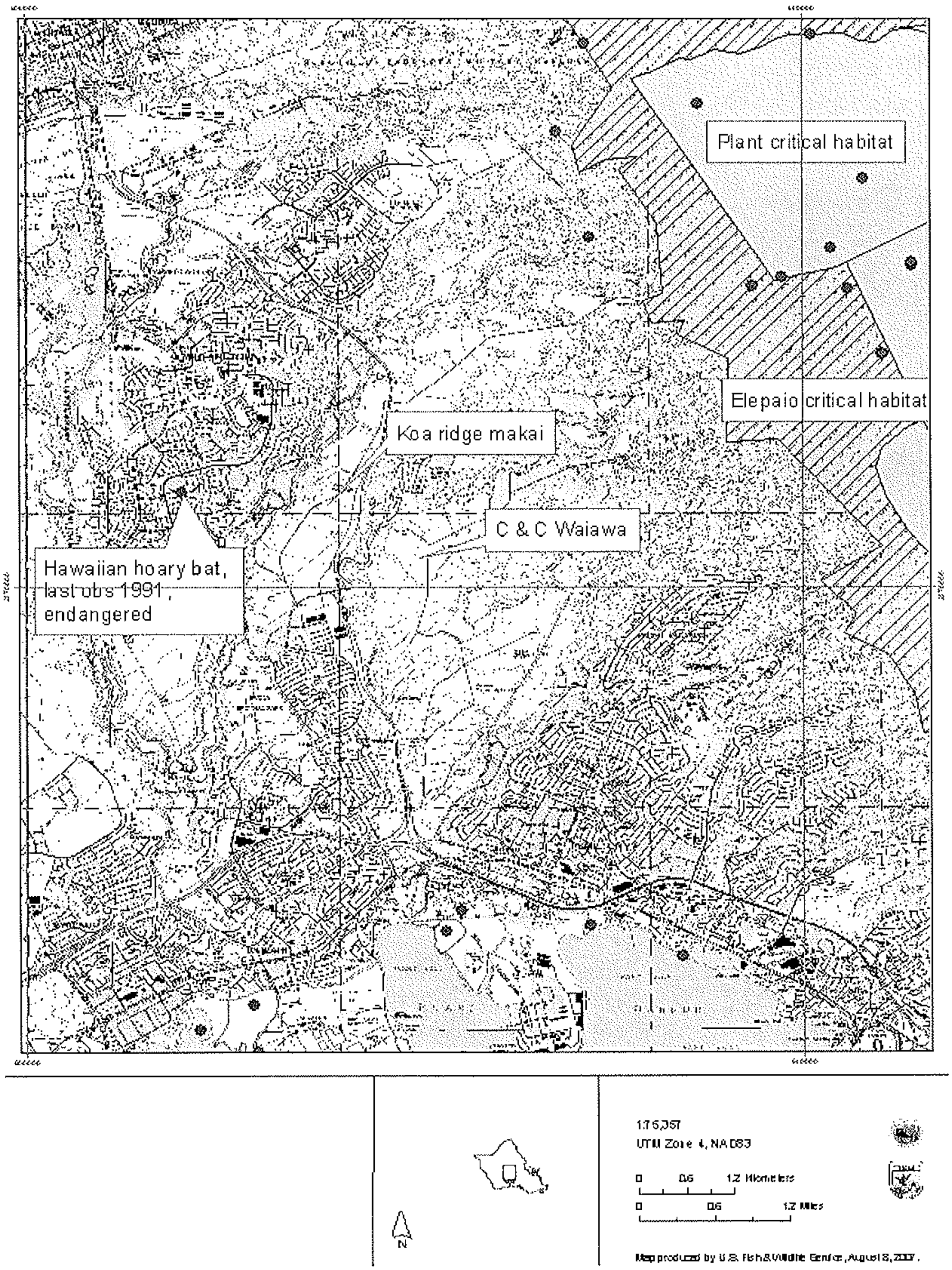

Fig. 2. Hawai'i Natural Heritage Program database map of federally listed plant species at the Castle and Cooke Waiawa study site.

firethorn (*Pyracantha* cf. *koidzumii*), were only tentatively identified, since they lacked fruits and/or flowers critical to their identification. Both species, however, are alien trees.

THE VEGETATION

Five types of vegetation can be recognized at the Waiawa study site (which includes the proposed new road route): (1) Managed Land Vegetation; (2) Wooded Guinea Grass Pasture; (3) Guinea Grass Grassland; (4) Albizzia Woodland; and (5) Alien-dominated Forest. These are often not distinct from each other, since they sometimes blend together, but the categories are useful for descriptive purposes. All these vegetation types can be categorized as "disturbed vegetation," and are nearly devoid of native species. The five types are described below.

(1) Managed Land Vegetation

This comprises the vegetation on areas that are under periodic or frequent management, such as roadsides. As described here, it does not include pastures, because pastures are mostly dominated by species (particularly Guinea grass) that are different from those found on roadsides. Roadsides are usually mowed or sprayed rather than being grazed, which leads to an entirely different set of dominant species. This description of the roadside vegetation applies to the road running north-south along the east side of the property. However, most of the roadsides beyond the study parcel and south of the correctional facility (near the route for the proposed new road) are overgrown with Guinea grass, as are the dirt roads in the area (Fig. 3). Although pastures are under current management by cattle, their botanical characteristics are intermediate between Managed Land Vegetation and Guinea Grass Grasslands. Some open areas at the study site appear to have been cultivated fairly recently, but this type of management has ended.

The dominant species on roadsides and other open areas include the alien weedy grasses stink grass (*Eragrostis cilianensis*), dropseed (*Sporobolus diander*), goose grass (*Eleusine indica*), swollen fingergrass (*Chloris barbata*), and Bermuda grass (*Cynodon dactylon*); and the dicot alien weeds beggar's-tick (*Bidens alba*), hierba del cabello (*Calyptocarpus vialis*), beggarweed (*Desmodium triflorum*), pink bindweed (*Ipomoea triloba*), and garden spurge (*Chamaesyce hirta*).

(2) Wooded Guinea Grass Pasture

This type of pasture is intermediate between typical pasture, which usually lacks trees, and the adjacent areas of forest, which are dominated by trees. It covers the northeastern third of the study site. It was the only area of the study site that had any cattle at the time of the survey. The herbaceous vegetation, which comprises the dominant life form here, is entirely dominated by Guinea grass that is actively being grazed by the cattle present. Few other herbaceous species can survive between the clumps of Guinea grass, but the few that do include sensitive plant (*Mimosa pudica*), hairy rattlepod (*Crotalaria incana*), and partridge pea (*Chamaecrista nictitans*). The shrub indigo (*Indigofera suffruticosa*) is also occasional here. All four of these species belong to the Pea Family Fabaceae.

Trees are scattered throughout the pasture (Fig. 4), with the most common one probably being Christmas berry (*Schinus terebinthifolius*). Less common species include *Macaranga* *tanarius*, koa haole (*Leucaena leucocephala*), African tulip tree (*Spathodea campanulata*), and guava (*Psidium guajava*). Even less common tree species include silk oak (*Grevillea robusta*), albizzia (*Paraserianthes falcataria*), ironwood (*Casuarina equisetifolia*), 'opiuma (*Pithecellobium dulce*), Java plum (*Syzygium cumini*), chinaberry tree (*Melia azedarach*), monkeypod (*Samanea saman*), and kukui (*Aleurites moluccana*). None of these trees are native.

(3) Guinea Grass Grassland

This type of vegetation covers areas that were probably once in cultivation, but which have now been abandoned. In places where no grazing is evident, Guinea grass can form dense thickets up to 8 ft or more in height that are traversed only with great difficulty. The grass is so thick that few other species can compete, and Guinea grass may comprise over 95% of the biomass. A few trees manage to survive here in the dense grass (Fig. 5), including koa haole (*Leucaena leucocephala*), with much fewer individuals of guava (*Psidium guajava*), Java plum (*Syzygium cumini*), Formosa koa (*Acacia confusa*), and 'opiuma (*Pithecellobium dulce*). This grassland occurs mostly in the southern half of the study site. The densest area, which shows no signs of grazing, covers the southwest quarter. A much lower type of grassland covers the central section of the proposed new road (Fig. 6). A sparse grassland with large patches of bare soil, which was either been grazed or was until recently cultivated (pineapple), covers most of the southeast and south-central portion of the study site (Fig. 7).

(4) Albizzia Woodland

This is the woodland dominated entirely by huge albizzia trees (*Paraserianthes falcataria*). It does not occur on the main study site, but is the dominant vegetation along the northern half of the proposed new road route, including the site of the proposed reservoir. The huge, somewhat spaced albizzia trees form a high, thin canopy (Fig. 8) and are almost the only trees found here. A few koa haole (*Leucaena leucocephala*) and strawberry guava (*Psidium cattleianum*) trees are interspersed, but are very short and scattered compared to the huge albizzia trees that form the mono-dominant canopy. The ground cover is equally mono-dominant, with Guinea grass forming a dense vegetation up to 8 ft or more in height that is traversed only with great difficulty. Few other species can survive in their dense growth, but scattered individuals of the alien weedy shrub Koster's curse (*Clidemia hirta*) do manage to eke out an existence in the dense grass.

(5) Alien-Dominated Forest

This is the forest dominated by alien tree species. It occurs in gullies in the center of the property and along the southern end of the proposed new road corridor, and along the edges of the pastures. These forests might be classified as the same "plant communities," since they have the same general form (forest) and are dominated by alien trees. However, they are heterogeneous, and at least three kinds can be distinguished. If these were dominated by native species, they might be considered "associations" all belonging the same large category, a lowland forest community, but varying from each other because they differ in species composition and probably in origin.

One area just to the south of the road that bisects the property going west to east is dominated by silk oak (*Grevillea robusta*). It is clear that this is a mono-dominant stand of plantation forest, since a single species dominates it, and the trees are aligned in rows (Fig. 9). A second area of forest occurs in the gully along the northern border of the bisecting road, just across the street from the plantation forest. This is probably a forestry project as well, with a variety of tree species rather than a single one, apparently planted to prevent erosion on the slopes of the gully (Fig. 10). The forest is not uniform, with some places dominated by a single species (mono-dominant) and others dominated by several species. Ironwood often forms mono-dominant forests with a thick layer of its needle-like leaves that typically excludes nearly all ground cover species. Tree species common here include *Chrysophyllum* cf. *mexicanum*, Koidzumi's firethorn (*Pyracantha* cf. *koidzumii*), and silk oak (*Grevillea robusta*). Other less common species include tropical ash (*Fraxinus uhdei*), Formosan koa (*Acacia confusa*), kukui (*Aleurites moluccana*), paperbark tree (*Melaleuca quinquenervia*), and narra (*Pterocarpus indicus*).

The third major area of forest occurred in gullies along the southern end of the proposed new road route (Fig. 11). This is dominated by large individuals of koa haole and Christmas berry, along with lesser amounts of *Chrysophyllum* cf. *mexicanum*, *Macaranga tanarius*, and Koidzumi's firethorn. Some very tall kukui trees were also present there, possibly an indicator of a former site of ancient Hawaiian habitation. The ground cover is fairly sparse, with Guinea grass being the most dominant species, as it is in the surrounding herbaceous plant communities. Seedlings of the *Chrysophyllum* are also common here.

THE FLORA

One hundred sixteen plant species were recorded at the study site (see Appendix). Only two of the 116 are native, both of them indigenous rather than endemic. Indigenous plants are species native to a region or place, but are also found elsewhere. Endemic plants are species restricted to a single region or area, i.e., in the case of Hawai'i, they are found only in Hawai'i. In biodiversity terms, the endemic status is the more important of the two categories, since if a species belonging to it is endangered or threatened in Hawai'i, it would likewise be classified globally. Indigenous species, however, can be rare in Hawai'i, but may be common elsewhere in the Pacific. Over 90% of the native plants in Hawai'i are endemic, one of the highest rates in the world.

The majority of the 116 species encountered during the survey are naturalized or weedy "alien" plants that were accidentally or intentionally introduced to Hawai'i, but which have now become established in the islands and can spread on their own. An earlier botanical survey by Funk (1996) included 110 species, but 36 of those were not found during the present survey. Some of these may have been misidentified (e.g., *Albizia lebbek* is on that checklist, but is probably an incorrect identification of *Paraserianthes falcataria*, which is not listed by Funk). Many of the others are weedy alien species associated with open crops, such as pineapple, but these areas have now largely been converted to pastures covered with the all-pervasive Guinea grass (*Panicum maximum*). A resurvey by Funk in 1999 after a fire the previous year turned up only 44 species. Funk attributed this to the loss of species during the fire and regeneration of the fire-resistant guinea grass, which soon became the dominant species in open areas. Another reason for the differences in the two checklists is the presence of open field agriculture in 1996, which was absent during the present survey. In both the Funk survey and the present one, only two native species are recorded, popolo (*Solanum americanum*) and ʻuhaloa (*Waltheria indica*).

DISCUSSION

Five types of vegetation can currently be found at the site: (1) Managed Land Vegetation; (2) Wooded Guinea Grass Pasture; (3) Guinea Grass Grassland; (4) Albizzia Woodland; and (5) Alien-dominated Forest. All of these are highly disturbed and unlikely to serve as a habitat for many native species.

A total of 116 plant species was recorded during the field work. A previous botanical survey had been carried out in 1996, with a follow-up visit in 1999. The 1996 survey recorded 110 species present. The follow-up survey, which took place after a major fire in the area, recorded far fewer species. Thirty-six of the species from the Funk 1996 survey were not found during the present study. Several reasons may account for this, the main one perhaps being a change in habitat (from cultivated to abandoned land and subsequent dominance by Guinea grass). This makes a total of 152 species recorded from the site in both surveys. Only two of the 152 species are native; popolo (*Solanum americanum*) and ʻuhaloa (*Waltheria indica*). Both of these are wide-ranging and common indigenous species and were found in both surveys. No federally listed threatened or endangered species have been recorded from the area (see Fig. 2), because of the highly disturbed nature of the vegetation present.

CONCLUSIONS

Two botanical factors can complicate proposed construction in Hawaiʻi. One is the presence of sensitive types of vegetation, the other is the presence of endangered plant species. Sensitive vegetation includes wetlands and native forest. No wetlands or native forests are found in the area, since the topography is not suitable (no basins) and the area is so highly disturbed. Only two native species turned up in the survey, both of them wide-ranging species common in Hawaiʻi. No federally listed threatened or endangered species have been reported in the area, since the native vegetation has long since disappeared. Consequently, there are no botanical reasons why development of the parcel cannot take place. This includes the main parcel, the smaller additional parcel at the southwest side of the main one, and the proposed site for the reservoir and road corridor leading to the reservoir. All of the site proposed for development is on very disturbed land.

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APPENDIX I. PLANT SPECIES CHECKLIST

The following is a checklist of the vascular plants inventoried during the field study at the Waiawa study site. The plants are divided into three groups: Ferns, Monocots, and Dicots. Within these groups, the species are presented taxonomically by family, with each family and each species in the family in alphabetical order. The taxonomy and nomenclature of the ferns follow Palmer 2003 and the flowering plants (Monocots and Dicots) follow Wagner *et al.* (1990). In most cases, common English and/or Hawaiian names listed here have been taken from St. John (1973) or Porter (1972).

For each species, the following information is provided:

1. Scientific name with author citation.
2. Common English and/or Hawaiian name, when known.
3. Biogeographic status. The following symbols are used.
   - E = endemic (found only in Hawaiʻi).
   - I = indigenous (native to Hawaiʻi as well as other geographic areas).
   - P = Polynesian introduction (introduced to Hawaiʻi by Polynesians before the advent of the Europeans).
   - X = Introduced or alien (not native, introduced to Hawaiʻi, either accidentally or intentionally, after the advent of the Europeans).
4. Relative frequency (abundant, locally common, occasional, uncommon, or cultivated).

Species	Common Names	Status	Abundance
FERNS			
POLYPODIACEAE (Common Fern Family)			
Phlebodium aureum (L.) J. Sm.	lauaʻe-haole	X	uncommon
Phymatosorus grossus (Langsd. & Fisch.) Brownlie	lauaʻe	X	locally common
MONOCOTS			
AGAVACEAE (Agave Family)			
Sansevieria fasciata Cornu ex Gérome & Labroy	bowstring hemp	X	uncommon
ARACEAE (Arum Family)			
Epipremnum pinnatum (L.) Engl.	pothos	X	uncommon
COMMELINACEAE (Spiderwort Family)			
Tradescantia zebrina Hort. ex Bosse	wandering Jew	X	uncommon
CYPERACEAE (Sedge Family)			
Cyperus rotundus L.	nutgrass	X	occasional
Cyperus gracilis R. Br.	McCoy grass	X	uncommon

Species	Common Names	Status	Abundance
POACEAE (Grass Family)			
Bothriochloa pertusa (L.) A. Camus	pitted beardgrass	X	uncommon
Chloris barbata (L.) Sw.	swollen fingergrass	X	uncommon
Cynodon dactylon (L.) Pers.	Bermuda grass	X	common
Digitaria ciliaris (Retz.) Koeler	crabgrass	X	occasional
Eleusine indica (L.) Gaertn.	goose grass	X	common
Eragrostis cilianensis (All.) Link	stink grass	X	common
Panicum maximum Jacq.	Guinea grass	X	abundant
Paspalum dilatatum Poir.	dallis grass	X	uncommon
Sporobolus diander (Retz.) P. Beauv.	dropseed	X	common
	DICOTS		
ACANTHACEAE (Acanthus Family)			
Asystasia gangetica (L.) T. Anderson	Chinese violet	X	uncommon
AMARANTHACEAE (Amaranth Family)			
Alternanthera pungens Kunth	khaki weed	X	uncommon
Amaranthus spinosus L.	spiny amaranth	X	occasional
Amaranthus viridis L.	slender amaranth	X	occasional
Gomphrena celosioides Mart.	----------	X	uncommon
ANACARDIACEAE (Mango Family)			
Schinus terebinthifolius Raddi	Christmas berry	X	common
APOCYNACEAE (Dogbane Family)			
Plumeria rubra L.	frangipani	X	cultivated
ARALIACEAE (Ginseng Family)			
Schefflera actinophylla (Endl.) Harms	octopus tree	X	occasional
ASTERACEAE (Sunflower Family)			
Ageratum conyzoides L.	ageratum	X	uncommon
Bidens alba (L.) DC.	beggar's-tick	X	common
Bidens cynapiifolia Kunth	West Indian beggar's-tick	X	occasional
Bidens pilosa L.	beggar's-tick	X	occasional
Calyptocarpus vialis Less.	hierba del cabello	X	common
Conyza bonariensis (L.) Cronq.	hairy horseweed	X	uncommon
Crassocephalum crepidioides (Benth.) S. Moore	crassocephalum	X	uncommon
Pluchea carolinensis (Jacq.) G. Don	pluchea	X	occasional
Sonchus oleraceus L.	sow thistle	X	uncommon
Tridax procumbens L.	coat buttons	X	uncommon
Youngia japonica (L.) DC.	Oriental hawksbeard	X	uncommon
Wedelia trilobata (L.) Hitchc.	wedelia	X	occasional
BASSELACEAE (Madeira Vine Family)			
Anredera cordifolia (Ten.) Steenis	Madeira vine	X	uncommon

Species	Common Names	Status	Abundance
BIGNONIACEAE (Bignonia Family)			
Spathodea campanulata P. Beauv.	African tulip tree	X	common
BRASSICACEAE (Mustard Family)			
Lepidium virginicum L.	wild peppergrass	X	uncommon
BUDDLEIACEAE (Butterfly-bush Family)			
Buddleia asiatica Lour.	dogtail, heulo'ilio	X	occasional
CASUARINACEAE (Ironwood Family)			
Casuarina equisetifolia L.	ironwood	X	common
CONVOLVULACEAE (Morning-Glory Family)			
Ipomoea triloba L.	pink bindweed	X	common
Merremia tuberosa (L.) Rendle	wood rose	X	uncommon
CRASSULACEAE (Stonecrop Family)			
Kalanchoë pinnata (Lam.) Pers.	air plant	X	uncommon
CUCURBITACEAE (Gourd Family)			
Coccinea grandis (L.) Voigt	ivy gourd	X	uncommon
EUPHORBIACEAE (Spurge Family)			
Aleurites moluccana (L.) Willd.	candlenut, kukui	P	occasional
Chamaesyce hirta (L.) Millsp.	garden spurge	X	common
Chamaesyce hypericifolia (L.) Millsp.	graceful spurge	X	common
Chamaesyce prostrata (Aiton) Small	prostrate spurge	X	occasional
Macaranga tanarius (L.) Muell. Arg.	----------	X	common
Ricinus communis L.	castor bean	X	uncommon
FABACEAE (Pea Family)			
Acacia confusa Merr.	Formosan koa	X	common
Chamaecrista nictitans (L.) Moench	partridge pea, lau-ki	X	common
Crotalaria incana L.	fuzzy rattlepod	X	occasional
Crotalaria pallida Aiton	smooth rattlepod	X	uncommon
Delonix regia (Bojer ex Hook.) Raf.	royal poinciana	X	cultivated
Desmanthus pernambucanus (L.) Thellung	virgate mimosa	X	occasional
Desmodium incanum DC.	Spanish clover	X	uncommon
Desmodium triflorum (L.) DC.	beggarweed	X	occasional
Glycine wightii (Wight & Arn.) Verdc.	----------	X	occasional
Indigofera suffruticosa Mill.	indigo, 'iniko	X	common
Leucaena leucocephala (Lam.) de Wit	koa haole	X	abundant
Macroptilium atropurpureum (DC) Urb.	wild bushbean	X	occasional
Melilotus indica L.	----------	X	occasional
Mimosa pudica L.	sensitive plant	X	occasional
Paraserianthes falcataria (L.) I. Nielsen	albizzia	X	abundant
Pithecellobium dulce (Roxb.) Benth.	'opiuma, Manila tamarind	X	common
Pterocarpus indicus Willd.	narra	X	uncommon

Species	Common Names	Status	Abundance
FABACEAE (cont'd.)			
Samanea saman (Jacq.) Merr.	monkeypod	X	occasional
Senna occidentalis (L.) Link	coffee senna	X	uncommon
Stylosanthes cf. *fruticosa* (Retz.) Alston	-----	X	uncommon
LAURACEAE (Laurel Family)			
Cinnamomum verum J. Presl	cinnamon	X	uncommon
MALVACEAE (Mallow Family)			
Hibiscus rosa-sinensis L.	red hibiscus	X	cultivated
Malvastrum coromandelianum (L.) Garcke	false mallow	X	occasional
Sida ciliaris L.	----------	X	occasional
Sida rhombifolia L.	Cuba jute	X	occasional
Sida spinosa L.	prickly sida	X	common
Sidastrum micranthum (St. Hil.) Fryx.	sand mallow	X	uncommon
MELASTOMATACEAE (Melastome Family)			
Clidemia hirta (L.) D. Don	Koster's curse	X	occasional
MELIACEAE (Mahogany Family)			
Melia azedarach L.	chinaberry tree	X	occasional
MYRTACEAE (Myrtle Family)			
Eucalyptus citriodora Hook.	lemon-scented gum	X	cultivated
Eucalyptus robusta Sm.	swamp mahogany	X	cultivated
Eucalyptus cf. *cinerea* F.v. Muell. Ex Benth.	Argyle apple	X	cultivated
Melaleuca quinquenervia (Cav.) Blake	paperbark tree	X	uncommon
Pimenta dioica (L.) Merr.	allspice	X	uncommon
Psidium cattleianum Sabine	strawberry guava	X	occasional
Psidium guajava L.	guava	X	occasional
Syzygium cumini (L.) Skeels	Java plum	X	common
MORACEAE (Mulberry Family)			
Ficus microcarpa L. f.	Chinese banyan	X	uncommon
Ficus rubiginosa Desf.	Port Jackson fig	X	uncommon
NYCTAGINACEAE (Four-o'-Clock Family)			
Boerhavia coccinea Mill.	----------	X	occasional
Bougainvillea glabra Choisey	bougainvillea	X	cultivated
OLEACEAE (Olive Family)			
Fraxinus uhdei (Wenzig) Lingelscheim	tropical ash	X	occasional
OXALIDACEAE (Wood-Sorrel Family)			
Oxalis corniculata L.	wood sorrel	P?	occasional
PASSIFLORACEAE (Passionflower Family)			
Passiflora edulis Sims	passionfruit, liliko'i	X	uncommon
Passiflora foetida L.	love-in-a-mist	X	uncommon
Passiflora laurifolia L.	yellow granadilla	X	uncommon
Passiflora suberosa L.	----------	X	uncommon

Species	Common Names	Status	Abundance
PHYTOLACCACEAE (Pokeweed Family)			
Rivina humilis L.	rouge plant	X	uncommon
PLANTAGINACEAE (Plantain Family)			
Plantago debilis R. Br.	----------	X	occasional
Plantago lanceolata L.	narrow-leafed plantain	X	occasional
PROTACEAE (Protea Family)			
Grevillea robusta A. Cunn. ex R. Br.	silk oak	X	common
ROSACEAE (Rose Family)			
Pyracantha cf. *koidzumii* Rehder	Koidzumi's firethorn	X	abundant
RUBIACEAE (Coffee Family)			
Spermacoce assurgens Ruiz & Pav.	buttonweed	X	uncommon
SAPOTACEAE (Sapodilla Family)			
Chrysophyllum oliviforme L.	satinleaf	X	uncommon
Chrysophyllum cf. *mexicanum* Brandegee	----------	X	abundant
Sideroxylon persimile (W. Hemsley) T.D. Pennington	bumelia	X	uncommon
SOLANACEAE (Nightshade Family)			
Solanum americanum Mill.	black nightshade, popolo	I?	uncommon
Solanum mauritianum Scop.	pua nana honua	X	common
Solanum seaforthianum Andr.	blue potato-vine	X	uncommon
STERCULIACEAE (Cacao Family)			
Waltheria indica L.	ʻuhaloa	I	uncommon
ULMACEAE (Elm Family)			
Trema orientalis (L.) Bl.	gunpowder tree	X	common
URTICACEAE (Nettle Family)			
Pilea microphylla (L.) Liebm.	rockweed	X	uncommon
VERBENACEAE (Verbena Family)			
Lantana camara L.	lantana	X	common
Stachytarpheta jamaicensis (L.) Vahl	Jamaica vervain, oi, owi	X	uncommon
Verbena litoralis Kunth	haʻuoi	X	uncommon

Fig. 3. Roadside of dirt road dominated by Guinea grass.

Fig. 4. Wooded Guinea Grass Pasture on the northeastern part of the study site.

Fig. 5. Dense Guinea Grass Pasture area with scattered koa haole trees.

Fig. 6. Guinea grass dominating former area of cultivation.

Fig. 7. Sparse grassland in area of former recent cultivation.

Fig. 8. Albizzia Woodland on the proposed reservoir site.

Fig. 9. Alien-dominated Forest planted with and dominated by silk oak.

Fig. 10. Alien-dominated Forest along the north side of the road crossing the site.

Fig. 11. Alien-dominated Forest near the south end of the proposed road corridor.

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WAIPIʻO INTERCHANGE BOTANICAL SURVEY LETTER REPORT

Introduction

The study site is located in central Oʻahu near the town of Mililani, just east and northeast of the Waipiʻo Costco store, and comprises about 70 acres. Two adjacent areas were studied by the survey team last year for proposed housing development (Whistler 2007a, 2007b), but the present study area was added to areas needing a botanical survey because interchange modifications centering around the intersection of the H-2 Highway and Ka Uka Blvd. were deemed necessary. The objectives of the current field study were to provide a general description of the vegetation types present at the site (particularly any sensitive types of vegetation that may harbor rare plant species), to make a checklist of all native and naturalized vascular plants found, to search for threatened and endangered species, and to prepare a letter report of the results.

Methodology

After a brief review of the literature, a botanical field survey was conducted at the study site by a two-person botanical team on 22 February 2008. A “walk-thorough survey” was employed, and all plant species encountered were recorded, along with an indication of their frequency. Particular care was taken in areas where native species were most likely to be found (in this case, the canyon). Vascular plant species encountered were incorporated into a checklist for each type of vegetation and each area. All plants recorded were put into a comprehensive checklist for the study site (see Table 1). Notes were also taken on vegetation types present, indicating the dominance and frequency of the plant species found there. These notes were written up to form the vegetation description below.

The Vegetation

Three types of vegetation can be recognized at the study site: (1) Managed Land Vegetation; (2) Guinea Grass Grassland; and (3) Alien-Dominated Forest. These are the same as described in Whistler (2007b) for the adjacent Waiawa development area. These types are often indistinct from each other, since in reality they can blend together, but the categories are useful for descriptive purposes. These vegetation types are all classified as “heavily disturbed vegetation,” and are virtually devoid of native species. The three types are described below.

(1) Managed Land Vegetation

This comprises vegetation on areas under periodic or frequent management, such as roadsides and cultivated areas. At the study site it comprises roadsides, a large storage area on the northwest corner of the proposed intersection, and grassy areas around the on- and off-ramps. Areas that are periodically mowed are dominated by grasses, such as pitted beardgrass (*Bothriochloa pertusa*), goose grass (*Eleusine indica*), and stink grass (*Eragrostis cilianensis*), and dicot herbs, such as false mallow (*Malvastrum coromandelianum*), narrow-leafed plantain (*Plantago lanceolata*), and *Sida ciliaris*. In some places, the pitted beardgrass is entirely dominant, and in others the *Sida ciliaris*. Most of the storage area in what is planned to be the center of an on-ramp circle is mostly barren soil, with scattered weeds providing a light cover. This whole area is surrounded by dense Guinea grass (*Panicum maximum*) vegetation like that described below.

(2) Guinea Grass Grassland

This type of vegetation covers most of the site and is dominated by Guinea grass (*Panicum maximum*). It grows so thick and so tall (up to 7 ft or more) that it often excludes all other herbaceous species. In places, scattered trees and shrubs may also be common, particularly in the southeast corner of the property and on the west-facing slopes on the eastern half of the study site. Koa haole (*Leucaena leucocephala*) shrubs dominate in some places, and in others large ironwood (*Casuarina equisetifolia*), paperbark tree (*Melaleuca quinquenervia*), Formosan koa (*Acacia confusa*), and several other less common tree species form a woodland surrounded by the dense Guinea grass.

(3) Alien-Dominated Forest

This is the forest dominated by alien tree species planted during reforestation projects. It covers much of the eastern half of the study site, particularly on the east-facing slopes. It is dominated by several tree species, including silk oak (*Grevillea robusta*) that towers above the other species, allspice (*Pimenta dioica*), koa haole (*Leucaena leucocephala*), West Indian mahogany (*Swietenia mahagoni*), and *Chrysophyllum* cf. *mexicanum*. The small thorny tree bumelia (*Sideroxylon persimile*) dominates the understory. The forest floor is so shady that it is mostly barren except for seedlings and saplings of the dominant trees. Under breaks in the canopy, however, Guinea grass (*Panicum maximum*) may form patches. Along the stream, kukui (*Aleurites moluccana*) may be locally common.

Flora

The flora recorded at the study site comprises 102 vascular plant species. Only four of these are native, all of them indigenous and common in Hawai‘i. Indigenous plants are species native to a region or place, but are also found elsewhere. Endemic plants are species restricted to a single region or area, i.e., in the case of Hawai‘i, they are found only in Hawai‘i. The majority of the 102 species encountered during the survey are naturalized or weedy “alien” plants that were accidentally or intentionally introduced to Hawai‘i, but which have now become established in the islands and can spread on their own.

Discussion and Conclusions

Three types of vegetation can currently be found at the site: (1) Managed Land Vegetation; (2) Guinea Grass Grassland; (3) Alien-Dominated Forest. All of these are highly disturbed and are poor habitat for native species. No wetlands or native forests are found in the area. The recorded vascular plant flora comprises 102 species, but only four of these are native: popolo (*Solanum americanum*), hau (*Hibiscus tiliaceus*), aʻaliʻi (*Dodonaea viscosa*), and ʻuhaloa (*Waltheria indica*). All four are wide-ranging and common indigenous species. No federally listed threatened or endangered species (USFWS 2005) have been recorded from the area nor are any recorded on the map of endangered species for the area (Anon. 2005) because of the highly disturbed nature of the vegetation present.

Because of the absence of sensitive types of vegetation and threatened or endangered plant species, there is little of botanical interest at the site. Consequently there are no botanical reasons why development of the parcel cannot take place and proposed. All of the proposed construction would be in very disturbed vegetation.

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Table 1. Waipiʻo interchange study area plant checklist

The following is a checklist of the vascular plants inventoried during the botanical survey at the Waipiʻo interchange study area. The plants are divided into two groups: Monocots, and Dicots. Within these groups, the species are presented taxonomically by family, with each family and each species in the family in alphabetical order. The taxonomy and nomenclature of the flowering plants (Monocots and Dicots) follow Wagner *et al*. (1999). In most cases, common English and/or Hawaiian names listed here have been taken from St. John (1973) or Porter (1972).

For each species, the following information is provided:

1. Scientific name with author citation.
2. Common English and/or Hawaiian name, when known.
3. Biogeographic status. The following symbols are used:
   E = endemic (found only in Hawaiʻi).
   I = indigenous (native to Hawaiʻi as well as other geographic areas).
   P = Polynesian introduction (introduced to Hawaiʻi by Polynesians before the advent of the Europeans).
   X = Introduced or alien (not native, introduced to Hawaiʻi, either accidentally or intentionally, after the advent of the Europeans).
4. Abundance (abundant, locally common, common, occasional, uncommon, or cultivated).

Species	Common Names	Status	Abundance
MONOCOTS			
ARACEAE (Arum Family)			
Alocasia macrorrhiza (L.) Schott	ʻape	P	uncommon
CYPERACEAE (Sedge Family)			
Cyperus rotundus L.	nutgrass	X	occasional
POACEAE (Grass Family)			
Bothriochloa pertusa (L.) A. Camus	pitted beardgrass	X	locally common
Cenchrus echinatus L.	sandbur	X	uncommon
Cenchrus ciliaris L.	Buffel grass	X	occasional
Chloris barbata (L.) Sw.	swollen fingergrass	X	occasional
Cynodon dactylon (L.) Pers.	Bermuda grass	X	occasional
Dactyloctenium aegyptium (L.) Willd.	beach wiregrass	X	uncommon
Digitaria insularis (L.) Mez ex Ekman	sour grass	X	uncommon
Eleusine indica (L.) Gaertn.	goose grass	X	common
Eragrostis cilianensis (All.) Link	stink grass	X	occasional
Panicum maximum Jacq.	Guinea grass	X	abundant
Paspalum fimbriatum Kunth	fimbriate paspalum	X	uncommon
Rhynchelytrum repens (Willd.) C.E. Hubb.	Natal redtop	X	occasional

Species	Common Names	Status	Abundance
DICOTS			
ACANTHACEAE (Acanthus Family)			
Asystasia gangetica (L.) T. Anderson	Chinese violet	X	uncommon
Ruellia graecizans Backer	----------	X	uncommon
AMARANTHACEAE (Amaranth Family)			
Alternanthera pungens Kunth	khaki weed	X	uncommon
Amaranthus spinosus L.	spiny amaranth	X	occasional
Amaranthus viridis L.	slender amaranth	X	uncommon
Gomphrena celosioides Mart.	weedy gomphrena	X	occasional
ANACARDIACEAE (Mango Family)			
Schinus terebinthifolius Raddi	Christmas berry	X	uncommon
ASTERACEAE (Sunflower Family)			
Ageratum conyzoides L.	ageratum	X	uncommon
Bidens alba (L.) DC.	beggar's-tick	X	occasional
Bidens pilosa L.	beggar's-tick	X	uncommon
Calyptcarpus vialis Less.	hierba del cabello	X	occasional
Emilia fosbergii Nicolson	red pualele, emilia	X	common
Pluchea carolinensis (Jacq.) G. Don	pluchea	X	occasional
Sonchus oleraceus L.	sow thistle	X	occasional
Tridax procumbens L.	coat buttons	X	common
Verbesina encelioides(Cav.) Benth. & Hook.	golden crownbeard	X	uncommon
BASSELACEAE (Madeira Vine Family)			
Anredera cordifolia (Ten.) Steenis	Madeira vine	X	uncommon
BIGNONIACEAE (Bignonia Family)			
Spathodea campanulata P. Beauv.	African tulip tree	X	occasional
BORAGINACEAE (Heliotrope Family)			
Heliotropium procumbens Mill.	weedy heliotrope	X	occasional
BRASSICACEAE (Mustard Family)			
Coronopus didymus (L.) Sm.	swine cress	X	uncommon
Lepidium virginicum L.	wild peppergrass	X	uncommon
CASUARINACEAE (Ironwood Family)			
Casuarina equisetifolia L.	ironwood	X	common
CONVOLVULACEAE (Morning-Glory Family)			
Ipomoea obscura (L.) Ker-Gawl.	bindweed	X	occasional
Ipomoea ochracea (Lindl.) G. Don	----------	X	uncommon
Ipomoea triloba L.	pink bindweed	X	occasional
Merremia tuberosa (L.) Rendle	wood rose	X	uncommon
CRASSULACEAE (Stonecrop Family)			
Kalanchoë pinnata (Lam.) Pers.	air plant	X	uncommon
CUCURBITACEAE (Gourd Family)			
Coccinea grandis (L.) Voigt	ivy gourd	X	uncommon
Momordica charantia L.	wild bittermelon	X	uncommon

Species Common Names Status

EUPHORBIACEAE (Spurge Family)			
Aleurites moluccana (L.) Willd.	candlenut, kukui	P	occasional
Chamaesyce hirta (L.) Millsp.	garden spurge	X	occasional
Chamaesyce hypericifolia (L.) Millsp. Croizat & Degener	graceful spurge	X	occasional
Chamaesyce prostrata (Aiton) Small	prostrate spurge	X	uncommon
Euphorbia tirucalli L.	pencil tree	X	cultivated
Macaranga tanarius (L.) Muell. Arg.	----------	X	uncommon
Ricinus communis L.	castor bean	X	occasional
FABACEAE (Pea Family)			
Acacia confusa Merr.	Formosan koa	X	common
Arachis pintoi Krapovikas & Gregory	golden glory	X	cultivated
Cassia x*nealii* Irwin and Barneby	rainbow shower	X	cultivated
Chamaecrista nictitans (L.) Moench	partridge pea, lau-ki	X	occasional
Crotalaria pallida Aiton	smooth rattlepod	X	occasional
Desmanthus pernambucanus (L.) Thellung	virgate mimosa	X	occasional
Desmodium tortuosum (Sw.) DC.	Florida beggarweed	X	uncommon
Glycine wightii (Wight & Arn.) Verdc.	----------	X	locally common
Indigofera suffruticosa Mill.	indigo, ‘iniko	X	occasional
Leucaena leucocephala (Lam.) de Wit	koa haole	X	abundant
Macroptilium atropurpureum (DC) Urb.	wild bushbean	X	occasional
Medicago lupulina L.	black medic	X	uncommon
Mimosa pudica L.	sensitive plant	X	uncommon
Paraserianthes falcataria (L.) I. Nielsen	albizzia	X	occasional
Pithecellobium dulce (Roxb.) Benth.	‘opiuma, Manila tamarind	X	uncommon
Prosopis pallida (Humb. & Bonpl.ex Willd.) Kunth	kiawe, mesquite	X	uncommon
Senna surattensis (Burm.) Irwin & Barneby	kolomona	X	uncommon
MALVACEAE (Mallow Family)			
Abutilon grandifolium (Willd.) Sweet	hairy abutilon	X	uncommon
Hibiscus rosa-sinensis L.	hibiscus	X	cultivated
Hibiscus tiliaceus L.	beach hibiscus, hau	I	uncommon
Malvastrum coromandelianum (L.) Garcke	false mallow	X	uncommon
Sida ciliaris L.	----------	X	locally common
Sida spinosa L.	prickly sida	X	uncommon
Sidastrum micranthum (St. Hil.) Fryx.	sand mallow	X	uncommon
MELASTOMATACEAE (Melastoma Family)			
Clidemia hirta (L.) D. Don	Koster’s curse	X	uncommon
MELIACEAE (Mahogany Family)			
Swietenia mahagoni (L.) W. Jacq.	West Indian mahogany	X	uncommon

Species	Common Names	Status	

MYRTACEAE (Myrtle Family)			
Melaleuca quinquenervia (Cav.) Blake	paperbark tree	X	common
Eucalyptus robusta Sm.	swamp mahogany	X	uncommon
Pimenta dioica (L.) Merr.	allspice	X	common
Psidium guajava L.	guava	X	uncommon
Syzygium cumini (L.) Skeels	Java plum	X	common
NYCTAGINACEAE (Four-o'-Clock Family)			
Boerhavia coccinea Mill.	----------	X	occasional
Bougainvillea x*buttiana* *Holttum & Standley*	bougainvillea	X	cultivated
OXALIDACEAE (Wood-Sorrel Family)			
Oxalis corniculata L.	wood sorrel	P	occasional
Oxalis debilis Kunth	pink wood-sorrel	X	uncommon
PASSIFLORACEAE (Passionflower Family)			
Passiflora suberosa L.	----------	X	uncommon
PHYTOLACCACEAE (Pokeweed Family)			
Rivina humilis L.	rouge plant	X	occasional
PLANTAGINACEAE (Plantain Family)			
Plantago lanceolata L.	narrow-leafed plantain	X	common
PORTULACACEAE (Purslane Family)			
Portulaca oleracea L.	common purslane	X	occasional
PROTACEAE (Protea Family)			
Grevillea robusta A. Cunn. ex R. Br.	silk oak	X	common
SAPINDACEAE (Soapberry Family)			
Dodonaea viscosa Jacq.	‘a‘ali‘i	I	uncommon
SAPOTACEAE (Sapodilla Family)			
Chrysophyllum oliviforme L.	satinleaf	X	uncommon
Chrysophyllum cf. *mexicanum* Brandegee	----------	X	uncommon
Sideroxylon persimile (W. Hemsley) T.D. Pennington	bumelia	X	common
SOLANACEAE (Nightshade Family)			
Lycopersicon pimpinellifolium (Jusl.) Mill.	currant tomato	X	uncommon
Nicotiana glauca R. C. Graham	tree tobacco	X	uncommon
Solanum americanum Mill.	black nightshade, popolo	I?	uncommon
Solanum seaforthianum Andr.	blue potato-vine	X	uncommon
STERCULIACEAE (Cacao Family)			
Waltheria indica L.	‘uhaloa	I	uncommon
URTICACEAE (Nettle Family)			
Pilea microphylla (L.) Liebm.	rockweed	X	uncommon
VERBENACEAE (Verbena Family)			
Lantana camara L.	lantana	X	occasional
Stachytarpheta jamaicensis (L.) Vahl	Jamaica vervain, oi, owi	X	uncommon

D | Faunal Studies

A Survey of Avian and Mammalian Resources for the Proposed Castle & Cooke Homes Hawaii, Inc. Koa Ridge Makai, Master Planned Community, ‘Ewa District, O‘ahu, Hawai‘i.

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Table of Contents

Figures & Tables

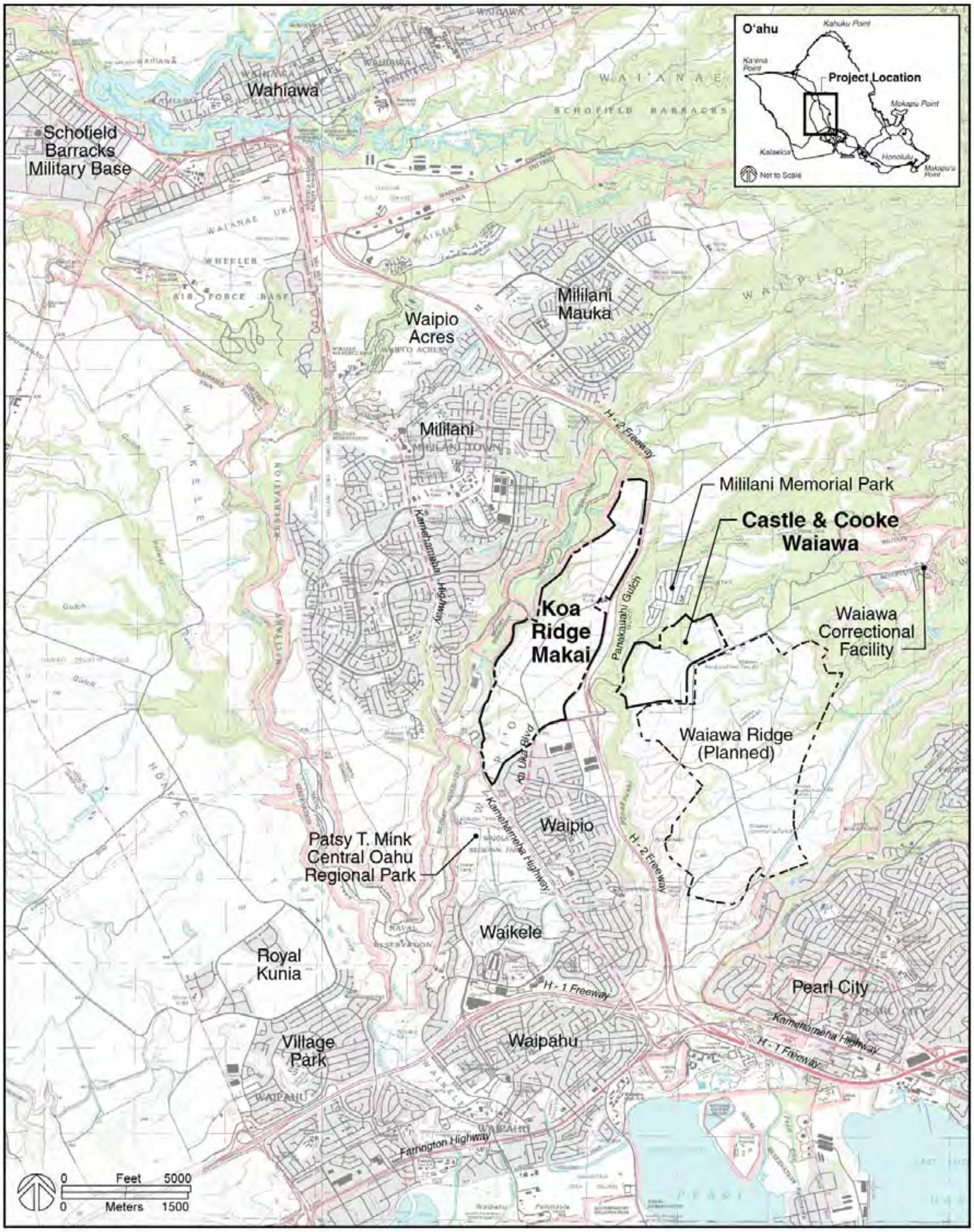
Introduction

Castle & Cooke Homes Hawaii, Inc. is proposing to develop a residential community on approximately 575-acres in Waiawa, ʻEwa District, Oʻahu, on lands identified as TMK (1) 9-4-06: 038, portions. 001, 002, 005, 039; and (1) 9-5-03: portions 001 and 004 (Figure 1). The proposed development, here forth called Koa Ridge Makai, will be a master planned community that will include residential, commercial, light industrial, and medical and health care components, with an integrated mixed-use village center. The residential component of the master plan is proposed to include the development of approximately 3,500 single-and multi-family homes, and sites for parks, recreation centers, schools, and neighborhood and community commercial development to serve the residents and surrounding region. The health care component will provide a range of medical and health care services potentially including a hospital, skilled nursing, physicians' offices, diagnostic and treatment facilities, and other specialized centers. The project also includes four potential off-site drainage detention basin sites and an additional drainage feature in Kīpapa Gulch, as well as associated access and staging areas (Figure 2). The proposal also includes an approximately 5,800-meter long off-site trunk sewer alignment extending from the southwest corner of Koa Ridge Makai to the Waipahu Wastewater Pump Station and a new H-2 Freeway interchange at the north end of the main Koa Ridge Makai site. The survey of avian and mammalian resources was limited to approximately 1700-meters of the proposed sewer line alignment along the western boundary of the Central Oahu Regional Park (CORP) (Figure 3), because the balance of the sewer alignment south of the CORP runs along various roads located in an area that is fully urbanized/developed.

This report summarizes the findings of the avian and mammalian surveys that were conducted on the subject parcels to determine the potential effects of the proposed development on biological resources present on the site and within the general project area. A primary goal of the surveys was to determine if there were any avian or mammalian species currently listed as endangered, threatened, or proposed for listing under either Federal or State of Hawaii endangered species statutes on, or immediately adjacent to the subject properties. Listed species status follows species identified in the following referenced documents (Department of Land and Natural Resources (DLNR) 1998, Federal Register 2005, U. S. Fish & Wildlife Service (USFWS) 2005, 2007). Fieldwork was conducted between August 25 and August 31, 2008.

The avian phylogenetic order and nomenclature used in this report follows *The American Ornithologists' Union Checklist of North American Birds 7th Edition* (American Ornithologists' Union 1998), and the 42nd through the 49th supplements to *Check-list of North American Birds* (American Ornithologists' Union 2000; Banks et al. 2002, 2003, 2004, 2005, 2006, 2007, 2008). Mammal scientific names follow *Mammals in Hawaii* (Tomich 1986). Plant names follow *Manual of the Flowering Plants of Hawaiʻi* (Wagner et al. and Wagner and Herbst, 1990, 1999). Place names follow *Place Names of Hawaii* (Pukui et al., 1974).

Hawaiian and scientific names are italicized in the text. A glossary of technical terms and acronyms used in the document, which may be unfamiliar to the reader, are included at the end of the narrative text on Page 18.



Location Map

Figure 1-1

KOA RIDGE MAKAI and WAIAWA DEVELOPMENT
CASTLE & COOKE HOMES HAWAII, INC.

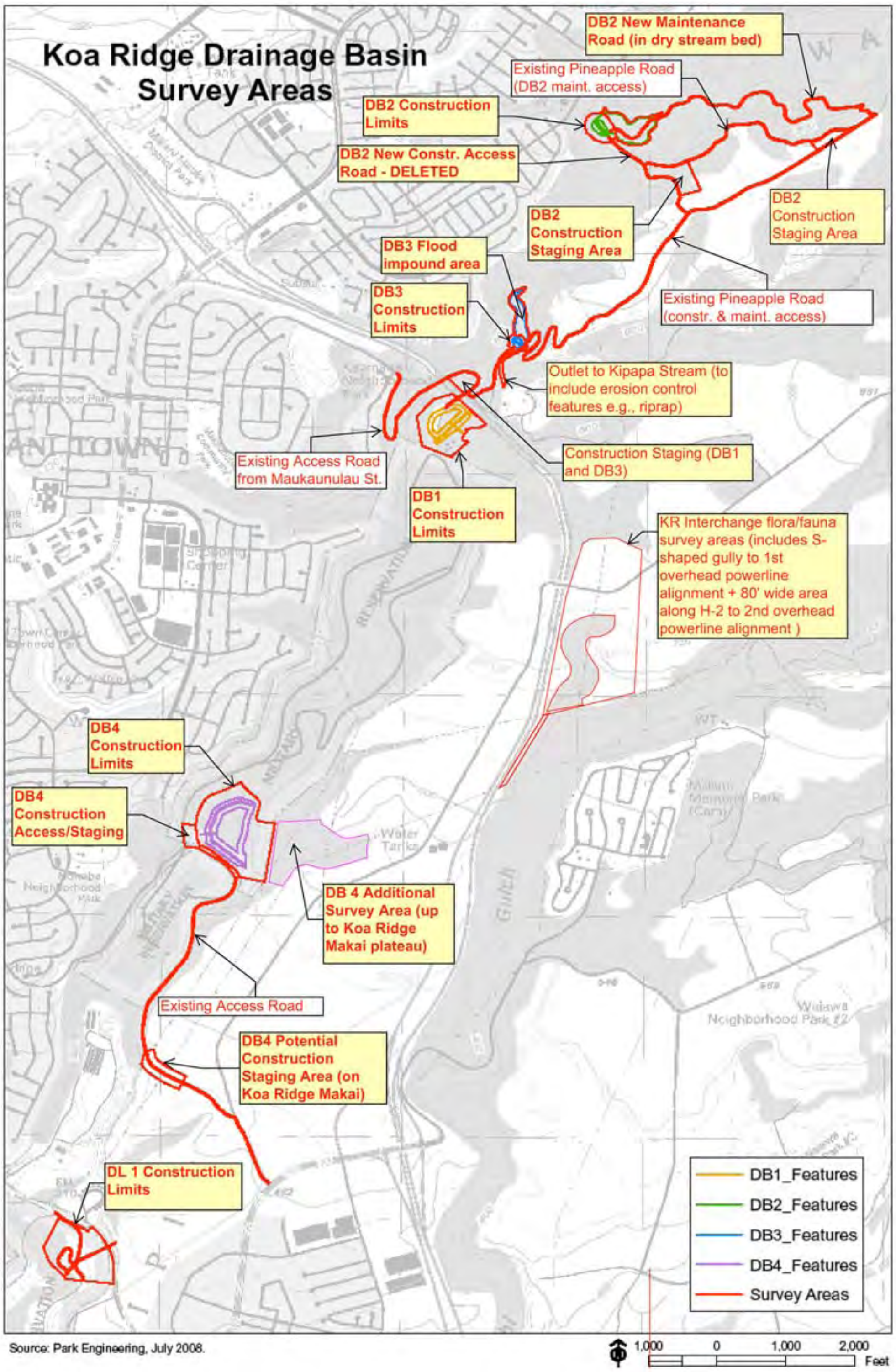


Figure 2 Proposed Koa Ridge Makai Off-site Infrastructure Improvements

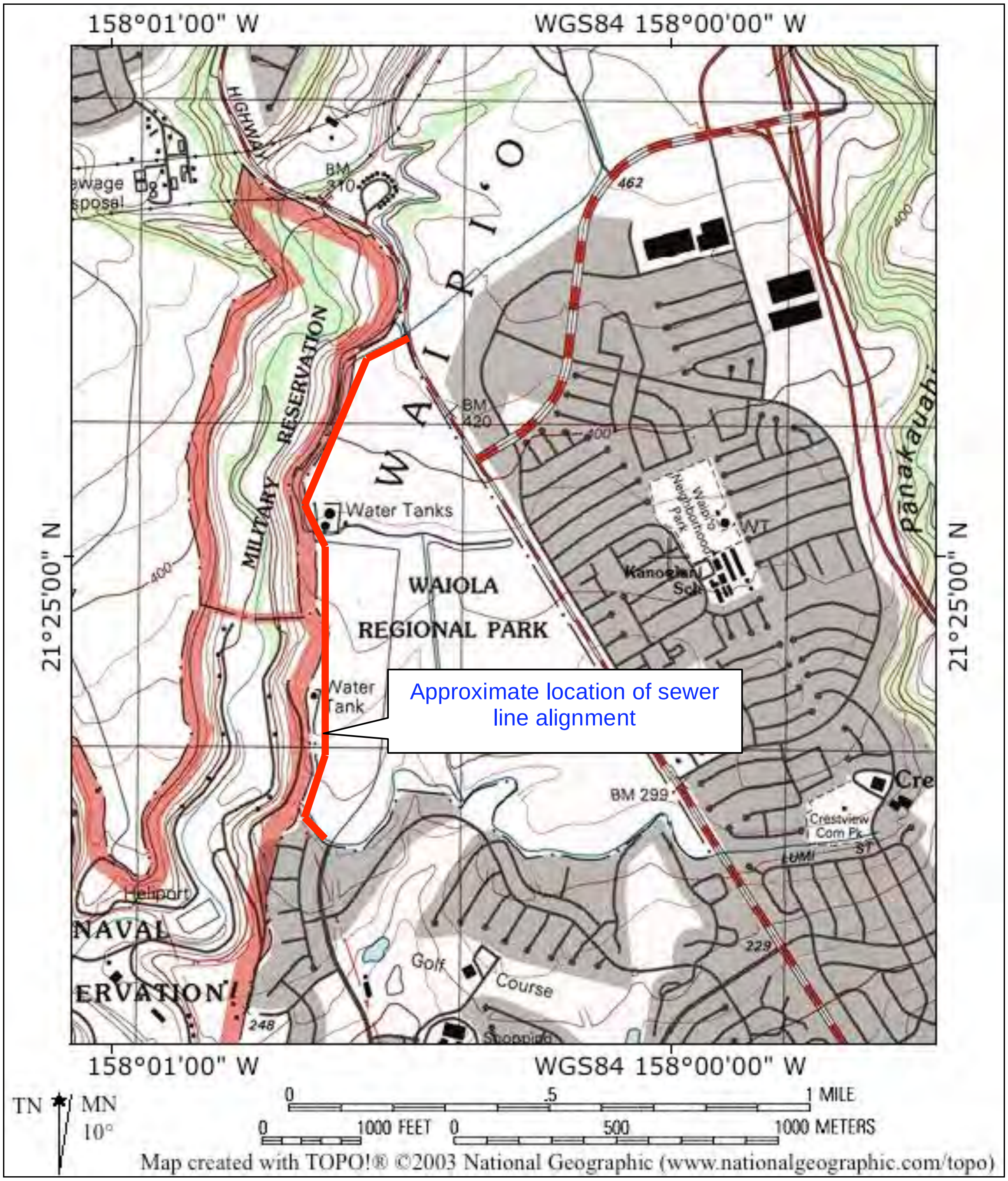


Figure 3 - Portion of proposed sewer line alignment surveyed

General Site Descriptions

Koa Ridge Makai "Main Site"

The primary development area covers approximately 575-acres of land. This main site is located west of the H-2 Freeway, and immediately northwest of the Waipiʻo Interchange (Figure 1). The main site is bound to the south by Ka Uka Boulevard and the Gentry Waipiʻo Business Park, and by the Central Oahu Regional Park, Kamehameha Highway and Kīpapa Gulch to the west and north. Approximately four acres of land bordering the west side of the H-2 Freeway, in the middle of the site, are occupied by two City and County of Honolulu-owned water storage tanks (Figure 1). The main development site was previously used for pineapple cultivation; much of that area now lies fallow (Figure 4). Almost all of the land is currently being leased by Dole Food Company Hawaiʻi and subleased to a tenant who cultivates a mix of diversified agricultural crops. Areas not under cultivation are vacant and predominantly vegetated with a mix of weedy species, open mixed scrub, and a variety of grasses (Figure 5). Approximately 3.5 acres at the southern end are adjacent to the Waipiʻo Business Park are leased to the Ironworkers Union for training. A portion of the Waiāhole Ditch system traverses in an east-west direction within the northern portion of the Koa Ridge Makai site.

Sewer Line Alignment

The proposed 5,800-meter long off-site sewer line alignment runs south from the main site, through the Central Oahu Regional Park, and into the Waikele Subdivision, and from their south, crossing the H-1 Freeway, and ultimately terminating at the Waipahu wastewater pumping station located south of Farrington Highway and east of Waipahu Depot Road. The portion of the sewer line that goes through non-paved areas extends approximately 1700-meters along the western boundary of the Central Oahu Regional Park. The vegetation along the sewer route in the park is composed of manicured lawns, and ruderal areas dominated by Guinea grass (*Panicum maximum*), and *kiawe* (*Prosopis pallida*) along Kīpapa Gulch (Figure 6). The southern approximately 4000-meters of the sewer line alignment was not surveyed since this portion of the alignment runs through a highly urbanized/developed area.

Drainage Improvements and Associated Features

The potential off-site drainage improvements are depicted in Figure 2. They include four potential detention basins (DB 1 – DB 4) and a drain line site (DL-1), described here from south to north. The southernmost feature "DL-1," is located in a former military facility, and is located in Kīpapa Gulch southwest of the main site and adjacent to Kamehameha Highway. The habitats within this site include a dry streambed, and a paved roadway that bisects a secondary growth forest and shrubby ruderal vegetation. Drainage feature "DB-4" is a proposed detention basin and associated access road, which is located on Army lands within the Kīpapa Military Reservation. It is accessible via an existing access road which extends from Ka Uka Boulevard across the main site and down into the floor of Kīpapa Gulch. Vegetation within this site is a mix of Guinea grass and *kiawe* grassland and a mixed species alien dominated forest. Site "DB-1" is a proposed detention basin located immediately west of the H-2 Freeway, which actually crosses over part of this site. There is a partially paved road down into the site off, of Maukaunalau Street in the Mililani Subdivision. Habitat within this site includes small-diversified agricultural crops and hillsides of mixed Guinea grass and Albizia (*Albizia moluccana*) trees (Figure 7). Sites "DB-3" and "DB-2" are both located off of the existing unpaved access road leading to Kīpapa Ridge.

Figure 4 Main Site, showing diversified agricultural crops and fallow fields

Figure 5 Guinea grass and Albizia trees typical of the currently uncultivated areas

Figure 6 Central Oahu Community Park showing lawns and ruderal areas along Kīpapa Gulch looking north along the sewer line alignment

Figure 7 Guinea grass and Albizia forest, in this case located in "DB-1"

Vegetation in these two sites and along the proposed access corridor is a mix of dense ravine forest and Guinea grass and Albizia trees. The vegetation in the two construction staging areas associated with site "DB-2," is similar in composition to the vegetation found within the general vicinity of site "DB-2'.

In addition to the proposed offsite drainage improvements, the proposal also includes a new Koa Ridge H-2 Freeway interchange at the north end of the main site (Figure 2). The survey area is located immediately east of the H-2 Freeway and includes a dirt road that extends some 600-meters south along the edge of the Freeway. The habitat present on the bulk of this site is currently being used for cattle pasturage (Figure 8), and there is also a wooded "S" shaped ravine in the southwestern corner of this site (Figure 9).

Mammalian Survey Methods

All observations of mammalian species were of an incidental nature. With the exception of the endangered Hawaiian hoary bat (*Lasiurus cinereus semotus*), or *ʻōpeʻapeʻa* as it is known locally, all terrestrial mammals currently found on the Island of Oʻahu are alien species, and most are ubiquitous. Two hours were spent within the project area on the evenings of August 25 through August 30, 2008, and again in the early morning hours of August 26 through August 31, 2008, in an attempt to detect Hawaiian hoary bats. The survey of mammals was limited to visual and auditory detection, coupled with visual observation of scat, tracks, and other animal signs. A running tally was kept of all vertebrate species observed and heard within the study area. The mammalian surveys were conducted in August, a time of year when all of the mammalian species resident on the island of Oʻahu can be expected to be detected if present within the areas surveyed.

Mammalian Survey Results

Six mammalian species were detected within the project sites all of which are considered to be alien to the Hawaiian Islands (Table 1). Domestic dogs (*Canis f. familiaris*) were seen within the Koa Ridge Makai main project area and several others were heard barking from outside the study area. Additionally, dogs were heard and/or seen along the sewer line alignment, and within the "DB-4" "DB-1 and DB-3" study areas and were heard in "DB-2". Several small Indian mongooses (*Herpestes a. auropunctatus*) were seen within the Koa Ridge Makai main site, as were two cats (*Felis catus*). A total of seven pigs (*Sus s. scrofa*) were seen along the western edge of the main site and within the "DB-4" study area. Domestic cattle (*Bos taurus*) were seen in "KR-Interchange" site, as was one horse (*Equus c. caballus*). Additionally, tracks, scat and sign of dog, mongoose, and cat were observed in all of the sites surveyed.

The endangered Hawaiian hoary bat was not recorded during the course of this survey. This finding is not surprising given that this species has rarely been documented from the Island of Oʻahu (Tomich 1986, USFWS 1998, David 2008a).

Figure 8 Cattle pasturage in site “KR Interchange”

Figure 9 Typical ravine forest dominated by alien species this is in site “KR Interchange”

Table 1. Mammalian Species Detected on the Koa Ridge Makai Sites			
Common name	*Scientific name*	***ST***	***DT***
	CARNIVORA- FLESH EATERS		
	Canidae – Wolves, Jackals & Allies		
Domestic dog	*Canis f. familiaris*	A	A,V, S
	Viverridae – Civets & Allies		
Small Indian mongoose	*Herpestes a. auropunctatus*	A	V,S
	Felidae- Cats		
House cat	*Felis catus*	A	V,S
	PERISSODACTYLA – ODD-TOED UNGULATES		
	Equidae – Horses, Asses & Zebras		
Domestic horse	*Equus c. caballus*	A	A,V,S
	ATRIODACTYLA – EVEN-TOED UNGULATES		
	Suicidae - Old World Swine		
Pig	*Sus s. scrofa*	A	A,V,S
	Bovidae - Hollow-horned Ruminants		
Domestic cattle	*Bos taurus*	A	V,S

KEY TO TABLE 1

ST Status

A Alien – introduced to the Hawaiian Islands by humans

DT Detection Type

V Visual observation – animal seen by the field observer

A Audio detection – animal heard by the field observer

S Sign – animal scat, tracks and sign seen by field observer

Avian Survey Methods

52-avian count stations were sited along linear transects running the length of the Koa Ridge main development site as well as through each of the proposed drainage improvement areas, and along approximately 1700-meters of the sewer line alignment that runs through the Central Oahu Regional Park. Six-minute point counts were made at each of the avian count stations. Field observations were made using Leitz 10 X 42 binoculars and by listening for avian vocalizations. Counts took place between 06:30 a.m. and 11:00 a.m., the peak of daily bird activity. An additional two hours was spent within the project area on the evenings of evenings of August 25 through August 30, 2008, and again in the early morning hours of August 26 through August 31, 2008, in an attempt to detect crepuscular and/or nocturnally flying seabirds and owls. Time not spent conducting station counts was used to search the subject properties for species and habitats not detected during count sessions. August is an ideal time to conduct avian surveys in the lowlands of the island of Oʻahu as all of the resident birds are present, as are the migratory shorebirds that are present within the state between late July and the end of April each year.

Avian Survey Results

A total of 2151 individual birds, of 27 different avian species, representing 19 separate families were recorded during station counts. These results are summarized in Table 2. One of the species recorded, Pacific Golden-Plover (*Pluvialis fulva*), is an indigenous migratory shorebird species. Pacific Golden-Plover breed in the high Arctic, and spend their winters in Hawai‘i and the tropical Pacific. The remaining 26 species detected are considered to be alien to the Hawaiian Islands (Table 2).

Avian diversity and densities were in keeping with the habitat and location of the study sites. Four species, Common Waxbill (*Estrilda astrild*), Red-vented Bulbul (*Pycnonotus cafer*), Zebra Dove (*Geopilia striata*), and Japanese White-eye (*Zosterops japonicus*), accounted for 47% of the total number of individual birds recorded. Common Waxbills were the most frequently recorded species, accounting for 18% of the total number of individual birds recorded during station counts. We recorded an average of 41 birds per station count.

Table 1. Avian Species Detected on the Koa Ridge Makai Sites

Common Name	*Scientific Name*	*ST*	*RA*
	GALLIFORMES		
	PHASIANIDAE - Pheasants & Partridges		
	Phasianinae - Pheasants & Allies		
Gray Francolin	*Francolinus pondicerianus*	A	0.54
Red Junglefowl	*Gallus gallus*	A	0.27
	ODONTOPHORIDAE - New World Quail		
California Quail	*Callipepla californica*	A	0.02
	CICONIIFORMES		
	ARDEIDAE - Herons, Bitterns & Allies		
Cattle Egret	*Bubulcus ibis*	A	0.29
	CHARADRIIFORMES		
	CHARADRIIDAE - Lapwings & Plovers		
	Charadriinae - Plovers		
Pacific Golden-Plover	*Pluvialis fulva*	IM	0.62
	COLUMBIFORMES		
	COLUMBIDAE - Pigeons & Doves		
Spotted Dove	*Streptopelia chinensis*	A	2.06
Zebra Dove	*Geopelia striata*	A	3.87

Table 2 continued

Common Name	*Scientific Name*	*ST*	*RA*
	PSITTACIFORMES		
	PSITTACIDAE - Lories Parakeets, Macaws & Parrots		
	Psittacinae - Typical Parrots		
Rose-ringed Parakeet	*Psittacula krameri*	A	0.06
	Arinae - New World Parakeets, Macaws & Parrots		
Red-crowned Parrot	*Amazona viridigenalis*	A	0.65
	PASSERIFORMES		
	ALAUDIDAE - Larks		
Sky Lark	*Alauda arvensis*	A	0.02
	PYCNONOTIDAE - Bulbuls		
Red-vented Bulbul	*Pycnonotus cafer*	A	4.31
Red-whiskered Bulbul	*Pycnonotus jocosus*	A	1.40
	SYLVIIDAE - Old World Warblers & Gnatcatchers		
	Sylviinae - Old World Warblers		
Japanese Bush-Warbler	*Cettia diphone*	A	0.38
	TURDIDAE - Thrushes		
White-rumped Shama	*Copsychus malabaricus*	A	0.52
	TIMALIIDAE - Babblers		
Hwamei	*Garrulax canorus*	A	0.40
	ZOSTEROPIDAE - White-Eyes		
Japanese White-eye	*Zosterops japonicus*	A	3.77
	MIMIDAE - Mockingbirds & Thrushes		
Northern Mockingbird	*Mimus polyglottos*	A	0.02
	STURNIDAE - Starlings		
Common Myna	*Acridotheres tristis*	A	3.46
	EMBERIZIDAE - Emberizids		
Saffron Finch	*Sicalis flaveola*	A	0.08
Red-crested Cardinal	*Paroaria coronata*	A	1.21
	CARDINALIDAE - Cardinals Saltators & Allies		
Northern Cardinal	*Cardinalis cardinalis*	A	1.06
	FRINGILLIDAE - Fringilline And Cardueline Finches & Allies		
	Carduelinae - Carduline Finches		
House Finch	*Carpodacus mexicanus*	A	2.94
	PASSERIDAE - Old World Sparrows		
House Sparrow	*Passer domesticus*	A	0.46
	ESTRILDIDAE - Estrildid Finches		
	Estrildinae - Estrildine Finches		
Common Waxbill	*Estrilda astrild*	A	7.33
Nutmeg Mannikin	*Lonchura punctulata*	A	0.52
Chestnut Munia	*Lonchura atricapilla*	A	3.27

Table 2 continued

Common Name	*Scientific Name*	*ST*	*RA*
Java Sparrow	*Padda oryzivora*	A	1.85

KEY TO TABLE 1

ST Status

A Alien – introduced to the Hawaiian Islands by humans

IM Indigenous Migrant – a native migratory species that winters in Hawai‘i but breeds elsewhere

RA Relative Abundance – number of birds detected divided by the number of count stations (52)

Discussion

The habitat present within the main development parcel, and within, and adjacent to the sewer line alignment and the proposed drainage improvements is predominately alien in its makeup. During the course of the botanical surveys of the projects sites a total of 223 species of plant species were identified, of these only six *koa* (*Acacia koa*), *‘ōhi‘a lehua* (*Metrosideros polymorpha*), *pā‘ūohi‘iaka* (*Jacquemontia ovalifolia*), *pōpolo* (*Solanum americanum*), *‘uhaloa* (*Waltheria indica*), and *‘ilima* (*Sida fallax*) are considered to native species, and only two of these, *koa* and *‘ōhi‘a lehua* are considered to be endemic to the Hawaiian Islands (Whistler 2007, 2008). The findings of the faunal surveys paint a similar picture, in that we recorded a total of six mammalian and 27 avian species, only one of which, Pacific Golden-Plover is a native, albeit migratory avian species.

Mammalian Resources

The findings of the mammalian survey are consistent with the findings of at least two other surveys conducted on portions of the same sites (Funk 1996, 1999), as well as with two recent surveys conducted on lands adjacent to, or close to these sites (David 2008b, 2008c), and with several others faunal surveys conducted in the general vicinity of the subject property in the recent past (David and Guinther 2000, 2006, David 2007a, 2007b, 2007c, 2007d, 2007e, 2007f). Our findings were more similar to the results of the two surveys conducted by the author on lands close to these sites (David 2008b, 2008c) than with those conducted by Funk in 1996 and 1999. This is likely due to the change in land usage in the general project area over the intervening years.

Although we did not detect any rodents on any of the sites it is probable that all four established *muridae* known from O‘ahu, European house mice (*Mus musculus domesticus*), roof rats (*Rattus r. rattus*), Norway rats (*Rattus norvegicus*), and Polynesian rats (*Rattus exulans hawaiiensis*), use resources within the project sites on occasion. These commensal species are all but ubiquitous on the island of O‘ahu. All of these introduced rodents are deleterious to remaining native ecosystems and the native floral and faunal species that are dependant on them for their survival.

As previously mentioned we did not detect the endangered Hawaiian hoary bat during the course of these surveys, this is not particularly surprising as bats have rarely been documented from the Island of O‘ahu (Tomich 1986, USFWS 1998, David 2008a). Though there is one reported sighting of a bat recorded in 1991 in the Hawaiʻi Natural Heritage Database from a location approximately 2.75 kilometers west of the main project site, whether this 17-year old record is legitimate is not known (Anon 2005). The author has never recorded a bat of any species on the island of Oʻahu in the course of over 20 years of fieldwork conducted on this island.

Avian Resources

The findings of the avian survey are consistent with the findings of at least two other surveys conducted on portions of the same sites (Funk 1996, 1999), as well as with two recent surveys conducted on lands adjacent to, or close to these sites (David 2008b, 2008c), and with several others faunal surveys conducted in the general vicinity of the subject property in the recent past (David and Guinther 2000, 2006, David 2007a, 2007b, 2007c, 2007d, 2007e, 2007f). Our findings were more similar to the results of the two surveys conducted by the author on lands close to these sites (David 2008b, 2008c) than with those conducted by Funk in 1996 and 1999, this is likely due to the change in land usage in the general project area over the intervening years.

A previously mentioned only one of the 27 avian species recorded during the course of this survey is a native species. This species, Pacific Golden-Plover is an indigenous migratory shorebird species that breeds in the high Arctic and spends the winter months in Hawaiʻi and the Tropical Pacific. Plover are readily seen throughout the Hawaiian Islands between late July and the end of April. The remaining 26-species detected are considered to be alien to the Hawaiian Islands (Table 2).

Although not detected during this survey, it is likely that the Hawaiian endemic sub-species of the Short-eared Owl *(Asio flammeus sandwichensis*), or *pueo* use resources within the general project area occasionally. This species is regularly seen along the Waiʻanae coast from the Lualualei Naval Reservation to Waimānalo Gulch (David 2007g). The Oʻahu population of the short-eared Owl is listed as an endangered species under the State of Hawaiʻi's endangered species program, though; it is not protected under the federal endangered species statutes (DLNR 1998).

From a native avian and mammalian perspective there is nothing unique about the habitat present within any of the project parcels, and none of the habitat is important habitat for any listed avian or mammalian species currently known from the Island of Oʻahu.

Critical Habitat

There is no federally designated Critical Habitat for any avian or mammalian species on, or adjacent to any of the parcels of land associate with this proposed development.

Conclusions

It is not expected that the modification of the habitat currently found within any of the project sites or the development of any of the sites will have a negative impact on any avian or mammalian species currently listed as endangered, threatened, or any that are currently proposed for listing under either Federal or State of Hawaiʻi endangered species statutes. The proposed action will not result in modification of any federally designated Critical Habitat, as there is none present on the subject property.

Glossary

Alien - Introduced to Hawaiʻi by humans
Commensal - Animals that share human food such as rats and mice
Crepuscular – Twilight hours
Endangered – Listed and protected under the ESA as an endangered species
Endemic – Native and unique to the Hawaiian Islands
Indigenous - Native to the Hawaiian Islands, but also found elsewhere naturally
Muridae - Rodents, including rats, mice and voles, one of the most diverse families of mammals.
Nocturnal – Night-time, after dark
ʻōpeʻapeʻa – Hawaiian hoary bat (*Lasiurus cinereus semotus*)
pueo – Hawaiian endemic cub-species of the Short-eared Owl (*Asio flammeus sandwichensis*)
Ruderal – Disturbed, rocky, rubbishy areas, such as old agricultural fields and rock piles
Threatened - Listed and protected under the ESA as a threatened species

DLNR – Hawaii State Department of Land & Natural Resources
TMK – Tax Map Key
USFWS – U.S. Fish & Wildlife Service

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September 11, 2007

Table of Contents

Figures & Tables

Introduction

Castle & Cooke Hawaii is proposing to develop a master planned residential community on approximately 191-acres of land in Waiawa, ‘Ewa District, O‘ahu (Figure 1). This report summarizes the findings of the avian and mammalian surveys that were conducted on the subject property to determine the potential effects of the proposed development on biological resources present on the site and within the general project area.

A primary goal of the surveys was to determine if there were any avian or mammalian species currently listed as endangered, threatened, or proposed for listing under either Federal or State of Hawaii endangered species statutes on, or immediately adjacent to the subject property. Listed species status follows species identified in the following referenced documents (Division of Land and Natural Resources (DLNR) 1998, Federal Register 2005, U. S. Fish & Wildlife Service (USFWS) 2005, 2007). Fieldwork was conducted on September 8, and 9, 2007.

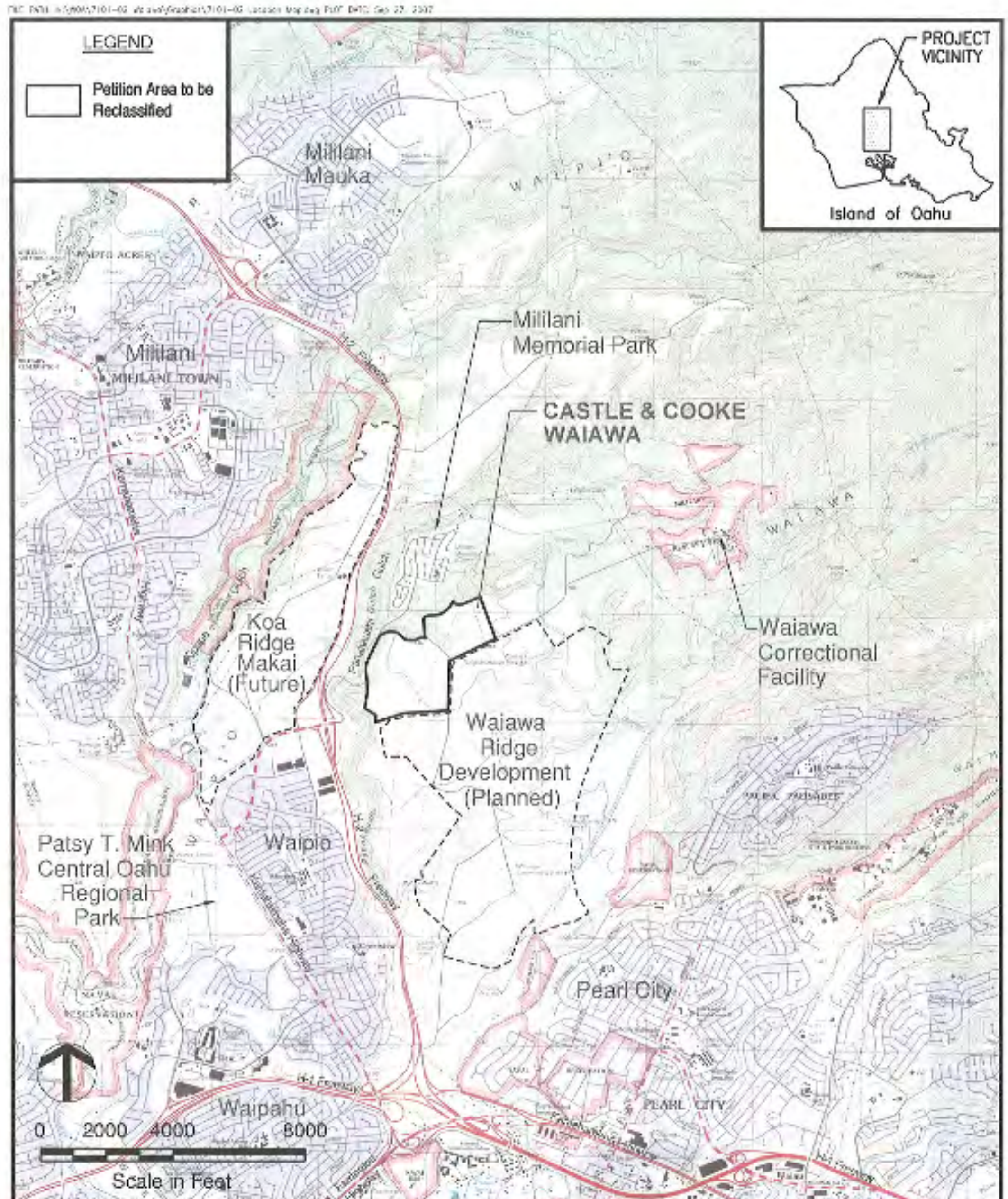
The avian phylogenetic order and nomenclature used in this report follows *The American Ornithologists’ Union Checklist of North American Birds 7th Edition* (American Ornithologists’ Union 1998), and the 42nd through the 48th supplements to *Check-list of North American Birds* (American Ornithologists’ Union 2000; Banks et al. 2002, 2003, 2004, 2005, 2006, 2007). Mammal scientific names follow *Mammals in Hawaii* (Tomich 1986). Plant names follow *Manual of the Flowering Plants of Hawai‘i* (Wagner et al. and Wagner and Herbst, 1990, 1999). Place names follow *Place Names of Hawaii* (Pukui et al. 1974).

Hawaiian and scientific names are italicized in the text. A glossary of technical terms and acronyms used in the document, which may be unfamiliar to the reader, are included at the end of the narrative text on Page 9.

General Site Description

The proposed development area encompasses approximately 191-acres of land identified as Tax Map Key (TMK) 9-4-06: por. 29 (117.488 acres) and 31 (0.358 acre), and all of TMK 9-6-04:21 (73.368 acres). The site is located east of the H-2 Freeway, north of the Waipi‘o Interchange, and adjacent to and northwest of the proposed Gentry Waiawa development (Figure 1). We also surveyed an approximately .3-acre sliver of land adjacent to the southwest side of the principal site, as well as an approximately two-acre offsite parcel located immediately west of the Waiawa Correctional Facility on which it is being proposed above ground reservoirs will be constructed, as well as approximately a 2.5-kilometer water transmission line corridor (Figure 2).

The project site is made up primarily of former pineapple fields and currently consists of vacant, fallow land with an overgrowth of alien vegetation which is dominated by Guinea grass (*Panicum maximum*). Recent botanical surveys conducted on the site recorded 116-species of plants, all but two are considered to be alien species in the Hawaiian Islands. The two indigenous species recorded are common indigenous ruderal species (Whistler 2007). Most of the site is currently leased for cattle grazing. About four acres is leased for a radio antenna site by the Broadcast Corporation of America. Mililani Memorial Park leases 0.690-acres for a filter bed and service

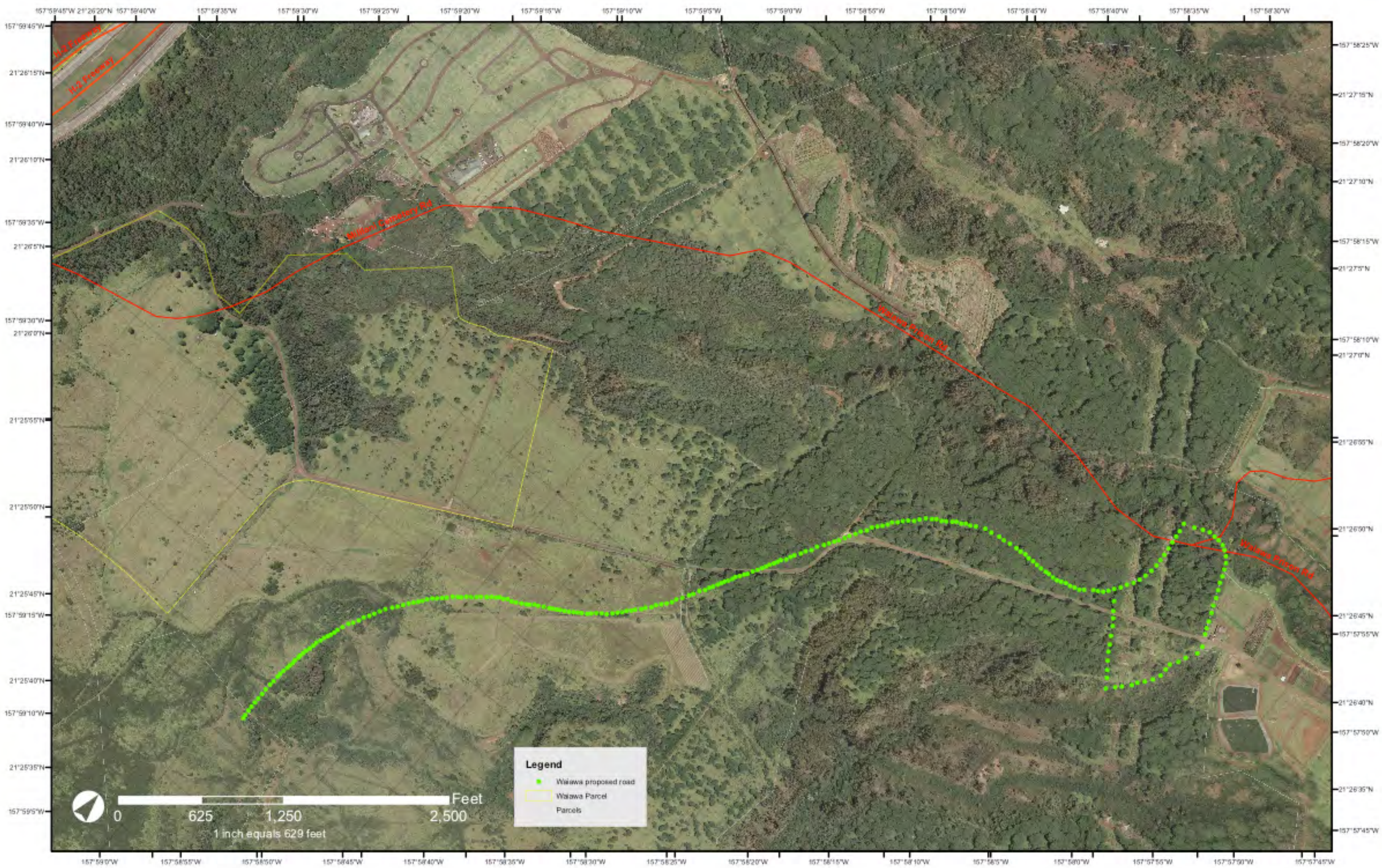


CASTLE & COOKE WAIAWA

Location Map **Figure 1-1**

Prepared for: Castle & Cooke Homes Hawaii, Inc.

Prepared by: Wilson Okamoto Corporation


Legend
Waiawa proposed road
Waiawa Parcel
Parcels
Feet
0
625
1,250
2,500
1 inch equals 629 feet

yard. The State of Hawaii also retains a roadway access easement through the project site to the Waiawa Correctional Facility. This easement is a permanent fixture and will remain in place as part of the Waiawa project, although the alignment may be adjusted.

Mammalian Survey Methods

All observations of mammalian species were of an incidental nature. With the exception of the endangered Hawaiian hoary bat (*Lasiurus cinereus semotus*), or *ʻōpeʻapeʻa* as it is known locally, all terrestrial mammals currently found on the Island of Oʻahu are alien species, and most are ubiquitous. Two hours were spent within the project area on the evening of September 8, 2007 and again in the early morning hours of September 9, 2007, in an attempt to detect Hawaiian hoary bats. The survey of mammals was limited to visual and auditory detection, coupled with visual observation of scat, tracks, and other animal signs. A running tally was kept of all vertebrate species observed and heard within the study area.

Mammalian Survey Results

Eight mammalian species were detected within the project site, all eight species are considered to be alien to the Hawiian Islands (Table 1). One undidentified rat was seen running across the proposed waterline route, west of the Waiawa Correctional Facility. Several European house mice (*Mus musculus domesticus*) were seen at several locations during the course of this survey. Domestic dog (*Canis f. familiaris*) were seen within the main project areas and several others were heard barking from outside the study area. Two small Indian mongooses (*Herpestes a. auropunctatus*) were seen within the main site, as was a single cat (*Felis catus*). One pig (*Sus s. scrofa*) was seen in one of the gulches. Domestic cattle (*Bos aurus*) were seen on the northern end of the main site. Additionally, tracks, scat and sign of dog, mongoose, cat, horse (*Equus c. caballus*), and domestic cattle were observed in numerous locations within the project site.

The endangered Hawaiian hoary bat was not recorded during the course of this survey. This finding is not surprising given that this species has rarely been documented from the Island of Oʻahu (Tomich 1986, USFWS 1998, David 2007g).

Table 1. Mammalian Species Detected on the Castle & Cooke Waiawa Site

Common name	*Scientific name*	Status
	RODENTIA – GNAWERS	
	Muridae – Old World Rats & Mice	
Rat sp.	*Rattus sp.*	A
European house mouse	*Mus musculus domesticus*	A
	CARNIVORA- FLESH EATERS	
	Canidae – Wolves, Jackals & Allies	
Domestic dog	*Canis f. familiaris*	A
	Viverridae – Civets & Allies	
Small Indian mongoose	*Herpestes a. auropunctatus*	A

Table 1 Continued

Common name	*Scientific name*	Status
	Felidae- Cats	
House cat	*Felis catus*	A
	PERISSODACTYLA - ODD-TOED UNGULATES	
	Equidae - Horses, Asses & Zebras	
Domestic horse	*Equus c. caballus*	A
	ATRIODACTYLA - EVEN-TOED UNGULATES	
	Suicidae - Old World Swine	
Pig	*Sus s. scrofa*	A
	Bovidae - Hollow-horned Ruminants	
Domestic cattle	*Bos taurus*	A

Avian Survey Methods

Seven avian count stations were sited along a linear transect running the length of the main site. Six-minute point counts were made at each of the seven-count stations. Additionally, an additional station was sited within the offsite water tank site, and an additional five count stations were located along the proposed water transmission line corridor.

Field observations were made using Leitz 10 X 42 binoculars and by listening for avian vocalizations. Counts took place between 06:30 a.m. and 11:00 a.m., the peak of daily bird activity. An additional two hours was spent within the project area on the evening of September 8, 2007 and again in the early morning hours of September 9, 2007, in an attempt to detect crepuscular and/or nocturnally flying seabirds and owls. Time not spent conducting station counts was used to search the subject property for species and habitats not detected during count sessions.

Avian Survey Results

A total of 399 individual birds, of 19-different avian species, representing 13-separate families were recorded during station counts. These results are summarized in Table 2. One of the species recorded, Pacific Golden-Plover (*Pluvialis fulva*), is an indigenous migratory shorebird species. Pacific Golden-Plover breed in the high Arctic, spending their winters in Hawaiʻi and the tropical Pacific. The remaining 18-species detected are considered to be alien to the Hawaiian Islands (Table 2).

Avian diversity was relatively low, not surprising given the habitat found on most of the site. Three species, Japanese White-eye (*Zosterops japonicus*), Red-vented Bulbul (*Pycnonotus cafer*), and Common Myna (*Acridotheres tristis*), accounted for slightly less than 35% of the total number of individual birds recorded. Japanese White-eyes were the most frequently recorded species, accounting for 13% of the total number of individual birds recorded during station counts. We recorded an average of 31 birds per station count.

Table 1. Avian Species Detected on the Castle & Cooke Waiawa Site			
Common Name	*Scientific Name*	*ST*	*RA*
	GALLIFORMES		
	PHASIANIDAE - Pheasants & Partridges		
	Phasianinae - Pheasants & Allies		
Gray Francolin	*Francolinus pondicerianus*	A	0.61
Erckel's Francolin	*Francolinus erckelii*	A	0.46
Ring-necked Pheasant	*Phasianus colchicus*	A	0.31
	CICONIIFORMES		
	ARDEIDAE - Herons, Bitterns & Allies		
Cattle Egret	*Bubulcus ibis*	A	1.31
	CHARADRIIFORMES		
	CHARADRIIDAE - Lapwings & Plovers		
	Charadriinae - Plovers		
Pacific Golden-Plover	*Pluvialis fulva*	IM	0.31
	COLUMBIFORMES		
	COLUMBIDAE - Pigeons & Doves		
Spotted Dove	*Streptopelia chinensis*	A	2.77
Zebra Dove	*Geopelia striata*	A	2.08
	PASSERIFORMES		
	ALAUDIDAE - Larks		
Sky Lark	*Alauda arvensis*	A	1.77
	PYCNONOTIDAE - Bulbuls		
Red-vented Bulbul	*Pycnonotus cafer*	A	3.54
	ZOSTEROPIDAE - White-Eyes		
Japanese White-eye	*Zosterops japonicus*	A	4.00
	MIMIDAE - Mockingbirds & Thrushes		
Northern Mockingbird	*Mimus polyglottos*	A	1.08
	STURNIDAE - Starlings		
Common Myna	*Acridotheres tristis*	A	3.15
	EMBERIZIDAE - Emberizids		
Red-crested Cardinal	*Paroaria coronata*	A	0.69
	CARDINALIDAE - Cardinals Saltators & Allies		
Northern Cardinal	*Cardinalis cardinalis*	A	1.00
	FRINGILLIDAE - Fringilline And Cardueline Finches & Allies		
	Carduelinae - Carduline Finches		
House Finch	*Carpodacus mexicanus*	A	2.23

Table 2 Continued

Common Name	*Scientific Name*	*ST*	*RA*
	ESTRILDIDAE - Estrildid Finches		
	Estrildinae - Estrildine Finches		
Common Waxbill	*Estrilda astrild*	A	1.46
Nutmeg Mannikin	*Lonchura punctulata*	A	0.62
Chestnut Munia	*Lonchura atricapilla*	A	2.92
Java Sparrow	*Padda oryzivora*	A	1.69

KEY TO TABLE 1

ST Status

A Alien – introduced to the Hawaiian Islands by humans

IM Indigenous Migrant – a native migratory species that winters in Hawai‘i but breeds elsewhere

RA Relative Abundance – number of birds detected divided by the number of count stations (13)

Discussion

Mammalian Resources

The findings of the mammalian survey are consistent with the findings of at least two other surveys conducted on the same site (Funk 1996, 1999), as well as with several others faunal surveys conducted in the general vicinity of the subject property in the recent past (David and Guinther 2000, 2006, David 2007a, 2007b, 2007c, 2007d, 2007e, 2007f).

As previously mentioned we did encounter several European house mice within the project site, as well as an unidentified rat. It is likely that all three rat species established in Hawaii, roof rats (*Rattus r. rattus*), Norway rats (*Rattus norvegicus*), and Polynesian rats (*Rattus exulans hawaiiensis*), use resources present within the project site. These commensal species are all but ubiquitous on the island of O‘ahu. All of these introduced rodents are deleterious to remaining native ecosystems and the native floral and faunal species that are dependant on them for their survival.

Avian Resources

The findings of the avian survey are consistent with the findings of at least two other surveys conducted on the same site (Funk 1996, 1999), as well as with several others faunal surveys conducted in the general vicinity of the subject property in the recent past (David and Guinther 2000, 2006, David 2007a, 2007b, 2007c, 2007d, 2007e, 2007f).

Only one of the 19-avian species recorded during the course of this survey is a native species. The species in question, Pacific Golden-Plover is an indigenous migratory shorebird species that breeds in the high Arctic and spends the winter months in Hawai‘i and the tropical Pacific. Plover are readily seen throughout the Hawaiian Islands between late July and the end of April. The remaining 18-species detected are considered to be alien to the Hawaiian Islands (Table 2).

Although not detected during this survey, it is likely that the Hawaiian endemic sub-species of the Short-eared Owl *(Asio flammeus sandwichensis*), or *pueo* uses resources within the general project area occasionally. This species is regularly seen along the Waiʻanae coast from the Lualualei Naval Reservation to Waimānalo Gulch (David 2007g). The Oʻahu population of the short-eared Owl is listed as an endangered species under the State of Hawaiʻi's endangered species program, though, it is not protected under the federal endangered species statutes (DLNR 1998).

From an avian and native mammalian perspective there is nothing unique about the habitat present within the subject property, and none of the habitat is important habitat for any listed avian or mammalian species currently known from the Island of Oʻahu.

There is no federal designated Critical Habitat for any avian or mammalian species on, or adjacent to the subject property.

Conclusions

It is not expected that the modification of the habitat currently found on the site or the development of the site will have a negative impact on any avian or mammalian species currently listed as endangered, threatened, or any that are currently proposed for listing under either Federal or State of Hawaiʻi endangered species statutes. The proposed action will not result in modification of any federally designated Critical Habitat as there is none present on the subject property.

Glossary

Alien - Introduced to Hawai‘i by humans
Commensal - Animals that share human food such as rats and mice
Crepuscular – Twilight hours
Endangered – Listed and protected under the ESA as an endangered species
Endemic – Native and unique to the Hawaiian Islands
Indigenous - Native to the Hawaiian Islands, but also found elsewhere naturally
Muridae - Rodents, including rats, mice and voles, one of the most diverse family of mammals.
Nocturnal – Night-time, after dark
‘ōpe‘ape‘a – Hawaiian hoary bat (*Lasiurus cinereus semotus*)
pueo – Hawaiian endemic cub-species of the Short-eared Owl (*Asio flammeus sandwichensis*)
Ruderal – Disturbed, rocky, rubbishy areas, such as old agricultural fields and rock piles
Threatened - Listed and protected under the ESA as a threatened species

DLNR – Hawaii State Department of Land & Natural resources
TMK – Tax Map Key
USFWS – U.S. Fish & Wildlife Service

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March 26, 2008

Table of Contents

Figures & Tables

Introduction

Castle & Cooke Hawaii is proposing to develop a master planned residential community on approximately 191-acres of land in Waiawa, ‘Ewa District, O‘ahu (Figure 1). This document was prepared in response to comments received from the Hawaii Department of Transportation, Highways Division (HDOT) to the Draft Environmental Impact Statement. They requested that the impacts to the environment posed by the improvements to the Waipio Interchange, required to mitigate traffic congestion created by the proposed Castle & Cooke Waiwa project be more fully assessed. We conducted a separate set of avian and mammalian surveys on an approximately 70-acre parcel of land identified as, TMK (1) 9-4-006:11, 27, 28, 29 and 31 (Figure 2). This report is presented as a supplement to our original report which covered the rest of the proposed development project (David 2007g).

A primary goal of the surveys was to determine if there were any avian or mammalian species currently listed as endangered, threatened, or proposed for listing under either Federal or State of Hawaii endangered species statutes on, or immediately adjacent to the subject property. Listed species status follows species identified in the following referenced documents (Division of Land and Natural Resources (DLNR) 1998, Federal Register 2005, U. S. Fish & Wildlife Service (USFWS) 2005, 2008). Fieldwork was conducted on March 25

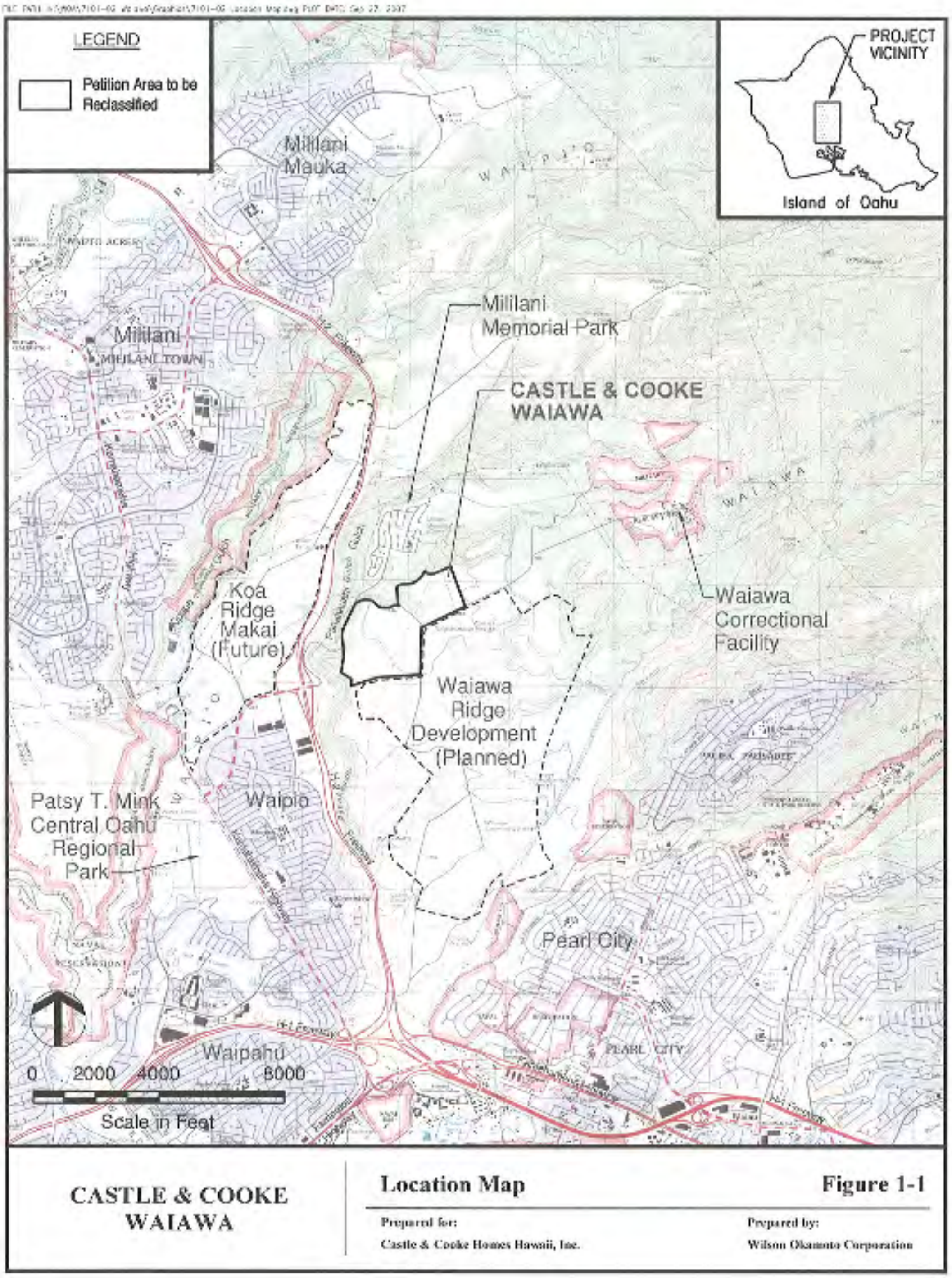
The avian phylogenetic order and nomenclature used in this report follows *The American Ornithologists' Union Checklist of North American Birds 7th Edition* (American Ornithologists' Union 1998), and the 42nd through the 48th supplements to *Check-list of North American Birds* (American Ornithologists' Union 2000; Banks et al. 2002, 2003, 2004, 2005, 2006, 2007). Mammal scientific names follow *Mammals in Hawaii* (Tomich 1986). Place names follow *Place Names of Hawaii* (Pukui et al. 1974).

Hawaiian and scientific names are italicized in the text. A glossary of technical terms and acronyms used in the document, which may be unfamiliar to the reader, are included at the end of the narrative text on Page 10.

General Site Description

The proposed project consists of building a northbound loop off-ramp connecting I-H2 to the westbound Ka Uka Boulevard (Figure 2). The study site is located at the intersection of Interstate Highway 2 (I-H2), Ka Uka Boulevard, and Mililani Cemetery Road. The eastern portion of the project site includes a portion of Pānakauahi Gulch and Mililani Cemetery Road. The western portion consists of a section of Ka Uka Boulevard, Moanini Street, and a HDOT construction staging area (Figure 2).

The project area is primarily contained within existing road right-of-ways maintained by the City and County of Honolulu and HDOT. The vegetation within the site is dominated almost to the exclusion of native species. Plant species are dominated by alien species typical of ruderal areas along roadways on O‘ahu. Areas adjacent to the Tony Honda dealership, and Costco are planted with commonly encountered ornamental landscape species.


LEGEND
Petition Area to be Reclassified
PROJECT VICINITY
Island of Oahu
Mililani Mauka
Mililani
Mililani Memorial Park
CASTLE & COOKE WAIAWA
Waiawa Correctional Facility
Koa Ridge Makai (Future)
Waiawa Ridge Development (Planned)
Patsy T. Mink Central Oahu Regional Park
Waipio
Pearl City
Waipahu
0 2000 4000 8000
Scale in Feet
CASTLE & COOKE WAIAWA
Location Map
Figure 1-1
Prepared for:
Castle & Cooke Homes Hawaii, Inc.
Prepared by:
Wilson Okamoto Corporation

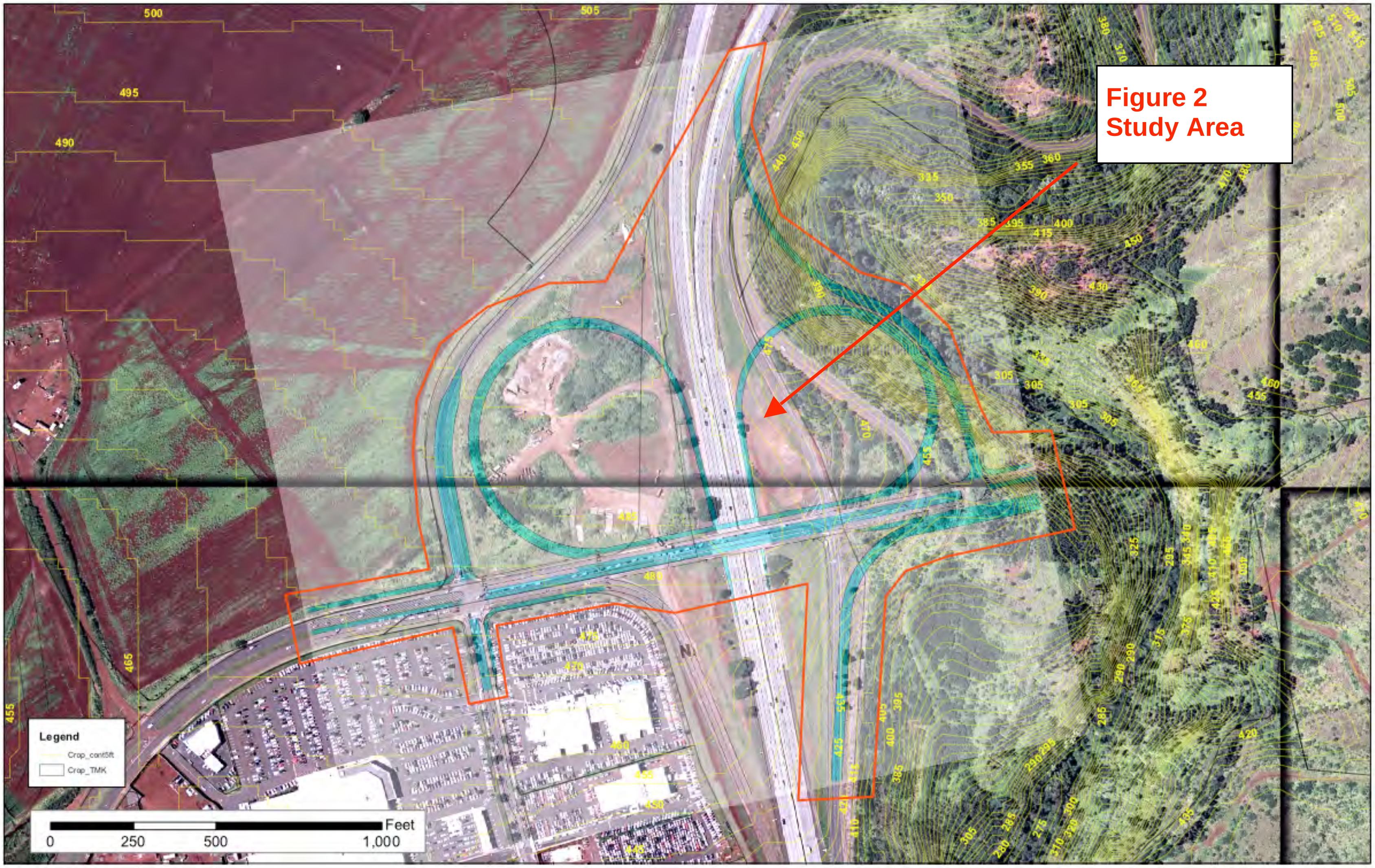


Figure 2
Study Area
Legend
Crop_cont5ft
Crop_TMK
0
250
500
1,000
Feet

Mammalian Survey Methods

All observations of mammalian species were of an incidental nature. With the exception of the endangered Hawaiian hoary bat (*Lasiurus cinereus semotus*), or *‘ōpe‘ape‘a* as it is known locally, all terrestrial mammals currently found on the Island of O‘ahu are alien species, and most are ubiquitous. The survey of mammals was limited to visual and auditory detection, coupled with visual observation of scat, tracks, and other animal sign. A running tally was kept of all vertebrate species observed and heard within the study area.

Mammalian Survey Results

No mammalian species other than humans were detected during the course of this survey.

Avian Survey Methods

Five avian count stations were evenly sited within the study area. Six-minute point counts were made at each of the five-count stations. Field observations were made using Leitz 10 X 42 binoculars and by listening for avian vocalizations. Counts took place between 08:00 a.m. and 10:00 a.m., the peak of daily bird activity. Time not spent conducting station counts was used to search the subject property for species and habitats not detected during count sessions.

Avian Survey Results

A total of 170 individual birds, of 16-different species, representing 13-separate families were recorded during station counts. These results are summarized in Table 1. One of the species recorded, Pacific Golden-Plover (*Pluvialis fulva*), is an indigenous migratory shorebird species. Pacific Golden-Plover breed in the high Arctic, spending their winters in Hawai‘i and the tropical Pacific. One species detected, Red Junglefowl (*Gallus gallus*). is not currently considered to be established in the wild on the island of O‘ahu. The remaining 14-species detected are established alien species commonly encountered on the Island of O‘ahu (Table 1).

Avian diversity was relatively low, not surprising given that the vast majority of the site is within the existing disturbed I-H2 right-of-way. Three species, House Finch (*Carpodacus mexicanus*), Red-vented Bulbul (*Pycnonotus cafer*), and Zebra Dove (*Geopilia striata*), accounted for slightly less than 52% of the total number of individual birds recorded. House Finch were the most frequently recorded species, accounting for 23% of the total number of individual birds recorded during station counts. We recorded an average of 34 birds per station count.

Table 1. Avian Species Detected, Waipio Interchange Site

Common Name	*Scientific Name*	*ST*	*RA*
	GALLIFORMES		
	PHASIANIDAE - Pheasants & Partridges		
	Phasianinae - Pheasants & Allies		
Red Junglefowl	*Gallus gallus*	D	2.20
Common Peafowl	*Pavo cristatus*	A	0.60
	CICONIIFORMES		
	ARDEIDAE - Herons, Bitterns & Allies		
Cattle Egret	*Bubulcus ibis*	A	1.20
	CHARADRIIFORMES		
	CHARADRIIDAE - Lapwings & Plovers		
	Charadriinae - Plovers		
Pacific Golden-Plover	*Pluvialis fulva*	IM	1.20
	COLUMBIFORMES		
	COLUMBIDAE - Pigeons & Doves		
Spotted Dove	*Streptopelia chinensis*	A	1.40
Zebra Dove	*Geopelia striata*	A	5.00
	PASSERIFORMES		
	PYCNONOTIDAE - Bulbuls		
Red-vented Bulbul	*Pycnonotus cafer*	A	4.80
Red-whiskered Bulbul	*Pycnonotus jocosus*	A	1.40
	SYLVIIDAE - Old World Warblers & Gnatcatchers		
	TURDIDAE - Thrushes		
White-rumped Shama	*Copsychus malabaricus*	A	0.40
	TIMALIIDAE - Babblers		
Red-billed Leiothrix	*Leiothrix lutea*	A	0.20
	ZOSTEROPIDAE - White-Eyes		
Japanese White-eye	*Zosterops japonicus*	A	1.40
	STURNIDAE - Starlings		
Common Myna	*Acridotheres tristis*	A	2.80
	EMBERIZIDAE - Emberizids		
Red-crested Cardinal	*Paroaria coronata*	A	0.40
	CARDINALIDAE - Cardinals Saltators & Allies		
Northern Cardinal	*Cardinalis cardinalis*	A	1.20

Table 2 Continued

Common Name	*Scientific Name*	*ST*	*RA*
	FRINGILLIDAE - Fringilline And Cardueline Finches & Allies		
	Carduelinae - Carduline Finches		
House Finch	*Carpodacus mexicanus*	A	7.80
	ESTRILDIDAE - Estrildid Finches		
	Estrildinae - Estrildine Finches		
Common Waxbill	*Estrilda astrild*	A	3.20

KEY TO TABLE 1

ST	Status
D	Domesticated species – not considered to be established in the wild on O‘au
A	Alien – introduced to the Hawaiian Islands by humans
IM	Indigenous Migrant species – a native migratory species that winters in Hawai‘i but breeds elsewhere
RA	Relative Abundance – number of birds detected divided by the number of count stations (5)

Discussion

Mammalian Resources

The findings of the mammalian survey are consistent with the habitat present within the project site. The majority of the site is contained within existing road right-of-ways maintained by the City and County of Honolulu and HDOT. Traffic along I-HI and Ka Uka Boulevard is very heavy, and thus disturbance to wildlife is relatively high. There is little habitat within the site conducive to supporting mammalian species.

Although we did not record and rodents during the course of this survey it is to be expected that all four established *muridae* species known from O‘ahu, roof rats (*Rattus r. rattus*), Norway rats (*Rattus norvegicus*), Polynesian rats (*Rattus exulans hawaiiensis*), and European house mouse (*Mus musculus domesticus*), likely use resources within the general project area on a seasonal basis. These commensal species are all but ubiquitous on the island of O‘ahu. All of these introduced rodents are deleterious to remaining native ecosystems and the native floral and faunal species that are dependant on them for their survival

The endangered Hawaiian hoary bat was not recorded during the course of this survey. This finding is not surprising given that this species has rarely been documented from the Island of O‘ahu (Tomich 1986, USFWS 1998, David 2008).

Avian Resources

The findings of the avian survey are consistent with several others faunal surveys conducted in the general vicinity of the subject property in the recent past (Funk 1996, 1999, David and Guinther 2000, 2006, David 2007a, 2007b, 2007c, 2007d, 2007e, 2007f, 2007g).

Avian diversity was relatively low, not surprising given that the vast majority of the site is within the existing disturbed I-H2 and Ka Uka Boulevards right-of-ways. Only one of the 16-avian species recorded during the course of this survey is a native species. The species in question, Pacific Golden-Plover is an indigenous migratory shorebird species that breeds in the high Arctic and spends the winter months in Hawai‘i and the tropical Pacific. Plover are readily seen throughout the Hawaiian Islands between late July and the end of April. One species detected, Red Junglefowl (*Gallus gallus*) is not currently considered to be established in the wild on the island of O‘ahu. We recorded both adult and sub-adult birds, indicting that this species continues to breed in the wild on O‘ahu, and continues to expand it’s feral population on the island. Whether this species has reached the point where it can maintain a wild breeding population without the further aid of humans is unclear at this juncture. The remaining 14-species detected are considered to be alien to the Hawaiian Islands (Table 1).

From a native avian and mammalian perspective there is nothing unique about the habitat present within the subject property, and none of the habitat is important habitat for any listed avian or mammalian species currently known from the Island of O‘ahu.

There is no federal designated Critical Habitat for any avian or mammalian species on, or adjacent to the subject property.

Conclusions

It is not expected that the modification of the habitat currently found on the site, or the development of the site will have a negative impact on any avian or mammalian species currently listed as endangered, threatened, or any that are currently proposed for listing under either Federal or State of Hawai‘i endangered species statutes. The proposed action will not result in modification of any federally designated Critical Habitat as there is none present on the subject property.

Glossary

Alien - Introduced to Hawai‘i by humans
Commensal - Animals that share human food such as rats and mice
Endangered – Listed and protected under the ESA as an endangered species
Endemic – Native and unique to the Hawaiian Islands
Indigenous - Native to the Hawaiian Islands, but also found elsewhere naturally
Muridae - Rodents, including rats, mice and voles, one of the most diverse family of mammals.
‘ōpe‘ape‘a – Hawaiian hoary bat (*Lasiurus cinereus semotus*)
Ruderal – Disturbed, rocky, rubbishy areas, such as old agricultural fields and rock piles
Threatened - Listed and protected under the ESA as a threatened species

DLNR – Hawaii State Department of Land & Natural resources
ESA – Endangered Species Act of 1973, as amended
HDOT– Hawaii Department of Transportation
TMK – Tax Map Key
USFWS – U.S. Fish & Wildlife Service

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Survey of Invertebrate Resources

at Waiawa, ’Ewa District, O’ahu, Hawai‘i

Prepared by:
Steven Lee Montgomery, Ph. D., Waipahu, Hawai’i

Submitted to:
Wilson Okamoto Corporation

March 19, 2008

Table of Contents

Figures & Tables

SUMMARY

The Waiawa project site sampled in this biological survey yielded predominantly adventive insect species, and a few native arthropods. No invertebrate listed under either federal or state endangered species statutes was located within the survey area.

INTRODUCTION

This report summarizes the findings of an invertebrate[1] survey conducted as part of an environmental assessment in support of a proposal to construct a residential community and supporting facilities in central O'ahu. Castle & Cooke Properties proposes to build on approximately 191 acres, within Tax Map Keys: 9-6-04:21, 9-4-06:29, and 9-4-06:31. This survey was conducted by Steven Lee Montgomery, Ph. D., with assistance from Anita Manning.

Invertebrates are often the dominant fauna in natural Hawaiian environments. The primary emphasis of this survey was on terrestrial invertebrates, particularly those that are endemic, indigenous, or threatened species, especially those having legal status under either, or both federal and state endangered species statutes (DLNR 1996, USFWS 2005a, 2006).

Native Hawaiian plant, vertebrate, and invertebrate populations are often interdependent. Certain insects are obligatorily attached to specific host plants and are able to use only that plant as their food. Those insect - host relationships are ancient and intertwined. The health of native Hawaiian invertebrate populations depends upon habitat quality and absence or low levels of predators introduced from the continents. Sufficient food sources, host plant availability, and the absence or low levels of introduced, continental predators and parasites comprise a classic native, healthy ecosystem. Consequently, where appropriate in the survey discussion, host plants and some introduced arthropods are also noted.

GENERAL SITE DESCRIPTION

The 191 acre Waiawa parcel, the area of this survey, lies east of the H-2 freeway and north of Waipi'o interchange, in central O'ahu. (Figure 1 and 2) Mililani Memorial Cemetery is to the north of the parcel and Waiawa Correctional Facility is to the east. The Waiawa parcel is bounded in part by the intersection of Mililani Memorial Park Road and Waiawa Correctional Facility Road.

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[1] Animals without backbones: insects, spiders, snails, shrimp, etc.

Figure 1: Map showing general location of project site on island of O'ahu, Hawaiian Islands.

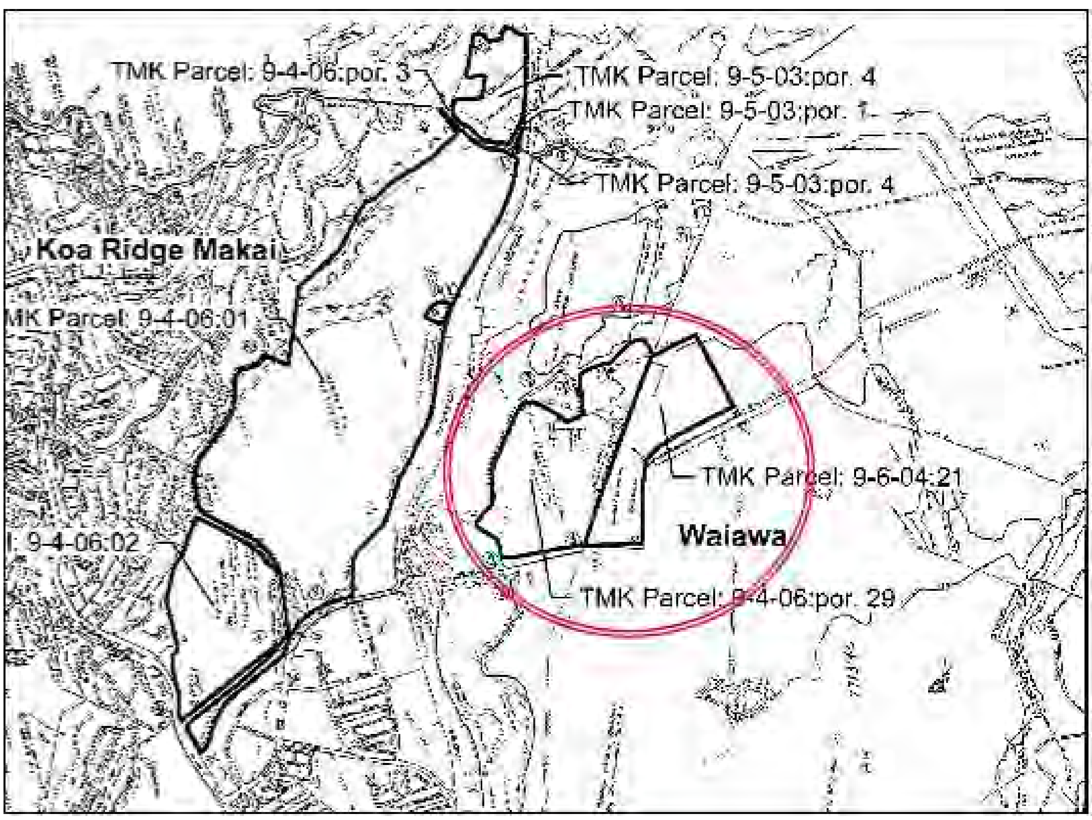

Figure 2: Map showing close up of project site Waiawa, 'Ewa, O'ahu.

From Figure 2, Koa Ridge Development , Castle & Cooke Homes Hawaii, Inc.

The parcel has been described by botanical consultants as "open grassland with intermittent scattered weed trees." (Funk 2005) Vegetation on the site is primarily alien species introduced since 1790. The land was for many decades planted as pineapple fields. Pineapple cultivation actively eradicated non-crop plants from the rows, interspaces, and borders. Fields were protected by a "stout and ever-ready defense" against the "aggression" of weeds (King in St. John and Hosaka 1932). To pineapple growers, the native plant 'ilima (*Sida* sp.), a host to many native insects, was a weed to be removed quickly because of the many seeds it produced (St. John and Hosaka 1932). Currently a large part of the property serves as grazing for cattle and is dominated by grasses and non-native trees that often invade abandoned fields. Signs can still be seen in the forested areas and some open locations of a 1998 fire that swept through the area (Funk 2002). Consequently, Native Hawaiian plants of interest as hosts or shelter for native invertebrates were limited or missing in comparison to less altered island locations at similar elevations and with parallel rainfall.

Figure 3: Typical grazed pasture

Figure 4: Typical area of concentrated trees

INVERTEBRATE SURVEY METHODS

Previous Surveys and Literature Search

Prior to the field survey, a search was made for publications relating to invertebrates associated with the Waiawa area. Care should be taken by reviewers in searches of the scientific literature when using the place name "Waiawa" as a guide. In addition to the project site, there are at least three locations on O'ahu with this place name: Waiawa Ridge, a high, wet location in the Koolau Mountains, Waiawa Stream / Gulch which travels from the Ko'olau Range down to Pearl Harbor, and Waiawa Springs (now part of Pearl Harbor National Wildlife Refuge). Waiawa is also an ahupua`a name.

Many 19th and early 20th century invertebrate collection specimen records give only "Waiawa" as the location. Careful comparison of the records, the locations associated with other individuals of a species, and the conditions at those locations, as well as other materials collected in the same expedition will assist in verifying or eliminating an association with one of the three Waiawa place names.

Our data base and literature search showed references to wetland invertebrate species associated with the Springs and higher elevation records of snails associated with the Waiawa Trail / Ridge. Most easily found is a record in the

Bishop Museum Freshwater & Terrestrial Mollusk Checklist for the landsnail *Amastra turritella subsp. waiawa* (Amastridae). Based on our comparison to other species of the genus and the location data, this species is certainly associated with the upland, wetter Waiawa Ridge area (Cowie, et al. 1995, Hyatt and Pilsbry 1911). There is no evidence this species were ever associated with this midland, drier location.

Our review shows no previous native invertebrate surveys in the project area. In addition to searches of the University of Hawaii and Bishop Museum libraries, online data bases of ARGIS, Biological Abstracts, Ingenta, NBII Pacific Basic Information Node, and Zoological Record were searched. University of Hawaii's Hawaii Pacific Journal Index which includes the listings for the *Proceedings of the Hawaiian Entomological Society* also produced no returns. Several generally applicable technical articles were noted as dealing with control of adventive insects considered pests by the pineapple industry (examples: Illingworth 1926, Sakimura1966.) Some botanical technical studies of the period when the land was occupied by pineapple fields deal with some native host plants as 'pests' in the fields (example: St. John and Hosaka 1932). None of the articles located mention the Waiawa area as a source of native insects. Recent botanical, avian, and mammalian surveys of the Waiawa site by Funk (1996, 1999, 2002), Whistler (2007), and David (2007) also show no reference or evidence of surveying for invertebrates. An archaeological survey of the area shows no evidence of lava tubes or land invertebrates such as snails (Goodman 1992).

Fieldwork

Field surveys were conducted at the Waiawa site in March 2008. I conducted a general assessment of terrain and habitats at the start of the survey. Surveying efforts were conducted at various times of day and night, a technique which is vital for a thorough survey. Native botanical resources identified by Funk (1996, 1999, 2002) and by Whistler (2007) were an assist in my searches.

See Figure 16 for survey locations within the project area.

Fieldwork schedule:

March 12, 2008	Site examination and general orientation light assisted survey using MV bulb
March 14, 2008	General daylight survey; light survey using MV and UV bulbs
March 17, 2008	Close examination of *S. mauritianum*; light survey using MV and UV bulbs

Survey Methods

Since 1969, I have taken part in field projects at other locations in similar locations on O'ahu and throughout the island chain. Those experiences and the results of those surveys provided the basis for my study design and my analysis of results. The following survey methods for terrestrial invertebrates were used as appropriate to the terrain, botanical resources, and target species.

Host plant searches: Potential host plants, both native and introduced, were searched for arthropods that feed or rest on plants. The property was traversed in a wandering manner, criss-crossing open, grazed, grassy areas to access potential host plants.


Figure 5: Light attracts arthropods

Light survey: A survey of insects active at night is vital to a complete record of the fauna. Many insects are only active at night to evade birds, avoid desiccation and high temperatures, or to use night food sources, such as night opening flowers. Light sampling uses a bright light source in front of a white cloth sheet. Night active insects seem to mistake the collecting light for the light of the moon, which they use to orient themselves. In attempting to navigate by the scientist's light, confused insects are drawn toward the light and land on the cloth in confusion. This type of survey is most successful during the dark phase of the moon or under clouds blocking starlight. Vegetation usually blocks light from being seen over long distances, and most moths and other night fliers are not capable of very distant flight. Consequently, light surveying does not call in many insects from outside the survey area.

Light surveying began at dark (7 p.m.) each night. Surveying was conducted for 2 hours on March 12, for 3 hours on March 14, and 2 ½ hours on March 17. The light source was a mercury vapor (MV) bulb powered by an electric generator on both nights. On the night of March 14 and 17, a second site was established with an ultra violet (UV) or black light bulb. Only Scarabaeidae (dung beetles and a smaller Scarab) responded to the UV spectrum. Both light wave lengths are known to be attractive to night active insects. Each location was monitored and visiting species noted.

Locations were chosen based on experience, host plant proximity, and terrain. The location of MV light sampling on March 12 was marked at 585 ft. by GPS[2] at a location of 4Q 0605180, 2370592; on March 14 marked at location 4Q 0604888, 2370757, and on March 17 the UV was at 4Q 0605363, 2370987, and the MV at 4Q 0605364, 2371058. All light survey locations and special sites are marked on Figure 16.

Sweep nets: This method assists in surveying many flying and perching insects. A fine mesh net was swept across plants, leaf litter, rocks, etc. to census any flying, perching or crawling insects.

Visual observation: At all times, we were vigilant for any visual evidence of arthropod presence or activity. Visual observations provide valuable evidence and are a cross check that extends the reach of survey techniques. Visual observation also included turning over rocks, dead wood, and other debris. Special searches were made of *Solanum mauritianum* plants to determine the cause of feeding damage. (See page 14-15)

Survey Limitations / Conditions

My ability to form advisory opinions is limited / influenced in the following ways:

Common alien species: No attempt was made to completely document the many common alien arthropod species present in the area.

Physical limitations: Within a very few areas of the site, the density and height of the alien grasses made travel difficult, however, such dense, alien, mono species dominated habitat is rarely attractive to native species. The size of the project area allowed a fairly comprehensive survey of the area. The resulting survey was representative and targeted in favor of locating and examining host plants which might be utilized by native invertebrates.

Survey conditions: Monitoring at a different time of the year, or for a longer period of time, might produce a longer or different arthropod list. Weather and seasonal vegetation plays an especially important role in any survey of invertebrates. Many arthropods time their emergence and breeding to overlap or follow seasonal weather or to coincide with growth spurts or fruiting of an important plant food. Host plant presence/absence, and seasonal changes, especially plant growth after heavy rains, affect the invertebrate species noted.

Weather was favorable for surveying during each day of fieldwork. This study was conducted during the end of the winter season, but vegetation was in a stage adequate for surveying, with the exception that only 2 Formosan koa (*Acacia confusa*) had the green seed pods favored by the native koa bug,

[2] GPS position is based on the UTM grid and the NAD 83 Datum

Coleotichus blackburniae. If vegetation were younger, or lusher, a longer insect list might have resulted.

On March 12, and 14, 2008, the moon presented minimal competition to light survey efforts being in its first quarter and should not have affected the number of insects attracted to the light. A slight cloud cover on the night of March 12 reduced interference. On March 14th skies were mostly clear, but passing clouds gave periods of reduced visibility of the moon. On March 17th the moon was obscured early in the evening with cloudy skies and light intermittent sprinkles. Later the moon was a competing factor as clouds cleared. Response to the light however did not substantially differ from previous nights. On March 12th, the moon rose at 10:19 a.m., was at midpoint at 5:18 p.m. and Moonset came at 12:21 a.m. March 13. On March 14th, the moon rose at 12:18 p.m. with Moonset at 2:25 a.m. March 15. On March 17th, the moon rose at 3:25 p.m. with Moonset at 4:44 a.m. March 18. (USNO) There were no competing streetlights or other distractions at either location. Streetlights along Mililani Memorial Park Road would have distracted arthropods outside the property from our light.

INVERTEBRATE SURVEY RESULTS:

Table 1 records the results of day and night invertebrate surveys. In addition to the invertebrate results noted in Table 1, we made several incidental observations:

At least seven plants of the solanaceous *Solanum mauritianum* were noted at the north-east end of the property. See page 14-15.

The Small Indian mongoose (*Herpestes auropunctatus*) was seen within the property, principally when it crossed the road.

At twilight, around 6 p.m. of March 12 and 14, the call of a long-tailed parrot was heard. On March 14, the large birds were observed flying into and among the large trees at the intersection of Mililani Memorial Park Road and Waiawa CF Road. On March 17, the same transit and calling was observed among the large trees just outside the upper portion of the property with the birds flying into the property.

Other avian incidental sightings included Kolea / Pacific Golden-Plover (throughout the open, grazed fields, often in pairs or a group of 3), Common Mynah, House Finch, (all at several locations); Red-whiskered Bulbul, White-rumped Shama, Japanese Bush-Warbler (all in stands of trees near the intersection of Mililani Memorial Park Road and Waiawa CF Road). One Japanese Bush-warbler was heard. A few wild chickens were observed along the Mililani Memorial Park Road edge of the property.

INVERTEBRATE RESOURCES
DISCUSSION

Native species observed on the property are discussed. Also, information is provided on several adventive species often observed by the public and misidentified or confused with native species.

ARTHROPODS

ARANEAE Lycosidae: *Lycosa* sp.

On the night of March 12, an individual *Lycosa*, a possibly native wolf spider (18 mm), came to hunt the insects attracted to the light. These are quick, strong predators which give maternal care to their young. They hide alone by day and hunt by night in established individual territories. (Manning/Montgomery in Liittschwager & Middleton 2001)

Lycosa spider species recorded on O'ahu are all endemics: *L. hawaiiensis*, *L. oahuensis*, and *L. perkinsi*. *L. hawaiiensis* and *L. oahuensis* are known from several islands. *L. perkinsi* is known only from O'ahu.

INSECTA

COLEOPTERA (beetles)

Scarabaeidae

Figure 6: Dung beetle

The dominant and first insect responding to the MV or UV light on each night of the survey was the purposefully introduced, hardworking dung beetle.

HYMENOPTERA (Wasps, Bees, Ants)
Anthophoridae: *Xylocopa sonorina*, the Sonoran carpenter bee

Figure 7: Carpenter bees

This large, introduced bee species was seen in several areas of the property. Their name derives from drilling distinctive round shallow holes for a home in dry, dead wood. Males are golden and limited in number; Females are numerous and black. Although relatively large, and noisy in flight, they are harmless and not know to sting humans. When workers begin to clear the property they will fly out to protest and come quiet close.

Figure 8: Crustacean eating ant

Formicidae: *Leptogenys falcigera*, an ant known for preying on crustaceans, such as sow bugs, was noted in dead Albizia wood. They do not sting or bite humans.

DIPTERA

Figure 9: Sap exudate on Formosan koa

A Formosan koa (*Acacia confusa*) exhibited a sap exudate. Some native *Drosophila* flies are known to lay eggs only in manna-like sap fluxes where sweet plant sap slowly leaks from a wound. Fermented by yeasts, the sap makes a rich food for larval flies. The introduced koa's tree sap "tastes" enough like the native koa to entice some native flies to lay eggs at this resource when populations of the fly are present. This wound had only the rat tailed maggots of the alien hover fly.

LEPIDOPTERA

Crambidae: *Eudonia* sp.

This endemic narrow winged, speckled moth is represented by 15 species known from O'ahu of the 60 species in the island chain. A specimen came to our light March 14th. A typical *Eudonia* feeds on mosses.

Gelechiidae (micro-moths)

Thyrocopa abusa complex

Thyrocopa moths are a dominant group of 50 species. The larvae feed mostly on dead wood and debris. They are of great interest to evolutionary scholars (Medeiros pers. comm.) Only one individual came to the light.

LEPIDOPTERA (continued)

Lycaenidae

Udara blackburni Blackburn butterfly or Koa butterfly

Although seen only once, in flight in an open field, my identification is relatively solid, since there is no other butterfly in Hawai’i exhibiting a green underside. Formosan koa (*Acacia confusa*) is known as a host to this species.

Noctuidae *Achaea janata*

See discussion on page 14-15 under Invertebrates Not Present, LEPIDOPTERA, Sphingidae: *Manduca blackburni*.

Noctuidae: *Ascalapha odorata*

The black witch moth has been widely distributed in the island chain since the 1920s. This large moth is occasionally mistaken for a bat. It was flushed from under the taller trees at dusk. The classic food plant of the caterpillars, Monkeypod (*Samanea saman*), was noted in the earlier botanical surveys. One individual (photo) was found on the trunk of a *Falcataria moluccana* tree in the process of pumping out its wings after emerging from its underground papal case.

Figure 10: black witch moth

Pyralidae: *Mestolobes* sp. near *miniscula* 8

This native moth was seen at our light. The adults also are often seen flying in daylight to flowers. The larvae are unknown.

ODONATA (Dragonflies and Damselflies)
Libellulidae: *Pantala flavescens* Globe skimmer


Figure 11: Glove skimmer file photo by A. Manning

This indigenous dragonfly was observed in all open grassy areas of the property. Among the most easily observed native insects, they are large, easily approached by people, and graceful in flight. Any small amount of fresh water will attract them and they often colonize human maintained water sources such as the cattle troughs. The adults lay eggs in the water where they develop into predatory young called naiads. The large number of insects associated with the cattle and cattle dung surely provide the adults with an easy living. The proposed habitat change will no doubt reduce their numbers, but they are likely to recolonize almost any water source. The native dragonflies are widely distributed throughout the Hawaiian Islands, from Kure to Hawai'i Island (HBS 2002; Nishida 2002).

ORTHOPTERA (Praying Mantis, Grasshoppers, Crickets, Katydids)
Tettigoniidae: *Euconocephalus nasutus* aggravating grasshopper
The distinctive noise, a bit like an electrical transformer gone bad, heard at dusk and early dark is the call of male aggravating grasshoppers.


Figure 12: aggravating grasshopper

Invertebrates Not Present

Plant and invertebrate populations are interdependent. Consequently, host plant presence is one way to review invertebrate health. The absence of classic native host plants such as koa *Acacia koa* and 'ilima (*Sida* sp.) contribute to the paucity of Hawaiian arthropods at Waiawa (Swezey 1935b).

Alien predatory ants are another major cause for the scarcity of native arthropods. The long-legged ant (*Anoplolepis gracilipes*) which preys on other insects (Zimmerman 1948-80) is present on the property. These ants are well documented as a primary cause of low levels of native arthropods at elevations up to 2000 ft. (Perkins 1913).

MOLLUSCA: Gastropoda (Snails) Pulmonata
No indigenous or endemic mollusca were noted during this survey.

Achatinellidae
The Oahu Tree Snail (*Achatinella)*, listed on the federal endangered species list, was not found (DLNR 1996; Federal Register 1981). The habitat (elevation, host plants, and moisture levels) make the area unsuitable for this snail.

ARTHROPODA
HYMENOPTERA

Apidae: *Apis mellifera* Linnaeus, 1758

Conspicuously absent during the entire survey was the honey bee. *Acacia confusa* trees in flower, for example, had not one honey been in attendance during the mid-day prime foraging period. This absence may be related to the relatively recent introduction into Hawaii's honey bee populations of the *Varroa* mite that preys on honey bees and is reducing colony vigor in both wild and managed hives.

LEPIDOPTERA

Sphingidae: *Manduca blackburni*


Figure 13: *Solanum mauritianum*


Figure 14: Feeding damage

Blackburn's sphinx moth (*Manduca blackburni*), an endangered species (Fed Reg 1999-2000) was not found in this survey. The moth has not been seen on O'ahu for many decades. The *Recovery Plan* (USFWS 2005b) for this large sphinx moth proposes only one Management Unit on O'ahu, at the Nature Conservancy's Honouliuli Preserve.

Neither of the moth's common solanaceous host plants, native 'aiea (*Nothocestrum* sp.), nor the best alien host, tree tobacco (*Nicotiana glauca*), was observed on the property in my own survey or recent botanical surveys.

Near the end of daylight on March 14, 2008, a tobacco family species *Solanum mauritianum* (Figure 13) was found in the upper portion of the property (see Figure 16)[3]. Although it was first recorded in 1909, *S. mauritianum* is not widely distributed in the islands. It has been reported from the Waiähole/Waikane area, on the opposite side of the Ko'olau Mountain ridge from Waiawa (Wagner et al. 1999). Several plants showed damage from insect feeding (Figure 14). A search did not reveal the cause of the damage during the remaining daylight.

[3] 604 ft, GPS 4 Q 0605403, 2370935

Figure 15: *Achaea janata* feeding on *S. mauritianum*

On March 17, after careful searches on numerous plants, the caterpillar of the noctuid moth, *Achaea janata*, was found feeding on the *S. mauritianum* plants. The A. janata moth was noted previously during the light survey. A wide variety of Noctuid family moth species are reported to eat a broad spectrum of solanaceous plants world wide. This particular feeding relationship appears to be previously unreported; however, *A. janata* is reported to feed on solanaceous *Capsicum annuum* (sweet peppers). (HOSTS)

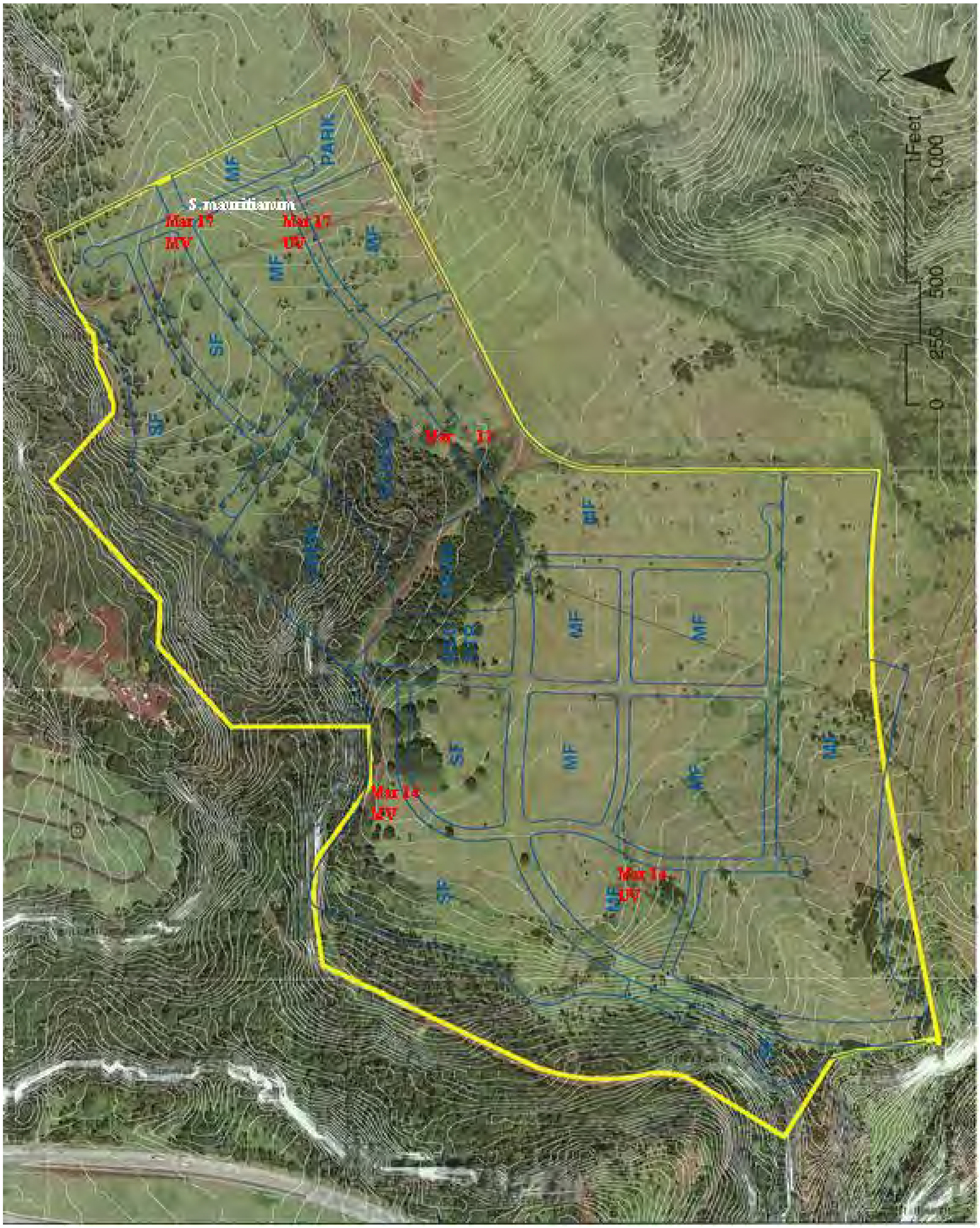

Figure 16: Aerial image of Waiawa project area showing light survey locations, and location of *Solanum mauritianum* plants

Table 1: List of Invertebrates[4]: Waiawa, O'ahu

Species / common name	Status	Abundance	Observed
ARTHROPODA ARANEAE (Spiders)			
Heteropodidae			
Heteropoda venatoria (Linnaeus), 1767 (large brown spider; cane spider)	Adv	O	at light
Lycosidae (wolf spider)			
Lycosa sp.	End	R	at light
Oxyopidae (lynx spiders)			
Oxyopes sp.	Adv?	O	at light
ARTHROPODA			
AMPHIPODA (sandhoppers)			
unidentified Amphipoda	Adv?	?	in stock tank
INSECTA			
COLEOPTERA (beetles)			
Scarabaeidae			
undetermined sp. 1 (black or brown dung beetle)	Pur	AA	at light
Staphylinidae			
unidentified rove beetle	Adv	A	at light
DERMAPTERA			
unidentified earwig	Adv	C	at light

[4] Names authority: Hawaii Biological Survey 2002; Nishida 2002; Zimmerman 1948-80; Zimmerman 2001

DIPTERA			
Culicidae			
Culex quinquefasciatus Say, 1823 (mosquito)	Adv	C	throughout
Ephydridae			
unidentified shore fly	Adv?	C	in stock tank
Syrphidae			
unidentified syrphid			
hover fly / rat tailed maggot	Adv	R	in sap exudate
Tipulidae			
unidentified crane fly	Adv?	R	at light
HYMENOPTERA (Wasps, Bees, Ants)			
Anthophoridae			
Xylocopa sonorina F. Smith, 1874 (Sonoran carpenter bee)	Adv	O	in dead wood
Formicidae			
Anoplolepis gracilipes (long-legged ant)	Adv	O	on soil
Camponotus variegatus (F. Smith, 1858) (carpenter ant)	Adv	R	at light
Leptogenys falcigera Roger, 1861 (crustacean eating ant)	Adv	O	in wood
ISOPTERA			
unidentified termite	Adv	A	at light
LEPIDOPTERA			
Crambidae (micro-moths)			
Eudonia sp. (moss moth)	End	R	at light
Herpetogramma licarsisalis (Walker, 1859) (grass webworm)	Adv	O	at light
Mestolobes sp.	End	?	at light
Spoladea recurvalis (beet webworm)	Adv	O	at light

LEPIDOPTERA (continued)			
Geometridae			
Anacamptodes fragilaria (Grossbeck, 1909) (koa haole looper)	Adv	?	at light
Lycaenidae			
Lampides boeticus (Linnaeus, 1767) (bean butterfly)	Adv	C	at light; in open field
Udara blackburni (Tuely), 1878 (Blackburn butterfly; koa butterfly)	End	R	in open field[5]
Noctuidae (Miller moths)			
Achaea janata (Linnaeus), 1758 (croton caterpillar)	Adv	O	at light
Ascalapha odorata (Linnaeus, 1758) (Black witch moth)	Adv	O	flushed
Hypena laceratalis Walker, 1858 (lantana caterpillar)	Pur	O	at light
Pseudaletia unipuncta (Haworth, 1809) (armyworm)	Adv	C	at light
unidentified cut worm moth	Adv	A	at light
Plutellidae			
Plutella xylostella (Linnaeus, 1758) (diamondback moth)	Adv	O	at light
Tortricidae			
Amorbia emigratella Busck, 1910 (Mexican leafroller)	Adv	O	at light
ODONATA (Dragonflies and Damselflies)			
Libellulidae (Skimmers)			
Pantala flavescens (Fabricius, 1798) (globe skimmer)	Ind	AA	grazed areas
ORTHOPTERA (Praying Mantis, Grasshoppers, Crickets, Katydids)			
Tettigoniidae			
Euconocephalus nasutus (Thunberg), 1815 (aggravating grasshopper)	Adv	A	heard along roadside

[5] Although seen only once, in flight, identification is relatively strong. There is no other butterfly exhibiting the green underside. Formosan koa is known as a host to this species.

Status:

End	endemic to Hawaiian Islands
Ind	indigenous to Hawaiian Islands
Adv	adventive
Pur	purposefully introduced
?	unknown

ABUNDANCE = occurrence ratings for plants by area:

R	Rare	seen in only one or perhaps two locations.
U	Uncommon-	seen at most in several locations
O	Occasional	seen with some regularity
C	Common	observed numerous times during the survey
A	Abundant	found in large numbers; may be locally dominant.
AA	Very abundant	abundant and dominant; defining vegetation type.

Medically important species

The Waiawa property currently is littered with discarded pieces of equipment (autos, washing machines, drums, etc.), piles of broken rock and cement, and abandoned bottles and cans. These are classic habitat for mosquitoes, centipedes, scorpions, and widow spiders.

Mosquitoes were observed during the survey and most likely breed in water filled cavities in the trash. In recent years, mosquito transmitted illnesses such as dengue have been a greater concern for the state's Department of Health. When clearing of the property begins and this trash is removed the mosquito problem should abate. Cattle watering troughs are likely a lesser contributor to mosquito breeding. Mosquitoes about to emerge are found close to the water's surface where cattle drink. Also, predators likely to feed on mosquito larvae were observed in the troughs. These same predators are unlikely to get access to the inside of a discarded beer bottle, however.

The other medically important species (centipedes, etc.) are almost certain to be present in, around, and under the abandoned equipment. Employees (surveyors, environmental assessment crew, construction workers) should be alert for these species when working on the property.

Although honey bees, paper or mud wasps were not seen, these can be encountered anywhere in the islands. Not seeing them during the short term of this survey does not mean they are not on the property.

All these species may pose a serious risk to some individuals, and supervisors should be aware of any special allergy by employees. Some individuals can experience anaphylactic reactions to venom. When moving trash, stones, or piled brush, use of gloves and long sleeves in addition to covered shoes & long pants will greatly reduce the risk of accidental contact and bites. Pulling socks up over pant cuffs reduces the chance of a stinging invertebrate crawling up a workers leg. Please see *What Bit Me?* for photos and discussion of each pest (Nishida and Tenorio 1993).

POTENTIAL IMPACTS

Potential Impacts on Native, Rare, Federally or State Listed Species

No federally or state listed endangered or threatened species were noted in this survey (USFWS 2006). No anticipated actions related to the proposed project activity in the surveyed locations are expected to threaten entire species or entire populations. There is no federally designated Critical Habitat for any invertebrate species on or adjacent to the subject property.

Recommendations

Landscape with native plants for low cost maintenance:

The *Draft EIS* (Wilson 2007) for Waiawa mentions creating park land and landscaping with native plants when practical. This should create habitats for many native species. Landscaping with native plants will serve to provide habitat for native arthropods while creating an interesting recreation area for walking and bird watching. Importantly, using native plants to landscape will mean lower long-term watering costs, following an initial establishment period. Native plants remain green and so more fire resistant through the summer. Plants chosen to fit the height and space requirements will have very low maintenance costs. Planted in a mix of ground cover, shrub, and tree heights the native plants will also help slow run off on slopes and retain moisture. Shrubs at the tops of gulches can define the edge and improve safety. The two most important plants for native invertebrates, commercially available and appropriate to the elevation and moisture levels at Waiawa, are koa (*Acacia koa*) and 'ilima (*Sida* sp.). The plantings will provide educational, visual, and aesthetic benefits to residents while holding soil at very low on-going cost. Native insects, and birds, will find this refuge over time.

ACKNOWLEDGMENTS

Thanks are extended to Mr. Alan Suwa, Wilson Okamoto, Castle & Cooke staff, and cattleman Robert Cherry for assistance with access to the site at the irregular times required for this survey. Thank you to Dr. Arthur Whistler for the identification of *Solanum mauritianum*. Anita Manning contributed to preparation of this report. Steven Lee Montgomery conducted all surveying and is responsible for all conclusions.

STANDARD NOMENCLATURE

Plant names follow those in *Manual of the Flowering Plants of Hawai'i* (Wagner et al. 1999) and *A tropical garden flora* (Staples and Herbst 2005).
Mammal names follow *Mammals in Hawai'i* (Tomich 1986).
Bird names follow *Hawaii's Birds* (Hawaii Audubon Society 2005).
Place name spelling follows *Place Names of Hawaii* (Pukui et al. 1976).

ABBREVIATIONS AND GLOSSARY

MV mercury vapor
n. new
sp. species
spp. more than one species
UV ultra violet
USFWS United States Fish and Wildlife Service

GLOSSARY[6]

Adventive: organisms introduced to an area but not purposefully.
Alien: occurring in the locality it occupies ONLY with human assistance, accidental or purposeful; not native. Both Polynesian introductions (e.g., coconut) and post-1778 introductions (e.g., guava, goats, and sheep) are aliens.
Arthropod: insects and related invertebrates (e.g., spiders) having an external skeleton and jointed legs.
Endemic: naturally occurring, without human transport, ONLY in the locality occupied. Hawaii has a high percentage of endemic plants and animals, some in very small microenvironments.
Indigenous: naturally occurring without human assistance in the locality it occupies; may also occur elsewhere, including outside the Hawaiian Islands. (e.g., Naupaka kahakai (*Scaevola sericea*) is the same plant in Hawai'i and throughout the Pacific).
Insects: arthropods with six legs, and bodies in 3 sections
Invertebrates: animals without backbones (insects, spiders, snails / slugs, shrimp)
Larva/larval: an immature stage of development in offspring of many types of animals.
Mollusk: invertebrates in the phylum Mollusca. Common representatives are snails, slugs, mussels, clams, oysters, squids, and octopuses.

6 Glossary based largely on definitions in *Biological Science: An Ecological Approach*, 7th ed., Kendall/Hunt Publishing Co., Dubuque, a high school text; on the glossary in *Manual of Flowering Plants of Hawai'i*, Vol.2, Wagner, et al., 1999, Bishop Museum Press, and other sources.

Glossary: cont.

Native: organism that originated in area where it lives without human assistance. May be indigenous or endemic.

Nocturnal: active or most apparent at night.

Purposefully introduced: an organism brought into an area for a specific purpose, for example, as a biological control agent.

Rare: threatened by extinction and low numbers.

Species: all individuals and populations of a particular type of organism, maintained by biological mechanisms that result in their breeding mostly with their kind.

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Survey of Invertebrate Resources
at Koa Ridge Makai, ’Ewa District, O’ahu, Hawai‘i

Prepared by:
Steven Lee Montgomery, Ph. D., Waipahu, Hawai’i

Submitted to:
Helber Hastert & Fee, Planners

February 3, 2009

Table of Contents

Tables

Figures

SUMMARY

The Koa Ridge Makai project site sampled in this biological survey yielded predominantly adventive insect species, and a few native arthropods. No invertebrate listed under either federal or state endangered species statutes was located within the survey area.

INTRODUCTION

This report summarizes the findings of an invertebrate[1] survey conducted as part of an environmental impact statement in support of a proposal to construct Koa Ridge Makai, a residential community, and supporting infrastructure in central O'ahu (Figure 1). Castle & Cooke Homes Hawaii proposes to build on approximately 575 acres, within Tax Map Keys: (1) 9-4-06: 38, portions of 1, 2, 5, 39; and 9-5-03: portions of 1 and 4 (Figure 2)[2]. Also surveyed were supporting drainage detention basin sites, access roads and staging areas, plus a proposed H-2 interchange, (Figure 3) and an off-site sewer line alignment between the Waipahu Wastewater Pump Station and the proposed subdivision trunk connection at Kamehameha Highway adjacent to Central Oahu Regional Park (Figure 29, page 31).

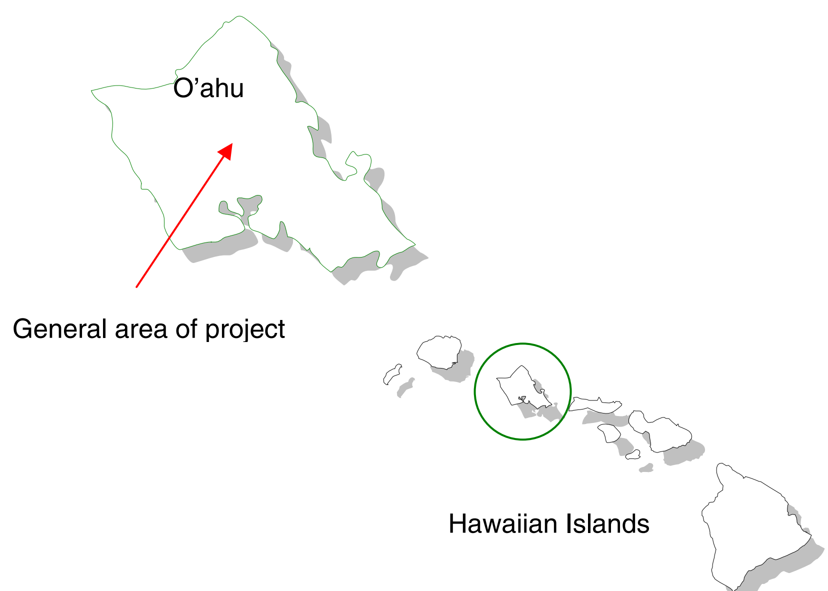


Figure 1: Map showing general location of project site on O'ahu

Invertebrates are often the dominant fauna in natural Hawaiian environments. The primary emphasis of this survey was on terrestrial invertebrates, particularly those that are endemic, indigenous, or threatened species, especially those

[1] Animals without backbones: insects, spiders, snails, shrimp, etc.
[2] For information on Castle & Cooke Waiawa see Montgomery 2008.

having legal status under either, or both federal and state endangered species statutes (DLNR 1996, 1997, USFWS 2005a, 2006).

Native Hawaiian plant, vertebrate, and invertebrate populations are often interdependent. Certain insects are obligatorily attached to specific host plants, using only that plant as their food. These insect relationships with hosts are ancient and often intertwined. The health of native Hawaiian invertebrate populations depends upon habitat quality and absence or low levels of predators introduced from the continents. Sufficient food sources, host plant availability, and the absence or low levels of introduced, continental predators and parasites comprise a classic native, healthy ecosystem. Consequently, where appropriate in the survey discussion, host plants and some introduced arthropods also are noted.

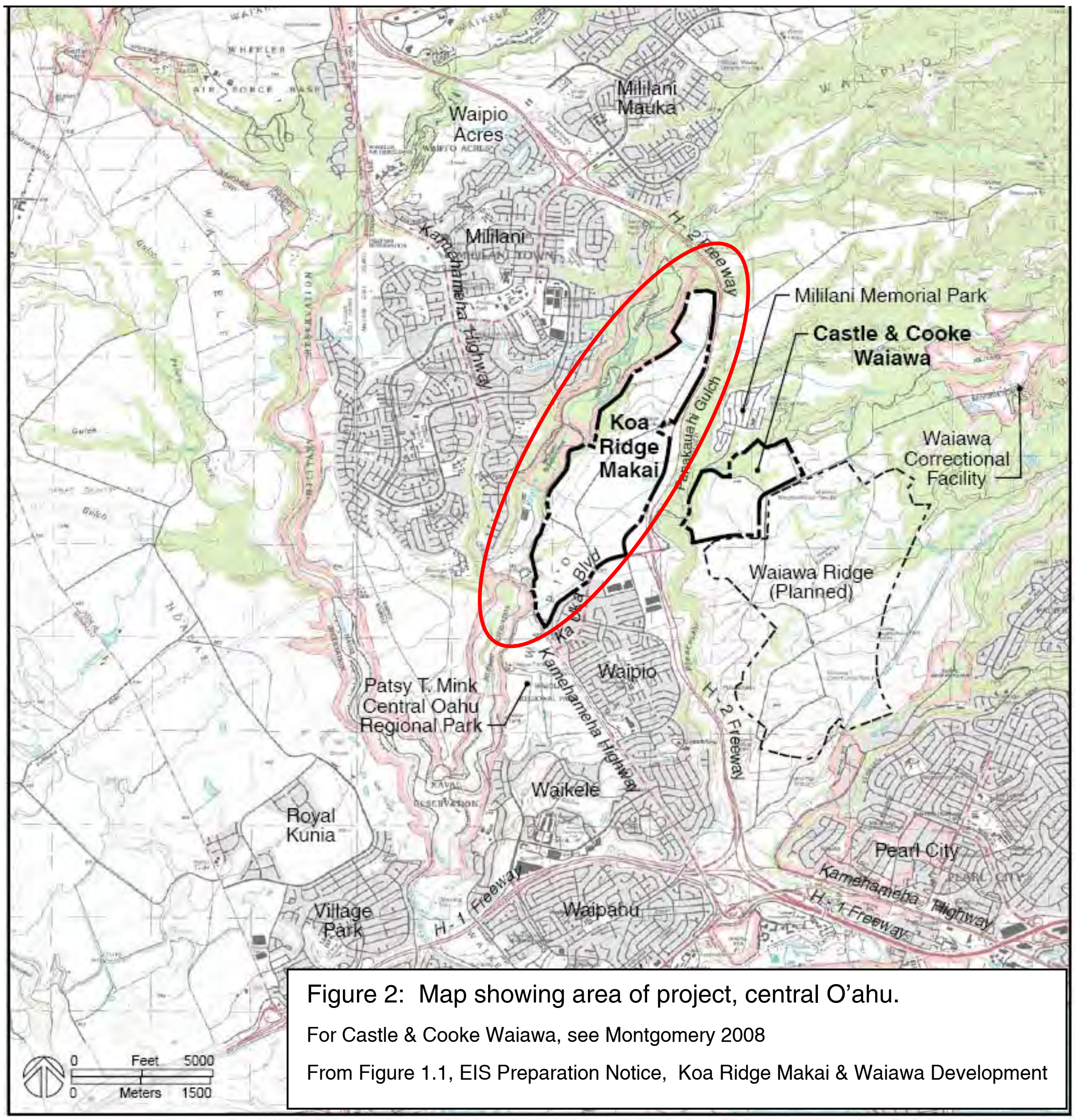


Figure 2: Map showing area of project, central O'ahu.

For Castle & Cooke Waiawa, see Montgomery 2008

From Figure 1.1, EIS Preparation Notice, Koa Ridge Makai & Waiawa Development

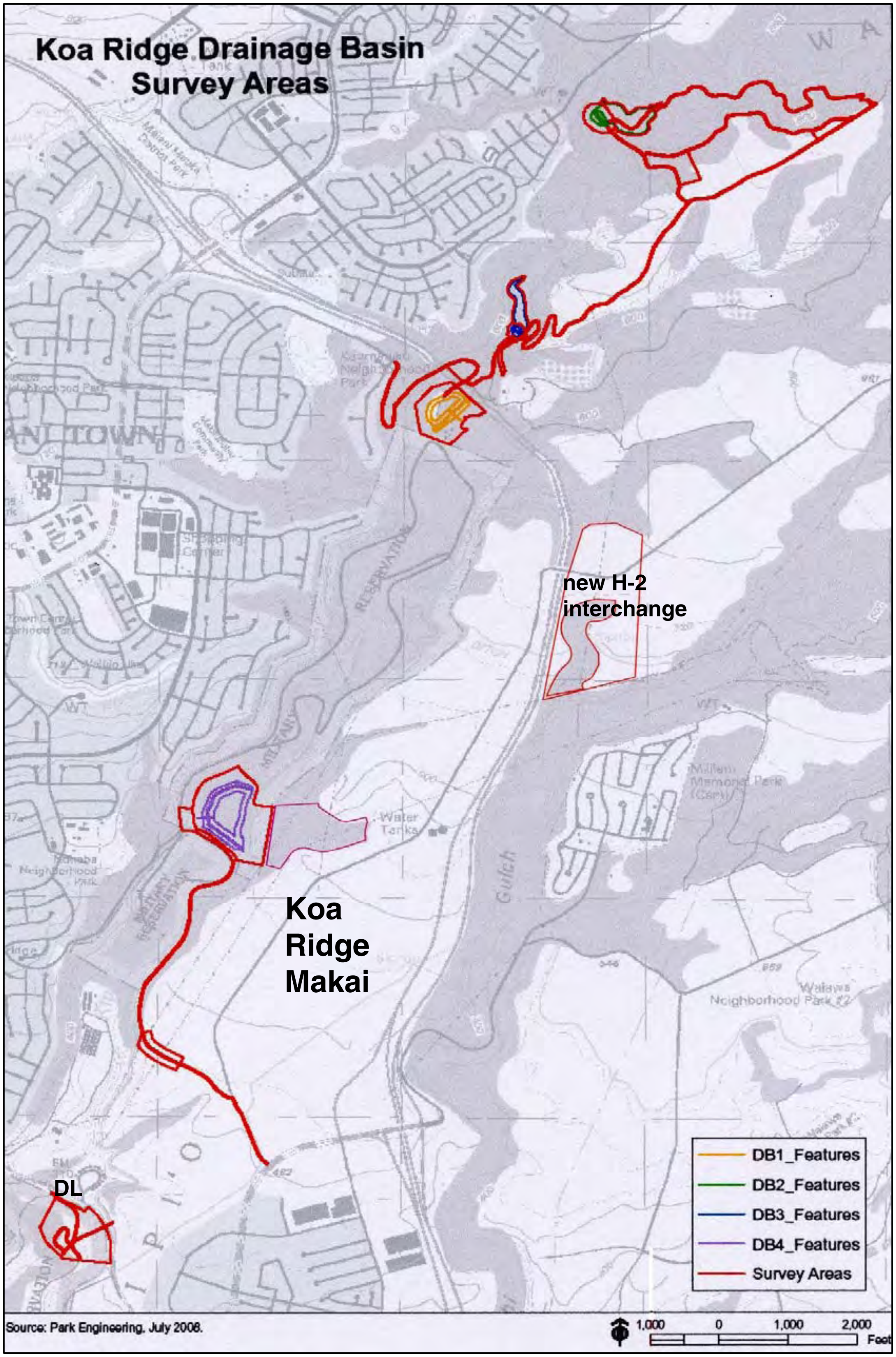


Figure 3. Map showing Koa Ridge Makai off-site infrastructure areas

GENERAL SITE DESCRIPTION

The 575 acre main Koa Ridge Makai parcel, lies west of the H-2 freeway and north of Waipi'o Business Park in central O'ahu. (Figure 1 and 2) Existing housing in Mililani flanks the west side of the property. The Waiāhole Ditch crosses the property. The proposed sewer line alignment travels mostly along existing city streets (Figure 29; page 31). Additional areas on the border of the main site include supporting drainage detention basin sites, access roads and staging areas, plus a proposed H-2 interchange (Figure 3).

Figure 4: Typical area between agricultural fields: solid blocks of grass with occasional koa haole plants.

The largest parcel has been described by botanical consultants as cultivated cropland with grasslands and woodlands dominated by alien species (Figure 4) (Funk 2002, Whistler 2007). Vegetation on the site is primarily alien species introduced since 1790. The land was for many decades planted as pineapple fields. Pineapple cultivators actively eradicated non-crop plants from the rows, interspaces, and borders. Fields were protected by a "stout and ever-ready defense" against the "aggression" of weeds (King in St. John and Hosaka 1932). To pineapple growers, the native plant 'ilima (*Sida* sp.), a host to many native insects, was a weed to be removed quickly because of the many seeds it produced (St. John and Hosaka 1932). Current agricultural crops may have changed but the clearing of land is just as thorough, leaving margins and roadsides to non-crop vegetation, predominantly grasses (Figure 5).

Consequently, Native Hawaiian plants of interest as hosts or shelter for native invertebrates were limited or missing in comparison to less altered island locations at similar elevations and with parallel rainfall.


Figure 5: Typical margin of agricultural area showing weedy areas

The areas planned for supporting infrastructure (construction staging, drainage detention basins, etc) are described by botanists as "disturbed vegetation," and "native [plant] species are nearly absent." (Whistler 2008)

An archaeological survey of the area shows no evidence of lava tubes (Hammatt et al. 1996; Hammatt & Shideler 1996; Shideler 1999, 2003) and none were found during my own survey.

INVERTEBRATE SURVEY METHODS

Previous Surveys and Literature Search

Prior to the field survey, a search was made for publications relating to invertebrates associated with the Koa Ridge Makai site and supporting infrastructure areas (e.g., drainage detention basins). Modern botanical, avian, and mammalian surveys of the sites by Funk (1996, 1999, 2002), and Whistler (2007, 2008) show no reference or evidence of surveying for invertebrates. The cultural survey report and current maps show several place names associated with the area now being called "Koa Ridge Makai." Most of the names are for features that extend over many miles (example: Waiahole Ditch) yet only a small portion of the feature is incorporated into the Koa Ridge project area.

Searches in data base and literature indices retrieve 19th and early 20th century invertebrate collection specimen records giving very general place names (e.g., Kīpapa Gulch) as the collecting site. In addition to searches of the University of Hawai'i and Bishop Museum libraries, the online data bases of AGRIS, Biological Abstracts, Ingenta, NBII Pacific Basic Information Node, and Zoological Record were searched. Our review shows no previous directed surveys of native invertebrates in the project area.

University of Hawaii's Hawai'i Pacific Journal Index shows the expected references to pest insects associated with previous agricultural use of the lands (example: Davis 1969). Several generally applicable technical articles were noted as dealing with control of adventive insects considered pests by the pineapple industry (examples: Illingworth 1926, Sakimura 1966). Some botanical studies of the period when the land was occupied by pineapple fields deal with some native host plants as 'pests' in the fields (example: St. John & Hosaka 1932).

In the 1920s and 1930s, economic entomologists like J. F. Illingworth made sporadic reports on arthropods, native and non-native, encountered in the course of their duties. Illingworth reported on insects found in Waiāhole Ditch where an eddy had caused insects to pile up "where the ditch crosses the Kamehameha Highway at Waipio" (1931a). Although the majority of the reported species were adventive, *Telmatogeton torrenticola* (Terry, 1913), an endemic Diptera, was included in the list. As *T. torrenticola*'s native breeding habitat is at a much higher elevation, the specimens found by Illingworth were doubtlessly carried by the ditch waters to the lower elevation. The species would not naturally occur at the Koa Ridge Makai elevation.

Figure 6. Section of Waiāhole Ditch as it passes through the property.

Terrestrial invertebrates from the general location of the project were collected over the decades. For example, Bishop Museum Curator of Collections E. H. Bryan, Jr., and Entomology staff Amy Suehiro were among the members of the Hawaiian Botanical Society making a field trip to Kīpapa Gulch in 1932. The Society members made an insect collection during the field trip, donating it to Bishop Museum (Gregory 1933). Also in the 1930s, Edward Hosaka, then Assistant to Bishop Museum Curator of Collections, made repeated visits to Kīpapa Gulch in research for his Master's degree (Hosaka 1937). Bishop Museum annual reports (Gregory 1934) show his periodic donations of Kīpapa Gulch insects doubtlessly found in his explorations and inspection of plants. Unfortunately, we know only that there were collections, but no details of species. Computer retrieval of entomological specimens by location is not yet possible for the majority of the millions of Bishop Museum specimens.

Fieldwork

Field surveys for this study were conducted September - December 2008 at the Koa Ridge Makai site, ancillary areas, and along the route of the proposed sewer trunk line. I conducted a general assessment of the terrain and habitats at each area as I started that segment of the survey. Surveying efforts were conducted at various times of day and night, a technique which is vital for a thorough survey. Native botanical resources identified by Funk (1996, 1999, 2002) and by Whistler (2007, 2008) were an assist in my searches. Hosaka's Kīpapa Gulch (1937) study was also reviewed.

See Figures 20-24 for locations of light surveys and special host plant or invertebrate populations. Dirt roads that cross many areas of the Koa Ridge Makai area were used to improve coverage. The survey for the proposed sewer alignment followed the actual route.

Fieldwork schedule:

Sep 28 and Oct 6 and 7, 2008	
	Day survey of proposed alignment of the sewer trunk line
Oct 26-27, 2008	Site examination and general orientation
	Light survey of Koa Ridge Makai (KRM) and DB 4
Oct 27-28, 2008	General day and light surveys KRM and DB 4
Nov 1 , 2008	Inspection of *Solanum mauritianum* plants
Nov 5 , 2008	Day survey of KRM; inspection of *S. mauritianum* plants
Nov 28, 2008	Day survey; light survey of DB 1; light survey of DL 1
Nov 30, 2008	General day survey; light survey of proposed freeway ramp addition; follow up survey DL 1
Dec 22-23, 2008	General day survey DB 1, 2, 3 ;light survey of DB 2; follow up survey area DL 1

Survey Methods
Since 1969, I have taken part in field projects at other locations in similar locations on O'ahu and throughout the island chain. Those experiences and the results of those surveys provided the basis for my study design and my analysis of results. The following survey methods for terrestrial invertebrates were used as appropriate to the terrain, botanical resources, and target species.

Host plant searches: Potential host plants, both native and introduced, were searched for arthropods that feed or rest on plants. The property was traversed in a wandering manner, criss-crossing areas to access potential host plants. Along the route of the proposed alignment of the sewer trunk line from Koa Ridge Makai to the Waipahu Wastewater Pump Station, the few potential host plants in waste areas and roadsides were examined.


©Figure 7. Light attracts arthropods

Light survey: A survey of insects active at night is vital to a complete record of the fauna. Many insects are only active at night to evade birds, avoid desiccation and high temperatures, or to use night food sources, such as night opening flowers. Light sampling uses a bright light source in front of a white cloth sheet (Figure 7). Nocturnal insects seem to mistake the collecting light for the light of the moon, which they use to orient themselves. In attempting to navigate by the scientist's light, confused insects are drawn around the light and land on the cloth in confusion. This type of survey is most successful during the dark phase of the moon or under clouds blocking starlight. Vegetation usually blocks light from being seen over long distances, and most moths and other night fliers are not capable of very distant flight. Consequently, light surveying does not call in many insects from outside the survey area.

Light surveying began at dark and was conducted for 8 -10 hours each day. The light source was a mercury vapor (MV) bulb powered by an electric generator. On most nights a second, nearby site was established with an ultra violet (UV) or black light bulb. Both light wave lengths are known to be attractive to night active insects. Each location was monitored and visiting species noted.

Locations were chosen based on experience, host plant proximity, and terrain. All light survey locations and special sites are marked on Figures 21-25.

Sweep nets: This method assists in surveying many flying and perching insects. A fine mesh net was swept across plants, leaf litter, rocks, etc. to census any flying, perching or crawling insects.

Visual observation: At all times, we were vigilant for any visual or aural evidence of arthropod presence or activity. Visual observations provide valuable information and are a cross check that extends the reach of survey techniques. Visual observation also included turning over rocks, dead wood, and other debris.

Survey Limitations / Conditions:
The survey schedule and duration certainly were adequate to assess potential impacts of the proposed project. Nevertheless, my ability to form advisory opinions regarding the large number and kinds of invertebrates present is limited by several factors.

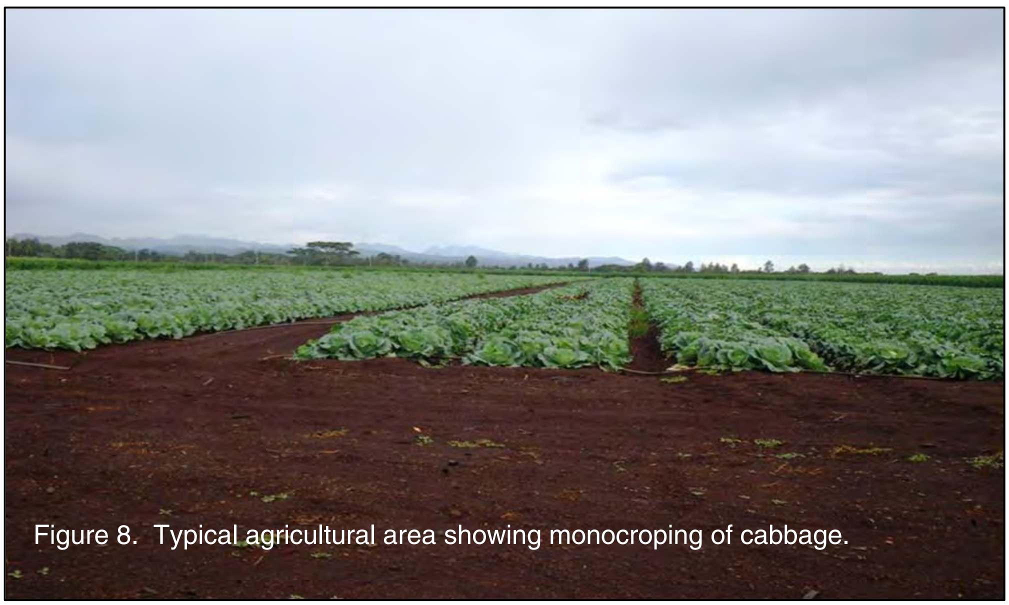


Figure 8. Typical agricultural area showing monocroping of cabbage.

Common alien species:
No attempt was made to document the many common alien arthropod species present in the area. With much of the property under cultivation, a number of crop pests were encountered. Monocultures (large fields of one plant) (Figure 8) often attracts specific arthropods and their predators. For example, lady beetles (general predators as larvae) were seen in several locations and the cabbage fields attracted the cabbage white butterfly (*Pieris rapae*).

Physical limitations: Within a few areas of the site, the density and height of the alien grasses (Figure 9) made travel difficult, however, such dense, single species dominated habitat is rarely attractive to native species. In almost every case, it was possible to obtain access to all host plants of interest. The light surveys compensated well for this reduced access. The size of the project area allowed a fairly comprehensive survey with the resulting survey being representative and targeted to locate and examine host plants which might be utilized by native invertebrates.

Figure 9. Example of 'grass wall'.

Survey conditions: Monitoring at a different time of the year, or for a longer period of time, might produce a longer or different arthropod list. Weather and seasonal vegetation play an especially important role in any survey of invertebrates. Many arthropods habitually emerge and breed to overlap or follow seasonal weather or to coincide with growth spurts or fruiting of an important plant food. The absence of host plants, however, was a stronger factor affecting the invertebrate species noted than seasonal changes, weather, or other causes.

Weather was favorable for surveying during most days of fieldwork. This study was conducted from the beginning of the winter season well into the rainy period, and the few native host plants were in a stage adequate for surveying. As the survey was interrupted and restarted, it spanned several months ensuring surveying under varying sun, rain, and moon conditions. On the majority of nights when light surveying was conducted the moon presented minimal or no competition to the survey lights. On some nights the moon was obscured wholly or partially with cloudy skies and / or light, intermittent sprinkles. On the last nights of the survey approaching the full moon in December (USNO), the moon was a competing factor as clouds cleared, however, response to the light did not substantially differ from previous nights. Additional surveying was conducted at the end of December when the moon again was minimal.

No light census was conducted along the route of the proposed alignment of the sewer trunk line from Koa Ridge Makai to the Waipahu Wastewater Pump Station. The entire route is dominated by commercial, residential, and street lighting during all hours of darkness. A light census at any location along that route would not have returned meaningful results.

INVERTEBRATE SURVEY RESULTS:

Table 1 records the results of day and night invertebrate surveys. In addition to the invertebrate results, we made several incidental observations:

Small Indian mongoose (*Herpestes auropunctatus*) and feral pig (*Sus scrofa*), signs of pig rooting, were seen within most portions of the property. The only native bird seen was Kolea / Pacific Golden-Plover (*Pluvialis fulva*) which was common throughout the open, agricultural areas with low vegetation.

DISCUSSION OF INVERTEBRATE RESOURCES

Native species observed on the property are discussed below. Information is provided on several alien species frequently observed by the public that may be misidentified or confused with native species. Alien species that affect the survival of native species and species that impact human health also are discussed.

NATIVE SPECIES

MOLLUSCA: GASTROPODA

PULMONATA Achatinellidae

The only native snail noted in the survey is a small brown species, either in the genus *Tornatellaria* or *Tornatellides*. The group, formerly in Tornatellinidae, has been reclassified into Achatinellidae. (Zimmerman 1948, HBS 2002b)

NATIVE SPECIES: continued

ARTHROPODS

ARANEAE Lycosidae: *Lycosa* sp.

On the night of December 23, an individual *Lycosa*, a possibly native wolf spider (18 mm), made a brief appearance to hunt the insects attracted to the light. These are quick, strong predators which give maternal care to their young. They hide alone by day and hunt by night in established individual territories. (Manning/Montgomery in Liittschwager & Middleton 2001)

© Figure 10. Typical example of *Lycosa* sp.

Lycosa spiders (example Figure 10) recorded on O’ahu are all endemics: *L. hawaiiensis* and *L. oahuensis*, known from several islands, and *L. perkinsi* known only from O’ahu.

INSECTA

DIPTERA (Flies and mosquitoes)

Pipunculidae: *Cephalops juvator juvator* (Perkins, 1905)

These native, big-headed flies came to light at two sites during our survey. They are valued as parasites in controlling Homoptera (examples: aphids, scale insects). The flies hover with extreme agility grasping then lifting their prey. The victim is released after an egg is laid on it. This will hatch and feed on the planthopper or sugar cane leafhopper. The flies use both native and alien Homoptera, and were a native assist to sugar cane crops.

LEPIDOPTERA (butterflies and moths)

Cosmopterigidae: *Hyposmocoma*

Two species of native *Hyposmocoma*, as caterpillars, were found on the rocky outcroppings and four species, in adult stage, came to light. Considering the population is likely at a low level due to the dry year, the diversity is note worthy. Properly called “case bearers,” the caterpillars are sometimes misleadingly called “bagworms.” Very young caterpillars of case bearers find safety in a hiding place like a leaf curl. When growth forces them out of that protection, they intricately weave a portable shell of their own silk from a lip spinneret. For camouflage, they add bits of their surroundings to the case using their silk: snips of dry grass or leaves, flakes of bark, maybe a little dirt. The case is then easily mistaken by a predator as another part of the landscape (Figure 11 shows oval tortoise case

NATIVE SPECIES: *Hyposmocoma*: continued

Figure 11. *Hyposmocoma* builds a tortoise shell like case to match the tree's bark

at DB 2). These bunkers are fitted with a hinged lid (operculum), pulled shut by mini-mandibles to defend them from enemies like beetles and micro wasps. Their relationship to the case is similar to that of a hermit crab to his shell. Although not physically connected to the case as a snail or turtle, they are dependent on it, and die if removed – even if protected from predators and given food. They don't move far, but feed while partly emerged from the case, dragging along their protective armor by their six true legs. (Manning/Montgomery in Liittschwager & Middleton 2001) With over 500 kinds, *Hyposmocoma* micromoths are the greatest assemblage of Hawaiian Island moths, showing astonishing diversity. After writing 630 pages on them, Dr. Elwood Zimmerman lamented the inadequacy of his study. He noted an enormous cluster of species with explosive speciation and diverging radiation (Zimmerman 1978). Much remains to be learned about the life ways of this interesting group of insects now under study by University of Hawaii's Dr. Daniel Rubinoff and colleagues (Rubinoff et al. 2008).

NATIVE SPECIES: LEPIDOPTERA: continued

Crambidae: *Eudonia* sp.
This endemic, narrow winged, speckled moth is represented by 15 species known from O'ahu of the 60 species in the island chain. Three specimens came to our lights during the surveys. A typical *Eudonia* feeds on mosses.

Pyralidae: *Mestolobes* sp.
Examples of this group of native moths were seen at light. The adults also are often seen flying in daylight to flowers. The larvae are unknown.

Xyloryctidae: *Thyrocopa ingeminata* Meyrick, 1915
Thyrocopa moths are a dominant group of 50 species, although this species is known only from O'ahu. The larvae feed mostly on dead wood and debris. They are of great interest to evolutionary scholars (Medeiros pers. comm.) Only one individual came to the light.

ODONATA (Dragonflies and Damselflies)
Libellulidae: *Pantala flavescens* Globe skimmer

Figure 12. The Waiāhole Ditch, looking toward H-2 Freeway

The Waiāhole Ditch (Figure 12) crosses the property near the H-2 freeway. Together with stock watering troughs, it provides a water source to support the indigenous dragonfly *Pantala flavescens* (Figure 13). Among the most easily observed native insects, they are large, easily approached by people, and graceful in flight. Any small amount of fresh water will attract them and they often colonize human maintained water sources such as golf course water hazards or home fish ponds The adults lay eggs in the water where they develop into young called naiads. Mosquito larvae are among the foods of the naiads.

NATIVE SPECIES: *Pantala flavescens*: continued

Insects associated with the cattle and crops surely provide the adults with an easy living. The proposed habitat change will no doubt reduce their numbers, but they are likely to recolonize almost any water source. The native dragonflies are widely distributed throughout the Hawaiian Islands, from Kure to Hawai'i Island (HBS 2002; Nishida 2002).

© Figure 13. Globe skimmer (*Pantala flavescens*)

ALIEN SPECIES
ARTHROPODS
INSECTA
HYMENOPTERA (Wasps, Bees, Ants)
Formicidae: *Leptogenys falcigera*

© Figure 14. Crustacean eating ant

Leptogenys falcigera (Figure 14) is an ant known for preying on terrestrial crustaceans, including native species. It nests in dead wood. They do not sting or bite humans but may be seen by crews moving dead logs or other nesting sites.

LEPIDOPTERA
Noctuidae: *Achaea janata*
This alien moth was seen in flight. See discussion on page 32-34 under Invertebrates Not Present, LEPIDOPTERA, Sphingidae: *Manduca blackburni*.

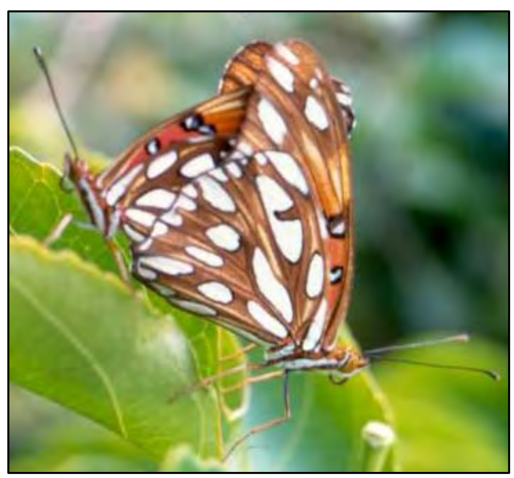
ALIEN SPECIES: LEPIDOPTERA: continued

Noctuidae: *Ascalapha odorata* Black witch moth

© Figure 15. Black witch moth; sometimes mistaken for a bat

The black witch moth has been widely distributed in the island chain since the 1920s. The classic food plant of the caterpillars, Monkeypod (*Samanea saman*), was noted by botanical surveyors and in my own survey in the Koa Ridge Makai area. Monkeypod also is common along the route of the proposed sewer trunk line (see page 28). Near homes the moth is seen resting under the eaves of roofs during the day. In rural areas it rests under foliage and against tree trunks. It is most frequently seen a dawn or dusk. When seen in flight in such low light, this large moth is occasionally mistaken for a bat.

Nymphalidae: *Agraulis vanillae*
The passion vine butterfly (Figure 16) was seen in several locations in the property. In quick flight its bright orange wings might be mistaken by members of the public for the Kamehameha butterfly (*Vanessa tameamea*). At rest, the silver markings on the underside of the wings easily distinguish it from the Kamehameha butterfly.



© Figure 16. Silver markings on the wings easily identify the passion vine butterfly

ALIEN SPECIES: LEPIDOPTERA: continued

Sphingidae: *Agrius cingulata* Sweet potato hornworm

© Figure 17. Sweetpotato hornworm showing pink markings

This large and often seen moth is most easily confused by the public with the Blackburn's sphinx moth (*Manduca blackburni*) described below. The adult *A. cingulata* having PINK markings (Figure 17) along both sides where *Manduca* has orange. When the moth is at rest with wings folded, these color markings are hidden. The caterpillars feed on all sweet potato, morning glory, and related plants. It is widely distributed around the Hawaiian Islands. (HBS 2002a, Nishida 2002)

ODONATA (Dragonflies and Damselflies)
Aeshnidae: *Anax junius* Common green darner
Also seen near the Waiāhole Ditch was the common green darner (*Anax junius* (Drury), 1770*)*. This non-native species is widely distributed, being known in North and South America, Europe and parts of Asia. It is sometimes confused with native species.

ALIEN SPECIES: continued

ORTHOPTERA (Praying Mantis, Grasshoppers, Crickets, Katydids)
Tettigoniidae: *Euconocephalus nasutus* Aggravating grasshopper
The distinctive noise of the aggravating grasshopper (Figure 18), a bit like an electrical transformer gone bad, is heard at dusk and early dark. The sound is the call of the male. People often hear the sound but can not associate it with the creator.

Figure 18. Aggravating grasshopper

MEDICALLY IMPORTANT SPECIES

Invertebrate species which negatively impact human health are discussed below.

The area hosts **centipedes, scorpions**, and likely **widow spiders**. Widow spiders are historically known from the pineapple fields in central O'ahu from the time of their first introduction to the island chain (Illingworth 1931b). Centipedes and scorpions are often disturbed when dead brush or trash is cleared.

LEPIDOPTERA

Stinging nettle caterpillar (*Darna pallivitta*)

This newly introduced pest is spreading across the islands. The adult responded to my light survey and it has been noted in Kīpapa Gulch by others (Nagata 2008). The species is likely to be found throughout the surveyed property by the time survey and construction crews are working more intensively in the area. The stinging spines may cause burning and itching sensations on the skin. Swelling and welts can last for several days, then a persistent rash may last for weeks. For any severe symptoms, especially breathing difficulty, seek medical help immediately. (DOA, HEAR)

Figure 19. Avoid contact with the spines of the stinging nettle caterpillar (HDA photo)

DIPTERA

Mosquitoes were observed during the survey and most likely breed where water is allowed to stand in discarded containers, animal troughs, and natural depressions. As winter rains intensify, mosquitoes will increase. The amount of trash on the property likely to be mosquito-friendly was lower than on some adjacent properties. Nevertheless, in recent years, mosquito transmitted illnesses, such as dengue fever, have been a greater concern for the state's Department of Health. When clearing of the property begins and trash is removed, the mosquito problem should abate. Animal watering troughs are likely a lesser contributor to mosquito breeding than trash. Mosquitoes about to emerge are found close to the water's surface where animals drink. Water in the Waiāhole Ditch is constantly moving, and thus presents poor habitat for mosquito breeding.

Medically important species: continued

HYMENOPTERA

The three **ants** noted in the survey, long-legged ant (*Anoplolepis gracilipes*), crustacean eating ant (*Leptogenys falcigera*), and the big-headed ant (*Pheidole megacephala*), are not known to bite or sting humans. Caution should be used, however, anywhere nests or large numbers of ants are found.

Honey bees (*Apis mellifera*) were seen principally in Koa Ridge Makai. Although their presence is important to the current agricultural operations, their sting is known to cause **severe allergic reaction** in sensitive individuals. **Paper wasps** (*Polistes exclamans*) were seen in several locations. Unlike honey bees they can sting repeatedly. Mud wasps were not seen, but they can be encountered anywhere in the islands. Not seeing them during the short term of this survey does not mean they are not on the property.

©Figure 20. Carpenter bee

The Sonoran **carpenter bee** (*Xylocopa sonorina*) a large, introduced bee (Figure 20) was seen in several areas of Koa Ridge Makai and the supporting infrastructure areas. Their name derives from their activity of chewing distinctive round, shallow tunnels for a home in soft, dry, dead wood. Males are golden and limited in number; females more numerous and black. Although relatively large, and noisy in flight, they are usually harmless. When workers begin to clear dry wood where carpenter bees might live, the bees will fly out to protest and come quite close to people, but do not sting unless handled.

Medically important species: continued

Recommendations:

Employees (surveyors, environmental assessment crew, construction workers) should be alert for all these species when working on the property as they may pose a serious risk to some individuals. Supervisors should be aware of any special allergy by employees. Some individuals can experience anaphylactic reactions to venom (e.g., bee stings). When moving trash, stones, or piled brush, use of gloves and long sleeves in addition to covered shoes & long pants will greatly reduce the risk of accidental contact and bites or stings. Pulling socks up over (outside of) pant cuffs reduces the chance of a stinging invertebrate crawling up a workers leg (e.g., stinging nettle caterpillar).

Please see *What Bit Me?* for photos and discussion of Hawaii's long-standing pests (Nishida and Tenorio 1993).

A compact location for information on identification, control, and response to the newly introduced stinging nettle caterpillar (*Darna pallivitta*) is the HEAR web site http://www.hear.org/species/darna_pallivitta/ which provides links to Hawaii Department of Agriculture and Cooperative Extension Service pamphlets.

Table 1: List of Invertebrates[3]: Koa Ridge Makai, and off-site infrastructure areas, O'ahu

			Location							
Species	Common name	Status	Koa Ridge Makai	DB1 DB3	DB2	DB4	DL1	new H2 ramps	General abundance	Site of recovery
MOLLUSCA										
GASTROPODA										
PULMONATA	snails / slugs									
Achatinellidae										
Tornatellides sp.		Ind					C			
ARTHROPODA										
ARANEAE	spiders									
Heteropodidae										
Heteropoda venatoria	large brown spider / cane spider	Adv							U	leaf litter
Lycosidae										
Lycosa sp.	wolf spider	End					R			at light
ARACHNIDA										
SCHIZOMIDA										
Scorpiones	scorpions									
Isometrus maculatus (De Geer)	lesser brown scorpion	Adv							O	bark
INSECTA										
DIPTERA	flies and mosquitoes									
Culicidae										
Culex quinquefasciatus Say, 1823	mosquito	Adv							C	throughout
Pipunculidae:										
Cephalops juvator juvator (Perkins, 1905)		End	U				U			
HYMENOPTERA	wasps, bees, ants									
Anthophoridae										
Xylocopa sonorina F. Smith, 1874	Sonoran carpenter bee	Adv							O	dead wood
Apidae										
Apis mellifera Linnaeus, 1758	honey bee	Pur							C	in flight
Formicidae	ants									
Anoplolepis gracilipes	long-legged ant	Adv							A	on soil
Camponotus variegatus (F. Smith, 1858)	carpenter ant	Adv							U	at light
Leptogenys falcigera Roger, 1861	crustacean eating ant	Adv							U	in wood cavities
Pheidole megacephala	big-headed ant	Adv							C	on soil
Solenopsis geminata (Fabricius, 1804)	fire ant	Adv							O	
Vespidae	wasps									
Polistes exclamans Viereck, 1906	common paper wasp	Adv							C	bushes

[3] Names authority: Hawaii Biological Survey 2002; Nishida 2002; Zimmerman 1948-80; Zimmerman 2001

Table 1: continued

			Location							
Species	Common name	Status	Koa Ridge Makai	DB1 DB3	DB2	DB4	DL1	new H2 ramps	General abundance	Site of recovery
INSECTA										
LEPIDOPTERA										
Cosmopterigidae	case bearers									
Hyposmocoma alliterata Walsingham, 1907	broad, pointed case	End	O					O		at light
Hyposmocoma sp. A	straight slender case	End			U		U			under stones
Hyposmocoma sp. B	curved, broad case	End			U		U			on bark
Hyposmocoma sp. C	oval tortoise case	End			R					on bark
Crambidae	micro-moths									
Eudonia sp.	moss moth	End	U				U	U		at light
Omiodes localis (Butler, 1879)	grass leaf roller	End					R	R		at light
Tamsica hyacinthina (Meyrick 1899)		End	U	U		U	U	U		at light
Limacodidae										
Darna pallivitta	stinging nettle caterpillar	Adv							U	
Noctuidae	miller moths									
Achaea janata (Linnaeus), 1758	croton caterpillar	Adv				A				at light
Ascalapha odorata (Linnaeus, 1758)	black witch moth	Adv							U	at light
Nymphalidae										
Agraulis vanillae (Linnaeus, 1758)	passion vine butterfly	Adv	O							field
Pyralidae										
Mestolobes miniscula (Butler 1881)		End	C	C	C		C	C		at light
Sphingidae	hawk moths									
Agrius cingulata (Fabricius, 1775)	sweetpotato hornworm	Adv					U			at light
Xyloryctidae										
Thyrocopa ingeminata Meyrick, 1915		End	R							at light
ODONATA	dragonflies and damselflies									
Aeshnidae										
Anax junius (Drury, 1770)	common green darner	Adv	O							Waiāhole Ditch
Libellulidae	skimmers									
Pantala flavescens (Fabricius, 1798)	globe skimmer	Ind	O	O						in flight pastures

Table 1: continued

			Location							
Species	Common name	Status	Koa Ridge Makai	DB1 DB3	DB2	DB4	DL1	new H2 ramps	General abundance	Site of recovery
INSECTA										
ORTHOPTERA	praying mantis, grasshoppers, crickets, katydids									
Tettigoniidae										
Euconocephalus nasutus (Thunberg), 1815	aggravating grasshopper	Adv	O							tall grass
CHILOPODA										
SCOLOPENDROMORPHA										
Scolopendridae	centipedes									
Scolopendra subspinipes Leach, 1815	large centipede	Adv							O	at light

Status:
End endemic to Hawaiian Islands
Ind indigenous to Hawaiian Islands
Adv adventive
Pur purposefully introduced
? unknown

Abundance = occurrence ratings:
R Rare: seen in only one or perhaps two locations
U Uncommon: seen at most in several locations
O Occasional: seen with some regularity
C Common: observed numerous times during the survey
A Abundant: found in large numbers
AA Very abundant: abundant and dominant

Figure 21. Map showing location of light census (**A**) to cover portions of Koa Ridge Makai and DB 4 area, Oct 26-27, 2008.

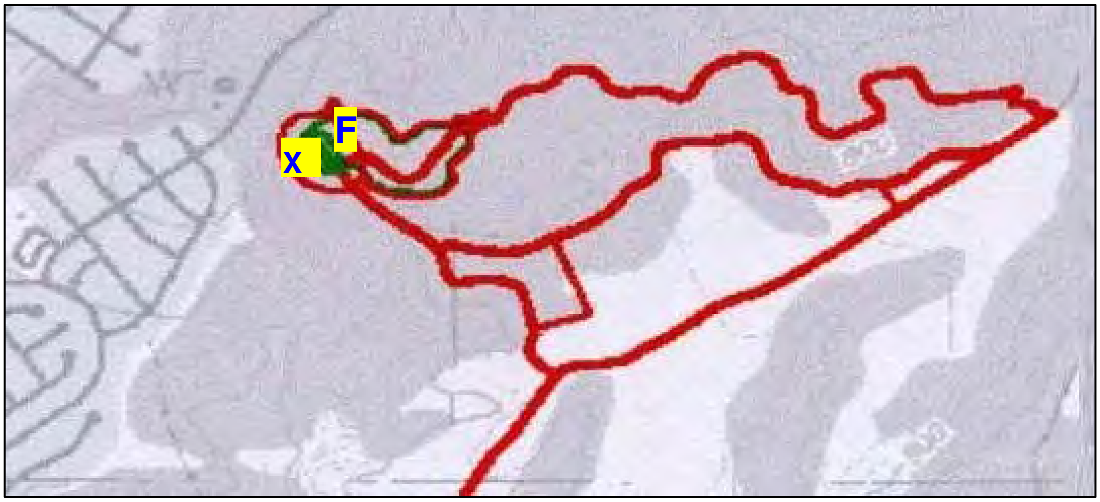


Figure 22. Area DB 2 showing location of light census (F); location of *Hyposmocoma* population (**X**), Dec 22-23, 2008

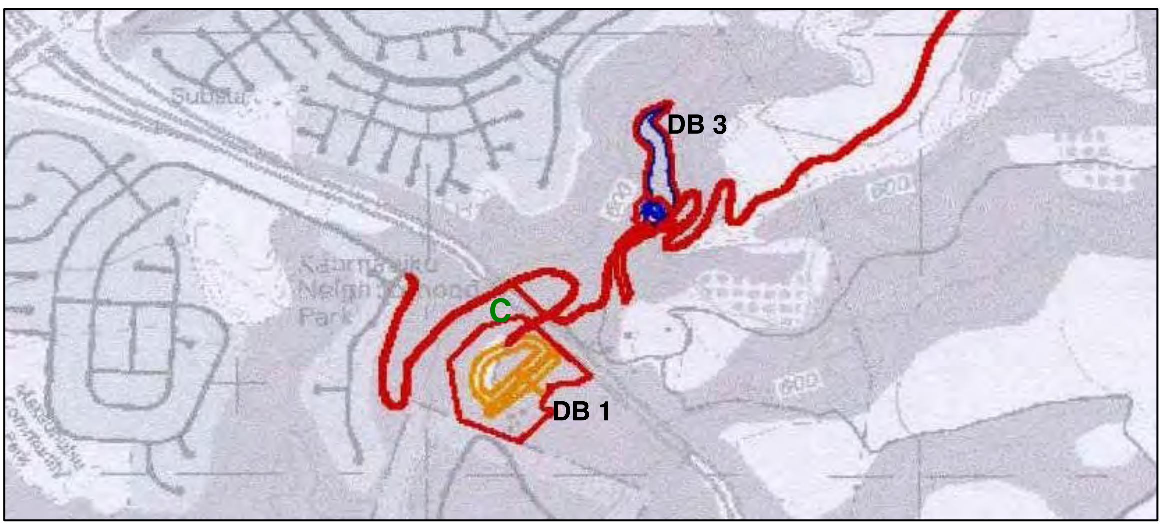


Figure 23. Areas DB 1 and 3 showing location of light census (**C**) Dec 4, 2008

Figure 24 . Area DL 1 showing location of light census (**B**) Nov 30, 2008, (**D**) Dec 5, 2008.

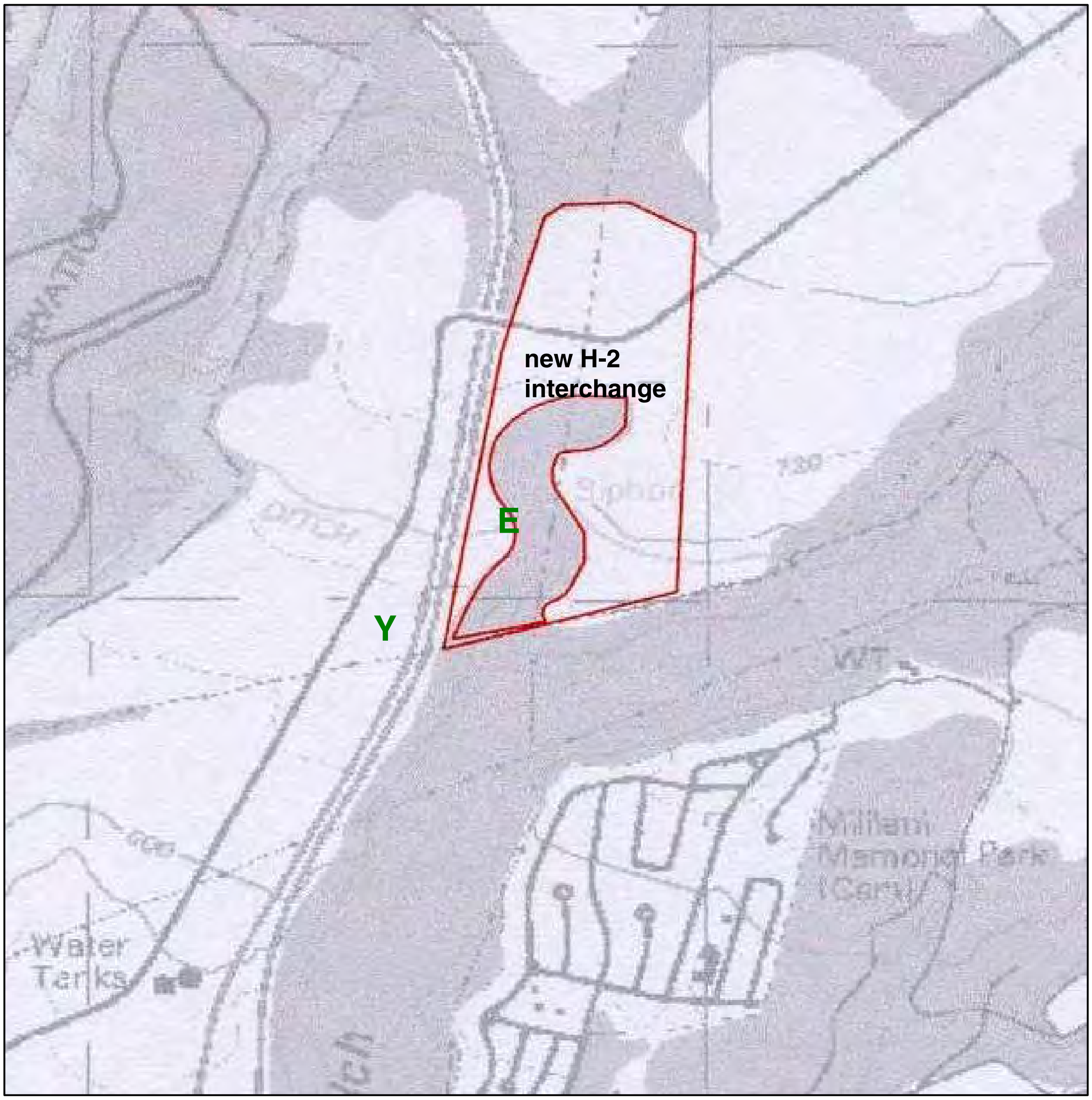


Figure 25. Area of new H-2 interchange light census location (E) Nov 28, 2008

Y = Location of grove of *Solanum mauritianum* plants (Figure 32)

INVERTEBRATES NOT PRESENT

Plant and invertebrate populations are interdependent. Consequently, host plant presence is one way to describe the health of invertebrate populations. The near absence of keystone native plants such as koa (*Acacia koa*) and 'ilima (*Sida* sp.) in the Koa Ridge Makai area (Whistler 2007) contributed much to the paucity of Hawaiian arthropods there (Swezey 1954). A few examples of native plants in some of the ancillary areas (Whistler 2008) did not result in a higher native insect population in that small area (near DB2, Figure 22).

Alien predatory ants are a major cause for the scarcity of native arthropods. The long-legged ant (*Anoplolepis gracilipes*) and the big-headed ant (*Pheidole megacephala*), which prey on other insects (Zimmerman 1948-80) are present on the property. These ants are well documented as a primary cause of low levels of native arthropods at elevations up to 2000 ft. (Perkins 1913).

SEWER TRUNK LINE PROPOSED ALIGNMENT

No native invertebrates were noted in a survey of the sewer alignment.

The route of the proposed sewer trunk line (Figure 29) runs primarily along established streets in business and residential areas. Along most of the route, frequently trimmed hedges, mowed lawns, and paved roadways predominate. Ants, a well-known enemy of native invertebrates, were common along the route. Native plants have been used as decorative plantings at a few locations along the route. These plantings (and any invertebrates using them as hosts) should be safe from the construction as they are contained in planters and on private property above the sidewalk.

The landscape surrounding the H-1 freeway interchange at Paiwa Street is regularly mowed, reducing the chance of native host plants. We observed the location regularly throughout the period September - December 2008, and never observed plants large enough or diverse enough to support native invertebrates.

Sewer Trunk Line: continued

Special attention was given to the area around Waipahu Wastewater Pump Station where Kapakahi Stream runs along the ewa side of Waipahu Depot Road and then into Puohala Marsh. A very few native and a scattering of adventive plants which could host native invertebrates sporadically occur along the ewa side of Waipahu Depot Road. One individual tree tobacco (*Nicotiana glauca*), the best alien host plant for the endangered Blackburn's sphinx moth (*Manduca blackburni*), was found on the Kapakahi Stream side of the road opposite the Waipahu Wastewater Pump Station. The plant showed no signs of feeding which could be attributed to *Manduca blackburni* (see page 32). The area where the plant was growing is under constant stress from parking cars (related to nearby Honolulu City refuse transfer station) and a subsequent follow-up inspection showed the plant had disappeared.

Figure 26. Waipahu Wastewater Pump Station (building far left) and Kapakahi Stream (distant right). Area of sporadically recurring host plants (red).

Although none were seen in our visits during this survey, it is probable that native and adventive Odonata (damselflies and dragonflies) use Kapakahi Stream as habitat.

Sewer Trunk Line: continued

Figure 27. Looking from terminus of Paiwa Street toward Central Oahu Regional Park.

The portion of the sewer route which passes Central Oahu Regional Park and moves to the mauka terminus of Paiwa Street was given special attention as well. At both ends of the route, the few native plants found are common in disturbed habitats (e.g., *Waltheria indica* or 'uhaloa) and are replicated along many streets and roadways throughout O'ahu. No native arthropods were noted.

See also *Ascalapha odorata* (page 16).

Figure 28. 'Uhaloa (*Waltheria indica*) was one of the few wild growing native host plants noted on the route.

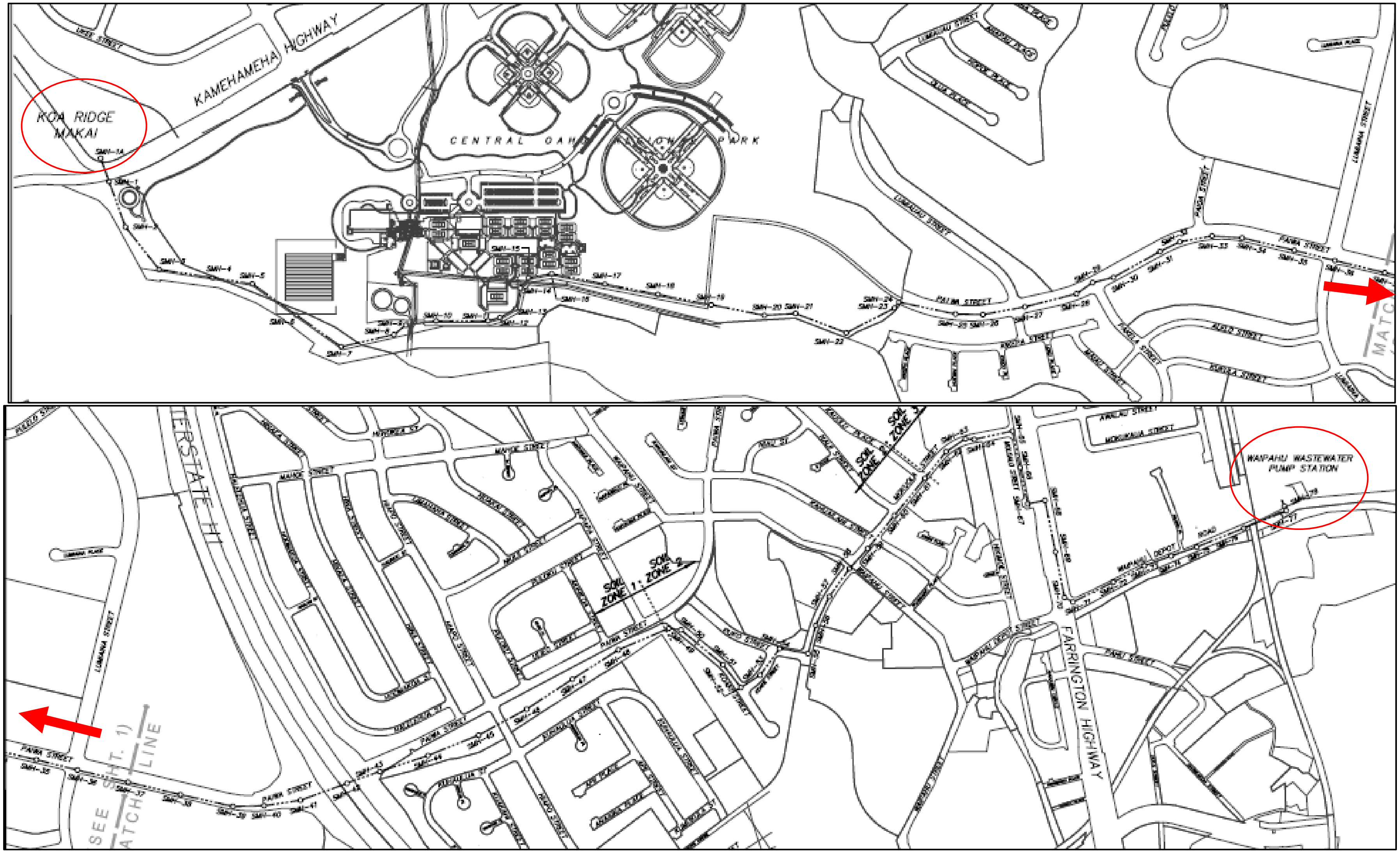


Figure 29. Koa Ridge Makai proposed alignment of sewer trunk line. (from Park Engineering sheets 1 and 2)

INVERTEBRATES NOT PRESENT**:** continued

KOA RIDGE MAKAI AND OFF-SITE INFRASTRUCTURE AREAS
MOLLUSCA: Gastropoda (Snails) Pulmonata
No endangered or threatened mollusca were noted in any of the project areas during this survey.

Achatinellidae
The Oahu Tree Snail (*Achatinella)*, listed on the federal endangered species list, was not found (DLNR 1996; Federal Register 1981). The habitat (elevation, host plants, and moisture levels) make the area unsuitable for this snail.

ARTHROPODA
DIPTERA

Drosophilidae*: Drosophila*

No native *Drosophila* were observed in any of the project areas during this survey. The location does not provide appropriate habitat for any of the 12 native *Drosophila* species recently listed as endangered or threatened. (USFWS 2006).

© Figure 30. Blackburn's sphinx moth is distinguished from other hawk moths by orange markings.

LEPIDOPTERA
Sphingidae: *Manduca blackburni*
Blackburn's sphinx moth (*Manduca blackburni*), an endangered species (Fed Reg 1999-2000) was not found in this survey. The moth has not been seen on O'ahu for many decades. The *Recovery Plan* (USFWS 2005b) for this large sphinx moth proposes only one Management Unit on O'ahu, at the Nature Conservancy's Honouliuli Preserve.

Figure 31. *Solanum mauritianum*, an alien solanaceous plant growing at Koa Ridge Makai.

Figure 32 . Grove of *Solanum mauritianum* at Koa Ridge Makai.

Figure 33 . Ants using the leaf midrib as a highway to protect and tend scale insects as they suck sap from *S. mauritianum* leaves.

Neither the moth's solanaceous native host plant, 'aiea (*Nothocestrum* sp.), nor the best alien host, tree tobacco (*Nicotiana glauca*) were observed in Koa Ridge Makai or the infrastructure areas in my own survey or recent botanical surveys. One tobacco plant was observed close to the Waipahu Wastewater Pump Station (see page 29). The plant showed no signs of *Manduca* feeding and subsequently disappeared.

Solanum mauritianum, an alien tobacco family species, (Figure 31), was found in the Koa Ridge Makai portion of the property in several locations. Although it was first recorded in the islands in 1909, *S. mauritianum* is not widely distributed on O'ahu. It has been reported from the Waiāhole/Waikane area, on the opposite side of the Ko'olau Mountain ridge from Koa Ridge (Wagner et al. 1999). Recent Bishop Museum surveys found the plant in the Mililani town area along roadsides and in Waialua pastures (Frohlich 2008) and it was found in March 2008 in the Waiawa area

INVERTEBRATES NOT PRESENT: continued

(Montgomery 2008). Several Waiawa plants showed damage from heavy insect feeding by the caterpillar of the noctuid moth, *Achaea janata*. A wide variety of Noctuid family moth species are reported to eat a broad spectrum of solanaceous plants world wide.

On Nov. 1, 2008, after a careful search of a grove of plants (Figure 32; **Y** on Figure 25, page 27), no Lepidoptera larvae were found feeding on the *S. mauritianum* plants. This is likely due to the swarms of ants patrolling the plant. In return for a sugar-like reward, the ants protect the adventive sap sucking scale insects and eliminate most of their competitors and enemies (Figure 33). A protein rich caterpillar often becomes an ant picnic on the underside of these *S. mauritianum* leaves.

Additional *S. mauritianum* plants were noted in several locations in Koa Ridge Makai. Only a few showed signs of feeding, mostly similar in pattern to the feeding patterns seen on the Waiawa plants. Other damage follows feeding patterns of the night flying adventive Chinese rose beetle (Scarabaeidae: *Adoretus sinicus* Burmeister, 1855) or the stinging nettle caterpillar (*Darna pallivitta*) (see page 19).

POTENTIAL IMPACTS

Potential Impacts on Native, Rare, Federally or State Listed Species

No federally or state listed endangered or threatened species were noted in this survey (USFWS 2006). No anticipated actions related to the proposed project activity in the surveyed locations are expected to threaten entire species or entire populations. There is no federally designated Critical Habitat for any invertebrate species on or adjacent to the subject property.

Recommendations

Landscape with native plants for low cost maintenance:

Landscaping with native plants in the common and public areas would serve several purposes. In addition to their beauty and the positive cultural and social values communicated by the use of native plants, these plants would provide habitat for native arthropods while creating a more interesting area for walking and contemplation. Native plants remain green and thus more fire resistant throughout the summer. Native plantings tend to have lower labor and maintenance costs when chosen to fit area needs. As native plants tend to reach a predicable height and foliage spread, well chosen plantings usually mean less hedge trimming and weeding. In steeper areas, native plants in a mix of ground cover, shrub, and tree heights will help slow run off and retain moisture when rains come while holding soil at very low on-going cost. The plantings will provide educational, visual, and aesthetic benefits to residents in the residential areas. Native insects and other creatures will find this refuge over time.

With prior arrangement, native plants can be as convenient for mass plantings as the introduced plants commonly used to revegetate after new construction. A list of suppliers of native plants (see page 3 for O'ahu) is available at

http://hbs.bishopmuseum.org/botany/riparian/pdf/propagators.pdf

Sewer trunk line proposed alignment:
Care should be taken during laying of the sewer line along Waipahu Depot Road to the Waipahu Wastewater Pump Station. Kapakahi Stream parallels Waipahu Depot Road on the ewa side and runs into Puohala Marsh. Construction waste, litter, and runoff pollutants should be prevented from entering the stream.

ACKNOWLEDGMENTS
Thanks are extended to Ms. Gail U. Renard, Helber Hastert & Fee, Planners, Castle & Cooke staff, and Alan Nagata and staff, US Army Real Estate Department, for maps and assistance with access to the site at the irregular times required for this survey. Anita Manning contributed to preparation of this report. Steven Lee Montgomery is responsible for all conclusions.

STANDARD NOMENCLATURE

Bird names follow *Hawaii's Birds* (Hawaii Audubon Society 2005).
Invertebrate names follow
Freshwater & Terrestrial Mollusk Checklist (HBS 2002b)
Common Names of Insects & Related Organisms (HES 1990)
Hawaiian Terrestrial Arthropod Checklist (HBS2002a; Nishida 2002)
Mammal names follow *Mammals in Hawaii* (Tomich 1986).
Place name spelling follows *Place Names of Hawaii* (Pukui et al. 1976).
Plant names follow
Manual of the Flowering Plants of Hawaii (Wagner et al. 1999)
A Tropical Garden Flora (Staples and Herbst 2005)

ABBREVIATIONS

ASL	above mean sea level
DLNR	Department of Land and Natural Resources, State of Hawai'i
DOFAW	Division of Forestry and Wildlife, State of Hawai'i
ft	feet
HBS	Hawai'i Biological Survey
m	meter
MV	Mercury Vapor
n.	new
sp.	species
spp.	more than one species
TMK	Tax Map Key
UH	University of Hawai'i
USFWS	United States Fish and Wildlife Service
UV	Ultraviolet

GLOSSARY[4]

Adventive: organisms introduced to an area but not purposefully.

Alien: occurring in the locality it occupies ONLY with human assistance, accidental or purposeful; not native. Both Polynesian introductions (e.g., coconut) and post-1778 introductions (e.g., guava, goats, and sheep) are aliens.

Anaphylactic: hypersensitivity resulting in a sudden severe and potentially fatal allergic reaction, marked by a drop in blood pressure, difficulty in breathing, itching, and swelling

Arthropod: insects and related invertebrates (e.g., spiders) having an external skeleton and jointed legs.

Endemic: naturally occurring, without human transport, ONLY in the locality occupied. Hawaii has a high percentage of endemic plants and animals, some in very small microenvironments.

Entomology: the study of insects and other arthropods

Indigenous: naturally occurring without human assistance in the locality it occupies; may also occur elsewhere, including outside the Hawaiian Islands. (e.g., Naupaka kahakai (*Scaevola sericea*) is the same plant in Hawai'i and throughout the Pacific).

Insects: arthropods with six legs, and bodies in 3 sections

Invertebrates: animals without backbones (insects, spiders, snails / slugs, shrimp)

Larva/larval: an immature stage of development in offspring of many types of animals.

Mollusk: invertebrates in the phylum Mollusca. Common representatives are snails, slugs, mussels, clams, oysters, squids, and octopuses.

Native: organism that originated in area where it lives without human assistance. May be indigenous or endemic.

Nocturnal: active or most apparent at night.

Purposefully introduced: an organism brought into an area for a specific purpose, for example, as a biological control agent.

Rare: threatened by extinction and low numbers.

Species: all individuals and populations of a particular type of organism, maintained by biological mechanisms that result in their breeding mostly with their kind.

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4 Glossary based largely on definitions in *Biological Science: An Ecological Approach*, 7th ed., Kendall/Hunt Publishing Co., Dubuque, a high school text; on the glossary in *Manual of Flowering Plants of Hawai'i*, Vol.2, Wagner, et al., 1999, Bishop Museum Press, and other sources.

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E | Archaelogical Inventory Survey

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STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES

STATE HISTORIC PRESERVATION DIVISION
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February 10, 2009

Mr. David Shideler
Cultural Surveys Hawai'i
P. O. Box 1114
Kailua, Hawai'i 96734

LOG NO: 2009.0605
DOC NO: 0902WT21
Archaeology

Dear Mr. Shideler:

SUBJECT: 6E-42 Historic Preservation Review--
DRAFT Archaeological Inventory Survey (AIS)--
of Proposed Detention Basins, Associated Appurtenances and an H-2 Freeway Interchange Associated with the Koa Ridge Makai Development Project, Waipi'o Ahupua'a, 'Ewa District, Island of O'ahu, Hawai'i
TMK: (1) 9-4-005: 006 por., 008 por.; 9-4-006: 001 por., 029 por.; 9-5-003: 001 por., 002, 011 por., 014 por.

Thank you for the opportunity to review this DRAFT AIS (*DRAFT Archaeological Inventory Survey of Proposed Detention Basins, Associated Appurtenances and an H-2 Freeway Interchange Associated with the Koa Ridge Makai Development Project, Waipi'o Ahupua'a, 'Ewa District, Island of O'ahu, Hawai'i, TMK: (1) 9-4-005: 006 por., 008 por.; 9-4-006: 001 por., 029 por.; 9-5-003: 001 por., 002, 011 por., 014 por. [Tulchin, Yucha, Shideler and Hammatt PhD, January 2009]*). The survey area is 123 acres primarily on gulch bottoms. The proposed project involves construction of a storm drain line, four storm water detention basins, access roads, and construction staging areas. Thirteen historic properties were recorded during this survey, and all were interpreted to be from historic military, agricultural and transportation activities in the gulch.

This report includes recommendations for historic properties identified during the survey to mitigate adverse impacts to these properties. First, it is recommended that a Preservation Plan (PP) be prepared for the historic properties recommended for preservation. Second, SIHP #50-80-09-7047, six historic period agricultural terraces and an excavated pit, will be impacted during construction, and it is recommended that a Data Recovery Plan (DRP) be prepared to mitigate adverse effects to this historic property.

This report is accepted and it meets the minimum requirements for compliance with 6E-42 and Hawaii Administrative Rules (HAR) §13-13-276 *Rules Governing Standards for Archaeological Inventory Studies and Reports.*

The complete, finalized report should be free of errors, contain good quality color photographs, color maps and assigned State site numbers. Once this subject archaeological inventory survey report has received final acceptance pursuant to HAR §13-276, please send one hardcopy of the document, clearly marked FINAL, along with a copy of this review letter and a text-searchable PDF version on CD to the attention of Wendy Tolleson "**SHPD Library**" at the Kapolei SHPD office.

Please call Wendy Tolleson at (808) 692-8024 if there are any questions or concerns regarding this letter.

Aloha,

Nancy A. McMahon

Nancy A. McMahon (Deputy SHPO)
State Historic Preservation Officer

Final

Archaeological Inventory Survey Of Proposed Detention Basins, Associated Appurtenances and an H-2 Freeway Interchange Associated with the Koa Ridge Makai Development Project, Waipi‘o Ahupua‘a, ‘Ewa District, Island of O‘ahu

TMK: [1] 9-4-005: 006 por., 008 por.; 9-4-006:001 por., 029 por.; 9-5-003:001 por., 002, 011 por. 014 por.

Prepared for

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and

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Management Summary

Reference	Archaeological Inventory Survey of Proposed Detention Basins, Associated Appurtenances, and an H-2 Freeway Interchange Associated with the Koa Ridge Makai Development Project, Waipiʻo Ahupuaʻa, ʻEwa District, Island of Oʻahu (TMK: [1] 9-4-005: 006 por., 008 por.; 9-4-006:001 por., 029 por. ; 9-5-003:001 por., 002, 011 por. 014 por.) (Tulchin, Yucha, Shideler and Hammatt 2009)
Date	January 2009
Project Number (s)	Cultural Surveys Hawaiʻi (CSH) Job Code: WAIPIO 5
Investigation Permit Number	The fieldwork component of the archaeological inventory survey investigation was carried out under archaeological permit number 08-14, issued by the Hawaiʻi State Historic Preservation Division/Department of Land and Natural Resources (SHPD/DLNR), per Hawaiʻi Administrative Rules (HAR) Chapter 13-282.
Project Location	The project area includes four discreet sections, generally located east of Mililani Town and Mililani Mauka. Much of the project lands are situated within Kīpapa Gulch or its tributaries. Portions of the project area are located on tablelands adjacent to Kīpapa Gulch, and one section of the project area is located within a tributary of Pānakauahi Gulch. The project area is depicted on the U.S. Geological Survey 7.5-Minute Series Topographic Map, Waipahu Quadrangle (1998).
Land Jurisdiction	Government, U.S. Army; and Private, Castle & Cooke Homes Hawaii, Inc.
Agencies	State Historic Preservation Division / Department of Land and Natural Resources (SHPD/DLNR)
Project Description	The proposed project involves construction of a storm drain line, four storm water detention basins, construction and maintenance access roads, and construction staging areas. The proposed project also includes an H-2 Freeway interchange, associated with the planned Koa Ridge Development Project. Minimally, land-disturbing activities would include grubbing and grading, and excavations associated with detention basin construction, freeway infrastructure construction, and subsurface utility installation.
Project Acreage	Approximately 123 acres
Area of Potential Effect (APE) and Survey Acreage	The project's APE is defined as the entire approximately 123-acre project area. The survey area for this archaeological inventory survey investigation included approximately 109-acres of the project area. Approximately 14 acres of the 123-acre project area are located on tablelands that were covered by an archaeological inventory survey conducted for the planned Koa Ridge Development Project (Hammatt et al. 1996).

Historic Preservation Regulatory Context	This document was prepared to support the proposed project's historic preservation review under Hawaiʻi Revised Statutes (HRS) Chapter 6E-42 and Hawaiʻi Administrative Rules (HAR) Chapter 13-284. The present study has been revised to address certain comments in a prior SHPD review (December 3, 2008; Log No 2008.5360, Doc No. 0812WT06). As portions of the project area are located on federal government lands, this project is considered a federal undertaking, requiring compliance with Section 106 of the National Historic Preservation Act (NHPA) and the National Environmental Policy Act (NEPA).
Document Purpose	At the request of Helber, Hastert, & Fee Planners, Inc. (HHF), Cultural Surveys Hawaiʻi Inc. (CSH) completed an archaeological inventory survey of proposed detention basins, associated appurtenances and an H-2 Freeway interchange associated with the Koa Ridge Makai Development Project. This investigation was prepared in consideration of the Secretary of the Interior's Standards and Guidelines for Archaeology and Historic Preservation, and was conducted to identify, document, and make National Register of Historic Places (National Register) and Hawaiʻi Register of Historic Places (Hawaiʻi Register) eligibility recommendations for the subject parcels' cultural resources[1]. In consultation with the Hawaiʻi State Historic Preservation Division (SHPD), this investigation was also designed to fulfill the State requirements for an archaeological inventory survey per Hawaiʻi Administrative Rules (HAR) Chapter 13-13-276. The investigation includes an undertaking-specific effect recommendation and treatment/mitigation recommendations for the cultural resources recommended National/Hawaiʻi Register eligible. This document is intended to support project-related historic preservation consultation among stake-holding federal and state agencies, interested Native Hawaiian groups and individuals, and community groups.
Fieldwork Effort	The CSH field crew included: Todd Tulchin, B.S.; Kulani Jones, B.S.; Trevor Yucha, B.S.; Doug Thurman, B.A.; Anthony Bush, B.A.; and Raʻimana Hunkin, B.A. Fieldwork was conducted between August 21, 2008 and January 6, 2009, and required 39 person-days to complete.
Cultural Resources/Historic Properties[2] Identified and Recommended Eligibility to the National/Hawaiʻi Register[3]	SIHP # 50-80-09-2268, portion of the historic Waiahole Ditch System, recommended National/Hawaiʻi Register-eligible under Criteria A, C, and D SIHP # 50-80-09-7044, historic road and stream channel improvements, recommended National/Hawaiʻi Register-eligible under Criterion D SIHP # 50-80-09-7045, plantation-era retaining walls, recommended National/Hawaiʻi Register-eligible under Criterion D SIHP # 50-80-09-7046, plantation-era clearing platform, recommended National/Hawaiʻi Register-eligible under Criterion D SIHP # 50-80-09-7047, plantation-era agricultural terrace complex, recommended National/Hawaiʻi Register-eligible under Criterion D SIHP # 50-80-09-7048, plantation-era charcoal kiln, recommended National/Hawaiʻi Register-eligible under Criterion D SIHP # 50-80-09-7049, plantation-era agricultural complex, recommended National/Hawaiʻi Register-eligible under Criterion D

	SIHP # 50-80-09-7050, plantation-era retaining wall and C-shaped wall, recommended National/Hawai‘i Register-eligible under Criterion D SIHP # 50-80-09-7051, plantation-era retaining wall, recommended National/Hawai‘i Register-eligible under Criterion D SIHP # 50-80-09-7052 military-related components of the U.S. Army Upper and Lower Kīpapa Ammunition Storage Sites, recommended National/Hawai‘i Register-eligible under Criteria A and D SIHP # 50-80-09-7053, historic roadbed and associated features (Old Kamehameha Highway alignment), recommended National/Hawai‘i Register-eligible under Criteria A and D SIHP # 50-80-09-9530, plantation-era agricultural and transportation complex, recommended National/Hawai‘i Register-eligible under Criteria A, C, and D SIHP # 50-80-09-9534, plantation-era agricultural and transportation complex, recommended National/Hawai‘i Register-eligible under Criterion D
Effect Recommendation	The archaeological inventory survey investigation identified thirteen cultural resources within and in the immediate vicinity of the project area. Ten cultural resources, SIHP #s 50-80-09-7044, -7047, -7048, -7049, -7050, -7051, -7052, -7053, -9530, and -9534, will likely, or potentially, be affected by the proposed project. CSH’s project-specific effect recommendation is “effect, with proposed mitigation commitments.” The recommended mitigation measures will reduce the project’s potential adverse effect on these significant cultural resources.
Mitigation Recommendations[4]	SIHP # 50-80-09-2268, portion of the historic Waiahole Ditch System: Preservation SIHP # 50-80-09-7044, historic road and stream channel improvements: No further work SIHP # 50-80-09-7045, plantation-era retaining walls: No further work SIHP # 50-80-09-7046, plantation-era clearing platform: Preservation SIHP # 50-80-09-7047, plantation-era agricultural terrace complex: Partial preservation and/or data recovery SIHP # 50-80-09-7048, plantation-era charcoal kiln: No further work SIHP # 50-80-09-7049, plantation-era agricultural complex: No further work SIHP # 50-80-09-7050, plantation-era retaining wall and C-shaped wall: No further work for Feature A, Data Recovery for Feature B. SIHP # 50-80-09-7051, plantation-era retaining wall: No further work SIHP # 50-80-09-7052, military-related components of the U.S. Army Upper and Lower Kīpapa Ammunition Storage Sites: No further work SIHP # 50-80-09-7053, historic roadbed and associated features (Old Kamehameha Highway alignment): Preservation SIHP # 50-80-09-9530, plantation-era agricultural and transportation complex: Preservation of Feature A irrigation ditch, no further work for remaining features

	SIHP # 50-80-09-9534, plantation-era agricultural and transportation complex: No further work It is recommended that a cultural resource preservation plan be prepared for the proposed project, in accordance with Hawai‘i Administrative Rules (HAR) 13-277-3, to address buffer zones and protective measures for all cultural resources recommended for preservation. This preservation plan should detail the short and long-term preservation measures that will safeguard the cultural resources during project construction and subsequent use of the project area.The preservation plan will also address any breaches of the SIHP # 50-80-09-9530 Feature A irrigation ditch. If SIHP # 50-80-09-7047 Features C-G will be impacted by the proposed project, it is recommended that an archaeological data recovery plan be prepared for SIHP # 50-80-09-7047, in accordance with HAR 13-278-3. The archaeological data recovery plan will detail the research questions and field methods necessary to gather sufficient data on the historic property to mitigate the adverse effect of proposed development activities.

[1]In historic preservation parlance, cultural resources are the physical remains and/or geographic locations that reflect the activity, heritage, and/or beliefs of ethnic groups, local communities, states, and/or nations. Generally, they are at least 50 years old, although there are exceptions, and include: buildings and structures; groupings of buildings or structures (historic districts); certain objects; archaeological artifacts, features, sites, and/or deposits; groupings of archaeological sites (archaeological districts); and, in some instances, natural landscape features and/or geographic locations of cultural significance.

[2]Historic properties, as defined under federal historic preservation legislation, are cultural resources that are at least 50 years old (with exceptions) and have been determined eligible for inclusion in the National Register of Historic Places based on their integrity and historic/cultural significance in terms of established significance criteria. Determinations of eligibility are generally made by a federal agency official in consultation with SHPD. Under federal legislation, a project’s (undertaking’s) potential effect on historic properties must be evaluated and potentially mitigated. Under Hawai‘i State historic preservation legislation, historic properties are defined as any cultural resources that are 50 years old, regardless of their historic/cultural significance under state law, and a project’s effect and potential mitigation measures are evaluated based on the project’s potential impact to “significant” historic properties (those historic properties determined eligible, based on their integrity and historic/cultural significance in terms of established significance criteria, for inclusion in the Hawai‘i Register of Historic Places). Determinations of eligibility to the Hawai‘i Register result when a state agency official’s historic property “significance assessment” is approved by SHPD, or when SHPD itself makes an eligibility determination for a historic property.

[3]Cultural resource significance is evaluated and expressed as eligibility for listing on the National and/or Hawai‘i Register. To be considered eligible for listing on the National and/or Hawai‘i Register a cultural resource should possess integrity of location, design, setting, materials, workmanship, feeling, and association, and meet one or more of the following broad cultural/historic significance criteria: “A” reflects major trends or events in the history of the state or nation; “B” is associated with the lives of persons significant in our past; “C” is an excellent example of a site type/work of a master; “D” has yielded or may be likely to yield information important in prehistory or history; and, “E” (Hawaii Register only) has traditional cultural significance to an ethnic group, includes religious structures and/or burials.

[4]Under Hawai‘i State historic preservation review legislation, there are five potential forms of historic preservation mitigation: A) Preservation; B) Architectural Recordation; C) Archaeological Data Recovery; D) Historical Data Recovery; and E) Ethnographic Documentation (HAR Chapter 13-275-8).

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Section 1 Introduction

1.1 Project Background

At the request of Helber, Hastert, & Fee Planners, Inc. (HHF), Cultural Surveys Hawaiʻi Inc. (CSH) completed an archaeological inventory survey of proposed detention basins, associated appurtenances, and an H-2 Freeway interchange associated with the Koa Ridge Makai Development Project, Waipiʻo Ahupuaʻa, ʻEwa District, Island of Oʻahu (TMK: [1] 9-4-005: 006 por., 008 por.; 9-4-006:001 por., 029 por.; 9-5-003:001 por., 002, 011 por., 014 por.). The present study has been revised to address certain comments in a prior SHPD review (December 3, 2008; Log No 2008.5360, Doc No. 0812WT06).

The project area includes four discreet sections, generally located east of Mililani Town and Mililani Mauka (Figures 1-5). Much of the project lands are situated within Kīpapa Gulch or its tributaries. Portions of the project area are located on tablelands adjacent to Kīpapa Gulch, and one section of the project area is located within a tributary of Pānakauahi Gulch. The project area is depicted on the U.S. Geological Survey 7.5-Minute Series Topographic Map, Waipahu Quadrangle (1998).

Portions of the project area are privately owned by Castle & Cooke Homes Hawaiʻi, Inc. Additional portions of the project area are owned by the federal government, under the jurisdiction of the U.S. Army. The proposed project involves construction of a storm drain line, four storm water detention basins, construction and maintenance access roads, and construction staging areas (Figure 6). The proposed project also includes an H-2 Freeway interchange, associated with the planned Koa Ridge Development Project. Minimally, land-disturbing activities would include grubbing and grading, and excavations associated with detention basin construction, freeway infrastructure construction, and subsurface utility installation. The project's Area of Potential Effect (APE) is defined as the entire approximately 123-acre project area. The survey area for this archaeological inventory survey investigation included approximately 109-acres of the project area. Approximately 14 acres of the 123-acre project area are located on tablelands that were covered by an archaeological inventory survey conducted for the planned Koa Ridge Development Project (Hammatt et al. 1996). The Hammatt et al. (1996) inventory survey report, titled *Archaeological Inventory Survey of a 1339-Acre Parcel at Castle and Cooke Lands Within Portions of Waipiʻo and Waiawa Ahupuaʻa, Oʻahu (TMK 9-4-06:01, 03, & 10 port.; and 9-5-03:01 port., 04, & 07; and 9-6-04:21)* was reviewed and accepted by SHPD in 2002 (Log No. 29403, Doc No. 0203EJ09) (see Appendix A)

This document was prepared to support the proposed project's historic preservation review under Hawaiʻi Revised Statutes (HRS) Chapter 6E-42 and Hawaiʻi Administrative Rules (HAR) Chapter 13-284. As portions of the project area are located on federal government lands, this project is considered a federal undertaking, requiring compliance with Section 106 of the National Historic Preservation Act (NHPA) and the National Environmental Policy Act (NEPA). The archaeological inventory survey investigation was prepared in consideration of the Secretary of the Interior's Standards and Guidelines for Archaeology and Historic Preservation, and was conducted to identify, document, and make National Register of Historic Places (National Register) and Hawaiʻi Register of Historic Places (Hawaiʻi Register) eligibility recommendations

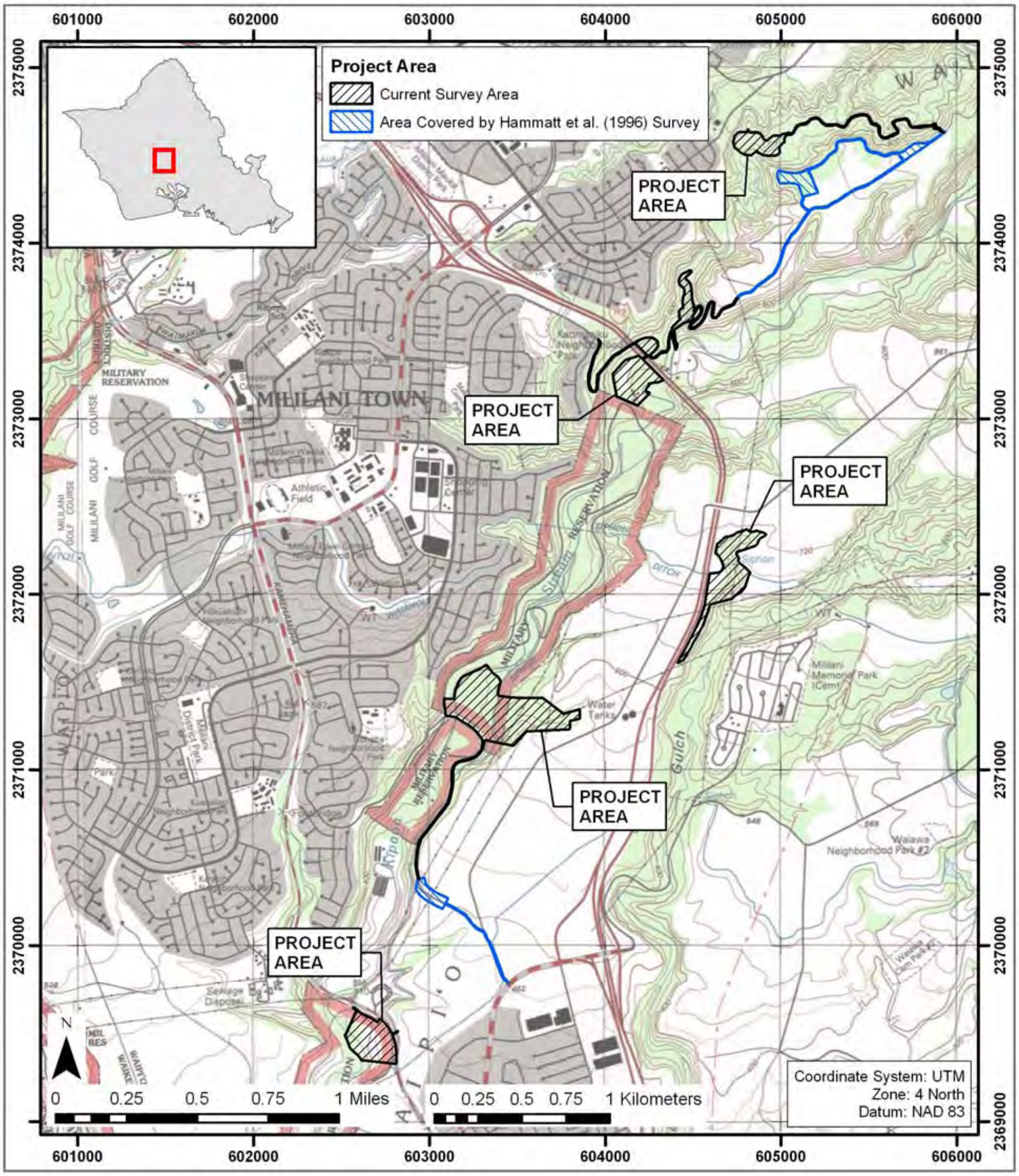

Figure 1. U.S. Geological Survey 7.5-Minute Series Topographic Map, Waipahu Quadrangle (1998), showing the location of the project area

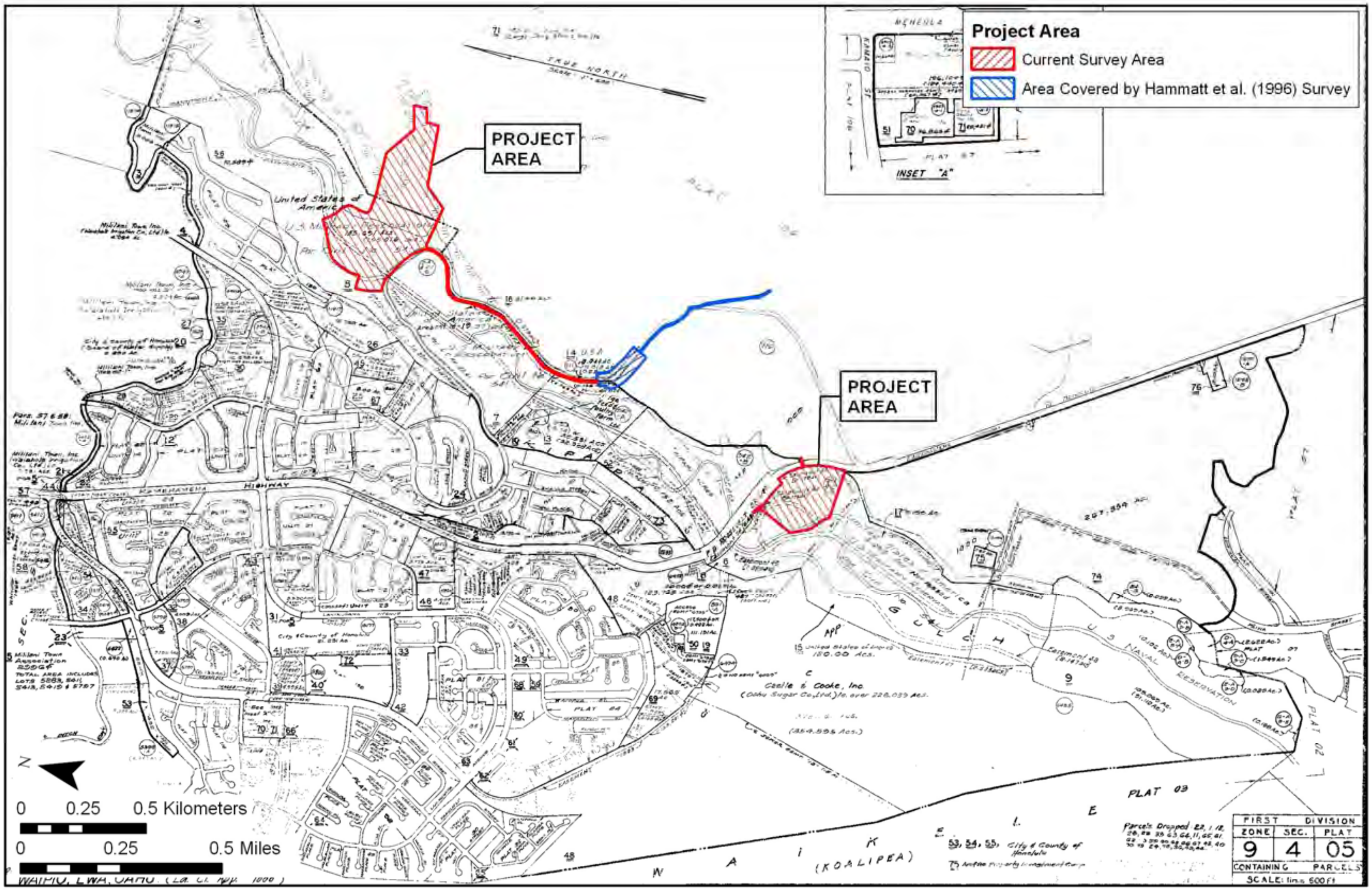

Figure 2. Tax Map Key Plat 9-4-05, showing the location of the project area

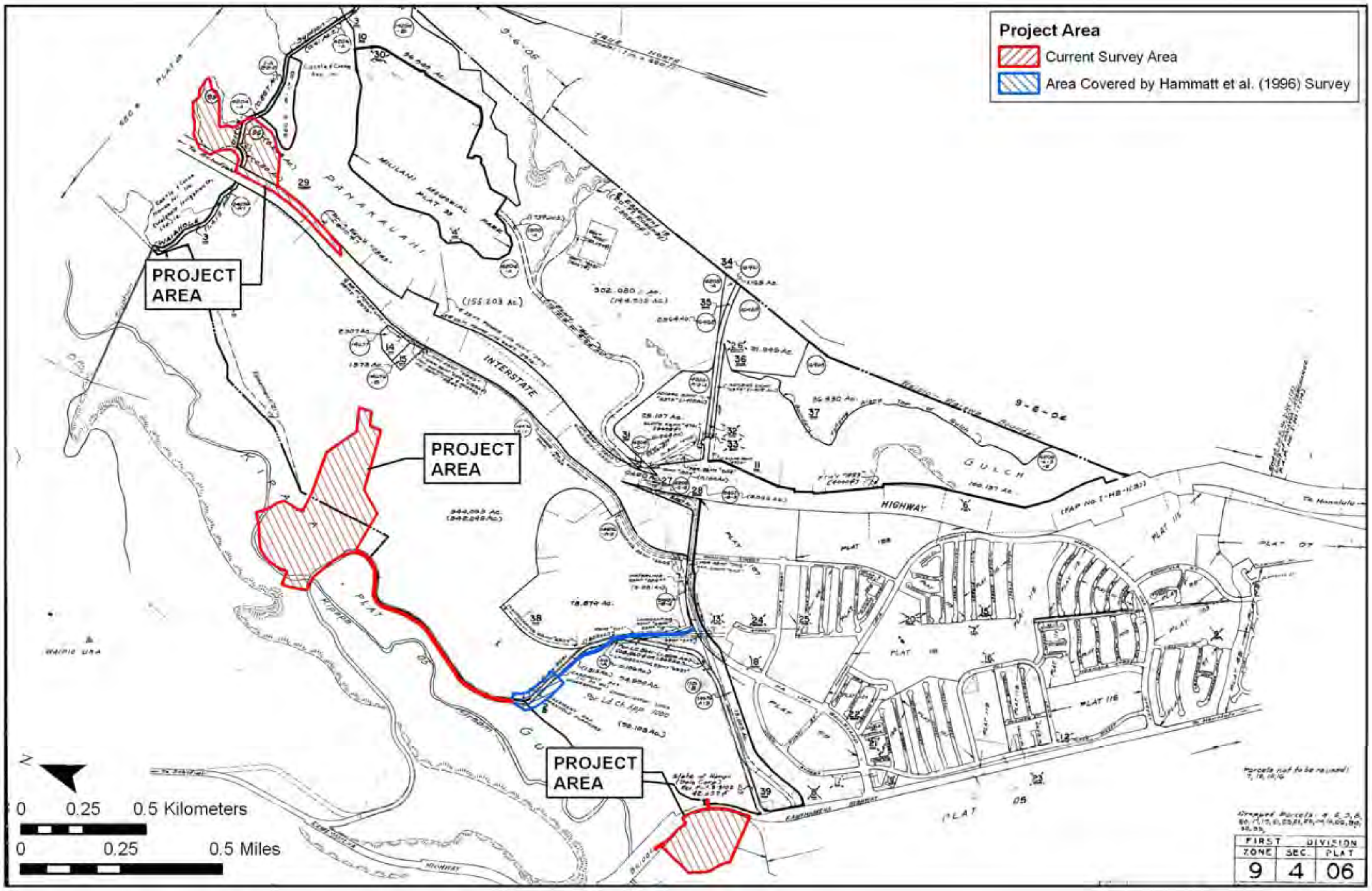

Figure 3. Tax Map Key Plat 9-4-06, showing the location of the project area

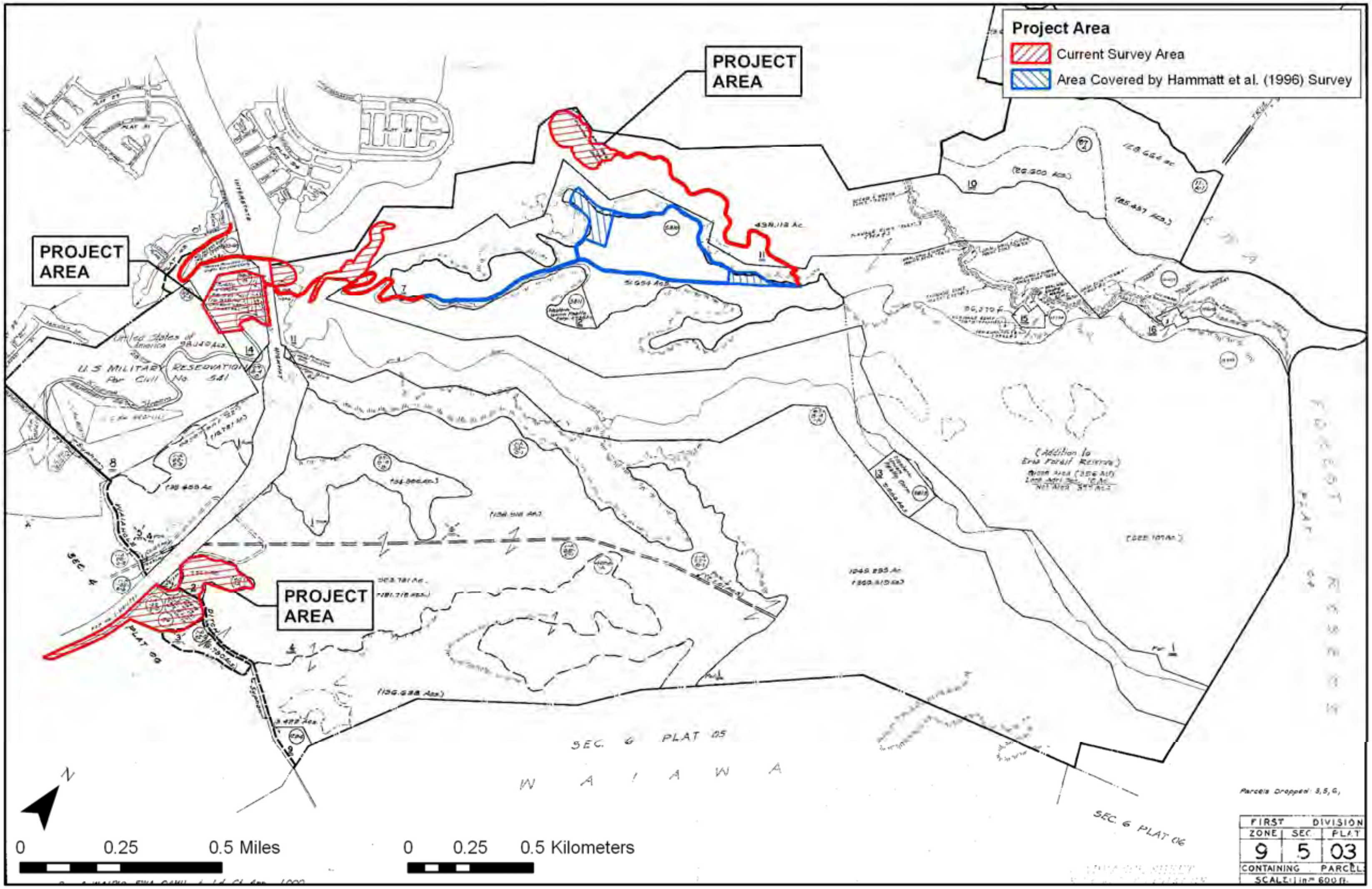

Figure 4. Tax Map Key Plat 9-5-03, showing the location of the project area

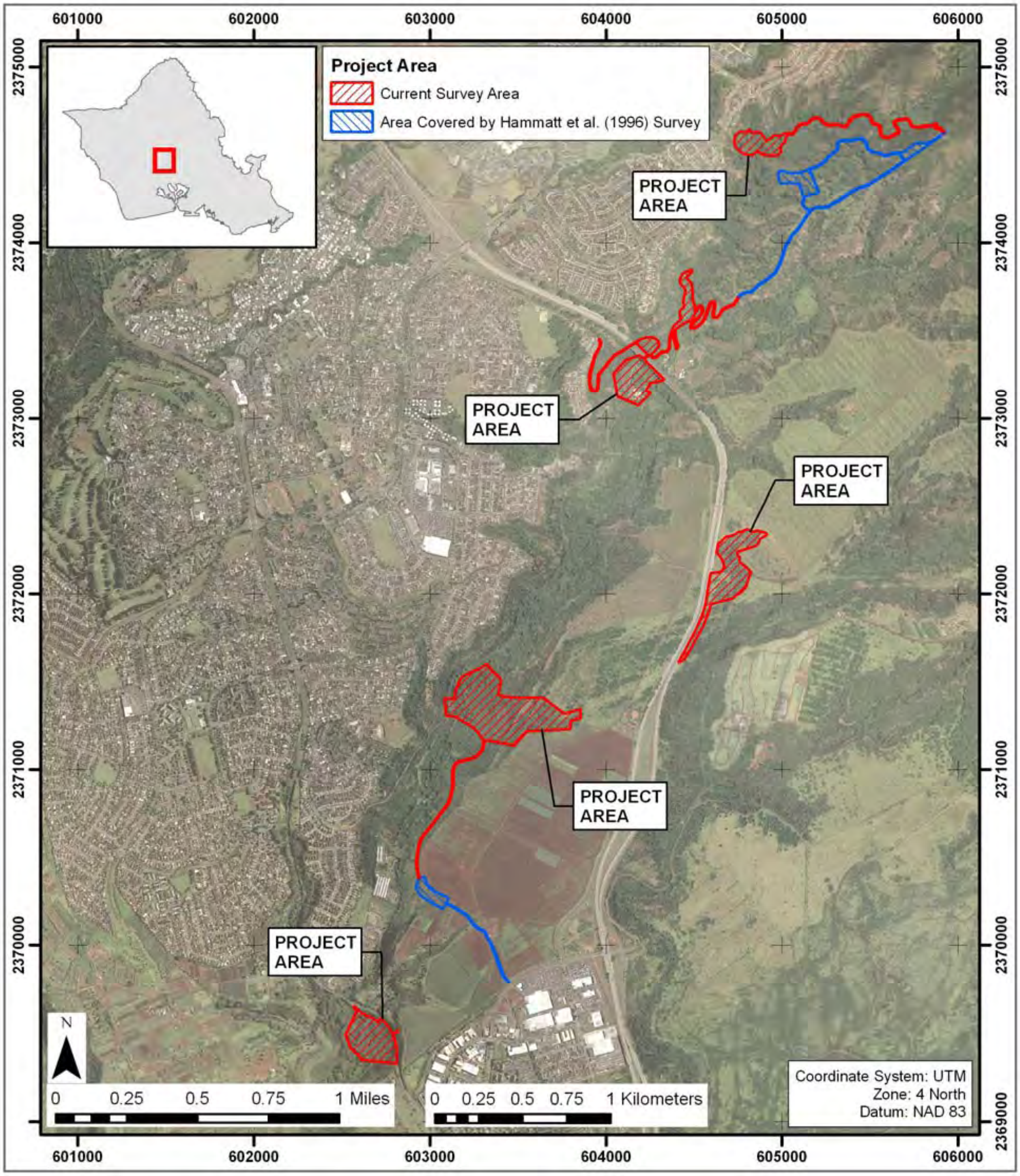

Figure 5. Aerial photograph (source: U.S.G.S Orthoimagery 2005), showing the location of the project area

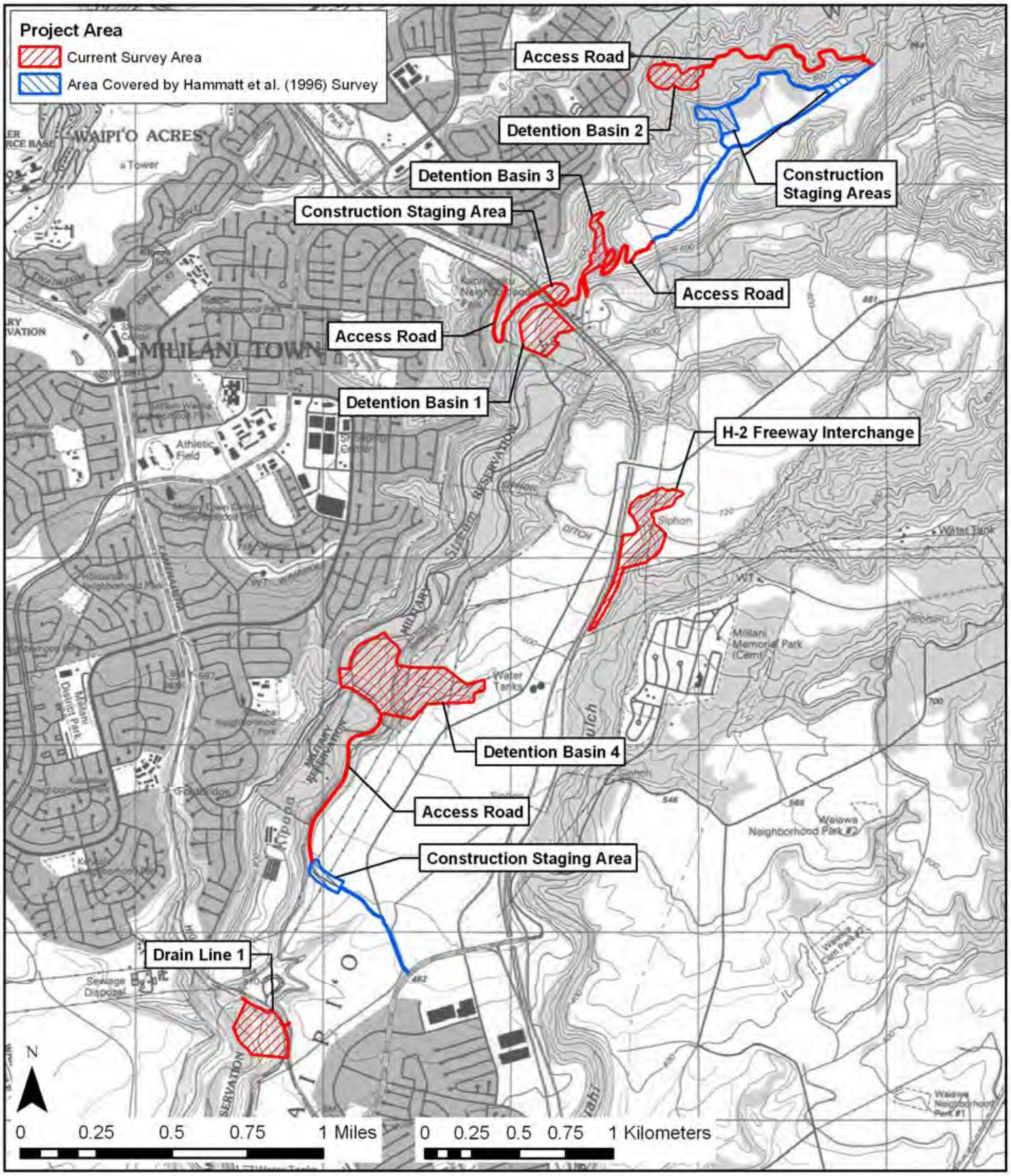

Figure 6. U.S. Geological Survey 7.5-Minute Series Topographic Map, Waipahu Quadrangle (1998), indicating proposed development within each section of the project area

for the subject parcels' cultural resources. In consultation with the Hawaiʻi State Historic Preservation Division (SHPD), this investigation was also designed to fulfill the State requirements for an archaeological inventory survey per HAR Chapter 13-13-276. The investigation includes an undertaking-specific effect recommendation and treatment/mitigation recommendations for the cultural resources recommended National/Hawaiʻi Register eligible. This document is intended to support project-related historic preservation consultation among stake-holding federal and state agencies, interested Native Hawaiian groups and individuals, and community groups.

1.2 Scope of Work

The archaeological inventory survey and its accompanying report documented all cultural resources within the project area. The following scope of work was designed to comply with both federal and Hawaiʻi State historic preservation legislation.

1. Historic and archaeological background research including a search of historic maps, written records, Land Commission Award documents, and the reports from prior archaeological investigations. This research focused on the specific project area's past land use, with general background on the pre-contact and historic settlement patterns of the *ahupuaʻa* and district. This background information was used to compile a predictive model for the types and locations of cultural resources that could be expected within the project area.
2. A complete (100% coverage) systematic pedestrian inspection of the project area to identify any potential surface cultural resources. Surface cultural resources were recorded with an evaluation of age, function, interrelationships, and significance. Documentation included photographs, scale drawings, and, if warranted, limited controlled excavation of select sites and/or features, and location of cultural resources with GPS survey equipment.
3. As appropriate, consultation with knowledgeable individuals regarding the project area's history, past land use, and the function and age of the cultural resources documented within the project area.
4. Preparation of this archaeological inventory survey report, including the following:
   a) A project description;
   b) A section of a USGS topographic map showing the project area boundaries and the location of all recorded cultural resources;
   c) Historical and archaeological background sections summarizing prehistoric and historic land use of the project area and its vicinity;
   d) Descriptions of all cultural resources, including selected photographs, scale drawings, and discussions of age, function, laboratory results, and significance, per the requirements of HAR 13-13-276. Each historic property was assigned a Hawaiʻi State Inventory of Historic Properties (SIHP) number;

e) If appropriate, a section concerning cultural consultations [per the requirements of HAR 13-276-5(g) and HAR 13-275/284-8(a) (2)].

f) A summary of historic property categories, integrity, and significance based upon the Hawaiʻi Register of Historic Places evaluation criteria;

g) A project effect recommendation;

h) Treatment recommendations to mitigate the project's potential adverse effect on cultural resources identified in the project area that are recommended eligible to the Hawaiʻi Register of Historic Places.

This scope of work includes full coordination with the State Historic Preservation Division (SHPD), and county relating to archaeological matters. This coordination takes place after consent of the landowner or representatives.

1.3 Environmental Setting

1.3.1 Natural Environment

Much of the project lands are situated within Kīpapa Gulch or its tributaries. Portions of the project area are located on tablelands adjacent to Kīpapa Gulch, and one section of the project area is located within a tributary of Pānakauahi Gulch. In general, the gulch lands include steep sloping valley walls, and gently sloping lands at the base of the gulches. The tablelands consist of nearly level to gently sloping lands adjacent to the gulches. Elevations within the project area range from approximately 65-290 m (210-950 ft.) above mean sea level.

Soils within the project area primarily consists of Helemano Silty Clay (HLMG), with additional areas of Manana Silty Clay (MpB), Manana Silty Clay Loam (MoC), Wahiawa Silty Clay (WaA, WaB, WaC), Kawaihapai Clay Loam (KlB, KlC), and Haleiwa Silty Clay (HeA, HeB) (Figure 7). Soils of the Helemano Series are described as "well-drained soils on alluvial fans and colluvial slopes on the sides of gulches…developed in alluvium and colluvium derived from basic igneous rock" (Foote et al. 1972). Soils of the Manana Series are described as "well-drained soils on uplands…developed in material weathered from basic igneous rock" (Foote et al. 1972). Soils of the Wahiawa Series are described as "well-drained soils on uplands…developed in residuum and old alluvium derived from basic igneous rock" (Foote et al. 1972). Soils of the Kawaihapai Series are described as "well-drained soils in drainage-ways and on alluvial fans…formed in alluvium derived from basic igneous rock in humid uplands" (Foote et al. 1972). Soils of the Haleiwa Series are described as "well-drained soils on fans and in drainage-ways…developed in alluvium derived from basic igneous material" (Foote et al. 1972).

The project area receives approximately 900-1700 mm (35-65 in.) of annual rainfall, with increased rainfall at higher elevations (Giambelluca et al. 1986). Vegetation within the project area includes: white monkeypod (*Albizia sp.*), strawberry guava (*Psidium cattleianum*), Christmas berry (*Schinus terebinthifolius*), *koa haole* (*Leucaena leucocephala*), mango (*Mangifera indica*), and various exotic weeds and grasses.

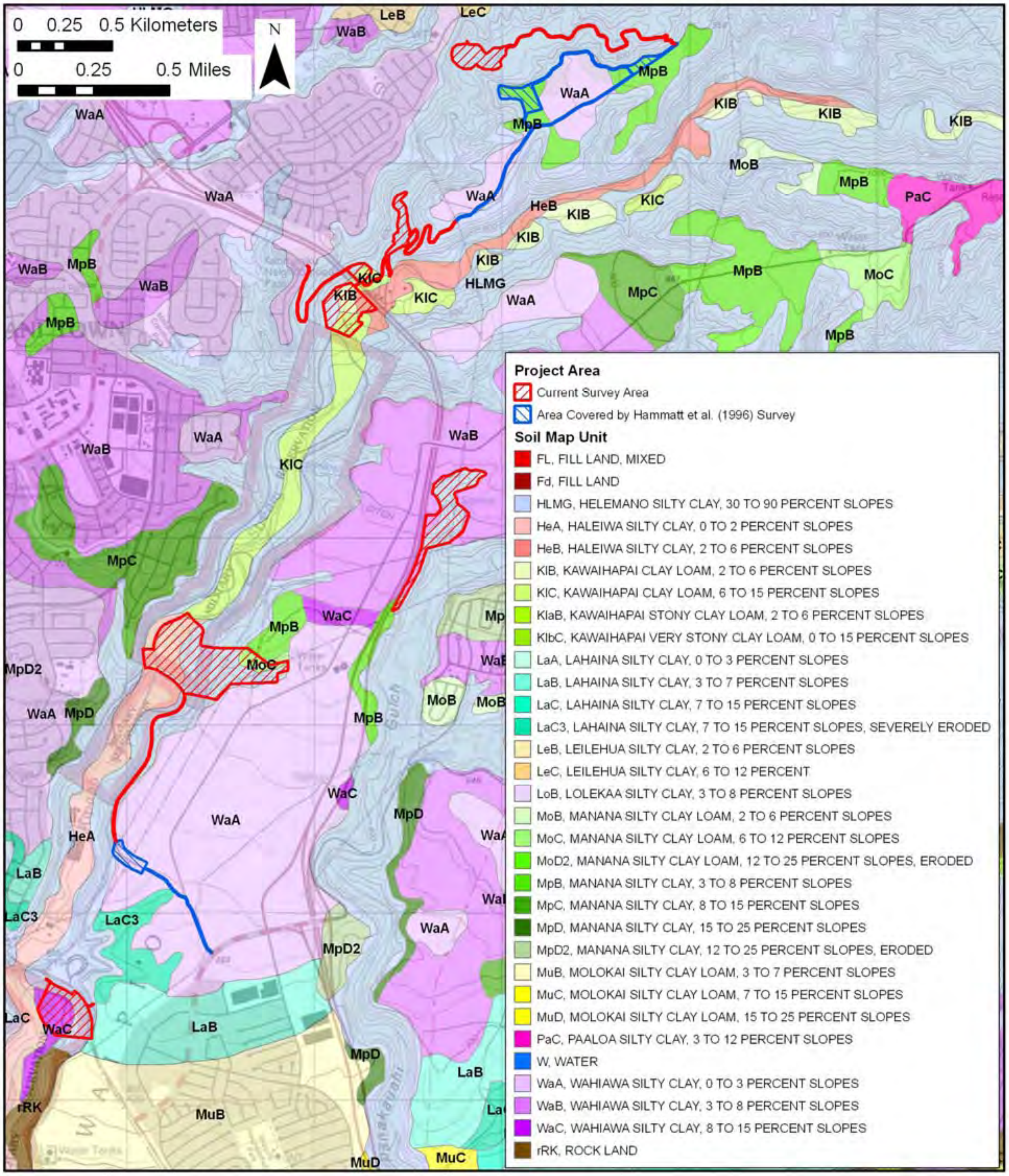

Figure 7. Overlay of the Soil Survey of Hawaiʻi (Foote et al. 1972), indicating sediment types within the project area

1.3.2 Built Environment

Much of the project lands are undeveloped. Lands in the northern portions of the project area, including the Detention Basin 2 (DB2), Detention Basin 3 (3), and H-2 Freeway Interchange project areas generally consist of undeveloped gulch lands or tablelands formerly under commercial pineapple cultivation. Portions of the Detention Basin 1 (DB1) project area include an active small-scale farm, consisting of cultivated fields, farm dwellings, and farm-related structures. The H-2 Freeway is also adjacent to the DB1 and H-2 Freeway interchange project areas. The Detention Basin 4 (DB4) and Drain Line (1) project areas include portions of the U.S. Army Upper and Lower Ammunition Storage Sites. Structures within the former ammunition storage sites include paved roads, storage tunnels, and building remnants. Much of the access road portions of the project area follow former and existing plantation roads or the Old Kamehameha Highway. Development in the surrounding area includes the master-planned residential community of Mililani to the east of the project area.

Section 2 Methods

2.1 Field Methods

The fieldwork component of the archaeological inventory survey investigation was carried out under archaeological permit number 08-14, issued by the Hawaiʻi State Historic Preservation Division/Department of Land and Natural Resources (SHPD/DLNR), per Hawaiʻi Administrative Rules (HAR) Chapter 13-282. The CSH field crew included: Todd Tulchin, B.S.; Kulani Jones, B.S.; Trevor Yucha, B.S.; Doug Thurman, B.A.; Anthony Bush, B.A.; and Raʻimana Hunkin, B.A. Fieldwork was conducted between August 21, 2008 and January 6, 2009, and required 39 person-days to complete.

Fieldwork consisted of a 100% coverage pedestrian inspection of the approximately 109-acre survey area. The pedestrian inspection of the survey area was accomplished through systematic sweeps. The interval between the archaeologists was generally 5-10 m. All cultural resources encountered were recorded and documented with a written field description, scale drawings, photographs, and each site was located using Trimble ProXH (sub-meter accuracy) or Garmin GPSmap 60CSx (accuracy 5-10 m) GPS survey technology.

2.2 Document Review

Historic and archival research included information obtained from the UH Hamilton Library, the State Historic Preservation Division Library, the Hawaiʻi State Archives, the State Land Survey Division, and the Archives of the Bishop Museum. Previous archaeological reports for the area were reviewed, as were historic maps and primary and secondary historical sources. Information on Land Commission Awards was accessed through Waihona ʻĀina Corporation's Māhele Data Base (www.waihona.com).

2.3 Community Consultation

A community consultation effort was undertaken as a component of this archaeological inventory survey investigation. The consultation was made in association with a companion Cultural Impact Assessment (CIA) for the current project. Per HAR Chapter 13-13-276, the community consultation effort for the archaeological inventory survey involved "notifying interested organizations and individuals that a project could affect historic properties of interest to them; seeking their views on the identification, significance evaluations, and mitigation treatment of these properties; and considering their views in a good faith and appropriate manner during the review process."

Hawaiian organizations, agencies and community members were contacted in order to identify potentially knowledgeable individuals with cultural expertise and/or knowledge of the project area and the vicinity. The organizations consulted included the State Historic Preservation Division (SHPD), the Office of Hawaiian Affairs (OHA), the Oʻahu Island Burial Council (OIBC), and community and cultural organizations including Hui Mālama I Nā Kūpuna ʻO Hawaiʻi Nei, Hui Pū and the Hawaiian Civic Club of Wahiawā. In all, twenty community contacts (government agency or Hawaiian cultural community organization representatives, or individuals such as long-time area residents and cultural practitioners) were contacted for the purposes of cultural consultation. 8 people responded and 5 *kūpuna* (elders) and/or *kama'āina* (native-born) were interviewed for more in-depth contributions. The reader is referred to the CIA, titled *Cultural Impact Assessment for Off-Site Drainage Detention Basins, Traffic Interchanges, and Sewer Line Work Related to the Koa Ridge Makai Development, Waipi'o and Waikele Ahupua'a, 'Ewa District, Island of O'ahu* (Cruz et al. 2008), for detailed information regarding the methods and full results of the consultation effort. A summary of the findings of the community consultation process pertinent to the archaeological inventory survey is provided below.

In general, the community contacts stressed the importance of not damaging any traditional Hawaiian cultural features in the project area. Community contacts indicated features such as trails, *ahu* (rock mounds), walls, petroglyphs, and overhang shelters or caves may exist within Kipapa Gulch, within or in the vicinity of the project area. Contacts also referred to the traditional battles that occurred within Kīpapa Gulch and suggested that human remains or funerary objects may be discovered in the project area. A *Huaka'i Pō* or "night marcher" trail was also indicated to be located within Kīpapa Gulch, near the Kamehameha Highway bridge.

Following the fieldwork component of this archaeological inventory survey, the findings of the study were discussed with community contacts. Community contacts suggested that stone platform and mound features identified in the project area and interpreted to be plantation-era features related to pineapple cultivation, in particular SIHP # 50-80-09-7046, may be of pre-contact origin. The contacts also indicated the structures, referred to as *ahu*, may have had a religious/ceremonial function, and are therefore important cultural resources to the native Hawaiian community and should be preserved.

Following the fieldwork component of this archaeological inventory survey, the findings of the study were discussed with Dr. Laurie Lucking of the U.S. Army face-to-face on October 22nd 2008. Preliminary discussions were held regarding proposed site nomenclature, proposed significance and proposed mitigation measures. Site nomenclature for archaeological features located on Army lands was adapted to respond to her concerns.

Section 3 Background Research

3.1 Traditional Background

3.1.1 Overview

Specific references and citations for information contained in this overview are provided, where applicable, in the subsections that follow (i.e. Sections 3.1.2 onward).

The project area is located in Waipiʻo Ahupuaʻa in the *moku* (traditional district) of Ke-ʻĀpana-o-ʻEwa, now simply known as ʻEwa. Waipiʻo Ahupuaʻa is bounded on the south by Ke-awa-lau-o-Puʻuloa (or simply Puʻuloa), known in modern times as Pearl Harbor. Puʻuloa, which has been a natural resource of enormous importance to Native Hawaiians living a subsistence lifestyle for well over a thousand years, is a large inland embayment of the Pacific Ocean essentially composed of drowned river valleys formed by erosion during a lower stand of the sea (Macdonald et al. 1983). The *ahupuaʻa* continues inland in a northerly direction upslope into the Līhuʻe uplands, known in modern times as the Schofield Plateau. The western boundary of the *ahupuaʻa* is Waikele Stream into which flows Waipiʻo's primary drainage, Kīpapa Gulch (or Stream). Leaving Waikele Stream, the western boundary turns northeast and then east, following another, more *mauka* tributary of Waikele, known as Waikakalaua Stream, and follows this drainage to the summit of the Koʻolau mountains some 21 kilometers distant. Waikele Ahupuaʻa (to the west) and Waiawa Ahupuaʻa (to the east) border Waipiʻo.

Portions of the project area are located within Kīpapa Gulch or its tributaries, Pānakauahi Gulch, and on the gently-sloping interfluvial plain (between Kīpapa and Pānakauahi) known as either Keahumoa or Kanoenoe, depending on the source. As illustrated below, there is a large body of specific oral-historical information associated with Kīpapa and Keahumoa.

The *makai* portions of Waipiʻo Ahupuaʻa, including the upper Waipiʻo Peninsula, were permanently settled in pre-Contact and early historic times, as these areas were prime gardening locations. The *mauka* portions of Waipiʻo Ahupuaʻa, outside of Kīpapa Gulch, were unlikely to be a location of either permanent Native Hawaiian settlement or traditional-style irrigated cultivation (e.g., *kalo*, or taro). However, Native Hawaiians almost certainly maintained *ʻokipu* or *ʻokipuʻu* gardens, that is, dry-land (non-irrigated) forest clearings, of sweet potatoes and other suitable crops interspersed among the native lowland forest and scrublands of this area. In traditional style, these gardens would have been tended periodically as people traveled from the coastal lowlands of Puʻuloa to the upper plateau of Līhue and beyond to the mountains for gathering purposes. Kīpapa Gulch, itself, was likely a place of small, scattered, living sites and gardens.

Portions of the project area are close to the location of an old Native Hawaiian trail connecting ʻEwa to the Waialua District through the Central Oʻahu Plains, as well as to Waiʻanae over Kolekole Pass. Documented *heiau* were located in both the *makai* portions of Waipiʻo at Hālaulani, near the old Loko ʻEo Fishpond (Ahuʻena Heiau), and *mauka* at the headwaters of Kīpapa Stream (Moaʻula Heiau and Heiau o ʻUmi).

By virtue of its location in Waipi‘o, the project area is generally associated with many *mo‘olelo* (oral histories and legends) and *wahi pana* (storied or legendary places) from the Pu‘uloa area, from ‘Ewa Moku and from the uplands of Līhu‘e and beyond, including Kūkaniloko. Legendary connections to the lowland areas of Waipi‘o include the famous gaming and competition sites of Pueohulunui and Hālaulani, fresh water springs and *loko* (fishpond), and the old village of Waipahu. Numerous other *mo‘olelo* and *wahi pana* are associated with the Kula o Keahumoa, including the demi-god / hero figures of Palila, Pikoi and Māui; the goddess Hi‘iaka; and other legendary individuals (e.g., Kalelealuakā and Nāmakaokapa‘o). There are also many references to battles in this area, which was also (especially the lowlands around Pu‘uloa) home to many hereditary elites (*ali‘i*).

In late pre-Contact and early historic times, Waipi‘o is also associated with intra- and inter-island struggles for control over O‘ahu Island and with the Hawaiian Kingdom’s entrance into the world market economy (i.e., the sandalwood trade). Later, the area was used for ranching and for various commercial agricultural crops, most notably sugar cane (Oahu Sugar Company) and later pineapple. The prominent 19th century Hawaiian, John Papa ‘Ī‘ī, was born at Hālaulani (near Loko ‘Eo) and provided several historic descriptions of life and times in Waipi‘o at the dawn of the historic era.

3.1.2 Place Names

Translations presented without attribution in this subsection are from Pukui et al. (1974), unless indicated otherwise. Many of the place names listed below are associated with specific *mo‘olelo* and *wahi pana*, which are presented in Section 3.3 (below). The locations of these prominent places are indicated on Figure 8.

Waipi‘o means “curved water” or “curved, winding water” (Sterling and Summers 1978:1), which presumably refers to the curving shorelines of the middle loch of Pearl Harbor, with its many adjacent fishponds.

Kīpapa translates literally as “placed prone (referring to corpses slain in the victory of O‘ahu forces over those of Hawai‘i in the fourteenth century)” (Pukui et al. 1974:113). Two *heiau* were once located at the headwaters of Kīpapa, Moaula (or Moa‘ula) Heiau and Heiau o ‘Umi. The seasonal drainage to the east of Kīpapa is known as Pānakauahi, which translates as “touched by smoke.”

Pueohulunui, a famed gaming place (where various traditional competitions such as *‘ulu maika* rolling and spear throwing took place), located in the *makai* portion of Waipi‘o Ahupua‘a, is not described by Pukui et al. (1974) as an O‘ahu place name (but rather one in Kā‘u, Hawai‘i Island). Regardless, Pueohulunui translates as “well-feathered owl.” Another such nearby place, Hālaulani, which was the location of Ahu‘ena Heiau, is not translated by Pukui et al. (1974). Ahu‘ena is translated as “red-hot heap,” and apparently refers to the human sacrifices that were carried out here. Both of these places (Pueohulunui and Hālaulani) and the *heiau* are associated with several different *mo‘olelo* (see below).

Kanoenoe and Keahumoa appear to be variant names for the same broad plain leading up to Kīpapa Stream. Keahumoa is associated with multiple *mo‘olelo* (see below).

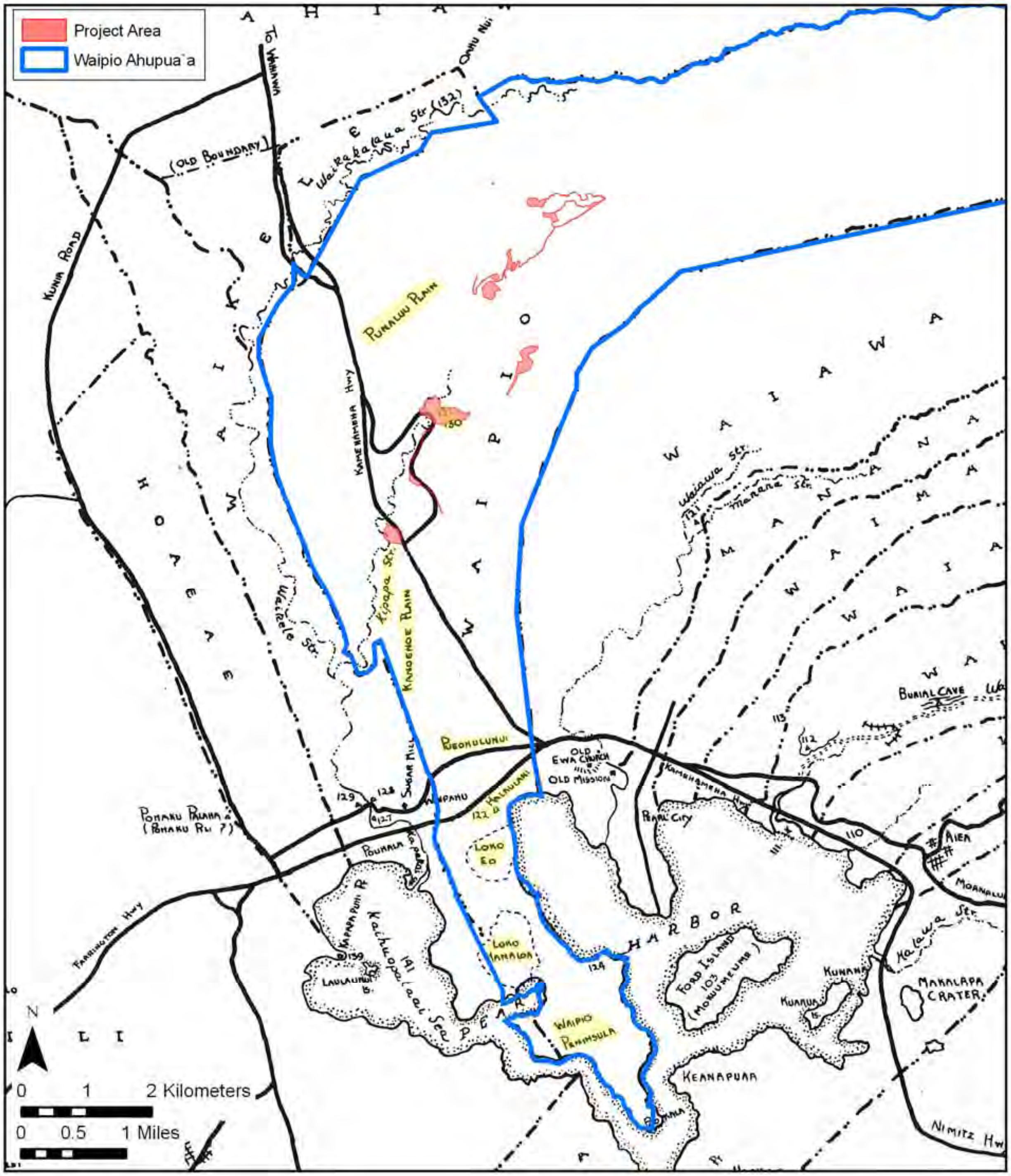

Figure 8. Map showing the locations of prominent places in Waipiʻo Ahupuaʻa discussed in the text (source: Bishop Museum 1959, in Sterling and Summers 1978), in relation to the project area

Loko (Fishpond) Eo, located in the makai portion of Waipiʻo Ahupuaʻa, is not translated by Pukui et al. (1974), whose entry for "Loko-ʻeo" says simply "Fishpond, Pearl Harbor, Oʻahu." They do provide another similar name, Loko ea, translated as "rising pond," and located near Waialua and Waipahu. The word *ʻeo* is translated by Pukui and Elbert (1986) as "full of food," and perhaps this is one of the meanings of the name Loko Eo (or ʻEo).

3.1.3 *Moʻolelo* Associated with Place Names

3.1.3.1 Waipiʻo Uka and the Legend of Kalelealuakā

In the *mauka* regions of Waipiʻo, legend (Thrum 1998:74-106) speaks of Kalelealuakā, who lived during the reign of the Oʻahu chief, Kākuhihewa (i.e., late 16th century to early 17th century). Kalelealuakā was the son of Kaopele, who was born in Waipiʻo, Oʻahu. Kaopele had a tendency to fall into deep trances for months at a time. While awake, he would create plantations of supernatural proportions. However, he was never able to enjoy the fruits of his labors because he would always fall into another deep sleep.

During one profound slumber when Kaopele was believed to be dead, he was taken to Wailua, Kauaʻi to be offered as a sacrifice. Upon awakening, he married a woman named Makalani and stayed on Kauaʻi. They had a son named Kalelealuakā, who was also blessed with supernatural powers. Kaopele instructed the boy in the arts of war and combat, which Kalelealuakā exhibited during two challenges with kings of Kauaʻi. One day, Kalelealuakā decided to travel to Oʻahu. A boy, Kaluhe, accompanied him and they paddled to Waiʻanae. There, he met another companion who he later named Keinohoʻomanawanui, the sloven. The three traveled toward the old plantation called Keahumoe (Keahumoa), in the *mauka* regions of Waipiʻo, which were formerly planted by Kaopele.

> . . . the three turned inland and journeyed till they reached a plain of soft, whitish rock, where they all refreshed themselves with food. They kept on ascending, until Keahumoe lay before them, dripping with hoary moisture from the mist of the mountain, yet as if smiling through its tears. Here were standing bananas with ripened, yellow fruit, upland *kalo*, and sugar cane, rusty and crooked with age, while the sweet potatoes had crawled out of the earth and were cracked and dry. [Thrum 1998:86-87]

To determine the best settlement location, Kalelealuakā shot an arrow to see where it would land. He then built a mountain house and called it "Lelepua" (meaning "arrow flight"), after his magic arrows.

3.1.3.2 Nāmakaokapaʻo and the Kula o Keahumoa (Plains of Keahumoa)

In the legend of Nāmakaokapaoʻo, one lowland area was called the "*kula o Keahumoa*" ("plain of Keahumoa"), which was the plain before reaching Kīpapa Gulch. As stated above (Section 3.1.2), an alternative name for this area may be Kanoenoe. Nāmakaokapaoʻo's mother was Pokai and his father was Kaulukahai, a great chief of Kahiki (the ancestral home of the Hawaiians). The father returned to his home before the birth of his son, leaving his Oʻahu family destitute. Nāmakaokapaoʻo is described as a small, brave child who disliked his stepfather, Pualiʻi, and pulled up the sweet potatoes Pualiʻi had planted at their home in Keahumoa. When

Puali‘i chased Nāmakaokapao‘o with an axe, Nāmakaokapao‘o delivered his death prayer and killed Puali‘i, hurling his head to a cave in Waipouli, near the beach at Honouliuli (Fornander 1919 V:274).

According to other versions of the legend of Nāmakaokapa‘o (Fornander Vol. 5, part 2, p.274):

> Pokai then assented and went to live with her husband Pualii, and resided at the plains of Keahumoa (the plain below Kipapa Gulch). They lived there tilling the soil, Pualii had two large taro patches which remain to this day. They are called Namakaokapaoo. [cited in Handy 1940:82]

The plains of Keahumoa are also mentioned in other Hawaiian stories. The goddess, Hi‘iaka, a sister of the volcano goddess Pele, passed through ‘Ewa and met some women wearing flower *lei* (published in *Ka Hōkū o Hawai‘i*, translated by Kepā Maly):

E lei ana ke kula o Keahumoa i ka ma‘o	The plain of Keahumoa wears the *ma‘o* blossoms as its lei
‘Ohu‘ohu wale nā wahine kui lei o ke kanahele	Adorning the women who string garlands in the wild.
	[cited in Jensen and Head 1997:17]

Pikoi was a legendary hero, the son of a crow (*‘alalā*) and brother to five god-sisters in the form of rats. He was famous for his ability to shoot arrows, and often made bets that he could hit rats from a long distance (Fornander 1917, Vol. IV, Part III:450-463). Pikoi’s skill was commemorated in a saying (Pukui 1983:200):

Ku aku la i ka pana a	Shot by the arrow of Pikoi-[son]
Pikoi-a-ka-‘alalā, keiki pana	of-the-crow, the expert rat-shooter
‘iole o ke kula o Keahumoa.	Of the plain of Keahumoa.

In the legend of the hero Palila, the warrior uses his supernatural war club to carry himself to Ka‘ena Point at Wai‘anae.

> After leaving Ka‘ena, he came to Kalena, then on to Pōhākea, then to Manuauna, then to Kānehoa, then to the plain of Keahumoa and looked toward ‘Ewa. At this place he stood and looked at the dust as it ascended into the sky caused by the people who had gathered there; he then pushed his war club toward Honouliuli. When the people heard something roar like an earthquake they were afraid and they all ran to Waikele. When Palila arrived at Waikele he saw the people gathered there to witness the athletic games that were being given by the king of O‘ahu, Ahupau by name. His palace was situated at Kalaepōhaku, close to Wailuakio at Kapālama. [Fornander 1918, Vol. V, part I:142].

3.1.3.3 Māui and Keahumoa

In the stories of the Māui-kupua (i.e., Māui-the-demi-god), Keahumoa is the home of Māui‘s grandfather, Kū-olokele (Kū-honeycreeper). One day, Māui’s wife, Kumu-lama, was stolen by the chief Pe‘ape‘amakawalu, called eight-eyed-Pe‘a-Pe‘a, who is identified in the creation chant Kumulipo, as the octopus god (Beckwith 1951:136). The chief disappeared with Kumulama in the sky beyond the sea, and escaped so quickly that Māui could not catch him. To recover his wife, Māui's mother advised him to visit the hut of his grandfather at Keahumoa:

> Maui went as directed until he arrived at the hut; he peeped in but there was no one inside. He looked at the potato field on the other side of Pōhā-kea, toward Hono-uli-uli, but could see no one. He then ascended a hill, and while he stood there looking, he saw a man coming toward Waipahu with a load of potato leaves, one pack of which, it is said, would cover the whole land of Keahumoa. [Thrum 1923:253-254]

Kū-olokele made a *moku-manu* ("bird-ship") for Māui, who entered the body of the bird and flew to Moanaliha, the land of the chief Peapeamakawalu. This chief claimed the bird as his own when it landed on a sacred box, and took it with him into the house he shared with Māui's wife, Kumulama. When Peʻapeʻamakawalu fell asleep, Māui killed him, cut off his head, and flew away back to Oʻahu with his wife and the chief's head (Thrum 1923:252-259; see also Kawaharada 1996).

3.1.3.4 Kanoenoe Plain

As stated above, it is possible that Keahumoa and Kanoenoe are variant names for the same plain that leads up to the headwaters of Kīpapa. A piece from the Hawaiian language newspaper *Ka Loea Kalaiaina* contains a few poetic lines that clearly associate Kanoenoe with other old Oʻahu place names:

> The icy wind of Lihue plied its spurs,
> Pulling up the bridle of Haleauau,
> Speeding headlong over Kalena
> And running over the plain of Kanoenoe.

3.1.3.5 The Battles of Kīpapa

Waipiʻo was the scene of more than one battle between local and invading *aliʻi* for political control of Oʻahu (Handy and Handy 1972:470). One of these was apparently fought during the reign of the 15th century *mōʻī* (king) Maʻilikūkāhi. Fornander's telling of this *moʻolelo* also explains how Kīpapa gulch and stream in Waipiʻo were named:

> I have before referred to the expedition by some Hawaii chiefs, Hilo-a-Lakapu, Hilo-a Hilo-Kapuhi, and Punaluu, joined by Luakoa of Maui, which invaded Oahu during the reign of Mailikukahi. It cannot be considered as a war between the two islands, but rather as a raid by some restless and turbulent Hawaii chiefs, whom the pacific temper of Mailikukahi and the wealthy condition of his island had emboldened to attempt the enterprise, as well as the eclat that would attend them if successful, a very frequent motive alone in those days. The invading force landed at first at Waikiki, but, for reasons not stated in the legend, altered their mind, and proceeded up the ʻEwa lagoon and marched inland. At Waikakalaua they met Mailikukahi with his forces, and a sanguinary battle ensued. The fight continued from there to Kipapa gulch. The invaders were thoroughly defeated, and the gulch is said to have been literally paved with the corpses of the slain, and received its name, "Kipapa," from this circumstance. Punaluu was slain on the

> plain which bears his name, the fugitives were pursued as far as Waimano, and the head of Hilo was cut off and carried in triumph to Honouliuli, and stuck up at a place still called Poo-Hilo. [Fornander 1996:89-90]

A second "Battle of Kīpapa," from the Hawaiian language newspaper *Hoku o Hawaii*, involves different main characters and, unlike the previous one, has the Oʻahu side losing to the Hawaiʻi Island *koa* (warriors):

> Mr. Kahikulani was a war leader of Puna, Hawaii. He came to battle against the [famous Oʻahu] chief Halemano whose cannibal meat dish became famous. He went inland and up to the very top of the mountain. He looked down on Kipapa stream where his warriors fought those of Chief Halemano in a great battle. The sun had not set when all of Halemano's warriors were destroyed. The land and stream of Kipapa was reddened with the blood shed in this battle. That was the first time that the public highway became peaceful in that period that is gone. Kakikulani was a man of power in Puna, Hawaii. [Na Anoai o Oahu nei, *Hoku o Hawaii*, Jan. 28, 1930, "Place Names," in Sterling and Summers 1978:20]

3.1.3.6 Spearing-throwing Contest at Pueohulunui and Hālaulani

An excerpt of a fragment of unfinished material authored by one Donald Angus Coll from the Hawaiian language newspaper *Kuokoa* describes a spear-throwing competition in Waipiʻo:

> The chief [Piliwale, ruling chief of ʻEwa at the time] had declared that if any man be found who was skilled in spear throwing and could out-match his instructor then the reward would be his daughter [Kohepalaoa]. The chief's spear throwing instructor was Awa. He could hold ten spears in his right hand and ten in his left. He could, with two thrusts send ten at the back, two to trip his opponent and two at the navel…
>
> The spear throwing contest lasted two days at Pueohulunui but none dared to challenge the instructor. As for Lo-Kaholialale, he observed the manner in which the expert instructor thrust and parried and he also knew how his own instructor fought. Ake-pao-a-na-ihe (Eager-to-thrust-with-spears) was the name of his own teacher.
>
> On the third day the contest was taken down to Halaulani. It was there the chief heard that a certain young chief of the upland of Lihue challenged Awa-hauna-laʻau-nui.
>
> There the young chief of Lihue showed his unequalled skill in parrying. The strokes by which he won was the pane (skull top) from above and the huʻalepo (dust scattering) from below. Two places were then named Ka-pahu (The thrust) and Hana-pouli (making-a-darkness) and they are at Waipio in Ewa. [in Sterling and Summers 1978:23]

3.1.3.7 Pānakauahi

The seasonal stream drainage located east of Kīpapa Gulch is associated with an interesting character named Ke-akua-ʻōlelo, as described by Pukui et al. (1974:178):

> A talkative local god, Ke-akua-ʻōlelo (the speaking god), lived here. According to some accounts he betrayed secrets. In another story he saw a chiefess hide a *lei palaoa* (whale-tooth pendant) in a stone called Pōhaku-hūnā-palaoa (stone hiding whale-tooth pendant); he promised to tell only her descendants.

3.1.4 Settlement and Subsistence

Waipiʻo Ahupuaʻa was a focus of Hawaiian settlement and activity on Oʻahu during the centuries preceding western contact. "The populous dwelling place of the *alii* was formerly located on an east point of Waipiʻo Peninsula known as Lēpau" (McAllister 1933:106). The *aliʻi* (chiefly class) at Waipiʻo were no doubt attracted to the great abundance the region offered. "The primary reason for ʻEwa's prominence in history and as an *aliʻi* stronghold was undoubtedly the existence of the great number of fishponds at different points around Pearl Harbor, which was ʻEwa territory. Two of the largest [Loko Eo and Loko Hanaloa] were on the peninsula, and another was at its northwest corner" (Handy and Handy 1972:470). The district of ʻEwa also contained other resources that were attractive to an expanding population:

> The lowlands, bisected by ample streams, were ideal terrain for the cultivation of irrigated taro. The hinterland consisted of deep valleys running far back into the Koʻolau range. Between the valleys were ridges, with steep sides, but a very gradual increase of altitude. The lower parts of the valley sides were excellent for the culture of yams and bananas. Farther inland grew the *ʻawa* for which the area was famous. The length or depth of the valleys and the gradual slope of the ridges made the inhabited lowlands much more distant from the *wao*, or upland jungle, than was the case on the windward coast. Yet the *wao* here was more extensive, giving greater opportunity to forage for wild foods in famine time. [Handy and Handy 1972:469]

Handy described the character and extent of the lowland cultivation areas in the Waipiʻo area:

> Between the West Loch of Pearl Harbor and Loko Eo the lowlands were filled with terraces which extended for over a mile up into the flats of Waikele Stream. The lower terraces were formerly irrigated partly from Waipahu Stream, which Hawaiians believe came all the way through the mountains from Kahuku. It is said that terraces formerly existed on the flats in Kipapa Gulch for at least 2 miles upstream above its junction with Waikele. Wild taros grow in abundance in upper Kipapa Gulch…[Handy 1940:82]

Writing in the mid-19th century, John Papa ʻĪʻī described how a period of famine was managed in Waipiʻo and what resources were available during the famine. These comments stress importance of upland resources to the *makaʻāinana* (commoners) of Waipiʻo:

> Here is a wonderful thing about the land of Waipio. After a famine had raged in that land, the removal of new crops from the taro patches and gardens was prohibited until all of the people had gathered and the farmers had joined in thanks to the gods. This prohibition was called *kapu ʻohiʻa* because, while the famine was upon the land, the people had lived on mountain apples (*ʻohiʻa ʻai*), tis [i.e., *kī* or *tī*], yams, and other upland foods. On the morning of Kane an offering of taro greens and other things was made to remove the *ʻohiʻa*

> prohibition, after which each farmer took of his own crops for the needs of his family. [‘Ī‘ī 1959:77]

‘Ī‘ī also talked about supplying a royal party connected with Liholiho (Kamehameha II, who ruled from 1819 to his death in 1824), including the King, himself, who were journeying overland from Honolulu and staying the night at Kūmelewai (near Hanaloa Fishpond, in the *makai* portion of Waipi‘o). ‘Ī‘ī's description suggests that all necessary resources for this purpose were obtained from Waipi‘o Ahupua‘a, including most especially its upland areas:

> Before the company arrived for the night, Ii was sent with a message to the dwellers of the land [i.e., the *maka‘āinana* of Waipi‘o Ahupua‘a] to be ready with fish, dogs, vegetable food, and clothing that would be of help to the travelers. Thus were all things supplied from upper Waipio to the sea. There was enough for the traveling company of the young chief [Liholiho], who was spending the night there. [‘Ī‘ī 1959:23]

3.1.5 Heiau

Located at Hālaulani, in the *makai* portion of Waipi‘o Ahupua‘a, Ahu‘ena Heiau (State Inventory of Historic Properties [SIHP] # 50-80-09-122) was described in the 1930s by McAllister (1933) of the Bishop Museum as follows:

> Ahu‘ena Heiau (Destroyed)…Only a small portion of paving of very small waterworn stone at the edge of the 25 foot elevation remains of what must have been an important heiau, for the site is known and remembered by all the old Hawaiians (kamaaina) in the district. There is a vague memory that this heiau was formerly located in the mountains in Honouliuli at Punahawele. Thrum states "Hon. John [Papa] Ii [the 19th century historian, member of the Land Commission and prominent citizen] used to be the custodian of its idols." [Sterling and Summers 1978:19]

McAllister (1933) described two other *heiau* (both "destroyed" by the time of his 1930s survey) located at the *mauka* headwaters of Kīpapa Stream. Moaula Heiau (SIHP # 50-80-09-130) was described as: "…on the Honouliuli side of Kīpapa Gulch just above Heiau o ‘Umi, to which it is said to be a companion structure…" Pukui et al. (1974) translate Moa‘ula (their preferred spelling for this *heiau*) as "red chicken." Heiau o ‘Umi (SIHP # 50-80-09-131) "…was just northeast of the government road in the bottom of Kīpapa Gulch on the slight elevation at the foot of the pali on the Honolulu side. The level elevation can still be seen, though planted in cane." ‘Umi presumably refers to the 16th century supreme ruler of Hawai‘i Island; therefore, this name—if not the entire *heiau*, may be a relatively recent (i.e., late pre-contact) phenomenon.

3.1.6 *Loko* (Fishponds)

Much of *makai* portion of the ‘Ewa District is traditionally well-known for its many *loko* (fishponds), both large and small. Within Waipi‘o Ahupua‘a was Loko ‘Eo, described in the *Dictionary of Hawaiian Localities* (*Saturday Press*, August 11, 1883) as a "…large fishpond in Ewa, well known for superior flavor of fishes" (Sterling and Summers 1978:20). As stated above, ‘*eo* is translated as "full of food" (Pukui and Elbert 1986:42). A nineteenth century visitor to Loko ‘Eo described it in the Hawaiian newspaper *Ka Nupepa Kuokoa* (Aug. 11, 1899):

> We rode and reached Waipio. Saw Halaulani House; only the house stood there for the inhabitants had gone to Mana. The bubbling water of the pond Eo rippled on the left. There a recollection came of the bundles of fat eel from that place and the delicious mullet of Makahanaloa. It was delicious clean and that is why the very juice in the ti leaves was sucked up by Kohala's son. [cited in Sterling and Summers 1978:20]

Just south of Loko ʻEo, on the Waipiʻo Peninsula, was Loko Hanaloa, reportedly very near to the actual birthplace of John Papa ʻĪʻī.

3.1.7 Trails

Portions of the project area are in the immediate vicinity of a well-documented traditional trail, which formerly connected ʻEwa to the Waialua District through the Central Oʻahu Plains, as well as to Waiʻanae over Kolekole Pass (Figure 9).

3.1.8 Other Traditional Resources of Waipiʻo

Several well-known sources, including Handy (1940), Handy and Handy (1972), Sterling and Summers (1978) and ʻĪʻī (1959), mention other traditional resources for which Waipiʻo is famous. These include: its extensive *wao* (upland jungle) and its diverse and abundant wild foods (e.g., *ʻōhiʻa ʻai* or mountain apple), birds such as *ʻōʻō* (a black honey eater, *Moho nobilis*) and *ʻiʻiwi* (Scarlet Hawaiian honey creeper, *Vestinaria coccinea*) for making feather capes, helmets and *lei*) and tapa-making plants such as *wauke* (paper mulberry, *Broussonetia papyrifera*) and *māmaki* (*Pipturis* spp.); and, a local variety of the mildly narcotic plant, *ʻawa* (also known as ʻkava,' *Piper methysticum*).

3.2 Historical Background

3.2.1 Late Pre-Contact and Early Historic Periods

In the first half of the 18th century, the island of Oʻahu was ruled by a chief named Kūaliʻi, who consolidated his supreme power over the entire island by defeating the chiefs of ʻEwa (Cordy 2002:32). Kūaliʻi met the competing army on the plains of Keahumoa, but the ʻEwa chiefs surrendered when they saw Kūaliʻi's overwhelming forces, and they ceded the lands of Koʻolau Loa, Koʻolau Poko, Waialua, and Waiʻanae to him (Fornander 1917, Volume IV (2):366, 400).

During the second half of the 18th century, Waipiʻo again became a focus of political intrigue and warfare. In 1783, the forces of the Maui chief Kahekili gained control of the island of Oʻahu by defeating the *mōʻī*, Kahāhana, "from the powerful ʻEwa chiefs' line" (Cordy 1981:207). According to the 19th century Hawaiian historian Samuel Kamakau, the defeated Oʻahu chiefs plotted to kill the Maui chiefs. Waipiʻo was given the name "Waipiʻo *kīmopō*," or "Waipiʻo of the secret rebellion," due to all the covert planning (Kamakau 1992:138). Pukui (1983) comments on this name:

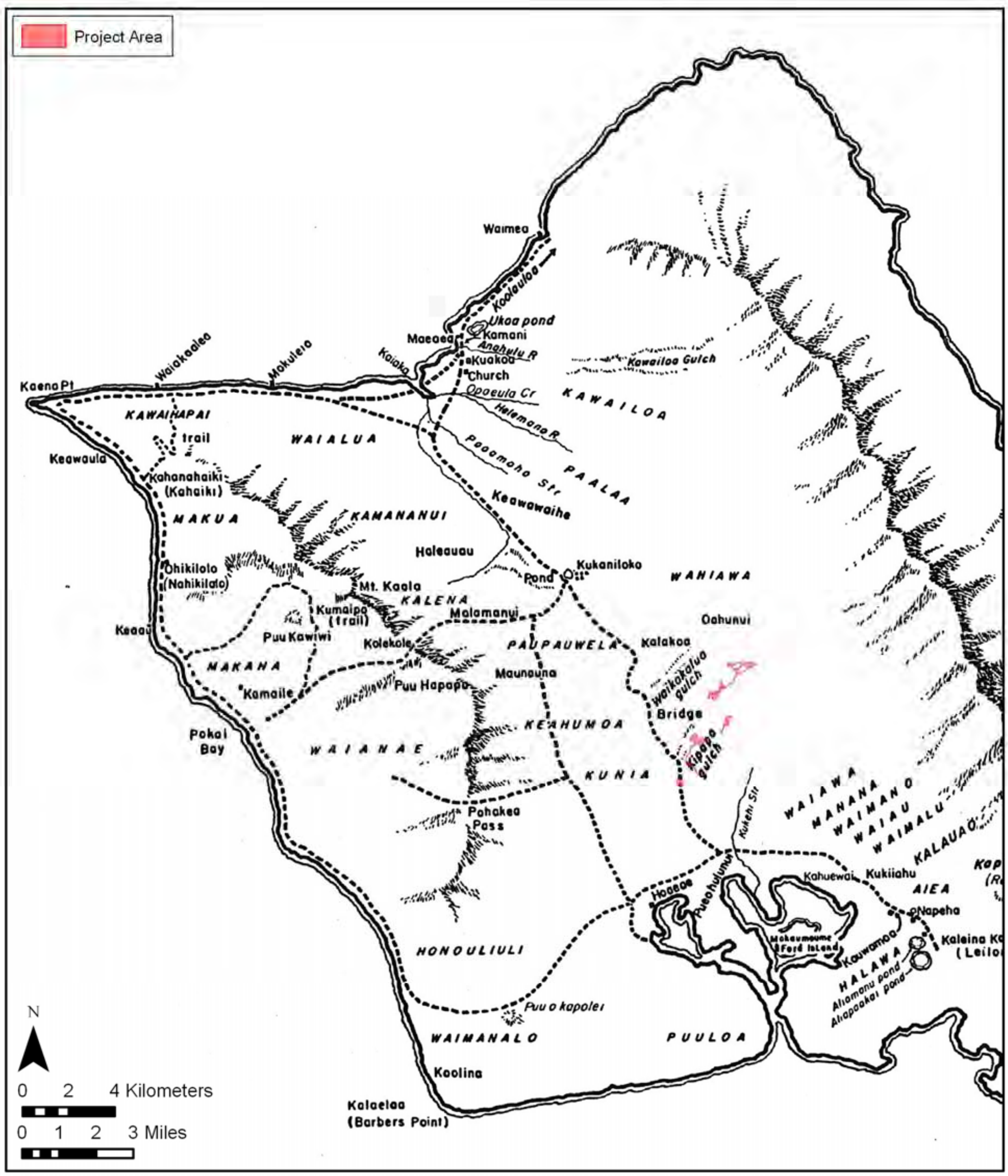

Figure 9. Map showing trails of leeward O‘ahu (source: Rockwood in ‘Ī‘ī 1959: 96), in relation to the project area

> An epithet for the people of Waipi‘o, O‘ahu. After the death of Kahāhana, the chiefs of Waipi‘o plotted to murder the chiefs of Maui, who were then in ‘Ewa. Someone warned the Maui chiefs and all but one escaped. To throw off suspicion, the Waipi‘o chiefs claimed that the one was killed by someone from Kaua‘i. Later Kahekili learned that Elani, chief of ‘Ewa, was in the plot, so he launched a massacre that choked the streams of Niuhelewai and Makāhi in Palama with the bodies of the dead. [Pukui 1983:319]

Kamakau adds some additional details. Following the plan’s failure, Kahekili took revenge on the ‘Ewa and Kona districts:

> …and when Ka-hekili learned that Elani of ‘Ewa was one of the plotters, the districts of Kona and ‘Ewa were attacked and men, women, and children were massacred, until the streams of Makaho and Niuhelewai in Kona and of Kahoa‘ai‘ai in ‘Ewa were choked with the bodies of the dead, and their waters became bitter to the taste, as eyewitnesses say, from the brains that turned the water bitter. All the O‘ahu chiefs were killed and the chiefesses tortured. [Kamakau 1992:138]

If Kamakau is correct, the population of Waipi‘o would have been decimated during the 1780s. Kahekili and the Maui chiefs retained control of O‘ahu until the 1790s. In 1794, Kahekili died at Waikīkī. His son, Kalanikūpule, was defeated the following year at the battle of Nu‘uanu by Kamehameha, who distributed the O‘ahu lands - including Waipi‘o Ahupua‘a - among his favorite followers, which resulted in the displacement of many families. “Land belonging to the old chiefs was given to strange chiefs and that of old residents on the land to their companies of soldiers, leaving the old settled families destitute” (Kamakau 1992:376-377).

3.2.2 1800 to 1850s

John Papa ‘Ī‘ī, one of the Hawaiian Kingdom’s most prominent citizens in the 19th century, and a member of the Land Commission that oversaw the distribution of lands during the Māhele, was placed in the household of Liholiho (Kamehameha II) when he was ten years old. He became Liholiho’s personal attendant and also maintained records of life in the Hawaiian Kingdom. ‘Ī‘ī was born in Waipi‘o Ahupua‘a in 1800. An autobiographical account of his birth details the establishment of ‘Ī‘ī’s family at Waipi‘o after the ascendancy of Kamehameha I on O‘ahu:

> John Papa Ii was born in Kumelewai, Waipio, in Ewa, Oahu , on the third day of August (Hilinehu in the Hawaiian calendar) in 1800, on the land of Papa Ii , whose namesake he was. Papa [‘Ī‘ī’s uncle] was the owner of the pond of Hanaloa and two other pieces of property, all of which he had received from Kamehameha, as did others who lived on that *ahupua‘a*, or land division, after the battle of Nuuanu. He gave the property to his *kaikuahine* [cousin] who was the mother of the aforementioned boy. Her names were Wanaoa, Pahulemu, and Kalaikane. [‘Ī‘ī 1959:20]

‘Ī‘ī’s writings provide glimpses of life within Waipi‘o Ahupua‘a during his lifetime. ‘Ī‘ī mentions the “family [going] to Kīpapa from Kūmelewai by way of upper Waipi‘o to make ditches for the farms” (‘Ī‘ī 1959:28), and recalls that during the visit to O‘ahu by the Kaua‘i chief

Kaumualiʻi and his entourage, the chief's attendants were provided with gifts: “From Waipio in Ewa and from some lands of Hawaii came *tapa* made of *mamaki* bark” (ʻĪʻī 1959:83).

ʻĪʻī also described witnessing the activities and ceremonies associated with the Makahiki, the annual traditional celebration, including sports and competition, religious observances and prohibitions of warfare. Traditionally, the Makahiki festival moved around the island, and ʻĪʻī witnessed and described it as it came through Waipiʻo. Given that he was moved to Waikīkī when approximately 10 years old, the following description probably comes from his memories before that age:

> Many people followed the procession on its tour over the land, among them the boxers, and all partook of the foods that were contributed by the people of each place. Ii followed the procession of the gods as far as Waipio in Ewa, and thus learned the customs of the *makahiki* period.
>
> In imitation of what he saw on his journey from Honolulu with the god of play, the boy made two images that looked very much like the *makahiki* gods. Beside them he placed ferns and a clump of bananas bearing fruit.
>
> For four days there was boxing with the boys from Waikele. The matches were held in front of the images, starting about four o’clock in the afternoon. Then, because the visiting boys plotted to take the images, they were put away in a safe place.
>
> At noon of the fifth day the battlers met at a designated place and fought back and forth with stones. One of the Waipio boys was struck by a Waikele boy, and so the battle was postponed until evening. Then those of both sides gathered. Kaapuiki, wearing his dark red shoulder covering, was on the side of the opponents, and when Ii threw his stone, it struck Kaapuiki on the eyebrow and made him cry. This ended their develish behavior; but Ii, having been told that the other was the son of a sorcerer, was frightened. Later he learned that the report was not true.
>
> After this “battle” of the children a sham battle between adults took place on the southwestern side of Kupapaulau at Waikele. Two chiefs who had gone from Honolulu to Puuloa with some chiefs of that locality landed at Aioloolo in Waikele, and the battle was staged between them and residents of Waikele that very afternoon. The two sides gathered at a place above Aioloolo on the slope of the hill leading down to Kupapaulau.
>
> The spectators noticed that both sides were equally skilled in stone throwing and in dodging the stones that flew back and forth. No one was hurt or harmed, and the skill of the participants and the chiefs who arranged the sham battle was praised. It seems that the chiefs watched to see how skilled their people were in battle.
>
> At about the time of the sham battle, a proclamation came from Kawelo, the overseer of the land at Waikele, for the men of the land to fetch the double canoe beached at Kupahu, on the northeastern side of Halaulani in Waipio. Because this proclamation came from Kawelo, who said the order was from Kalanimoku, the

> men of Waipio made ready to detain the canoe. They felt that the command should have come from their own leader, Papa.
>
> When Kawelo and the men of Waikele had taken their places from prow to stern of the canoe and the command, “Go ahead,” was given, the canoe did not budge. It was being held back by the men of Waipio, Kawelo’s men tried again to make it go forward, but to no avail, so Kawelo asked the Waipio men why they held on. Kaimihau answered, “You cannot do this, for we were not told of it by our leaders. If Kalanimoku had made this request through our own leaders, we should have heard of it and therefore done nothing to prevent the removal of the canoe. If you persist in the idea of taking the canoe, day may change to night and night to day without its budging from its resting place. All things left here at Waipio are protected, from the sea to the upland, and we shall not let them go unless we hear from our own leaders.” O companions, see how well the people served their leader. The peace of the land of Waipio was well known while the high chiefs were in charge and up to the time of Papa’s death.

The end of the 18th century and beginning of the 19th century marked Hawai‘i’s entry into world trade networks. One of the chief exports at this time was sandalwood (*Santalum* spp.) or *‘iliahi*, which was prized in China for its unique fragrance and was used in the manufacture of household items, and as incense, perfume, and medicine (St. John 1947). The central plains of ‘Ewa supplied the Hawaiian Kingdom with *‘iliahi*. One of the first generation missionaries, Sereno Bishop (1901), described his memories of the central O‘ahu region in the 1830s:

> Our family made repeated trips to the home of Rev. John S. Emerson at Waialua during those years (Bishop Family moved to Ewa in 1836.) There was then no road save a foot path across the generally smooth upland. We forded the streams. Beyond Kipapa gulch the upland was dotted with occasional groves of Koa trees. On the high plains the ti plant abounded, often so high as to intercept the view. No cattle then existed to destroy its succulent foliage. According to the statements of the natives, a forest formerly covered the whole of the then nearly naked plains. It was burned off by the natives in search of sandalwood, which they detected by its odor when burning. [cited in Sterling and Summers 1933:89]

The dry forests formerly covering this region probably never came back, particularly considering the harm done to the *‘iliahi* seedlings with the introduction of cattle soon thereafter (Judd 1933). It is also important to point out that other types of hardwood were in great demand as Honolulu was built up during the 19th century.

Native Hawaiian activity and habitation at the middle of the 19th century clustered in the *makai* lowlands and the fishponds near the coast. The *ahupua‘a’s makai* landscape was dominated by an extensive network of taro *lo‘i* (irrigated fields). Archibald Campbell, travelling through ‘Ewa in 1809, recorded describe the ‘Ewa landscape at Pearl Harbor as it had been developed by the Hawaiians by the early decades of western contact:

> We passed by footpaths winding through an extensive and fertile plain, the whole of which is in the highest state of cultivation. Every stream was carefully embanked, to supply water for taro beds. Where there was no water, the land was

> under crops of yams and sweet potatoes. The roads and numerous houses are shaded by cocoa-nut trees, and the sides of the mountains are covered with wood to a great height. [Campbell 1967:103]

The botanist F.J.F. Meyen, visiting in 1831, confirms the state of cultivation of the low lands fronting Pearl Harbor:

> At the mouth of the Pearl River the ground has such a slight elevation, that at high tide the ocean encroaches far into the river, helping to form small lakes which are so deep, that the long boats from the ocean can penetrate far upstream. All around these water basins the land is extraordinarily low but also exceedingly fertile and nowhere else on the whole island of Oahu are such large and continuous stretches of land cultivated. The taro fields, the banana plantations, the plantations of sugar cane are immeasurable. [Meyen 1981:63]

In contrast to the well-populated *makai* lands of Waipi‘o, the *mauka* regions were often described in 19th century accounts as virtually uninhabited. The missionary William Ellis described the interior regions of ‘Ewa in 1823-24:

> The plain of Eva is nearly twenty miles in length, from the Pearl River to Waialua, and in some parts nine or ten miles across. The soil is fertile, and watered by a number of rivulets, which wind their way along the deep water-courses that intersect its surface, and empty themselves into the sea. Though capable of a high state of improvement, a very small portion of it is enclosed or under any kind of culture, and in traveling across it, scarce a habitation is to be seen. [Ellis 1963:7]

Despite Ellis’ impressions, there is evidence that during the early nineteenth century, the Waipi‘o population was not solely focused on the fertile coast. In an inventory of advances in education during the reign of Kamehameha III (from 1825 to 1854), “schools were built in the mountains and in the crowded settlements. Waipi‘o had school houses near the coast and in the uplands” (Kamakau 1992:424). The placement of a school “in the uplands” of Waipi‘o suggests that some portion of the *ahupua‘a* population had settled there.

Censuses taken by Protestant missionaries throughout the Hawaiian Islands beginning in 1831 provide the earliest record of the size of the native population after the first decades of western contact. In the 1831-32 census of O‘ahu, a population of 913 was recorded within Wahiawa and Waipi‘o Ahupua‘a. Three years later, in 1835, 513 individuals were recorded in Waipi‘o alone. By the late 1840s, approximately 300 persons were listed as living in Waipi‘o Ahupua`a (Schmitt 1973:19,22).

During the 1830s, cattle grazing began in the *mauka* regions of Waipi‘o (Bishop 1901:87). In 1847, residents of Waipi‘o petitioned the Minister of the Interior, John Young, to resolve the problem of stray animals. These stray animals may have been from herds of cattle and goats grazing on Waipi‘o’s *kula* lands. In addition to damage from stray animals on the lands of Waipi‘o, the impact of grazing animals was noted several kilometers away at Pu‘uloa (Pearl Harbor):

> The subsequent occupation of the uplands by cattle denuded the country of herbiage, and caused vast quantities of earth to be washed down by storms into the lagoons, shoaling the water for a long distance seaward. [Bishop 1901:87]

3.2.3 The Māhele

The Organic Acts of 1845 and 1846 initiated the process of the Māhele, the division of Hawaiian lands, which introduced private property into Hawaiian society. In 1848, the crown, the Hawaiian government, and the *aliʻi* (royalty) received their land titles. The common people (*makaʻāinana*) received their *kuleana* awards (individual land parcels) in 1850. It is through Land Commission records generated during the Māhele that the first specific documentation of life in Waipiʻo Ahupuaʻa, as it had evolved up to the mid-nineteenth century, comes to light.

John Papa ʻĪʻī was awarded most of the *ahupuaʻa* of Waipiʻo in LCA 8241, comprising approximately 20,540 acres. Included in the documentation for ʻĪʻī's award is a list of the people living on the land of Waipiʻo at the time of the Māhele (see Appendix B for Native Register vol. 5:512-517). A substantial award within the *ahupuaʻa* was to Abner Pākī, Bernice Pauahi Bishop's father. Part of LCA 10613 awarded to Pākī comprised the 350 acres of the *ʻili* of Hanaloa:

> Abnera Pākī (age forty) as a grandson of Kamehamehanui, a former Māui Mōʻī, and brother of the great Kahekili, was an *Aliʻi Nui* by Māui standards, but he was not closely related to Kamehameha. Therefore, he held only 9 *ʻĀina* before the *Māhele*: 6 on Oʻahu [including Hanaloa *ʻili*], 1 on Māui, 1 on Molokaʻi, and 1 on Kauaʻi…
>
> Pākī was treated very well by the *Mōʻī*: only 33 percent of his *ʻĀina* were taken. His remaining property included valuable Oʻahu *ʻĀina*: the entire *ahupuaʻa* of Heʻeʻia in Koʻolaupoko, the *ʻili* of Waialae in Waikīkī, and the *ʻili* of Hanaloa in Waipiʻo, ʻEwa. [Kameʻeleihiwa 1992:267]

William Harbottle also received a land award (LCA 2937) in Waipiʻo, consisting of two acres at Hanapouli *ʻili*.

The remaining land claims documented in the Land Commission records, a total of 99 (not all of which were awarded), are *kuleana* claims, where the commoners of Waipiʻo worked and lived. The majority of awarded land parcels were located in the *makai* portions of Waipiʻo, at or just above the Waipiʻo Peninsula. Predominant among the claimed land usages in Waipiʻo are 312 *loʻi* (irrigated taro patches) of various sizes. Wetland taro cultivation was the primary agricultural pursuit within the *ahupuaʻa* at the mid-19th century, and likely reflects a long history of taro farming. At the coast, four fishponds are claimed.

In the *mauka* reaches of Waipiʻo, 53 claims were made for portions of *kula* (pasture land) and 25 for "*okipu*" (forest clearings). The fact that several claims were made in the *mauka* regions suggests that Waipiʻo residents had particular locales that they traveled to repeatedly. This also confirms other accounts (e.g., see Handy and Handy 1972:469-470) suggesting this area had especially abundant and diverse uplands. *Kula* land is a general term for open fields, pastures, uncultivated fields, or fields for cultivation, and upland (drier), which is distinct from meadow or wetland (Lucas 1995:60). *Kula* lands were often used for opportunistic plantings such as bananas, sugar cane, sweet potatoes, dry land taro, and others that did not depend heavily on a consistent source of water. *Okipu* is defined as a forest clearing (Lucas 1995:82), a place that was presumably used to gather forest products and medicinal herbs and or for pasturage.

The locations of Land Commission Awards in the vicinity of the project area are indicated on Figure 10. All of the awarded lands are located within Kīpapa Gulch or its tributaries, and includes lands at the base of the gulch, as well as the gulch slopes. Table 1 presents land use information for the Land Commission Awards, as documented in testimony to the land commission by the claimants. In general, each of the Land Commission Awards consists of a *moʻo* (land division smaller than an *ʻili*) including a house lot, *kula* (dry land field), and ʻ*okipu* (forest clearing). The house lot claims indicate Native Hawaiians were permanently settled in upland Waipiʻo, primarily within Kīpapa Gulch, focusing on dry land agriculture and gathering of forest resources for subsistence.

3.2.4 1850s to 1900

As sugar plantations were developed and expanded in the islands during the middle decades of the 19th century, the need for increased numbers of field laborers prompted passage of contract labor laws. By mid-century, the first Chinese contract laborers arrived in the Hawaiian kingdom. Contracts were for five years and pay was $3 a month plus room and board. Upon completion of their contracts, a number of the immigrants remained in the islands, many becoming merchants or rice farmers.

The Hawaiian Islands were well-positioned for rice cultivation. A market for rice in California had developed as increasing numbers of Chinese laborers immigrated there. Similarly, as Chinese immigration to the islands also accelerated, a domestic market opened. Typically, groups of Chinese began leasing or purchasing former taro lands for conversion to rice farming. The decrease in the availability of taro lands throughout the islands in the second half of the 19th century reflected the declining demand for taro as the native Hawaiian population diminished. At Hālawa Ahupuaʻa in ʻEwa, most of the taro *loʻi* had already been replaced by rice fields in the 1860s (Klieger 1995:78), and it is likely that a similar displacement was taking place at Waipiʻo during that period.

After John Papa ʻĪʻī's death in 1870, his estate, including the Waipiʻo lands, was inherited by his daughter Irene ʻĪʻī Brown. Shortly after, small parcels within the *ahupuaʻa* were sold off. However, it was not until the late 1890s that large tracts of land were leased for commercial agricultural endeavors.

In 1889, Benjamin F. Dillingham organized the Oahu Railway and Land Company (O.R. & L.), with the intent of connecting the outlying areas of Oʻahu to Honolulu. By 1890, the railroad reached from Honolulu to Pearl City, and continued on to Waiʻanae in 1895, to Waialua Plantation in 1898, and to Kahuku in 1899 (Kuykendall 1967:100). In 1897, the newly organized Oahu Sugar Company, described as an "annexation plantation, a direct promotion of Benjamin F. Dillingham," leased 3,400 acres of Waipiʻo land from the ʻĪʻī estate (Condé and Best 1973:313). A few years earlier (ca. 1895), the O.R. & L. had leased a tract through Kīpapa Gulch to transport sugar and pineapple from Wahiawā to Honolulu. The growth of the sugar and pineapple industries would comprise the major transformation of lands in the *mauka* portion of Waipiʻo Ahupuaʻa.

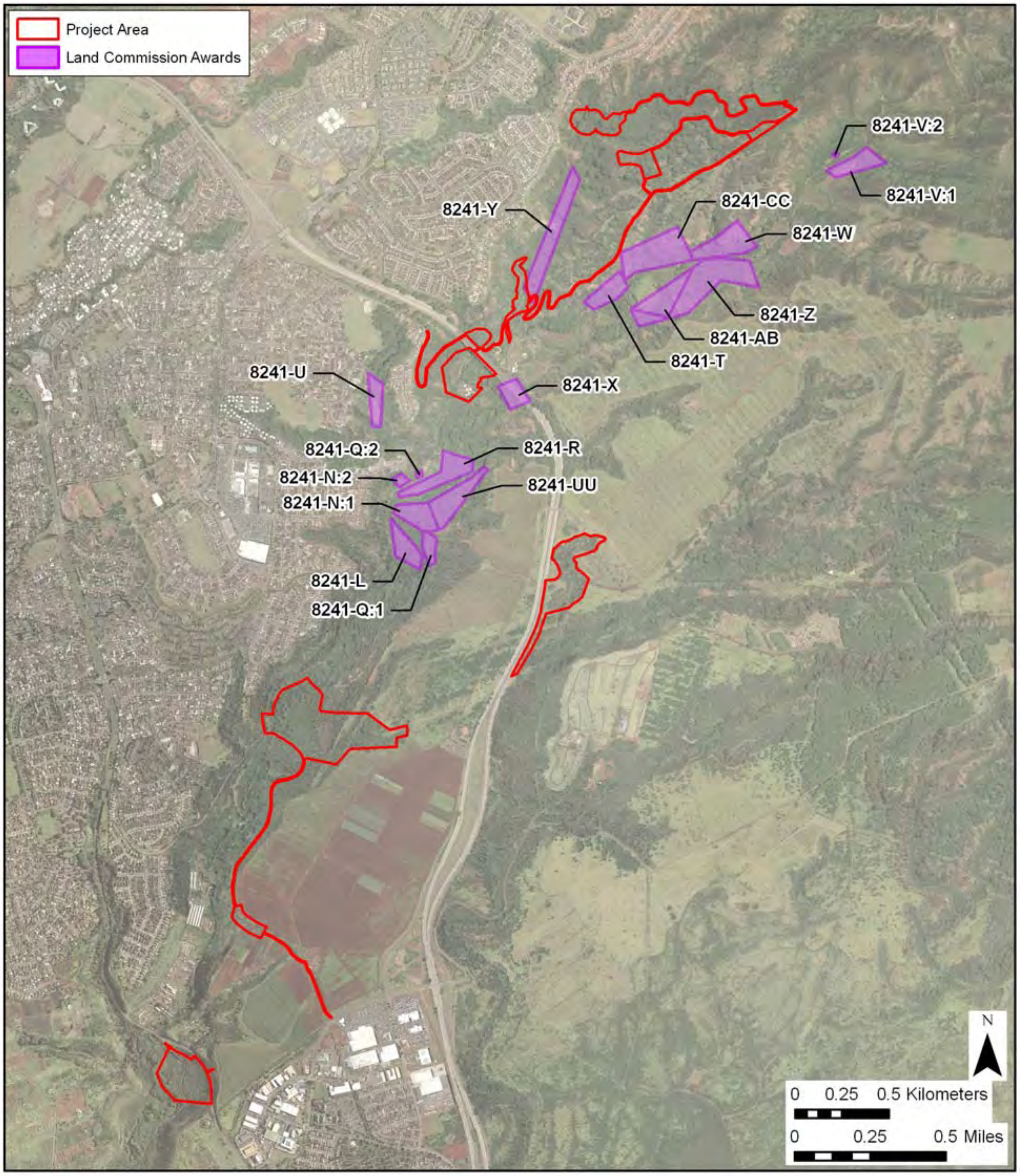

Figure 10. Land Commission Awards in the *mauka* portions of Waipi‘o Ahupua‘a, in relation to the project area

Table 1. Land Commission Awards in the Vicinity of the Project Area

Claim No.	Claimant	*‘Ili*	Land Use	Land Awarded
8241L	Mokunui	Kamalo, Kauhola	1 *mo‘o*, 1 *kula*, 1 house lot	1 *‘āpana*, 5 ac.
8241N	Ukeke	Maheu, Lelepua	1 *mo‘o*, 1 *kula*, 1 house lot, 2 *‘okipu*	2 *‘āpana*, 5.5 ac., 0.9 Ac.
8241Q	Kamakahi	Kuana, Waianeki	1 *mo‘o*, 1 *kula*, 1 house lot, 2 *‘okipu*	2 *‘āpana*, 2.2 ac., 0.3ac.
8241R	Meahale	Waiakapuaa	1 *mo‘o*, 1 *kula*, 1 house lot	1 *‘āpana*, 6.9 ac.
8241T	Kailio	Kaneulupoo	1 *mo‘o*, 1 *kula*, house lot, 1 *‘okipu*	1 *‘āpana*, 5.7 ac.
8241U	Kailihao	Kapoipuka	1 *mo‘o*, 1 *kula*, 1 house lot, 1 *‘okipu*	1 *‘āpana*, 3.8 ac.
8241V	Kauluoaiwi	Honowaka	1 *mo‘o*, 1 *kula*, house lot, 1 *‘okipu*	2 *‘āpana*, 0.3 ac., 5.5 ac.
8241W	Kaneakauhi	Kaohai	1 *mo‘o*, 1 *kula*, 1 house lot, 1 *‘okipu*	1 *‘āpana*, 8.2 ac.
8241X	Halelaau	Kopilau	1 *mo‘o*, 1 *kula*, 1 house lot, 1 *‘okipu*	1 *‘āpana*, 3.7 ac.
8241Y	Hepa	Kīpapa	1 *mo‘o*, 1 *kula*, 1 house lot, 4 *‘okipu*	1 *‘āpana*, 12.3 ac.
8241Z	Kaioe	Puulu	1 *mo‘o*, 1 *kula*, 1 house lot	1 *‘āpana*, 18.7 ac.
8241AB	Palekaluhi	Kamuku	1 *mo‘o*, 1 *kula*, 1 house lot	1 *‘āpana*, 6.4 ac.
8241CC	Poupou	Papa	1 *mo‘o*, 1 *kula*, 1 house lot	1 *‘āpana*, 14.4 ac.
8241UU	Kalaiku	Lelepua	1 *mo‘o*, 1 *kula*, 1 house lot, 1 *‘okipu*	1 *‘āpana*, 13.2 ac.

3.2.5 1900s

In 1901, the U.S. Congress formally ratified the annexation of the Territory of Hawai‘i, and the first 1,356 acres of Pearl Harbor land were transferred to U.S. ownership. The U.S. Navy began a preliminary dredging program, which created a 30-foot deep entrance channel measuring 200 feet wide and 3,085 feet long. In 1908, money was appropriated for five miles of entrance channel dredged to an additional 35 feet down (Downes 1953). In 1909, the government appropriated the Waipi‘o peninsula from the ‘Ī‘ī estate. The land was valued at $10,000 for purposes of fair compensation (Dept. of Land and Natural Resources Land Record Books 1909:228-235).

By the early decades of the 20th century, rice farming in Waipi‘o, and throughout the Hawaiian Islands, was in decline, beset by crop diseases and cheaper prices for rice from the Mainland. Sugar dominated commercial agriculture, particularly due to the founding and development of the Oahu Sugar Company. A significant problem for the expanding Oahu Sugar Company was difficulty obtaining sufficient water to cultivate sugar.

In 1913, the Waiahole Water Company, a subsidiary of the Oahu Sugar Company, began a project to transport irrigation water from the well-watered windward side of O‘ahu, through the Ko‘olau Range, to the fields and mill of the Oahu Sugar company in ‘Ewa. The water system, named the Waiahole Ditch System, was declared “an engineering feat of epic proportion for those times” (Conde and Best 1973:37). The original system, when completed, collected water from stream intakes and water tunnels from Kahana Valley in the north to Waiāhole Valley in the south. The main tunnel was through Waiāhole Valley to Waiawa, and water was then transported by ditch westward to Honouliuli, covering approximately 22 miles (Conde and Best 1973:37). The ditch system was completed in 1916 and, with some modifications, remains in use today.

In the early 1900s, lands in the *mauka* portions of Waipi‘o Ahupua‘a were also being acquired for commercial pineapple cultivation. A 1908 lease from the John ‘Ī‘ī Estate, Ltd. to Yoshisuke Tanimoto and Kintaro Izumi led to the formation of the Waipi‘o Pineapple Company, which cleared and cultivated approximately 223 acres in portions of Kīpapa Gulch. In 1915, Libby, McNeill & Libby took over Waipio Pineapple Company’s leases and continued to cultivate pineapple in the area. By the late 1920s, James Dole’s Hawaiian Pineapple Company, incorporated in 1901, was cultivating pineapple on thousands of acres leased from the ‘Ī‘ī estate in the *mauka* lands of Waipi‘o.

The 1919 War Department map (Figure 11) shows the extensive network of unpaved roads, railroad lines, and irrigation infrastructure attributable to commercial pineapple and sugar cane cultivation in the *mauka* area of Waipi‘o. Plantation camps to house the immigrant labor force and spur line of the O. R. & L. railway leading to a pineapple cannery are shown in the general vicinity of the project area. A plantation railroad line, as well as a network of unpaved roads are shown within Kīpapa Gulch, crossing through portions of the project area, indicating agricultural cultivation of the gulch lands, in addition to the extensive cultivation of the adjacent tablelands. Also shown crossing through portions of the project area are Kamehameha Highway and the Waiahole Ditch.

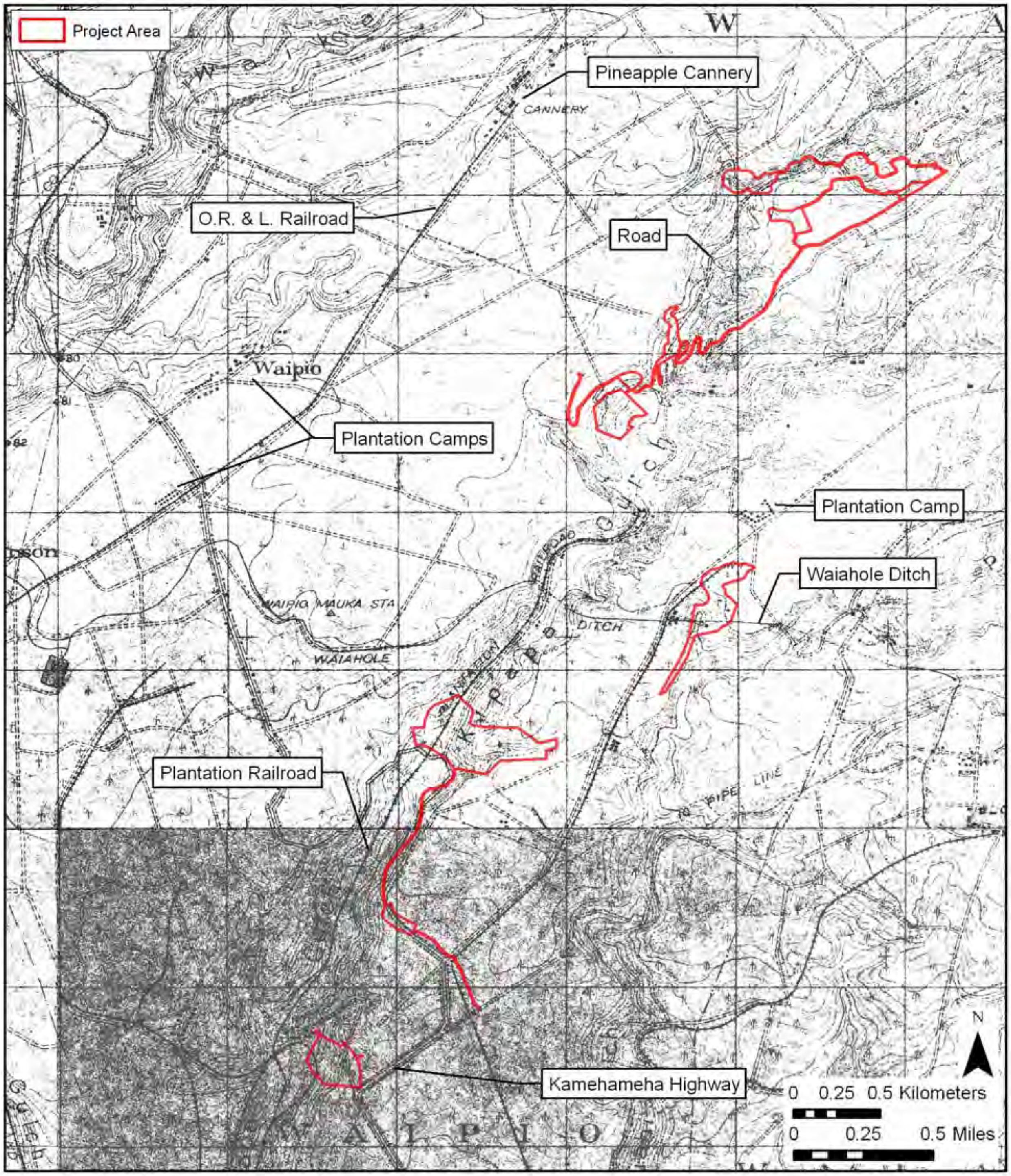

Figure 11. 1919 War Department Fire Control Map, Wahiawā and Pearl Harbor Quadrangles, showing the location of the project area and features discussed in the text

A map of the Oahu Sugar Co. lands (Figure 12) shows the extent of sugar cane cultivation in the vicinity of the project area ca. 1925. Lands cultivated in sugar cane are generally restricted to areas *makai* of the Waiahole Ditch, with areas *mauka* of the ditch understood to have been under pineapple cultivation. The map indicates the southern portions of the project area, within Kīpapa Gulch, are planted in sugar cane.

In the 1920s, the Oahu Sugar Co. continued to make improvements to the railroad lines and fields throughout the plantation, including within Kīpapa Gulch. In 1920, the plantation imported “45-pound rails to replace lighter rail throughout the road” (Conde and Best 1973:314). In 1926:

> A fill containing 48,000 cubic yards of material was built in the Kīpapa Gulch, with large culverts, for Kīpapa Stream and a tunnel for the Hano Branch of the O‘ahu Railway and Land Co…The Kīpapa Stream bed was straightened and improved, thus eliminating several small railroad bridges…[Conde and Best 1973:314]

Additional improvements were made within Kīpapa Gulch in 1928:

> New stream beds were dug and fills were put in to replace bridges at three points in Kipapa Gulch. As a result of this work 12.5 acres of cane land were added to the fields in Kipapa Gulch. Eight wooden bridges were replaced with fills. [Conde and Best 1973:315]

The O‘ahu Sugar Company’s infrastructure for transporting cane from the fields to the mill was described in 1931 as:

> All cane is delivered to the factory via the 36” gauge plantation railroad that is 55.55 miles in length…
>
> The rolling stock consists of 984 cars total and eight locomotives…
>
> Additional cane handling facilities are one mile of permanent flume, 4 miles of temporary flume, and about 10 miles of 16-pound and 20-pound rail portable track.
>
> Some 6% of the total crop is handled by flume, from inaccessible upper level fields; the cane being flumed into cars at loading stations in the field and cane flume water run into cars at the loading stations is run onto the growing cane after serving as a carrier…
>
> The railroad track system extends to each field. The locomotives deliver empty cars to the main line switch from mules and tractors haul the cars over the portable tracks to loading positions and then reassemble the loaded cars into trains on the main line. [Conde and Best 1973:315]

The 1928 U.S. Geological Survey (USGS) topographic map (Figure 13) continues to show the extensive network of plantation infrastructure throughout the *mauka* lands of Waipi‘o. Plantation camps, railroad lines, roads, and irrigation infrastructure are indicated throughout the area, including both the tablelands and Kīpapa Gulch.

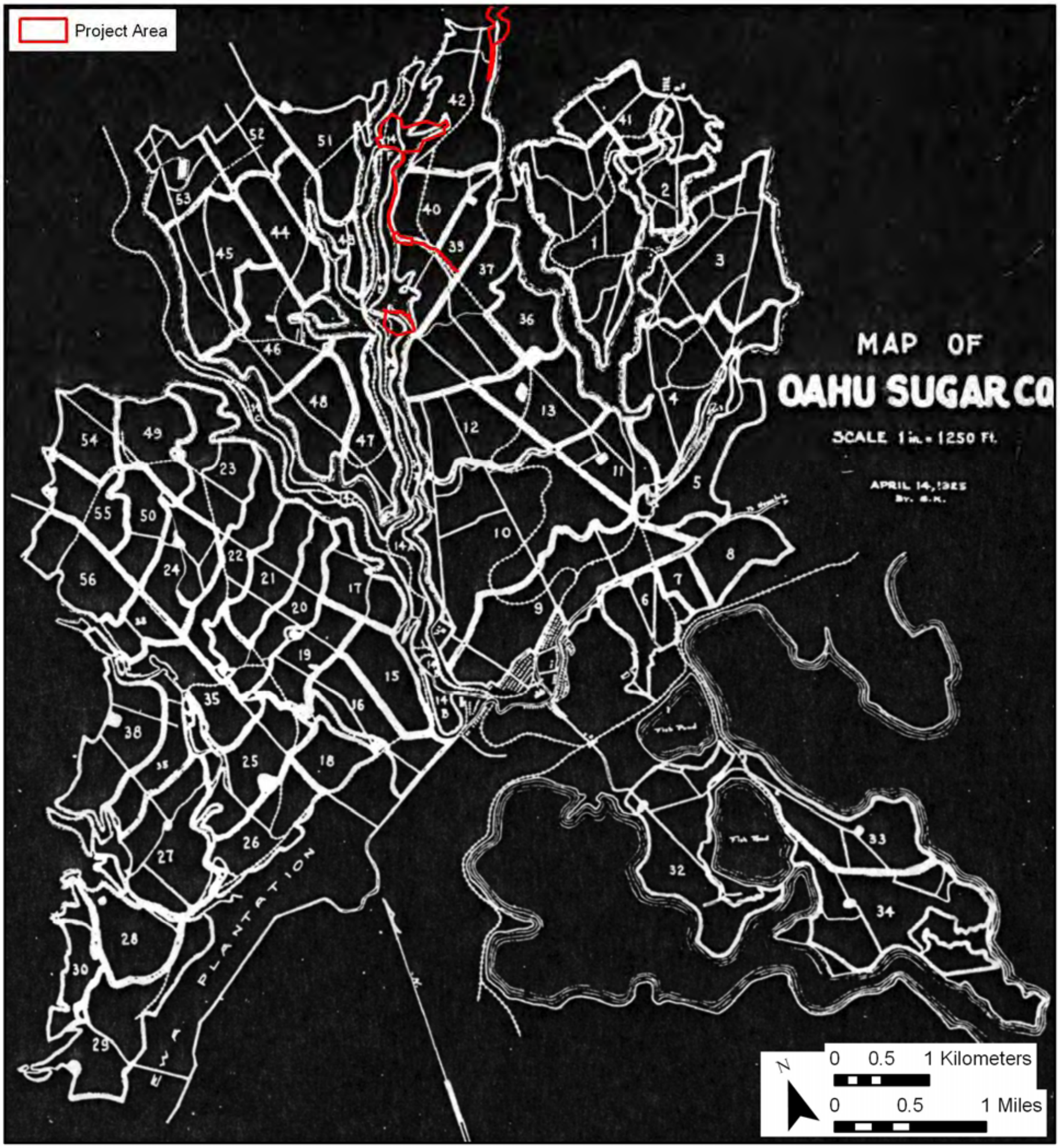

Figure 12. Map of Oahu Sugar Company cane fields ca. 1925 (source: Conde and Best 1973:316), in relation to the southern portions of the project area

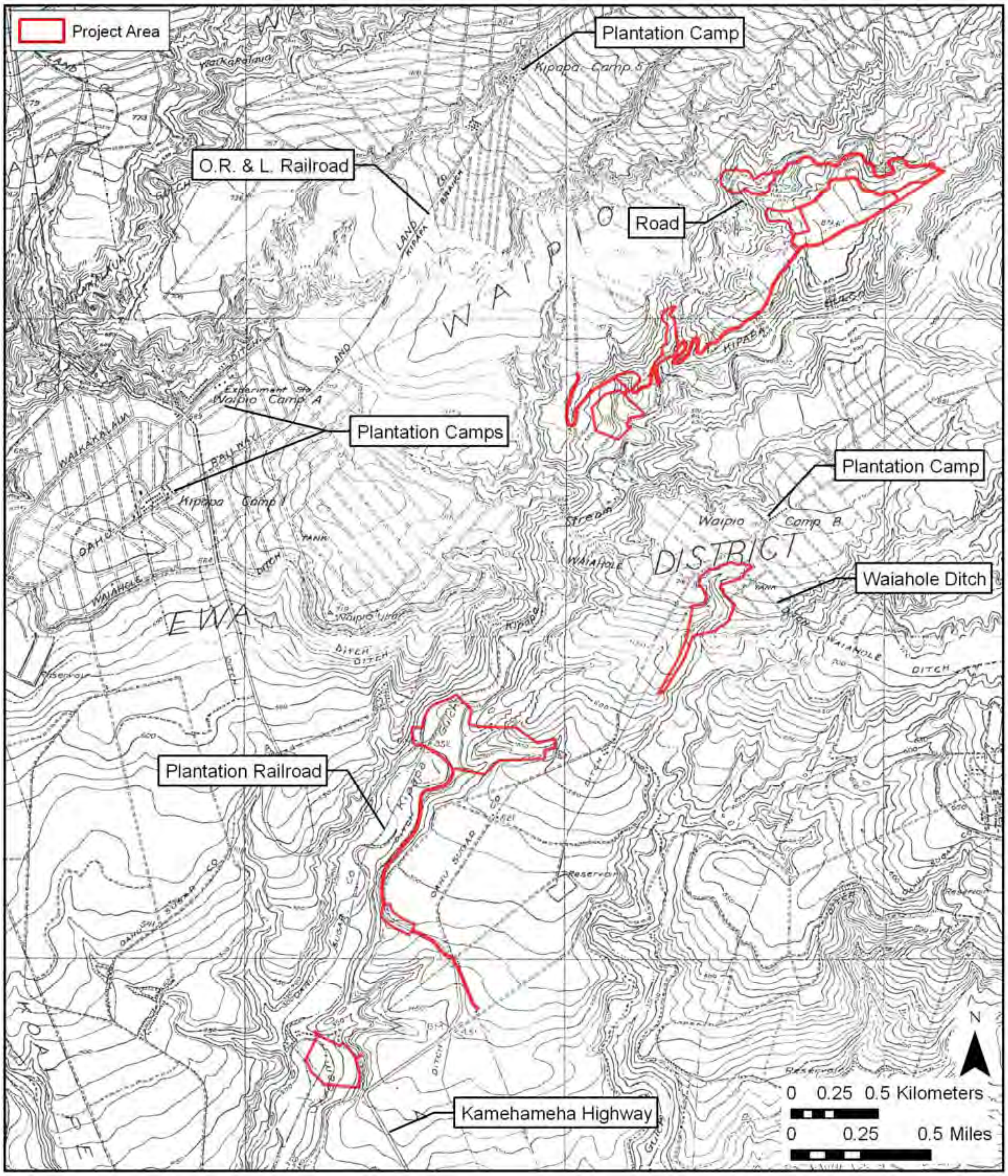

Figure 13. 1928 U.S. Geological Survey Topographic Map, Waipahu and Wahiawa Quadrangles, showing the location of the project area and features discussed in the text

In the early 1930s, improvements were made to Kamehameha Highway's crossing of Kīpapa Gulch, with the completion of the Roosevelt Bridge in 1934. Again, the excavated material was used by Oahu Sugar Co. as fill for improvements within Kīpapa Gulch. Hosaka (1937) conducted an ecological study of Kīpapa Gulch, documenting agricultural cultivation zones. Hosaka noted: "the lower third of this agricultural land is planted in sugar cane and the upper two thirds is cultivated in pineapple and truck crops" (Hosaka 1937:178). Figure 14 indicates the agricultural zones described by Hosaka (1937:176). Based on the data produced by Hosaka, the southern portions of the project area, *makai* of the Waiahole Ditch, were planted in sugar cane, and the northern portions of the project area were planted in pineapple.

During the 1930s, the U.S. military use of Waipiʻo lands extended well *mauka* of the peninsula at Pearl Harbor. The military began the appropriation of portions of Kīpapa Gulch ca. 1938. By 1941, Pacific Naval Air Bases expenditures for new construction at Pearl Harbor were in the hundreds of millions of dollars. The Japanese attack on Pearl Harbor, December 7, 1941, damaged or destroyed much of the new construction. Reconstruction was instituted to double Pearl Harbor's war capacity. Military planners approved a new ammunition depot in the mountainside of Waipahu, a large new hospital in ʻAiea, and thousands of additional changes to the Navy Yard to accommodate the new aircraft carrier task forces (Woodbury 1946).

The 1943 War Department Topographic Map (Figure 15) continues to indicate the extensive network of plantation infrastructure in the *mauka* areas of Waipiʻo. The map also shows the realignment of Kamehameha Highway, as well as an airfield constructed west of Kīpapa Gulch. Kīpapa Airfield was constructed by the U.S. military shortly after the U.S. entered World War II, for use by the Navy for training of carrier-based aircraft squadrons (Trojan n.d.). During World War II, the military also used the plantation railroad system to "haul large quantities of ammunition" to and from storage sites in Kīpapa and Waikele gulches (Condé and Best 1973:315). The 1956 Army Map Service Topographic Map (Figure 16) shows two military reservations within Kīpapa Gulch, the Upper and Lower Kīpapa Ammunition Storage Sites, including portions of the project area. Approximately 80 tunnels were constructed within the gulch walls, including 52 in Upper Kīpapa and 28 in Lower Kīpapa. Much of the excavated material was used to create a ledge along the base of the nearly vertical gulch walls where access roads were constructed. The storage tunnels and related infrastructure of the Upper and Lower Kīpapa Ammunition Storage Sites are detailed in Figure 17 and Figure 18.

Following the acquisition of Kīpapa Gulch lands by the U.S. military, the plantation sugar cane and pineapple fields within the gulch were abandoned. The remaining lands not under control of the military were subsequently leased to small farmers for truck farming. The plantation railroad system was also abandoned and replaced by roads. The tablelands of the *mauka* portion of Waipiʻo continued to be under cultivation by pineapple and sugar plantations through the 1950s. The 1956 Army Map Service Topographic Map (Figure 16) continues to indicate extensive plantation-cultivated lands, as well as a plantation camp and Kīpapa School. Kīpapa Airfield is also indicated, though on a much reduced scale.

During the second half of the 20th century, growth in Waipiʻo Ahupuaʻa focused on the development of the master-planned community of Mililani. In 1964, the state Land Use Commission re-designated 705 acres of agricultural land in Waipiʻo for urban use. The first

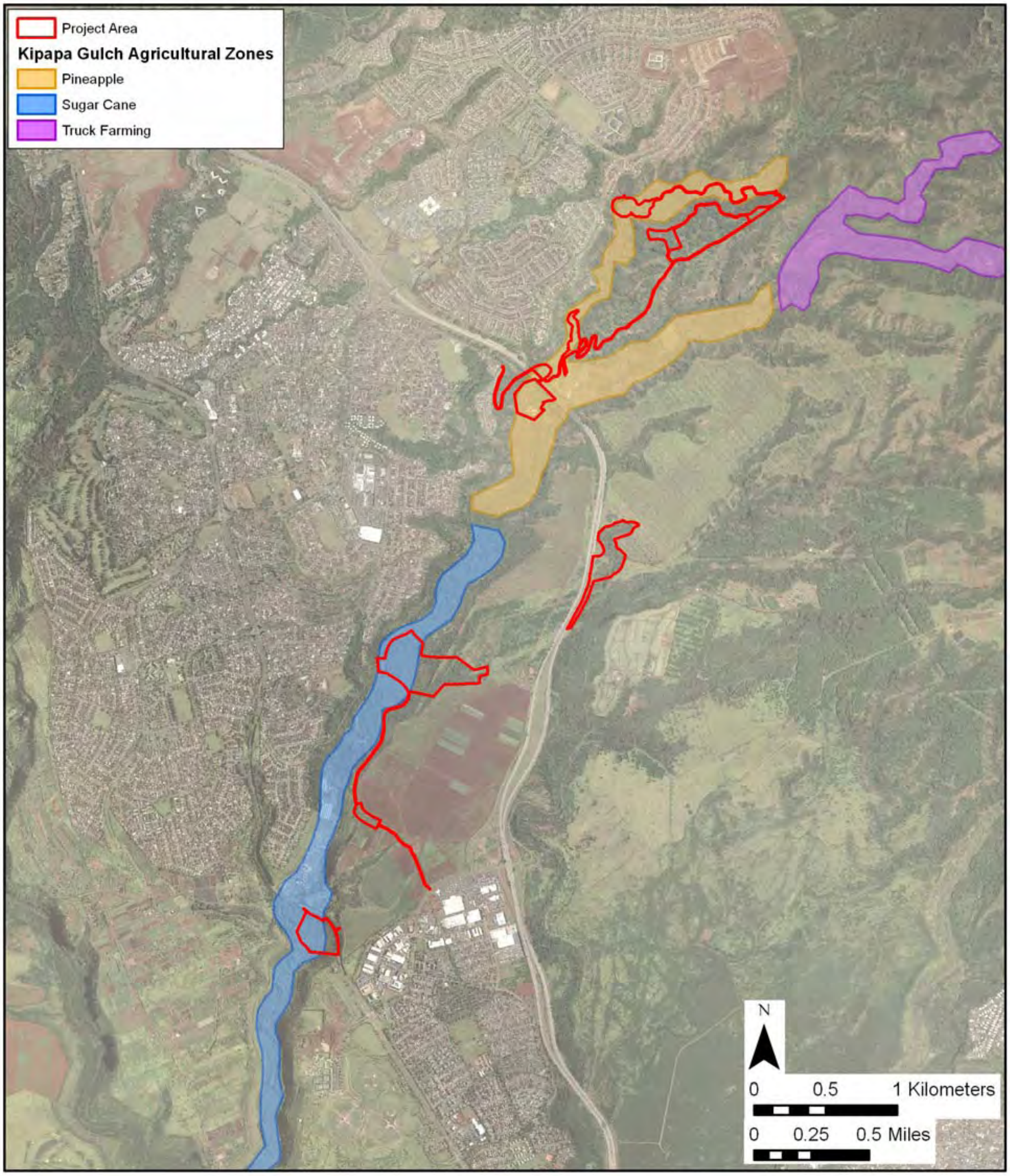

Figure 14. Aerial photograph (source: U.S.G.S. Orthoimagery 2005) showing areas within Kīpapa Gulch cultivated in sugar cane, pineapple, and truck crops ca. early 1930s, based on botanical survey data from Hosaka (1937)

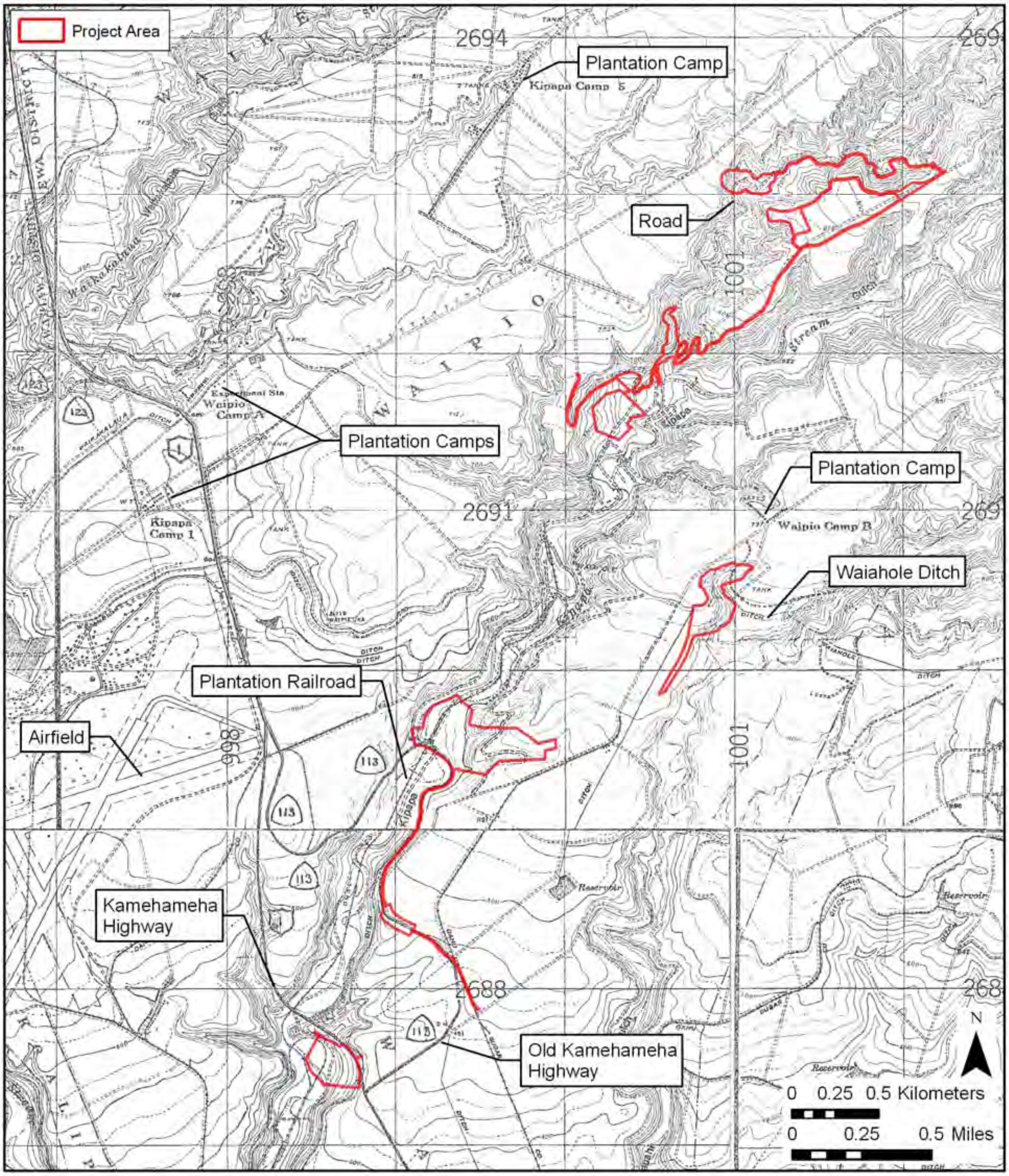

Figure 15. 1943 War Department Topographic Map, Waipahu and Wahiawa Quadrangles, showing the location of the project area and features discussed in the text

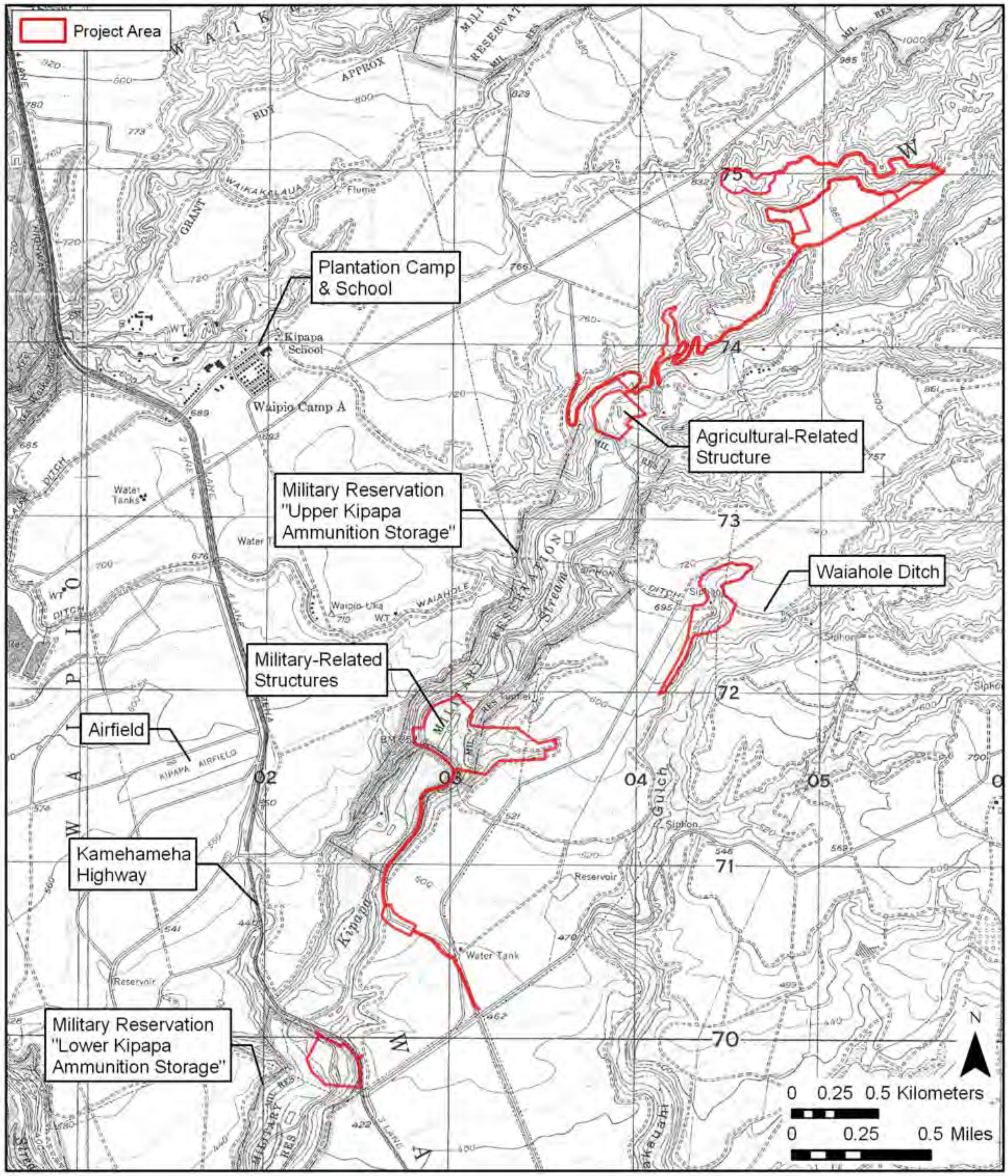

Figure 16. 1956 Army Map Service Topographic Map, Waipahu and Schofield Barracks Quadrangles, showing the location of the project area and features discussed in the text

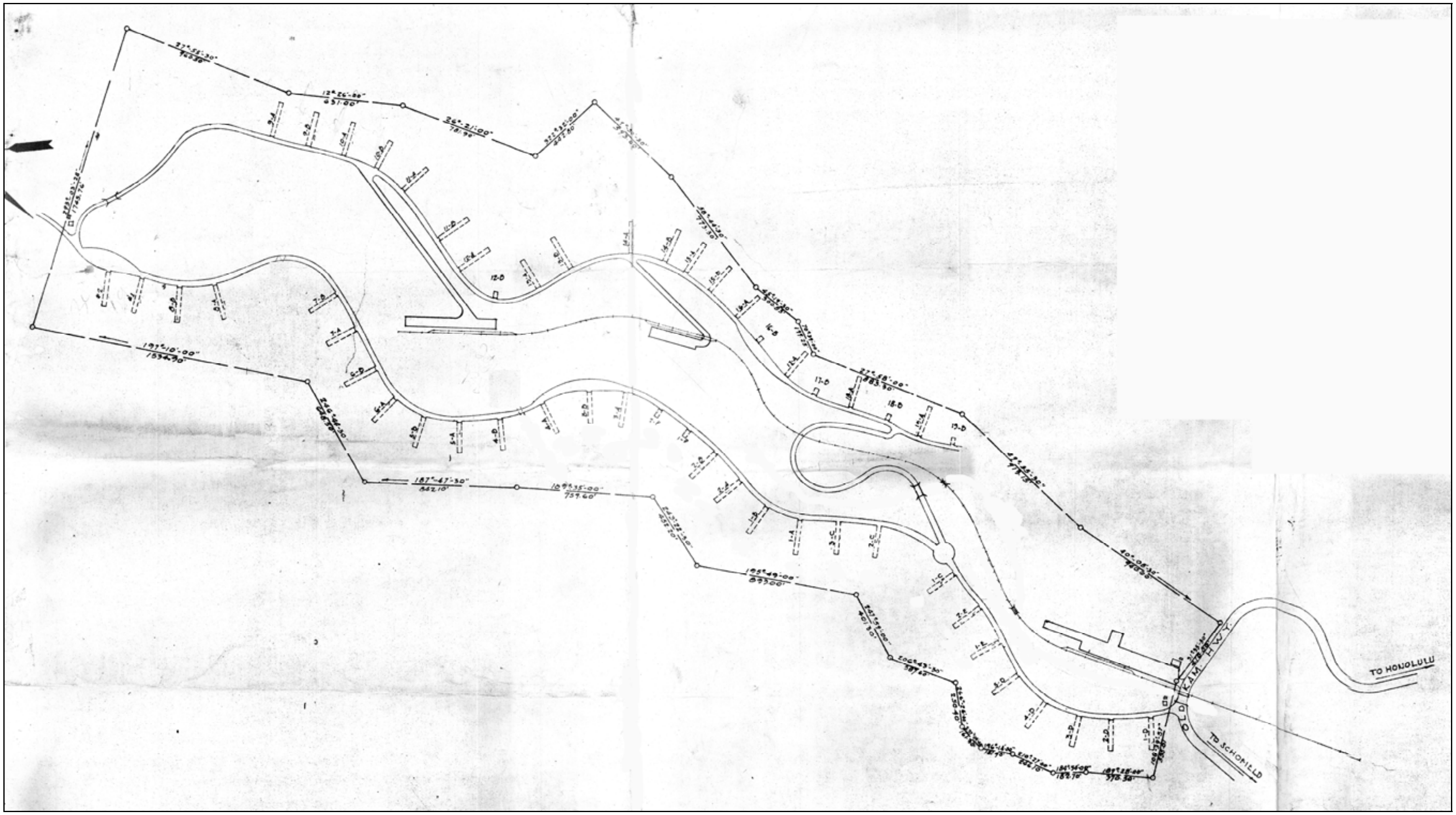

Figure 17. U.S. Army map ca. 1950s of the Upper Kīpapa Ammunition Storage Site, showing storage tunnels and infrastructure within Kīpapa Gulch

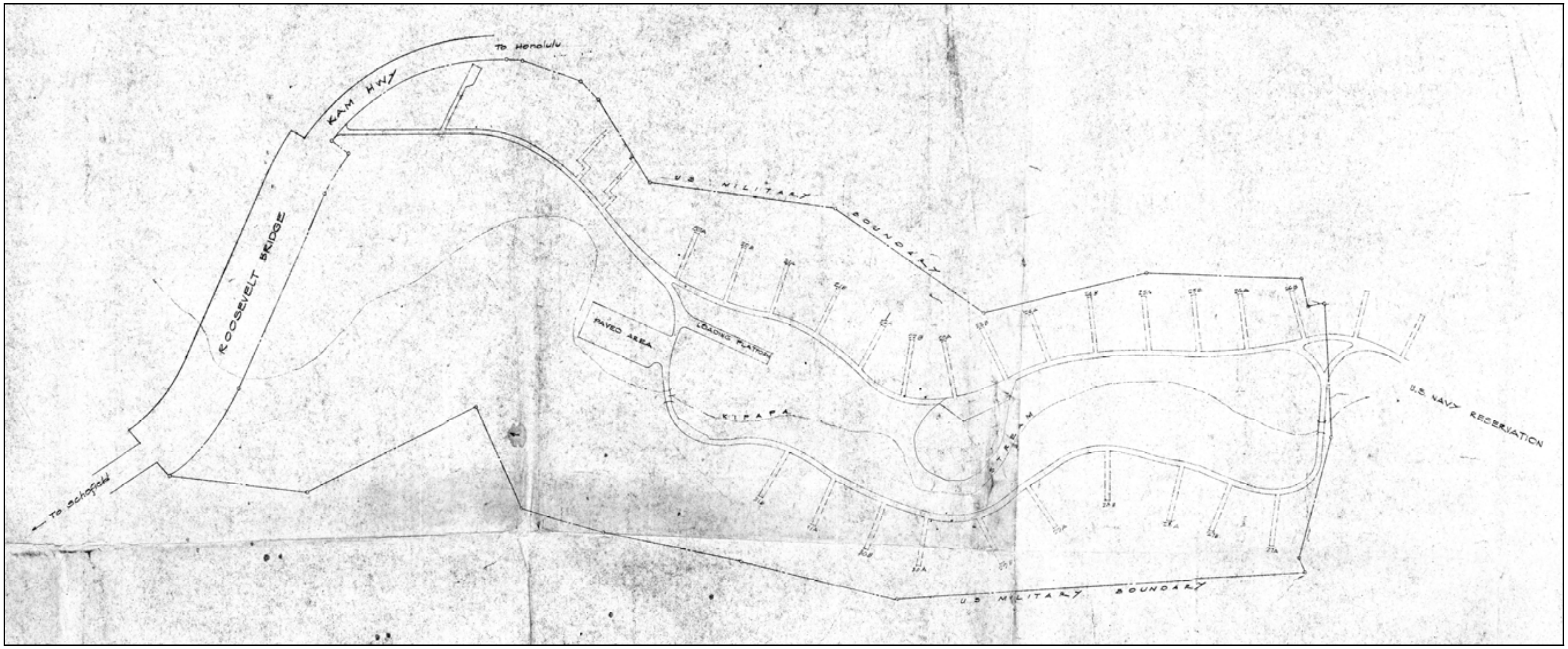

Figure 18. U.S. Army map ca. 1950s of the Lower Kīpapa Ammunition Storage Site, showing storage tunnels and infrastructure within Kīpapa Gulch

section of Mililani Town opened in June 1968. In 1973, construction began on the H-2 freeway across Waipiʻo, connecting Mililani to the H-1 freeway. The 1977 U.S. Geological Survey aerial photograph (Figure 19) shows the H-2 Freeway and the growing town of Mililani in the vicinity of the project area. Through the late 20th century and into the early 21st century, agricultural lands in Waipiʻo continued to be incrementally replaced by residential and commercial development. Much of the Kīpapa Gulch lands remained under control of the U.S. military. Kīpapa Gulch lands outside of the military reservations lands that were suitable for agriculture were leased to individuals for small-scale farming operations.

3.3 Previous Archaeological Research

Previous archaeological studies in the vicinity of the current project area are presented in Table 2 and shown in Figure 20. The following is a summary of these archaeological studies:

The earliest archaeological documentation in the *mauka* portions of Waipiʻo Ahupuaʻa was conducted by J. Gilbert McAllister in the 1930s. McAllister identified two sites in the vicinity of the project area: Site 130 (Moaula Heiau) and Site 131 (Heiau o Umi) (Figure 20). Both sites were indicated to have been destroyed prior to McAllister's study. The following descriptions were provided:

> Site 130 (Destroyed). Moaula heiau, on the Honolulu side of Kipapa Gulch just above Heiau o Umi, to which it is said to be a companion structure. The site is now covered in cane.
>
> Site 131 (Destroyed). Heiau o Umi, was just northeast of the government road in the bottom of Kipapa Gulch on the slight elevation at the foot of the pali on the Honolulu side. The level elevation can still be seen, though planted in cane. [McAllister 1933 in Sterling & Summers 1978: 20]

In 1977, the Bishop Museum Department of Anthropology conducted an archaeological inventory survey of portions of the Upper and Lower Kīpapa Ammunition Storage Sites within Kīpapa Gulch (Rosendahl 1977). The survey was part of a statewide project to locate, inventory, and evaluate archaeological resources located on lands owned or controlled by the U.S. Army. Five historic properties were listed in the Kīpapa Ammunition Storage sites. Three newly identified sites included: SIHP # 50-80-09-9529, a post-contact occupation complex; SIHP # 50-80-09-9530, a post-contact platform and terraces; and SIHP # 50-80-09-9534, a post-contact platform. Due to the broad nature of the study detailed, site descriptions and site locations were not provided. Rosendahl (1977) also listed the two *heiau* identified by McAllister (1933), SIHP #s 50-80-09-130 (Moaula Heiau) and 50-80-09-131 (Heiau o Umi), though both sites were noted to have been destroyed before 1930.

In 1986, the Bishop Museum Department of Anthropology conducted an archaeological survey of portions of the Waikele Branch of the Lualualei Naval Magazine, including 264 acres along the lower reaches of Kīpapa and Waikakalaua gulches (Rilford & Cleghorn 1986). Five historic properties were identified, all located within Waikakalaua Gulch: SIHP # 50-80-09-2919, a pre-contact temporary habitation, consisting of an overhang rock shelter with a stacked

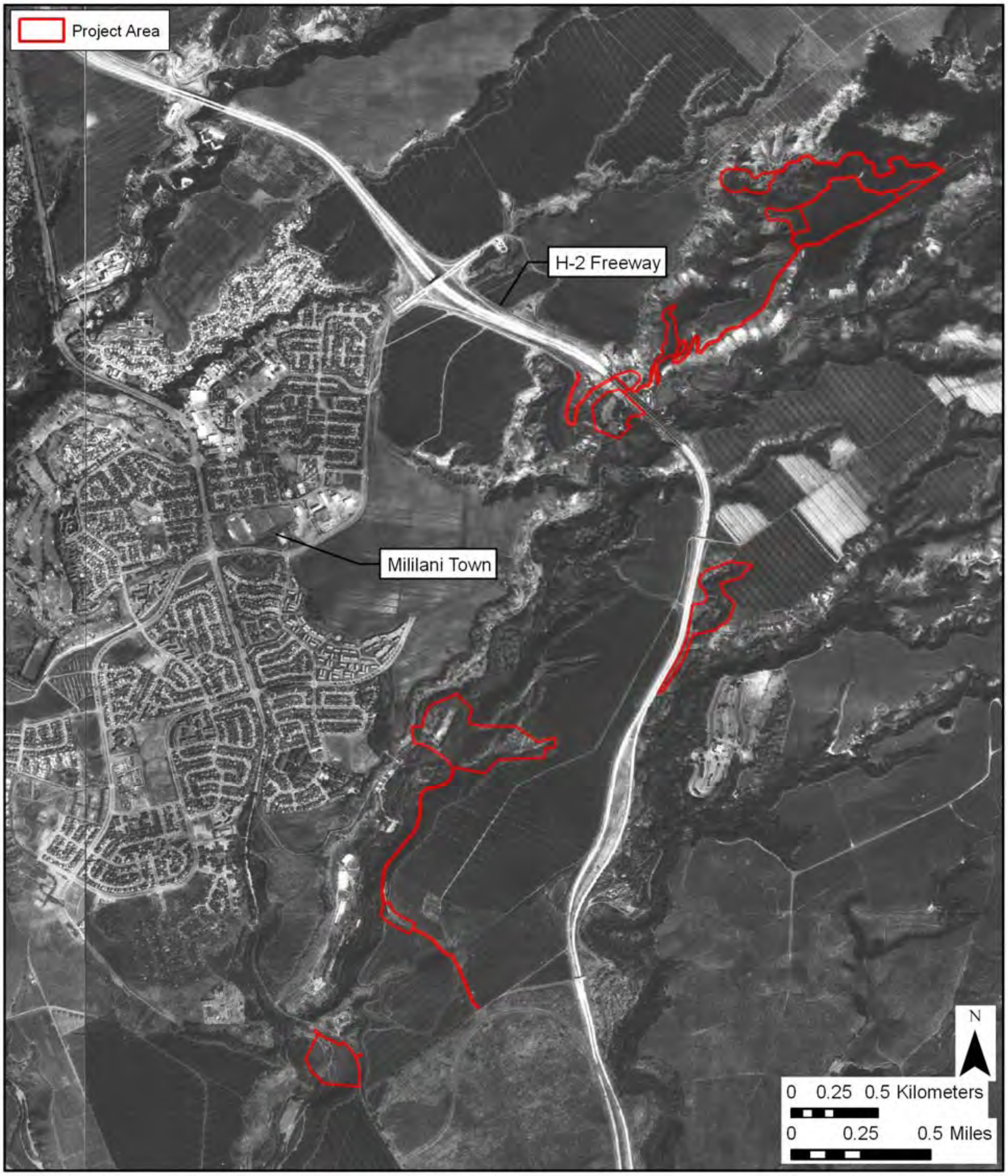

Figure 19. 1977 U.S. Geological Survey Orthophotograph, Waipahu and Schofield Barracks Quadrangles, showing the location of the project area and features discussed in the text

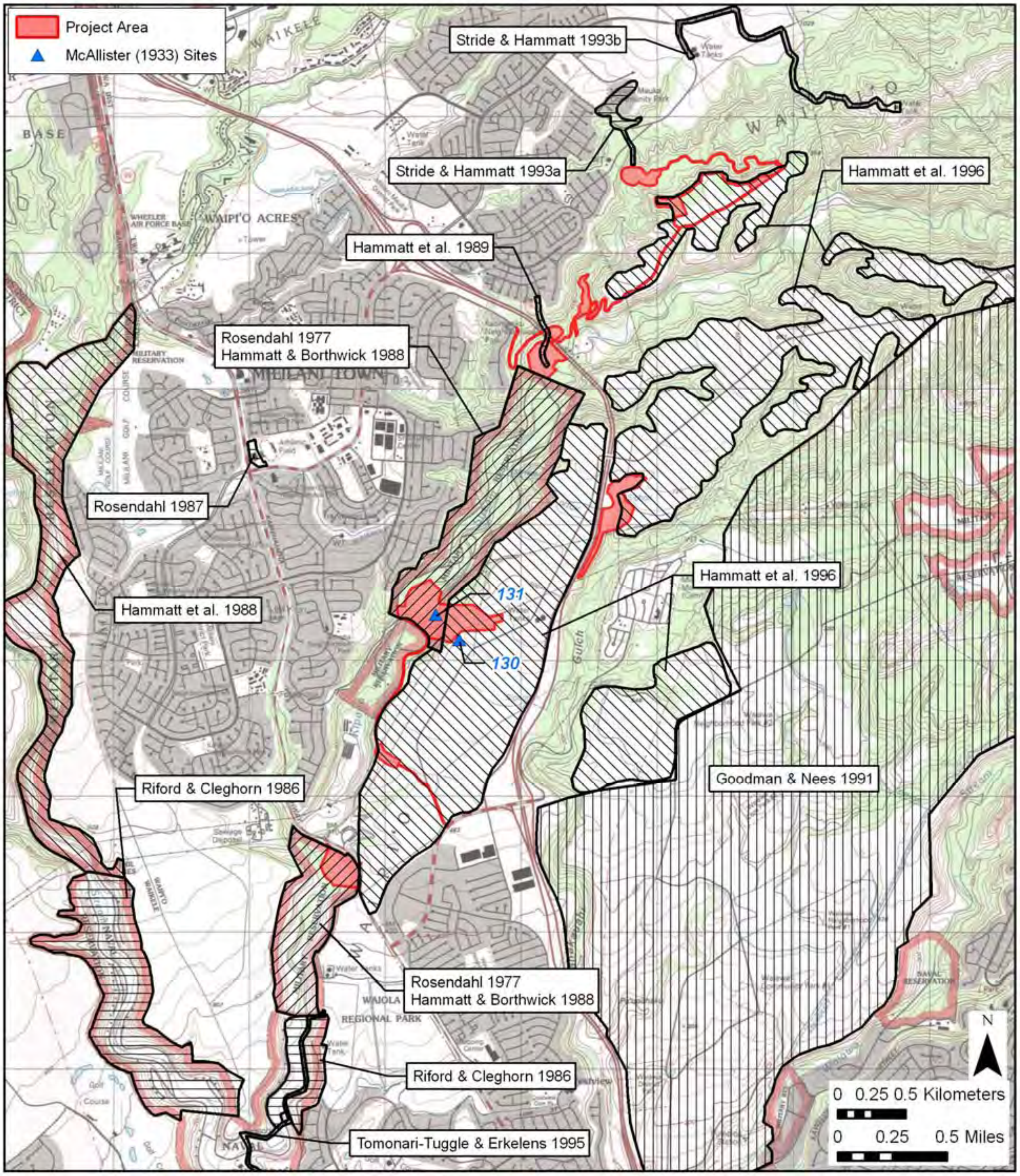

Figure 20. U.S. Geological Survey 7.5-Minute Series Topographic Map, Waipahu Quadrangle (1998), showing the locations of previous archaeological studies and McAllister (1933) sites in the vicinity of the project area

Table 2. Previous Archaeological Studies in the Vicinity of the Project Area

Reference	Location	Nature of Study	Results
McAllister 1933	Island of Oʻahu	Island-wide archaeological survey	Two historic properties identified: Site 130 (Moaula Heiau, destroyed) and Site 131 (Heiau o Umi, destroyed).
Rosendahl 1977	State of Hawaiʻi	State wide archaeological inventory survey of all U.S. Army lands	Five historic properties identified: SIHP #s 50-80-09-130 Moaula Heiau, destroyed; -131 Heiau o Umi, destroyed; -9529 post-contact occupation complex; -9530 post-contact platform & terraces; and, -9534 post-contact platform
Rilford & Cleghorn 1986	Lower portions of Kīpapa and Waikakalaua gulches	Archaeological survey	Five historic properties identified: SIHP #s 50-80-09-2919, pre-contact temporary habitation rock shelter; SIHP -2920, pre-contact temporary habitation caves; SIHP -2921, pre-contact temporary habitation cave; .SIHP -2922, post-contact basalt quarry; and SIHP -2923, a post-contact stacked stone wall
Rosendahl 1987	Mililani Town Station, TMK [1] 9-5-001: 054	Archaeological reconnaissance	No historic properties identified.
Hammatt & Borthwick 1988	Kīpapa Military Reservation	Archaeological reconnaissance & subsurface testing	Three previously identified sites (Rosendahl 1977) were observed: SIHP #50-80-09-9529, a post-contact habitation (historic artifact scatter & cement building foundation); SIHP -9530, post-contact irrigation infrastructure; and SIHP -9534, a post-contact stone platform.
Hammatt et al. 1988	Waikakalaua Storage Tunnels Site	Archaeological reconnaissance	Two small post-contact terraces and a railroad berm observed.
Hammatt et al. 1989	Kīpapa Gulch	Archaeological reconnaissance	No historic properties identified.

Reference	Location	Nature of Study	Results
Goodman & Nees 1991	3600 acres bounded by H-1, H-2, and Waiawa Stream	Archaeological inventory survey	17 historic properties, among them are: a prehistoric rockshelter complex with petroglyphs, historic plantation infrastructure, a small cemetery, a road and railroad system, historic fire pits and trash dumps.
Stride & Hammatt 1993a	Kīpapa Gulch	Archaeological inventory survey	No historic properties identified.
Stride & Hammatt 1993b	Kīpapa Gulch	Archaeological inventory survey	No historic properties identified.
Tomonari-Tuggle & Erkelens 1995	NAVMAG – Waikele (Lower portion of Kīpapa Gulch)	Archaeological inventory survey	Two historic properties identified: SIHP #50-80-09-4935, a pre-contact rock shelter and adjacent cave containing indigenous Hawaiian artifacts [an oʻo (wooden digging stick) and an ulu maika (game stone)]; and SIHP -4936, a 20th century railroad bed.
Hammatt et al 1996	1339 acres in Waipiʻo and Waiawa just east of Mililani Town	Archaeological inventory survey	One historic property identified: SIHP #50-80-09-2268, a segment of Waiāhole Ditch

stone retaining wall at the entrance and *kukui* nut shells and marine shell midden observed scattered on the surface interior; SIHP # 50-80-09-2920, a pre-contact temporary habitation, consisting of three caves and a crawl space shelter; SIHP # 50-80-09-2921, a pre-contact temporary habitation, consisting of a cave and crawl space with water worn pebbles and *kukui* nut fragments observed on the surface; SIHP # 50-80-09-2922, a post-contact basalt quarry, consisting of an area of large boulders and outcrops with negative flake scars and an unfaced debitage mound constructed of loosely stacked basalt flakes; and SIHP # 50-80-09-2923, a post-contact stacked stone wall associated with an access road to a military ammunition storage area. Rilford & Cleghorn (1986) note that the numerous pre-contact temporary habitations identified along Waikakalaua Gulch, in conjunction with LCA documentation and historic maps, support the idea that Waikakalaua Gulch was a transportation corridor between the south coast and central and western Oʻahu.

In 1987, Paul H. Rosendahl, Ph.D., Inc. (PHRI) conducted an archaeological reconnaissance of Mililani Town Station, consisting of a 2.75-acre parcel in Mililani Town (Rosendahl 1987). Significant disturbance associated with modern construction was observed throughout the parcel. No historic properties were observed and no further archaeological work was recommended.

In 1988, CSH conducted an archaeological reconnaissance and subsurface testing of approximately 371 acres within the Upper and Lower Kīpapa Ammunition Storage Sites (Hammatt & Borthwick 1988). Three historic properties previously identified by Rosendahl (1977) were observed: SIHP # 50-80-09-9529, a post-contact habitation consisting of the remnants of a plantation laborers’ camp, including a historic artifact scatter and cement building foundation associated with the Waiahole Water Co. siphon construction; SIHP # 50-80-09-9530, post-contact irrigation infrastructure consisting of concrete slabs, mortared alignments, and a dressed stone lined ditch; and SIHP # 50-80-09-9534, a post-contact stone platform associated with Oahu Sugar Company operations (Hammatt and Borthwick 1988).

In 1988, CSH conducted an archaeological reconnaissance survey of the Waikakalaua Ammunition Storage Tunnels Site within Waikakalaua Gulch (Hammatt et al. 1988). Two small terraces associated with post-contact sugar cultivation and a railroad berm were observed, but were determined not archaeologically significant. No further archaeological work was recommended for the study area.

In 1989, CSH conducted an archaeological reconnaissance survey of a proposed drainage channel in Kīpapa Gulch (Hammatt et al. 1989). The drainage channel ran from the edge of the gulch near the H-2 Freeway overpass to Kīpapa Stream. No historic properties were identified.

In 1991, the Applied Research Group, Bishop Museum, conducted an archaeological reconnaissance and inventory survey of 3600 acres in Waiawa Ahupuaʻa (Goodman & Nees 1991). Seventeen historic properties were identified (SIHP 50-80-09-1469 to 1472 and 2261 to 2273). Four pre-contact sites were identified including: a rock-shelter complex, a mound complex, a trail, and a lithic scatter. The remaining 13 sites consisted of plantation and WWII military infrastructure. SIHP # 50-80-09-2268, a segment of the Waiahole Ditch, was also identified. Of particular interest to the current project is the discussion of the findings in gulch lands. Goodman and Nees (1991:115) note “ all of the gulches in Waiawa contain some evidence of sugar cane and pineapple tenure…” Historic modifications related to water control within the gulches included plantation irrigation systems and modifications to the stream channels to protect roads and associated plantation infrastructure from flooding and erosion. Roads along the bases of gulches were supported by boulder alignments, linear mounds, or retaining walls along the edges. Goodman and Nees also note that as the upper tablelands of the area were used almost exclusively for pineapple and sugar cane cultivation, the gulch lands were the locations of plantation camps and associated agricultural areas to support the plantation workers.

In 1993, CSH conducted an archaeological inventory survey of a proposed drainage channel in Kīpapa Gulch (Stride and Hammatt 1993a). The study area included portions of two tributary gulches of Kīpapa Gulch. No historic properties were identified.

In 1993, CSH conducted an archaeological inventory survey for a water line across a portion of Kīpapa Gulch (Stride and Hammatt 1993b). No historic properties were identified.

In 1995, International Archaeological Research Institute, Inc. conducted an inventory survey of a proposed 46kV sub-transmission line through NAVMAG – Waikele, within the lower portion of Kīpapa Gulch (Tomonari-Tuggle & Erkelens 1995). Two historic properties were identified: SIHP # 50-80-09-4935, a pre-contact rock shelter and adjacent cave containing indigenous Hawaiian artifacts; and SIHP # 50-80-09-4936, a 20th century railroad bed.

In 1996, CSH conducted an archaeological inventory survey of four discrete parcels in Waipiʻo and Waiawa covering a total area of 1,339 acres (Hammatt et al 1996). All four parcels, located on tablelands, were either in active pineapple cultivation or were lying fallow. One historic property was identified: SIHP #50-80-09-2268, a segment of Waiahole Ditch, consisting of a 3600 ft long concrete and mortar ditch running at an east-west direction through the middle of the study area. Also of note was an isolated adz fragment observed on the surface of a pineapple access road on the edge of a steeply sloping tributary of Kīpapa Gulch.

3.4 Background Summary and Predictive Model

3.4.1 Background summary

Background research indicated traditional Hawaiian settlement in Waipiʻo Ahupuaʻa was focused on the Pearl Harbor coast, where marine resources including fishponds, along with abundant stream water for wetland agricultural development, were readily available. The broad and flat bottomed Kīpapa Gulch also supported inland settlement, where Handy indicates agricultural terraces extended up Kīpapa Gulch over two miles upstream of Kīpapa and Waikele streams. The upper reaches of Kīpapa Gulch and its tributaries, along with the tablelands adjacent to the gulches, also provided forest resources for traditional gathering. A cluster of land commission awards are located within Kīpapa Gulch, in the vicinity of the H-2 Freeway crossing of the gulch, indicating a permanent settlement area. Kīpapa Gulch is also known as the locale of multiple battles between native chiefs and their forces.

Major land use changes occurred in the uplands of Waipiʻo with the development of commercial plantation agriculture. In general, all suitable lands, including the tablelands, gulch bottoms and gulch slopes, were cleared and utilized for pineapple and sugar cane cultivation. Infrastructure including irrigation systems, plantation camps, canneries, roads, and railroads were constructed throughout the plantation lands. Following World War II, the U.S. military acquired much of the lower portions of Kīpapa Gulch for use as ammunition and fuel storage areas to support the Navy at Pearl Harbor and Army at Schofield Barracks. Small-scale truck farming later replaced plantation agriculture in the upper reaches of Kīpapa Gulch.

3.4.2 Predictive Model

Prior to the extensive land alteration caused by decades of commercial plantation agricultural activities, portions of the project area would likely have contained cultural resources related to *kula* (dry land) gardening activities, wetland agricultural development, and habitation remnants. Traditional features may have included rock mounds or terraces, and temporary or permanent habitation structures such as platforms or C-shaped walls. Previous archaeological studies have also documented overhang shelters along the gulch slopes, and petroglyph sites. Land modification from decades of plantation agriculture is likely to have removed much of the evidence of traditional land uses. Remnants of historic plantation infrastructure are likely to exist within the current project area. Features may include irrigation ditches and flumes, terraces, road and railroad networks, and other plantation-related structures. Military-related structures are also likely to exist in portions of the project area. Features may include storage tunnels, roads, and building remnants.

Section 4 Results of Fieldwork

4.1 Survey Findings

The project area includes discreet sections, comprised of proposed drainage basins, drain lines, access roads, construction staging areas, and an H-2 Freeway interchange. For descriptive purposes, the findings of the archaeological inventory survey (Table 3) are discussed in five sections, including: 1) Detention Basin 2 (DB2) project area (Figure 21 and Figure 22); 2) Detention Basin 1 (DB1) and Detention Basin 3 (DB3) project areas (Figure 23 and Figure 24); 3) H-2 Freeway Interchange project area (Figure 25 and Figure 26); 4) Detention Basin 4 (DB4) project area (Figure 27 and Figure 28); and 5) Drain Line 1 (DL1) project area (Figure 29 and Figure 30).

As previously discussed, portions of the project area were covered by an archaeological inventory survey conducted for the planned Koa Ridge Development Project (Hammatt et al. 1996). The areas covered by the Hammatt et al. (1996) study are indicated on the above referenced site location maps. Hammatt et al. (1996) did not document any cultural resources in the current project area. The portions of the current project area covered by the Hammatt et al. (1996) study were subjected to brief field inspections during the current inventory survey investigation. The areas, generally consisting of level tablelands, were confirmed to be former pineapple fields lacking cultural resources.

Pedestrian inspection of the remaining portions of the project area was completed at 100% coverage. Thirteen (13) cultural resources, comprised of sixty-two (62) archaeological features, were identified within the project area and immediate vicinity. Five cultural resources were identified in the Detention Basin 2 (DB2) and DB2 access road project areas. SIHP # 50-80-09-7044 consists of a historic road and associated stream channel improvements. The road generally parallels the stream channel, running along the base of the tributary gulch of Kīpapa Gulch. Stream channel improvements include stone mounds, alignments, and walls that are situated along the banks of or immediately upslope of the stream channel. SIHP # 50-80-09-7045 consists of two plantation-era retaining walls located near the central portion of the Detention Basin 2 (DB2) Access Road project area. SIHP # 50-80-09-7046 is a platform, interpreted to be a plantation-era clearing feature, located near the eastern portion of the DB2 Access Road project area. SIHP # 50-80-09-7047 is an historic agricultural terrace complex located near the eastern portion of the DB2 Access Road project area. SIHP # 50-80-09-7048 is a stone-lined pit, interpreted to be a historic charcoal kiln, located within the southern portion of the DB2 project area.

Two cultural resources were identified in the Detention Basin 1 (DB1) and Detention Basin 3 (DB3) project areas. SIHP # 50-80-09-7049 is a complex of ten historic agricultural features, located within the Detention Basin 3 (DB3) portion of the project area. The features generally consist of large mounds and terraces, constructed at the base of the gulch and along the gulch slopes, interpreted to be related to plantation-era agricultural activities. SIHP # 50-80-09-7050 consists of a retaining wall and C-shaped wall, interpreted to be plantation-era agricultural features, located in the Detention Basin 1 (DB 1) project area.

Table 3. Cultural Resources Identified Within and in the Immediate Vicinity of the Project Area

SIHP # (50-80-09)	Site Type	Features	Probable Age	Function	Significance Criteria	Mitigation Recommendations
2268	Waiahole Ditch and Wall	2	Post-Contact	Agricultural (Irrigation)	A, C, D	Preservation
7044	Historic Road and Stream Channel Improvements	17	Post-Contact	Transportation, Agricultural Clearing and Water Control	D	NFW
7045	Retaining Walls	2	Post-Contact	Agricultural (Water Control and Field Improvements)	D	NFW
7046	Platform	1	Post-Contact	Agricultural (Clearing)	D	Preservation
7047	Terrace Complex, Charcoal Kiln	7	Post-Contact	Agricultural	D	Partial Preservation and/or Data Recovery
7048	Charcoal Kiln	1	Post-Contact	Agricultural	D	NFW
7049	Agricultural Complex	10	Post-Contact	Agricultural (Stream Channel Improvements, Clearing, and Erosion Control)	D	NFW
7050	Terrace and C-Shape	2	Post-Contact	Agricultural	D	NFW
7051	Terrace	1	Post-Contact	Agricultural (Erosion Control)	D	NFW
7052	Tunnel, Asphalt Pad, and Concrete Slab	3	Post-Contact	Storage and Building Foundation (Military)	A, D	NFW

SIHP # (50-80-09)	Site Type	Features	Probable Age	Function	Significance Criteria	Mitigation Recommendations
7053	Roadway Improvements (Old Kamehameha Highway)	3	Post-Contact	Transportation	A, D	Preservation
9530	Complex	7	Post Contact	Agriculture (Water Control) and Transportation	A, C, D	Preservation
9534	Complex	6	Post-Contact	Agricultural and Transportation	D	NFW

NFW = No Further Work

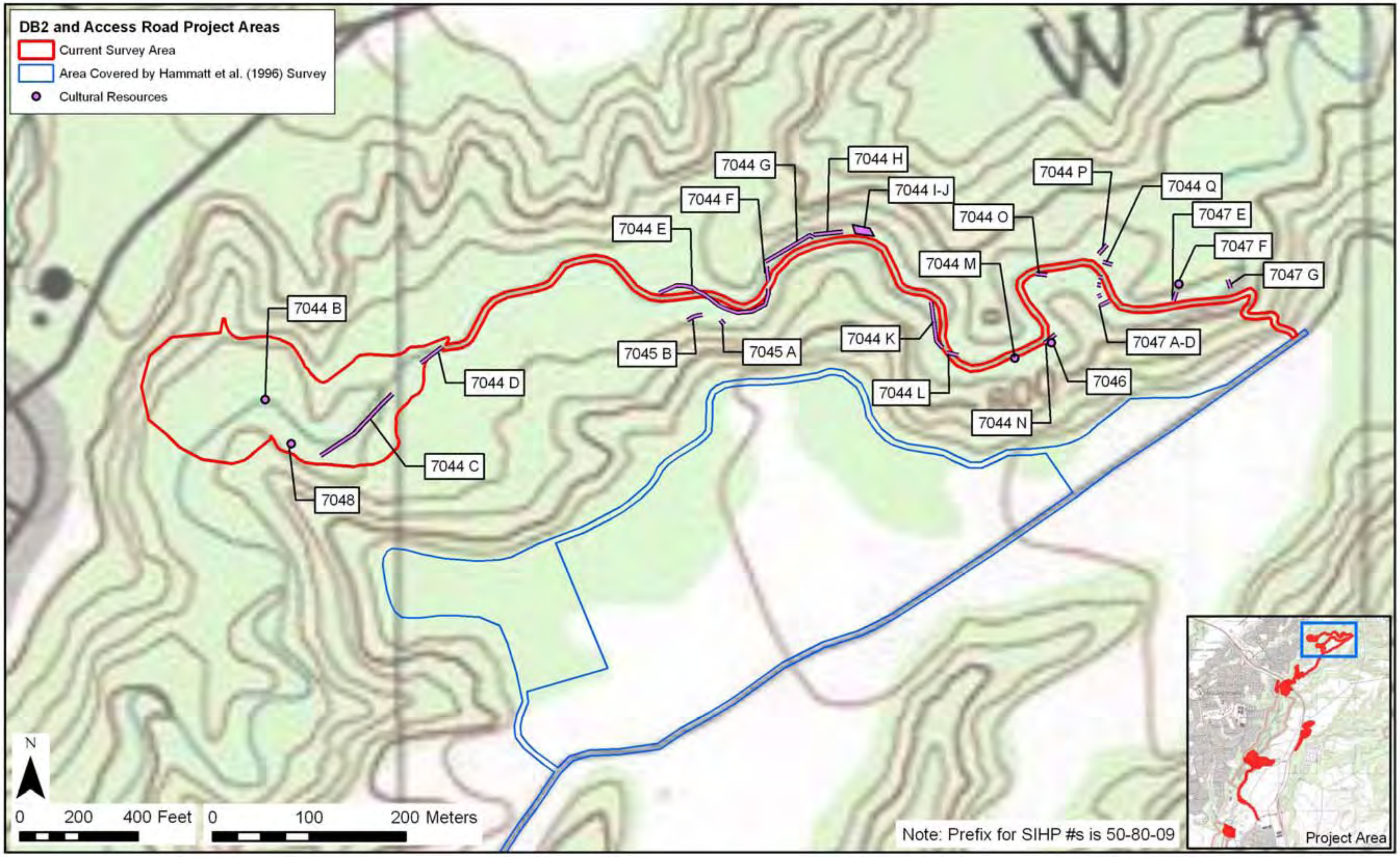

Figure 21. U.S. Geological Survey 7.5-Minute Series Topographic Map, Waipahu Quadrangle (1998), showing the locations of cultural resources in the Detention Basin 2 (DB2) and DB2 Access Road project areas

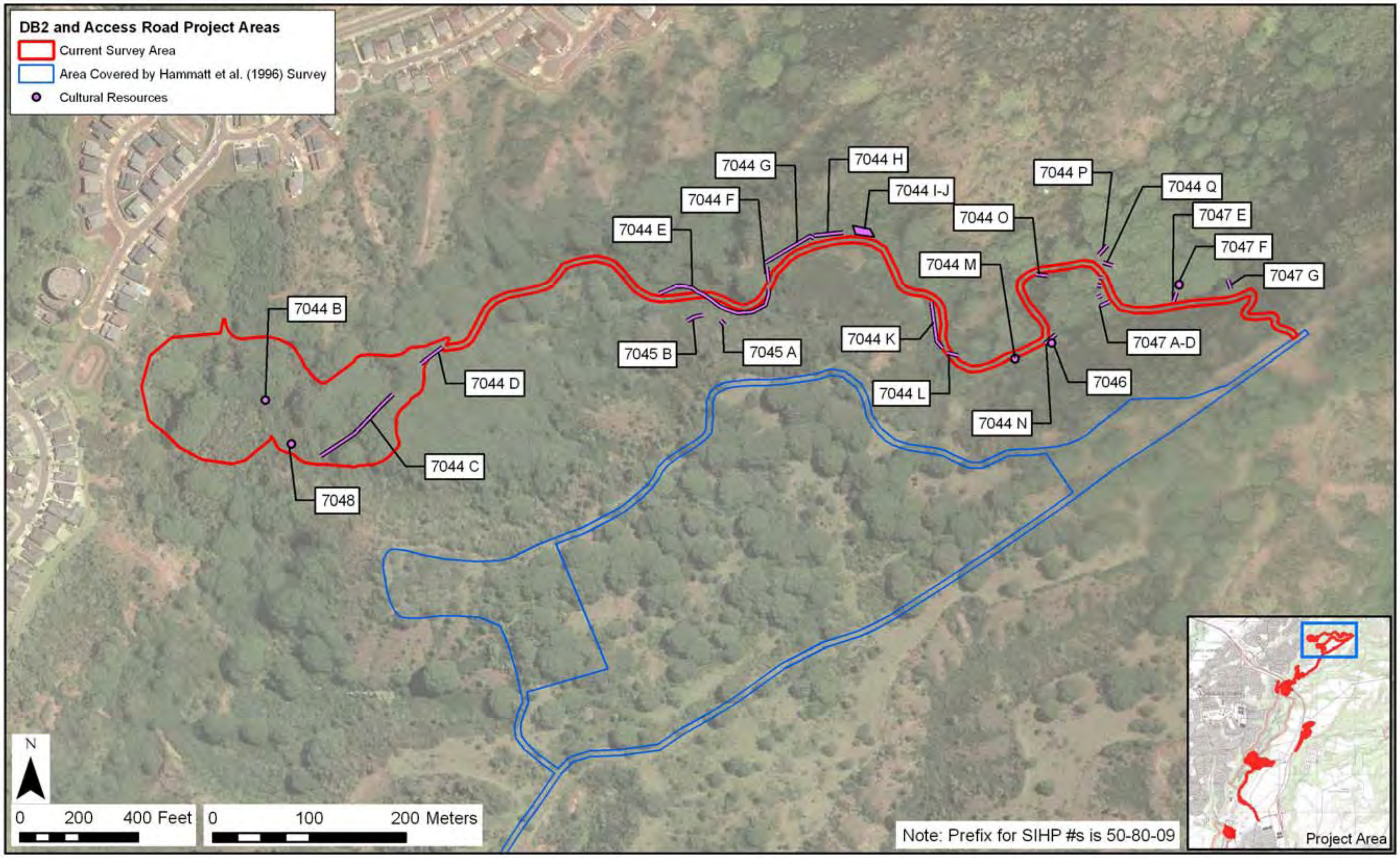

Figure 22. Aerial photograph (source: U.S. Geological Survey Orthoimagery 2005), showing the locations of cultural resources in the Detention Basin 2 (DB2) and DB2 Access Road project areas

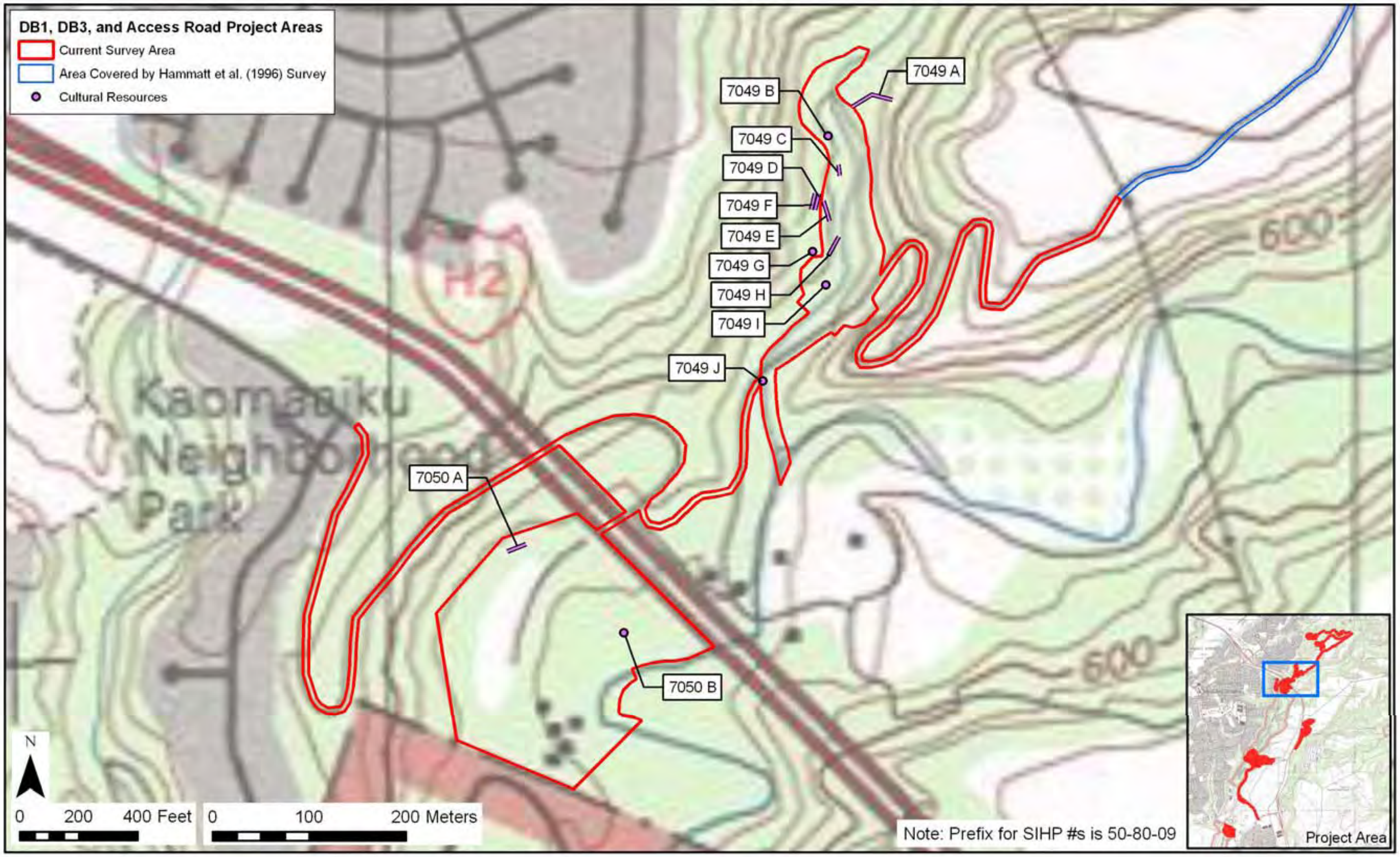

Figure 23. U.S. Geological Survey 7.5-Minute Series Topographic Map, Waipahu Quadrangle (1998), showing the locations of cultural resources in the Detention Basin 1 (DB1) and Detention Basin 3 (DB3) project areas

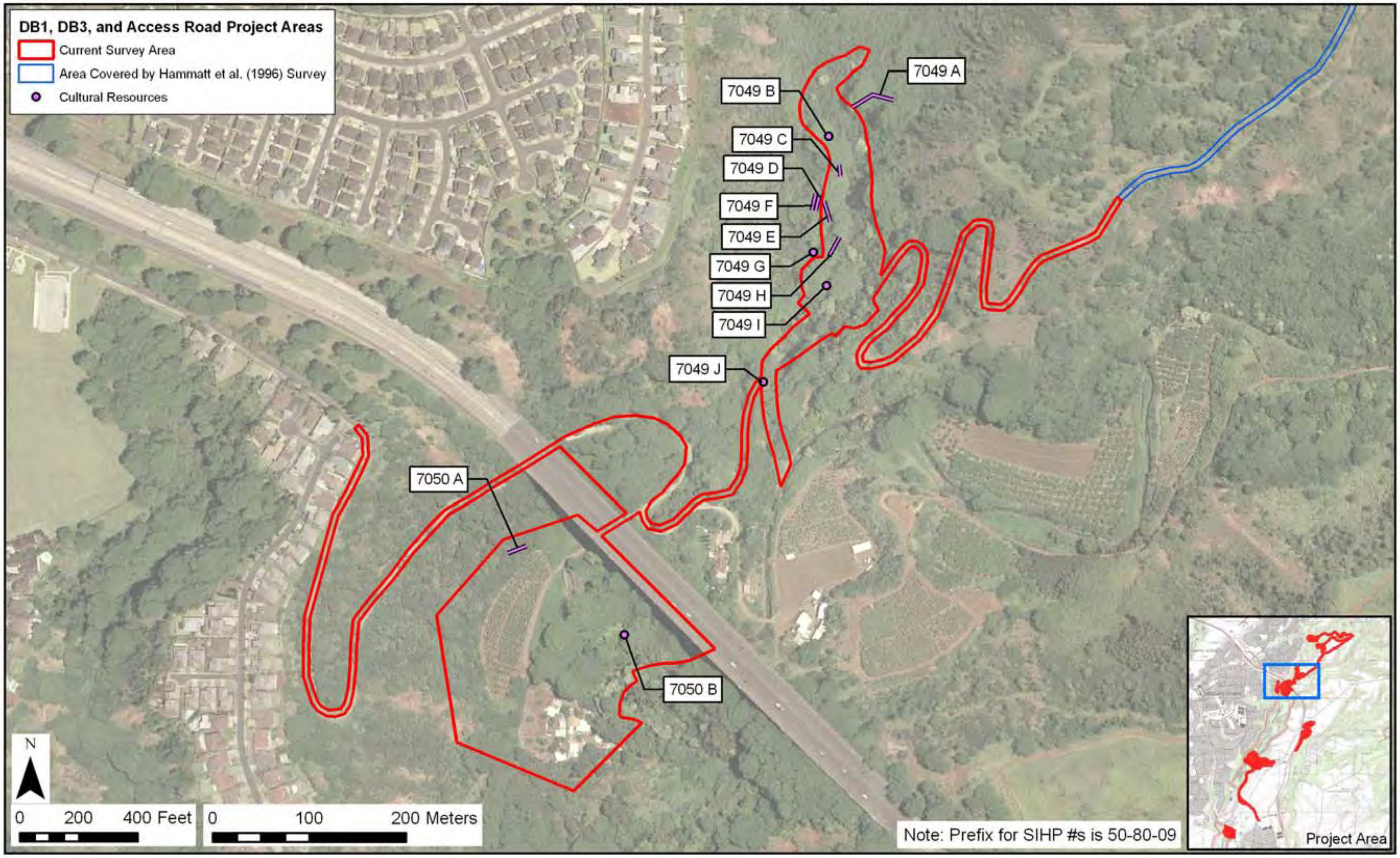

Figure 24. Aerial photograph (source: U.S. Geological Survey Orthoimagery 2005), showing the locations of cultural resources in the Detention Basin 1 (DB1) and Detention Basin (DB3) project areas

Figure 25. U.S. Geological Survey 7.5-Minute Series Topographic Map, Waipahu Quadrangle (1998), showing the locations of cultural resources in the H-2 Freeway Interchange project area

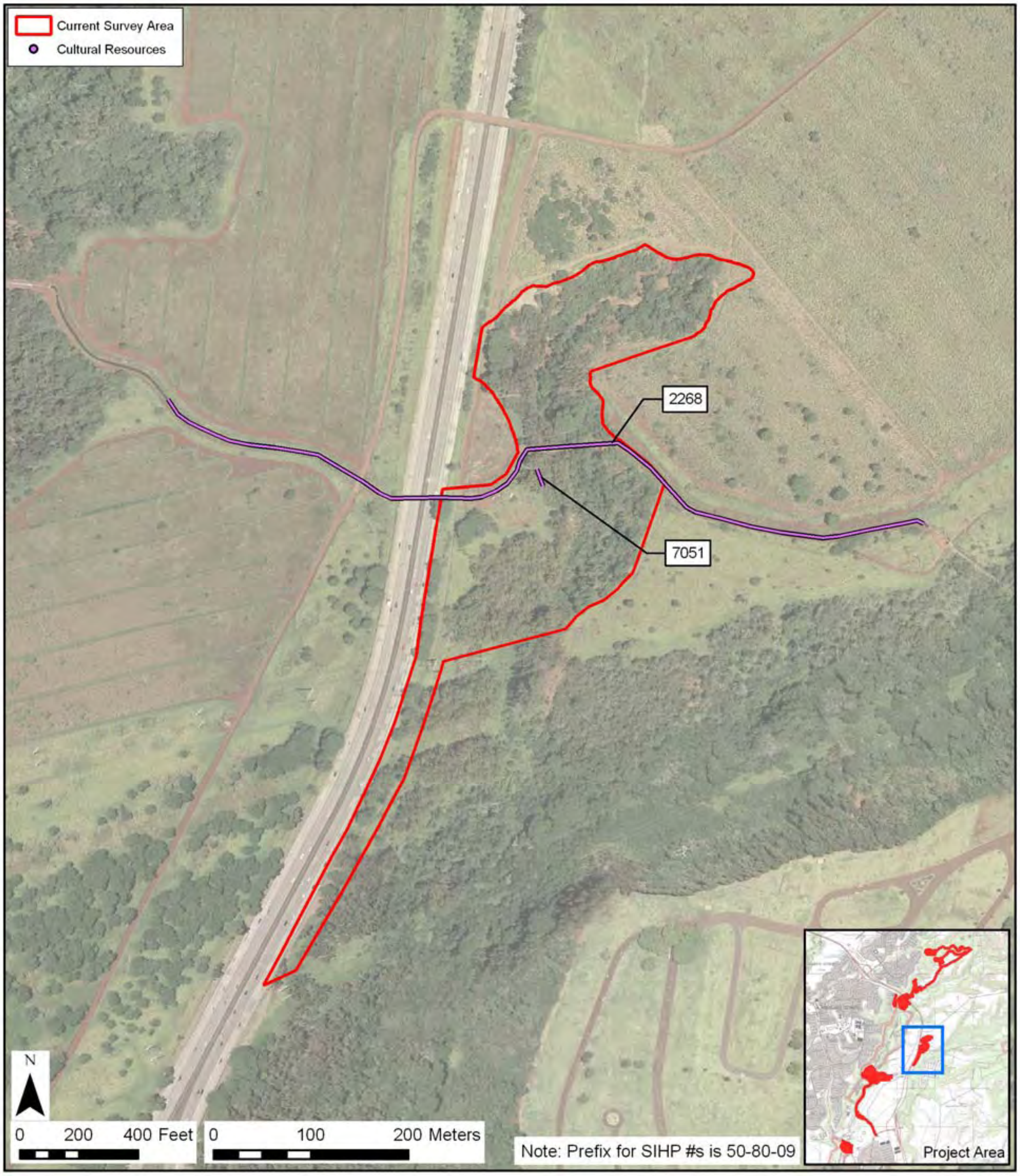

Figure 26. Aerial photograph (source: U.S. Geological Survey Orthoimagery 2005), showing the locations of cultural resources in the H-2 Freeway Interchange project area

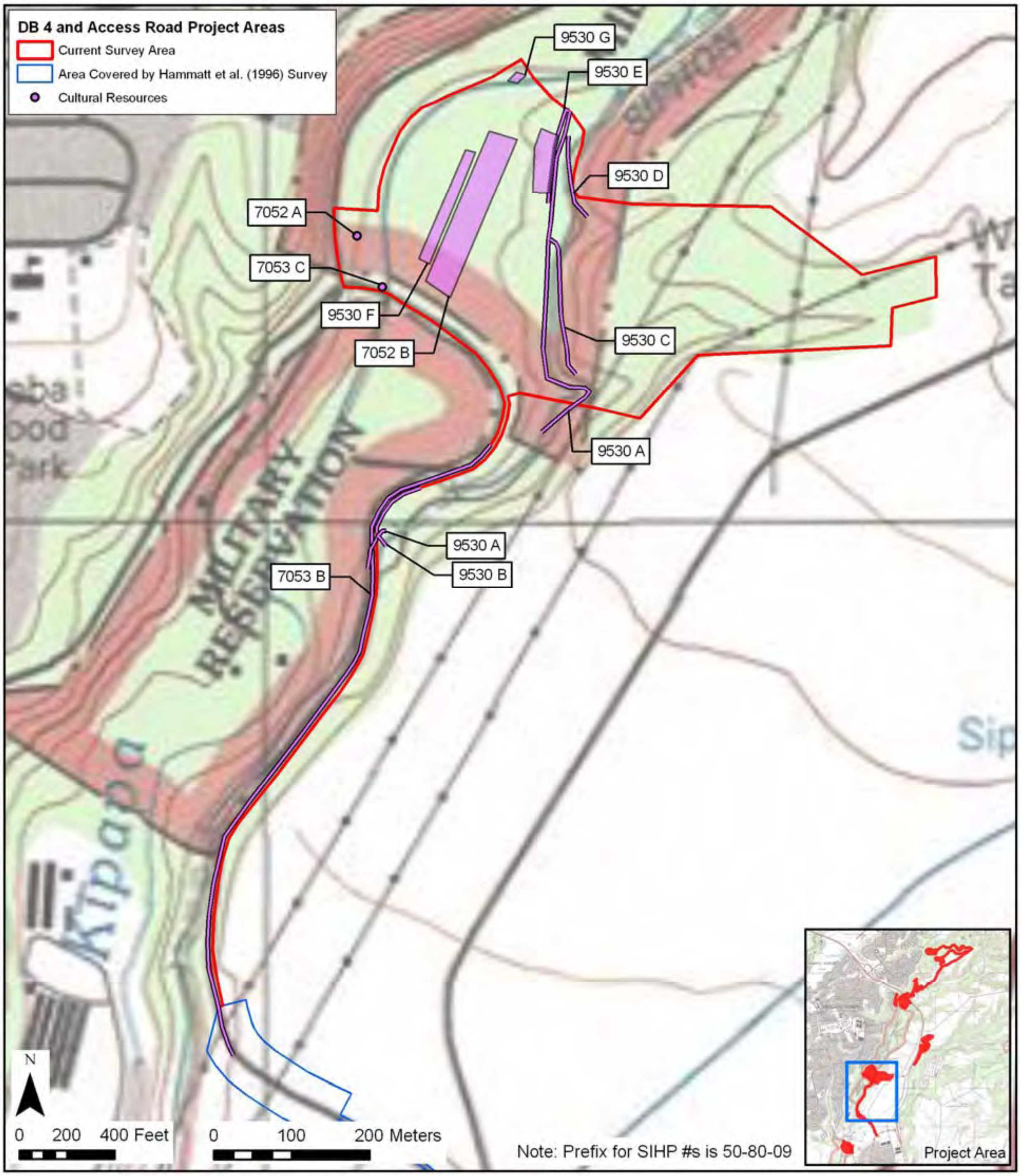

Figure 27. U.S. Geological Survey 7.5-Minute Series Topographic Map, Waipahu Quadrangle (1998), showing the locations of cultural resources in the Detention Basin 4 (DB4) and DB4 Access Road project areas

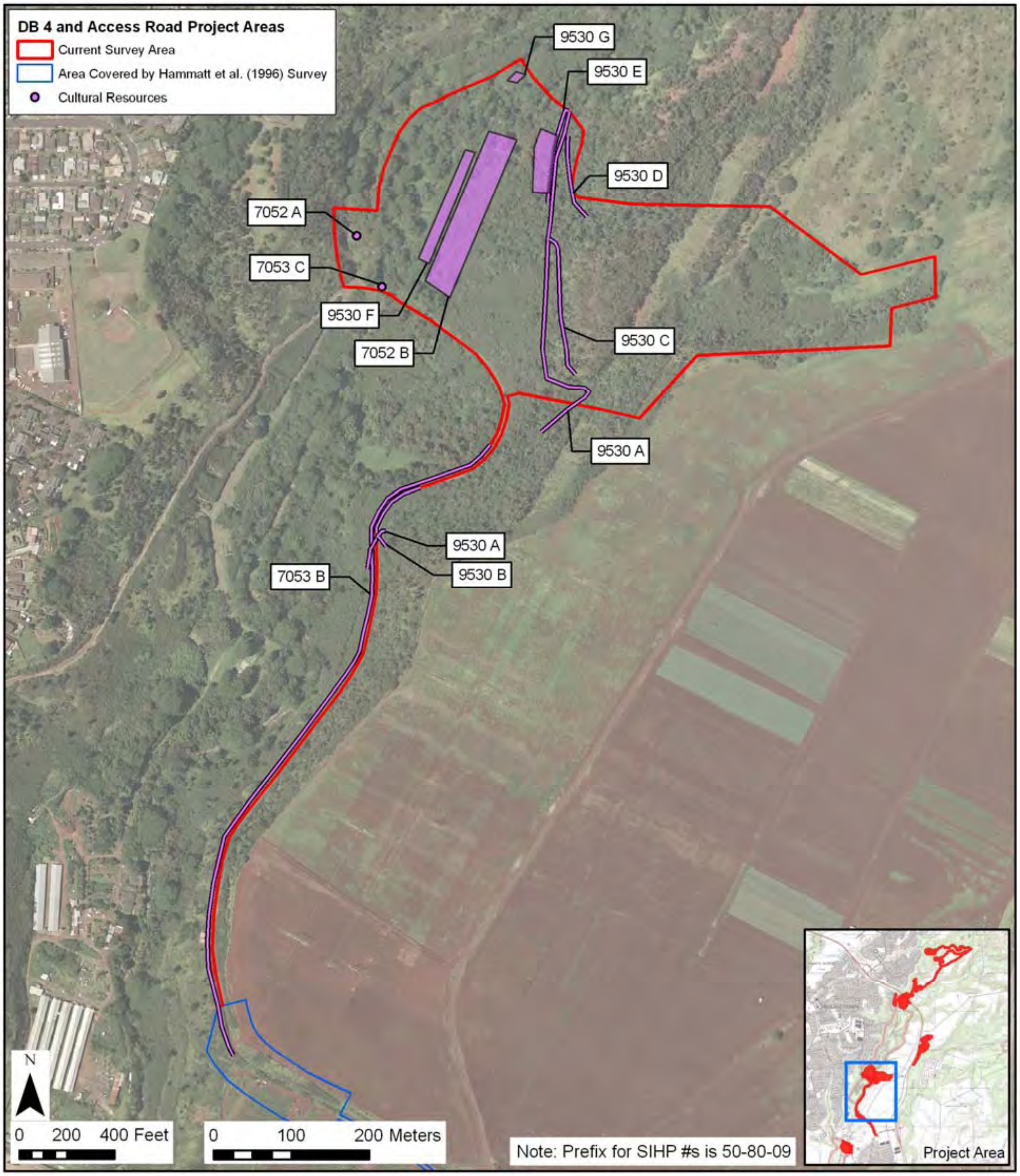

Figure 28. Aerial photograph (source: U.S. Geological Survey Orthoimagery 2005), showing the locations of cultural resources in the Detention Basin 4 (DB4) and DB4 Access Road project areas

Figure 29. U.S. Geological Survey 7.5-Minute Series Topographic Map, Waipahu Quadrangle (1998), showing the locations of cultural resources in the Drain Line 1 (DL1) project area

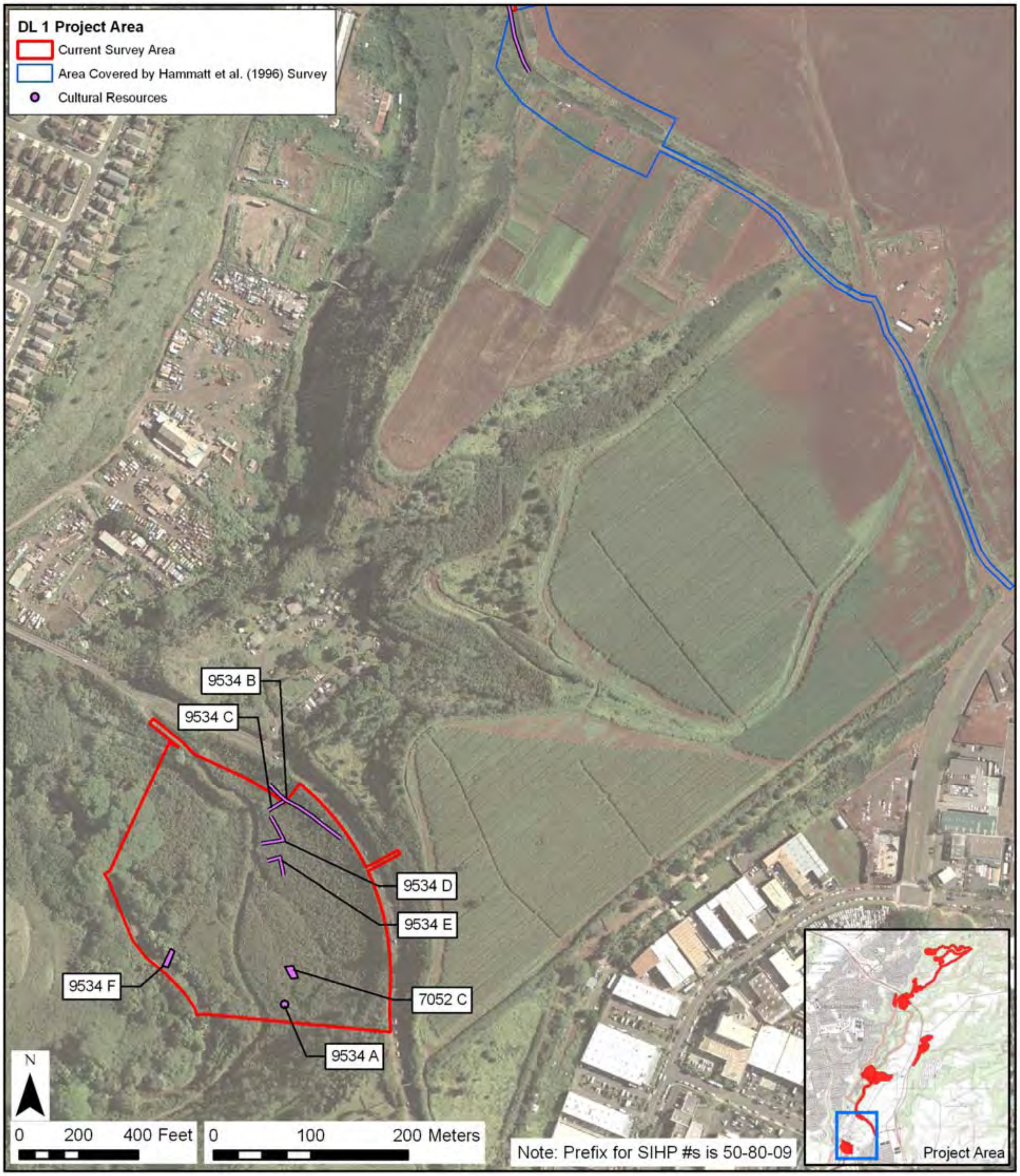

Figure 30. Aerial photograph (source: U.S. Geological Survey Orthoimagery 2005), showing the locations of cultural resources in the Drain Line (DL1) project area

Two cultural resources were identified in the H-2 Freeway Interchange project area. SIHP # 50-80-09-2268 is the Waiahole Ditch, a plantation-era irrigation ditch that crosses roughly east to west through the central portion of the H-2 Freeway Interchange project area. SIHP # 50-80-09-7051 is a retaining wall, interpreted to be a plantation-era erosion control feature, located in the central portion of the H-2 Freeway Interchange project area.

Three cultural resources were identified in the Detention Basin 4 (DB4) project area. SIHP # 50-80-09-9530 consists of plantation-era irrigation and transportation related structures located throughout the DB4 project area. Features include irrigation ditches, a railroad berm, and railroad/road bridge foundations. SIHP # 50-80-09-7052 consists of a storage tunnel and asphalt pad, located in the Detention Basin 4 (DB4) project area, and a large concrete slab located in the southern portion of the of the Drain Line 1 (DL1) project area. The features are military-related components of the U.S. Army Upper and Lower Kīpapa Ammunition Storage Sites. SIHP # 50-80-09-7053 historic roadbed and associated features, located within the proposed Detention Basin 4 Access Road project area. The road is the original alignment of Kamehameha Highway, known as the "Old Kamehameha Highway."

Two cultural resources were identified in the Drain Line 1 (DL1) project area. SIHP # 50-80-09-9534 consists of plantation-era irrigation and transportation related structures located throughout the DL1 project area. Features include a platform, irrigation ditches, an alignment, and railroad bridge foundation. A feature of the SIHP # 50-80-09-7052 military-related structures was also located in the DL1 project area.

Detailed descriptions of all cultural resources identified during the current study are presented below.

4.2 Site Descriptions

4.2.1 SIHP #: 50-80-09-2268

SITE TYPE: Irrigation Ditch (Siphon)
FUNCTION: Agricultural
FEATURES: 2
DIMENSIONS: Approximately 270 m in length within the project area
CONDITION: Good
PROBABLE AGE: Post-Contact
TAX MAP KEY: [1] 9-4-006:003

DESCRIPTION:

SIHP # 50-80-09-2268 is the Waiahole Ditch, an extensive irrigation system that extends approximately 22 miles, bringing water from the windward Koʻolau Range through central Oʻahu and on to the ʻEwa Plain (see Section 3.2 Historical Background). The Waiahole Ditch crosses roughly east to west through the central portion of the H-2 Freeway Interchange project area, extending approximately 270 m in length within the project area (see Figure 25 and Figure 26). Within the project area, the ditch primarily consists of a siphon crossing a tributary of Pānakauahi Gulch (Figure 31). The siphon consists of an enclosed cast-iron pipe measuring approximately 2 m (6 ft.) in diameter. The siphon extends across the entire width of the gulch, with areas outside of the gulch, on the upper tablelands, consisting of an open ditch. At the base of the gulch, two short stone wall segments are located adjacent to the siphon, one at each edge of the stream channel, immediately south of the siphon. The wall segments are constructed of stacked basalt boulders and cobbles, 3-4 courses high, and 1 m in length (Figure 32). The wall segments likely function as support structures for the siphon, preventing damage to the siphon during flooding events at the base of the gulch. The open ditch portions of the Waiahole Ditch consist of a cement-lined U-shaped channel, with a flat bottom and nearly vertical side walls, generally measuring 1 m wide and 1 m deep (Figure 33).

The SIHP # 50-80-09-2268 Waiahole Ditch System was completed ca. 1916 and was described as “an engineering feat of epic proportion for those times” (Conde and Best 1973:37). Much of the Waiahole Ditch system, including the portion crossing through the project area, remains in-use and is actively maintained. SIHP # 50-80-09-2268 is assessed as significant under Criterion A (associated with events that have made an important contribution to the broad patterns of our history), Criterion C (embody the distinctive characteristics of a type period or method of construction), and Criterion D (have yielded, or may be likely to yield information important in prehistory or history) of the National and Hawaiʻi Registers of Historic Places evaluation criteria.

Figure 31. Photograph of SIHP # 50-80-09-2268 Waiahole Ditch, showing siphon across tributary of Pānakauahi Gulch, view to west

Figure 32. Photograph of SIHP # 50-80-09-2268 Waiahole Ditch, showing stone wall adjacent to siphon, view to north

Figure 33. Photograph of SIHP # 50-80-09-2268 Waiahole Ditch, showing open ditch and siphon entrance, view to northwest

4.2.2 SIHP #: 50-80-09-7044

SITE TYPE: Historic Road and Stream Channel Improvements
FUNCTION: Transportation, Agricultural Clearing and Water Control
FEATURES: 17
DIMENSIONS: Features located along approximately 1.3 km long corridor
CONDITION: Good
PROBABLE AGE: Post-Contact
TAX MAP KEY: [1] 9-5-003:011

DESCRIPTION:

SIHP # 50-80-09-7044 consists of a historic road and associated stream channel improvements, located within the Detention Basin 2 (DB2) and DB 2 Access Road project areas (see Figure 21 and Figure 22). The SIHP # 50-80-09-7044 features are situated along an approximately 1.3 km long corridor at the base of a tributary of Kīpapa Gulch. The Feature A historic road consists of an approximately 4-5 m wide graded path (Figure 34) that generally parallels the dry stream channel, or in some instances is located within the stream channel. No paving of the road surface was observed. The Feature A historic road is indicated on topographic maps from 1919 (see Figure 11) through 1943 (see Figure 15). The road is indicated to enter the DB2 portion of the project area from the southwest, generally follows the proposed DB2 access road corridor, and then continues up the gulch beyond the project area. Within the project area, much of the Feature A road alignment is difficult to discern, due in part to the effects of erosion, sedimentation, and heavy vegetation growth.

In addition to the Feature A historic road, 16 features were identified along the stream channel corridor (Table 4). Features B-Q generally consist of stone mounds, alignments, and walls that are situated along the banks of or immediately upslope of the stream channel. Much of the stream channel within the project area appeared to have been artificially improved. The channel is generally uniform in width and depth. In addition, very few surface stones were observed within the current stream channel, indicating the channel was improved or realigned in many areas.

Feature B (Figure 35) is a stone mound adjacent to the Feature A road (Figure 36). The mound is likely a bulldozer push-pile created during the construction of the road. Several historic artifacts, including bottles and ceramic fragments were observed within and adjacent to the mound. Feature C begins as a soil and rock berm (Figure 37) at its southern end and transitions to a boulder alignment (Figure 38) and stacked-stone retaining wall (Figure 39) at its northern end. Feature C is generally constructed along the southern stream bank, though at the northern end of the feature consists of a retaining wall along the southern stream bank and boulder alignment along the northern stream bank (Figure 36). Feature D (Figure 40) is a boulder alignment constructed along the southern stream bank. The areas southeast of Features C and D are large, relatively level areas cleared of surface stones, likely representing former agricultural fields (Figure 36).

Table 4. List of SIHP # 50-80-09-7044 Features

Feature	Type	Function	Dimensions	Photograph(s)
A	Road	Transportation	W: 4-5 m	Figure 34
B	Mound	Clearing associated w/ road construction	L: 4.3 m W: 2.5 m H: 1.3 m	Figure 35
C	Berm, alignment, retaining wall	Clearing, field border, stream channel improvements	L: 101 m; W: 0.9-1.4 m; H: 0.5-0.9 m	Figure 37; Figure 38; Figure 39
D	Alignment	Clearing, field border, stream channel improvements	L: 33 m W: 0.4 m H: 0.4 m	Figure 40
E	Wall, alignment	Clearing, field border, stream channel improvements	L: 140 m W: 0.8-2.5 m H: 0.5-1.3 m	Figure 42
F	Alignment	Stream channel improvements	L: 16 m W: 0.8 m H: 0.8 m	Figure 43
G	Alignment	Stream channel improvements	L: 16 m W: 0.8 m H: 0.5 m	Figure 44
H	Linear mound	Clearing, stream channel improvements	L: 31 m W: 2.0 m H: 1.2 m	Figure 45
I	Linear mound	Clearing, stream channel improvements	L: 19 m W: 1.7 m H: 1.0 m	Figure 46
J	Linear mound	Clearing, stream channel improvements	L: 25 m W: 1.5-5.3 m H: 0.7-1.2 m	Figure 47

Feature	Type	Function	Dimensions	Photograph(s)
K	Mounded wall	Clearing, stream channel improvements	L: 52 m W: 1.6 m H: 0.8 m	Figure 49
L	Mounded wall	Clearing, stream channel improvements	L: 13 m W: 2.1 m H: 1.1 m	Figure 50
M	Mounded wall	Clearing, stream channel improvements	L: 8 m W: 1.0 m H: 0.8 m	Figure 51
N	Wall	Clearing, stream channel improvements	L: 16 m W: 1.2 m H: 0.8-1.2 m	Figure 52
O	Mound	Clearing, stream channel improvements	L: 21 m W: 3.2 m H: 1.2 m	Figure 55
P	Mound	Clearing, stream channel improvements	L: 21 m W: 2.0 m H: 0.9 m	Figure 57
Q	Retaining Wall	Clearing	L: 9 m W: 3.5 m H: 1.7 m	Figure 56

Figure 34. Photograph of SIHP # 50-80-09-7044 A historic road, view to southeast

Figure 35. Photograph of SIHP # 50-80-09-7044 B clearing mound along edge of historic road, view to west

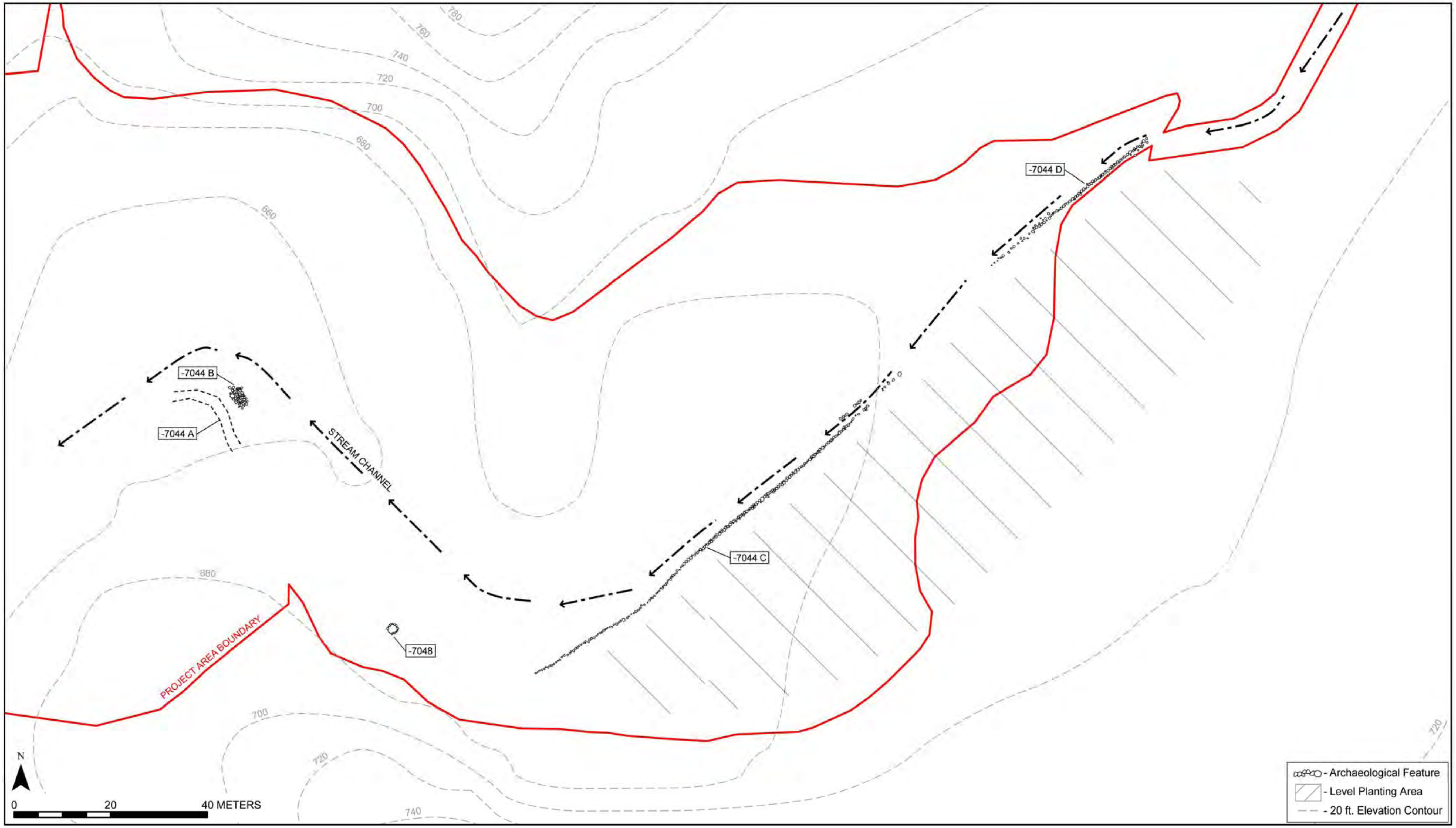

Figure 36. Plan-view diagram of SIHP # 50-80-09-7044 A road, -7044 B mound, -7044 C alignment/retaining wall, -7044 D alignment, and 50-80-09-7048 charcoal kiln

Figure 37. Photograph of southern portion of SIHP # 50-80-09-7044 C stream channel improvements, showing soil and cobble berm, view to west

Figure 38. Photograph of central portion of SIHP # 50-80-09-7044 C stream channel improvements, showing boulder alignment, view to southeast

Figure 39. Photograph of northern portion of SIHP # 50-80-09-7044 C stream channel improvements, showing boulder alignment (right) and stacked-stone retaining wall (left), view to southeast

Figure 40. Photograph of SIHP # 50-80-09-7044 D stream channel improvements, showing boulder alignment, view to northeast

Feature E begins as a boulder alignment at its western end and transitions to a well-constructed stacked-stone wall at its eastern end (Figure 41). The wall portion of Feature E is a bi-faced, core-filled construction, with stones stacked 3-6 courses high (Figure 42). The alignment and wall are constructed along the southern bank of the stream channel. The most substantial construction of the Feature E wall is situated along a pronounced curve in the stream channel. In the vicinity of Feature E the stream channel is well defined, and the Feature A historic road is located adjacent to the northern stream bank. Areas to the south of Feature E are large, relatively level areas cleared of surface stones, likely representing former agricultural fields.

Feature F (Figure 43) and Feature G (Figure 44) are boulder alignments constructed along the northern stream bank. In the vicinity of Feature G, the stream is heavily channelized, and may also be the alignment of the Feature A historic road. Feature H (Figure 45) is a large linear mound, constructed just upslope of the northern stream bank, along the base of the sloping hillside. Feature I (Figure 46) is a boulder alignment constructed along the northern stream bank. Feature J (Figure 47) is a linear mound located immediately upslope of Feature I, along the base of the sloping hillside. Lands upslope of Features H and J appear to have been cleared of surface stones, likely representing former agricultural areas. Features F-J are indicated on Figure 48.

Feature K (Figure 49), Feature L (Figure 50), and Feature M (Figure 51) are mounded walls constructed along the southern stream bank. In the vicinity of Features K and L, the Feature A historic road is located approximately 10 m upslope of the northern stream bank. Feature N (Figure 52) is a stacked-stone wall constructed along the southern stream bank. The wall is a bi-faced, core-filled construction, with stones stacked 3-6 courses high. Feature N is situated along a pronounced curve in the stream channel. Features K-N are indicated on Figure 53.

Features O-Q are indicated on Figure 54. Feature O (Figure 55) is a large linear mound constructed along the south stream bank. Lands upslope of Feature O appear to have been cleared of surface stones, likely representing former agricultural areas. Feature P (Figure 56) is a large mound located upslope of Feature Q. Feature Q (Figure 57) is a stacked-stone retaining wall constructed along the base of the slope bordering the Feature A historic road. Lands upslope of Feature Q appear to have been cleared of surface stones, likely representing former agricultural areas.

SIHP # 50-80-09-7044 consists of a road and stream channel improvements, associated with historic agricultural cultivation in Kīpapa Gulch and its tributaries. Background research indicated the base and slopes of the gulch lands including the DB2 portion of the project area were cultivated in pineapple ca. 1930s (see Figure 14). The Feature A historic road provided vehicular access through the gulch. The many improvements to the stream channel were likely made to better define the stream channel, as the base of the gulch is generally wide and flat in many areas. The improvements to the stream channel keep the water flow within a defined channel, whereby improving water flow and preventing flooding of the adjacent road and cultivated agricultural lands. Much of the stones used to construct the stream channel improvements appear to have been the result of clearing of the stream channel and the gulch slopes of surface stones, to improve the lands for agricultural cultivation. The features of SIHP # 50-80-09-7044 are generally in good condition, with limited disturbance due to erosion and heavy vegetation growth. SIHP # 50-80-09-7044 is assessed as significant under Criterion D (have yielded, or may be likely to yield information important in prehistory or history) of the National and Hawaiʻi Registers of Historic Places evaluation criteria.

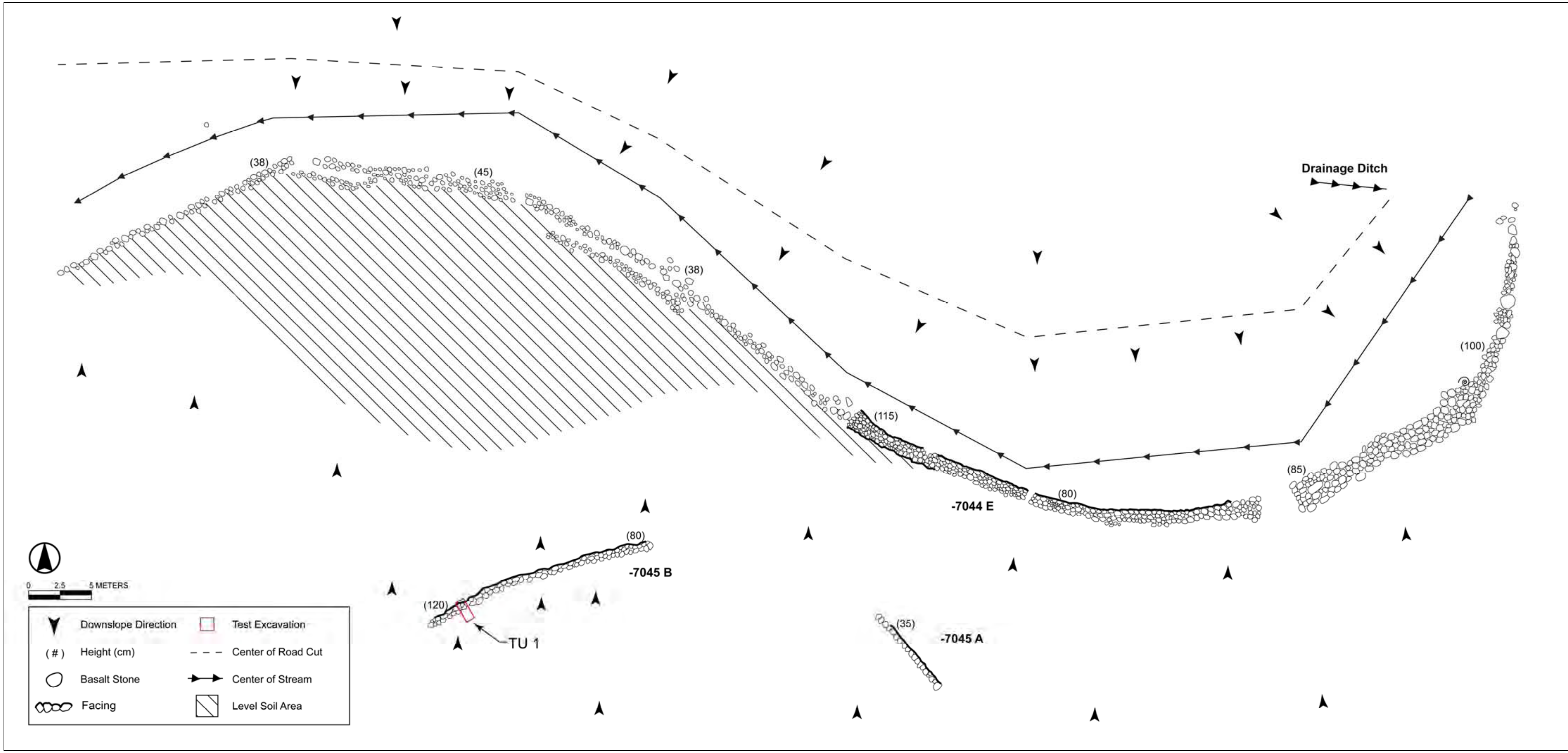

Figure 41. Plan-view diagram of SIHP # 50-80-09-7044 A road, -7044 E wall, 50-80-09-7045 A retaining wall, and -7045 B retaining wall

Figure 42. Photograph of SIHP # 50-80-09-7044 E stream channel improvements, showing stacked-stone wall along edge of stream channel, view to west

Figure 43. Photograph of SIHP # 50-80-09-7044 F stream channel improvements, showing boulder alignment, view to northwest

Figure 44. Photograph of SIHP # 50-80-09-7044 G stream channel improvements, showing boulder alignment, view to northeast

Figure 45. Photograph of SIHP # 50-80-09-7044 H stream channel improvements, showing linear mound, view to northeast

Figure 46. Photograph of SIHP # 50-80-09-7044 I stream channel improvements, showing linear mound, view to northeast

Figure 47. Photograph of SIHP # 50-80-09-7044 J stream channel improvements, showing linear mound, view to northeast

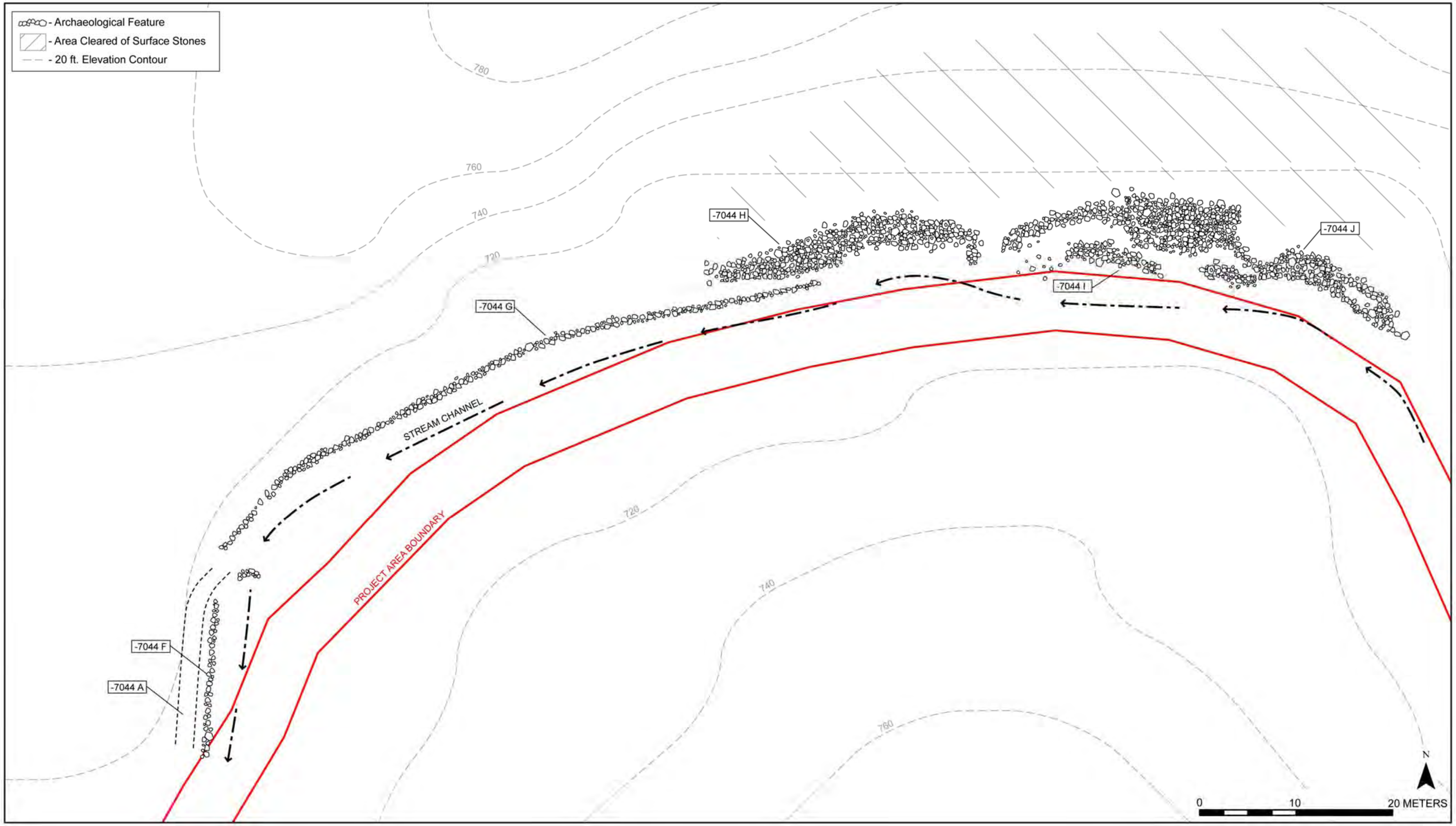

Figure 48. Plan-view diagram of SIHP # 50-80-09-7044 A road, -7044 F alignment, -7044 G alignment -7044 H mound, -7044 I mound, and -7044 J mound

Figure 49. Photograph of SIHP # 50-80-09-7044 K stream channel improvements, showing mounded wall, view to south

Figure 50. Photograph of SIHP # 50-80-09-7044 L stream channel improvements, showing mounded wall, view to southeast

Figure 51. Photograph of SIHP # 50-80-09-7044 M stream channel improvements, showing mounded wall, view to southeast

Figure 52. Photograph of SIHP # 50-80-09-7044 N stream channel improvements, showing stacked-stone wall, view to south

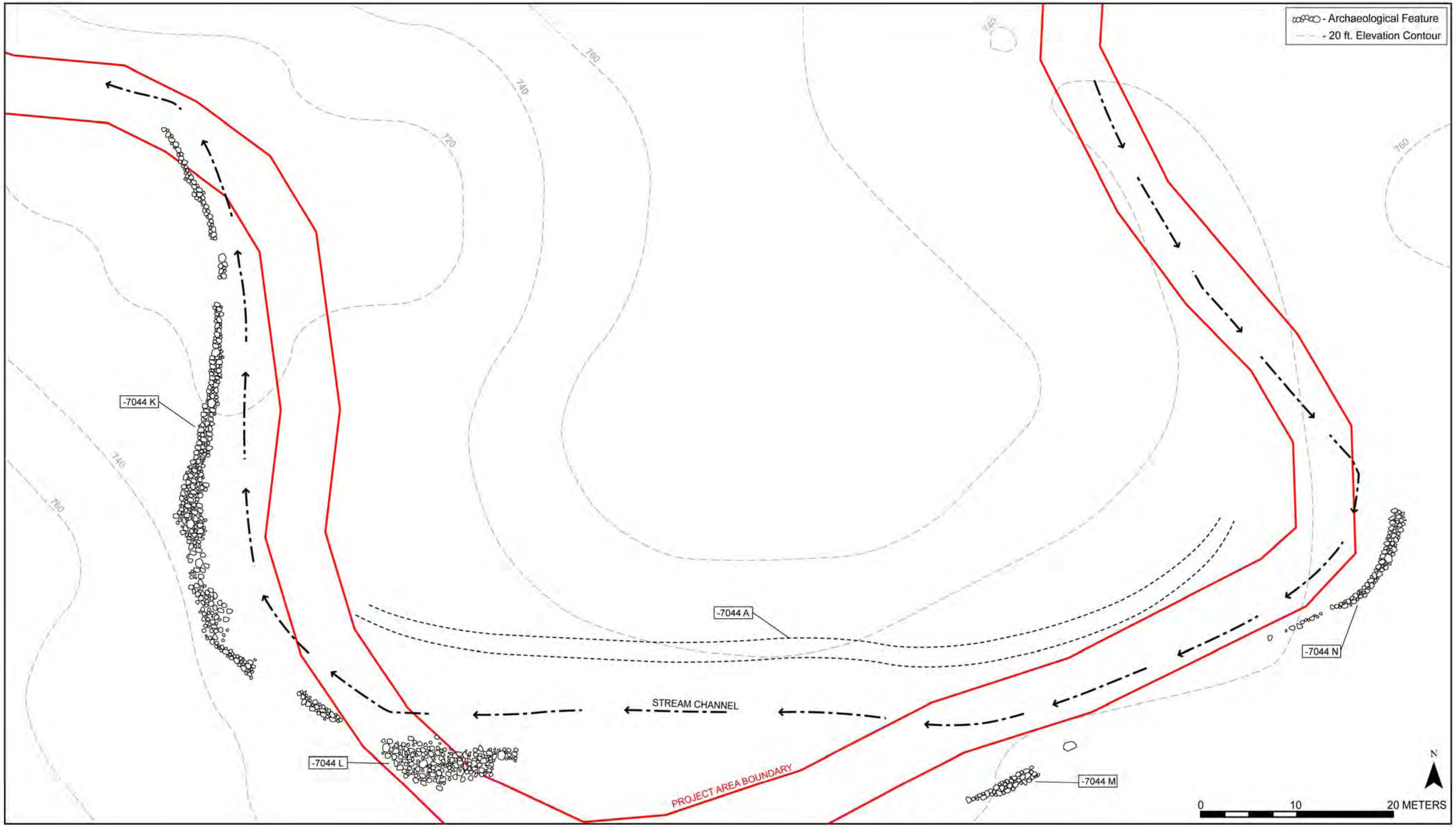

Figure 53. Plan-view diagram of SIHP # 50-80-09-7044 A road, -7044 K mounded wall, -7044 L mounded wall, -7044 M mounded wall, and -7044 N wall

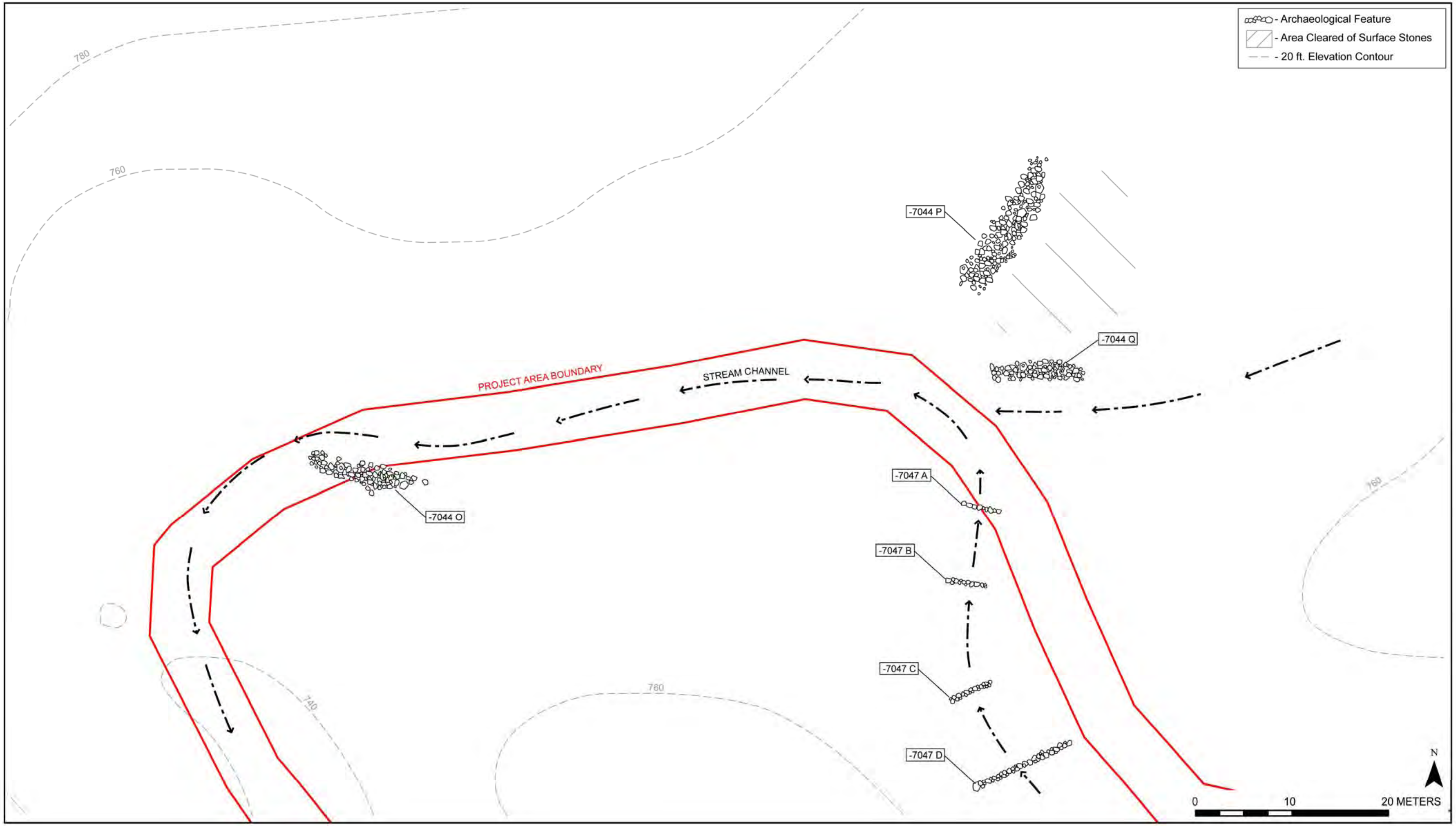

Figure 54. Plan-view diagram of SIHP # 50-80-09-7044 O mound, -7044 P mound, -7044 Q retaining wall, and -7047 A-D terraces

Figure 55. Photograph of SIHP # 50-80-09-7044 O stream channel improvements, showing mound, view to east

Figure 56. Photograph of SIHP # 50-80-09-7044 P stream channel improvements, showing mound, view to northeast

Figure 57. Photograph of SIHP # 50-80-09-7044 Q stream channel improvements, showing retaining wall, view to north

4.2.3 SIHP #: 50-80-09-7045

SITE TYPE: Retaining Walls
FUNCTION: Agricultural
FEATURES: 2
DIMENSIONS: Feature A: 7.6 m NE/SW; Feature B: 17.7 m NE/SW
CONDITION: Good
PROBABLE AGE: Post-Contact
TAX MAP KEY: [1] 9-5-003:011

DESCRIPTION:

SIHP # 50-80-09-7045 consists of two retaining walls located near the central portion of the Detention Basin 2 (DB2) Access Road project area (see Figure 21 and Figure 22). Feature A retaining wall is located approximately 13 m upslope of SIHP 50-80-09-7044 , situated along the steep sloping southern gulch wall, and is oriented cross-slope (see Figure 41). The 7.6 m long retaining wall is constructed of stacked basalt boulders and cobbles, 3-5 courses high, with a maximum height of 0.8 m (Figure 58). The wall retains an approximately 0.7 m wide sloping soil area upslope.

Feature B retaining wall is located approximately 25 m south of SIHP 50-80-09-7044 Feature E. The retaining wall is situated along the base of the steep sloping southern gulch wall, generally following the contour of the slope (see Figure 41). The 17.7 m long retaining wall is constructed of stacked basalt boulders and cobbles, 3-6 courses high, with a maximum height of 1.3 m (Figure 59). The top surface of the wall is generally flush with the sloping hillside.

Figure 58. Photograph of SIHP # 50-80-09-7045 A retaining wall, view to southeast

Figure 59. Photograph of SIHP # 50-80-09-7045 B retaining wall, view to northeast

Based on similar construction methods and proximity to features associated with historic agricultural endeavors, SIHP # 50-80-09-7045 is interpreted to also be associated with historic agriculture. The function of the SIHP # 50-80-09-7045 Feature A retaining wall is unclear. The retaining wall may function in diverting water draining from the gulch wall away from the well-constructed portion of the SIHP 50-80-09-7044 Feature E wall that is immediately down slope. The area between SIHP # 50-80-09-7045 Feature B and 50-80-09-7044 Feature E is a large, level alluvial/colluvial terrace that appears to have been cleared of surface stones. The area was likely an agricultural planting area, with the SIHP # 50-80-09-7045 Feature B retaining wall constructed along the slope bordering the planting area to prevent erosion. The slope may have also been cut to enlarge the planting area prior to the construction of the retaining wall. SIHP # 50-80-09-7045 is in good condition with limited disturbance due to erosion. SIHP # 50-80-09-7045 is assessed as significant under Criterion D (have yielded, or may be likely to yield information important in prehistory or history) of the National and Hawaiʻi Registers of Historic Places evaluation criteria.

4.2.4 SIHP #: 50-80-09-7046

SITE TYPE: Platform
FUNCTION: Agricultural / Water Diversion
FEATURES: 1
DIMENSIONS: 4.0 m E/W x 2.8 m N/S
CONDITION: Fair
PROBABLE AGE: Post-Contact
TAX MAP KEY: [1] 9-5-003:011

DESCRIPTION:

SIHP # 50-80-09-7046 is a platform located approximately 8 m south of SIHP # 50-80-09-7044 Feature N, near the eastern portion of the DB2 Access Road project area (see Figure 21 and Figure 22). The platform is situated at the base of the southern gulch slope, in the central portion of a drainage swale, with the south end of the platform constructed against the sloping hillside (Figure 60). The platform is roughly triangular shaped, with a point of the triangle oriented upslope, and the flat edge of the triangle parallel to the contour of the slope (Figure 61). The platform is well-constructed of stacked basalt boulders and cobbles, 7-8 courses high on the down slope side and 3-5 courses on the upslope side, measuring 4.0 m by 2.8 m wide with a maximum height of 1.3 m on the down slope side and 0.8 m on the upslope side. The platform is faced on all sides, with larger boulders at the base of the structure and progressively smaller stones in the upper courses, and an interior fill of smaller cobbles and pebbles. The surface of the platform is sloping, with disturbance due to a large Christmas berry tree growing through the center of the platform. The platform appears to have been partially constructed over a natural bedrock outcrop or very large boulder.

Based on similar construction methods and proximity to features associated with historic agricultural endeavors, SIHP # 50-80-09-7046 is interpreted to also be associated with historic agriculture. The platform appears to have dual functions, both as an agricultural clearing feature, with the stones used in the construction generated by clearing of adjacent planting areas, and as a water diversion feature. The platform is situated at the base of the gulch slope, in the center of a drainage swale, and is immediately upslope of a well-constructed wall (i.e. SIHP # 50-80-09-7044 Feature N). The platform would appear to disperse water draining from the swale, preventing damage to SIHP # 50-80-09-7044 Feature N wall. SIHP # 50-80-09-7046 is in fair condition, with a portion of the platform collapsed due to disturbance by a large tree growing through the center of the platform. SIHP # 50-80-09-7046 is assessed as significant under Criterion D (have yielded, or may be likely to yield information important in prehistory or history) of the National and Hawaiʻi Registers of Historic Places evaluation criteria.

Figure 60. Photograph of SIHP # 50-80-09-7046 platform, view to southeast

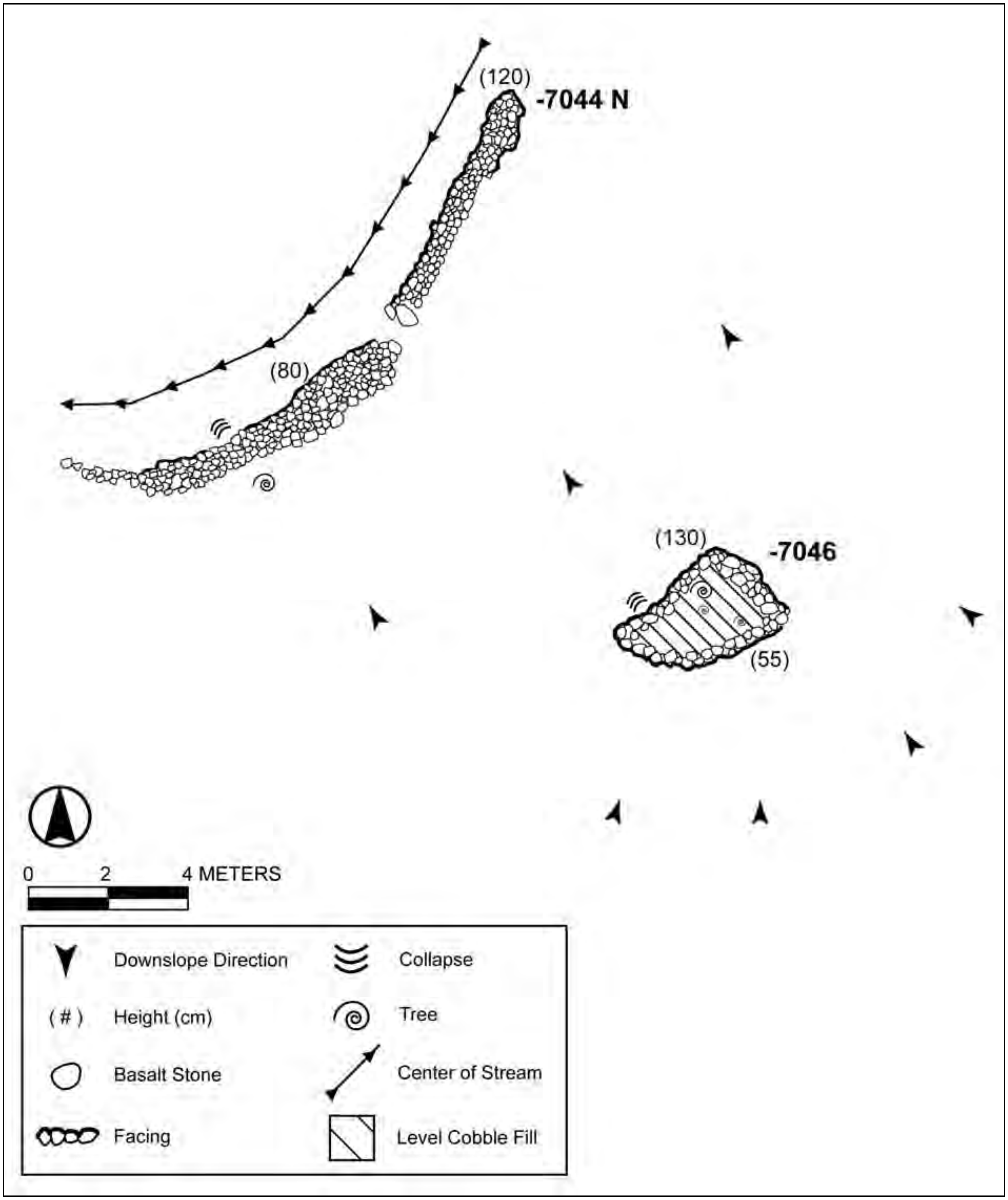

Figure 61. Plan-view diagram of SIHP # 50-80-09-7046 platform and SIHP # 50-80-09-7044 N wall

4.2.5 SIHP #: 50-80-09-7047

SITE TYPE: Terrace Complex
FUNCTION: Agricultural
FEATURES: 7
DIMENSIONS: Features located within an approximately 180 m long portion of gulch
CONDITION: Good
PROBABLE AGE: Post-Contact
TAX MAP KEY: [1] 9-5-003:011

DESCRIPTION:

SIHP # 50-80-09-7047 is an agricultural terrace complex located near the eastern portion of the DB2 Access Road project area (see Figure 21 and Figure 22). The complex consists of 6 terraces (Features A-E and G) and 1 excavated pit (Feature F), situated along the base of a relatively narrow tributary gulch. The gulch has a relatively wide and flat bottom with steep sides. The six terraces (i.e. Features A-E and G) are generally constructed across the entire width of the gulch floor, up to the sloping sides. Feature A is the most down slope of the terraces, and is constructed across the narrowest portion of the tributary gulch, where the smaller side gulch connects with the main gulch. Features B-E and G retaining walls are progressively longer and more substantial constructions as the width of the gulch increases upslope of Feature A. Each of the walls retains level soil areas upslope, which are free of surface stones. Features A-D (Figure 62) are clustered together in the lower reaches of the tributary gulch, with Features E-G (Figure 63 and Figure 64) located further up the gulch. The lands upslope of Feature D are naturally level, and were likely able to be cultivated without the construction of retaining walls to level to land. The lands upslope of Feature E is also relatively level, which accounts for the large distance between the Feature E and G terraces.

Feature A is a single-course boulder alignment with limited stacking, measuring 4.3 m long and 0.4 m high (Figure 65). Feature B is located 8 m upslope of Feature A. Feature B is constructed with a 4.4 m long, 0.9 m wide, and 0.4 m high retaining wall. The wall is bi-faced, composed of stacked basalt boulders and cobbles, 1-2 courses high (Figure 66). Feature C is located 11 m upslope of Feature B. Feature C is constructed with a 4.9 m long, 1.0 m wide, and 0.5 m high retaining wall. The wall is bi-faced, composed of stacked basalt boulders and cobbles 2-3 courses high, with larger boulders along the outside edges of the wall and smaller boulders and cobbles in the interior (Figure 67). Feature D is located 8.5 m upslope of Feature C. Feature D is constructed with an 11.5 m long, 1.6 m wide, and 1.0 m high retaining wall. The wall is bi-faced, composed of stacked basalt boulders and cobbles, 3-4 courses high (Figure 68). Feature E is located approximately 70 m upslope of Feature D. Feature E is constructed with a 9.9 m long, 1.1 m wide, 0.7 m high retaining wall. The wall is bi-faced, composed of stacked basalt boulders and cobbles, 2-4 courses high, with larger boulders along the outside edges of the wall and smaller boulders and cobbles in the interior (Figure 69). Feature F is an excavated pit located 7.5 m north of Feature E. The pit is excavated into the base of the northern gulch slope, measuring approximately 3 m in diameter and 2.5 m deep (Figure 70). The down slope edge of the pit, along the base of the gulch slope, is lined with a stacked-stone retaining wall. The wall is constructed of stacked basalt boulders and cobbles, 2-4 courses high, measuring 2.8 m long and 0.6 m high.

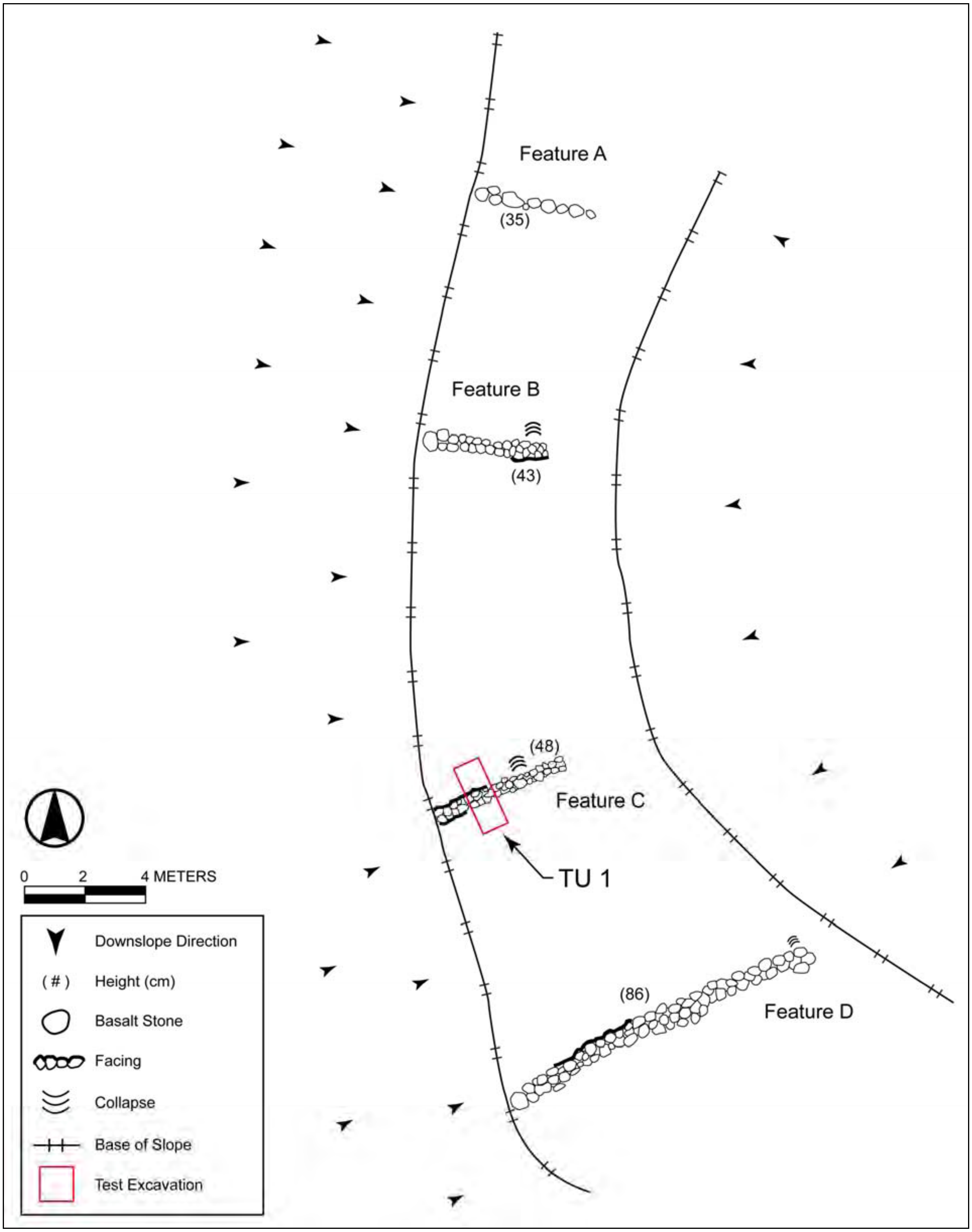

Figure 62. Plan-view diagram of SIHP # 50-80-09-7047 Features A-D terraces

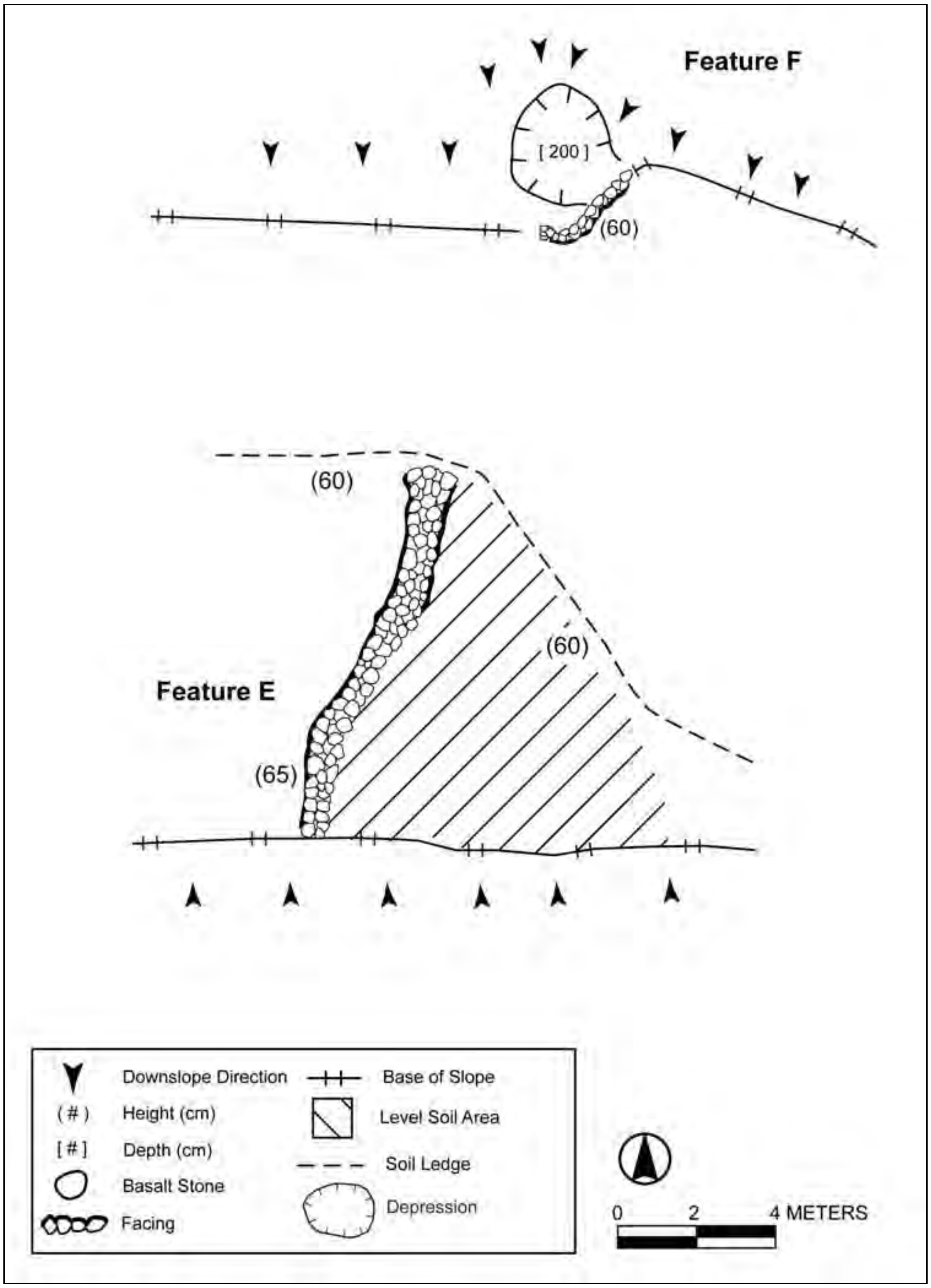

Figure 63. Plan-view diagram of SIHP # 50-80-09-7047 E terrace and -7047 F charcoal kiln

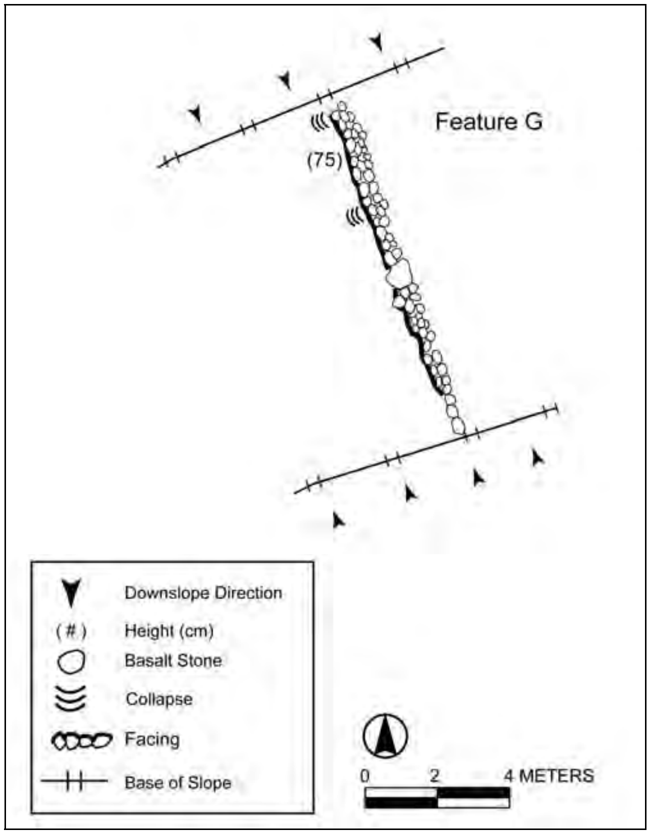

Figure 64. Plan-view diagram of SIHP # 50-80-09-7047 G terrace

Figure 65. Photograph of SIHP # 50-80-09-7047 A terrace, view to southeast

Figure 66. Photograph of SIHP # 50-80-09-7047 B terrace, view to southeast. Note Features C and D in background

Figure 67. Photograph of SIHP # 50-80-09-7047 C terrace, view to east. Note Feature D in background

Figure 68. Photograph of SIHP # 50-80-09-7047 D terrace, view to east

Figure 69. Photograph of SIHP # 50-80-09-7047 E terrace, view to southeast

Figure 70. Photograph of SIHP # 50-80-09-7047 F charcoal kiln, view to west

The interior of the pit was not observed to be stone-lined, though heavy sedimentation within the pit may have substantially buried any lining. Feature G is located approximately 60 m upslope of Feature E. Feature G is constructed with a 10.0 m long, 1.0 m wide, and 0.8 m high retaining wall. The wall is bi-faced, composed of stacked basalt boulders and cobbles, 2-3 courses high, with larger boulders along the outside edges of the wall and smaller boulders and cobbles in the interior (Figure 71).

Based on similar construction methods and proximity to features associated with historic agricultural endeavors, SIHP # 50-80-09-7047 is interpreted to also be associated with historic agriculture. Features A-E and G terraces function in leveling lands at the base of the small tributary gulch for agricultural cultivation. Feature F excavated pit is interpreted to be a charcoal kiln, associated with historic agricultural endeavors in the vicinity. The pit was excavated into the sloping hillside for the soil to provide insulation for the burning of wood and production of charcoal. For an in-depth discussion of charcoal making in Hawai‘i, see Meeker (1995:89-120). Based on the analysis of charcoal kilns by Meeker (1995), the Feature F charcoal kiln is of the “earth-covered pit kiln” type. The earth-covered pit kiln is described as:

> In size, it could range from an excavated hole of about 1 or 2 m^3 to a hillside pit measuring 4 m in diameter. Dug into the slope, the side and rear walls of the pit are formed by vertical cuts in the natural earth. Sometimes the walls are reinforced by a brick or stone lining. There may be a air vent or flue cut into the rear wall. Emrich (1985:24) further notes that “after loading, the pit is covered with a layer of leaves normally 20 cm thick and on top with a layer of soil of the same thickness.” [Meeker 1995:98-99]

Figure 71. Photograph of SIHP # 50-80-09-7047 G terrace, view to northeast

SIHP # 50-80-09-7047 is in good condition, with limited disturbance due to erosion and sedimentation. SIHP # 50-80-09-7047 is assessed as significant under Criterion D (have yielded, or may be likely to yield information important in prehistory or history) of the National and Hawaiʻi Registers of Historic Places evaluation criteria.

4.2.6 SIHP #: 50-80-09-7048

SITE TYPE: Stone-lined Pit
FUNCTION: Charcoal Kiln
FEATURES: 1
DIMENSIONS: Approximately 2.5 m in diameter
CONDITION: Fair
PROBABLE AGE: Post-Contact
TAX MAP KEY: [1] 9-5-003:011

DESCRIPTION:

SIHP # 50-80-09-7048 is an excavated pit located within the southern portion of the DB2 project area (see Figure 21 and Figure 22). The pit is excavated into the base of the southern gulch slope, measuring approximately 2.5 m in diameter and 2.5 m deep (Figure 72 and Figure 73). The interior sides of the pit are lined with a single course alignment of basalt boulders (Figure 74). The base of the pit was not observed to be stone-lined, though heavy sedimentation within the pit may have substantially buried any lining. The down slope edge of the pit has a

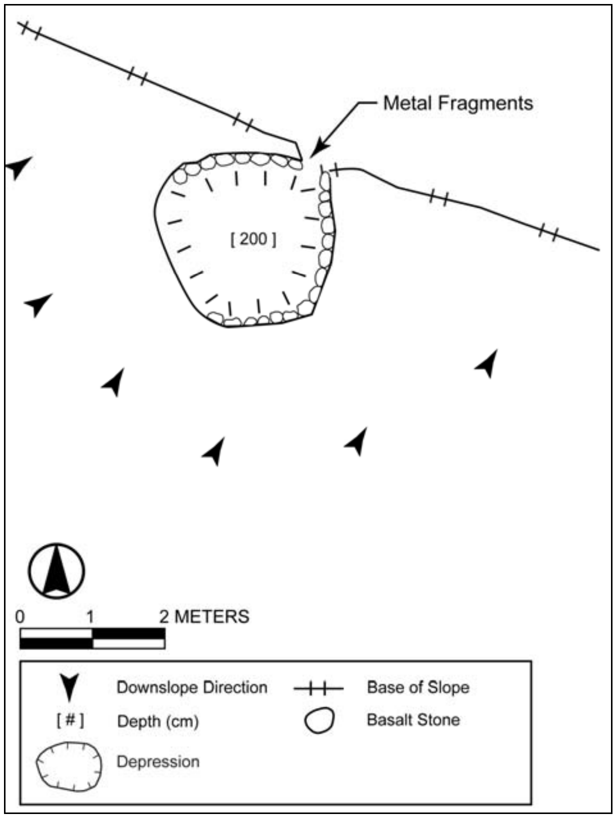

Figure 72. Plan view diagram of SIHP # 50-80-09-7048 charcoal kiln

Figure 73. Photograph of SIHP # 50-80-09-7048 charcoal kiln, view to southwest

Figure 74. Photograph of SIHP # 50-80-09-7048 charcoal kiln, showing interior stone lining, view to east

constructed gap in the stone lining, measuring 35 cm wide. Scattered through out the vicinity of the constructed gap are three rusting metal bolts and hardware fragments, possibly representing hinge brackets for a door (Figure 75).

SIHP # 50-80-09-7048 is interpreted to be a charcoal kiln, associated with historic agricultural endeavors in the vicinity. The pit was excavated into the sloping hillside for the soil to provide insulation for the burning of wood and production of charcoal. As previously discussed, an in-depth discussion of charcoal making in Hawai'i is provided by Meeker (1995:89-120). Based on the analysis of charcoal kilns by Meeker (1995), the SIHP # 50-80-09-7048 charcoal kiln is of the "earth-covered pit kiln" type. SIHP # 50-80-09-7048 is in fair condition, with disturbance due to erosion and sedimentation. SIHP # 50-80-09-7048 is assessed as significant under Criterion D (have yielded, or may be likely to yield information important in prehistory or history) of the National and Hawai'i Registers of Historic Places evaluation criteria.

Figure 75. Photograph of SIHP # 50-80-09-7048 charcoal kiln, showing constructed gap and metal fragments

4.2.7 SIHP #: 50-80-09-7049

SITE TYPE: Agricultural Complex
FUNCTION: Agricultural
FEATURES: 10
DIMENSIONS: Features located along approximately 350 m long portion of gulch
CONDITION: Good
PROBABLE AGE: Post-Contact
TAX MAP KEY: [1] 9-5-003:011

DESCRIPTION:

SIHP # 50-80-09-7049 is a complex of ten historic agricultural features, located within the Detention Basin 3 (DB3) portion of the project area (see Figure 23 and Figure 24). The features are located primarily along the moderately sloping western face of a tributary of Kīpapa Gulch, with the exception of Feature A which is located on the eastern gulch slope (Figure 76). Features A-I (Table 5) generally consist of large mounds and terraces, constructed at the base of the gulch and along the gulch slopes. The areas in the vicinity of the features were observed to lack surface stones, indicating the features are likely related to agricultural land-clearing efforts.

Feature A is a mounded wall located on the eastern gulch slope. The wall is situated on moderately sloping land and is oriented upslope-down slope (Figure 77). The wall is located at a clear break in slope, as lands to the south of the feature are very steep and lands north of the

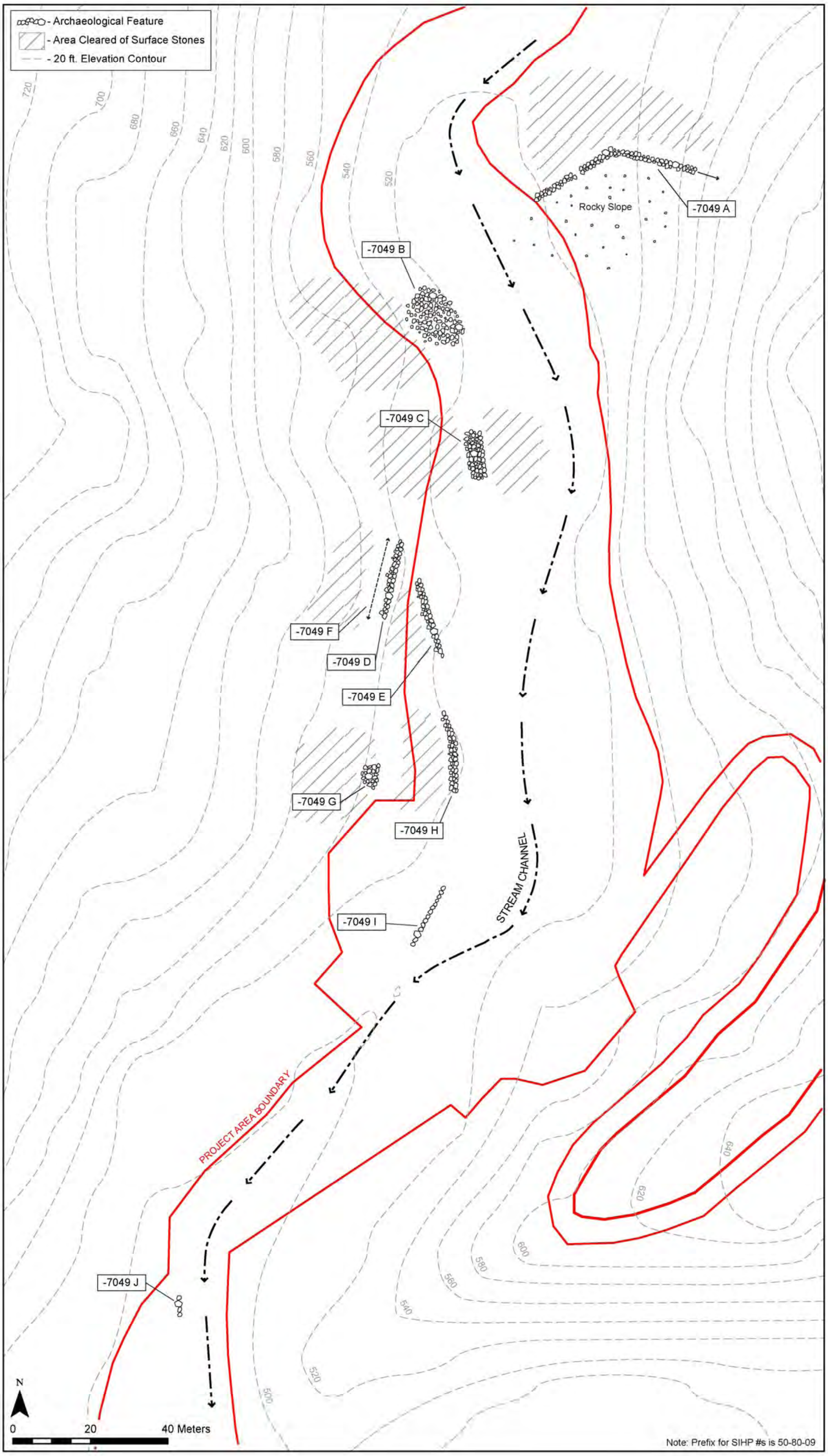

Figure 76. Plan view diagram of SIHP # 50-80-09-7049 Features A-J

Table 5. List of SIHP # 50-80-09-7049 Features

Feature	Type	Function	Dimensions	Photograph(s)
A	Mounded Wall	Clearing, field border	L: 45+ m W: 2.0 m H: 0.7-1.0 m	Figure 78
B	Mound	Clearing	L: 15 m W: 6 m H: 5 m	Figure 79
C	Terrace	Clearing	L: 18 m W: 4.6 m H: 2.3 m	Figure 81
D	Terrace	Clearing, erosion control	L: 31 m W: 4.3 m H: 3.5 m	Figure 83
E	Terrace	Clearing, erosion control	L: 21.6 m W: 2.5 m H: 1.1 m	Figure 84
F	Road/Trail	Transportation	L: 15+ m W: 1.5 m	--
G	Mound	Clearing	L: 5.8 m W: 4.4 m H: 2.5 m	Figure 86
H	Terrace	Clearing, erosion control	L: 29.3 m W: 1.8 m H: 0.5-2.3 m	Figure 88
I	Alignment	Clearing, stream channel improvements	L: 20 m W: 0.5 m H: 0.5 m	Figure 89
J	Retaining wall	Stream channel improvements	L: 2.0 m W: 0.5 m H: 0.7 m	Figure 90

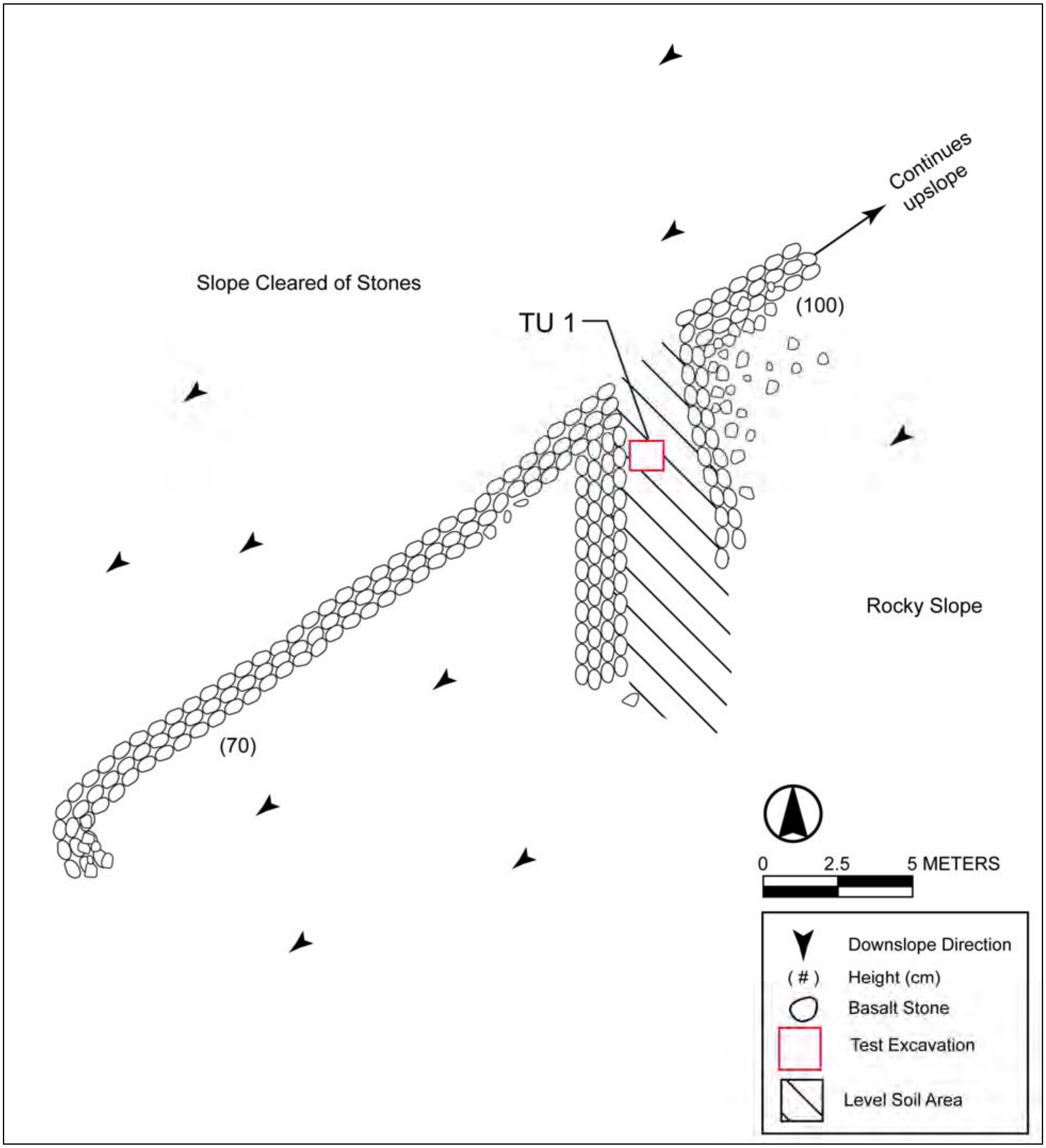

Figure 77. Plan-view diagram of SIHP # 50-80-09-7049 A mounded wall

feature are gently to moderately sloping. The area south of the wall is also very rocky, while the area to the north is generally free of surface stones. In the vicinity of the project area, the wall extends approximately 45 m, continuing upslope beyond the current survey area. The wall is generally a mounded construction, with little stacking or facing observed (Figure 78). The wall is constructed of basalt boulders and cobbles, measuring 2.0 m wide with a maximum height of 1.0 m. Feature A was likely constructed as the southern boundary of an agricultural planting area to the north, with the stones used to construct the wall generated by clearing of the planting area.

Feature B is a large mound located immediately upslope of the western stream bank of the gulch. The mound consists of a haphazardly constructed accumulation of basalt boulders and cobbles piled against the moderately sloping hillside (Figure 79). Lands upslope of the mound are gently to moderately sloping and generally free of surface stones. Feature B was likely constructed during land clearing efforts associated with agricultural cultivation.

Feature C is a large terrace located approximately 30 m south of Feature B, situated at the base of the western gulch slope (Figure 80). Down slope of Feature C is level alluvial/colluvial terrace, adjacent to the western stream bank. Lands upslope of Feature C are gently to moderately sloping. Feature C terrace is constructed of stacked basalt boulders and cobbles, 5-9 courses high, measuring 18 m long, 4.6 m wide, with a maximum height of 2.3 m (Figure 81). The terrace is faced on the downslope edge and sides, and is flush with the slope on the upslope edge. The terrace is a two-tiered construction, with two levels of facing on the down slope edge. The surface of the terrace is sloping and uneven, lacking any paving. Lands in the vicinity of Feature C are clear of surface stones. Feature C was likely constructed during land clearing efforts associated with agricultural cultivation.

Features D and E are large terraces located approximately 30 m southwest of Feature C. Features D and E are constructed along the contour of the western gulch slope, situated on moderately sloping land (Figure 82). Feature D is constructed of stacked basalt boulders and cobbles, 6-10 courses high, measuring 31 m long, 4.3 m wide, with a maximum height of 3.5 m (Figure 83). The down slope edge of the terrace is faced. The surface of the terrace is mounded and is nearly flush with the sloping hillside. Lands immediately upslope and downslope of Feature D are moderately sloping, clear of surface stones. Feature E terrace is located approximately 13 m down slope of Feature D, and is nearly parallel to Feature D. The terrace is constructed of stacked basalt boulders and cobbles, 2-4 courses high, measuring 21.6 m long, 2.5 m wide, with a maximum height of 1.1 m (Figure 84). Feature E is constructed along a prominent break in slope, with lands down slope of the terrace dropping steeply to the stream channel below. Features D and E were likely constructed during land clearing efforts associated with agricultural cultivation. In addition, the terraces likely functioned as erosion control structures. Approximately 7 m upslope of Feature D is Feature F, a graded path, measuring 1.5 m wide. The Feature F path may have been a trail or cart road and appeared to continue upslope, beyond the current survey area.

Feature G is a mound located approximately 40 m south of Features D and E. The mound is situated on moderately sloping lands along the western gulch slope (Figure 85). The mound is constructed of piled basalt boulders and cobbles, with larger stones along the base and perimeter of the mound and smaller stones in the interior (Figure 86). The edges of the mound are not faced, and the top surface is sloping and uneven. Feature G measures 5.8 m by 4.4 m wide with a

Figure 78. Photograph of SIHP # 50-80-09-7049 Feature A mounded wall, view to northeast

Figure 79. Photograph of SIHP # 50-80-09-7049 Feature B mound, view to southwest

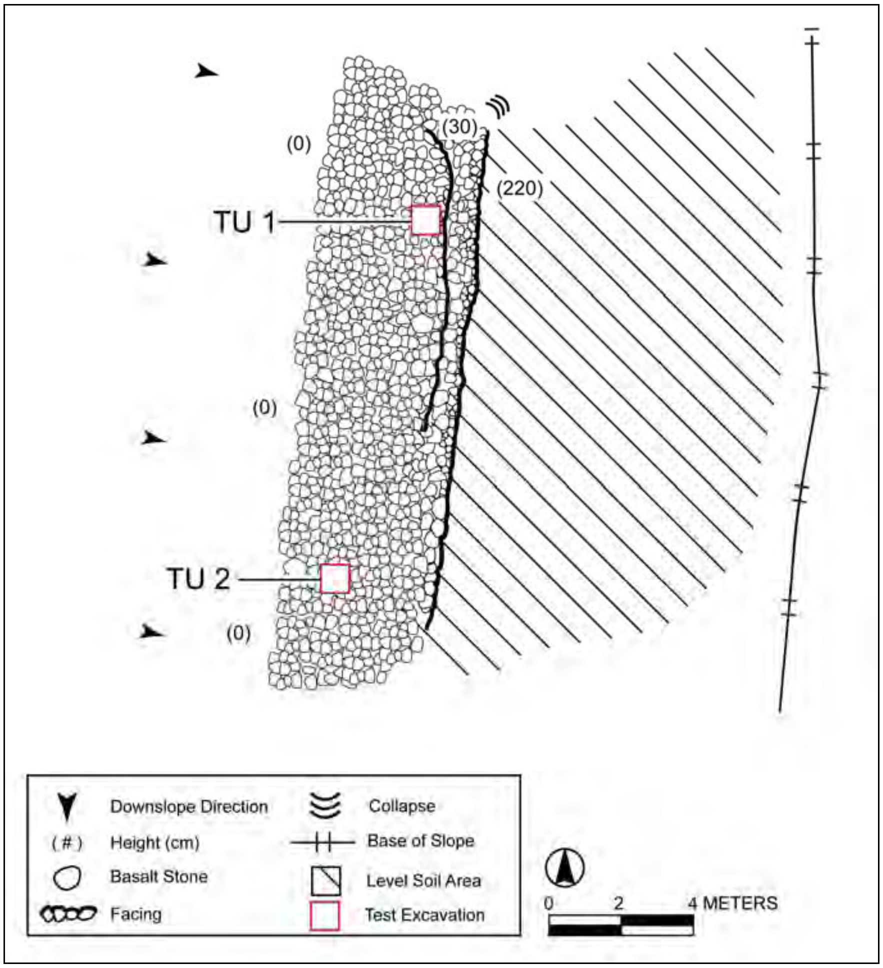

Figure 80. Plan-view diagram of SIHP # 50-80-09-7049 C terrace

Figure 81. Photograph of SIHP # 50-80-09-7049 C terrace, view to northwest

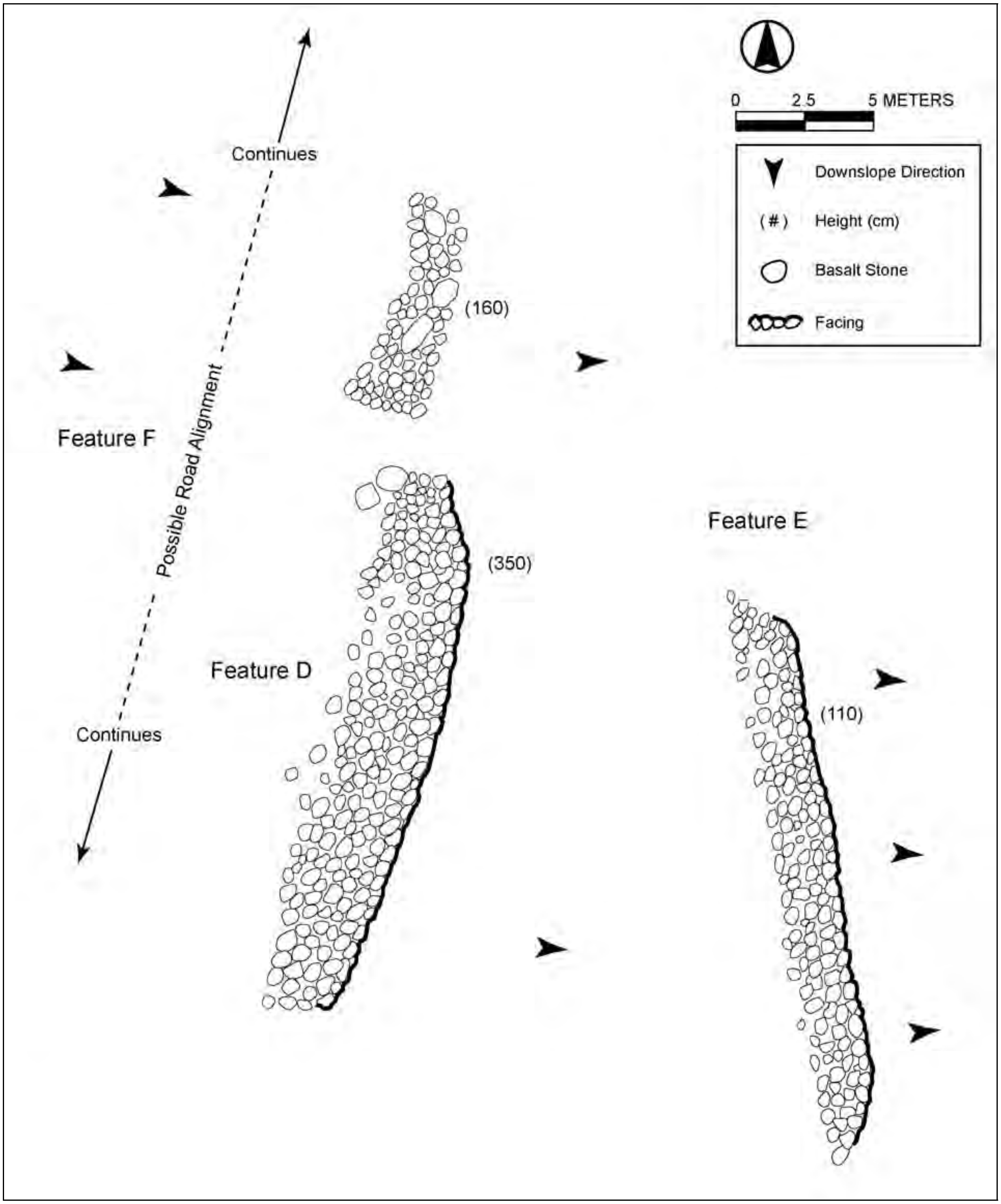

Figure 82. Plan-view diagram of SIHP # 50-80-09-7049 D and E terraces and -7049 F road/trail

Figure 83. Photograph of SIHP # 50-80-09-7049 D terrace, view to southwest

Figure 84. Photograph of SIHP # 50-80-09-7049 E terrace, view to south

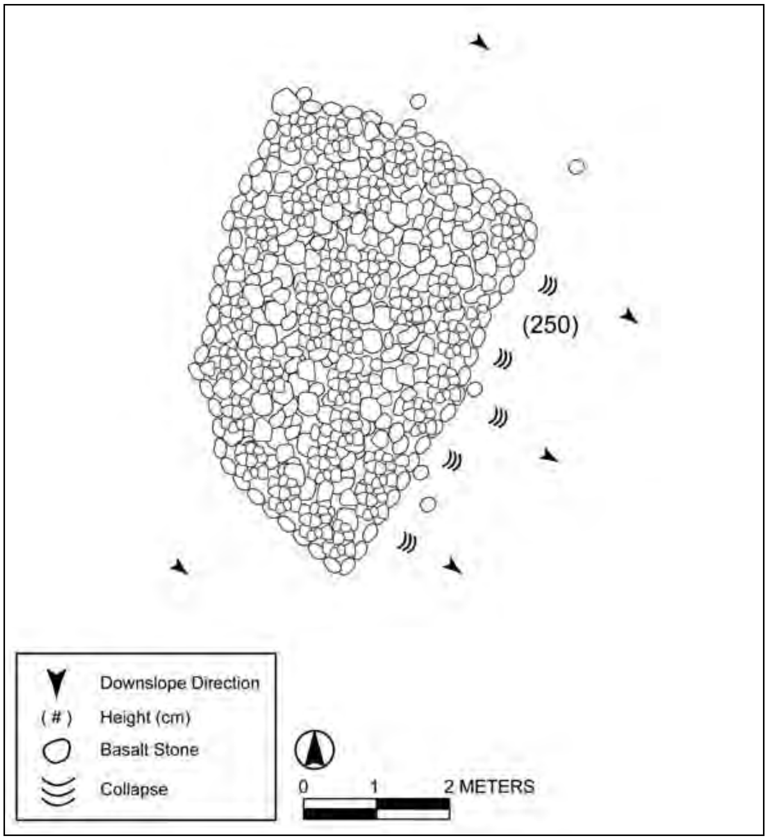

Figure 85. Plan-view diagram of SIHP # 50-80-09-7049 G mound

Figure 86. Photograph of SIHP # 50-80-09-7049 G mound, view to southwest

maximum height of 2.5 m. Lands in the vicinity of Feature G are clear of surface stones. Feature G was likely constructed during land clearing efforts associated with agricultural cultivation.

Feature H is a large terrace located approximately 16 m down slope of Feature G. The terrace is situated on moderately sloping lands along the western gulch slope, oriented along the contour of the sloping hillside. The terrace is constructed along a prominent break in slope, with lands down slope of the terrace dropping steeply to the stream channel below (Figure 87). The terrace is constructed of stacked basalt boulders and cobbles, 12-14 courses high on the south end, tapering to 3-5 courses at the north end (Figure 88). The top of the terrace is generally flush with the slope. The top surface of the southern portion of the terrace is level and roughly paved with basalt cobbles. Feature H measures 29.3 m long, 1.8 m wide, with a maximum height of 2.3 m. Lands upslope of Feature H are clear of surface stones. Feature H was likely constructed during land clearing efforts associated with agricultural cultivation. In addition, the terrace likely functioned as an erosion control structure.

Feature I is a boulder alignment located approximately 30 m south of Feature H. The alignment is constructed along an approximately 20 m long portion of the western stream bank, at the edge of an alluvial/colluvial terrace. Feature I consists of a single course alignment of basalt boulders, measuring 0.5 m wide and 0.5 m high (Figure 89). The alignment was likely constructed during land clearing efforts associated with agricultural cultivation, and functions as an erosion control structure.

Feature J is a remnant retaining wall located approximately 115 m south of Feature I. The wall is situated along the western stream bank, generally within the stream channel. The wall is constructed of stacked basalt boulders, 2-3 courses high, measuring 2.0 m long, 0.5 m wide, and 0.7 m high (Figure 90). Much of the wall structure has been destroyed by flooding and erosion of the stream bank. Feature J likely functioned as a reinforcement of the stream bank to prevent erosion.

SIHP # 50-80-09-7049 agricultural complex is interpreted as related to historic commercial agricultural cultivation. Background research indicated the base and slopes of the gulch lands including the DB3 portion of the project area were cultivated in pineapple ca. 1930s (see Figure 14). The large mounds and terraces are the result of clearing of the gulch slopes of stones to improve the land for pineapple cultivation. The terraces likely also function as erosion control features. In addition, improvements to the stream channel were made to control erosion of the stream bank and preserve adjacent alluvial/colluvial terraces for agricultural cultivation. The features of SIHP # 50-80-09-7049 are generally in good condition, with limited disturbance due to erosion and heavy vegetation growth. SIHP # 50-80-09-7049 is assessed as significant under Criterion D (have yielded, or may be likely to yield information important in prehistory or history) of the National and Hawaiʻi Registers of Historic Places evaluation criteria.

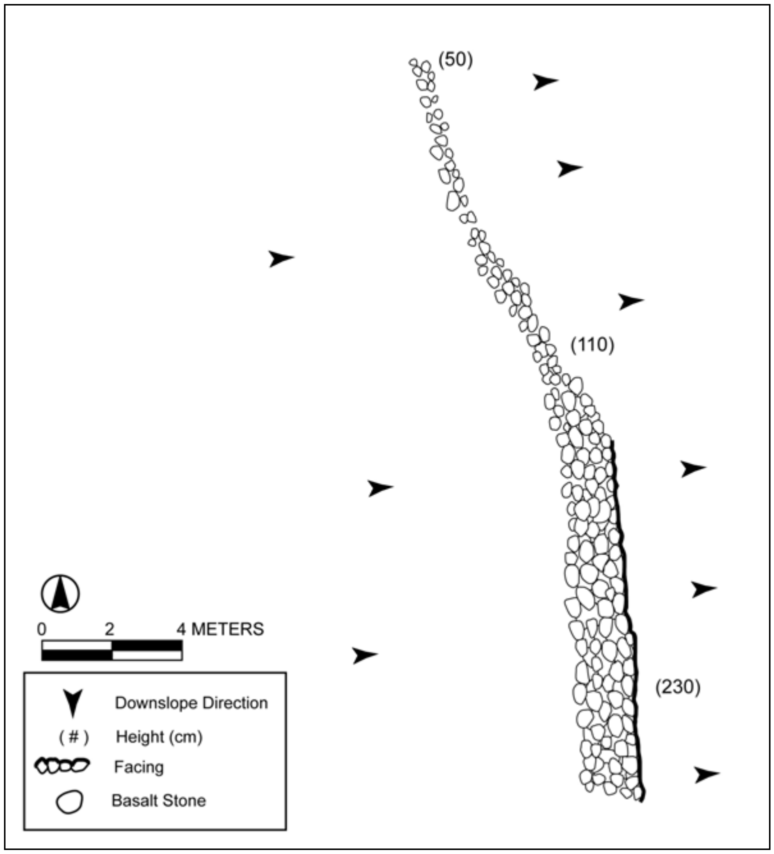

Figure 87. Plan-view diagram of SIHP # 50-80-09-7049 H terrace

Figure 88. Photograph of SIHP # 50-80-09-7049 H terrace, view to north

Figure 89. Photograph of SIHP # 50-80-09-7049 I alignment, view to southwest

Figure 90. Photograph of SIHP # 50-80-09-7049 J retaining wall, view to southwest

4.2.8 SIHP #: 50-80-09-7050

SITE TYPE: Retaining Wall and C-Shaped Wall
FUNCTION: Agricultural
FEATURES: 2
DIMENSIONS: Feature A: 20.7 m E/W; Feature B: 8.7 m N/S x 7.6 m E/W
CONDITION: Fair
PROBABLE AGE: Post-Contact
TAX MAP KEY: [1] 9-5-003:011

DESCRIPTION:

SIHP # 50-80-09-7050 consists of a retaining wall and C-shaped wall located in the Detention Basin 1 (DB 1) project area (see Figure 23 and Figure 24). The Feature A retaining wall is situated on gently to moderately sloping land near the base of the eastern wall of Kīpapa Gulch. The retaining wall is constructed along the contour of the slope, measuring 20.7 m long, 1.4 m wide, with a maximum height of 1.3 m. The retaining wall is composed of stacked basalt boulders and cobbles, 2-3 courses high (Figure 91). The top surface of the wall is generally flush with the sloping hillside.

Feature B is a C-shaped wall situated on a level alluvial/colluvial terrace, approximately 10 m west of the Kīpapa Stream channel. The C-shaped wall consists of a semi-circular wall constructed of stacked basalt boulders and cobbles, 1-3 courses high (Figure 92). Portions of the wall incorporate large boulders greater than 1 m diameter. The C-shaped wall measures 8.7 m by 7.6 m wide, with the open end of the structure facing east (Figure 93). The wall measures 2.0 m wide with a maximum height of 0.7 m.

Based on similar construction methods and proximity to features associated with historic agricultural endeavors, SIHP # 50-80-09-7050 is interpreted to also be associated with historic agriculture. The area down slope of SIHP # 50-80-09-7050 Feature A is a large, level alluvial/colluvial terrace that is presently under agricultural cultivation. The Feature A retaining wall was likely constructed along the slope bordering the planting area to prevent erosion. The slope may have also been cut to enlarge the planting area prior to the retaining wall's construction. The function of the Feature B C-shaped wall is unclear, but may have been used to define a planting area and possibly, due to its close proximity to Kīpapa Stream, as a flood control feature. SIHP # 50-80-09-7050 is in fair condition, with limited disturbance due to erosion and possible disturbance related to land clearing by modern farming operations. SIHP # 50-80-09-7050 is assessed as significant under Criterion D (have yielded, or may be likely to yield information important in prehistory or history) of the National and Hawaiʻi Registers of Historic Places evaluation criteria.

Figure 91. Photograph of SIHP # 50-80-09-7050 A terrace, view to west

Figure 92. Photograph of SIHP # 50-80-09-7050 B C-shaped wall, view to south

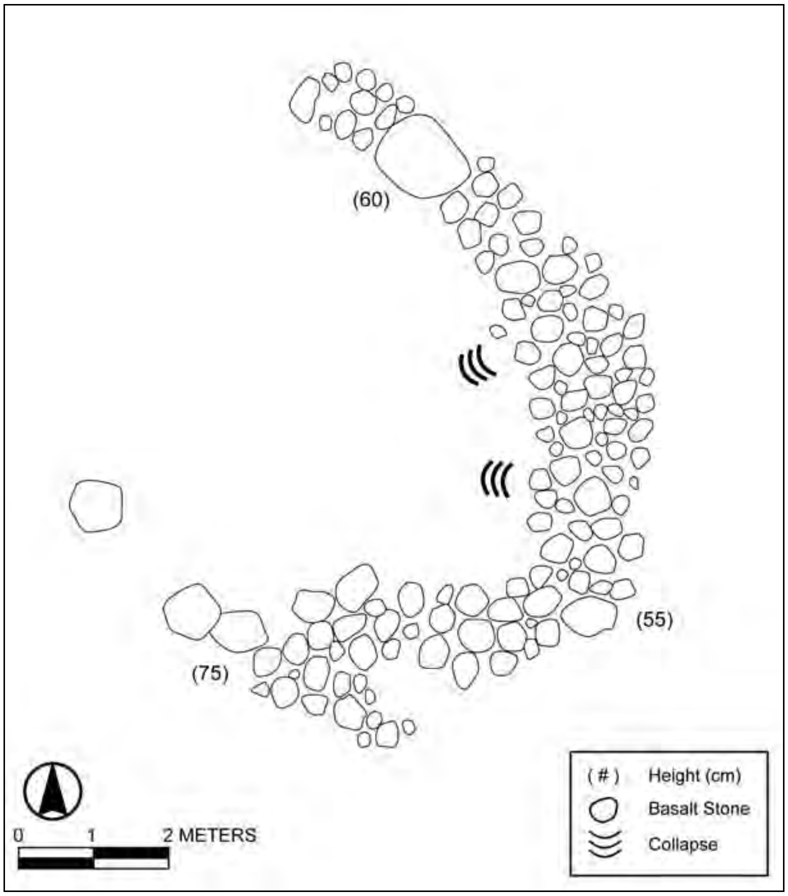

Figure 93. Plan-view diagram of SIHP # 50-80-09-7050 B C-shaped wall

4.2.9 SIHP #: 50-80-09-7051

SITE TYPE: Retaining Wall
FUNCTION: Agricultural
FEATURES: 1
DIMENSIONS:
CONDITION: Good
PROBABLE AGE: Post-Contact
TAX MAP KEY: [1] 9-4-006:029

DESCRIPTION:

SIHP # 50-80-09-7051 is a retaining wall located in the central portion of the H-2 Freeway Interchange project area (see Figure 25 and Figure 26). The retaining wall is situated along the western edge of the tablelands bordering the tributary of Pānakauahi Gulch. The retaining wall is constructed along the contour of the slope, measuring 16.3 m long. The wall is composed of stacked basalt boulders and cobbles, 3-4 courses high, with a maximum height of 0.5 m (Figure 94). The top surface of the wall is generally flush with the sloping hillside.

Figure 94. Photograph of SIHP # 50-80-09-7051 retaining wall, view to northwest

Based on similar construction methods and proximity to features associated with historic agricultural endeavors, SIHP # 50-80-09-7051 is interpreted to also be associated with historic agriculture. The retaining wall likely functions as an erosion control structure, preventing erosion of the tablelands upslope. The SIHP # 50-80-09-7051 retaining wall is also located immediately down slope of a portion of the SIHP # 50-80-09-2268 Waiahole Ditch, and may have been constructed in association with the ditch. SIHP # 50-80-09-7051 is in good condition, with limited disturbance due to erosion. SIHP # 50-80-09-7051 is assessed as significant under Criterion D (have yielded, or may be likely to yield information important in prehistory or history) of the National and Hawaiʻi Registers of Historic Places evaluation criteria.

4.2.10 SIHP #: 50-80-09-7052

SITE TYPE: Tunnel, Asphalt Pad, Building Foundation
FUNCTION: Military Related
FEATURES: 3
DIMENSIONS: Feature A: Unknown; Feature B: 180 NE/SW x 15 NW/SE; Feature C: 15 m N/S x 10 m E/W
CONDITION: Good
PROBABLE AGE: Post-Contact
TAX MAP KEY: [1] 9-4-005:006, 008

DESCRIPTION:

SIHP # 50-80-09-7052 consists of a storage tunnel and asphalt pad, located in the Detention Basin 4 (DB4) project area (see Figure 27 and Figure 28), and a large concrete slab located in the southern portion of the Drain Line 1 (DL1) project area (see Figure 29 and Figure 30). Feature A is a gated tunnel located near the western boundary of the DB4 project area. The tunnel entrance is situated along the western slope of Kīpapa Gulch. The only accessible portion of SIHP# 50-

80-09-7052 is a painted concrete facade around a central arched entrance (Figure 95). The entrance measures 2.5 m high and 1.9 m wide, and is secured with two heavy, hinged steel doors that have been welded shut. An electrical breaker switchbox is located on the concrete façade, north of the tunnel entrance, with an electrical conduit leading upward and into the tunnel. An asphalt-paved access road extends along a raised ledge above the western bank of Kīpapa Stream, fronting the tunnel entrance, with the ledge likely created from material generated by the tunnel excavation.

Feature B is a remnant asphalt pad, located in the central portion of the DB4 project area. The asphalt pad is situated on level land at the base of Kīpapa Gulch, north of the SIHP # 50-80-09-7053 Old Kamehameha Highway. The asphalt pad (Figure 96) measures approximately 180 long by 15 m wide, and is generally oriented north-south, parallel to SIHP # 50-80-09-9530 Feature F railroad alignment. Portions of the asphalt pad have been disturbed by land clearing activities in the vicinity. Several piles of concrete and asphalt, as well as a large amount of modern glass bottles and cans were observed in the vicinity of Feature B. A pair of large, rectangular pads is first indicated on the 1956 Army Map Service topographic map (see Figure 16) in the location of Feature B.

Feature C is a rectangular concrete slab situated on a level ground surface, measuring 15 m N/S by 10 m E/W (Figure 97). A soil berm borders the concrete slab to the northeast (Figure 98), and a remnant road surface borders the slab to the southwest. A large, rusted metal tank is located at the southeast corner of the concrete slab (Figure 99).

SIHP # 50-80-09-7052 Features A and B are components of the U.S. Army Upper Kīpapa Ammunition Storage Site, which consists of a series of 52 storage tunnels and associated infrastructure constructed by the U.S. Army following World War II (see Section 3.2 Historical Background). The Feature A tunnel is the southernmost of the 30 tunnels constructed along the western slope of Kīpapa Gulch, and is designated tunnel “1-D” (see Figure 17). Feature A is likely in excellent condition, as the entrance to the tunnel was sealed following its abandonment. However, the interior of the tunnel was unable to be inspected during the current study. Feature B asphalt pad is also related to storage of military-related material, possibly associated with the transfer of material from the nearby railroad line to and from the storage tunnels. Feature C is interpreted to be a historic building foundation associated with the Lower Kīpapa Ammunition Storage Site. SIHP# 50-80-09-7052 is in fair condition. No evidence of a former building or other structure was observed. SIHP # 50-80-09-7052 is assessed as significant under Criterion A (associated with events that have made an important contribution to the broad patterns of our history) and Criterion D (have yielded, or may be likely to yield information important in prehistory or history) of the National and Hawaiʻi Registers of Historic Places evaluation criteria.

Figure 95. Photograph of SIHP# 50-80-09-7052 A ammunition storage tunnel, showing tunnel entrance, view to west

Figure 96. Photograph of SIHP # 50-80-09- 7052 B remnant asphalt pad, view to east

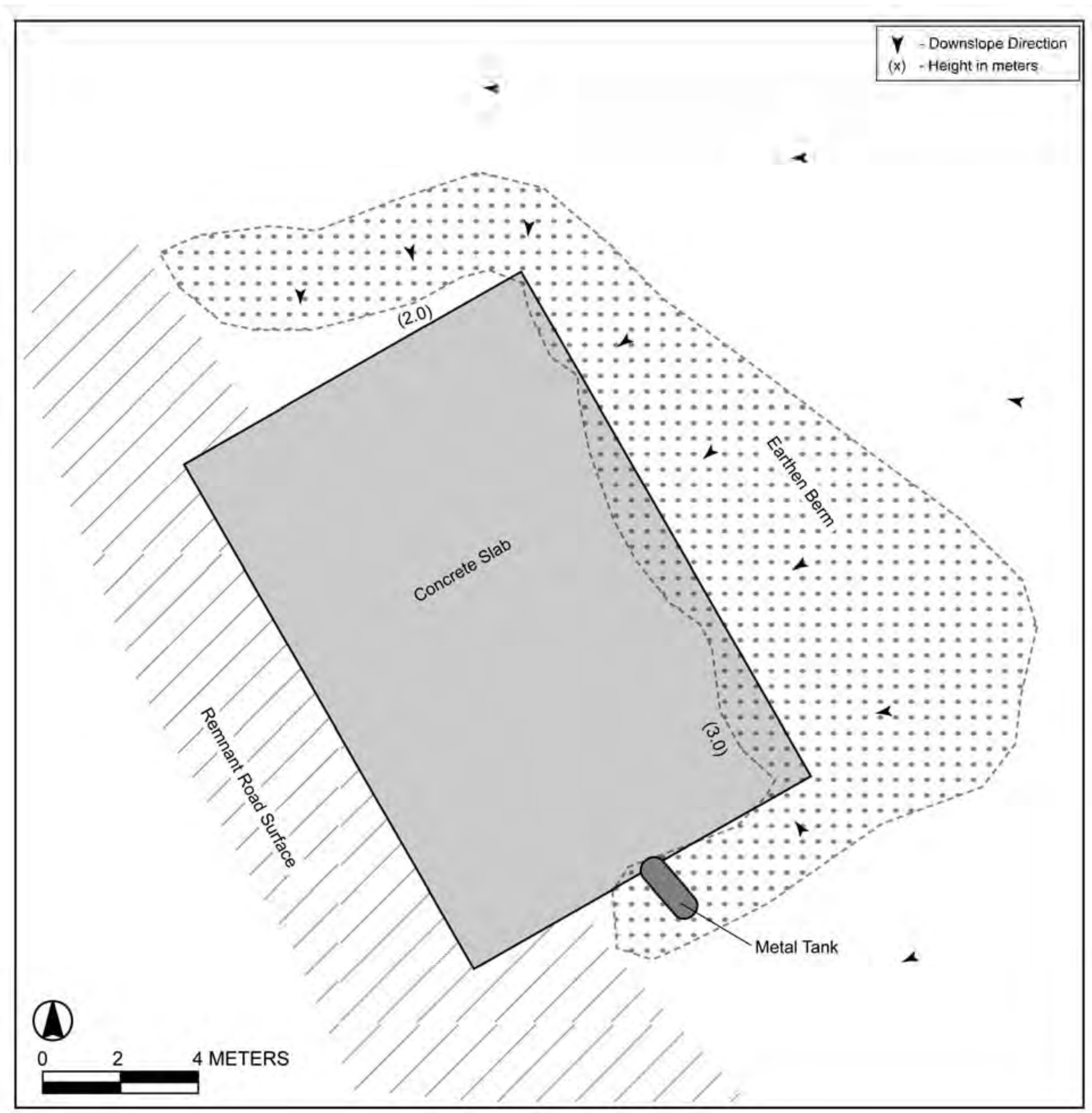

Figure 97. Plan-view diagram of SIHP # 50-80-09-7052 C concrete building foundation

Figure 98. Photograph of SIHP # 50-80-09-7052 C concrete building foundation, view to northwest

Figure 99. Photograph of SIHP # 50-80-09-7052 C concrete building foundation, showing metal tank, view to southeast

4.2.11 SIHP #: 50-80-09-7053

SITE TYPE: Historic Roadway (Old Kamehameha Highway)
FUNCTION: Transportation
FEATURES: 3
DIMENSIONS: Features located along approximately 1.2 km long corridor
CONDITION: Good
PROBABLE AGE: Post-Contact
TAX MAP KEY: Old Kamehameha Highway Right-of-Way

DESCRIPTION:

SIHP # 50-80-09-7053 is a historic roadbed and associated features, located within the proposed Detention Basin 4 Access Road project area (see Figure 27 and Figure 28). The road is the original alignment of Kamehameha Highway, known as the “Old Kamehameha Highway.” Feature A is the Old Kamehameha Highway roadbed. The roadbed generally measures 5-6 m wide, with a combination of asphalt and concrete paving. The road enters the project area from the south, at the top edge of the eastern slope of Kīpapa Gulch. The road then progresses north, along the eastern slope of Kīpapa Gulch, gradually heading down slope to the base of the gulch. Along the gulch slope, the road is cut into the sloping hillside. The portion of the road along the gulch slope includes a wall (Feature B) that extends along the western (down slope) edge of the road for approximately 900 m (Figure 100). The wall is constructed of 2-4 courses of cut and mortared basalt blocks, with an average width of 0.3 m and heights ranging from 0.4-1.0 m (Figure 101). An approximately 110 m long wall segment is also located along a portion of the upslope edge of the road, where the road curves around a steep portion of the gulch slope. The Feature B wall functions as a barrier to prevent vehicles from driving off the edge of the road to the gulch below. The wall along the upslope portion of the road also functions as an erosion control feature, preventing sediment from eroding on to the road from the slope above. Portions of the downslope wall have collapsed due to erosion. At the base of Kīpapa Gulch, the road crosses the Kīpapa Stream via a concrete bridge (Feature C; Figure 102). The Kīpapa Stream bridge was constructed in 1923 (Figure 103).

Until the construction of the H-2 freeway in the 1970s, Kamehameha Highway was the major vehicular transportation corridor through central Oʻahu. The SIHP # 50-80-09-7053 Old Kamehameha Highway alignment was in use until the highway was realigned with the construction of the Roosevelt Bridge across Kīpapa Gulch in 1934. SIHP # 50-80-09-7053 is in good condition, with limited disturbance due to erosion. SIHP # 50-80-09-7053 is assessed as significant under Criterion A (associated with events that have made an important contribution to the broad patterns of our history) and Criterion D (have yielded, or may be likely to yield information important in prehistory or history) of the National and Hawaiʻi Registers of Historic Places evaluation criteria.

Figure 100. Photograph of SIHP # 50-80-09-7053 Old Kamehameha Highway roadbed (Feature A), showing wall (Feature B) along down slope edge (right), view to south

Figure 101. Photograph of SIHP # 50-80-09-7053 B wall, view to west

Figure 102. Photograph of SIHP # 50-80-09-7053 C Kīpapa Stream bridge, showing bridge foundation, view to southwest

Figure 103. Photograph of SIHP # 50-80-09-7053 C Kīpapa Stream Bridge, showing “C&C 1923” date inscription

4.2.12 SIHP #: 50-80-09-9530

SITE TYPE: Complex
FUNCTION: Agriculture and Transportation
FEATURES: 7
DIMENSIONS: Features located within approximately 13 acres
CONDITION: Good
PROBABLE AGE: Post-Contact
TAX MAP KEY: [1] 9-4-005:008

DESCRIPTION:

SIHP # 50-80-09-9530 was initially identified as "Kīpapa Platform and Terraces" during an inventory survey of lands owned by the U.S. Army lands by the Bishop Museum (Rosendahl 1977:2-21). In a subsequent archaeological study by Hammatt and Borthwick (1988), SIHP # 50-80-09-9530 was redefined to include features "related to activities of the Oahu Sugar Co." (Hammatt and Borthwick 1988:42). These features included a stone-lined ditch, a cement dam, cement slabs, stone and mortar alignments, former roadways, and a railroad berm. Seven features associated with SIHP # 50-80-09-9530 were identified within the Detention Basin 4 (DB4) project area (see Figure 27, Figure 28, and Figure 104; Table 6). Four features (i.e. Features A-C, and E) are plantation irrigation-related structures. Three features (i.e. Features D, F and G) are plantation transportation-related structures.

Feature A is a well-constructed irrigation ditch. The ditch, based on observations by Hammatt and Borthwick (1988) and Hammatt et al. (1996), originates at a dam within Kīpapa Stream, approximately 0.7 km north of the project area. From the intake at Kīpapa Stream, the ditch progresses south, situated along the eastern slope of Kīpapa Gulch. The ditch runs along the eastern slope of the gulch, through the project area, and continues to the south, beyond the project area. As the ditch progresses south, it gradually climbs the east slope of Kīpapa Gulch until reaching the top of the gulch slope and progressing along the tablelands of the *makai* portion of Waipiʻo.

Within the current project area, the Feature A ditch extends approximately 440 m along the eastern slope of Kīpapa Gulch. The ditch is generally U-shaped, with a flat bottom and sloping side walls, measuring 1.5 m wide at the base and 2.5 m wide at the top surface, with a depth of 1.4 m. The interior of the ditch is lined with cut ("dressed") and mortared basalt blocks, each measuring approximately 30 by 30 cm, with stones 3-5 courses high along the side walls of the ditch (Figure 105). Portions of the ditch also have 2-3 courses of stacked basalt cobbles above the mortared blocks (Figure 106). Two sluice gates (Figure 107) are constructed within the western (down slope) edge of the Feature A ditch, allowing irrigation water from the ditch to be released to secondary ditches or fields down slope. Within the project area, the Feature A ditch crosses two relatively small tributary gulches. At the crossings, stone and mortar foundations are constructed along the upslope (Figure 108) and down slope (Figure 109) edges of the ditch (Figure 110 and Figure 111). These stone and mortar foundation constructions likely supported

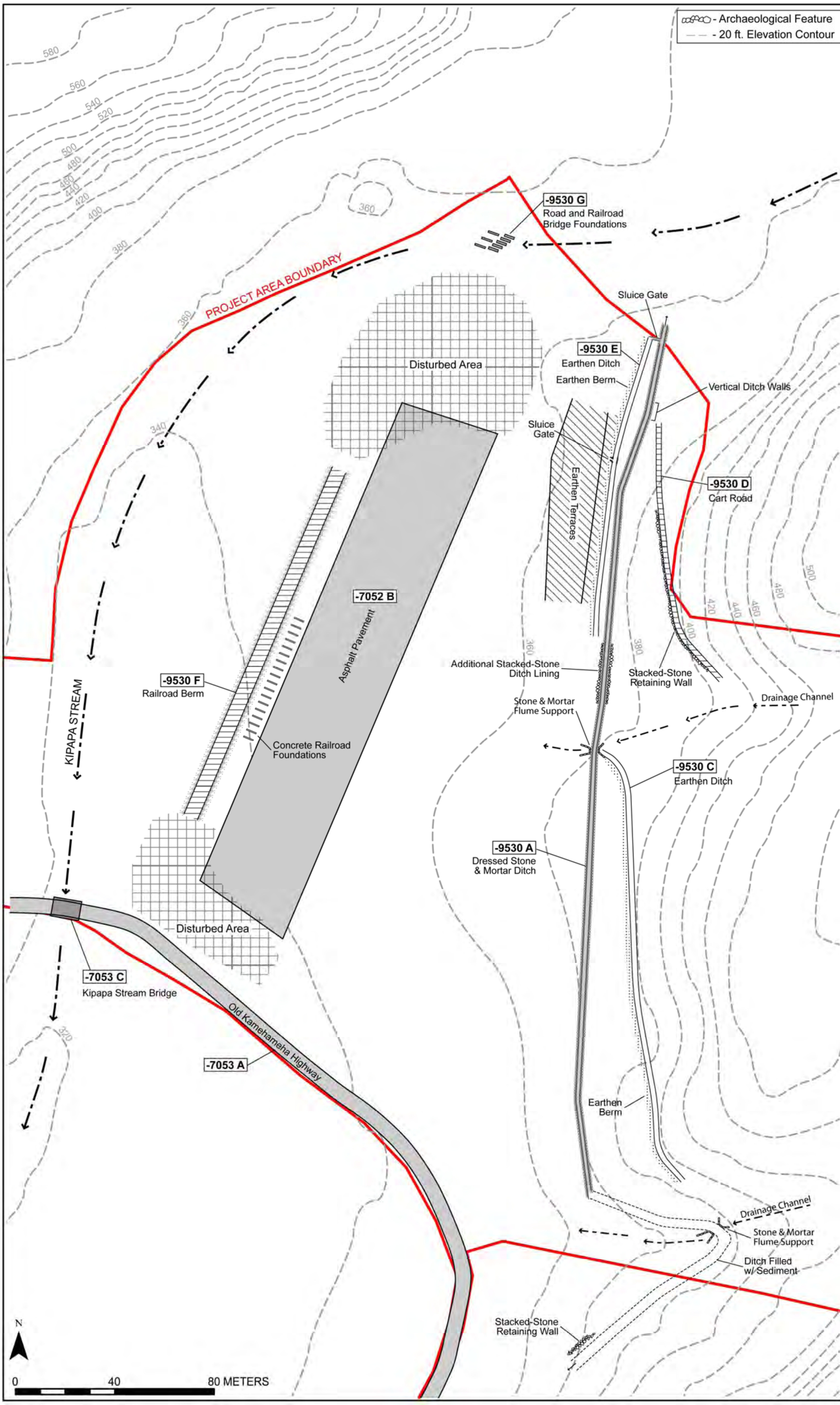

Figure 104. Plan-view diagram of SIHP # 50-80-09-9530 Features A-G, including -7052 B, -7053 A, and -7053 C

Table 6. List of SIHP # 50-80-09-9530 Features

Feature	Type	Function	Dimensions	Photograph(s)
A	Irrigation Ditch	Plantation Irrigation	L: 440 m + W: 1.5-2.5 m D: 1.4 m	Figure 105 Figure 106 Figure 107 Figure 108 Figure 109 Figure 114 Figure 115
B	Irrigation Ditch	Plantation Irrigation	L: 25 m + W: 1.5 m D: 0.7 m	Figure 116
C	Drainage Ditch	Flood Control	L: 180 m W: 2-4 m D: 0.5 m	Figure 117
D	Cart Road	Transportation	L: 140 m W: 2.2 m	Figure 118 Figure 119
E	Irrigation Ditch	Plantation Irrigation	L: 120 m W: 1.0 m D: 0.5 m	Figure 120 Figure 121
F	Railroad Berm	Plantation / Military Transportation	L: 160 m	Figure 122 Figure 123 Figure 124
G	Railroad / Road Bridge Foundations	Plantation / Military Transportation	L: 12 m W: 12 m H: 3 m	Figure 127 Figure 129

Figure 105. Photograph of SIHP# 50-80-09-9530 A irrigation ditch, showing cut basalt block lining, view to south

Figure 106. Photograph of SIHP# 50-80-09-9530 A irrigation ditch, showing cut basalt block lining with stacked basalt cobbles above, view to east

Figure 107. Photograph of SIHP # 50-80-09-9530 A irrigation ditch, showing sluice gate along western (down slope) edge of the ditch, view to west

Figure 108. Photograph of SIHP # 50-80-09-9530 A irrigation ditch, showing flume support along eastern (upslope) edge of the ditch, view to north

Figure 109. Photograph of SIHP # 50-80-09-9530 A irrigation ditch, showing flume support along western (down slope) edge of the ditch, view to southwest

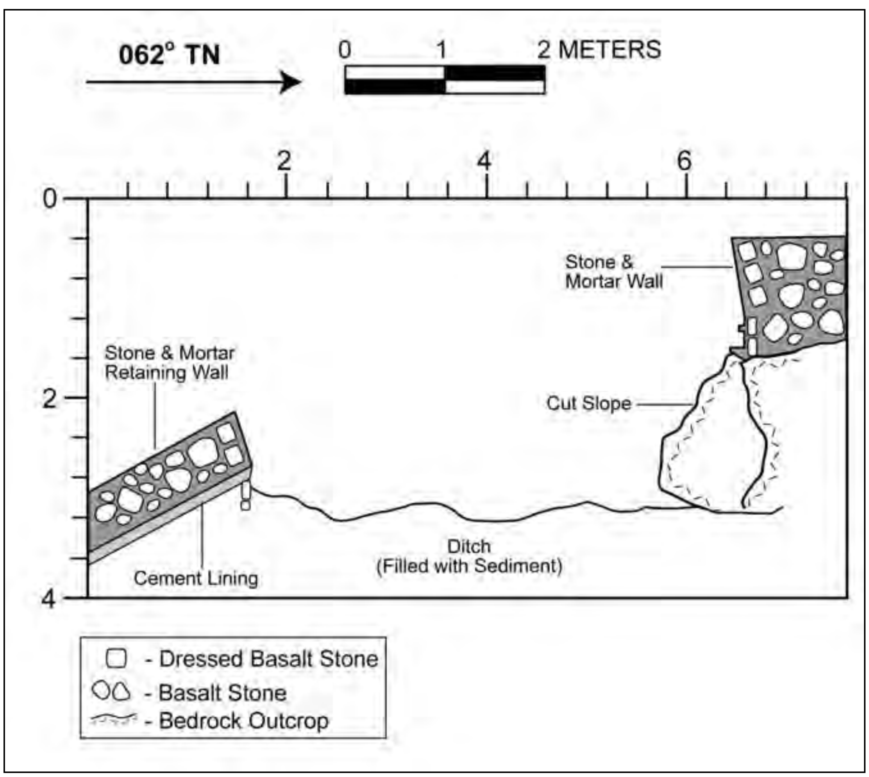

Figure 110. Cross-section diagram of foundations for flume-type structure crossing over SIHP # 50-80-09-9530 A irrigation ditch

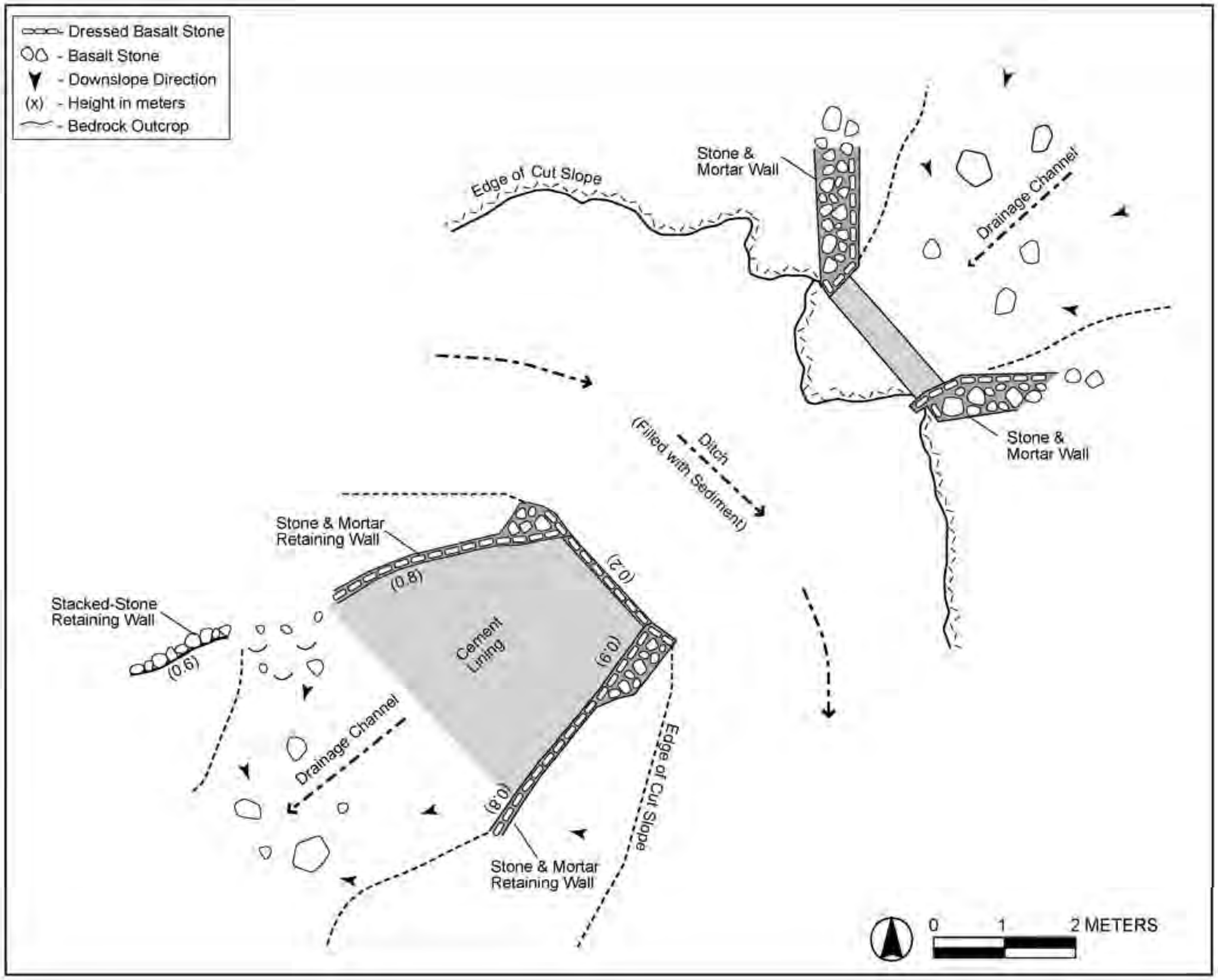

Figure 111. Plan-view diagram of foundations for flume-type structure crossing over SIHP # 50-80-09-9530 A irrigation ditch

rectangular wooden flume structures that ran perpendicular to the Feature A ditch. Similar stone and mortar foundations, along with an intact flume structure (Figure 112), were documented by Hunkin et al. (2008) along a portion of SIHP # 50-80-09-2268 Waiahole Ditch in Honouliuli, where the ditch intersects with a drainage gully. The flume-type structures would have allowed storm water draining from the tributary gulches to flow over the Feature A ditch, thereby reducing damage to and sedimentation of the ditch during periods of heavy rainfall. No remains of the wooden flume structures was observed. Near the southern boundary of the DB4 project area, near the intersection of a tributary gulch, a portion of the Feature A ditch has been disturbed. The cut slope and graded path of the ditch are visible, however, the ditch has become completely filled and covered with sediment. The disturbance to this portion of the ditch may be associated with the construction of a power line corridor located immediately upslope of the area, as well as sedimentation due to erosion of upslope areas.

South of the disturbed portion of the Feature A ditch, in the vicinity of the DB4 access road portion of the project area, is an intact portion of the Feature A ditch, including a ditch tunnel (Figure 113). At the intersection of the Feature A ditch and the SIHP # 50-80-09-7053 Old Kamehameha Highway, a concrete bridge is constructed over the ditch (Figure 114). Approximately 12 m northeast of the edge of the Old Kamehameha Highway is the southern end of a ditch tunnel. The tunnel entrance is constructed of cut (“dressed”) and mortared basalt blocks, with a U-shaped ditch channel and arched ceiling, measuring 1.8 m wide and 1.0 m high (Figure 115). A “1931” date plaque is set in the tunnel entrance, just above the arched ceiling. The tunnel was observed to extend approximately 80 m to the northeast, through a portion of the eastern gulch slope, before ending in an area of impassable ceiling collapse. South of the tunnel entrance, Feature A is an open ditch, similar in construction to the previously described northern portions, including lining of cut basalt blocks and mortar. The Feature A ditch was observed to continue to the south beyond the concrete bridge, downslope of and roughly paralleling the Old Kamehameha Highway.

Feature B is an irrigation ditch that connects to the southern documented portion of Feature A ditch, between the ditch tunnel and the Old Kamehameha Highway bridge (see Figure 113). The Feature B ditch is of similar construction as Feature A, including a lining of mortared basalt blocks (Figure 116). The Feature B ditch is oriented upslope, extending beyond the current survey area. The ditch likely connects to an associated ditch system on the tablelands outside of Kīpapa Gulch, allowing water from that system to be transferred to the ditches and fields within the gulch.

Feature C is an earthen ditch that extends along the eastern slope of Kīpapa Gulch, upslope from, and generally parallel to Feature A. The ditch consists of an earthen channel measuring 2-3 m wide and 0.5 m deep, with an earthen berm along the downslope edge (Figure 117). No stone lining or retaining walls were observed. Feature C originates at the north edge of a tributary gulch and extends north for approximately 180 m at a slight downslope angle, and terminates at an intersection with the Feature A ditch. At the intersection is a previously described flume support structure, adjacent to the Feature A ditch. Feature C likely functioned as a water diversion feature. The ditch collects storm water draining from the eastern gulch slope, upslope of the Feature A irrigation ditch. The water is collected along the length of the Feature C ditch and is then directed over the Feature A irrigation ditch via the aforementioned flume system, thereby preventing flooding and sedimentation of the Feature A irrigation ditch.

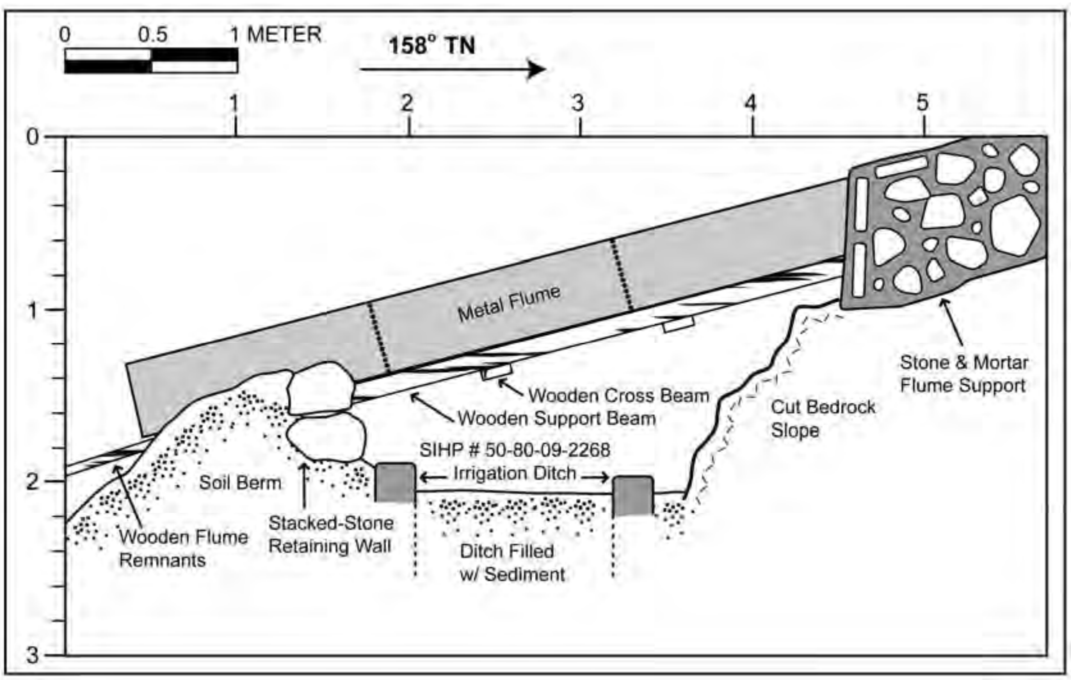

Figure 112. Photograph (above) and cross-section diagram (below) of stone and mortar foundations and metal flume crossing portion of SIHP # 50-80-09-2268 Waiahole Ditch (Hunkin et al. 2008:56-57)

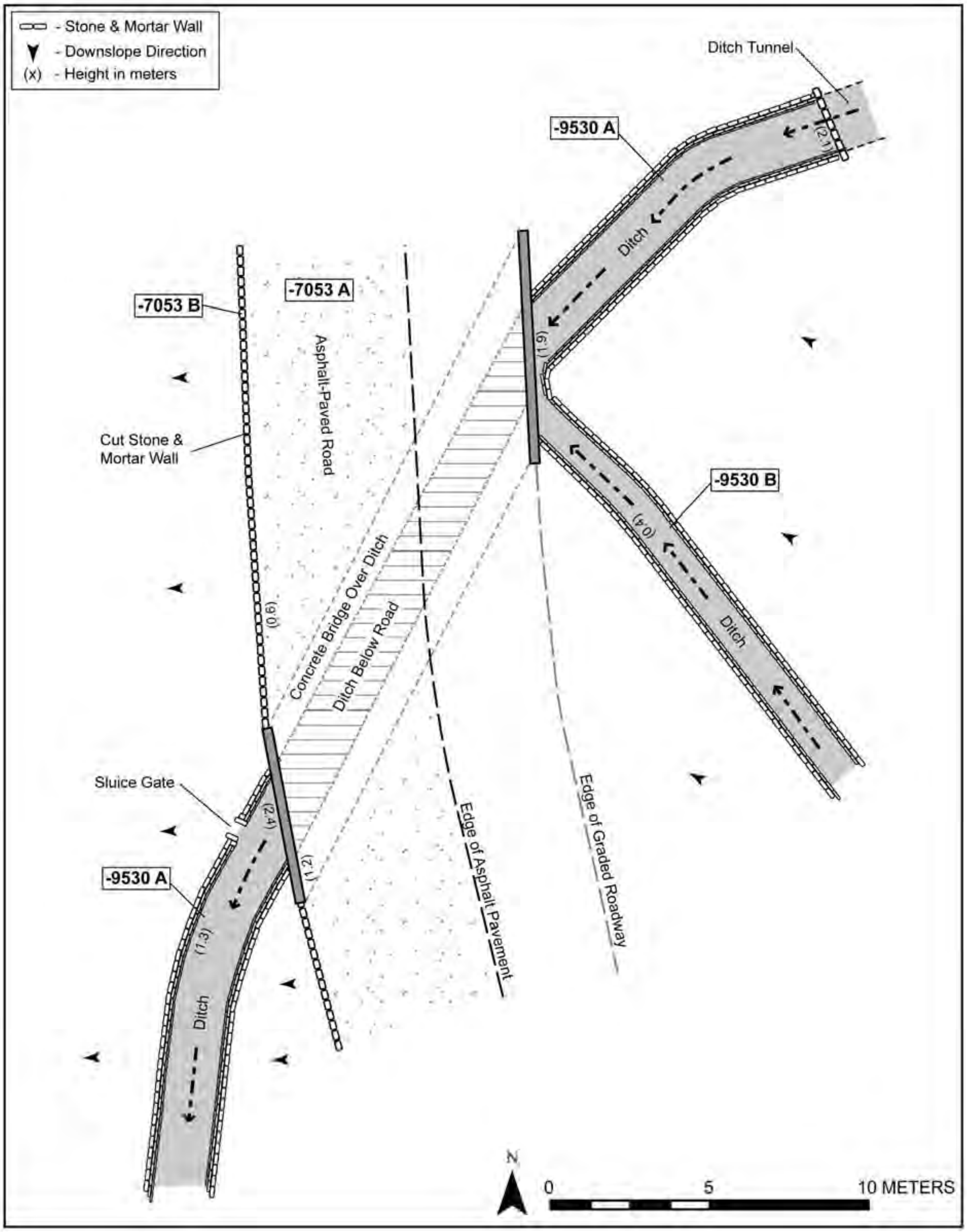

Figure 113. Plan-view diagram of SIHP # 50-80-09-9530 A and B irrigation ditches, at the intersection with SIHP # 50-80-09-7053 A and B Old Kamehameha Highway

Figure 114. Photograph of concrete bridge over SIHP # 50-80-09-9530 A irrigation ditch, view to northeast

Figure 115. Photograph of SIHP # 50-80-09-9530 A irrigation ditch, showing tunnel entrance, view to northeast. Note the "1931" date plaque.

Figure 116. Photograph of SIHP # 50-80-09-9530 B irrigation ditch, view to southeast

Figure 117. Photograph of SIHP # 50-80-09-9530 C earthen ditch, view to north

Feature D is a cart road that extends along the eastern slope of Kīpapa Gulch, upslope of the Feature A ditch. The road consists of an approximately 2 m wide graded path cut into the moderately sloping hillside (Figure 118). Portions of the road include a retaining wall along the down slope edge, particularly in steep areas or curves in the road (Figure 119). The retaining wall is constructed of stacked basalt boulders and cobbles, 1-4 courses high, with a maximum height of 1.3 m. Feature D originates at an intersection with the Feature A ditch and extends south for approximately 140 m at a slight upslope angle before curving east into a tributary gulch. Within the tributary gulch, the road alignment is difficult to discern due to heavy erosion. The cart road likely continued up the tributary gulch to the plantation road network on the tablelands outside of Kīpapa Gulch. At the intersection of the cart road and the Feature A ditch, the walls of the ditch are vertical, whereas in all other observed portions of the ditch the side walls are sloping. The vertical ditch side walls at the intersection of the Feature D cart road may indicate a bridge was constructed over the ditch at this location.

Feature E is an earthen irrigation ditch that extends along the eastern slope of Kīpapa Gulch, down slope from, and generally parallel to Feature A. The ditch consists of an earthen channel measuring 1.0 m wide with an average depth of 0.5 m (Figure 120). The ditch is supported along the down slope edge by a basalt boulder and soil berm. Feature E originates at a sluice gate constructed in the eastern edge of the Feature A irrigation ditch, near the northern boundary of the project area. The ditch then extends south for approximately 120 m at a slight down slope angle, and terminates at a drainage swale. A stone and mortar sluice gate (Figure 121), as well as several small, un-gated openings, are constructed along the down slope edge of the Feature E ditch, allowing water from the ditch to be released to fields down slope. Two planting areas are located down slope of the Feature E irrigation ditch. The planting areas consist of leveled soil terraces without retaining walls. The terraces are parallel to the Feature E ditch, measuring approximately 120 m in length, with the upslope terrace measuring 6 m wide and the middle terrace measuring 10 m wide.

Feature F is a segment of a railroad berm, located at the base of Kīpapa Gulch. The railroad alignment is generally oriented north-south, providing access up or down the gulch, with the raised berm portion of the railroad alignment measuring approximately 160 m long. The railroad berm is constructed of crushed coral and basalt pebbles, measuring approximately 1.5 m high along the downslope edge. A series of parallel concrete beams are located along a portion of the eastern edge of the railroad berm, oriented perpendicular to the railroad alignment (Figure 122). A rectangular concrete foundation is also located adjacent to the railroad berm (Figure 123). The southern portion of Feature F appears to have been disturbed by land clearing activities. A pile of utility pole supports and steel railroad rails (Figure 124), as well as a large quantity of modern glass bottles, cans, and refuse were observed in the vicinity. The railroad alignment is indicated on historic maps as early as 1919 (see Figure 11). The railroad was constructed by Oahu Sugar Company to support plantation agricultural activities (see Section 3.2 Historical Background). Following the establishment of the Kīpapa Ammunition Storage Sites within Kīpapa Gulch, the railroad was used to transport military-related material. A map of the Upper Kīpapa Ammunition Storage Site (see Figure 17) indicates the Feature F railroad berm was the location of a loading area where material was transferred from the railroad to a road network. The series of concrete beams adjacent to the railroad berm likely supported a parallel section of railroad associated with

Figure 118. Photograph of SIHP # 50-80-09-9530 D cart road, view to south

Figure 119. Photograph of SIHP # 50-80-09-9530 D cart road, showing retaining wall along down slope edge, view to northeast

Figure 120. Photograph of SIHP # 50-80-09-9530 E irrigation ditch, view to northeast

Figure 121. Photograph of SIHP # 50-80-09-9530 E irrigation ditch, showing sluice gate, view to east

Figure 122. Photograph of SIHP # 50-80-09-9530 F railroad berm, showing adjacent concrete support beams, view to north

Figure 123. Photograph of concrete foundation adjacent to SIHP # 50-80-09-9530 F railroad berm, view to southwest

Figure 124. Photograph of discarded steel rails associated with the SIHP # 50-80-09-9530 F railroad berm, view to northwest

the loading/unloading of rail cars. A parallel section of railroad is indicated on the map of the Upper Kīpapa Ammunition Storage Site (see Figure 17), and this section of track was likely constructed in association with military development in the area, postdating the main railroad berm.

Feature G consists of two parallel alignments of bridge foundations that extend northeast/southwest across Kīpapa Stream (Figure 125 and Figure 126), near the northern boundary of the project area. The eastern bridge alignment consists of a series of five foundations constructed of reinforced concrete (Figure 127). Each foundation measures 4.9 m long by 2.4 m wide, with a maximum height of 1.8 m. The western bridge alignment consists of a series of three foundations (Figure 128), with two stacked-stone retaining walls constructed along both edges of the stream bank, immediately upslope of the foundations. The stacked basalt boulder retaining walls measure 3.5-5.0 m long by 0.6-1.0 m wide, with a maximum height of 2.5 m (Figure 129). Historic maps dating as early as 1919 (see Figure 11) indicate a plantation railroad and road crossing Kīpapa Stream at the location of Feature G. Based on the elevation difference between the top of the stream bank and the top of the concrete foundations (Figure 126), the foundations likely supported wooden trellis-type bridges for the road and railroad.

SIHP # 50-80-09-9530 consists of historic irrigation and transportation related structures attributable to the Oahu Sugar Company. Background research indicated plantation sugar cane cultivation within Kīpapa Gulch began in the early 1900s and continued until the U.S. military acquired the land in the mid 1900s. The plantation ditches (i.e. Features A-C, E) provided

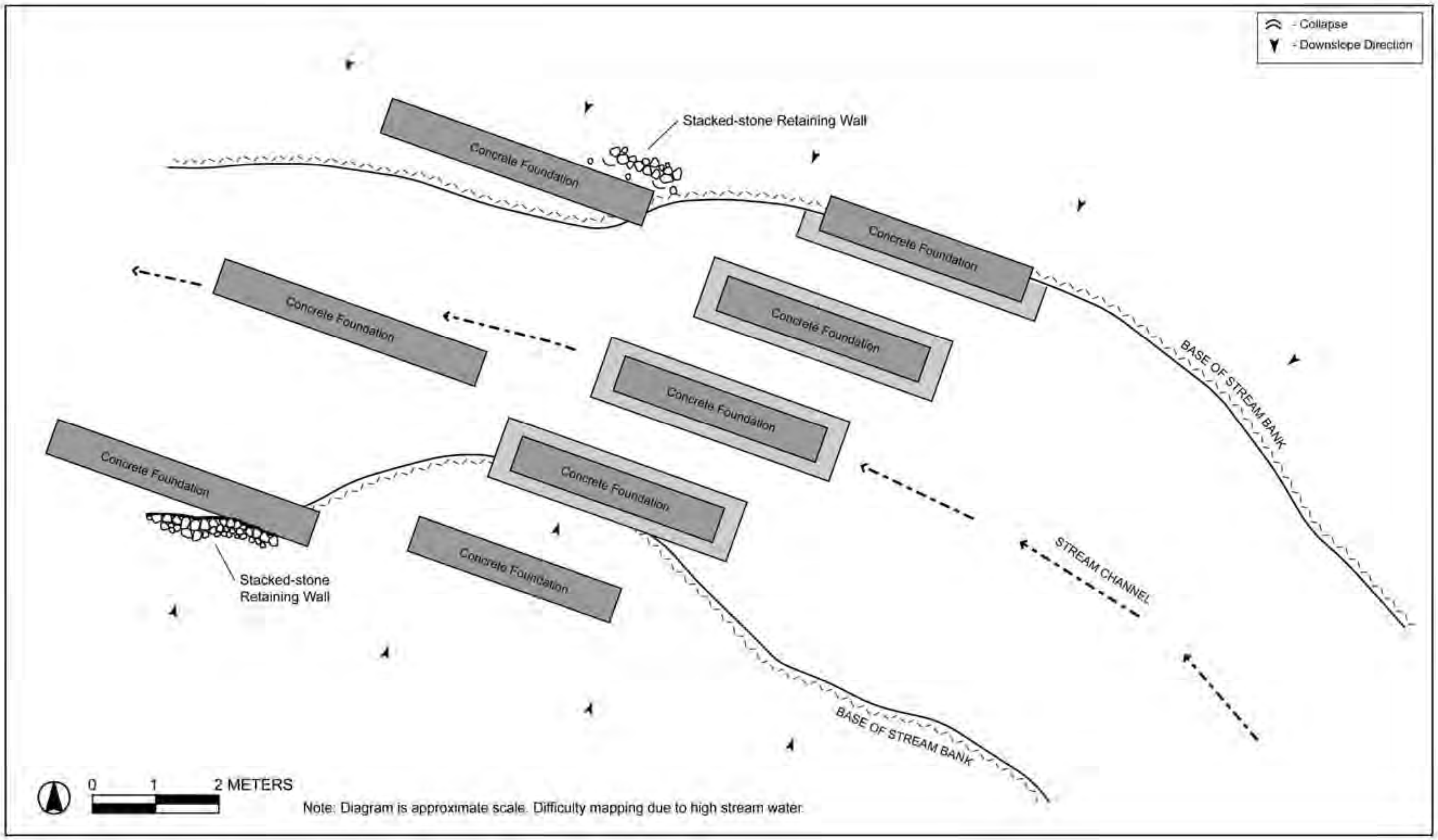

Figure 125. Plan-view diagram of SIHP # 50-80-09-9530 G railroad and road bridge foundations

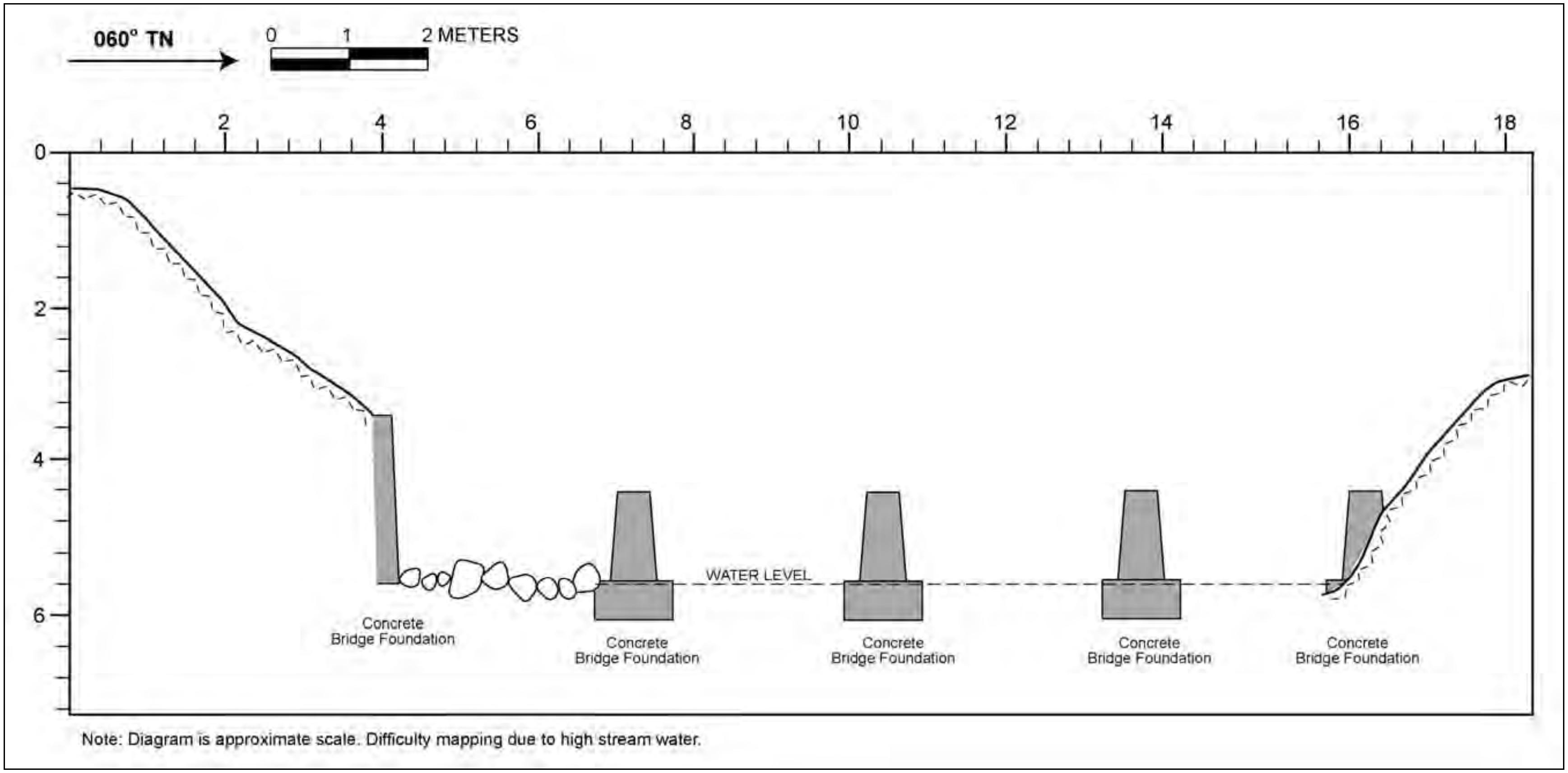

Figure 126. Cross-section diagram of SIHP # 50-80-09-9530 G railroad bridge

Figure 127. Photograph of SIHP # 50-80-09-9530 G reinforced concrete bridge foundations, eastern alignment, view to northeast

Figure 128. Photograph of SIHP # 50-80-09-9530 G reinforced concrete bridge foundations, western alignment, view to north

Figure 129. Photograph of SIHP# 50-80-09-9530 G stacked-stone retaining wall along stream bank, view to south

irrigation water tapped from Kīpapa Stream to fields within the project area and lands to the south. The plantation railroad and road network (i.e. Features D, F and G) provided access through Kīpapa Gulch to support the plantation agricultural activities. The railroad was also subsequently used by the U.S. Army to transport materials to and from the Kīpapa Ammunition Storage Sites. SIHP # 50-80-09-9530 is in good condition. Portions of the component features have been disturbed by erosion and land clearing activities. SIHP # 50-80-09-9530 is assessed as significant under Criterion A (associated with events that have made an important contribution to the broad patterns of our history), Criterion C (embody the distinctive characteristics of a type period or method of construction), and Criterion D (have yielded, or may be likely to yield information important in prehistory or history) of the National and Hawaiʻi Registers of Historic Places evaluation criteria.

4.2.13 SIHP #: 50-80-09-9534

SITE TYPE: Complex
FUNCTION: Agricultural/Transportation
FEATURES: 6
DIMENSIONS: Features located within approximately 14 acres
CONDITION: Fair
PROBABLE AGE: Post-Contact
TAX MAP KEY: [1] 9-4-005:006

DESCRIPTION:

SIHP# 50-80-09-9534 was initially identified as "Kīpapa Platform" during a survey of Army lands by Bishop Museum (Rosendahl 1977: 2-21). In a subsequent archaeological study by Hammatt and Borthwick (1988), the function of SIHP # 50-80-09-9534 was evaluated as relating to railroad construction, based on "construction style (all large boulders)" and "location (between two rail roads)" (Hammatt and Borthwick 1988:45). The presence of four tin cans within platform was also noted (Hammatt and Borthwick 1988). The previously identified SIHP # 50-80-09-9534 platform (i.e. Feature A) was relocated within the Drain Line 1 (DL1) project area (see Figure 29 and Figure 30). Five additional plantation-related features (i.e. Features B-F) were also identified within the project area and are being included in the SIHP # 50-80-09-9534 designation (Table 7).

Feature A is an irregular-shaped platform located near the base of the eastern slope of Kīpapa Gulch. The platform is approximately 10 m east of a modern access road that extends roughly north-south through the center of the project area. The platform measures 12.0 m by 8.0 m wide, with a maximum height of 2.5 m along the down slope edge (Figure 130). The platform is constructed of stacked basalt boulders, 3-6 courses high (Figure 131). The boulders within the platform construction are generally large, in excess of 1 m in diameter. The upslope edge of the platform is nearly flush with the sloping hillside. A portion of the down slope edge of the platform has suffered from collapse.

Feature B is an earth-lined ditch that extends approximately 90 m along the eastern slope of Kīpapa Gulch, roughly parallel to Kamehameha Highway (Figure 132). The Feature B ditch measures 1-2 m wide, with a maximum depth of 0.5 m, and includes a stone and soil berm along the down slope edge (Figure 133). A 70 cm high stacked-stone retaining wall is also constructed along a portion of the downslope edge of the ditch. The eastern end of the Feature B ditch is truncated, likely during the construction of Kamehameha Highway or other land-clearing activities in the vicinity. Feature C is an earth-lined ditch that connects to the northern portion of the Feature B ditch. The Feature C ditch runs down slope, perpendicular to Feature B. At the intersection of the Feature B and Feature C ditches is a sluice gate constructed of mortared basalt blocks (Figure 134). The Feature C ditch extends approximately 23 m before terminating near the road-cut of the asphalt-paved access road. Feature D is a remnant irrigation ditch located approximately 30 m south of Feature C, situated on a gently sloping portion of the eastern edge of Kīpapa Gulch. The ditch is earth-lined, running downslope of an roughly parallel to the

Table 7. List of SIHP # 50-80-09-9534 Features

Feature	Type	Function	Dimensions	Photograph(s)
A	Platform	Plantation Clearing	L: 12.0 m W: 8.0 m H: 2.5 m	Figure 131
B	Irrigation Ditch	Plantation Irrigation	L: 90 m W: 3 m D: 0.3 m	Figure 133
C	Irrigation Ditch	Plantation Irrigation	L: 23 m W: 1 m D: 0.5 m	Figure 134
D	Remnant Irrigation Ditch	Plantation Irrigation	N/A	Figure 135
E	L-Shaped Alignment	Field Boundary	L: 15 m W: 8 m H: 0.5 m	Figure 136
F	Railroad Bridge	Plantation Transportation	L: 34 m W: 8 m H: 3.0 m	Figure 139; Figure 140

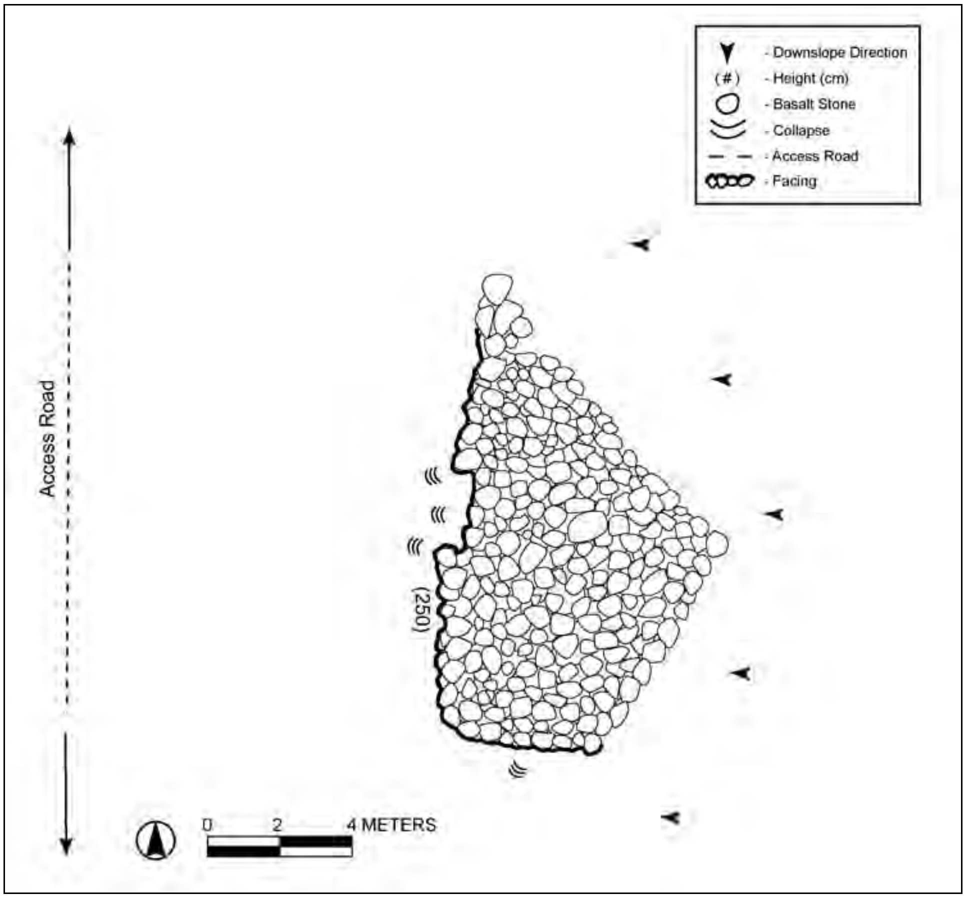

Figure 130. Plan-view diagram of SIHP # 50-80-09-9534 A platform

Figure 131. Photograph of SIHP# 50-80-09-9534 A platform, view to south

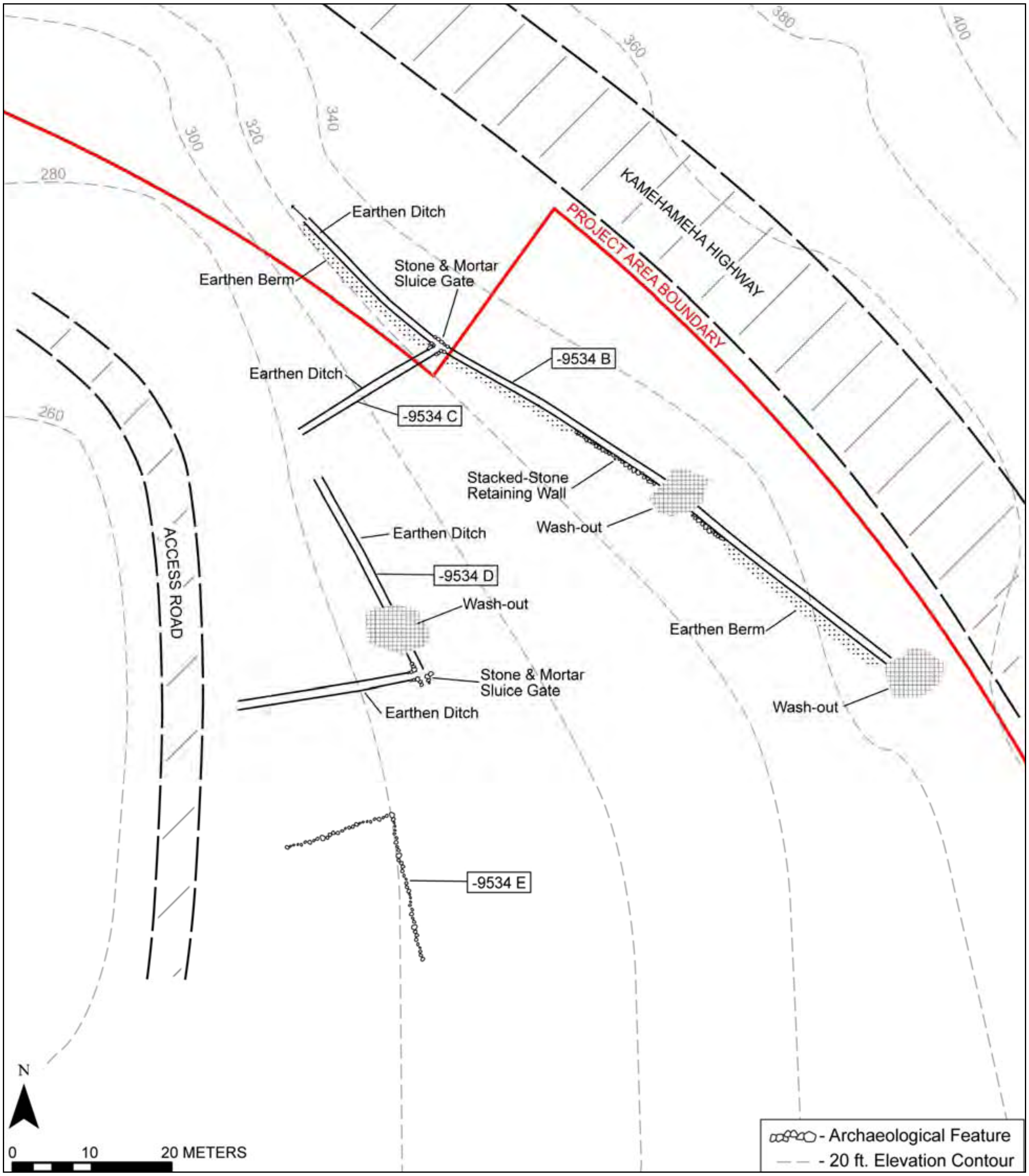

Figure 132. Plan-view diagram of SIHP # 50-80-09-9534 Features B-E

Figure 133. Photograph of SIHP # 50-80-09-9534 B ditch, view to east

Figure 134. Photograph of SIHP # 50-80-09-9534 B ditch, showing sluice gate, view to west

Feature B ditch. A T-intersection, constructed of mortared basalt blocks (Figure 135) allows water to be diverted down slope or continue cross-slope through the use of sluice gates, similar to the gate between Features B and C. Earth-lined ditches likely extended beyond the stone and mortar ditch intersection, though only remnants of these ditches were observed, due to land disturbing activities in the vicinity. Feature D was also likely to have been connected to Feature B or C, functioning as single irrigation system.

Feature E consists of an L-shaped alignment, located approximately 10 m east of the modern access road (see Figure 132). The alignment is constructed with a single course of basalt boulders and cobbles, extending 15 m N/S until angling 90º to the west and extending 8 m (Figure 136). The average width of the alignment is 0.2 m, with a maximum height of 0.3 m. Evidence of land clearing activities was observed immediately south of the alignment.

Feature F consists of bridge foundations for a crossing of Kīpapa Stream, including two foundations within the stream channel and two foundations/retaining walls along the stream banks (Figure 137 and Figure 138). The bridge foundations located within the Kīpapa Stream channel are trapezoidal-shaped, with a wide base and narrower top surface, constructed of cut basalt blocks and mortar, 6-10 courses high (Figure 139). The northern foundation has collapsed due to erosion of the stream channel. The southern foundation remains standing, measuring 3.8 m by 1.3 m wide at the base, with a maximum height of 3.0 m. A bridge foundation/retaining wall is constructed on the northern bank of the Kīpapa Stream channel. The foundation/retaining wall consists of an earthen berm with a cut basalt block and mortar retaining wall along the stream bank, with an additional stacked basalt boulder and cobble retaining wall along the edges of the berm (Figure 140). On the southern stream bank, all that remains of the bridge foundation is an earthern berm. The bridge foundation was likely similar in construction to the foundation/retaining wall on the northern stream bank. However, erosion has removed any evidence of a stone and mortar retaining wall.

Based on similar construction methods and proximity to features associated with historic agricultural endeavors, SIHP # 50-80-09-9534 is interpreted to also be associated with historic agriculture. The Feature A platform appears to have functioned as an agricultural clearing feature, with the stones used in the construction generated by clearing of adjacent planting areas. In addition, base on accurate location of Feature A during the current study, the platform is not located between two former plantation railroad lines as Hammatt and Borthwick (1988) had initially reported, and is therefore not thought to relate to railroad construction. Features B-D are interpreted to be a portions of an irrigation ditch system, related to historic agricultural activities in the vicinity. The Feature E alignment is interpreted as related to historic agricultural activities, possibly functioning as a boundary for a field or activity area. Feature F is interpreted to be bridge foundations for a railroad crossing of Kīpapa Stream. Historic maps dating as early as 1919 (see Figure 11) indicate a plantation railroad system within Kīpapa Gulch, and indicate a crossing of Kīpapa Stream at the location of Feature F. SIHP # 50-80-09-9534 is in fair condition, with portions of the features disturbed by erosion and land clearing activities. SIHP # 50-80-09-9534 is assessed as significant under Criterion D (have yielded, or may be likely to yield information important in prehistory or history) of the National and Hawai‘i Registers of Historic Places evaluation criteria.

Figure 135. Photograph of SIHP # 50-80-09-9534 D irrigation ditch, showing ditch intersection and sluice gate, view to south

Figure 136. Photograph of SIHP # 50-80-09-9534 E L-shaped alignment, view to west

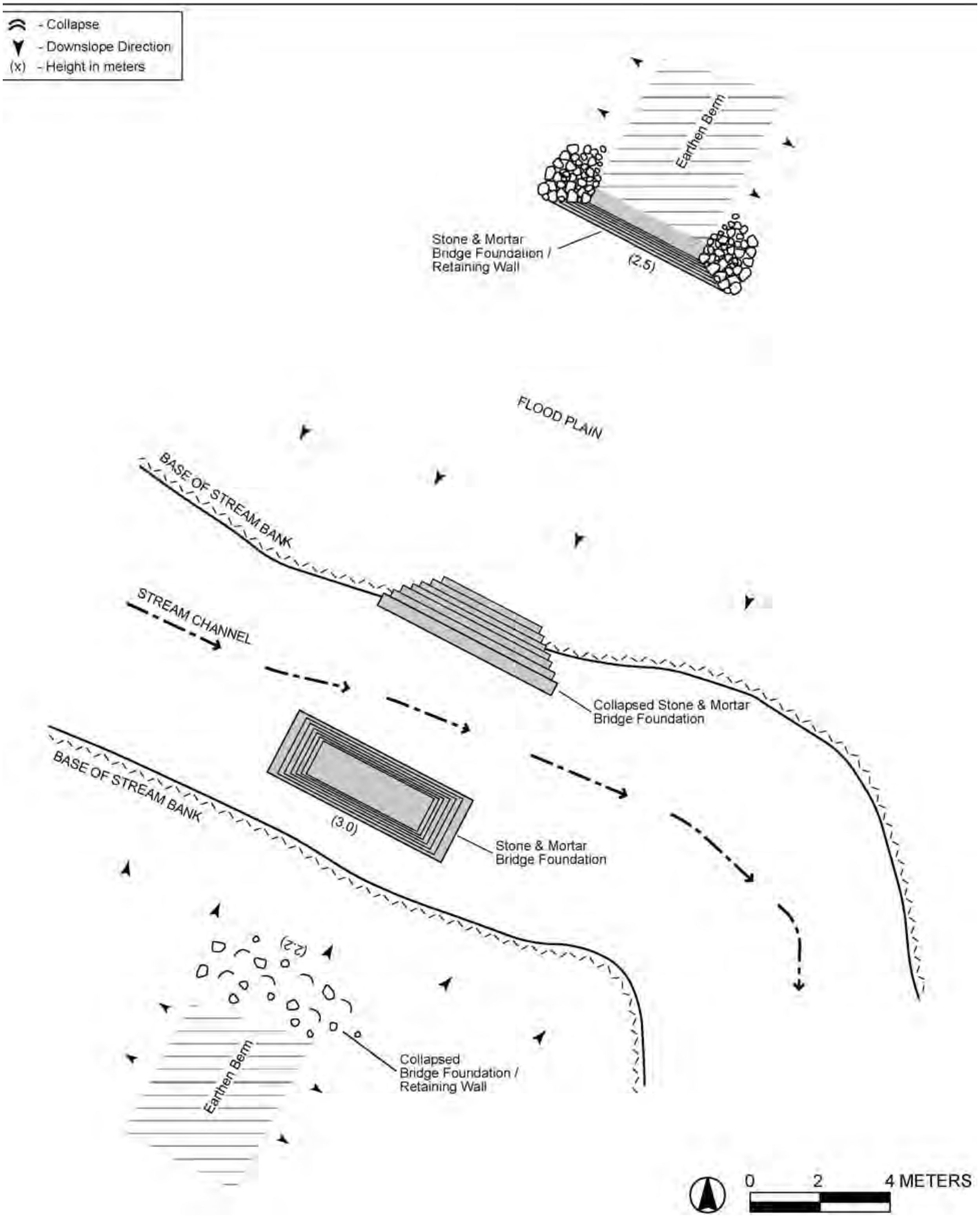

Figure 137. Plan-view diagram of SIHP # 50-80-09-9534 F railroad bridge

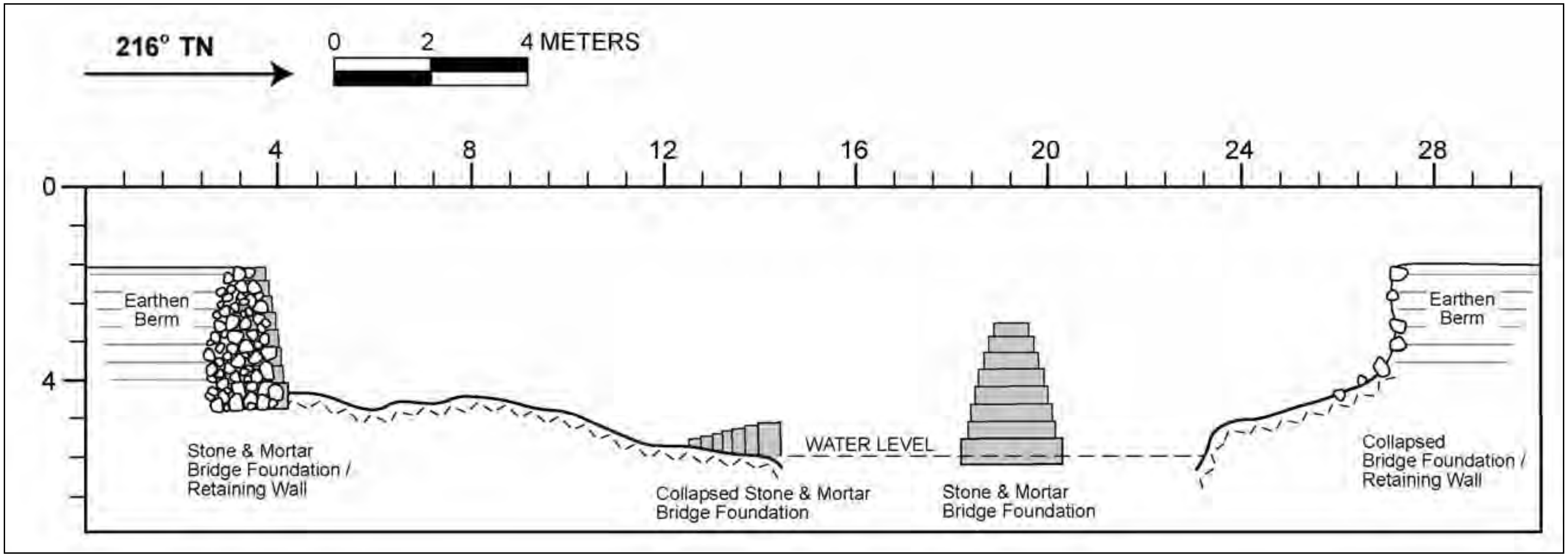

Figure 138. Cross-section diagram of SIHP # 50-80-09-9534 F railroad bridge

Figure 139. Photograph of SIHP # 50-80-09-9534 F bridge foundations with the Kīpapa Stream channel, view to east

Figure 140. Photograph of SIHP # 50-80-09-9534 F bridge foundation/retaining wall on northern stream bank, view to northeast

4.3 Test Excavation Findings

4.3.1 SIHP # 50-80-09-7045 Test Unit 1

A 1 m by 2 m test excavation was made through the western portion of the SIHP# 50-80-09-7045 retaining wall to better determine the function, age, and method of construction of the feature (see Figure 41). The test excavation was located in a well-constructed and minimally disturbed portion of the retaining wall.

The sloping surface of the test excavation consisted of stacked basalt boulders and cobbles retaining sediment on the upslope side, covered with a layer of leaf litter and humus (Figure 141). Deconstruction of the retaining wall revealed the stones were loosely stacked to a height of 80 cm above the current soil surface, with a mixed soil and stone matrix extending to the base of excavation (Figure 142). The sediment accumulation behind the terrace construction indicates the terrace structure functioned in retaining soil. The stones comprising the terrace structure consisted of a mix of water-rounded basalt cobbles to medium boulders near the base of the structure and angular basalt slabs near the top of the structure that appear to have been fractured.

Two sediment strata were observed through the excavation of Test Unit 1 (Figure 143). Stratum I consisted of a dark brown clay loam sediment, representing developing top soil. A small, scattered amount of charcoal was encountered at a depth of 45 cmbs. Approximately 5.0 g of charcoal was recovered. Stratum II consisted of a dark brown clay loam sediment, similar to Stratum I, but more compact and rocky. Stratum II represents soil accumulation at the base of the terrace construction. The test excavation was terminated at the base of the terrace structure at a depth of 82 cmbs. No cultural material was observed through the test excavation.

Following the test excavation, the excavated area was reconstructed as closely as possible to its original state. Detailed sediment descriptions are as follows:

Strata	Depth (cmbs)	Description
Stratum I	0-60	7.5YR 3/3 dark brown clay loam; moderate, fine crumb structure; dry, loose consistency; non-plastic; no cementation; terrestrial origin; includes leaf litter, abundant roots and rootlets, 50% colluvial basalt pebbles, and small amount of charcoal; Lower Boundary (LB) is diffuse, smooth.
Stratum II	60-BOE	7.5YR 3/4 dark brown clay loam; moderate, medium crumb structure; dry, loose consistency; slightly plastic; no cementation; terrestrial origin; includes 10% colluvial basalt pebbles and cobbles; no cultural material was present; Lower Boundary (LB) is below base of excavation.

Figure 141. Photograph of SIHP # 50-80-09-7045 Test Unit 1 pre-excavation, view to southeast

Figure 142. Photograph of SIHP # 50-80-09-7045 Test Unit 1 post-excavation, view to southeast

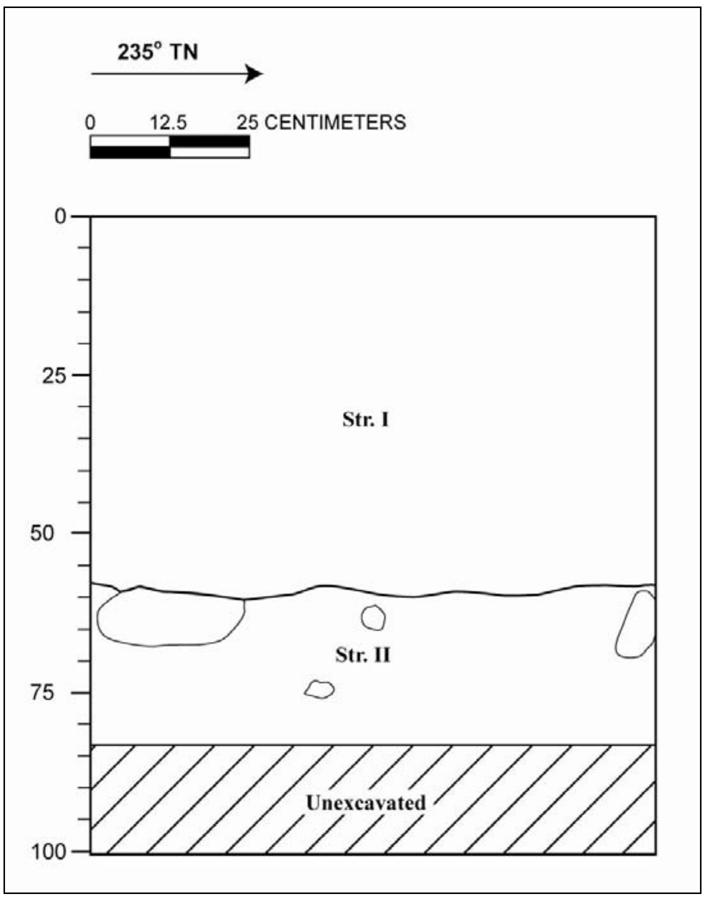

Figure 143. Photograph (above) and stratigraphic profile (below) of the southeast wall of SIHP # 50-80-09-7045 Test Unit 1

4.3.2 SIHP # 50-80-09-7047 Feature C Test Unit 1

A 1 m by 3 m test excavation was made through the central portion of the SIHP# 50-80-09-7047 Feature C terrace retaining wall to better determine the function, age, and method of construction of the feature (see Figure 62). The test excavation was located in a well-constructed and minimally disturbed portion of the terrace.

The surface of the test excavation consisted of a portion of the retaining wall structure, consisting of stacked basalt boulders and cobbles, surrounded by level soil on both sides and covered with a thick layer of leaf litter and humus (Figure 127). Deconstruction of the retaining wall revealed the stones were loosely stacked to a height of 40 cm above the current soil surface extending to a depth of 30 cm below the current soil surface as a mixed soil and stone matrix (Figure 128). The sediment accumulation behind the retaining wall construction indicates the structure functioned in retaining soil to create a level terrace upslope. The stones comprising the terrace structure consisted of a mix of water-rounded basalt cobbles to medium boulders near the base of the structure and angular basalt slabs near the top of the structure that appear to have been fractured.

One sediment strata was observed through the excavation of Test Unit 1 (Figure 129). Stratum I consisted of a dark brown clay loam sediment, representing developing top soil. Scattered pieces of charcoal were encountered at a depth of 10 cmbs. Approximately 11.3 g of charcoal was recovered. The test excavation was terminated below the base of the terrace structure at a depth of 55 cmbs.

Following the test excavation, the excavated area was reconstructed as closely as possible to its original state. Detailed sediment descriptions are as follows:

Strata	Depth (cmbs)	Description
Stratum I	0-BOE	7.5YR 3/3 dark brown clay loam; moderate, medium crumb structure; moist, friable consistency; slightly plastic; no cementation; terrestrial origin; includes leaf litter, humus, roots and rootlets, and small pieces of charcoal; Lower Boundary (LB) is below base of excavation.

Figure 144. Photograph of SIHP # 50-80-09-7047 C Test Unit 1 pre-excavation, view to northwest

Figure 145. Photograph of SIHP # 50-80-09-7047 C Test Unit 1 post-excavation, view to northwest

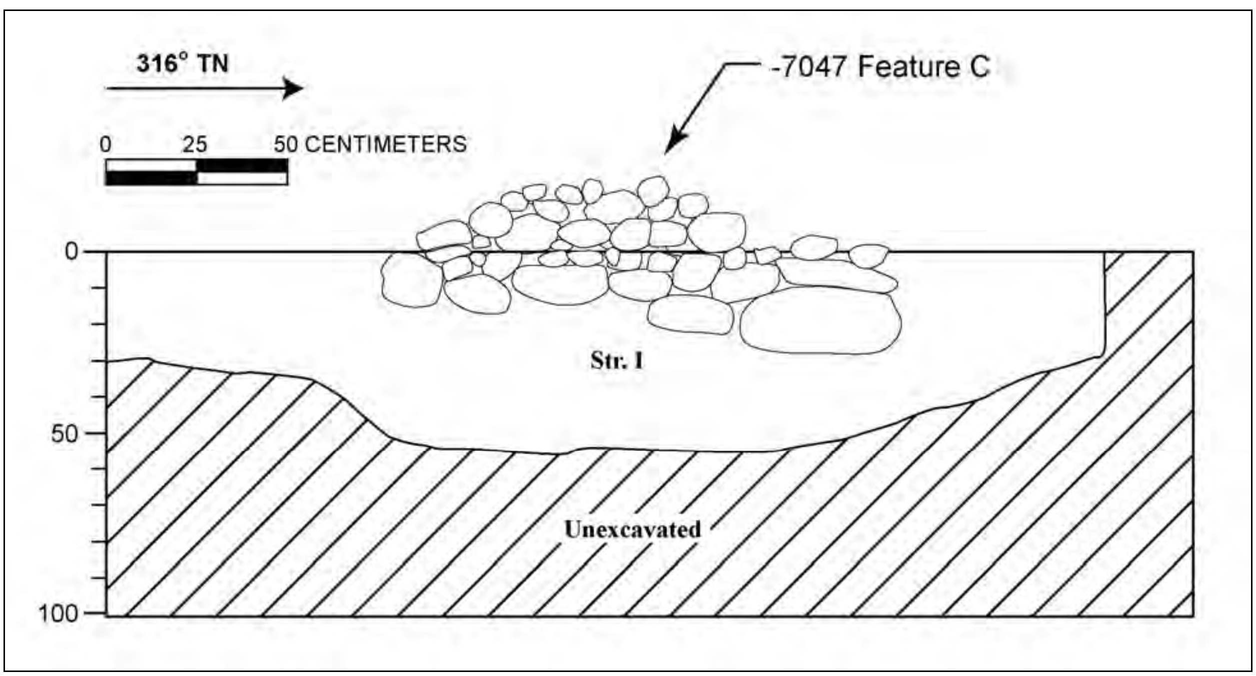

Figure 146. Photograph (above) and stratigraphic profile (below) of the west wall of SIHP # 50-80-09-7047 C Test Unit 1

4.3.3 SIHP # 50-80-09-7049 Feature A Test Unit 1

A 1 m by 1 m test excavation was made within the central portion of a level soil terrace adjacent to the SIHP# 50-80-09-7049 Feature A wall to better determine the function, age, and method of construction of the feature (see Figure 77). The test excavation was located upslope (east) of a well-constructed and minimally disturbed portion of the terrace.

The level surface of the test excavation consisted of soil covered with a layer of leaf litter, humus, and loose basalt cobbles (Figure 147). Excavation revealed a deep accumulation of sediment containing several large basalt cobbles to large boulders extending to the base of excavation (Figure 148). Two sediment strata were observed through the excavation of Test Unit 1 (Figure 149). Stratum I consisted of a dark brown clay loam sediment, representing developing top soil. Scattered pieces of charcoal were encountered at a depth of 20 cmbs. Approximately 8.3 g of charcoal was recovered. Stratum II consisted of a sterile, dark reddish brown clay sediment. The test excavation was terminated at a depth of 38 cmbs, within clearly sterile Stratum II sediments.

Following the test excavation, the excavated area was reconstructed as closely as possible to its original state. Detailed sediment descriptions are as follows:

Strata	Depth (cmbs)	Description
Stratum I	0-20	10 YR 3/3 dark brown clay loam; weak, medium crumb structure; dry, loose consistency; non-plastic; no cementation; terrestrial origin; includes leaf litter, abundant roots and rootlets, and small pieces of charcoal; Lower Boundary (LB) is clear, smooth.
Stratum II	20-BOE	5YR 3/2 dark reddish brown clay; moderate, fine crumb structure; dry, slightly hard consistency; slightly plastic; no cementation; terrestrial origin; no cultural material was present; Lower Boundary (LB) is below base of excavation.

Figure 147. Photograph of SIHP # 50-80-09-7049 A Test Unit 1 pre-excavation, view to south

Figure 148. Photograph of SIHP # 50-80-09-7049 A Test Unit 1 post-excavation, view to south

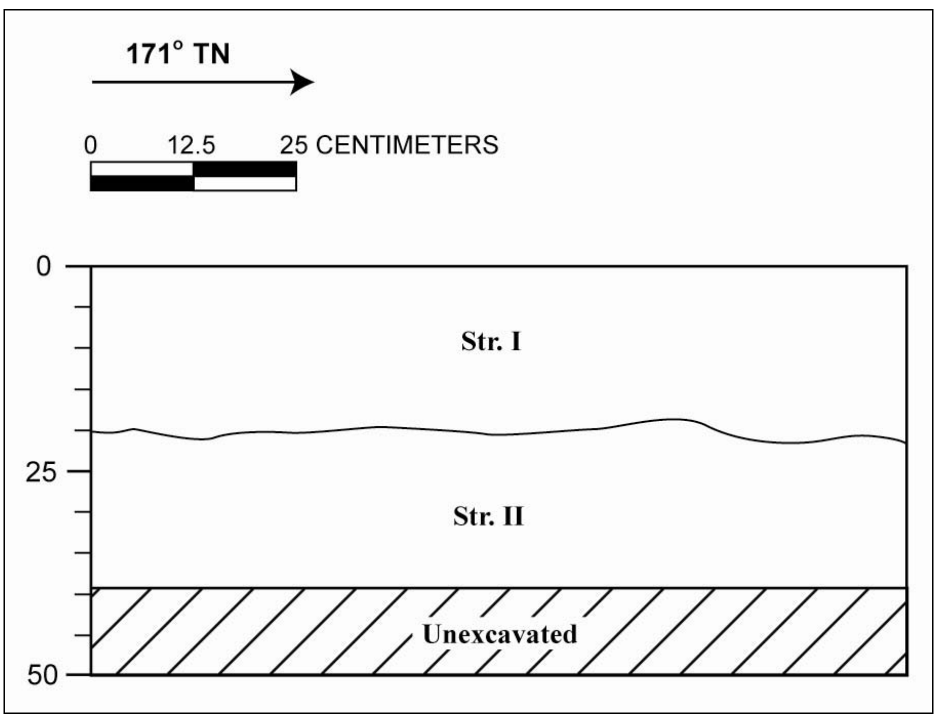

Figure 149. Photograph (above) and stratigraphic profile (below) of the east wall of SIHP # 50-80-09-7049 A Test Unit 1

4.3.4 SIHP # 50-80-09-7049 Feature C Test Unit 1

A 1 m by 1 m test excavation was made within the northern portion of the SIHP# 50-80-09-7049 Feature C terrace to better determine the function, age, and method of construction of the feature (see Figure 80). The test excavation was located in a well-constructed and minimally disturbed portion of the terrace, upslope (west) of a faced internal alignment. The roughly level surface of the test excavation consisted of piled basalt boulders and cobbles, covered with a layer of leaf litter, humus, and moss (Figure 150). Deconstruction of the terrace feature revealed the stones were loosely piled with a thin accumulation of soil amongst the stone matrix extending to the base of excavation (Figure 151). The stones comprising the terrace structure were unsorted, with pebbles to large cobbles distributed throughout the construction. Several massive boulders were also incorporated into the terrace construction.

One sediment strata was observed through the excavation of Test Unit 1. Stratum I consisted of a dark brown silt loam sediment, representing developing top soil within the stone matrix of the terrace structure. The test excavation was terminated at 85 cmbs at a point of heavy rock density and a lack of sediment to excavate. No cultural material was observed.

Following the test excavation, the excavated area was reconstructed as closely as possible to its original state. Detailed sediment descriptions are as follows:

Strata	Depth (cmbs)	Description
Stratum I	0-BOE	7.5YR 3/3 dark brown silt loam; moderate, fine crumb structure; dry, loose consistency; non-plastic; no cementation; terrestrial origin; includes leaf litter and humus; no cultural material observed; Lower Boundary (LB) is below base of excavation

Figure 150. Photograph of SIHP # 50-80-09-7049 C Test Unit 1 pre-excavation, view to south

Figure 151. Photograph of SIHP # 50-80-09-7049 C Test Unit 1 post-excavation, view to south

4.3.5 SIHP # 50-80-09-7049 Feature C Test Unit 2

A 1 m by 1 m test excavation was made within the southern portion of the SIHP# 50-80-09-7049 Feature C terrace to better determine the function, age, and method of construction of the feature (see Figure 80). The test excavation was located in a well-constructed and minimally disturbed portion of the terrace, approximately 8 m southwest of Test Unit 1. The roughly level surface of the test excavation consisted of piled basalt boulders and cobbles, covered with a layer of leaf litter, humus, and moss (Figure 152). Deconstruction of the terrace feature revealed the stones were loosely piled with a thin accumulation of soil amongst the stone matrix extending to the base of excavation (Figure 153). The stones comprising the terrace structure were unsorted, with pebbles to large cobbles distributed throughout the construction. Several massive boulders were also incorporated into the mound construction.

One sediment strata was observed through the excavation of Test Unit 2. Stratum I consisted of a dark brown silt loam sediment, representing developing top soil within the stone matrix of the terrace structure. The test excavation was terminated at 38 cmbs, at a point of heavy rock density and a lack of sediment to excavate. No cultural material was observed.

Following the test excavation, the excavated area was reconstructed as closely as possible to its original state. Detailed sediment descriptions are as follows:

Strata	Depth (cmbs)	Description
Stratum I	0-BOE	7.5YR 3/3 dark brown silt loam; moderate, fine crumb structure; dry, loose consistency; non-plastic; no cementation; terrestrial origin; includes leaf litter and humus; no cultural material observed; Lower Boundary (LB) is below base of excavation

Figure 152. Photograph of SIHP # 50-80-09-7049 C Test Unit 2 pre-excavation, view to south

Figure 153. Photograph of SIHP # 50-80-09-7049 C Test Unit 2 post-excavation, view to south

Section 5 Summary and Interpretation

The current archaeological inventory survey investigation identified thirteen cultural resources within and in the immediate vicinity of the project area. With the exception of SIHP # 50-80-09-7052 and SIHP # 50-80-09-7053, each of the remaining eleven cultural resources is interpreted as related to commercial pineapple or sugar cane cultivation. These plantation-era structures are remnants of the extensive field, irrigation, and transportation systems that supported large-scale agriculture in the upland Waipiʻo area. Large-scale plantation agriculture began in Waipiʻo in the late 1800s and was widespread through the mid-1900s. Both the upper tablelands, as well as the gulch lands were used for cultivation. Background research indicated a general pattern of sugar cane fields occupying lands *makai* of the Waiahole Ditch (SIHP # 50-80-09-2268) and pineapple fields *mauka* of the ditch.

The findings of this archaeological inventory survey support the predictive model based on the background research. In the surveyed gulch lands *mauka* of the Waiahole Ditch, archaeological features included large stone mounds, terraces, and platforms along the less steep areas of the gulch slope and roads and stream channel improvements along the base of the gulch. The large stone structures are interpreted to be the result of clearing of the gulch slopes of stones to improve the land for pineapple cultivation. In addition, improvements to the stream channel were made to control erosion of the stream bank and preserve adjacent alluvial/colluvial terraces for agricultural cultivation. The surveyed lands *makai* of the Waiahole Ditch contained features typical of sugar cane cultivation, including irrigation ditches and railroad infrastructure.

SIHP # 50-80-09-7052 includes military-related structures constructed in association with the development of the U.S. Army Upper and Lower Kīpapa Ammunition Storage Sites. Following World War II, the U.S. military acquired much of the lower portions of Kīpapa Gulch for use as ammunition and fuel storage areas to support the Navy at Pearl Harbor and Army at Schofield Barracks. SIHP # 50-80-09-7053 is the “Old Kamehameha Highway” alignment. Until the construction of the H-2 freeway in the 1970s, Kamehameha Highway was the major vehicular transportation corridor through central Oʻahu. The Old Kamehameha Highway alignment was in use until the highway was realigned with the construction of the Roosevelt Bridge across Kīpapa Gulch in 1934.

The archaeological inventory survey confirmed that decades of commercial pineapple and sugar cane cultivation within the project area removed any evidence of traditional land uses. No pre-contact traditional Hawaiian sites were identified within the project area. However, previous archaeological sites in Kīpapa Gulch and other gulches in the area did identify pre-contact cultural resources, namely overhang shelters or caves in the gulch walls. Similar features may exist in the vicinity of the project area, as the current survey area generally focused on the base of the gulch and lower gulch slopes.

Section 6 Significance Assessments

Each cultural resource identified by the current study was evaluated for significance according to the broad criteria established for the National and Hawaiʻi Registers of Historic Places. The five criteria are:

A Associated with events that have made an important contribution to the broad patterns of our history;

B Associated with the lives of persons important in our past;

C Embodies the distinctive characteristics of a type, period, or method of construction, represents the work of a master, or possesses high artistic value;

D Have yielded, or is likely to yield information important for research on prehistory or history;

E Have an important value to the native Hawaiian people or to another ethnic group of the state due to associations with cultural practices once carried out, or still carried out, at the property, or due to associations with traditional beliefs, events or oral history accounts – these associations being important to the group's history and cultural identity.

SIHP # 50-80-09-7044 consists of a historic road and associated stream channel improvements, located within the Detention Basin 2 (DB2) and DB 2 Access Road project areas. SIHP # 50-80-09-7044 is interpreted to be associated with historic agricultural cultivation in Kīpapa Gulch and its tributaries. SIHP # 50-80-09-7044 is assessed as significant under Criterion D (have yielded, or may be likely to yield information important in prehistory or history) of the National and Hawaiʻi Registers of Historic Places evaluation criteria.

SIHP # 50-80-09-7045 consists of two retaining walls located near the central portion of the DB2 Access Road project area. The retaining walls are interpreted to be associated with historic agricultural endeavors, likely functioning as water diversion and erosion control features. SIHP # 50-80-09-7045 is assessed as significant under Criterion D (have yielded, or may be likely to yield information important in prehistory or history) of the National and Hawaiʻi Registers of Historic Places evaluation criteria.

SIHP # 50-80-09-7046 is a platform located near the eastern portion of the DB2 Access Road project area. The platform is interpreted to be associated with historic agricultural endeavors, likely functioning as both an agricultural clearing feature, with the stones used in the construction generated by clearing of adjacent planting areas, and as a water diversion feature. SIHP # 50-80-09-7046 is assessed as significant under Criterion D (have yielded, or may be likely to yield information important in prehistory or history) of the National and Hawaiʻi Registers of Historic Places evaluation criteria.

SIHP # 50-80-09-7047 is an agricultural terrace complex located near the eastern portion of the DB2 Access Road project area. SIHP # 50-80-09-7047 is interpreted to be associated with historic agricultural endeavors, functioning as an agricultural planting area and charcoal kiln. SIHP # 50-80-09-7047 is assessed as significant under Criterion D (have yielded, or may be likely to yield information important in prehistory or history) of the National and Hawaiʻi Registers of Historic Places evaluation criteria.

SIHP # 50-80-09-7048 is a stone-lined pit located within the southern portion of the DB2 project area. SIHP # 50-80-09-7048 is interpreted to be associated with historic agricultural endeavors, functioning as a charcoal kiln. SIHP # 50-80-09-7048 is assessed as significant under Criterion D (have yielded, or may be likely to yield information important in prehistory or history) of the National and Hawaiʻi Registers of Historic Places evaluation criteria.

SIHP # 50-80-09-7049 is a complex of nine historic agricultural features, located within the Detention Basin 3 (DB3) portion of the project area. The large mounds and terraces are interpreted to be the result of agricultural clearing, with the terraces likely also functioning as erosion control features. In addition, improvements to the stream channel were made to control erosion of the stream bank and preserve adjacent alluvial/colluvial terraces for agricultural cultivation. SIHP # 50-80-09-7049 is assessed as significant under Criterion D (have yielded, or may be likely to yield information important in prehistory or history) of the National and Hawaiʻi Registers of Historic Places evaluation criteria.

SIHP # 50-80-09-7050 consists of a retaining wall and C-shaped wall located in the Detention Basin 1 (DB 1) project area. SIHP # 50-80-09-7050 is interpreted to be associated with historic agricultural endeavors, likely functioning as erosion control and planting area boundary features. SIHP # 50-80-09-7050 is assessed as significant under Criterion D (have yielded, or may be likely to yield information important in prehistory or history) of the National and Hawaiʻi Registers of Historic Places evaluation criteria.

SIHP # 50-80-09-2268 is the Waiahole Ditch, an extensive plantation irrigation system that extends approximately 22 miles, bringing water from the windward Koʻolau Range through central Oʻahu and on to the ʻEwa Plain. SIHP # 50-80-09-2268 is assessed as significant under Criterion A (associated with events that have made an important contribution to the broad patterns of our history), Criterion C (embody the distinctive characteristics of a type period or method of construction), and Criterion D (have yielded, or may be likely to yield information important in prehistory or history) of the National and Hawaiʻi Registers of Historic Places evaluation criteria.

SIHP # 50-80-09-7051 is a retaining wall located in the central portion of the H-2 Freeway Interchange project area. SIHP # 50-80-09-7051 is interpreted to also be associated with historic agricultural endeavors, likely functioning as an erosion control structure, preventing erosion of the tablelands upslope. SIHP # 50-80-09-7051 is assessed as significant under Criterion D (have yielded, or may be likely to yield information important in prehistory or history) of the National and Hawaiʻi Registers of Historic Places evaluation criteria.

SIHP # 50-80-09-9530 consists of historic irrigation and transportation related structures identified within the Detention Basin 4 (DB4) project area. four features are plantation irrigation-related structures, including irrigation ditches, and three features are plantation transportation-related structures, including a cart road, railroad berm and bridge foundations. SIHP # 50-80-09-9530 is assessed as significant under Criterion A (associated with events that have made an important contribution to the broad patterns of our history), Criterion C (embody the distinctive characteristics of a type period or method of construction), and Criterion D (have yielded, or may be likely to yield information important in prehistory or history) of the National and Hawaiʻi Registers of Historic Places evaluation criteria.

SIHP # 50-80-09-7052 consists of a storage tunnel and asphalt pad, located in the Detention Basin 4 (DB4) project area, and a large concrete slab located in the southern portion of the of the Drain Line 1 (DL1) project area. SIHP # 50-80-09-7052 are components of the U.S. Army Upper and Lower Kīpapa Ammunition Storage Sites, which consists of storage tunnels and associated infrastructure constructed by the U.S. Army following World War II. SIHP # 50-80-09-7052 is assessed as significant under Criterion A (associated with events that have made an important contribution to the broad patterns of our history) and Criterion D (have yielded, or may be likely to yield information important in prehistory or history) of the National and Hawaiʻi Registers of Historic Places evaluation criteria.

SIHP # 50-80-09-7053 is a historic roadbed and associated features, located within the proposed Detention Basin 4 Access Road project area (see Figure 27 and Figure 28). The road is the original alignment of Kamehameha Highway, known as the "Old Kamehameha Highway." SIHP # 50-80-09-7053 is assessed as significant under Criterion A (associated with events that have made an important contribution to the broad patterns of our history) and Criterion D (have yielded, or may be likely to yield information important in prehistory or history) of the National and Hawaiʻi Registers of Historic Places evaluation criteria.

SIHP # 50-80-09-9534 consists of historic agriculture and transportation related structures identified within the Drain Line 1 (DL1) project area. One feature is related to agricultural clearing, three features are irrigation ditches, one feature is a possible field boundary, and one feature is a remnant of a railroad bridge. SIHP # 50-80-09-9534 is assessed as significant under Criterion D (have yielded, or may be likely to yield information important in prehistory or history) of the National and Hawaiʻi Registers of Historic Places evaluation criteria.

Section 7 Project Effect and Mitigation Recommendations

The following project effect discussion and cultural resource management recommendations are intended to facilitate project planning and support the proposed project's required historic preservation consultation. This discussion is based on the results of this archaeological inventory survey investigation and CSH's communication with agents for the project proponents regarding the project's potential impacts to the cultural resources described in the Results of Fieldwork section, above.

7.1 Project Effect

The proposed project involves construction of a storm drain line, four storm water detention basins, construction and maintenance access roads, and construction staging areas (Figure 6). The proposed project also includes an H-2 Freeway interchange, associated with the planned Koa Ridge Development Project. Minimally, land-disturbing activities would include grubbing and grading, and excavations associated with detention basin construction, freeway infrastructure construction, and subsurface utility installation. The project's Area of Potential Effect (APE) is defined as the entire approximately 123-acre project area.

This archaeological inventory survey investigation identified the following thirteen cultural resources within or in the immediate vicinity of the project area. These cultural resources will likely, or potentially, be affected by the proposed project:

1. SIHP # 50-80-09-2268, portion of the historic Waiahole Ditch System, evaluated as significant under Criteria A, C, and D of the National and Hawaiʻi Registers of Historic Places evaluation criteria. Project proponents indicated the Waiahole Ditch is owned by the State of Hawaiʻi, independent of the lands owned by the project proponents. The proposed project may require one or more small, localized alterations of SIHP # 50-80-09-2268.
2. SIHP # 50-80-09-7044, historic road and stream channel improvements, evaluated as significant under Criterion D of the National and Hawaiʻi Registers of Historic Places evaluation criteria. The proposed project may have an adverse effect on multiple features of the site complex.
3. SIHP # 50-80-09-7045, plantation-era retaining walls, evaluated as significant under Criterion D of the National and Hawaiʻi Registers of Historic Places evaluation criteria. SIHP # 50-80-09-7045 Features A and B are located 15+ m from the proposed Detention Basin 2 (DB2) Access Road project area. The proposed project is therefore likely to have no effect on SIHP # 50-80-09-7045.
4. SIHP # 50-80-09-7046, plantation-era clearing platform, evaluated as significant under Criterion D of the National and Hawaiʻi Registers of Historic Places evaluation criteria. SIHP # 50-80-09-7046 is located approximately 10 m from the proposed Detention Basin 2 (DB2) Access Road project area. In addition, due to community concerns over the potential cultural significance of the platform, project proponents have indicated the feature will be avoided during project-related construction and

maintenance activities. The proposed project is therefore likely to have no effect on SIHP # 50-80-09-7046.

5. SIHP # 50-80-09-7047, plantation-era agricultural terrace complex, evaluated as significant under Criterion D of the National and Hawaiʻi Registers of Historic Places evaluation criteria. The proposed project may have an adverse effect on multiple features of the site complex.
6. SIHP # 50-80-09-7048, plantation-era charcoal kiln, evaluated as significant under Criterion D of the National and Hawaiʻi Registers of Historic Places evaluation criteria. The proposed project may have an adverse effect on the charcoal kiln.
7. SIHP # 50-80-09-7049, plantation-era agricultural complex, evaluated as significant under Criterion D of the National and Hawaiʻi Registers of Historic Places evaluation criteria. The proposed project may have an adverse effect on multiple features of the site complex.
8. SIHP # 50-80-09-7050, plantation-era retaining wall and C-shaped wall, evaluated as significant under Criterion D of the National and Hawaiʻi Registers of Historic Places evaluation criteria. The proposed project may have an adverse effect on the retaining wall and C-shaped wall.
9. SIHP # 50-80-09-7051, plantation-era retaining wall, evaluated as significant under Criterion D of the National and Hawaiʻi Registers of Historic Places evaluation criteria. The proposed project may have an adverse effect on the retaining wall.
10. SIHP # 50-80-09-7052, military-related components of the U.S. Army Upper and Lower Kīpapa Ammunition Storage Sites, evaluated as significant under Criteria A and D of the National and Hawaiʻi Registers of Historic Places evaluation criteria. The proposed project may have an adverse effect on multiple features of the site complex.
11. SIHP # 50-80-09-7053, historic roadbed and associated features (Old Kamehameha Highway alignment), evaluated as significant under Criteria A and D of the National and Hawaiʻi Registers of Historic Places evaluation criteria. The proposed project may have an adverse effect on multiple features of the road alignment.
12. SIHP # 50-80-09-9530, plantation-era agricultural and transportation complex, evaluated as significant under Criteria A, C, and D of the National and Hawaiʻi Registers of Historic Places evaluation criteria. The proposed project may have an adverse effect on multiple features of the site complex.
13. SIHP # 50-80-09-9534, plantation-era agricultural and transportation complex, evaluated as significant under Criterion D of the National and Hawaiʻi Registers of Historic Places evaluation criteria. The proposed project may have an adverse effect on multiple features of the site complex.

CSH's project-specific effect recommendation is "effect, with proposed mitigation commitments." The recommended mitigation measures will reduce the project's potential adverse effect to significant cultural resources.

7.2 Mitigation Recommendations

To reduce the proposed project's potential adverse effect on significant historic properties, the following mitigation measures are recommended. The mitigation measures should be completed prior to any land disturbing activities within the project area.

1. SIHP # 50-80-09-2268, portion of the historic Waiahole Ditch System, was documented with a detailed written description, photographs, and accurately located with GPS survey equipment. The Waiahole Ditch is an excellent example of a plantation-era irrigation ditch, described as "an engineering feat of epic proportion for those times" (Conde and Best 1973:37). The ditch is actively maintained and continues to be used for irrigation of fields in central O‘ahu, with the ditch undergoing minor alterations from time to time. Generally preservation, in the form of avoidance and protection, is recommended for the Waiahole Ditch. If modifications of the ditch are necessary for the proposed project then it is recommended that consultation take place with the SHPD to determine what, if any, mitigation may be appropriate.
2. SIHP # 50-80-09-7044, historic road and stream channel improvements, was documented with a detailed written description, photographs, scale drawings of select features, and accurately located with GPS survey equipment. No further work is recommended for SIHP # 50-80-09-7044. Sufficient information regarding the location, function, age, and construction methods of the historic road and stream channel improvements has been generated by the current inventory survey investigation to mitigate any adverse effect caused by proposed development activities.
3. SIHP # 50-80-09-7045, plantation-era retaining walls, was documented with a detailed written description, photographs, scale drawings, and accurately located with GPS survey equipment. No further work is recommended for SIHP # 50-80-09-7045. Sufficient information regarding the location, function, age, and construction methods of the plantation-era retaining walls has been generated by the current inventory survey investigation to mitigate any adverse effect caused by proposed development activities.
4. SIHP # 50-80-09-7046, plantation-era clearing platform, was documented with a detailed written description, photographs, scale drawings, and accurately located with GPS survey equipment. Due to community concerns over the potential cultural significance of the platform, preservation, in the form of avoidance and protection, is recommended for SIHP # 50-80-09-7046.
5. SIHP # 50-80-09-7047, plantation-era agricultural terrace complex, was documented with a detailed written description, photographs, scale drawings, and accurately located with GPS survey equipment. SIHP # 50-80-09-7047 is a good example of a plantation-era agricultural complex and is a potential resource for future archaeological research. Preservation, in the form of avoidance and protection, is recommended for SIHP # 50-80-09-7047 Features C-G. If portions of Features C-G must be impacted for the proposed project to proceed, archaeological data recovery of the features could be conducted as a mitigation measure. Features A and B are located

in an area that is critical for the proposed project to proceed. As Features A and B are the poorest examples of the terraces in the SIHP # 50-80-09-7047 complex, no further work is recommended for these two minor features. Sufficient information regarding the location, function, age, and construction methods of Features A and B terraces has been generated by the current inventory survey investigation to mitigate any adverse effect caused by proposed development activities. .

6. SIHP # 50-80-09-7048, plantation-era charcoal kiln, was documented with a detailed written description, photographs, scale drawings, and accurately located with GPS survey equipment. No further work is recommended for SIHP # 50-80-09-7048. Sufficient information regarding the location, function, age, and construction methods of the charcoal kiln has been generated by the current inventory survey investigation to mitigate any adverse effect caused by proposed development activities.

7. SIHP # 50-80-09-7049, plantation-era agricultural complex, was documented with a detailed written description, photographs, scale drawings of select features, and accurately located with GPS survey equipment. No further work is recommended for SIHP # 50-80-09-7049. Sufficient information regarding the location, function, age, and construction methods of the plantation-era agricultural complex has been generated by the current inventory survey investigation to mitigate any adverse effect caused by proposed development activities. In addition, several similar features were observed just outside of the current survey area. Based on these observations, along with background research, it is likely that numerous similar plantation-era agricultural features exist in nearby areas of Kīpapa Gulch that were not covered by the current study.

8. SIHP # 50-80-09-7050, plantation-era retaining wall and C-shaped wall, was documented with a detailed written description, photographs, scale drawings, and accurately located with GPS survey equipment. No further work is recommended for SIHP # 50-80-09-7050 Feature A. Sufficient information regarding the location, function, age, and construction methods of the retaining wall has been generated by the current inventory survey investigation to mitigate any adverse effect caused by proposed development activities. If SIHP # 50-80-09-7050 Feature B must be impacted for the proposed project to proceed, archaeological data recovery of the feature could be conducted as a mitigation measure to better determine the function of the C-shaped wall.

9. SIHP # 50-80-09-7051, plantation-era retaining wall, was documented with a detailed written description, photographs, and accurately located with GPS survey equipment. No further work is recommended for SIHP # 50-80-09-7051. Sufficient information regarding the location, function, age, and construction methods of the retaining wall has been generated by the current inventory survey investigation to mitigate any adverse effect caused by proposed development activities.

10. SIHP # 50-80-09-7052, military-related components of the U.S. Army Upper and Lower Kīpapa Ammunition Storage Sites, was documented with a detailed written description, photographs, and accurately located with GPS survey equipment. No further work is recommended for SIHP # 50-80-09-7052. Sufficient information

regarding the location, function, age, and construction methods of the features has been generated by the current inventory survey investigation to mitigate any adverse effect caused by proposed development activities. In addition, the Feature A storage tunnel is one of 52 similar storage tunnels within the Upper Kīpapa Ammunition Storage Site.

11. SIHP # 50-80-09-7053, historic roadbed and associated features (Old Kamehameha Highway alignment), was documented with a detailed written description, photographs, and accurately located with GPS survey equipment. Preservation, in the form of avoidance and protection is recommended for the historic roadbed and associated features.
12. SIHP # 50-80-09-9530, plantation-era agricultural and transportation complex, was documented with a detailed written description, photographs, and accurately located with GPS survey equipment. Feature A is an excellent example of a dressed basalt block lined irrigation ditch. Preservation, in the form of avoidance and protection is recommended for SIHP # 50-80-09-9530 Feature A. Preservation of this irrigation ditch was also recommended by Hammatt and Borthwick (1988). As Feature A is a linear ditch, including approximately 440 m within the project area and extending north and south beyond the project boundaries, a breach of the ditch for the installation of an approximately 10 ft. wide storm drain culvert may occur without significantly detracting from the integrity of the feature. Portions of the ditch were also observed to have been previously disturbed. Any proposed breaches of the Feature A irrigation ditch will require consultation with and approval of the State Historic Preservation Division when the details of the proposed project become available. No further work is recommended for the remaining features of SIHP # 50-80-09-9530. Sufficient information regarding the location, function, age, and construction methods of the features has been generated by the current inventory survey investigation to mitigate any adverse effect caused by proposed development activities.
13. SIHP # 50-80-09-9534, plantation-era agricultural and transportation complex, was documented with a detailed written description, photographs, scale drawings of select features, and accurately located with GPS survey equipment. No further work is recommended for SIHP # 50-80-09-9534. Sufficient information regarding the location, function, age, and construction methods of the complex has been generated by the current inventory survey investigation to mitigate any adverse effect caused by proposed development activities.

It is recommended that a cultural resource preservation plan be prepared for the proposed project, in accordance with Hawaiʻi Administrative Rules (HAR) 13-277-3, to address buffer zones and protective measures for all cultural resources recommended for preservation. This preservation plan should detail the short and long-term preservation measures that will safeguard the cultural resources during project construction and subsequent use of the project area. The preservation plan will also address any breaches of the SIHP # 50-80-09-9530 Feature A irrigation ditch.

If SIHP # 50-80-09-7047 Features C-G will be impacted by the proposed project, it is recommended that an archaeological data recovery plan be prepared for SIHP # 50-80-09-7047, in accordance with HAR 13-278-3. The archaeological data recovery plan will detail the research questions and field methods necessary to gather sufficient data on the historic property to mitigate the adverse effect of proposed development activities.

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Appendix A SHPD Review Hammatt et al. (1996)

BENJAMIN J. CAYETANO
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CONVEYANCES
FORESTRY AND WILDLIFE
HISTORIC PRESERVATION
LAND
STATE PARKS

March 18, 2002

David Shideler
O`ahu Office Manger
Cultural Surveys Hawaii
733 N. Kalaheo Ave.
Kailua, Hawaii 96734

LOG NO: 29403
DOC NO: 0203EJ09

Dear Mr. Shideler:

SUBJECT: **Archaeological Inventory Survey of a 1339-Acre Parcel at Castle and Cooke Lands within Portions of Waipi`o and Waiawa Ahupua`a, O`ahu**
Waipi`o and Waiawa, `Ewa, O`ahu
<u>TMK: 9-4-006:001, 003, 010por.; 9-5-003:001por. 004, 007 and 9-6-004:021</u>

Thank you for the submission of a report on an archaeological inventory survey of Castle and Cooke Lands in Waipi`o and Waiawa, O`ahu [*Archaeological Inventory Survey of a 1339-Acre Parcel at Castle and Cooke Lands within Portions of Waipi`o and Waiawa Ahupua`a, O`ahu* (Hammatt et al, June 1996)]. We received the report in June 2001.

We believe that the survey was performed acceptably, finding one site, portions of Waiahole Ditch (State Site No. 50-80-09-2268) within the subject parcels. One other site, portions of Kipapa ditch (State Site No. 50-80-09-9529), were identified outside of the project area. The Waiahole Ditch is clearly likely to be significant under multiple criteria of the Hawaii Register of Historic Places, as it played a significant role in the early 1900s agricultural history of O`ahu. We agree that appropriate mitigative measures will need to be agreed upon should future development have the potential to have an adverse effect on this site.

We have placed the CSH report in the SHPD library where it will be available for the public's use and benefit.

Should you have any questions, please feel free to call Sara Collins at 692-8026 or Elaine Jourdane at 692-8027.

Aloha,

Don Hibbard, Administrator
State Historic Preservation Division

EJ:jk

Appendix B LCA 8241 Documentation

Mahele Database Documents
Number: 08241

Claim Number:	**08241**
Claimant:	**Ii, Ioane / Ii, John**
Other claimant:	
Other name:	Ii, John
Island:	**Oahu**
District:	**Kona, Ewa**
Ahupuaa:	**Honolulu, Waikiki, Waipio**
Ili:	**Pawaa, Kalawahine**

Apana:	**8**	Awarded:	**1**
Loi:		FR:	
Plus:		NR:	**512v5**
Mala Taro:		FT:	**554v3**
Kula:		NT:	**148v10**
House lot:		RP:	**5699, 5704, ,5732**
Kihapai/Pakanu:		Number of Royal Patents:	**3**
Salt lands:		Koele/Poalima:	**No**
Wauke:		Loko:	**No**
Olona:		Lokoia:	**No**
Noni:		Fishing Rights:	**No**
Hala:		Sea/Shore/Dunes:	**No**
Sweet Potatoes:		Auwai/Ditch:	**No**
Irish Potatoes:		Other Edifice:	**No**
Bananas:		Spring/Well:	**No**
Breadfruit:		Pigpen:	**No**
Coconut:		Road/Path:	**No**
Coffee:		Burial/Graveyard:	**No**
Oranges:		Wall/Fence:	**No**
Bitter Melon/Gourd:		Stream/Muliwai/River:	**No**
Sugar Cane:		Pali:	**No**
Tobacco:		Disease:	**No**
Koa/Kou Trees:		Claimant Died:	**No**
Other Plants:		Other Trees:	
Other Mammals:	**No**	Miscellaneous:	**Lists 110 tenants living on the land**

No. 8241, Ioane Ii, Honolulu, February 1, 1848
N.R. 512-517v5

Greetings to the Land Commissioners: I hereby state my claim for land, on Oahu only. An ahupua`a, Waipio, Ewa, is from the mountain to the sea, however, there are no ku lands situated within it because of the Mo`i - that is up to the Mo`i. The ones with the right to live there are listed below.

[No.] 2. Pawaa is the second of my lands on Oahu. It is at Waikiki, next to G.L. Kapeau, at Pawaa. This `Ili was gotten after the /Battle of/ Nuuanu by my makuas, from Kamehameha I, and these lands and other lands on other islands are held. The reason they, and I, got them, was by the actions of Kamehameha I and Kamehameha II, but they have been divided at this time and separated by the Government and the Mo`i -- nine lands for them and two for me. Below are the names of the people living on this land.

[No.] 3. A small lot claim, in Honolulu, is leased to Dr. Epener and Dr. Rooke; perhaps Samisona has the occupancy at this time for the remaining years. My retainers lived there in 1837 and in 1841, perhaps, it was leased as aforesaid.

Here are the names of the people living on the land of Waipio in Ewa:
Name of the Man, Mo`o, Lo`i, House lot, House(s), Children
Ulakaipo, 1 Mo`o, 1 Lo`i, 1 House lot, 1 House(s), 3 Children
M. Luheluhe, 1 Mo`o, 4 Lo`i, 1 House lot, 1 House(s), 1 Child
Nahua, 1 Mo`o, 7 Lo`i, 1 House lot, 2 House(s), 3 Children
Luaka, 1 Mo`o, 5 Lo`i, 1 House lot, 1 House(s), 2 Children
Kalauli, 1 Mo`o, 9 Lo`i, 1 House lot, 1 House(s), 2 Children
Nahea, 1 Mo`o, 4 Lo`i, 1 House lot, 1 House(s), 2 Children
Kaakau, widow*, 1 Mo`o, 3 Lo`i, 1 House lot, 1 House(s), 2 Children
Manoha, 1 Mo`o, 7 Lo`i, 1 House lot, 1 House(s), 3 Children
Neliikuhoe, 1 Mo`o, 3 Lo`i, 1 House lot, 1 House(s), 3 Children
Ohilau, 1 Mo`o, 16 Lo`i, 1 House lot, 1 House(s), 1 Child
Makaloka, 1 Mo`o, 9 Lo`i, 1 House lot, 1 House(s), 1 Child
Puakea, 1 Mo`o, 6 Lo`i, 1 House lot, 1 House(s), 1 Child
Keahekahuole, 1 Mo`o, 7 Lo`i, 1 House lot, 1 House(s), 1 Child
Kaapaahili, 1 Mo`o, 10 Lo`i, 1 House lot, 1 House(s), 1 Child
Puhipaka, 1 Mo`o, 4 Lo`i, 1 House lot, 1 House(s), 1 Child
Kalili, 1 Mo`o, 4 Lo`i, 1 House lot, 1 House(s), 1 Child
Kahuainana, 1 Mo`o, 3 Lo`i, 1 House lot, 1 House(s), 1 Child
Pi, 1 Mo`o, 7 Lo`i, 1 House lot, 1 House(s), 1 Child
Poikeo, 1 Mo`o, 3 Lo`i, 1 House lot, 1 House(s), 1 Child
Kula, 1 Mo`o, 2 Lo`i, 1 House lot, 1 House(s), 1 Child
Paumano, 1 Mo`o, 3 Lo`i, 1 House lot, 1 House(s), 1 Child
Kupehe, widow*, 1 Mo`o, 7 Lo`i, 1 House lot, 1 House(s), 1 Child
Pohano, 1 Mo`o, 3 Lo`i, 1 House lot, 1 House(s), 1 Child
Hana, 1 Mo`o, 1 Lo`i, 1 House lot, 1 House(s), 1 Child
Kaiki, 1 Mo`o, 3 Lo`i, 1 House lot, 1 House(s), 1 Child
Kamaka, 1 Mo`o, 4 Lo`i, 1 House lot, 1 House(s), 4 Children
Niau, w, 1 Mo`o, 5 Lo`i, 1 House lot, 1 House(s), 1 Child
Kupokii, 1 Mo`o, 3 Lo`i, 1 House lot, 1 House(s), 3 Children
Nau w, 1 Mo`o, 5 Lo`i, 1 House lot, 1 House(s), 1 Child
Manuwa, 1 Mo`o, 8 Lo`i, 1 House lot, 1 House(s), 1 Child
Paakiki, 1 Mo`o, 5 Lo`i, 1 House lot, 1 House(s), 1 Child
Uma, 1 Mo`o, 8 Lo`i, 1 House lot, 1 House(s), 4 Children
Kuaana, 1 Mo`o, 7 Lo`i, 1 House lot, 1 House(s), 4 Children
Kuhanapilo, 1 Mo`o, 1 Lo`i, 1 House lot, 1 House(s), 1 Child
Kauhi, 1 Mo`o, 2 Lo`i, 1 House lot, 1 House(s), 1 Child
Kakaukola, 1 Mo`o, 2 Lo`i, 1 House lot, 2 House(s), 4 Children
Kauhiohewa, 1 Mo`o, 1 Lo`i, 1 House lot, 1 House(s), 1 Child
Luukia, wahine, 1 Mo`o, 2 Lo`i, 1 House lot, 1 House(s), 1 Child
Hanaiuka, 1 Mo`o, 3 Lo`i, 1 House lot, 1 House(s), 1 Child
Nawahinelawaia, 1 Mo`o, 1 Lo`i, 1 House lot, 1 House(s), 4 Children
Leoiki, 1 Mo`o, 10 Lo`i, 1 House lot, 1 House(s), 2 Children
Kaanaana, 1 Mo`o, 2 Lo`i, 1 House lot, 1 House(s), 4 Children
Hinaumai, 1 Mo`o, 9 Lo`i, 1 House lot, 1 House(s), 4 Children
Kaholohua, 1 Mo`o, 9 Lo`i, 1 House lot, 5 House(s), 4 Children
Homa, 1 Mo`o, 9 Lo`i, 1 House lot, 1 House(s), 4 Children
Kaheau, 1 Mo`o, 9 Lo`i, 1 House lot, 1 House(s), 4 Children
Kaluluahi, 1 Mo`o, 9 Lo`i, 1 House lot, 1 House(s), 4 Children
Paamua, 1 Mo`o, 9 Lo`i, 1 House lot, 1 House(s), 4 Children

Kamauli, 1 Mo`o, 9 Lo`i, 1 House lot, 2 House(s), 4 Children
Lio, 1 Mo`o, 1 Kula, 1 House lot, 2 House(s), 4 Children
Naokiai, 1 Mo`o, 1 Kula, 1 House lot, 2 House(s), 4 Children
Kailihao, 1 Mo`o , 1 Kula, 1 House lot, 1 House(s), 4 Children
Kaulewaiwi, 1 Mo`o, 1 Kula, 1 House lot, 1 House(s), 3 Children
Kalaepoha, 1 Mo`o, 1 Kula, 1 House lot, 1 House(s), 3 Children
Hepa, 1 Mo`o, 1 Kula, 1 House lot, 1 House(s), 3 Children
Kamakahi, 1 Mo`o, 1 Kula, 1 House lot, 1 House(s) Children, 3
Kaualelehuna, 1 Mo`o, 1 Kula, 1 House lot, 1 House(s), 3 Children
Halelaau, 1 Mo`o, 1 Kula, 1 House lot, 1 House(s), 1 Child
Kaneakauhi, 1 Mo`o, 1 Kula, 1 House lot, 1 House(s), 1 Child
Opunui, 1 Mo`o, 1 Kula, 1 House lot, 1 House(s), 2 Children
Keahale, 1 Mo`o, 1 Kula, 1 House lot, 2 House(s), 3 Children
Kahuluhulu, 1 Mo`o, 1 Kula, 1 House lot, 2 House(s), 3 Children
Kaimoleihonua, 1 Mo`o, 1 Kula, 1 House lot, 2 House(s), 3 Children
Naiapapa, 1 Mo`o, 1 Kula, 1 House lot, 2 House(s), 3 Children
Kaleiku, 1 Mo`o, 1 Kula, 1 House lot, 2 House(s), 3 Children
Kailio, 1 Mo`o, 1 Kula, 1 House lot, 2 House(s), 3 Children
Kahili, 1 Mo`o, 1 Kula, 1 House lot, 1 House(s), 3 Children
Haikoi, 1 Mo`o, 1 Kula, 1 House lot, 1 House(s), 3 Children
Uoo, 1 Mo`o, 1 Kula, 1 House lot, 1 House(s), 3 Children
Kanealu, 1 Mo`o, 1 Kula, 1 House lot, 1 House(s), 3 Children
Kaioe, 1 Mo`o, 1 Kula, 1 House lot, 1 House(s), 2 Children
Kuhoomalana, 1 Mo`o, 1 Kula, 1 House lot, 1 House(s), 2 Children
Uao, 1 Mo`o, 1 Kula, 1 House lot, 1 House(s), 2 Children
Kaliiwahinui, 1 Mo`o, 1 Kula, 1 House lot, 1 House(s), 2 Children
Poupou, 1 Mo`o, 1 Kula, 1 House lot, 1 House(s), 2 Children
Palekaluhi, 1 Mo`o, 1 Kula, 1 House lot, 1 House(s), 1 Child
Kahakai, 1 Mo`o, 1 Kula, 1 House lot, 1 House(s), 1 Child
Kaopuaua, 1 Mo`o, 1 Kula, 1 House lot, 1 House(s), 1 Child
Naniu, 1 Mo`o, 1 Kula, 1 House lot, 1 House(s), 1 Child
Kawaihae, 1 Mo`o, 1 Kula, 1 House lot, 1 House(s), 1 Child
Ukeke, 1 Mo`o, 1 Kula, 1 House lot, 1 House(s), 1 Child
Kaihumua, 1 Mo`o, 1 Kula, 1 House lot, 1 House(s), 1 Child
Mokunui, 1 Mo`o, 1 Kula, 1 House lot, 1 House(s), 2 Children
Kauleeku, 1 Mo`o, 1 Kula, 1 House lot, 1 House(s), 2 Children
Humehume 1 mo`o, 2 kula, 1 House lot, 1 House(s), 2 Children
Moku 1 Mo`o, 5 Kula, 1 House lot, 1 House(s), 1 Child
Kaia, 1 Mo`o, 2 Kula, 1 House lot, 2 House(s), 1 Child
Kaliikanakaole, 1 Mo`o, 5 Kula, 1 House lot, 1 House(s), 1 Child
Kapule, 1 Mo`o, 5 Kula, 1 House lot, 1 House(s), 1 Child
Kaneaumoana, 1 Mo`o, 1 Kula, 1 House lot, 1 House(s), 1 Child
Nahokunui, 1 Mo`o, 5 Kula, 1 House lot, 1 House(s), 1 Child
Kailua, 1 Mo`o, 5 Kula, 1 House lot, 1 House(s), 1 Child
Kapela, 1 Mo`o, 5 Kula, 1 House lot, 2 House(s), 3 Children
Holomoana, 1 Mo`o, 2 Kula, 1 House lot, 2 House(s), 2 Children
Kaumiumi, 1 Mo`o, 1 Kula, 1 House lot, 1 House(s), 2 Children
Nahona, 1 Mo`o, 2 Kula, 1 House lot, 1 House(s), 4 Children
Puou, 1 Mo`o, 3 Kula, 1 House lot, 1 House(s), 4 Children
Koleaka, 1 Mo`o, 3 Kula, 1 House lot, 1 House(s), 4 Children
Kaluwahinenui, 1 Mo`o, 1 Kula, 1 House lot, 1 House(s), 1 Child
Alele, 5 Mo`o, 5 Kula, 1 House lot, 1 House(s), 1 Child
Kuhiwahiwa, 1 Mo`o, 5 Kula, 1 House lot, 1 House(s), 3 Children
Ope, 1 Mo`o, 2 Kula, 1 House lot, 1 House(s), 4 Children
Keawekolohe, 1 Mo`o, 2 Kula, 1 House lot, 1 House(s), 3 Children
Makahiwahiwa 1 Mo`o, 2 Kula, 1 House lot, 1 House(s), 3 Children
Kekahili 1 Mo`o, 2 Kula, 1 House lot, 1 House(s), 2 Children
Lokai, 4 Mo`o, 4 Kula, 1 House lot, 1 House(s), 2 Children
Kaheananaui, 1 Mo`o, 2 Kula, 1 House lot, 1 House(s), 2 Children
Ainui, 1 Mo`o, 2 Kula, 1 House lot, 1 House(s), 2 Children
Uma , 1 Mo`o, 2 Kula, 1 House lot, 1 House(s), 2 Children
Kahoowaha, 1 Mo`o, 2 Kula, 1 House lot, 1 House(s), 2 Children

Land Two, Pawaa is the name, at Waikiki. Names of people living on this land:
Ia, Oopa, Kaheleloa, Mahoe, Nahuakai, Laau, Kamokuahanui, Kaolei, Napohaku, Naukana, Mu, Kua, Nakaikuaana, Kaaiahua.

These lands are my share from the Government, therefore, two thirds only remain to us and the people. The explanation is in the Mahele Book.
I am, respectfully, your obedient servant.
IOANE II

/*The initials w, k, m, are shown, which I take to mean wahine, kane, make, or widow/

The fourth of the land claims is at Waiakimi, with three lo`i and a kula in Honolulu land, in Kalawahine. It was transferred to the wahine of Ioane Ii from the year 1830 until this time.

F.T. 554v3
No. 8241, Ioane Ii

Keekapu, sworn, says she knows the Kuleana of Ii in "Kalawahine." Honolulu Aina. It consists of some Kalo patches in one piece with a small piece of kula adjoining.

It is bounded:
Mauka by the land of Kaauhauhula
On Waikiki side by a stream
Makai by L. Haalilea & Kekuanaoa
On Ewa side by the land of Rosalie Marini.

Claimant received this land from his father, Kalimahauna, in the time of Kinau, and has held it ever since. There is not dispute to this claim.

Witness knows the House Lot in "Manamana" Honolulu, claim by Ii.

It is bounded:
Mauka by Ala Beretane
On Waikiki side by Kaluahinenui's lot
Makai by Kalaiheana & Pahana's lots
Ewa side by Hinau's lot.

This lot was anciently a waste place and was taken up by claimant in the time of Kinau & he has held possession of it ever since, without dispute.

K. Kapaakea, sworn, says he knows this house lot, and confirms in full the testimony given by Keekapu.

N.T. 148v10
No. 8241, Ionae Ii

Waipio ahupuaa, Ewa, Oahu
Pawaa ili, Waikiki, Kona, Oahu.

This distribution is correct and the lands are for John Ii. Permission has been granted to present this before the land officers who settle claims.
(Sign) Kamehameha
Royal Palace, 27 January 1848

[Award 8241; R.P. 5699; Kalawahine Honolulu Kona; 1 ap.; .77 Ac.; no R.P. Pawaa Kona; 1 ap.; 2.59 Acs; R.P. 5704; Pawaa Kona; 5 ap.; 250.8 Acs; R.P. 5732; Waipio Ewa; (ahupua`a);1 ap.; 20,546 Acs; See other names for other claims]

Cultural Surveys Hawai'i Inc.
Archaeological and Cultural Impact Studies
Hallett H. Hammatt, Ph.D., President

Providing Excellence in Cultural Resource Management

O'ahu P.O. Box 1114
Kailua, HI 96734
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Fax.: (808) 262-4950

Maui 16 S. Market St., #2N
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Lawai, HI 96765
Ph.: (808) 245-4883

March 18 2009

Ms. Wendy Tolleson, Oʻahu Island Archaeologist
State Historic Preservation Division (SHPD)
Kākuhihewa Building,
601 Kamōkila Blvd., Suite 555
Kapolei, Hawaiʻi 96707

Cultural Surveys Hawaiʻi, Inc. (CSH) Job Code: WAIPIO 2

Subject: CSH's re-submittal to SHPD of the archaeological inventory survey report (Tulchin et al. 2009) for the Trunk Sewer Line Alignment as part of Off-Site Improvements for the Proposed Koa Ridge Makai Community Development, Waipiʻo & Waikele Ahupuaʻa, ʻEwa District, Oʻahu, TMK: [1] 9-4-002:024, [1] 9-4-005: por. 074, [1] 9-4-006: por. 005, [1] 9-4-007, 011, 013, 014, 015, 017, 020, 026, 160, & [1] 9-4-096:149--for SHPD review under HRS Chapter 6E-42 and HAR Chapter 13-284.

Dear Ms. Tolleson:

Thank you for your review letter of the above referenced study dated March 5, 2009 (copy attached). As per this review letter, attached please find a single revised hard copy of the archaeological inventory survey report (Tulchin et al. 2009) marked "final" for SHPD review along with a CD.

We are requesting an acceptance letter for this study. Please let us know if you have any questions, comments, or concerns.

Sincerely,

David W. Shideler
Cultural Surveys Hawaiʻi, Inc.

Tulchin, Jon, Kathryn Whitman and Hallett H. Hammatt
2009 *Archaeological Inventory Survey for a Trunk Sewer Line Alignment as part of Off-Site Improvements for the Proposed Koa Ridge Makai Community Development, Waipiʻo & Waikele Ahupuaʻa, ʻEwa District, Oʻahu, TMK: [1] 9-4-002:024, [1] 9-4-005: por. 074, [1] 9-4-006: por. 005, [1] 9-4-007, 011, 013, 014, 015, 017, 020, 026, 160, & [1] 9-4-096:149.* Job Code: WAIPIO 2. Cultural Surveys Hawaiʻi, Inc., Kailua, HI.

Date: 03/18/09 CSH Job Code: Waipio 2

Submittal Sheet for Historic Preservation Review Filling Fees

State Historic Preservation Division
Department Land and Natural Resources

Agency/Firm (Requesting Review): Cultural Surveys Hawaii, Inc.

Contact: David Shideler

Phone: 262-9972 Fax: 262-4950

Address: P. O. Box 1114 Kailua, HI 96734

E-Mail: dshideler @culturalsurveys.com

Title of Report/Plan:

Archaeological Inventory Survey for a Trunk Sewer Line Alignment as part of Off-Site Improvements for the Proposed Koa Ridge Makai Community Development, Waipi'o & Waikele Ahupua'a, 'Ewa District, O'ahu, TMK: [1] 9-4-002:024, [1] 9-4-005: por. 074, [1] 9-4-006: por. 005, [1] 9-4-007, 011, 013, 014, 015, 017, 020, 026, 160, & [1] 9-4-096:149 (Tulchin et al. 2008)

Island:	Oahu	District:	'Ewa	Ahupua`a:	Waipio

TMK [(1) 1-1-001:001]: see above

Acreage inventoried (hectares):	15 acres	Number of new sites inventoried: 1
Please characterize survey level: Reconnaissance or Intensive	Intensive	

Submitted Plan/Report Fee & Type: (All reports or plans submitted to the SHPD for review shall be accompanied by the appropriate fee in accordance with HAR §13-275-4 and §284-4).

x		Check if Report is a Re-Submittal (no fee charged)
____	$50	Archaeological Assessment
____	$150	Archaeological Inventory Survey Plan
____	$450	Archaeological, Architectural or Ethnographic Survey Report
____	$150	Preservation Plan
____	$25	Monitoring Plan
____	$150	Archaeological Data Recovery Plan
____	$250	Burial Treatment Plan
____	$100	Archaeological Monitoring Report, if resources reported
____	$450	Archaeological Data Recovery Report
____	$450	Ethnographic Documentation Report
____	$25	Burial Disinterment Report
____	$50	Osteological Analysis Report

Fee Total: 00 (Make check payable to "Hawaii Historic Preservation Special Fund")

For Office Use Only:

Date Received:	Payment Method: Cash $ Check: Check No.:
Log. No.:	Receipt Issued:

RECEIVED
HISTORIC PRES. DIV.
DEPT. OF LAND & NATURAL RESOURCES
2009 MAR 18 P 1:47

LINDA LINGLE
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES

STATE HISTORIC PRESERVATION DIVISION
601 KAMOKILA BOULEVARD, ROOM 555
KAPOLEI, HAWAII 96707

March 5, 2009

Mr. David Shideler
Cultural Surveys Hawai'i
P. O. Box 1114
Kailua, Hawai'i 96734

LOG NO: 2008.5435
DOC NO: 0903WT29
Archaeology

Dear Mr. Shideler:

**SUBJECT: 6E-42 Historic Preservation Review—
Request for Revisions—
DRAFT Archaeological Inventory Survey for a Trunk Sewer Line Alignment as Part of Off-Site Improvements for the Proposed Koa Ridge Makai Community Development,
Waipi'o & Waikele Ahupua'a, 'Ewa District, O'ahu
TMK: (1) 9-4-002: 024; 9-4-005: por. 074; 9-4-006: por. 005; 9-4-007, 011, 013, 104, 015, 017, 020, 026, 160 & 9-4-096:149**

Thank you for providing the opportunity to review this DRAFT Archaeological Inventory Survey *(DRAFT Archaeological Inventory Survey for a Trunk Sewer Line Alignment as Part of Off-Site Improvements for the Proposed Koa Ridge Makai Community Development, Waipi'o & Waikele Ahupua'a, 'Ewa District, O'ahu TMK: (1) 9-4-002: 0 [Tulchin, Whitman and Hammatt, PhD November 2008])* which we received on November 28, 2008. We apologize for the delay in this review as we have been short-staffed. This project was the 100% pedestrian survey of a right-of-way for a proposed sewer trunk line extending 3 miles from upland Waikele down through Waipi'o and Waipahu town terminating at the Waipahu Sewage Treatment plant. A single historic property SIHP# 50-80-09-6959, an irrigation ditch and water control feature related to historic sugar cane agriculture was recorded in the mauka section of the project area.

The report is of good quality. However before we can accept this report please consider the following comments: Please remind your staff of the importance of reviewing reports and correcting discrepancies prior to submission for SHPD review. Failure to provide quality plans and reports that are proof read and edited prior to submittal could result in delays and increased costs for you and your clients. The following discrepancies that need to be corrected for a final version include:

1) References: There are numerous references in the References Cited section that are not in the body of the report, and vice versa. Also, please be sure to check references on the maps as well. Please carefully edit your reports to make sure all the references match.

2) Please convert the linear footage of the ROW into acres and include in the Summary Section.

We look forward to receiving a revised report. The complete, finalized report should be free of errors, contain good quality color photographs, color maps and assigned State site numbers. Please send a copy of the revised edition clearly marked FINAL so we can accept it, along with a copy of this review letter and a text-searchable PDF version on CD to the attention of Wendy Tolleson and the **"SHPD Library"** at the Kapolei SHPD office.

Please contact Wendy Tolleson at (808) 692-8024 if you have any questions or concerns regarding this letter.

Aloha,

Nancy A. McMahon

Nancy A. McMahon (Deputy SHPO)
State Historic Preservation Officer

FINAL

Archaeological Inventory Survey for a Trunk Sewer Line Alignment as part of Off-Site Improvements for the Proposed Koa Ridge Makai Community Development, Waipi‘o & Waikele Ahupua‘a, ‘Ewa District, O‘ahu

TMK: [1] 9-4-002:024, [1] 9-4-005: por. 074, [1] 9-4-006: por. 005, [1] 9-4-007, 011, 013, 014, 015, 017, 020, 026, 160, & [1] 9-4-096: 149

Prepared for

Wilson Okamoto Corporation

and

Helber Hastert & Fee, Planners

Prepared by

Jon Tulchin, B.A.,

Kathryn Whitman, M.S.

and

Hallett H. Hammatt, Ph.D.

Cultural Surveys Hawai‘i, Inc.

Kailua, Hawai‘i

(Job Code: WAIPIO 2)

March 2009

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Management Summary

Reference	Archaeological Inventory Survey for a Trunk Sewer Line Alignment as part of Off-Site Improvements for the Proposed Koa Ridge Makai Community Development, Waipiʻo & Waikele Ahupuaʻa, ʻEwa District, Oʻahu, TMK: [1] 9-4-002:024, [1] 9-4-005: por. 074, [1] 9-4-006: por. 005, [1] 9-4-007, 011, 013, 014, 015, 017, 020, 026, 160, & [1] 9-4-096:149 (Tulchin et al. 2008)
Date	March 2009
Project Number (s)	Cultural Surveys Hawaii (CSH) Job Code WAIPIO 2
Investigation Permit Number	Fieldwork for this investigation was performed under CSH's annual archaeological fieldwork permit, # 08-14, issued by the Hawaiʻi Department of Land and Natural Resources / State Historic Preservation Division (DLNR / SHPD)
Project Area Definition and Background	Castle and Cooke Homes Hawaii proposes the Koa Ridge Makai Development on approximately 574 acres located between Kīpapa Gulch and the H-2 Freeway (TMK [1] 9-4-006:001, 002, 038 and [1] 9-5-003:004). Potential off-site improvements related to the proposed development involve a trunk sewer line connecting the proposed Koa Ridge Makai Community Development to the Waipahu Wastewater Pump Station. For the purposes of this investigation, the project area is defined and limited to the footprint of the proposed trunk sewer line alignment.
Project Area Location	The project area extends south from the southernmost portion of the proposed Koa Ridge Makai Development to the Waipahu Wastewater Pump Station. The project area crosses Kamehameha Highway, just north of the intersection at Ka Uka Boulevard, and runs south along the western boundary of the Patsy T. Mink Central Oʻahu (Waiola) Regional Park, then continues south along Paiwa Street, crossing the H1 freeway and running through an existing bus parking lot (TMK's [1] 9-4-096: 149 & [1] 9-4-002: 024), then it makes its way south on Mokuola Street, heads west on Moloalo Street and Farrington Highway, and then makes its final turn south along Waipahu Depot Road where the project area terminates at the Waipahu Wastewater Pump Station. Due to the project area's length and *mauka-makai* orientation, it crosses through two distinct pre-contact indigenous Hawaiian occupation/resource zones. As a result, this study has divided the project area into two sections, "Mauka" and "Makai", in order to properly address each zone in relation to the proposed project. The project area is depicted on the 1998 Waipahu USGS 7.5-minute topographic quadrangle.

Project Area Dimensions	The project area is long and linear and totals approximately 15-acres. It is approximately 6 km (3.7 mi) long and 6 m (20 ft) wide, with the exception of a 625 m (2050 ft) segment at an existing bus parking facility (TMK's [1] 9-4-096: 149 & [1] 9-4-002: 024) where the project area expands to 45 m (148 ft) in width.
Project Funding	The proposed trunk sewer line will be privately funded by Castle and Cooke Homes Hawaii.
Project Area Land Jurisdiction	The majority of the project area is under the land jurisdiction of the City and County of Honolulu. Of note is the short segment where the project area crosses Kamehameha Highway, which is under the land jurisdiction of the Hawaii State Department of Transportation, and the southern portion of the bus parking facility (TMK [1] 9-4-002: 024), which is under the land jurisdiction of Castle and Cooke Homes Hawaii.
Agencies	State Historic Preservation Division (SHPD)
Project Description	The proposed sewer line will be installed using open trenching or microtunneling within an approximately 20-foot wide corridor along the route described above. Microtunneling pits will be approximately 20 feet wide by 30 to 50 feet long.
Area of Potential Effect (APE) and Survey Acreage	The proposed trunk sewer line is located amid existing city streets and housing developments. Based on available information, these proposed off-site improvements related to the Koa Ridge Makai development will not impose adverse visual, auditory or other environmental impact to any known historic properties, including standing architecture, located outside the project area. Accordingly, the proposed project, based on available information lacks potential to affect historic properties outside the project area. As a result the project's APE is the same as the project area. The survey area for the current investigation included the entire approximately 6 km (3.7 mi) corridor along the path of the proposed sewer line.
Historic Preservation Regulatory Context	At the request of the Wilson Okamoto Corporation and Helber Hastert and Fee Planners, CSH undertook this archaeological inventory survey. In consultation with SHPD, the inventory survey investigation was designed to fulfill the state requirements for archaeological inventory surveys [Hawaiʻi Administrative Rules (HAR) Chapter 13-13-276]. This document was prepared to support the proposed project's historic preservation review under HRS Chapter 6E-42 and HAR Chapter 13-13-284, as well as the project's environmental review under HRS Chapter 343.
Fieldwork Effort	Fieldwork was accomplished on February 11th and September 16th, 2008 by Jon Tulchin, B.A., Nifae Hunkin, B.A., and Katie Whitman, M.S. under the general supervision of Hallett H. Hammatt, Ph.D.(principal investigator), requiring 3 person-days to complete.

Number of Historic Properties Identified	One, State Inventory of Historic Properties (SIHP) # 50-80-09-6959, Plantation era irrigation infrastructure including ditches and a water control feature, recommended Hawaiʻi Register eligible under Criterion D.
Effect Recommendation	CSH's project specific effect recommendation is "effect, with proposed mitigation commitments." The proposed trunk sewer line has the potential to adversely affect subsurface cultural resources, including human burials, which may be located within the project's APE. The recommended mitigation measures will reduce the project's effect to any cultural resources that may be located within the alignment of the proposed trunk sewer line and be pro-active in addressing possible community concerns.
Mitigation Recommendation	Background research has indicated that the *makai* section of the project area, from Koaki Street to the Waipahu Wastewater Pump Station, was intensively utilized by pre-contact Hawaiians for agriculture, aquaculture, and habitation; and by the Oahu Sugar Company as a transport hub, a sugar processing facility, and residences for field workers and supervisors. Thus it is very likely that subsurface historic properties, associated with both pre- and post-contact land use, are present within the *makai* project area in the form of cultural layers and/or structural remnants buried by modern and/or historic fill layers. In order to mitigate the potential damage to these potential historic properties within the *makai* project area, it is recommended that project construction proceed under an archaeological monitoring program. It is understood that much or all of the sewer line work in the *makai* area may be conducted by micro-tunneling. It may be appropriate to limit archaeological monitoring to the excavation of the micro-tunneling pits. Such specifics will be addressed in the archaeological monitoring plan to be reviewed and approved by the State Historic Preservation Division. This monitoring program will facilitate the identification and proper treatment of any burials that might be discovered during project construction, and will gather information regarding the project's non-burial archaeological deposits, should any be discovered. No further historic preservation work is recommended for SIHP # 50-80-09-6959. Sufficient information regarding the location, function, age, and construction methods of SIHP # 50-80-09-6959 have been generated by the current inventory survey investigation to mitigate any adverse effect caused by proposed development activities.

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Section 1 Introduction

1.1 Project Background

At the request of Wilson Okamoto Corporation and Helber Hastert & Fee, Planners, Cultural Surveys Hawaii, Inc. (CSH) conducted an archaeological inventory survey for a trunk sewer line alignment planned as part of the off-site improvements for the proposed Koa Ridge Makai Community Development, Waipiʻo and Waikele Ahupuaʻa, ʻEwa District, Oʻahu, TMK: [1] 9-4-002:024, [1] 9-4-005: por. 074, [1] 9-4-006: por. 005, [1] 9-4-007, 011, 013, 014, 015, 017, 020, 026, 160, & [1] 9-4-096:149.

Castle and Cooke Homes Hawaii proposes the Koa Ridge Makai Development on approximately 574 acres located between Kīpapa Gulch and the H-2 Freeway [TMK (1) 9-4-006:001, 002, 038 and (1) 9-5-003:004] (Figure 1). Potential off-site improvements related to the proposed development involve a trunk sewer line connecting the proposed Koa Ridge Makai Community Development to the Waipahu Wastewater Pump Station. For the purposes of this investigation, the project area is defined and limited to the footprint of the proposed trunk sewer line alignment.

The project area extends south from the southernmost portion of the proposed Koa Ridge Makai Development to the Waipahu Wastewater Pump Station (see Figure 1). The project area crosses Kamehameha Highway, just north of the intersection at Ka Uka Boulevard, and runs south along the western boundary of the Patsy T. Mink Central Oʻahu (Waiola) Regional Park, then continues south along Paiwa Street, crossing the H1 freeway and running through an existing bus parking lot (TMK's [1] 9-4-096: 149 & [1] 9-4-002: 024), then it makes its way south on Mokuola Street, heads west on Moloalo Street and Farrington Highway, and then makes its final turn south along Waipahu Depot Road where the project area terminates at the Waipahu Wastewater Pump Station. Due to the project area's length and *mauka-makai* orientation, it crosses through two different *ahupuaʻa* (Waipiʻo and Waikele) as well as two distinct pre-contact indigenous Hawaiian occupation/resource zones. As a result, this study has separated the project area into two segments, "Mauka" and "Makai", in order to properly address each segment in relation to the proposed project. The project area is depicted on the 1998 Waipahu USGS 7.5-minute topographic quadrangle, a Tax Map Key (TMK) map, and an aerial photograph (Figure 2, Figure 3, & Figure 4).

The project area is long and linear and totals approximately 15 acres. It is approximately 6 km (3.7 mi) long and 6 m (20 ft) wide, with the exception of a 625 m (2050 ft) segment at an existing bus parking facility (TMK's [1] 9-4-096: 149 & [1] 9-4-002: 024) where the project area expands to 45 m (148 ft) in width (Figure 5).

The majority of the project area is under the land jurisdiction of the City and County of Honolulu. Of note is the short segment where the project area crosses Kamehameha Highway, which is under the land jurisdiction of the Hawaii State Department of Transportation, and the southern portion of the bus parking facility (TMK [1] 9-4-002: 024), which is under the land jurisdiction of Castle and Cooke Homes Hawaii.

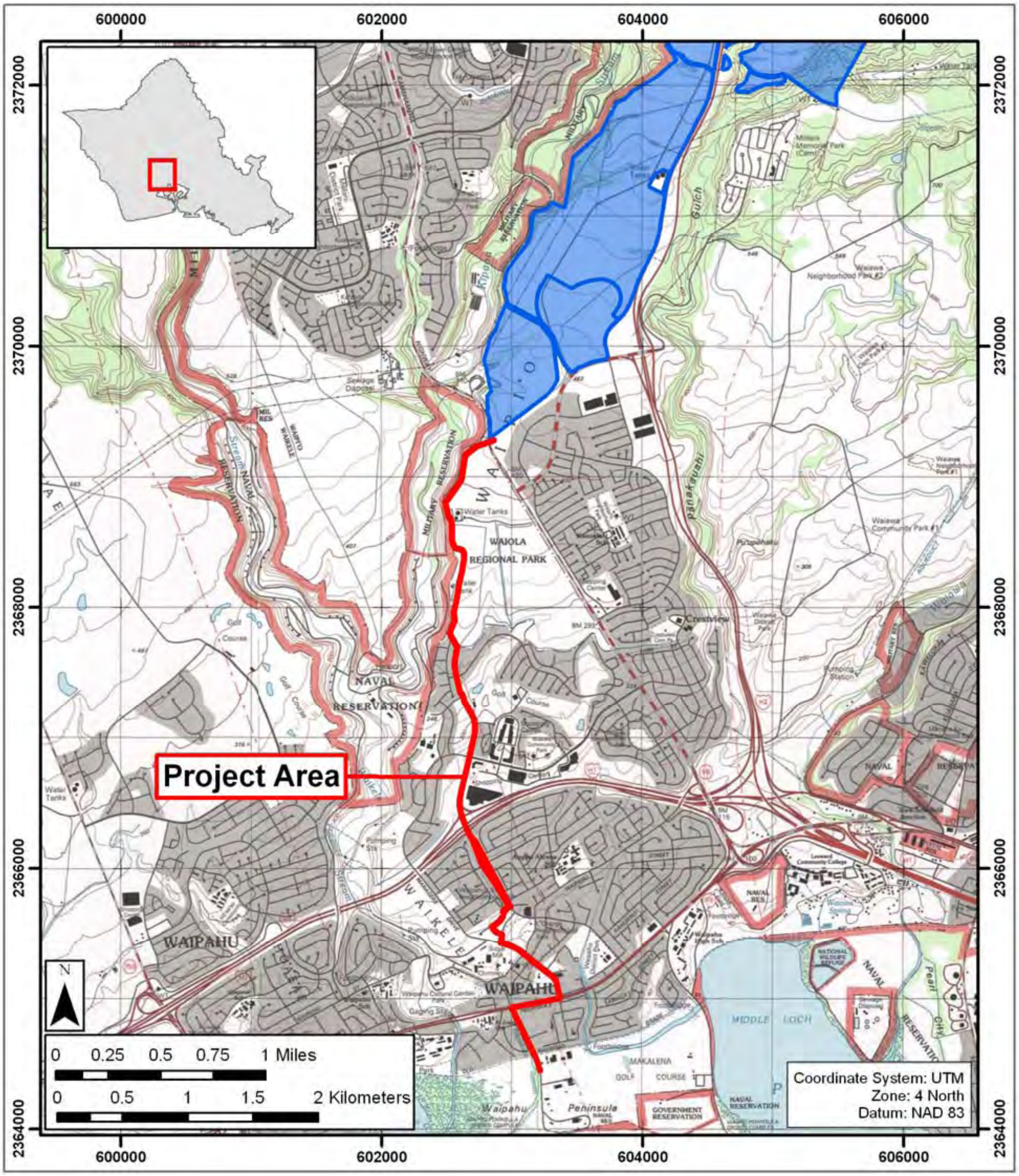

Figure 1. Portion of the 1998 Waipahu USGS 7.5-minute topographic quadrangle, showing the project area (in red) and the proposed Koa Ridge Makai development (indicated in blue)

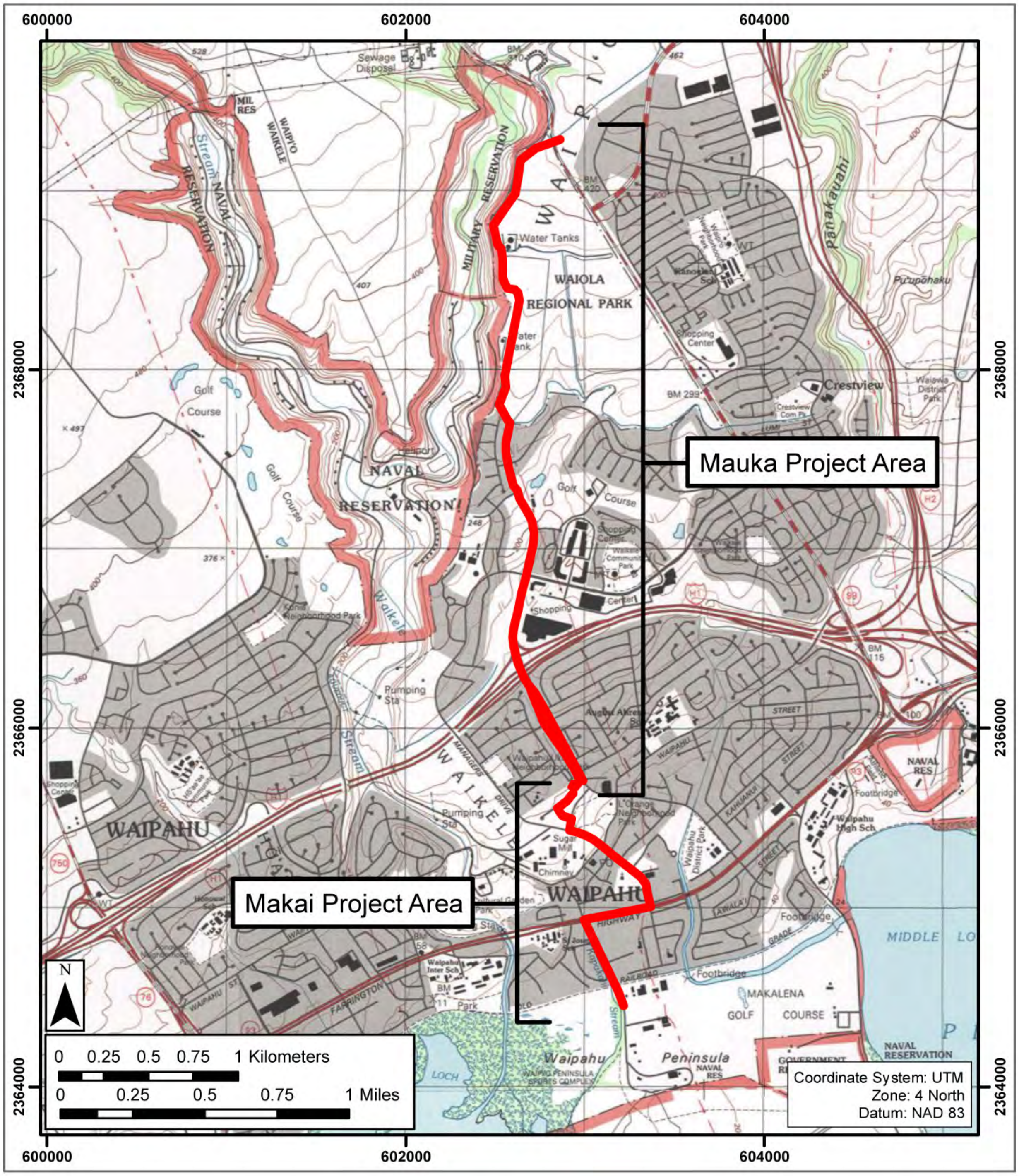

Figure 2. Portion of the 1998 Waipahu USGS 7.5-minute topographic quadrangle, showing the project area (in red) divided into *mauka* and *makai* sections

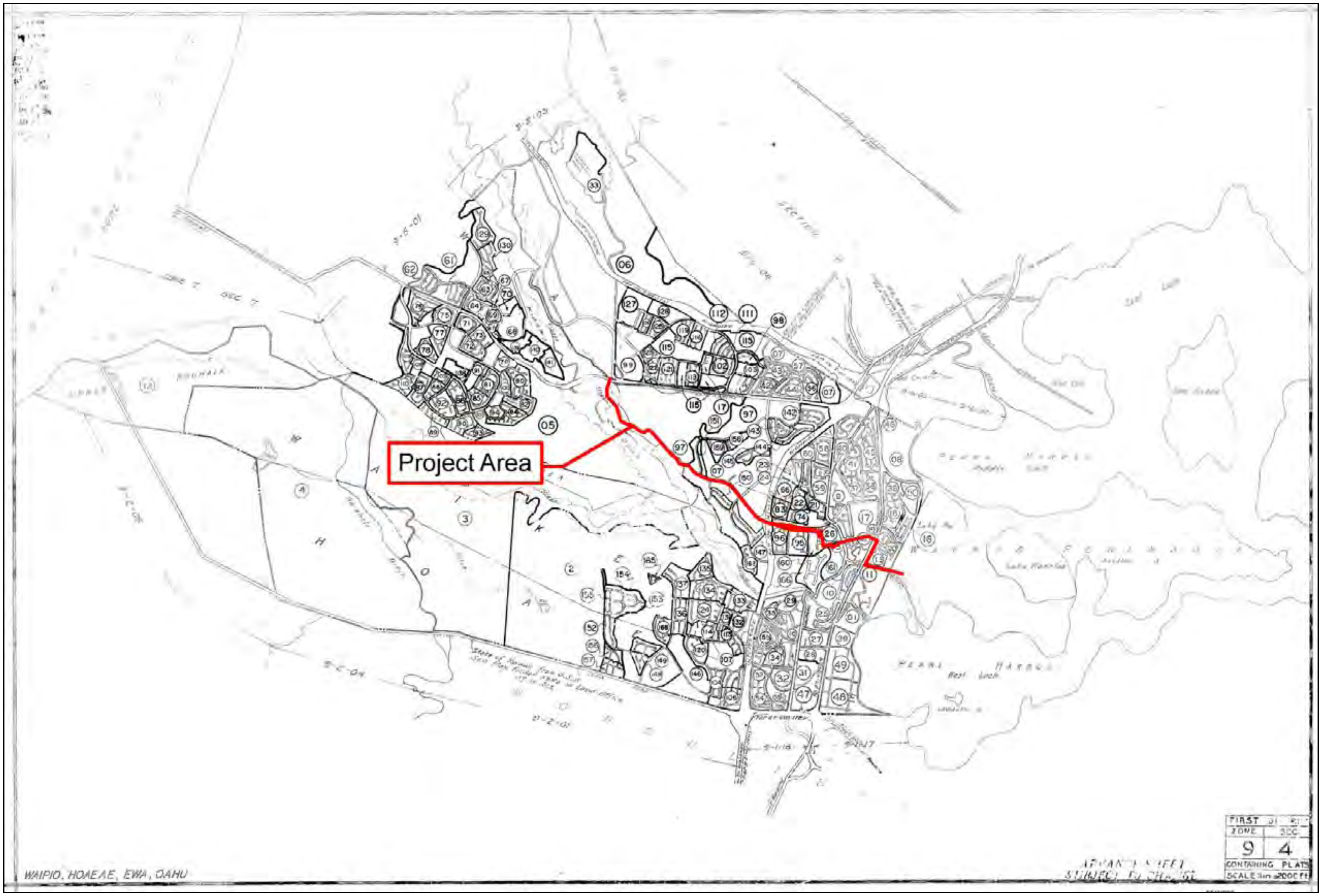

Figure 3. Tax Map Key [1] 9-04 showing the project area

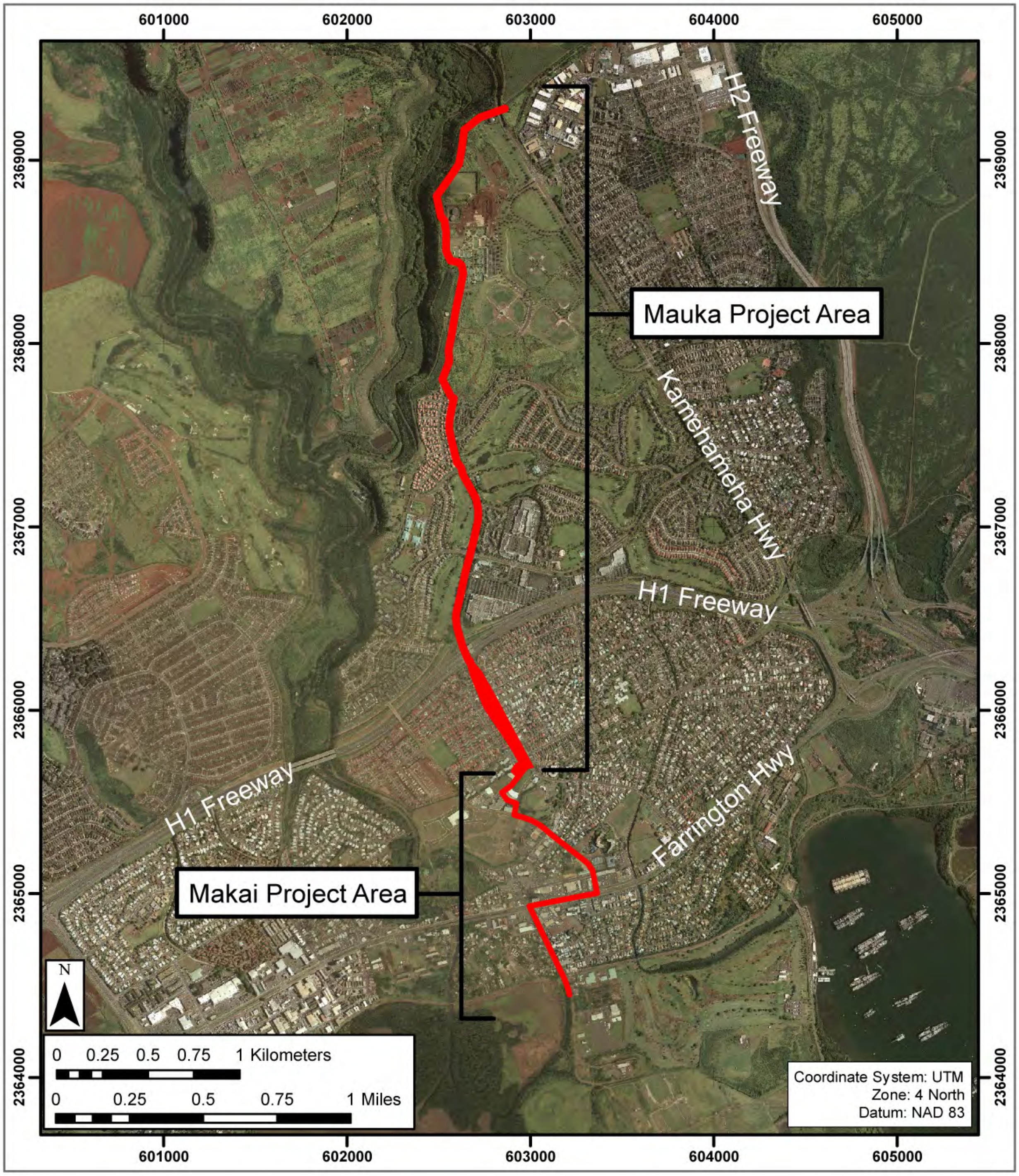

Figure 4. Aerial photograph showing the project area (in red) divided into *mauka* and *makai* sections (source: USGS Orthoimagery 2005)

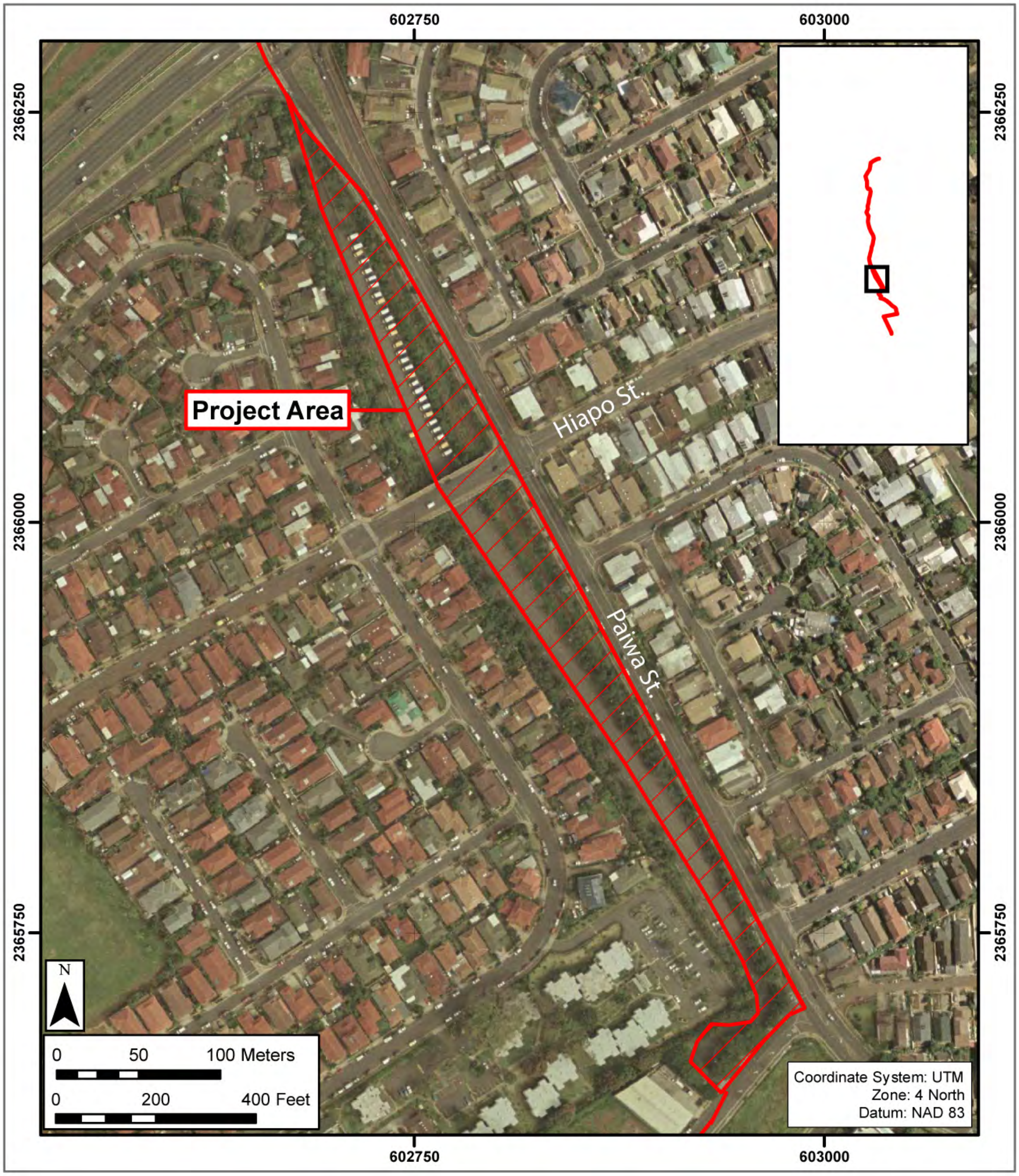

Figure 5. Aerial photograph showing the location of the bus parking lot along Paiwa Street (TMK’s 9-4-096: 149 & 9-4-002: 024)

The proposed sewer line will be installed using open trenching or microtunneling within an approximately 20-foot wide corridor along the route described above. Microtunneling pits will be approximately 20 feet wide by 30 to 50 feet long.

The proposed trunk sewer line is located amid existing city streets and housing developments. Based on available information, these proposed off-site improvements related to the Koa Ridge Makai development will not impose adverse visual, auditory or other environmental impact to any known historic properties, including standing architecture, located outside the project area. Accordingly, the proposed project, based on available information lacks potential to affect historic properties outside the project area. As a result the project's APE is the same as the project area. The survey area for the current investigation included the entire approximately 6 km (3.7 mi) corridor along the path of the proposed sewer line.

In consultation with SHPD, this inventory survey investigation was designed to fulfill the state requirements for archaeological inventory surveys [Hawai‘i Administrative Rules (HAR) Chapter 13-13-276]. This document was prepared to support the proposed project's historic preservation review under HRS Chapter 6E-42 and HAR Chapter 13-13-284, as well as the project's environmental review under HRS Chapter 343.

1.2 Scope of Work

The archaeological inventory survey and its accompanying report will document all historic properties within the subject parcel. The prepared inventory survey will be in compliance with state standards and will be submitted for review and approval to the State Historic Preservation Division/Department of Land and Natural Resources (SHPD/DLNR).

The following steps will satisfy the State and County requirements for an archaeological inventory survey:

1. A complete ground survey of the entire project area for the purpose of historic property identification and documentation. All historic properties were located, described, and mapped with evaluation of function, interrelationships, and significance. Documentation included photographs and scale drawings of selected historic properties. All historic properties were assigned *Inventory of Historic Properties* numbers by the State and located with a handheld GPS unit. This GPS data is presented in the report in ArcGIS format and is sufficient for planning purposes.
2. Research on historic and archaeological background, including search of historic maps, written records, and Land Commission Award documents was carried out. This research focused on the specific area with general background on the *ahupua‘a* and district and will emphasize settlement patterns.
3. Preparation of this survey report which includes the following:
    a. A topographic map of the survey area showing all historic properties;
    b. Description of all historic properties with selected photographs, scale drawings, and discussions of function;

c. Historical and archaeological background sections summarizing pre-contact and post-contact land use as they relate to the project area's historic properties;

d. A summary of historic property categories and their significance in an archaeological and historic context;

e. Recommendations based on all information generated that specify what steps should be taken to mitigate impact of development on the project area's significant historic properties - such as data recovery (excavation) and preservation of specific areas. These recommendations were developed in consultation with the client and the State agencies.

This scope of work also includes full coordination with SHPD and the City and County of Honolulu relating to archaeological matters. This coordination takes place after consent of the owner or representatives.

1.3 Environmental Setting

1.3.1 Natural Environment

The project area extends from 1 to 3 miles from the coast of Peal Harbor's West Loch. The northern portion of the project area is approximately 100 to 300 m east of Kīpapa Stream, while the southern portion of the project area is approximately 500 to 1000 m east of Waikele Stream.

The project area receives 24 to 40 inches of rainfall annually (Giambelluca et al. 1986).

In pre-contact Hawai‘i, the project area would have been covered by lowland dry shrub and grassland, currently it is dominated by a variety of exotic grasses, weeds, and shrubs.

The project area lies on the table lands bordering the eastern edge of Kīpapa Gulch and continues south (*makai*) into Waikele across the ‘Ewa Plain. Lands within the project area are relatively level with elevations ranging from 70 to 430 ft above mean sea level (AMSL).

According to USDA Soil Survey results, the project area, from north (*mauka*) to south (*makai*), contains the following soil types (Foote et al. 1972) (Figure 6):

- Lahaina silty clay (LaB) – The Lahaina series consists of "well-drained soils on uplands…developed in material weathered from basic igneous rock…used for sugarcane and pineapple" (Foote et al. 1972).
- Molokai silty clay loam (MuB) & Molokai silty clay loam (MuD) – The Molokai series consists of "well-drained soils on uplands…formed in material weathered from basic igneous rock…used for sugarcane, pineapple, pasture, wildlife habitat, and home sites" (Foote et al. 1972).
- Waipahu silty clay (WzC) – The Waipahu series consists of "well-drained soils on marine terraces…developed in old alluvium derived from basic igneous rock…used for sugarcane and home sites" (Foote et al. 1972).

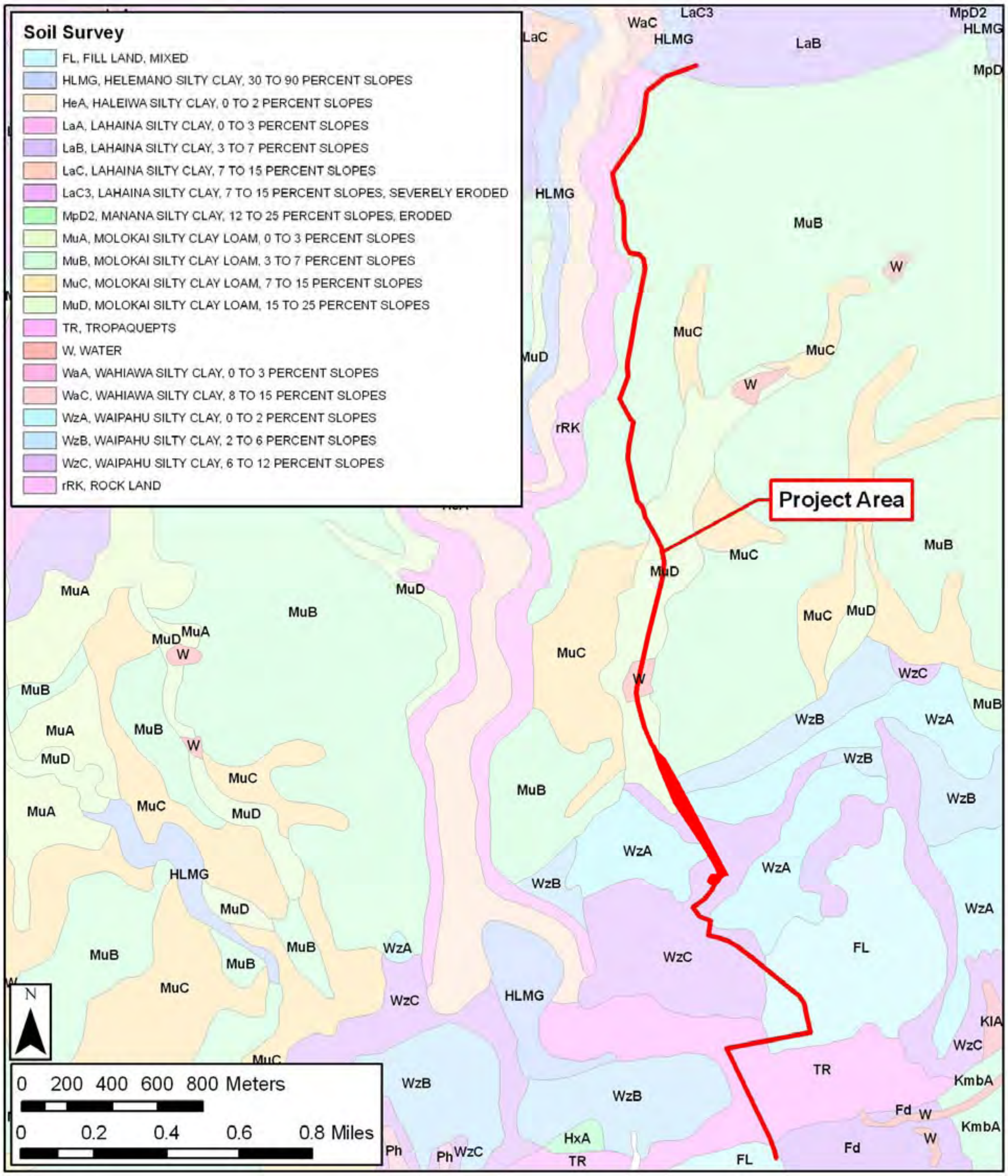

Figure 6.Overlay of Soil Survey of the State of Hawai'i (Foote et al. 1972), indicating sediment types within the project area

- Fill land (FL) - This land type consists of “areas filled with material from dredging, excavation from adjacent uplands, garbage, and bagasse and slurry from sugar mills” (Foote et al. 1972).
- Tropaquepts (TR) - Tropaquepts are “poorly drained soils that are periodically flooded by irrigation in order to grow crops that thrive in water…used for production of taro, rice, and watercress on flooded paddies” (Foote et al. 1972).

1.3.2 Built Environment

The southern portion (primarily the “*makai*” portion) of the project area consists of asphalt paved roads bordered by residential development. Near the southern end of the sewer line alignment, the project area passes through a paved bus parking facility situated between the H1 freeway and the intersection of Paiwa and Koaki streets. The northern portion (primarily the “*mauka*” portion) of the project area is within the western edge of the Patsy T. Mink Central Oahu Regional Park and is situated within a network of dirt roads previously utilized to access pineapple and sugarcane fields. At the northern tip, the project area crosses Kamehameha Highway and stops within an overgrown field.

Section 2 Methods

2.1 Field Methods

Fieldwork was accomplished on February 11th and September 16th, 2008 by Jon Tulchin, B.A., Nifae Hunkin, B.A., and Katie Whitman, M.S. under the general supervision of Hallett H. Hammatt, Ph.D.(principal investigator), requiring 3 person-days to complete.

The archaeologists carried out a 100% pedestrian inspection of the project area. The pedestrian inspection of the study area was accomplished through systematic sweeps. The interval between the archaeologists was generally 5-10 m. All historic properties encountered were recorded and documented with a written field description, scale drawings, photographs, and were located using a GARMIN GPSMAP60Cx unit (accuracy +/- 2-5 m).

Background research revealed that lands within the project area had been continuously disturbed for over a century by agriculture, and subsequently by modern development. These disturbances would have destroyed any subsurface cultural deposits that may have been present beneath the surface. Additionally no surface historic properties were identified that required subsurface testing to aid in the determining of function or age. Thus it was determined that subsurface investigations were not necessary as a component of this archaeological inventory survey.

2.2 Document Review

Background research included a review of previous archaeological studies on file at the State Historic Preservation Division (SHPD) of the Department of Land and Natural Resources (DLNR); a review of geology and cultural history documents at Hamilton Library of the University of Hawaiʻi, the Hawaiʻi State Archives, the Mission Houses Museum Library, the Hawaiʻi Public Library, and the Archives of the Bishop Museum; study of historic photographs at the Hawaiʻi State Archives and the Archives of the Bishop Museum; and a study of historic maps at the Survey Office of the DLNR. Information on Land Commission Awards (LCAs) was accessed through Waihona ʻĀina Corporation’s Māhele Data Base (www.waihona.com).

This research provided the environmental, cultural, historic, and archaeological background for the project area. The sources studied were used to formulate a predictive model regarding the expected type and location of sub-surface pre and post-contact historic properties in the project area.

Section 3 Mauka Project Area Background Research

This section reviews the available documentary evidence for the general character of Waipiʻo *ahupuaʻa* in an attempt to establish land use patterns which will be applied toward generating a predictive model of expected archaeological finds within the *mauka* segment of the project area.

3.1 Traditional and Historical Background

3.1.1 Historical Setting

Waipiʻo Ahupuaʻa was a focus of Hawaiian settlement and activity on Oʻahu during the centuries preceding western contact. "The populous dwelling place of the alii was formerly located on an east point of Waipiʻo Peninsula known as Lepau" (McAllister 1933:106). The *aliʻi* (chiefly class) at Waipiʻo were no doubt attracted to the great abundance the region offered. "The primary reason for ʻEwa's prominence in history and as an *aliʻi* stronghold was undoubtedly the existence of the great number of fishponds at different points around Pearl Harbor, which was ʻEwa territory. Two of the largest were on the peninsula, and another was at its northwest corner" (Handy and Handy 1972:470). The district of ʻEwa also contained other resources that were attractive to an expanding population:

> The lowlands, bisected by ample streams, were ideal terrain for the cultivation of irrigated taro. The hinterland consisted of deep valleys running far back into the Koʻolau range. Between the valleys were ridges, with steep sides, but a very gradual increase of altitude. The lower parts of the valley sides were excellent for the culture of yams and bananas. Farther inland grew the ʻawa for which the area was famous. The length or depth of the valleys and the gradual slope of the ridges made the inhabited lowlands much more distant from the wao, or upland jungle, than was the case on the windward coast. Yet the wao here was more extensive, giving greater opportunity to forage for wild foods in famine time [Handy and Handy 1972:469].

Handy and Handy (1972:470) characterize Waipiʻo and its peninsula as "an aliʻi stronghold," and it is known as the scene of many battles between local and invading *aliʻi* for political control of Oʻahu. Several accounts relate the "Battle of Kīpapa", fought during the reign of the fifteenth century *mōʻī* (king) Maʻilikūkāhi; it explains how the gulch and stream in Waipiʻo were named.

3.1.2 Mythological and Traditional Accounts

3.1.2.1 Waipiʻo Uka and Kūkaniloko

It is difficult to write of the traditions of ʻEwa or Waialua, Oʻahu without mentioning Kūkaniloko (the location of the royal birthing stones). Located in the uplands of Kamananui, Waialua, Kūkaniloko was thought to have been established in the twelfth century "by Nanakaoko and his wife, Kahihiokalani, whose son Kapawa, heads the list of important *aliʻi* born there" (McAllister 1933:135). A child born to a *kapu* chiefess at Kūkaniloko was considered to be a "child with the highest *mana* (spiritual or divine power) and revered as a god that could not be touched” (Alameida 1993:19). Part of Kūkaniloko’s significance lay in its location at the crossroads of the Wai‘anae, Waialua and ‘Ewa Districts. One of the major traditional trails receiving traffic from Kona and portions of ‘Ewa leading to Kūkaniloko passed through Waipi‘o Uka.

Even long after Kūkaniloko had been abandoned and the seat of Hawaiian political power had moved from ‘Ewa to Kona, the memory of Kūkaniloko is still revered. The oral tradition of Kūkaniloko lives on today as one of our informants relayed to us. Kalama Makaneole’s mother, who grew up in Waikele, kept the tradition alive when she shared the history of Kūkaniloko with her son, Kalama.

3.1.2.2 Kīpapa and Mā‘ilikūkahi

Born *ali‘i kapu* at Kūkaniloko, Mā‘ilikūkahi became *mō‘ī* of O‘ahu in the late fourteenth century (Kamakau, 1991: 54). Mā‘ilikūkahi was popular during his reign and was remembered for initiating land reforms, which brought about peace, and for encouraging agricultural production, which brought about prosperity. He also prohibited the chiefs from plundering the *maka‘āinana* with punishment of death (Kamakau, 1991: 55).

Mā‘ilikūkahi’s peaceful reign was interrupted by an invasion which would change Waipi‘o ‘Uka forever. The following is a description of the Battle of Kīpapa by Fornander:

> I have before referred to the expedition by some Hawaii chiefs, Hilo-a-Lakapu, Hilo-a-Hilo-Kapuhi, and Punaluu, joined by Luakoa of Maui, which invaded Oahu during the reign of Mailikukahi. It cannot be considered as a war between the two islands, but rather as a raid by some restless and turbulent Hawaii chiefs... The invading force landed at first at Waikiki, but for reasons not stated in the legend, altered their mind, and proceeded up the Ewa lagoon and marched inland. At Waikakalaua they met Mailikukahi with his forces, and a sanguinary battle ensued. The fight continued from there to the Kīpapa gulch. The invaders were thoroughly defeated, and the gulch is said to have been literally paved with the corpses of the slain, and received its name “Kīpapa”, from this circumstance. Punaluu was slain on the plain which bears his name, the fugitives were pursued as far as Waimano, and the head of Hilo was cut off and carried in triumph to Honouliuli, and stuck up at a place still called Poo-Hilo (Fornander 1969, Vol.II:89).

Apparently, Kīpapa Gulch was named after this particular battle, or more likely renamed. In old Hawai‘i, places were often given names based on historic events. The literal translation of the work *kīpapa* is “to be paved,” as in “paved with the corpses of the slain.”

3.1.2.3 Waipi‘o Uka and the Legend of Kalelealuaka

In the *mauka* regions of Waipi‘o, legend speaks of Kalelealuaka, who lived during the reign of the O‘ahu chief, Kākuhihewa (Thrum, 1998). Blessed with supernatural powers, Kalelealuaka travels to O‘ahu from his home on Kaua‘i and settles in the *mauka* regions of Waipi‘o with his two companions Kaluhe and Keinohoomanawanui. This place is called Keahumoe and here they build their mountain house Lelepua, named after Kalelealuaka’s magic arrows. One night, Kalelealuaka makes known his wish:

> The beautiful daughters of Kakuhihewa to be my wives; his fatted pigs and dogs to be baked for us; his choice *kalo*, sugar cane, and bananas to be served up for us; that Kakuhihewa himself send and get timber and build a house for us; that he pull the famous *awa* of Kahuone; that the King send and fetch us to him; that he chew the *awa* for us in his own mouth, strain and pour it for us, and give us to drink until we are happy, and then take us to our house (Thrum, 1998: 89).

Upon hearing such a request, the *mō‘ī* Kākuhihewa confers with his priests and instead of killing Kalelealuaka, decides to test him in battle with Kūali‘i. Kalelealuaka proves worthy in battle and is given charge of Kākuhihewa’s kingdom.

3.1.2.4 Waipi‘o Lowlands

Many of the legends of Waipi‘o pertain to lands in the vicinity of modern day Pearl Harbor. The name of the *ahupua‘a* itself means “curved, winding water” (Sterling and Summers 1978:1), which probably refers to the curving shorelines of the middle loch of Pearl Harbor, with its many adjacent fishponds. The loch waters were extensively used for gathering *limu* (seaweed), shellfish and other invertebrates, and fish.

The lowland areas were used for agriculture, as described in the following excerpt by E. Craighill Handy in the 1940s.

> Between the West Loch of Pearl Harbor and Loko Eo the lowlands were filled with terraces that extended for over a mile up into the flats of Waikele Stream. The lower terraces were formerly irrigated partly from Waipahu Stream, which Hawaiians believe came all the way through the mountains from Kahuku. It is said that terraces formerly existed on the flats in Kīpapa Gulch for at least two miles upstream above its junction with Waikele. Wild taros grow in abundance in upper Kīpapa Gulch [Handy 1940:82].

In the legend of Nāmakaokapao‘o, one lowland area was called *kula o* Keahumoa (“plain of Keahumoa), which was the plain before reaching Kīpapa gulch when traveling from the sea. Nāmakaokapao‘o’s mother was Pokai and his father was Kaulukahai, a great chief of Kahiki (the ancestral home of the Hawaiians). The father returned to his home before the birth of his son, leaving his O‘ahu family destitute. Nāmakaokapao‘o is described as a small, brave child who disliked his stepfather, Puali‘i, and pulled up the sweet potatoes Puali‘i had planted at their home in Keahumoa. When Puali‘i chased Nāmakaokapao‘o with an axe, Nāmakaokapao‘o delivered his death prayer and killed Puali‘i, hurling his head to a cave in Waipouli, near the beach at Honouliuli (Fornander 1918 V:274).

3.1.3 Early Historic Period

In the first half of the eighteenth century, the island of O‘ahu was ruled by a chief named Kūali‘i; he consolidated his supreme power over the entire island by defeating the chiefs of ‘Ewa (Cordy 2002:32). Kūali‘i met the competing army on the plains of Keahumoa, but the ‘Ewa chiefs surrendered when they saw Kūaliʻi's overwhelming forces, and they ceded the lands of Koʻolauloa, Koʻolaupoko, Waialua, and Waiʻanae to him (Fornander 1917, Volume IV (2):366, 400).

During the second half of the eighteenth century, Waipiʻo again became a focus of political intrigue and warfare. In 1783, the forces of the Maui chief Kahekili gained control of the island of Oʻahu by defeating the *mōʻī*, Kahahana, "from the powerful ʻEwa chiefs' line" (Cordy 1981:207).

According to the nineteenth-century Hawaiian historian Samuel Kamakau, the defeated Oʻahu chiefs plotted to kill the Maui chiefs. Waipiʻo was given the name Waipiʻo *kīmopō,* "Waipiʻo of secret rebellion," due to all the covert planning (Kamakau 1992:138). Following the plan's failure, Kahekili took revenge on the ʻEwa and Kona districts:

> . . . and when Ka-hekili learned that Elani of ʻEwa was one of the plotters, the districts of Kona and ʻEwa were attacked and men, women, and children were massacred, until the streams of Makaho and Niuhelewai in Kona and of Kahoaʻaiʻai in ʻEwa were choked with the bodies of the dead, and their waters became bitter to the taste, as eyewitnesses say, from the brains that turned the water bitter. All the Oʻahu chiefs were killed and the chiefesses tortured [Kamakau 1992:138].

If Kamakau is correct, the population of Waipiʻo would have been decimated during the 1780s. "The Oʻahu society never rose again" (Cordy 1981:208).

Kahekili and the Maui chiefs retained control of Oʻahu until the 1790s. Kahekili died at Waikīkī in 1794. His son, Kalanikūpule, was defeated the following year at the battle of Nuʻuanu by Kamehameha, who distributed the Oʻahu lands - including Waipiʻo Ahupuaʻa - among his favorite followers where ". . . land belonging to the old chiefs was given to strange chiefs and that of old residents on the land to their companies of soldiers, leaving the old settled families destitute" (Kamakau 1992:376-377).

3.1.4 1800 to 1850s

John Papa ʻĪʻī was placed in the household of Liholiho (Kamehameha II) when he was ten years old. He became Liholiho's personal attendant and also maintained records of life in the Hawaiian Kingdom. He was born in Waipiʻo Ahupuaʻa at the beginning of the nineteenth century. An account of his birth details the establishment of ʻĪʻī's family at Waipiʻo after the ascendancy of Kamehameha on Oʻahu:

> John Papa Ii was born in Kumelewai, Waipio, in Ewa, Oahu, on the third day of August (Hilinehu in the Hawaiian calendar) in 1800, on the land of Papa Ii, whose namesake he was. Papa [ʻĪʻī's uncle] was the owner of the pond of Hanaloa and two other pieces of property, all of which he had received from Kamehameha, as did others who lived on that ahupuaʻa, or land division, after the battle of Nuuanu. He gave the property to his kaikuahine, or cousin, who was the mother of the

> aforementioned boy. Her names were Wanaoa, Pahulemu, and Kalaikane [ʻĪʻī 1959:20].

ʻĪʻī's writings provide glimpses of life within Waipiʻo Ahupuaʻa during ʻĪʻī's lifetime. ʻĪʻī mentions the "family [going] to Kīpapa from Kumelewai by way of upper Waipio to make ditches for the farms" (ʻĪʻī 1959:28) and recalls that, during the visit to Oʻahu by the Kauaʻi chief Kaumualiʻi and his entourage, the chief's attendants were provided with gifts: "From Waipio in Ewa and from some lands of Hawaii came *tapa* made of *mamaki* bark" (ʻĪʻī 1959:83).

ʻĪʻī notes how a period of famine was managed in Waipiʻo and what resources were available during the famine:

> Here is a wonderful thing about the land of Waipio. After a famine had raged in that land, the removal of new crops from the taro patches and gardens was prohibited until all of the people had gathered and the farmers had joined in thanks to the gods. This prohibition was called kapu ʻohiʻa because, while the famine was upon the land, the people had lived on mountain apples [*ʻōhiʻa ʻai*], ti, yams, and other upland foods. On the morning of Kane an offering of taro greens and other things was made to remove the ʻohiʻa prohibition, after which each farmer took of his own crops for the needs of his family [ʻĪʻī 1959:77].

The end of the eighteenth century and beginning of the nineteenth century marked Hawaiʻi's entry into world trade networks. One of the chief exports at this time was sandalwood (*Santalum* sp.) or *ʻiliahi*, which was prized in China for its unique fragrance and used in the manufacture of household items such as incense, perfume, and medicine (St. John 1947). The central plains of ʻEwa supplied the Hawaiian Kingdom with *ʻiliahi*.

One of the first generation missionaries, Sereno Bishop (1901), described his memories of the central Oʻahu region in the 1830s:

> Our family made repeated trips to the home of Rev. John S. Emerson at Waialua during those years. There was then no road save a foot path across the generally smooth upland. We forded the streams. Beyond Kīpapa gulch the upland was dotted with occasional groves of Koa trees. On the high plains the ti plant abounded, often so high as to intercept the view. No cattle then existed to destroy its succulent foliage. According to the statements of the natives, a forest formerly covered the whole of the then nearly naked plains. It was burned off by the natives in search of sandalwood, which they detected by its odor burning [cited in Sterling and Summers 1978:89].

The dry forests formerly covering this region probably never came back, particularly considering the harm done to the *ʻiliahi* seedlings with the introduction of cattle soon thereafter (Judd 1933).

3.1.5 The Māhele

The Organic Acts of 1845 and 1846 initiated the process of the Māhele, the division of Hawaiian lands, which introduced private property into Hawaiian society. In 1848 the crown, the

Hawaiian government, and the *aliʻi* (royalty) received their land titles. The common people (*makaʻāinana*) received their *kuleana* awards (individual land parcels) in 1850. It is through records for Land Commission Awards (LCAs) generated during the Māhele that the first specific documentation of life in Waipiʻo Ahupuaʻa, as it had evolved up to the mid-nineteenth century come to light. No LCAs are located within or in the immediate vicinity of the *mauka* portion of the project area, however a review of LCAs in the general area can provide insight in to the types of traditional Hawaiian land use that may have occurred.

John Papa ʻĪʻī was awarded most of the *ahupuaʻa* of Waipiʻo in LCA 8241, comprising approximately 20,540 acres. Also of note was a substantial grant awarded to Abenera Pākī, Bernice Pauahi Bishop's father. Part of LCA 10613 given to Pākī comprised the 350 acres of the *ʻili* of Hanaloa.

The remaining land claims for the *makai* portions of Waipiʻo, a total of 99 (not all of which were awarded), are *kuleana* claims. Predominant land usage indicated by the claims are taro cultivation via *loʻi* (irrigated taro patches) *kula* (dry land agricultural plots) and habitation. Also of note are the mention of *loko* (fishponds) and *lokoia* (inland fishpond utilizing irrigated *loʻi* plots).

In the *mauka* reaches of Waipiʻo, 53 claims were made (Figure 7 & Table 1). Predominant land usage indicated by the claims are *kula* (dry land agricultural plots) *ʻokipuʻu* (forest clearings), and habitation. The fact that several claims were made in the *mauka* regions suggests that Waipiʻo residents had particular locales that they traveled to repeatedly. *Kula* is a general term for open fields, pastures, uncultivated fields, or fields for cultivation. *Kula* lands were often used for opportunistic plantings such as bananas, sugar cane, sweet potatoes, and dry land taro that did not depend on a consistent source of water. *Okipuʻu* is defined as a forest clearing (Lucas 1995:82), a place that was presumably used to gather forest products and medicinal herbs and or for pasturage.

3.1.6 1850 to 1900

During the late 1800s, taro fields in the *makai* areas of Waipio were converted to rice fields as Chinese immigrants began to lease and purchase land. *Mauka* lands were cultivated in sugar and pineapple. Extensive tracts of Waipiʻo land were leased for large-scale commercial agriculture in the late 1890s.

After John Papa ʻĪʻī's death in 1870, his estate--including the Waipiʻo lands-- was inherited by his daughter Irene ʻĪʻī Brown. Shortly after, small parcels within the *ahupuaʻa* were sold off.

In 1889, Benjamin Dillingham organized the Oahu Railway and Land (O.R.& L.) Company; his rail road line connected outlying areas of Oʻahu to Honolulu. By 1890, the railroad reached from Honolulu to Pearl City and continued on to Waianae in 1895, to Waialua Plantation in 1898, and to Kahuku in 1899 (Kuykendall 1966:100). O. R. & L. transported sugar and pineapple from Wahiawā through Waipiʻo to Honolulu. In 1897, the newly organized Oahu Sugar Company leased 3,400 acres of Waipiʻo land from the ʻĪʻī estate (Condé and Best 1973:313). Sugarcane cultivation in Waipiʻo directly affected and transformed the *mauka* portion of the project area during the twentieth century.

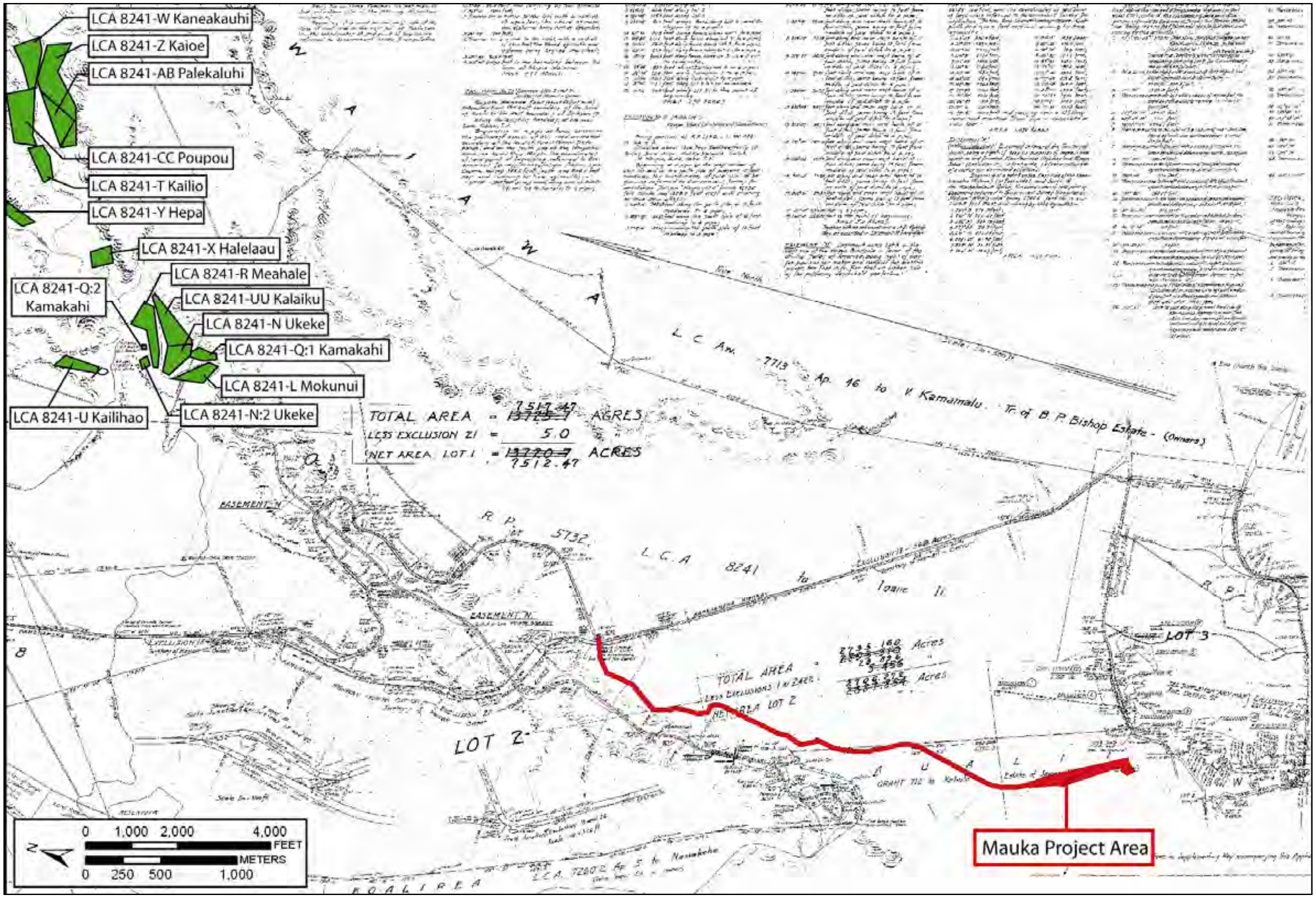

Figure 7. Map of Land Court Application 1000 spanning the *ahupua'a* of Waipio showing LCAs (shown in green) in the *mauka* portion of Waipio in the vicinity of the *mauka* portion of the project area (shown in red)

Table 1. Māhele Claims and Awards in the *mauka* portion of Waipiʻo

Claimant	Claim No.	Name of Land Claimed	Land Use	Land Awarded
Koikoi	No number	Kamanuiki in Waipiʻo Uka (entire portion of valley of Waikakalaua Stream)	1 house, no other land use indicated	unknown
Mokunui	8241L	Kamalokauhola	1 *moʻo*, 1 *kula*, 1 house lot, 1 house	Waipiʻo Uka Kamalokauhola 1 *ʻāp*. .54 Acs.
Ukeke	8241N	Maheu, Lelepua in Waipiʻo Uka	1 *moʻo*, 1 *kula*, house lot, house, 2 *ʻokipuʻu* of mountain taro	Maheu 1 ap., 5.507 Acs.; Waipiʻo Uka 1 *ʻāp*., .9 Acs.
Kamakahi	8241Q	Kuana, Waianeki in Waipiʻo Uka	1 *moʻo*, 1 *kula*, house lot, 1 house, 2 *okipuʻu* in 1 piece	Kuana 1 *ʻāp*. 2.217 Acs.; Waianeki 1 *ʻāp*. .256 Acs.
Keahale	8241R	Waiakapuaa	1 *moʻo*, 1 *kula*, house lot, 2 houses	Waipiʻo Uka Waiakapuaʻa 1 *ʻāp*. 6.882 Acs.
Kailio	8241T	Kaneulupoo	1 *moʻo*, 1 *loʻi*, house lot, 2 houses	Waipiʻo Uka Kaneulupoo 1 *ʻāp*. 5.665 Acs.
Kailihao	8241U	Kapoipuka	1 *moʻo*, 1 *kula*, house lot, 1 house	Pupuka 1 *ʻāp*. 3.804 Acs.
Kauluoaiwi/ Kaulewaiwi	8241V	Honowaka in Waipiʻo Uka	1 *moʻo*, 1 *kula*, house lot, 1 house	Hanauaka 1 *ʻāp*. .256 Acs.; Waipiouka 1 ap. 5.475 Acs.
Kaneakauhi	8241W	Kaohai in Waipiʻo Uka, Wailele	1 *moʻo*, 1 *kula*, house lot, 1 house	Waipiʻo Uka Kaohi 1 *ʻāp*. 8.162 Acs.

Claimant	Claim No.	Name of Land Claimed	Land Use	Land Awarded
Halelaau	8241X	Kopilau, Hokapiele	1 house, 2 *ʻokipuʻu*	Awarded, but no description
Hepa	8241Y	Kīpapa	1 house, 4 *ʻokipuʻu*	Kepapa 1 *ʻāp*. 12.25 Acs.
Hepa	8241Y	Kīpapa	1 house, 4 *ʻokipuʻu*	Kepapa 1 *ʻāp*. 12.25 Acs.
Kaioe	8241Z	Moakea, Puulu, Palikea in Waipiʻo Uka	1 *moʻo*, 1 *kula*, house lot, 1 house	Puulu 1 *ʻāp*. 18.72 Acs.
Palekaluhi	8241AB	Kamuku, Lapili	1 house, 9 *loʻi*, 1 *kula*, 1 *moʻo*	Kamuku 1 *ʻāp*. 6.363 Acs.
Poupou	8241CC	Papa, Leoiki	1 *moʻo*, 1 *kula*, house lot, 1 house	Waipiʻo Uka Papa 1 *ʻāp*. 18.72 Acs.
Kalaiku	8241UU	Lelepua in Waipiʻo Uka	1 *moʻo*, 1 *kula*, house lot, 1 house, *ʻokipuʻu*	Lelepua Waipiʻo ʻEwa 1 *ʻāp*. 13.15 Acs.
Kaualelehuna	8241XX	Walepoai in Waipiʻo Uka	*Moʻo*, *kula*, house lot, 1 house, a ravine, 2 *ʻokipuʻu*	Not Awarded
Kahuluhulu	8241YY	Waipiʻo Valley	2 houses, 2 *ʻokipuʻu*	Not Awarded
Kaimileihonua	9361B	Waipiʻo Uka	1 *moʻo*, 1 *kula*, house lot, 2 houses	Not Awarded
Kalaiku	11205	Lelepua	1 *ʻokipuʻu*	Not Awarded; See 8241UU
Kanealu	11206	Kahaikei, Luanui	1 *moʻo*, 1 *kula*, house lot, 1 house	Not Awarded
Naniu	11207	Liloa, Kamae in Waipiʻo Uka	1 *moʻo*, 1 *kula*, house lot, 1 house, mountain *kalo* land	Not Awarded

Claimant	Claim No.	Name of Land Claimed	Land Use	Land Awarded
Kaopuana	11208	Kahalo, Kepooakaholu in Waipiʻo Uka	1 *moʻo*, 1 *kula*, house lot, 1 house	Not Awarded
Kawaihae	11209	Kaluahine, Kanewahine in Waipiʻo Uka	1 *moʻo*, 1 *kula*, house lot, 1 house, *ʻokipuʻu*	Not Awarded
Kaluehinue	11210	Kauloa, Waipiʻo Uka	1*ʻokipuʻu*	Not Awarded

3.1.7 1900s to Present

By the early decades of the twentieth century, rice farming in Waipiʻo, and throughout the Hawaiian Islands, was in decline, beset by crop diseases and cheaper prices for rice from the mainland. Sugar dominated commercial agriculture, particularly due to the founding and development of the Oahu Sugar Company.

3.1.7.1 Pineapple and Sugarcane Cultivation

In the early 1900s, lands in *mauka* Waipiʻo were being acquired for pineapple cultivation. A 1908 lease from the John ʻĪʻī Estate, Ltd. to Yoshisuke Tanimoto and Kintaro Izumi led to the formation of the Waipiʻo Pineapple Company, which cleared and cultivated approximately 223 acres in portions of Kīpapa Gulch. In 1915, Libby, McNeill & Libby took over Waipiʻo Pineapple Company's leases and continued to cultivate pineapple in the area. By the late 1920s, James Dole's Hawaiian Pineapple Company, incorporated in 1901, was cultivating pineapple on thousands of acres leased from the ʻĪʻī estate in the *mauka* area of Waipiʻo.

A 1925 Oahu Sugar Company map indicates that a majority of the *mauka* portion of the project area was being cultivated (Figure 8), while a 1943 War Department map shows numerous irrigation ditches and roads running through or in the immediate vicinity of the *mauka* portion of the project area (Figure 9).

The proposed trunk sewer line runs through the Patsy T. Mink Central Oʻahu Regional Park, previously under pineapple cultivation on lands acquired by the Hawaiian Pineapple Company. In 1931, Castle & Cooke acquired 21% of the Hawaiian Pineapple Company and in 1961, Dole merged completely with Castle & Cooke. The *mauka* portion of the project area stayed under pineapple cultivation, as seen on a photogrammetric map of the area taken in 1995 (Figure 10), until the City purchased the land from Castle & Cooke in 1999. The City then built the Patsy T. Mink Central Oahu Regional Park, which was officially opened in July of 2001 (Pang 2001).

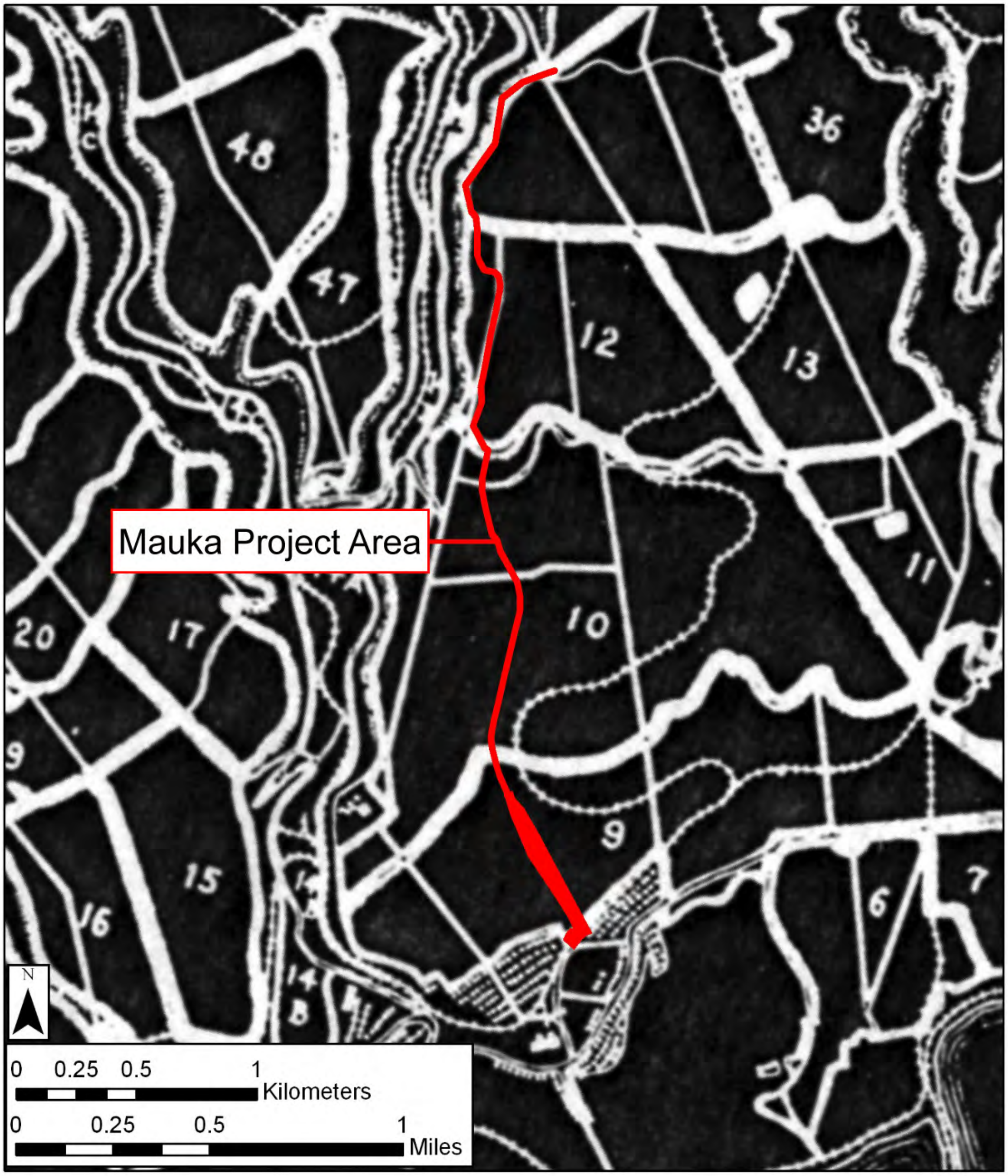

Figure 8. A portion of a 1925 Oahu Sugar Company Map showing that the *mauka* portion of the project area was under cultivation

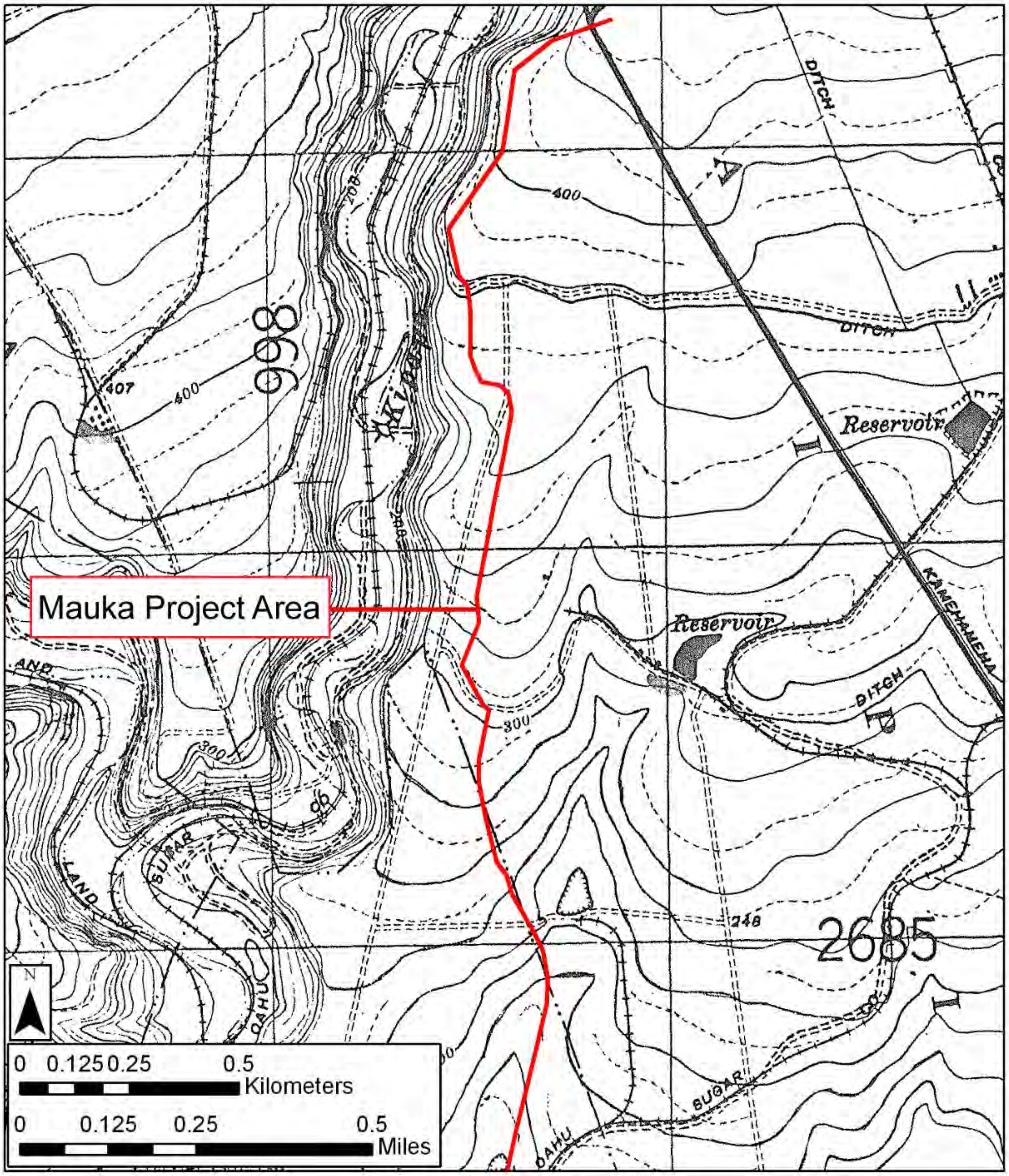

Figure 9. 1943 War Department map showing numerous irrigation ditches and roads running through or in the immediate vicinity the *mauka* portion of the project area (shown in red)

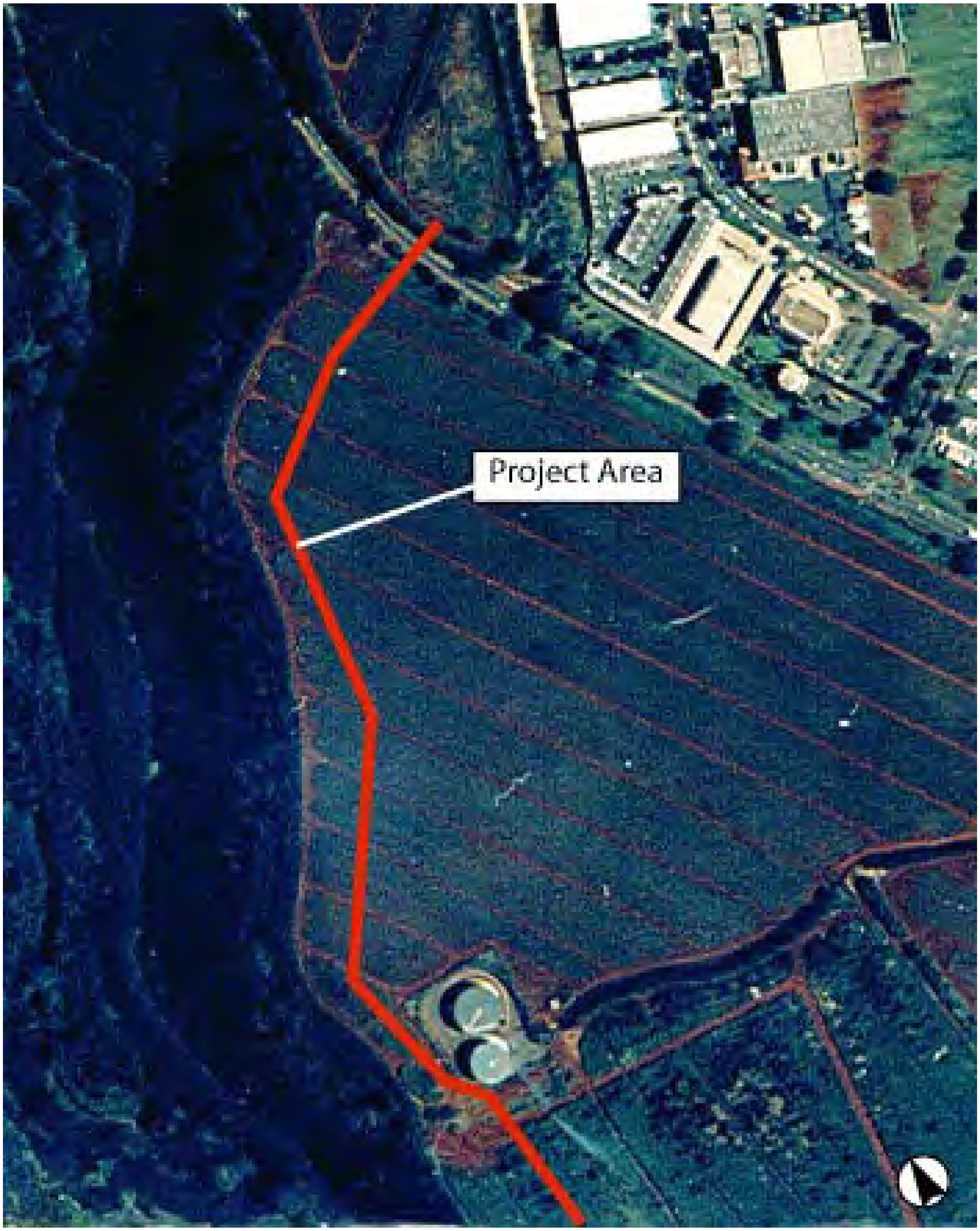

Figure 10. 1995 photogrammetric map (N. 1515 No. 2) of Waipi'o, 'Ewa, O'ahu showing the *mauka* portion of the project area (shown in red) within pineapple fields

3.1.7.2 Military Use

During the 1930s, U.S. military use of Waipiʻo extended well *mauka* of the peninsula at Pearl Harbor. The military began the appropriation of Kīpapa Gulch around 1938. Military planners approved a new ammunition depot in the mountainside of Waipahu (NAVMAG – Waikele), a large new hospital in ʻAiea, and thousands of additional changes to the Navy Yard to accommodate the new aircraft carrier task forces (Woodbury 1946). During World War II, the military used the sugar cane rail system to "haul large quantities of ammunition" (Condé and Best 1973:315).

The Navy made use of a portion of Kīpapa Gulch adjacent to the current project area for the NAVMAG - Waikele. Starting in 1933, guard towers were built on either side of Kīpapa Gulch and a series of tunnel magazines were built into the sidewalls of the gulch for munitions storage. The O. R. & L. railroad line through Kīpapa Gulch transitioned from pineapple and sugarcane transport to the primary function of transporting ammunition from the tunnels to Pearl Harbor. NAVMAG – Waikele was utilized extensively at the end of WWII and during the years following. Additional support facilities, such as administrative buildings and housing, were built in the 1950s and 1970s.

3.2 Previous Archaeological Research

Table 2 lists and briefly describes previous archaeological studies in the vicinity of the *mauka* portion of the project area. Figure 11 shows the previous archaeology study areas with respect to the *mauka* portion of the project area.

McAllister 1933

The earliest archaeological work in Waipiʻo Ahupuaʻa was conducted by J. Gilbert McAllister in the 1930s. He described several sites in Waipiʻo, most of them located *makai* of the *mauka* portion of the project area near the marine resources and the fishponds of Pearl Harbor or on the wide coastal plain of the Waipiʻo Peninsula (Figure 12).

The following are McAllister sites are is the vicinity of the *mauka* portion of the project area:

> Site 122 is the now destroyed Ahuena Heiau located just northwest of the *pā* (fence or enclosure) between Loko Eo and Middle Loch.
>
> Site 127, Mokoula Heiau, "has been completely destroyed for building purposes of the neighborhood" (McAllister 1978:106).
>
> Site 128 was Waipahu spring, which was described as being "famous in tradition as the place at which the tapa mallet appeared after having been lost in Kahuku." (McAllister cited from Sterling and Summers, 1978:25).
>
> Site 129 is Hapupu Heiau, although nothing remains of the site.

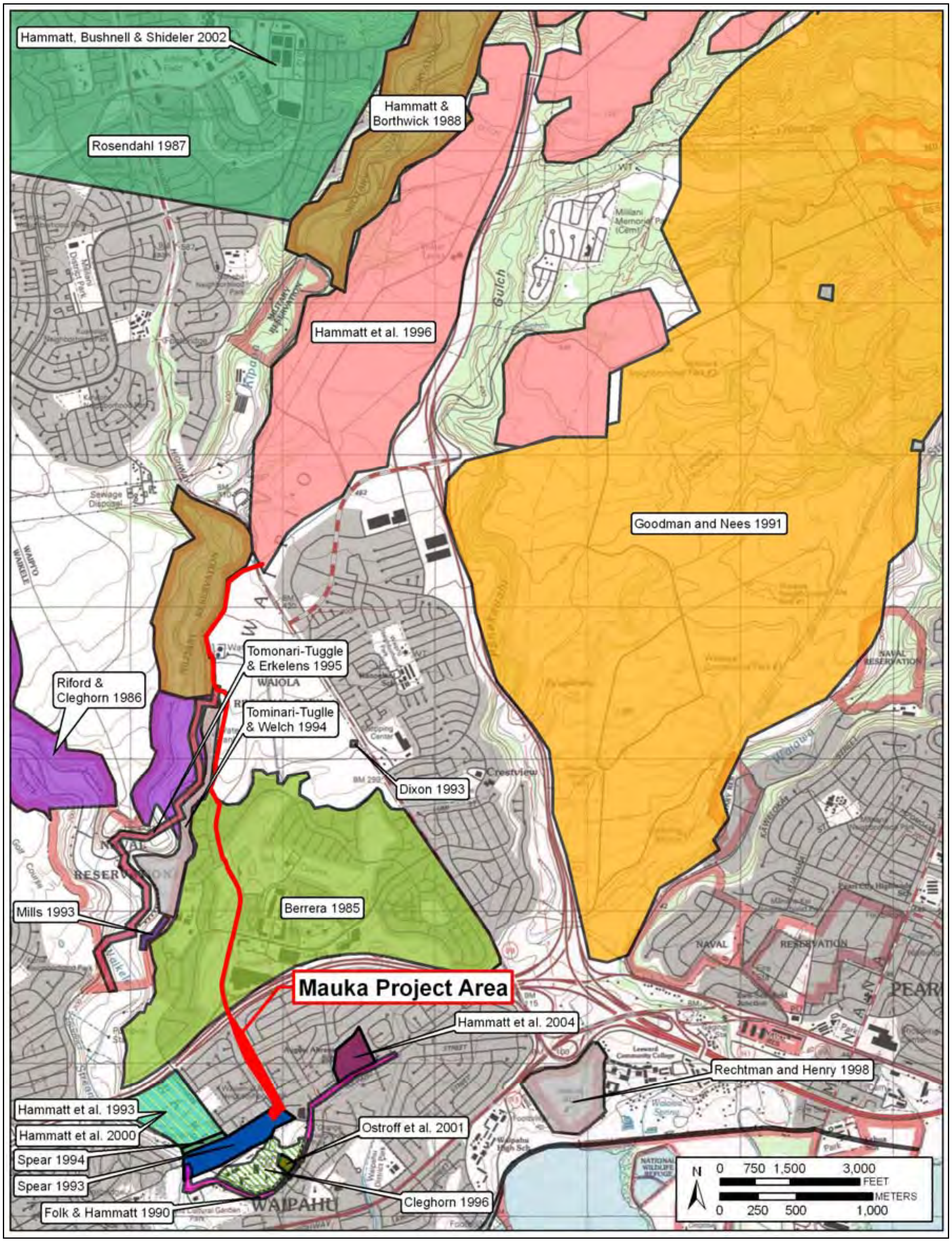

Figure 11. Map showing previous archaeology studies in the vicinity of the *mauka* portion of the project area (shown in red)

Table 2. Previous Archaeological Research in Waipi‘o Ahupua‘a

REFERENCE	LOCATION	NATURE OF STUDY	FINDINGS
McAllister (1933)	Island of O‘ahu	Island Archaeological Survey	Identifies Ahuena Heiau (site 122), Mokoula Heiau (Site 127), Mo‘aula Heiau (site 130), Heiau o Umi (Site 131), and O‘ahunui Stone (site 204)
Barrera (1985)	586 acres in Waikele	Archaeological Reconnaissance	Was observed that sugar cane cultivation had removed all evidence of archaeological remains. No cultural materials were found.
Riford and Cleghorn (1986)	Waikele Branch of the Lualualei Naval Magazine	Archaeological Inventory Survey	Documents five archaeological sites (50-80-08-2919 to -2923) Twenty-one overhang caves and crawl spaces were identified in Waikakalaua Gulch including one modified cave and eleven with pre-contact material. Further archaeological testing was recommended for only one site, Site 50-80-08-2919.
Rosendahl (1987)	Mililani Town	Archaeological Reconnaissance Survey of 2.75 acres	No archaeological resources were identified and no further archaeological work recommended.
Hammatt and Borthwick (1988)	Upper and Lower Kīpapa Gulch	Archaeological reconnaissance and subsurface testing of approximately 371 acres	Three previously identified sites were encountered: laborers’ camp (SIHP 50-80-09-9529), an Oahu Sugar Company Weir Station (SIHP 50-80-09-0530), and a stockpile of rocks (SIHP 50-80-09-9534) associated with the Oahu Sugar Company
Folk and Hammatt (1990)	Waipahu Street	Archaeological Reconnaissance and Background Historical Research	Portions of the project area along Waikele Stream were never cultivated in sugarcane. It is likely that archaeological deposits would be encountered during excavation activities. Monitoring recommended.

REFERENCE	LOCATION	NATURE OF STUDY	FINDINGS
Goodman and Nees (1991)	3600 acres in Waiawa and Waipi‘o Ahupua‘a	Archaeological Reconnaissance Survey	17 sites reported (SIHP 50-80-09-1469 to 1472; 2261 to 2273). Four pre-contact sites: a rock-shelter complex, a mound complex, a trail, and a lithic scatter. Post-contact features: irrigation ditches, a railroad system, and a cannery. Four features associated with WWII military training.
Dixon (1993)	Five exploratory wells, one in Waipahu	Archaeological Reconnaissance	The land had been highly utilized during the historic period. No cultural remains were found.
Hammatt et al. (1993) & Hammatt et al. (2000)	39.6 acre parcel in Waikele	Archaeological Investigation	Two archaeological sites – SIHP # 50-80-09-530, a petroglyph field, and SIHP # 50-80-09-4660, remnants of the former Oahu Sugar Plantation camp. Due to extensive sugar cane cultivation, it was deemed unlikely that any subsurface archaeological resources would remain.
Mills (1993)	approximately 2000 feet of electrical transmission line through Schofield Plateau	archaeological inventory survey	No cultural resources were found, and no additional work was recommended.
Spear (1993 & 1994)	Oahu Sugar Mill (TMK: 9-4-02: various)	Archaeological Reconnaissance	No significant archaeological sites were located in the project area and no further investigations were recommended.
Tomonari-Tuggle and Welch (1994)	approximately 38 acres of (NAVMAG – Waikele)	Archaeological Inventory Survey and Historical Review	A flagpole, two arms ammunitions igloos, and a number of concrete foundations from WWII; Two Guard/Watch Towers, Guard/Watch Tower S84 (built in 1954) and Guard/Watch Tower S68 (built in 1933). Only the towers were considered significant cultural resources.

REFERENCE	LOCATION	NATURE OF STUDY	FINDINGS
Tomonari-Tuggle and Erkelens (1995)	1.5 mile long transmission line through NAVMAG – Waikele	Archaeological Inventory Survey	A post-contact rock shelter and adjacent cave with cultural materials (SIHP # 50-80-09-4935) and a 20th century railroad bed (SIHP # 50-80-09-4936). The ammunition magazines within Kīpapa Gulch were also evaluated as significant historical structures in 1993.
Cleghorn (1996)	23-acres of Oahu Sugar Mill land in Waipahu	Archaeological Inventory Survey	No surface archaeological sites were observed.
Hammatt et al. (1996)	*mauka* areas of Waipi‘o and Waiawa Ahupua‘a	Archaeological Inventory Survey of 1339 acres	No evidence of historic settlement was found. A portion of the Waiāhole Ditch System (Site 50-80-09-2268) was identified within project area. Recommendations made to take appropriate mitigative measures if the site was to be impacted during development of area. No further archaeological work recommended.
Rechtman and Henry (1998)	‘Ewa Drum Filling and Fuel Storage area	Archaeological Reconnaissance Survey	No significant historic properties were identified.
Ostroff, Moore, and Kennedy (2001)	Filipino Community Center in Waikele	Inadvertent Discovery of Human Remains	SIHP # 50-80-09-5882: articulated Native Hawaiian adult found in a flex position and in a stratum devoid of historic materials.
Hammatt, Bushnell, and Shideler (2002)	Mililani Town Center	Archaeological and cultural impact evaluation	Area completely developed. It was deemed that there would be no impact to historic or cultural resources or properties.
Hammatt, Freeman, and Shideler (2004)	38-acre area in Waipahu town	Archaeological and Cultural Assessment	No cultural resources or ongoing traditional cultural practices were found within the project area, and no additional work was recommended.

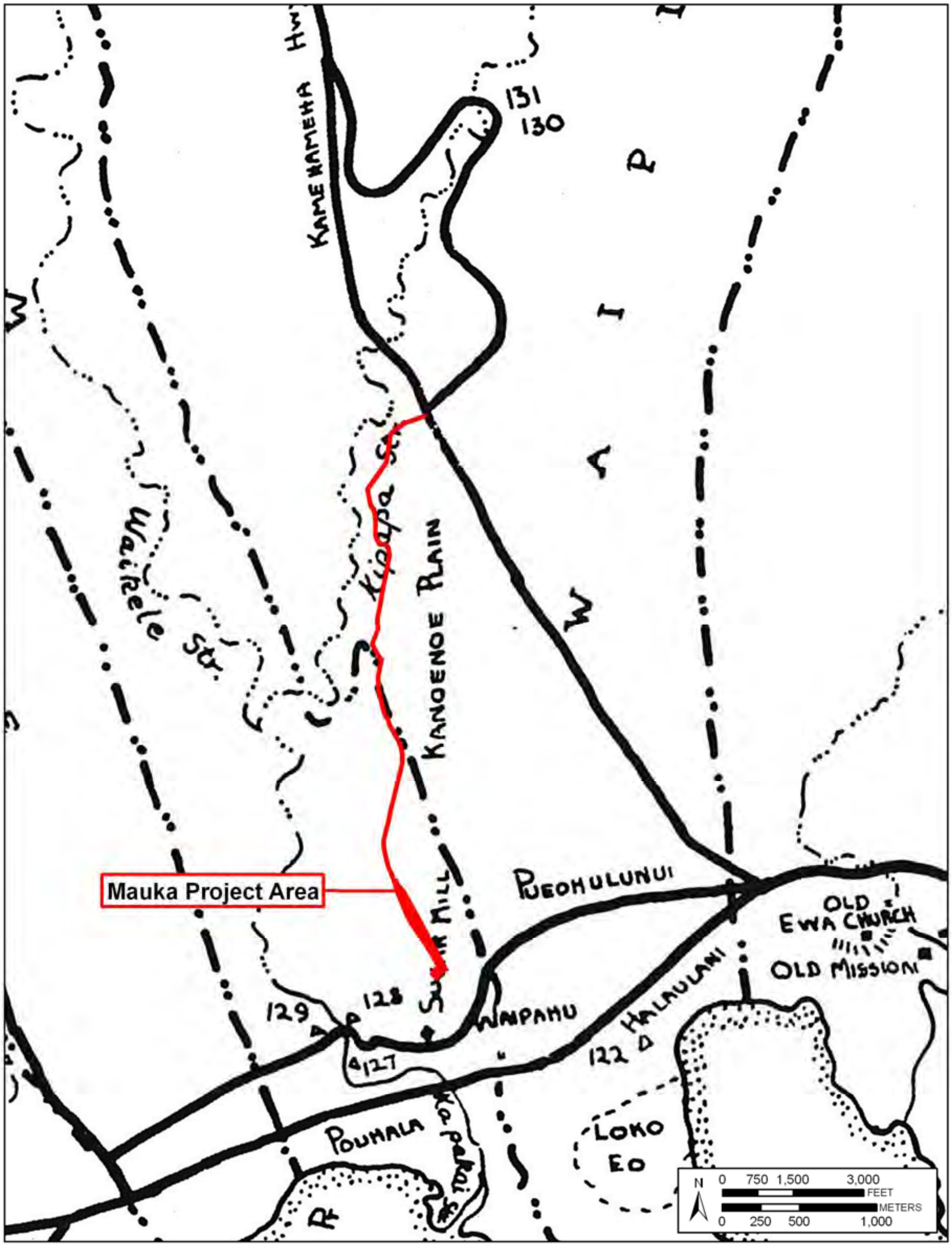

Figure 12. Sterling and Summers (1978) map showing McAllister's (1933) archaeological sites in the vicinity of the *mauka* portion of the project area (shown in red)

Barrera 1985

In 1985, William Barrera Jr. conducted an archaeological reconnaissance survey on approximately 586 acres in Waikele, which included a large portion of the *mauka* portion of the project area consisting of the segment between Central Oʻahu (Waiola) Regional Park and the bus parking lot at the corner of Paiwa Street and Koaki Street (see Figure 11). Barrera noted that sugarcane agriculture had removed all evidence of past land use in the study area. No historic properties were identified and no further archaeological work was recommended (Barrera 1985).

Riford and Cleghorn 1986

A survey of the Waikele Branch of the Lualualei Naval Magazine documented five historic properties, SIHP #50-80-08-2919 to 50-80-08-2923 (Riford and Cleghorn 1986). This study area consisted of 264 acres along Kīpapa and Waikakalaua streams near their confluence. Twenty-one overhang caves and crawl spaces were identified in Waikakalaua Gulch including one modified cave and eleven with pre-contact material. The rock shelters are suggested as temporary habitation sites for a possible travel route from Puʻuloa over Kolekole Pass and into Waiʻanae. Several historic features were also recorded (though not deemed archaeological sites) in Waikakalaua Valley including cement boulders, portions of an old roadbed, boulder and cobble paving associated with an abandoned railroad berm, scattered boulder mounds and facings connected to historic agricultural clearing activities and boulder rock tailings associated with road construction or ammunition storage facility excavation.

In Kīpapa Gulch, three rock shelters were observed as well as segments of a railroad berm, remains of a railroad cane-hauling car, and rock tailings.

Rosendahl 1987

In 1987, Rosendahl conducted an archaeological reconnaissance of Mililani Town Station, consisting of a 2.75 acre parcel in Mililani Town, north of the *mauka* portion of the current project area (Rosendahl 1987). Significant disturbance associated with modern construction was observed throughout the parcel. No historic properties were observed and no further archaeological work was recommended.

Hammatt and Borthwick 1988

In 1988, CSH conducted an archaeological reconnaissance and subsurface testing of approximately 371 acres was conducted in upper and lower portions of Kīpapa Gulch, located northeast of the *mauka* portion of the current project area. Three previously identified sites (Rosendahl 1977) were observed: a plantation laborers' camp (SIHP 50-80-09-9529), an Oahu Sugar Company Weir Station (SIHP 50-80-09-9530), and a stockpile of rocks associated with the Oahu Sugar Company (SIHP 50-80-09-9534) (Hammatt and Borthwick 1988). All of the re-identified sites were located over 4 km northeast of the *mauka* portion of the current project area.

Folk and Hammatt 1990

In 1990, CSH conducted an archaeological reconnaissance and background historical research for the proposed Waipahu Street widening project, just south of the *mauka* portion of the current project area. The project area was determined to be "archaeologically sensitive" because historical data "points to the present day Waipahu town as occupying the same physical space as the earlier traditional Hawaiian village of Waikele" (Folk and Hammatt 1990:9). Of note was the fact that portions of the project area along Waikele Stream were never cultivated in sugarcane. Thus it was suggested that pre-contact and early post-contact archaeological remains may be preserved beneath urban streets and construction. Archaeological monitoring of all ground disturbances was recommended.

Goodman and Nees 1991

In 1991, the Bishop Museum conducted an archaeological reconnaissance and inventory survey of 3600 acres in Waiawa Ahupua‘a, located east of the *mauka* portion of the current project area (Goodman and Nees 1991). Seventeen historic properties were identified (SIHP 50-80-09-1469 to 1472; 2261 to 2273). Four pre-contact sites were identified including: a rock-shelter complex, a mound complex, a trail, and a lithic scatter. The remaining 13 sites consisted of plantation and WWII military infrastructure. No historic properties were identified in the vicinity of the current project area.

Dixon 1993

In 1993, the Bishop Museum conducted an archaeological reconnaissance for five exploratory waters wells proposed by the Board of Water Supply (Dixon 1993). One of the proposed well sites was located along Kamehameha Highway, just east of the *mauka* portion of the current project area. No historic properties were identified.

Mills 1993

In 1993, BioSystems Analysis, Inc. conducted an archaeological inventory survey for approximately 2000 linear feet of electrical transmission line on the bluff of the Schofield Plateau, just west of the *mauka* portion of the current project area (Mills 1993). No historic properties were observed and no further archaeological work was recommended.

Spear 1993 & 1994

In 1993 and 1994, reconnaissance surveys were conducted at the site of proposed rezoning and development of the Oahu Sugar Mill (TMK: 9-4-02: various) (Spear 1993, Spear 1994). No historic properties were observed and no further archaeological work was recommended.

Tomonari-Tuggle and Welch 1994

In 1994, International Archaeological Research Institute, Inc. conducted an archaeological inventory survey of approximately 38 acres of the Waikele Branch of Naval Magazine Lualualei (NAVMAG – Waikele), located immediately west of the *mauka* portion of the current project area (Tomonari-Tuggle and Welch 1994). Numerous WWII Era features were observed: a flagpole, two arms ammunitions igloos, and a number of concrete foundations. However the only significant historic properties identified within the project area consisted of two guard towers, Guard/Watch Tower S84, built in 1954 and Guard/Watch Tower S68, built in 1933.

Tomonari-Tuggle and Erkelens 1995

In 1995, International Archaeological Research Institute, Inc. conducted an inventory survey of a proposed corridor, 100 feet wide and approximately 1.5 miles long, for a 46kV sub-transmission line through NAVMAG – Waikele, located immediately west of the mauka portion of the current project area (Tomonari-Tuggle and Erkelens 1995). Two historic properties were identified: a post-contact rock shelter and adjacent cave with cultural materials (SIHP # 50-80-09-4935) and a 20th century railroad bed (SIHP # 50-80-09-4936). It was also suggested that the ammunition magazines within Kīpapa Gulch may also be affected as they were evaluated as significant historical structures in 1993.

Cleghorn 1996

A 23-acre inventory survey investigated the Oahu Sugar Mill in Waipahu and its surroundings. The mill and associated buildings comprised 60% of the project area; the remainder comprised Skill Village, a plantation supervisors' residential area. No surface archaeological sites were observed within the project area (Cleghorn 1996).

Hammatt et al. 1996

In 1996, CSH conducted an archaeological inventory survey for 1339 acres of Castle and Cooke lands slated for residential development in the *mauka* areas of Waipiʻo and Waiawa Ahupuaʻa, located immediately to the northeast of the *mauka* portion of the current project area (Hammatt et al. 1996). No evidence of pre-contact settlement was found. This was attributed to the fact that the majority of the project area lands had been cultivated in pineapple in the historic to modern periods. A portion of the Waiāhole Ditch System (Site 50-80-09-2268) and the Kīpapa Ditch Site (50-80-098-9529) were identified within the project area.

Rechtman and Henry 1998

Rechtman and Henry (1998) conducted an archaeological reconnaissance survey of the ʻEwa Drum Filling and Fuel Storage area, west of Leeward Community College. No significant historic properties were identified.

Hammatt et al. 2000

In 2000, CSH conducted an archaeological inventory survey of a 40-acre parcel in the *ahupuaʻa* of Waikele, located just southwest of the mauka portion of the current project area (Hammatt et al. 2000). Two historic properties were identified: SIHP #50-80-09-530, a petroglyph field, and SIHP #50-80-09-4660, remnants of the former Oahu Sugar Plantation camp. No subsurface cultural deposits were expected within the project area due to the extensive sugar cultivation documented within the project area.

Ostroff, Moore, and Kennedy 2001

An inadvertent discovery of human remains occurred during the installation of a new storm drain at the Filipino Community Center in Waikele, south of the *mauka* portion of the current project area. The remains were designated SIHP #50-80-09-5882 and were determined to be an articulated Native Hawaiian adult found in a flexed position and in a stratum devoid of historic materials.

Hammatt, Bushnell, and Shideler 2002

In 2004, CSH conducted an archaeological and cultural impact evaluation of parcel in TMK 9-5-53: por. 2 in support of the proposed Mililani Transit Center project (Hammatt et al. 2002). The subject lands constituted a portion of the Meheʻula Parkway and a portion of the Town

Center of Mililani. All the lands within this area had been completely graded and developed. It was deemed that no properties or remains of historic or cultural value would be impacted by the development of the transit center.

Hammatt, Freeman, and Shideler 2004

Hammatt et al. (2004) conducted an archaeological and cultural assessment of an approximately 38-acre area in the immediate vicinity of the August Ahrens School in the environs of urban Waipahu town, just east of the *mauka* portion of the current project area. No historic properties or ongoing traditional cultural practices were found within the project area, and no additional work was recommended.

3.3 Waipi‘o Background Summary and Predictive Model

Waipi‘o was a highly utilized *ahupua‘a* in pre-contact times. Native Hawaiians utilized the lowland region around Pearl Harbor for habitation, fish farming, and extensive taro cultivation. The gulches in the upland regions provided additional areas for taro cultivation and some of the *mauka* lands above the gulches were utilized for the collection of medicinal plants and as *kula* for dry land cultivation. A review of LCA records for the *ahupua‘a* indicates an absence of land claims within the Waipi‘o plateau, located between the resource rich lowlands and the upland forest. This suggests that this area, which is where the *mauka* portion of the current project area is situated, lacked the recourses necessary for extensive indigenous Hawaiian settlement and agriculture.

During the post-contact period, large portions of Waipi‘o Ahupua‘a were utilized for the cultivation of sugarcane and pineapple. Historic maps indicate that the entire *mauka* portion of the project area was under cultivation from the early 20th century through modern times. The maps also indicate irrigation ditches crossing through and in the immediate vicinity of the *mauka* portion of the project area.

Modern urban development followed the extensive post-contact agricultural pursuits. Of note are the development and expansion of the Waipahu and Waikele neighborhoods as well as the construction of the Patsy T. Mink Central Oahu Regional Park. The *mauka* portion of the project area has been affected by all of these urban developments. The northern half of the *mauka* portion of the project area is situated within the western edge of Patsy T. Mink Central Oahu Regional Park, while the southern half of the *mauka* portion of the project area is situated beneath asphalt roads associated with residential neighborhoods and a bus parking lot.

Previous archaeology indicates that it is unlikely that any pre-contact historic properties will be found within the *mauka* portion of the project area. In 1985, Barrera conducted an archaeological reconnaissance that included a large portion of the *mauka* portion of the current project area consisting of the segment between the Patsy T. Mink Central Oahu Regional Park and the bus parking lot at the corner of Paiwa Street and Koaki Street. Barrera noted that sugarcane agriculture had removed all evidence of past land use in the area. At the southern end of the *mauka* portion of the project area, Spear (1993 & 1994), determined that no archaeological sites were present. Other nearby investigations did identify pre-contact historic properties such as modified caves and temporary shelters, however these were located within gulches and not on the table lands where the *mauka* portion of the present project area is situated (Riford and Cleghorn 1986, Goodman and Nees 1991, Tomonari-Tuggle and Erkelens 1995).

Post-contact plantation era infrastructure consisting of railroad bedding, irrigation ditches, and labor camps have been identified in the vicinity of the *mauka* portion of the project area and represent the dominant land use in the area and the most likely type of historic properties that could be encountered (Hammatt et al. 2000, Hammatt et al. 1996, and Tomonari-Tuggle and Erkelens 1995). Historic military sites were also identified in the vicinity (Tomonari-Tuggle and Welch 1994); however all were confined within the NAVMAG-Waikele military reservation which is not included as a part of the current project area. It is not likely that lands located outside of the military reservation would contain evidence of historic military land use.

The extensive post-contact cultivation of the entire *mauka* portion of the project area for sugarcane and/or pineapple would have destroyed all surface pre-contact historic properties that may have been present. Additionally, any pre-contact subsurface cultural deposits that may have been present would have been severely disturbed and/or destroyed. Following post-contact agriculture the entire *mauka* portion of the project area was subjected to extensive land modifications associated with modern urban development including the construction of asphalt paved roads, housing developments, and the Patsy T. Mink Central O‘ahu Regional Park. These modern developments would have likely removed all evidence of post-contact land use within the *mauka* portion of the project area. If any remnants of Plantation Era infrastructure do remain within the *mauka* portion of the project area, they would likely be located within the northern half of the *mauka* portion of the project area which skirts the western edge of the Patsy T. Mink Central Oahu Regional Park, as this area may not have been impacted by park construction.

Thus, as a result of background research, expected finds during the archaeological inventory survey of the *mauka* portion of the project area could include evidence of post-contact Plantation Era infrastructure including: irrigation ditches, flumes, and reservoirs.

Section 4 *Makai* Project Area Background Research

This section reviews the available documentary evidence for the general character of the *makai* portion of Waikele Ahupuaʻa, where the *makai* segment of the project area is located, in an attempt to establish land use patterns which will be applied toward generating a predictive model of expected archaeological finds within this segment of the project area.

4.1 Traditional and Historical Background

4.1.1 Historical Setting

The ʻEwa District, was a focus of Hawaiian settlement and activity during the centuries preceding western contact. Handy and Handy (1972) provide the historical context of a prominent ʻEwa District coveted by the Hawaiian *aliʻi* (aristocracy):

> The primary reason for ʻEwa's prominence in history…was undoubtedly the existence of the great number of fishponds at different points around Pearl Harbor, which was ʻEwa territory. Two of the largest were on the peninsula, and another was at its northwest corner (Handy and Handy 1972:470).
>
> The lowlands, bisected by ample streams, were ideal terrain for the cultivation of irrigated taro. The hinterland consisted of deep valleys running far back into the Koʻolau range. Between the valleys were ridges, with steep sides, but a very gradual increase of altitude. The lower parts of the valley sides were excellent for the culture of yams and bananas. Farther inland grew the ʻawa for which the area was famous. The length or depth of the valleys and the gradual slope of the ridges made the inhabited lowlands much more distant from the wao, or upland jungle, than was the case on the windward coast. Yet the wao here was more extensive, giving greater opportunity to forage for wild foods in famine time (Handy and Handy 1972:469).

The lowland areas of Waikele, where the *makai* portion of the project area is located, were used for agriculture, as described by E. Craighill Handy in the 1940s:

> Between the West Loch of Pearl Harbor and Loko Eo the lowlands were filled with terraces that extended for over a mile up into the flats of Waikele Stream. The lower terraces were formerly irrigated partly from Waipahu Stream, which Hawaiians believe came all the way through the mountains from Kahuku. It is said that terraces formerly existed on the flats in Kipapa Gulch for at least two miles upstream above its junction with Waikele. Wild taros grow in abundance in upper Kipapa Gulch (Handy 1940:82).

A 1881 Hawaiian Government Survey Oʻahu Island map places the *makai* portion of the project area directly in the middle of the West Loch of Pearl Harbor and Loko Eo, a man-made pond utilized for aquaculture, an area described by E. Craighill Handy (1940) as "filled with terraces" (Figure 13).

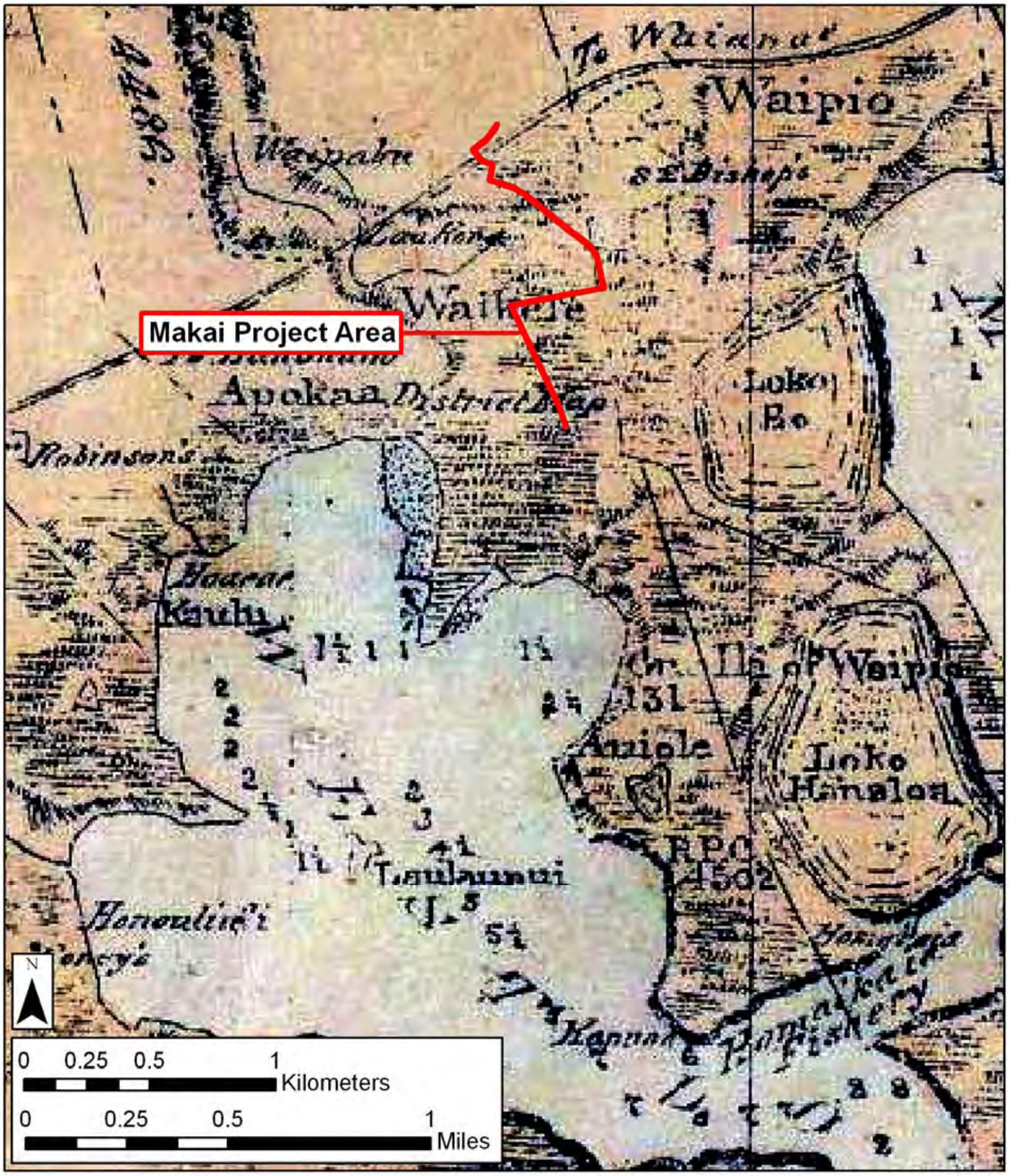

Figure 13. 1881 O'ahu Island Hawaiian Government Survey map showing the *makai* portion of the project area

4.1.2 Traditional Accounts

There are numerous references to Waikele in the traditional literature. With one exception, all of these references are to areas and events which existed or occurred within two kilometers of Pearl Harbor. There is reference to the Waipahu Spring — designated site 128 by Gilbert McAllister during the 1930s — where a tapa mallet from Kahuku appeared. This spring is also famous as the location where Kaʻahupāhau (a shark goddess) swam up from the sea to bathe in the fresh water (Sterling and Summers 1978:25). Mary Kawena Pukui (in Sterling and Summers 1978:24) details many legends and traditional places with mythical or cultural meaning in Waikele. There is reference to the Pōhaku-pili (a stone) that belonged to the gods Kane and Kanaloa who divided the lands of `Ewa when they came to earth and established the boundaries of Waikele, which have remained the same ever since. The Pōhaku-pili is said to be supernatural and lies on the boundary of Waikele and Hōʻaeʻae on the edge of a cliff (ibid.:29).

Samuel M. Kamakau (1992:71, 75, 136 & 137) makes numerous references to Waikele as the abode of chiefs. Some of these accounts deal with battles, sacrifice and politics which were conducted in the *ahupuaʻa*. The great Ka-laniʻōpuʻu, grandfather of Kamehameha, was born "at the waters of Alelele above Waipahu, at Waikele" (ibid.:110).

John Papa ʻĪʻī (1959:32) refers to Kapuna in Waikele as a "good place for dyeing tapa. There, patches of taro were grown, draw nets made, and houses built." He goes on the say that the people of Waikele do their fishing in the sea of Honouliuli. ʻĪʻī also refers to a sham battle that occurred in Waikele — under the direction of the chief of Waikele and a visiting chief from Honolulu — between people from Honolulu and the inhabitants of Waikele (ibid.:76), suggesting that Waikele was a well populated locality where chiefly activities were not uncommon.

The only reference to an area well *mauka* of the environs of Pearl Harbor is to a locale in Waikakalaua Gulch which is where, according to Abraham Fornander, the invading chiefs from Hawaiʻi met Mailikūkāhi, *mōʻī* of Oʻahu, in battle. "The fight continued from [Waikakalaua] to Kīpapa Gulch. The invaders were thoroughly defeated and the gulch is said to have been literally paved with the corpses of the slain" (Sterling and Summers 1978:31).

4.1.3 Late Pre-contact/Early Post-contact Land Use Documentation

Fresh water, good agricultural land and sea food were plentifully available around Pearl Harbor. From both historic references and historical documentary data, it seems clear that, at least in the late pre-contact/early post-contact period, the population of Waikele was concentrated around these abundant resources. George Vancouver was anchored off the entrance to West Loch in 1793 and was told of the area at "a little distance from the sea, [where] the soil is rich and all the necessaries of life are abundantly produced" (Sterling and Summers 1978:36). A Mr. Whitbey, one of Vancouver's crew, observed "from the number of houses within the harbor it should seem to be very populous; but the very few inhabitants who made their appearance were an indication of the contrary" (ibid.). E.S. Craighill Handy notes that:

> In the flatland, where the Kamehameha Highway crosses the lower valley of Waikele Stream, there are the remains of terraces on both sides of the road, now

> planted in bananas, beans, cane and small gardens. For at least 2 miles upstream there were small terrace areas. (1940:82)

It would appear that — with permanent streams and springs, and productive soil — this area was very productive agriculturally.

There are also references to the abundant marine resources that Pearl Harbor had to offer. Charles Wilkes, leader of the Wilkes Expedition of 1838 to 1842, recorded: "Pearl-River Harbour affords an abundant supply of fine fish. Two species of clams are procured here, called by the natives *‘ōkupe* and *‘ōlepe*" (in Sterling and Summers 1978:49). Gilbert McAllister reports that the entire West Loch of Pearl Harbor was known as Kaihuo Pala‘ai and this body of water was renowned for the large schools of mullet which arrived every year between March and April (ibid.:52).

The numerous fishponds of Waikele are another resource that would have greatly increased the productivity of the area. A 1959 Bishop Museum map of Pearl Harbor shows the locations of numerous *loko* (fishponds) compiled from maps dating from 1873 to 1915 (Figure 14). Apple and Kikuchi (1975:2) discuss the impact that such fishponds have on the general population of an area:

> Accessibility to these ponds and their products was limited to the elite minority of the native population - the chiefs and priests. Prehistoric ponds and pond products appear to have been taboo to the vast majority of Hawaiians and to have yielded them no direct benefit. However, indirect public benefit came from ownership by the chiefs of exclusive food sources. Royal fishponds...insured less demand on the commoners' food production resources. Every fish taken from a royal fishpond left its counterpart in the natural habitat available to lesser chiefs and commoners.

The fishponds of Waikele, although not necessarily representing beneficial resources for the commoners, can be seen as evidence for a thriving chiefly class in the *ahupua‘a*. Of note is the *makai* portion of the project area’s proximity to Loko Eo (Figure 15 & Figure 16), where the word *loko* is translated as “pond” and *‘eo* is translated as “full of food” (Pukui and Elbert 1986:42). A nineteenth century visitor to Loko ‘Eo provides testimony to the abundant marine resources found in the area:

> We rode and reached Waipio. Saw Halaulani House; only the house stood there for the inhabitants had gone to Mana. The bubbling water of the pond Eo rippled on the left. There a recollection came of the bundles of fat eel from that place and the delicious mullet of Makahanaloa. It was delicious clean and that is why the very juice in the ti leaves was sucked up by Kohala’s son (*Ka Nūpepa Kū‘oko‘a* Aug. 11, 1899 cited in Sterling and Summers 1978:20).

The size of the population of Waikele in the late pre-contact/early post-contact period can only be speculated. Levi Chamberlain, secular agent for the Protestant Mission, visited Waikele in 1828 and estimated that between 300 and 400 persons gathered to hear his presentation (Riford and Cleghorn 1986:21) The earliest missionary census - accomplished between 1831 and

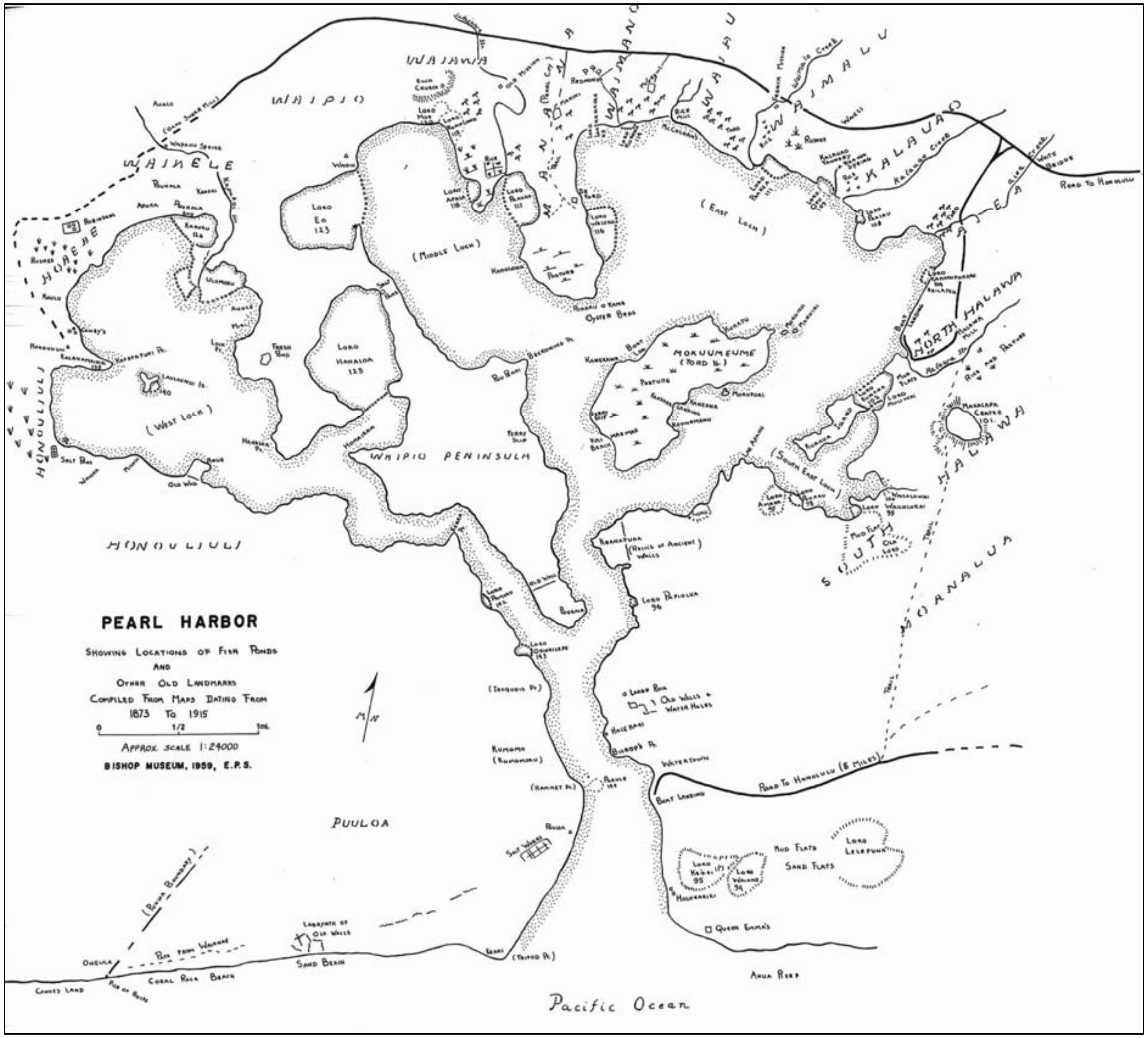

Figure 14. 1959 Bishop Museum map of Pearl Harbor showing the locations of fish ponds

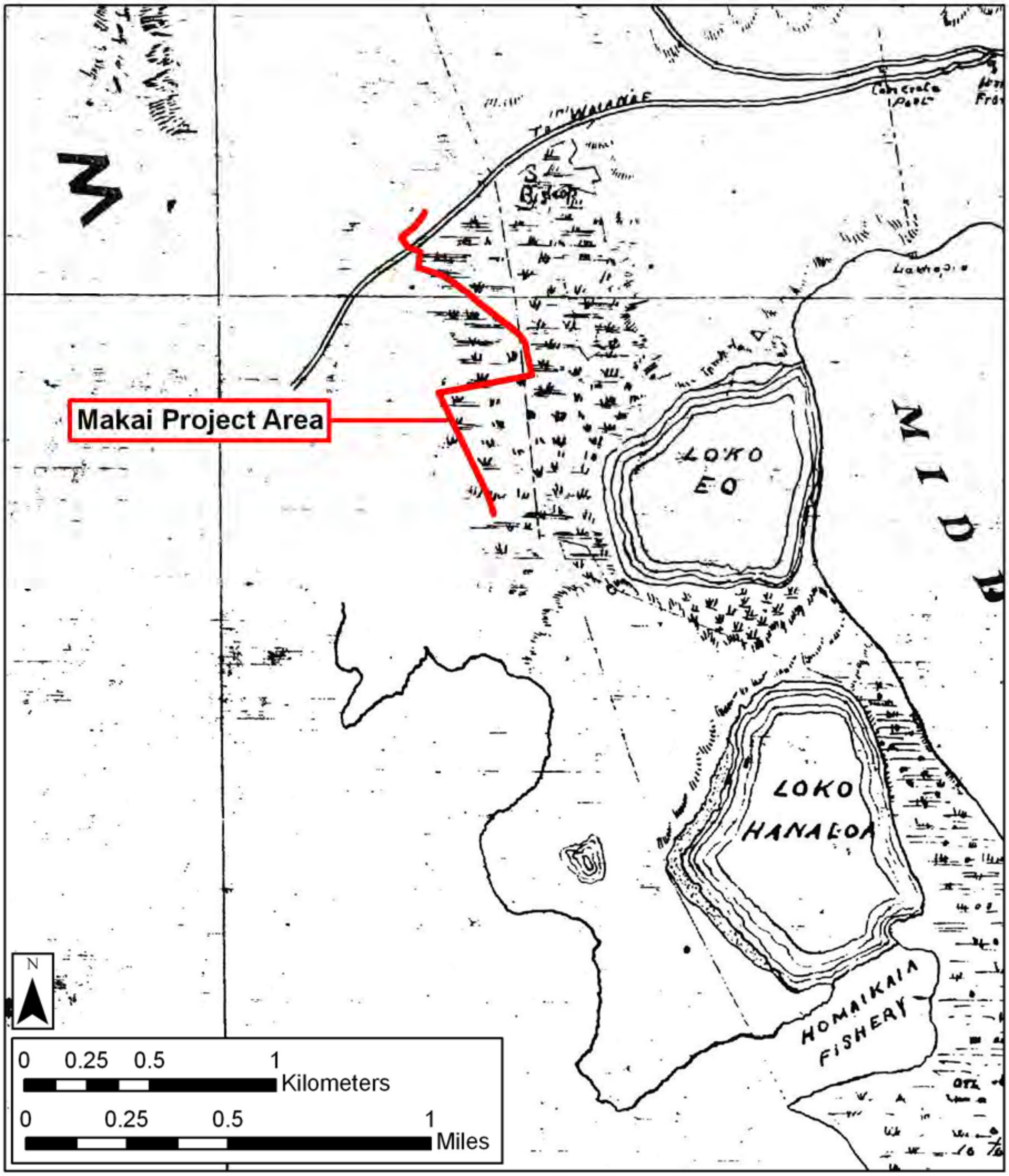

Figure 15. 1877 J.F. Brown map showing the *makai* portion of the project area in close proximity to Loko 'Eo

Figure 16. Historic Photograph of Loko 'Eo (Source: Chong 1998:109)

1832 - counted in Waikele and Hōʻaeʻae Ahupuaʻa a total of 723 inhabitants: 278 adult males, 282 adult females, 73 male children, and 90 female children (Schmitt 1973:19). Total population counted in the thirteen *ahupuaʻa* comprising `Ewa District was 4015 (ibid.:38).

4.1.4 The Māhele

The Organic Acts of 1845 and 1846 initiated the process of the Māhele, the division of Hawaiian lands, which introduced private property into Hawaiian society. In 1848, the crown and the *aliʻi* received their land titles. The common people (*makaʻāinana*) received their *kuleana* awards (individual land parcels) in 1850. It is through records for Land Commission Awards (LCAs) generated during the Māhele that the first specific documentation of life in Waikele Ahupuaʻa, as it had evolved up to the mid-nineteenth century come to light.

A 1889 map of the *makai* portion of Waikele shows the *makai* portion of the project area crossing thru eight LCAs and surrounded by numerous others (Figure 17). Documentation from the eight LCAs was reviewed in an attempt to reconstruct traditional Hawaiian land use patterns within the *makai* portion of the project area during the mid nineteenth century (Table 3; see Appendix A). LCA documentation indicates that the *makai* project area was utilized for traditional Hawaiian habitation, agriculture, and aquaculture. The presence of house lots, *ʻauwai* (irrigation ditches), *loʻi* (wet land taro patches), *loko* (fish ponds), *kula* (dry land agricultural plots), and *kōʻele* (small land units farmed for the chief) are all indicated, documenting extensive traditional Hawaiian land use within the project area.

4.1.5 1850's to 1900

As the sugar industry throughout the Hawaiian kingdom expanded in the second half of the 19th century, the need for increased numbers of field laborers prompted passage of contract labor laws. In 1852 the first Chinese contract laborers arrived in the islands. Contracts were for five years, and pay was $3 a month plus room and board. Upon completion of their contracts, a number of the immigrants remained in the islands, many becoming merchants or rice farmers.

As was happening in other locales, in the 1880s, groups of Chinese began leasing and buying — from the Hawaiians of Waikele and Waipiʻo *ahupuaʻa* — former taro lands for conversion to rice farming. The taro lands' availability throughout the islands in the late 1800s reflected the declining demand for taro as the native Hawaiian population diminished.

The Hawaiian islands were well-positioned for rice cultivation. A market for rice in California had developed as increasing numbers of Chinese laborers immigrated there since the mid-19th century. Similarly, as Chinese immigration to the islands also accelerated, a domestic market opened.

The 1877 Brown map of Waipiʻo Ahupuaʻa (see Figure 15) shows a majority of the *makai* portion of the project area as swamplands, which would be suitable for rice cultivation.

In 1889, Benjamin Dillingham organized the Oahu Railway and Land (OR&L) Company. The railroad connected the outlying areas of Oʻahu to Honolulu. By 1890, the railroad reached from Honolulu to Pearl City and continued on to Waianae in 1895, to Waialua Plantation in 1898, and to Kahuku in 1899 (Kuykendall 1967:100). A 1919 War Department map shows

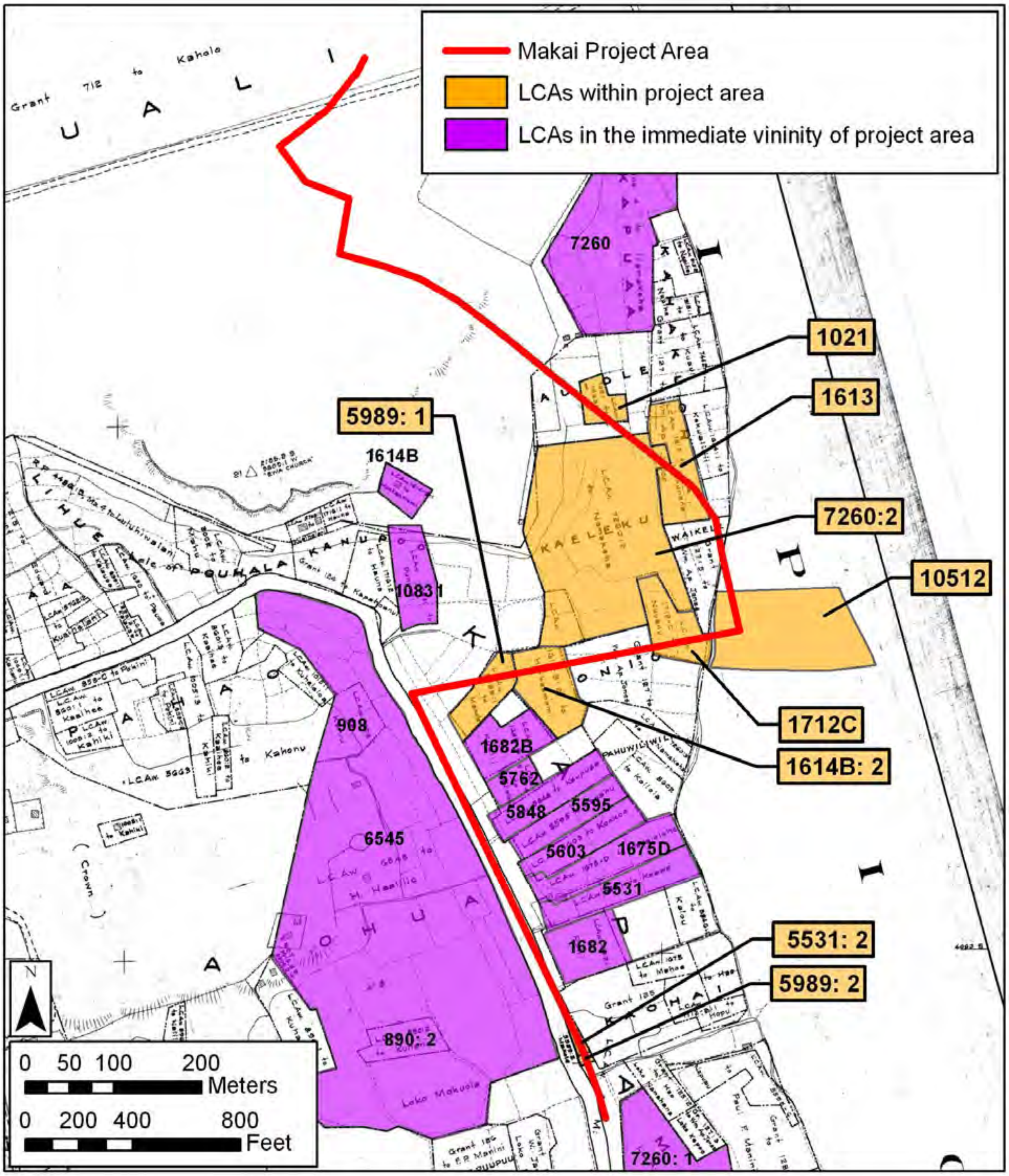

Figure 17. 1889 Brown map of Waikele showing LCAs within and in the vicinity of the *makai* portion of the project area

Table 3. Land Commission Awards Located within the *Makai* Project Area

Land Claim #	**Claimant**	***‘Ili***	**Land Use**	**Landscape Feature**	**Awarded**
5531	Keawe	Kapakahi	House lot, 4 *lo‘i* (wet land taro patch), *kula* (dry land agricultural plot)	Stream	2 *‘āp*.; 1.07 Ac.
5989	Makole	Kapakahi	House lot, 3 *lo‘i*, *kula*, *loko* (fish pond, *ko‘ele* (small land unit farmed by a tenant for the chief)	*‘auwai* (irrigation ditch), boundary walls, stream	2 *‘āp*.; 0.66 Ac.
7260	Namakeha	Waikele	No land use listed	None listed	4 *‘āp*.; 39.13 Ac
1020	Maawa	Auiole	3 *lo‘i*	None listed	1 *‘āp*.; 0.54 Ac.
1613	Kaihunana	Kahakuohia	4 *lo‘i*	None listed	1 *‘āp*.; 1.38 Ac.
1614B	Hookaamomi	Keahupuaa, Ahualii, Mikiokai	4 *lo‘i*, house lot	Boundary walls	1 *‘āp*.; 0.598 Ac; 1 *‘āp*.; 1.405 Acs.
1712C	Nuuanu	Keahupuaa	4 *lo‘i*, house lot	None listed	1 *‘āp*.; 0.518 Ac.
10512	Nahuina	Kauaka	3 *lo‘i*	None listed	1 *‘āp*.; 3.64 Ac.

railroad tracks running through the northern and southern ends of the *makai* portion of the project area (Figure 18).

4.1.6 1900's to Present

By the early decades of the twentieth century, rice farming in the area (as in the rest of the Hawaiian Islands) was in decline, beset by crop diseases and cheaper prices for rice from the mainland. Commercial agriculture became dominated by sugar, particularly with the founding and development of the Oahu Sugar Company.

A 1925 Oahu Sugar Company map and a 1927-28 USGS map indicate that the *makai* portion of the project area was within the boundaries of Oahu Sugar Company operations (Figure 19 & Figure 20). The *makai* portion of the project area does not appear to have been planted with cane, but is situated within the heart Oahu Sugar Company operations. Extensive sugar transport (railroad stations), harvesting (field workers quarters) and processing (sugar mill) infrastructure are indicated within and in the immediate vicinity of the *makai* portion of the project area.

Early in the twentieth century, the U.S. Government began acquiring the coastal lands of ʻEwa for the development of a naval base at Pearl Harbor. The U.S. Navy began a preliminary dredging program, which created a 30-foot deep entrance channel measuring 200 feet wide and 3,085 feet long. In 1908, money was appropriated for five miles of entrance channel dredged to an additional 35 feet down (Downes 1953).In 1909, the government appropriated the entire Waipiʻo peninsula from the ʻĪʻī estate.

By 1941, Pacific Naval Air Bases expenditures for new construction at Pearl Harbor were in the hundreds of millions of dollars. The Japanese attack on Pearl Harbor, December 7, 1941, damaged or destroyed much of the new construction. Reconstruction was instituted to double the Pearl Harbor's war capacity. Military planners approved a new ammunition depot in the mountainside of Waipahu, a large new hospital in ʻAiea, and thousands of additional changes to the Navy Yard to accommodate the new aircraft carrier task forces (Woodbury 1946). During World War II, the military used the sugar cane rail system to "haul large quantities of ammunition" (Condé and Best 1973:315). A 1956 U.S. Army Map Service map shows Loko ʻEo completely drained, filled in, and converted into a "naval reservation" (Figure 21).

A 1968 Dept of Defense Map and a 1977 aerial photograph indicate that the project area is now completely developed with residential structures and associated infrastructure (Figure 22 & Figure 23).

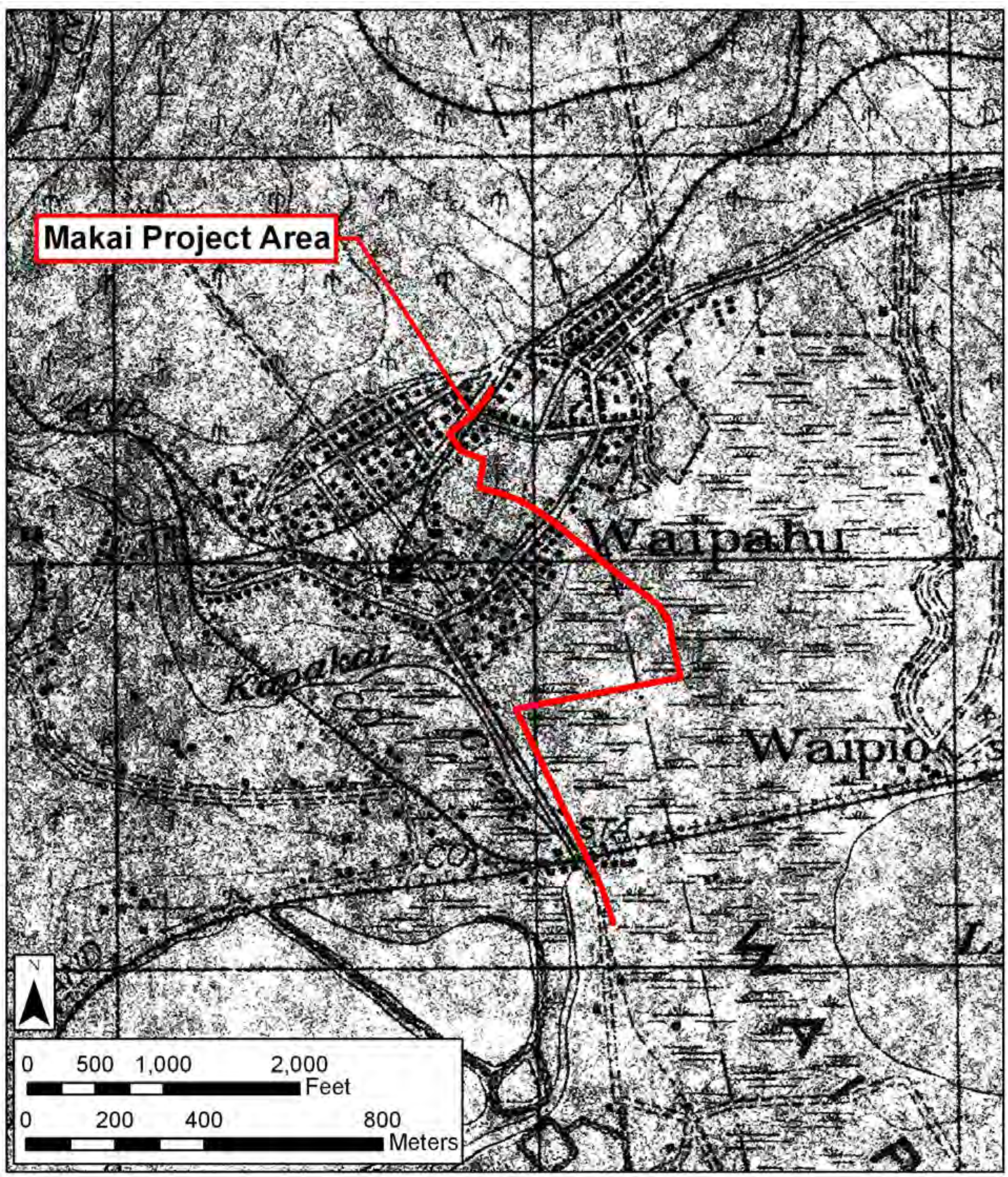

Figure 18. 1919 War Department map showing the location of the *makai* portion of the project area

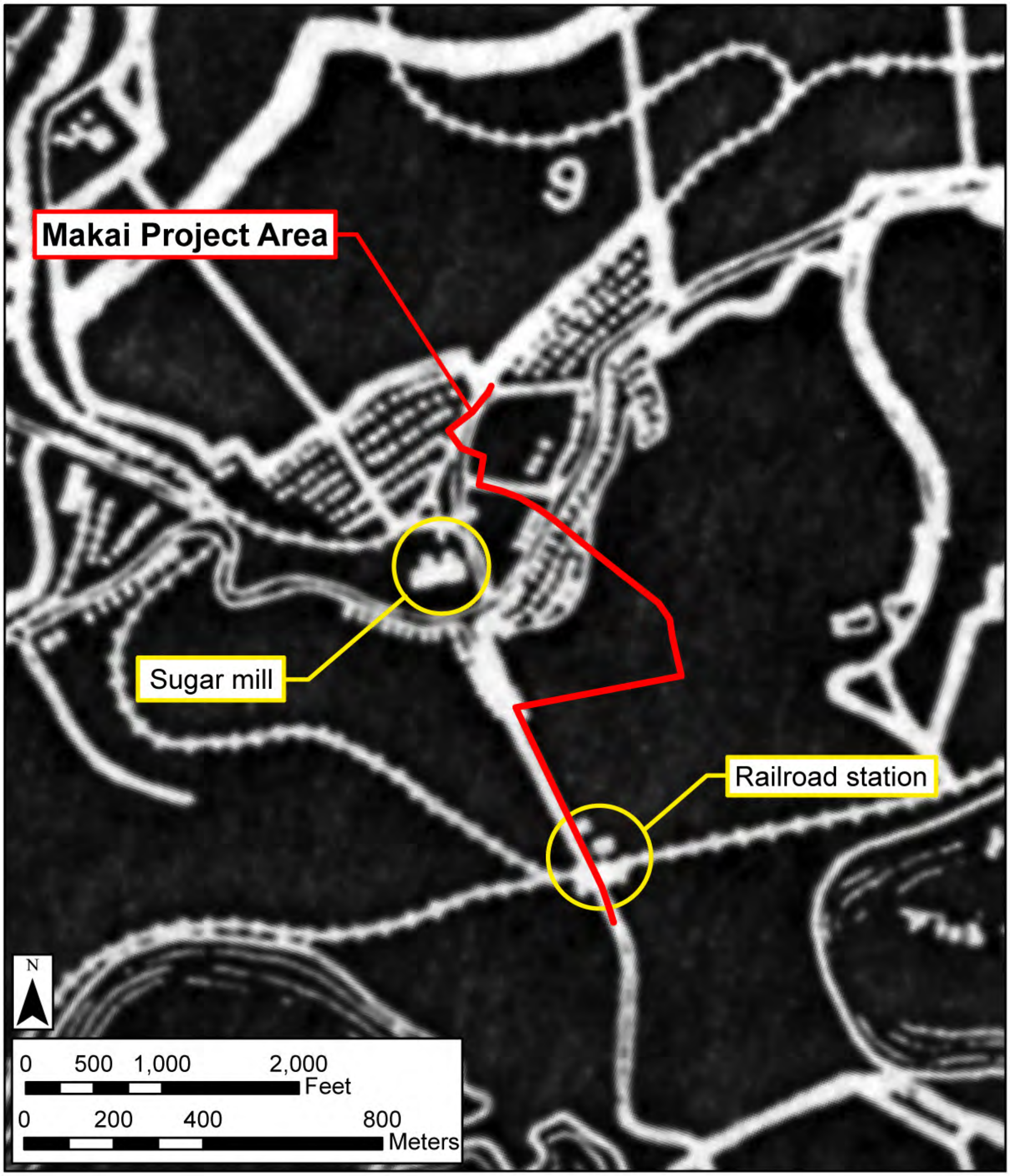

Figure 19. 1925 Oahu Sugar Company map showing extensive sugar harvesting and processing infrastructure within and in the immediate vicinity of the *makai* portion of the project area

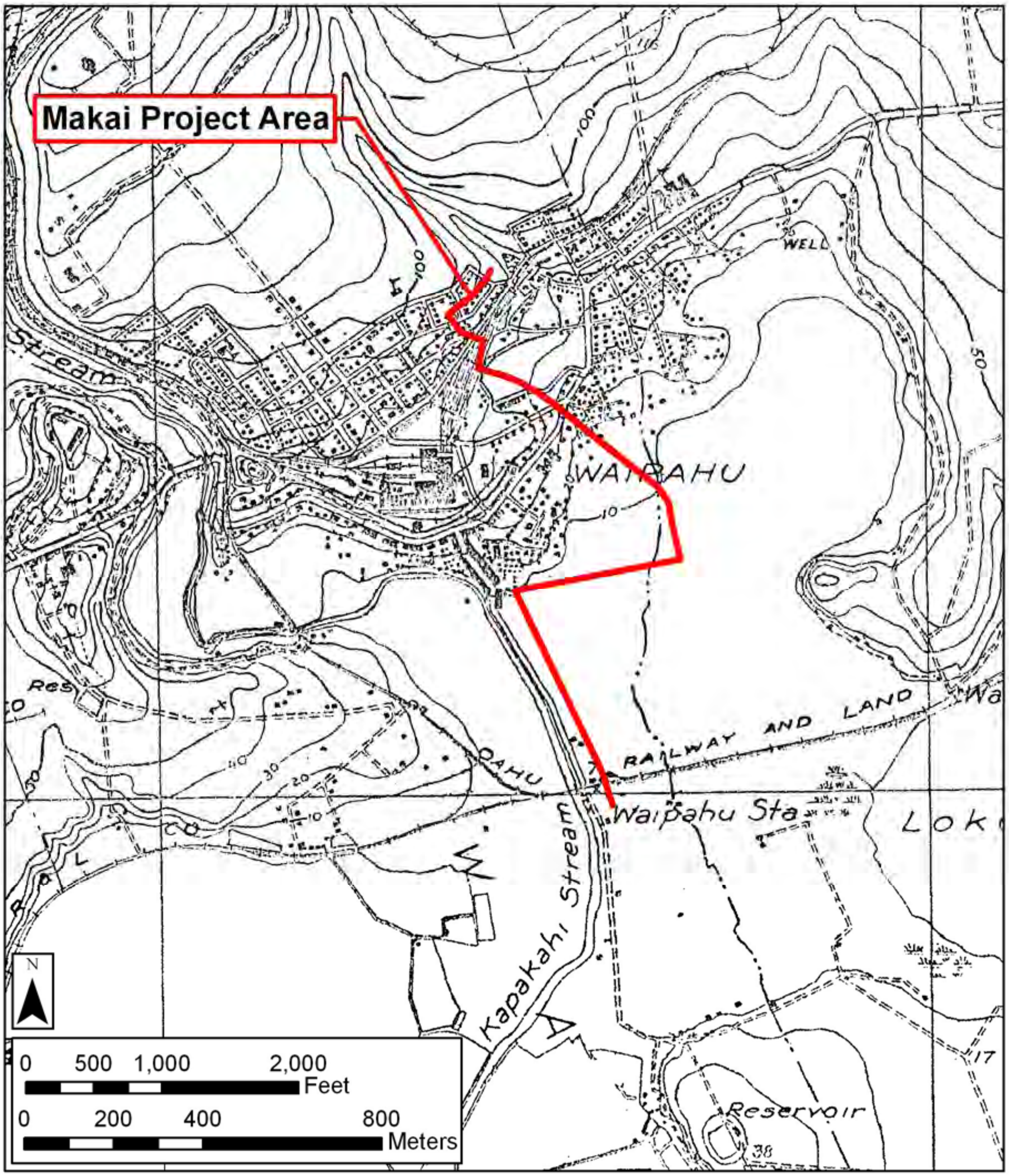

Figure 20. 1927 USGS map showing location of the *makai* portion of the project area

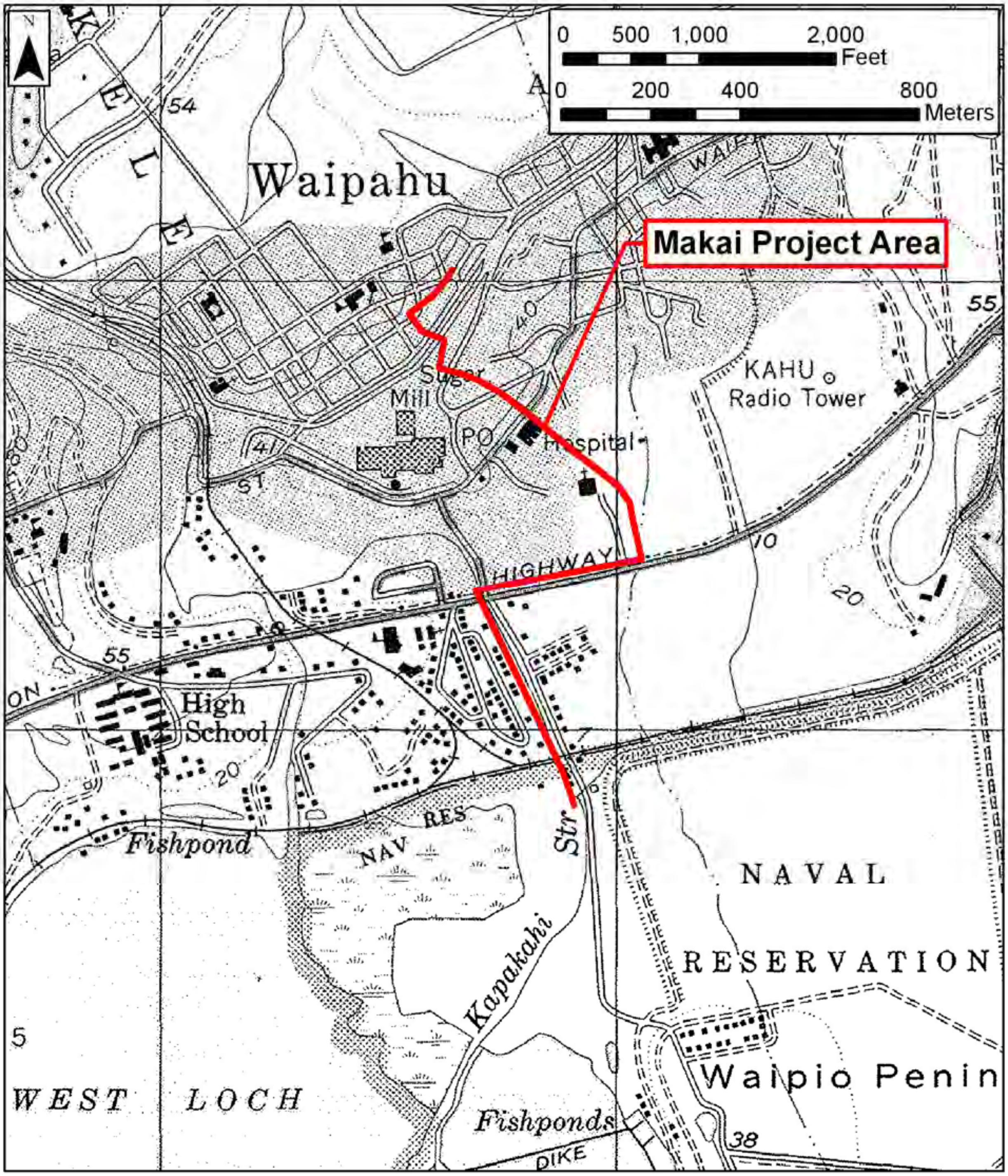

Figure 21. 1956 U.S. Army Map Service map showing *makai* portion of the project area location

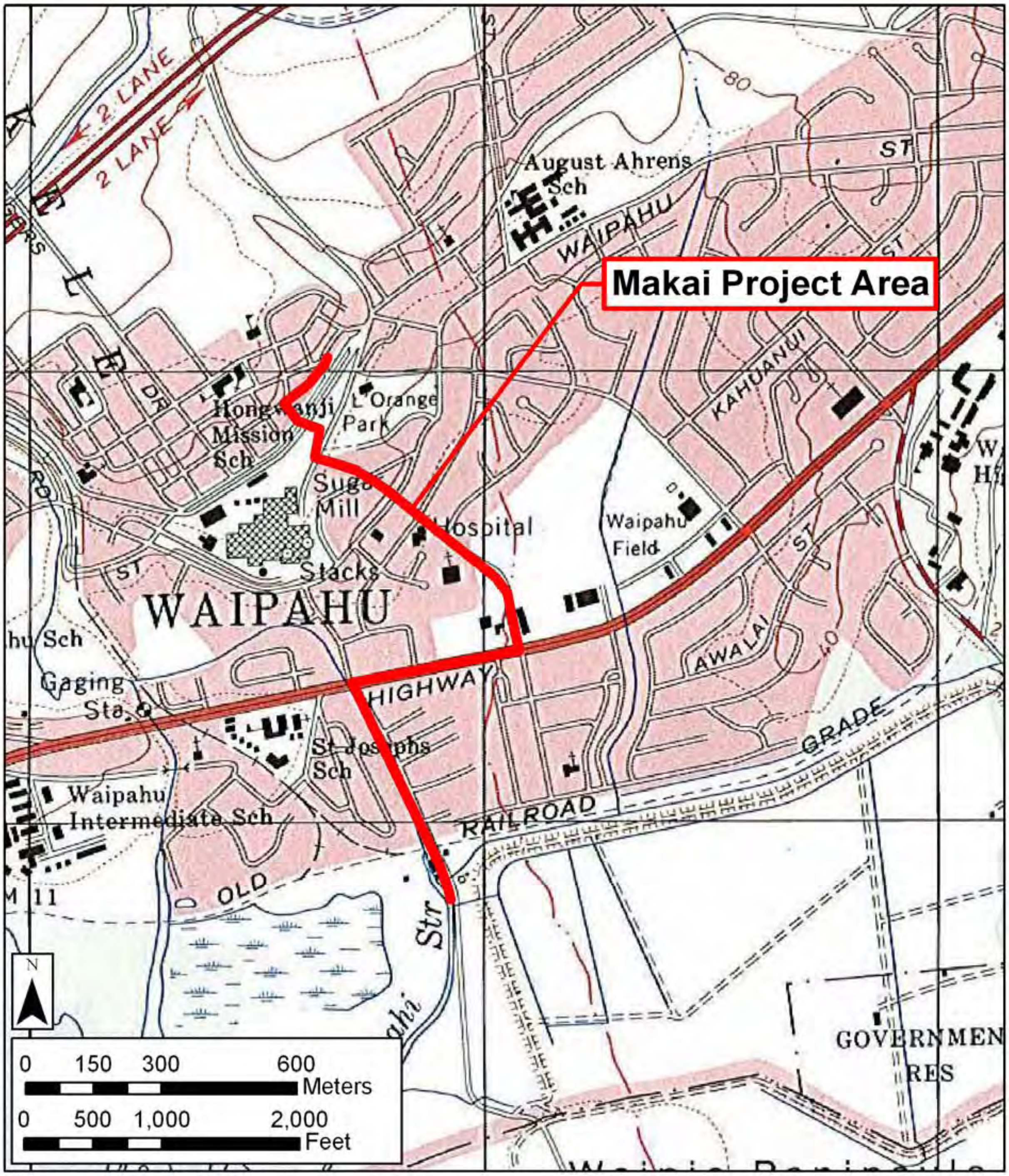

Figure 22. 1968 Dept of Defense Map showing location of the *makai* portion of the project area

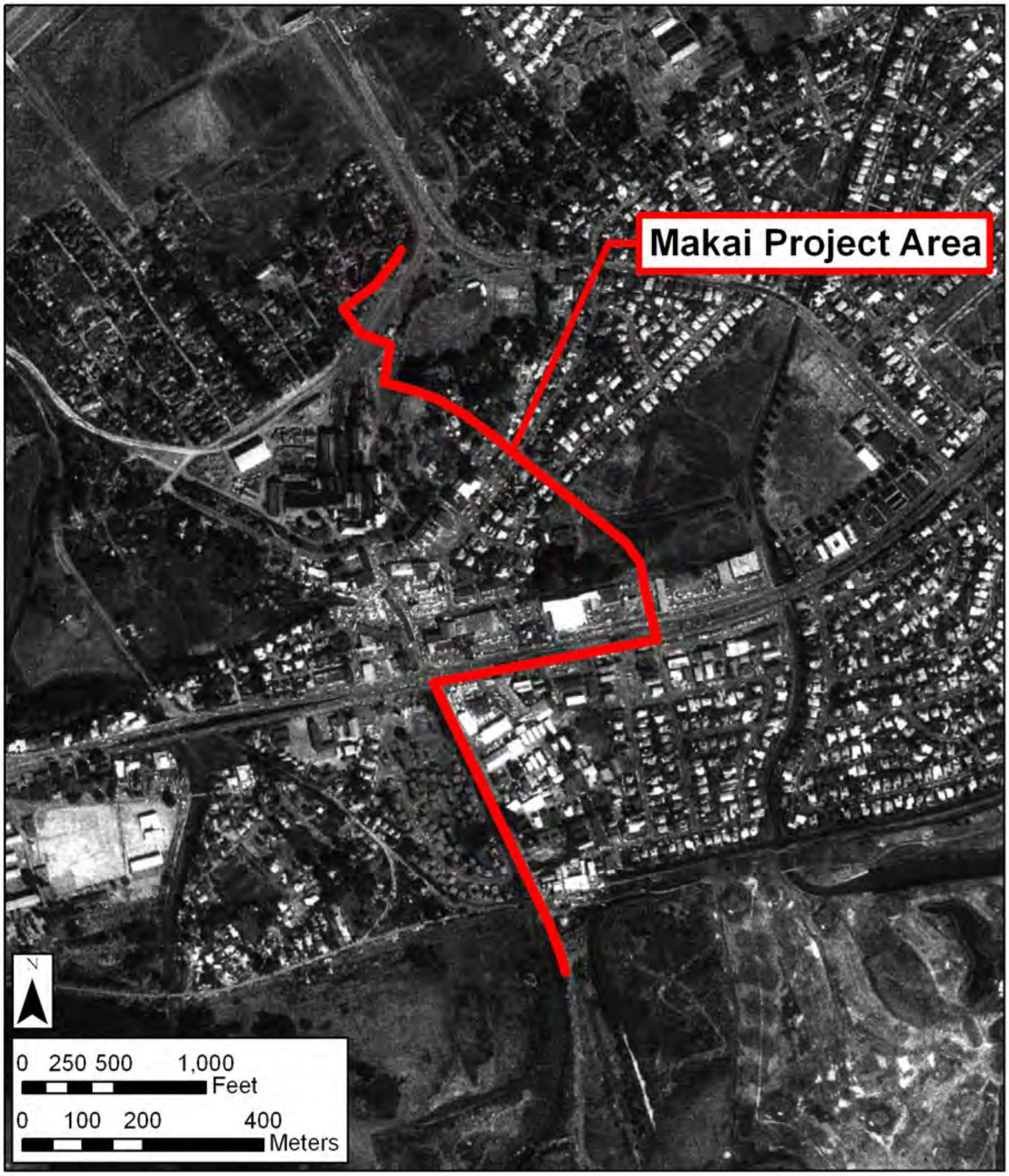

Figure 23. 1977 aerial photograph showing the location of the *makai* portion of the project area (source: USGS orthoimagery)

4.2 Previous Archaeological Research

Previous archaeological studies in the vicinity of the current project area are presented in Table 4 and shown in Figure 24. Historic properties identified in the vicinity of the project area are shown on Figure 25. The following is a summary of these archaeological studies.

McAllister 1933

The earliest archaeological documentation in the *makai* portions of Waikele and Waipiʻo Ahupuaʻa was conducted by J. Gilbert McAllister in the 1930s. McAllister identified five sites in the vicinity of the project area: Site 122 (Ahuena Heiau), Site 123 (Loko Eo), Site 127 (Mokoʻula Heiau), Site 128 (Waipahu Spring), and Site 129 (Loko ʻEo) (Figure 26).

Site 122 is the now destroyed ʻAhuʻena Heiau (meaning "red-hot heap"), located approximately 930 m east of the *makai* project area. McAllister describes what was left of the *heiau* (altar, oracle tower, shrine, etc.) during his site visit:

> Site 122. Ahuena heiau, Halaulani, Waipio, just seaward of the Experimental Station of the Hawaiian Sugar Planters' Assn.
>
> Only a small portion of paving of very small water-worn stones at the edge of the 25 foot elevation remains of what must have been an important heiau, for the site is known and remembered by all the old Hawaiians (kamaaina) in the district. There is a vague memory that this heiau was formerly located in the mountains in Honouliuli at Punahawele. Thrum states "Hon. John Ii used to be the custodian of its idols." (McAllister 1933 in Sterling & Summers 1978: 19)

Site 123 consists of Loko Eo, a large fish pond, approximately 137 acres, surrounded on three sides by a wall. Loko Eo is located approximately 600 m southeast of the *makai* project area, but was drained and filled in by the military during the 1950's.

Site 127 is the now destroyed Mokoula Heiau, located approximately 560 m northwest of the *makai* project area. McAllister describes what was left of the *heiau* (altar, oracle tower, shrine, etc.) during his site visit:

> Site 127. (Destroyed) Mokoula Heiau, southwest of the main road in the village of Waipahu.
>
> The heiau has been completely destroyed for the building purposes of the neighborhood. The site is at the edge of a 50 foot elevation which projects out into the present rice fields and was pointed out by Kaluawai, a kamaaina undoubtedly more than 100 years old (McAllister 1933 in Sterling & Summers 1978: 25).

Site 128 consists of Waipahu Spring located approximately 490 m west of the *makai* project area. A pump had already been placed over the spring upon McAllister visit of the site. McAllister describes that the spring was the place "at which the tapa mallet appeared after having been lost in Kahuku" (McAllister 1933 in Sterling & Summers 1978: 25).

Table 4. Previous Archaeological Studies in the Vicinity of the *Makai* Project Area

Reference	Location	Nature of Study	Results
McAllister 1933	Island of O‘ahu	Island-wide archaeological survey	Identified Site, 122 (Ahuena Heiau), Site 123 (Loko Eo), Site 127 (Mokoula Heiau), Site 128 (Waipahu Spring), and Site 129 (Loko ‘Eo).
Folk 1990	Waipahu Street (from Amokili Street to August Athens School)	Archaeological reconnaissance	No historic properties identified.
Kawachi & Griffin 1990	94-1049 Kahuailani (TMK [1] 9-4-026: 078)	Inadvertent burial discovery	Identified one historic property: SIHP #50-80-09-4245, early post-contact human burial.
Spear 1993	TMK [1] 9-4-002: various	Archaeological reconnaissance	Remains of an abandoned plantation camp identified, but determined not significant.
Cleghorn 1996	TMK [1] 9-4-002: por. 004	Archeological inventory survey	Remains of Oahu Sugar Mill observed, but were determined to be “outside the scope of work” of the project.
Hammatt & Chiogioji 2000a	TMK [1] 9-3-002: por. 009	Archaeological & cultural assessment	No historic properties identified.
Hammatt & Chiogioji 2000b	Farrington Highway (from Anini Place to Waipahu Depot Road)	Archaeological assessment	No historic properties identified.
Hammatt et al. 2000	TMK [1] 9-4-002: 005	Archeological inventory survey	Identified two historic properties: SIHP #50-80-09-530, pre-contact petroglyphs and #50-80-09-4660, remnants of Oahu Sugar Company plantation camp (Higashi Camp).
Ostroff et al. 2001	Filipino Community Center (TMK [1] 9-4-161: 001)	Inadvertent burial discovery	Identified one historic property: SIHP #50-80-09-5882, pre-contact human burial.

Reference	Location	Nature of Study	Results
Hammatt et al. 2004	TMK [1] 9-4-009 & [1] 9-4-059: 072, 073, 074)	Archaeological & cultural assessment	No historic properties identified.
Perzinski et al. 2004	TMK [1] 9-4-038: 083 & [1] 9-4-050: 59	Archeological inventory survey	Identified three historic properties: SIHP 50-80-09-6671, the historic remnants of the Brown estate, SIHP -6672, pre- and post-contact cultural layer, and SIHP -6673, pre- and post-contact cultural layer with two associated pre-contact burials.

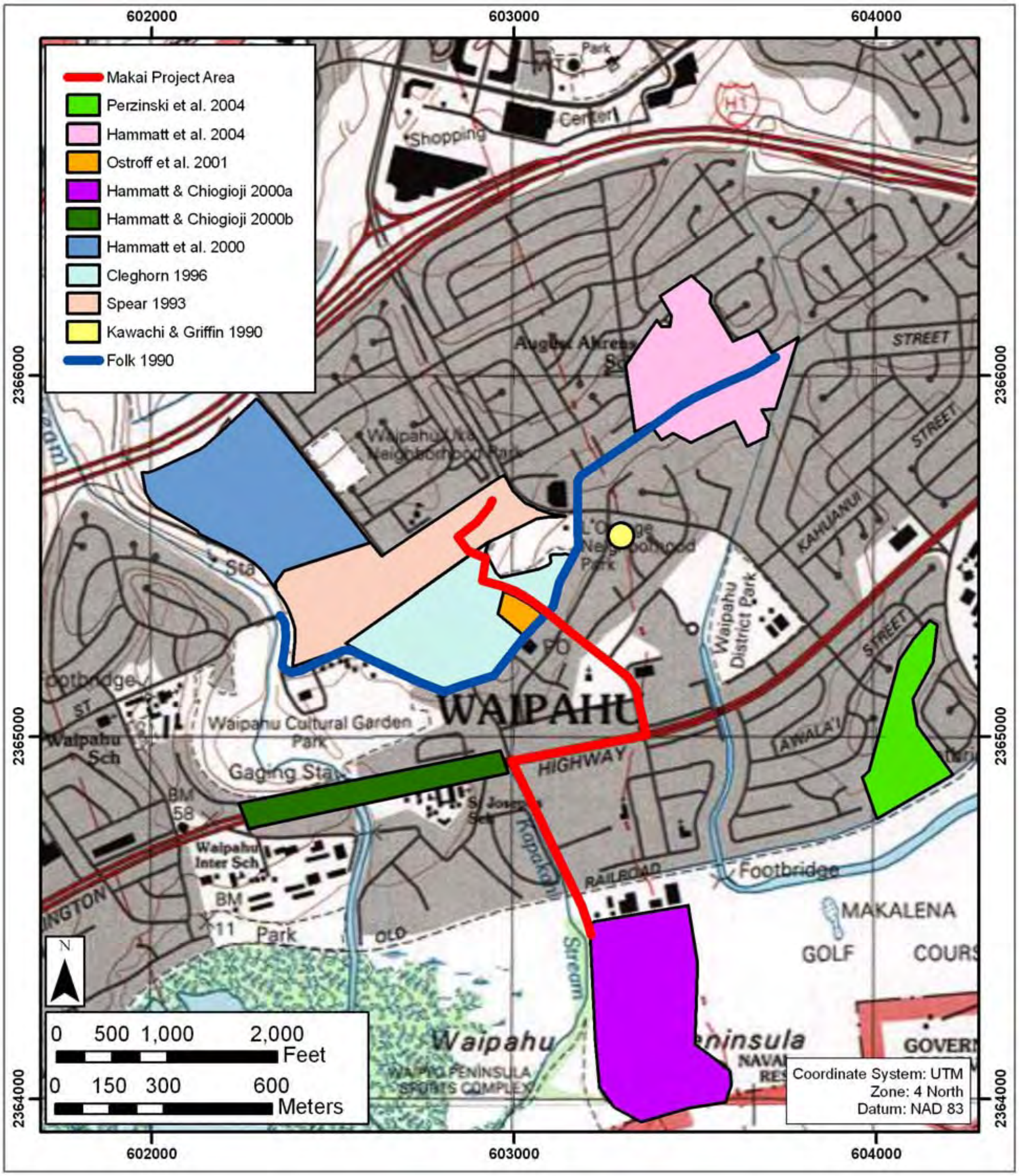

Figure 24. USGS 7.5-Minute Series Topographic Map, Pearl Harbor quadrangle (1999), showing archaeological studies in the vicinity of the Makai Project Area

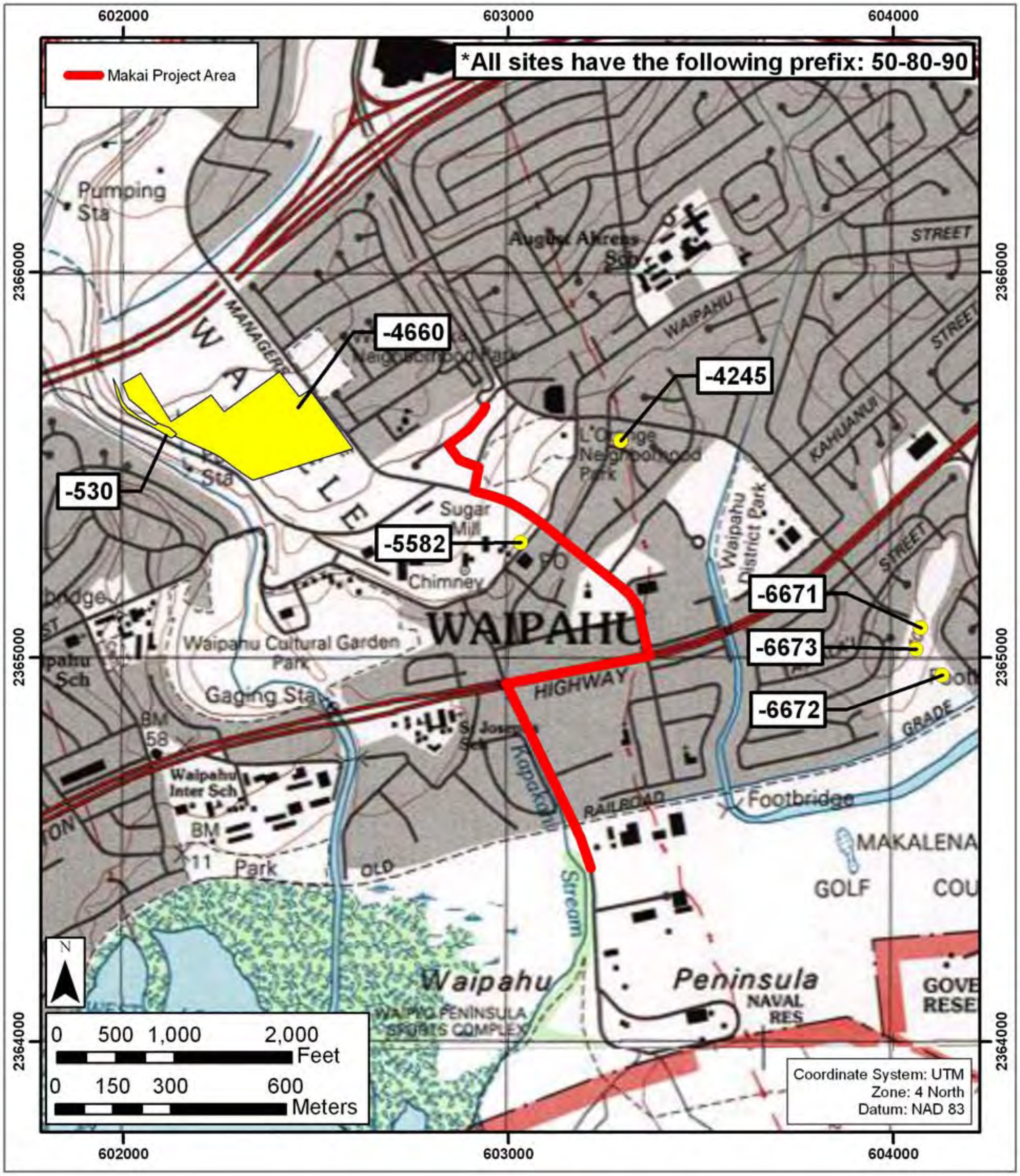

Figure 25. USGS 7.5-Minute Series Topographic Map, Pearl Harbor quadrangle (1999), showing historic properties in the vicinity of the Makai Project Area

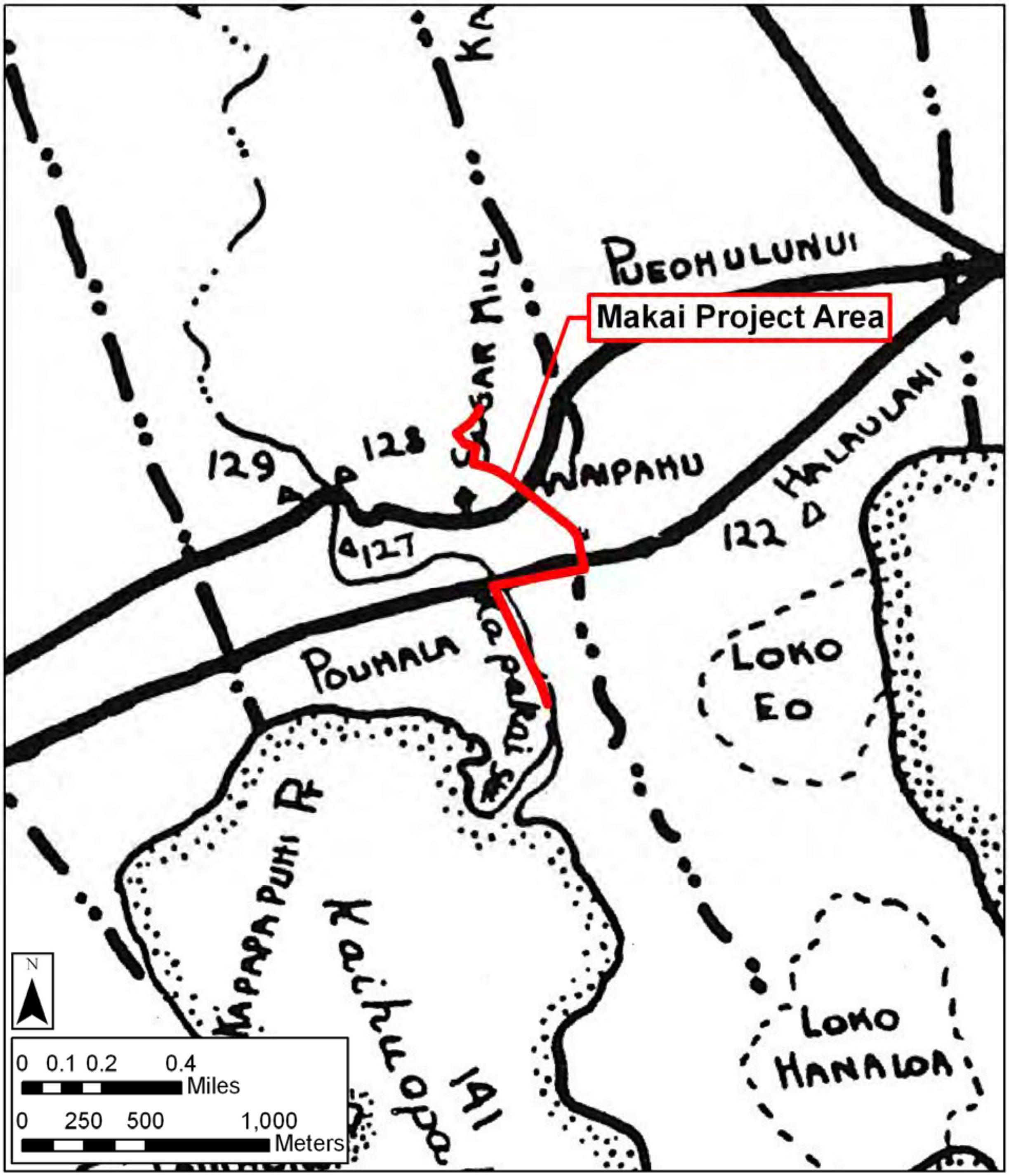

Figure 26. 1959 Bishop Museum map of Ewa showing McAllister sites in the vicinity of the *makai* project area

Site 129 is the now destroyed Hapupu Heiau, located approximately 730 m west of the *makai* project area. McAllister describes what was left of the *heiau* (altar, oracle tower, shrine, etc.) during his site visit:

> Site 129. (Destroyed) Heiau, Waipahu, said to be named Hapupu.
>
> The Waipahu plantation stables on the mountain side of the road across from the schoolhouse west of the town now occupy the site of the former heiau at Waikele. Nothing remains of the heiau. According to Thrum it was at "Heiau pookanaka, where the chief Hao was surprised during temple worship and slain with his priest and attendant chiefs by direction of the moi of Oahu, about 1650." The site was pointed out by Kapano (McAllister 1933 in Sterling & Summers 1978: 25).

Kawachi & Griffin 1990

In 1990, SHPD responded to an inadvertent burial discovery at 94-1049 Kahuailani Street, located approximately 300 m northeast of the *makai* portion of the current project area (Kawachi & Griffin 1990). The burial was discovered during grading in preparation to construct a house foundation. SHPD determined the burial to be non-Hawaiian and that disinterment would be the appropriate mitigation (Kawachi & Griffin 1990). The burial was observed to be in a supine position and was approximately 1 m below the existing ground surface. Artifacts collected during disinterment consisted of a pair of scissors, a mirror, and over a thousand colored glass beads. The artifact assemblage suggested that the burial was of post-contact origin. This burial has been designated as SIHP #50-80-09-4245.

Folk 1990

In 1990, CSH conducted an archaeological reconnaissance for the proposed Waipahu Street widening project, which crosses thru the northern portion of the *makai* project area. No historic properties were identified, however based on background research it was determined that pre-contact and early post-contact archaeological remains may be preserved beneath urban streets and construction (Folk 1990). Archaeological monitoring of all ground disturbances was recommended.

Spear 1993

In 1993, Scientific Consultant Services conducted a reconnaissance survey at the site of proposed rezoning and development for the Oahu Sugar Mill Project (TMK: 9-4-02: various) (Spear 1993). This resonance included the northern tip of the *makai* portion of the current project area. Extensive cutting, grading, and bulldozer push piles were observed throughout the area. The remains of an abandoned plantation camp associated with the Oahu Sugar Company were observed in the southwestern portion of the project area, and consisted primarily of concrete and stone house foundations and historic wall segments. Spear (1993) concluded that there were no significant archaeological sites within the project area and thus no further archaeological work was recommended.

Cleghorn 1996

In 1996, Pacific Legacy conducted an archaeological inventory survey of 23-acres surrounding and including the Oahu Sugar Mill (TMK [1] 9-4-002: por. 004) (Cleghorn 1996). This inventory survey included a 300 m segment of the northern section of the *makai* portion of the current project area. Oahu Sugar Company infrastructure was observed throughout the entire study area. Sixty percent of the infrastructure was associated with the sugar mill (machinery, buildings, paved and graded roadways) and forty percent was associated with Oahu Sugar Company supervisors' residences, known as Skill Village. No historic property designation was assigned to the Oahu Sugar Company infrastructure as it was considered to be "outside the scope of work" of the project (Cleghorn 1996: 13).

Hammatt et al. 2000

In 2000, CSH conducted an archaeological inventory survey of a 40-acre parcel along the western edge of Manager's Drive (TMK [1] 9-4-002: 005), located approximately 250 m west of the *makai* project area (Hammatt et al. 2000). Two historic properties were identified: SIHP #50-80-09-530, a pre-contact petroglyph field, and SIHP #50-80-09-4660, the remnants (concrete building foundations, stone and mortar walls, road remnants, etc.) of an Oahu Sugar Company plantation camp (Higashi Camp). SIHP -530 was recommended for preservation, while no further work was recommended for SIHP -4660 (Hammatt et al. 2000).

Hammatt and Chiogioji 2000a

In 2000, CSH conducted an archaeological and cultural assessment of a City and County of Honolulu-owned parcel on Waipiʻo Peninsula, located immediately south of the current project area (Hammatt and Chiogioji 2000a). No surface archaeological sites associated with traditional Hawaiian occupation were observed in any portion of the study area. An existing land fill and modern building activities have eliminated any remnant sites. Additionally, it was determined that intact subsurface evidence of traditional Hawaiian occupation would have been similarly eliminated during the decades of rice farming documented within the study area. No further archaeological investigation of the study area was recommended.

Hammatt and Chiogioji 2000b

In 2000, CSH conducted an archaeological assessment of an approximately 26000-ft portion of Farrington Highway between Anini Place and Waipahu Depot Road, located just west of the *makai* portion of the current project area (Hammatt & Chiogioji 2000b). No historic properties were identified during a field inspection of the study area. No further work was recommended as it was believed that decades of urban development would have removed the presence of any subsurface cultural deposits that may have once been present (Hammatt & Chiogioji 2000).

Ostroff et al. 2001

In 2001, Archaeological Consultants of the Pacific, Inc. conducted archaeological documentation and disinterment of a human burial inadvertently discovered during the installation of a storm drain at the Filipino Cultural Center (TMK [1] 9-4-161: 001), located 50 m west of the *makai* portion of the current project area (Ostroff et al. 2001). The burial, designated as SIHP #50-80-09-5882, was located approximately 1 m below the existing surface within a dark yellowish brown silty clay. Observations of *in situ* portions of the burial, not impacted by construction, indicated a flexed position. Also of note was that the burial was capped by a stratum containing historic debris but was situated within a stratigraphic layer that did not contain evidence of historic land use. Thus based on the lack of burial goods, a flexed burial position, and stratigraphic observations, the burial was determined to be of pre-contact origin and ethnically Hawaiian (Ostroff et al,. 2001).

Hammatt et al. 2004

In 2004, CSH conducted an archaeological and cultural assessment of an approximately 38-acre area in the immediate vicinity of the August Ahrens School, located approximately 430 m northeast of the *makai* project area (Hammatt et al. 2004). No historic properties were identified during a field inspection of the study area. It was determined that decades of urban development and sugar cultivation would have destroyed any subsurface cultural deposits that may have once existed within the study area.

Perzinski et al. 2004

In 2004, CSH conducted an archaeological inventory survey of a 13-acre parcel located 640 m east of the *makai* portion of the current project area (Perzinski et al. 2004). Three historic properties were identified: SIHP #50-80-09-6671, the historic remnants of the Brown estate consisting of concrete and cinder block foundations; SIHP #50-80-09-6672, a subsurface cultural layer containing evidence of both pre- and post-contact land use; and SIHP #50-80-09-6673, a pre- and post-contact cultural layer containing two pre-contact flexed human burials.

4.3 Waikele Background Summary and Predictive Model

The *makai* portion of Waikele including the Waipiʻo Peninsula and the surrounding loch waters of Pearl Harbor contained abundant marine resources and arable land which would have been extremely favorable to pre-contact Hawaiian populations for the development of large scale taro cultivation and the implementation of aquaculture in the form of large fish ponds or *loko*. A 1889 J.F. Brown map of the *makai* portion of Waikele shows the *makai* portion of the project area crossing thru 8 LCAs and completely surrounded by others (see Figure 15). LCA documentation indicates that by the mid-eighteenth century the entire *makai* portion of the project area was in an extensive network of irrigation ditches, agricultural fields, fish ponds, and habitations, developed over many centuries. Previous archaeological research has also documented pre-contact subsurface cultural layers, human burials, and petroglyphs in the immediate vicinity of the *makai* project area (Perzinski et al. 2004; Ostroff et al. 2001; and Hammatt et al. 2000), providing further evidence of the pre-contact Hawaiian occupation of the area.

During the late nineteenth century the Oahu Sugar Company established sugarcane operations in Waikele. A 1925 Oahu Sugar Company map indicates that the entire *makai* portion of the project area was within the boundaries of Oahu Sugar Company operations (see Figure 19). The *makai* portion of the project area does not appear to have been planted with cane, but is situated within the heart of the Oahu Sugar Company operations. Extensive sugar transport (railroad stations), harvesting (field workers quarters) and processing (sugar mill) infrastructure are indicated within and in the immediate vicinity of the *makai* portion of the project area. Previous archaeological research has identified remnants of Oahu Sugar Company infrastructure, in the form of abandoned plantation camps and sugar mill architecture and machinery, within and in the immediate vicinity of the *makai* project area (Hammatt et al. 2000; Cleghorn 1996; and Spear 1993).

Based on background research, no surface historic properties (i.e. archaeological sites) are expected to be encountered during the pedestrian inspection of the *makai* project area. Land modifications within the project area associated with historic sugar agriculture, as well as modern urban development (i.e. asphalt paved roads) have caused extensive land disturbances (i.e. grading, leveling, filling, etc.) which would have destroyed and/or buried any evidence of both pre- and post-contact land use. However, it is very likely that subsurface historic properties, associated with both pre- and post-contact land use, are present within the *makai* project area in the form of cultural layers and/or structural remnants buried by modern and/or historic fill layers. Evidence of pre-contact land use could be in the form of human burials, midden deposits, artifacts (i.e. stone tools), *loʻi* deposits (organically enriched sediment indicative of taro cultivation), as well as buried *loʻi* or fishpond walls. Evidence of post-contact land use could be in the form of human burials, trash pits, privies, and building foundations.

Section 5 Results of Fieldwork

5.1 Survey Findings

A 100% pedestrian inspection of the entire project area identified one historic property: SIHP #50-80-09-6959, a post-contact Plantation Era irrigation ditch and water control box. A detailed description of SIHP #50-80-09-6959 is presented in Section 5.2 Historic Property Descriptions below.

The presence of only a single historic property within the project area can be attributed to the extensive land disturbance observed throughout the entire project area. The observed disturbances are associated with modern urban development as well as post-contact Plantation Era agriculture. The following is a discussion of the observed disturbance within the project area.

5.1.1 Mauka Project Area

To help orient the reader, a map illustrating the locations of photographs taken within the project area is presented in Figure 27.

The southern portion of the *mauka* project area, consisting of a bus parking lot and the length of Paiwa Road leading up to the Patsy T. Mink Central O'ahu Regional Park, was almost completely paved and was bordered by the Waikele Golf Course and recently constructed residential complexes (Figure 28 & Figure 29). Additionally, the bus parking lot (TMK's [1] 9-4-096: 149 & [1] 9-4-002: 024) located at the southern tip of the *mauka* project area, appeared to be situated within an artificially constructed gully created through the excavation and removal of a significant amount of earth. This was determined due to the significantly lower elevation of the parking lot in relation to the surrounding houses and streets, as well as the presence of road cuts on both sides of the parking lot (Figure 30). Also of note was the presence of grading and modern utilities along the road cuts (Figure 31).

The northern section of the *mauka* project area skirts along the western edge of the Patsy T. Mink Central Oahu Regional Park. A majority of this section of the *mauka* project area has been disturbed by post-contact sugar and/or pineapple cultivation. This entire section of the *mauka* project area, with the exception of the northern tip, is situated within dirt roads which were probably utilized as vehicular transit corridors during the Plantation Era (Figure 32 & Figure 33). The northern tip of the project area borders a modern water tank, crosses Kamehameha Highway, and terminates in a fallow agricultural field.

5.1.2 Makai Project Area

The entire *makai* project area is completely paved with asphalt roads and bordered by residential infrastructure at the north (Figure 34) and by semi-industrial development to the south (Figure 35). It is likely that the entire *makai* project area has been impacted through grading as well as by excavations associated with the installation of subsurface utilities (sewer, water, electric, etc.).

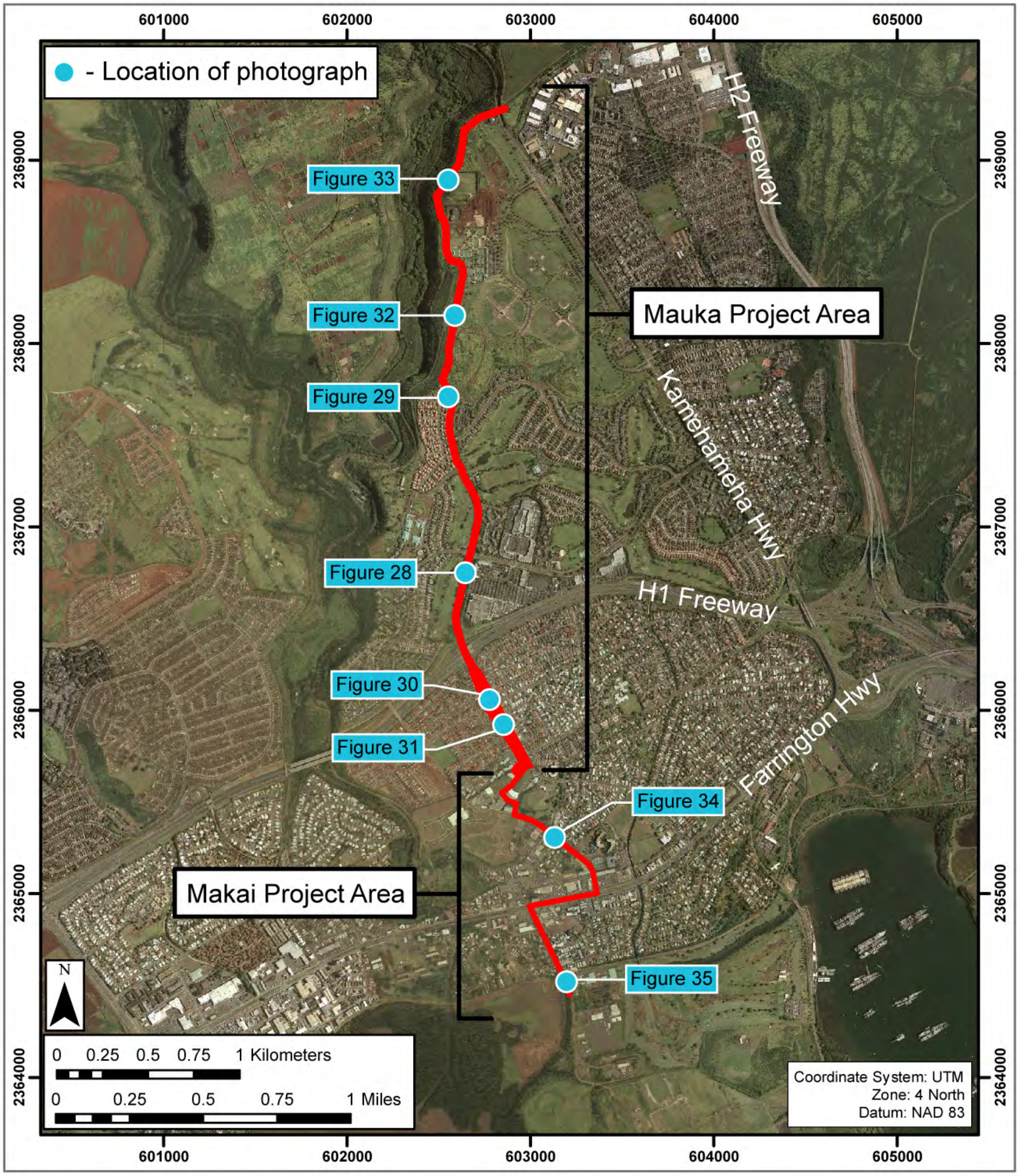

Figure 27. Aerial photograph showing the locations of photographs taken within the project area (source: USGS Orthoimagery 2005)

Figure 28. Photograph of Waikele Golf Course along Paiwa Street, view to northwest

Figure 29. Photograph of a residential complex along Paiwa Street, view to northwest

Figure 30. Photograph showing bus parking lot elevation in relation to surface streets as well as surrounding road cuts, view to northwest

Figure 31. Photograph of modern utilities along road cut, view to northeast

Figure 32. Photograph showing dirt road corridor that made up a majority of the northern portion of the *mauka* project area, view to northeast

Figure 33. Photograph of the modern power line corridors and park facilities bordering the northern portion of the *mauka* project area, view to north

Figure 34. Photograph of asphalt paved streets within *makai* project area, taken at Mokuloa Street, view to southeast

Figure 35. Photograph of asphalt paved streets within *makai* project area, taken at Waipahu Wastewater Pump Station, view to south east

5.2 Historic Property Descriptions

5.2.1 SIHP #50-80-09-6959

FORMAL TYPE:	Irrigation ditch and water control box
FUNCTION:	Agriculture
# OF FEATURES:	NA
AGE:	Post-contact
DIMENSION:	13+ m long (N-S) by 5 m wide (W-E)
LOCATION:	Northern tip of project area
TAX MAP KEY:	TMK: (1) 9-4-005: por. 074
LAND JURISDICTION:	Public, City & County of Honolulu

SIHP No. 50-80-09-6959 consists of a irrigation ditch and water control box located at the northern tip of the project area, approximately 6 m southwest of Kamehameha Highway, along the upslope edge of a road cut (Figure 36 & Figure 37; see Appendix B for UTM coordinates). The topography of the immediate area is relatively level, while the geology consists of deep deposits of silty clay with a few basalt rocks on the surface.

The dimensions of this historic property are approximately 13 m long (N-S) by 5 m wide (W-E). Of note is the fact that SIHP -6959 extends for an undetermined distance to the north, well beyond the project area boundaries. Also, the ditch appears to have extended to the east towards fallow agricultural fields situated across Kamehameha Highway, as indicated by the presence of a collapsed ditch segment extending to the edge of a modified slope, cut during the construction of the highway. This section of the ditch was probably destroyed during the construction of Kamehameha Highway.

As noted above, SIHP -6959 consists of an irrigation ditch and water control box. The irrigation ditch is roughly linear and runs in a north-south direction (see Figure 37). It measures approximately 13 m long and 1 m wide, and has been excavated approximately 30 to 90 cm below the ground surface. It is primarily constructed of cut basalt and mortar retaining walls with an earthen floor (Figure 38). The northern and southern ends of the ditch were earthen without cut stone components. Concrete was used near the northern portion of the documented ditch segment to construct a sluice gate, which likely built up water behind it, diverting the water towards the water control box (see Figure 37). Grooves for a wooden or metal sluice gate were observed near the northern end of the ditch (Figure 39).

The water control box consists of a concrete box measuring 2 m long by 1.5 m wide, and set approximately 75 cm beneath the ground surface. A 50 cm wide gap containing grooves for a sluice gate is present in the northeastern side of the box (Figure 40). A concrete ditch, measuring 2.5 m long and 0.7 m wide, extends from the southwestern end of the water control box and

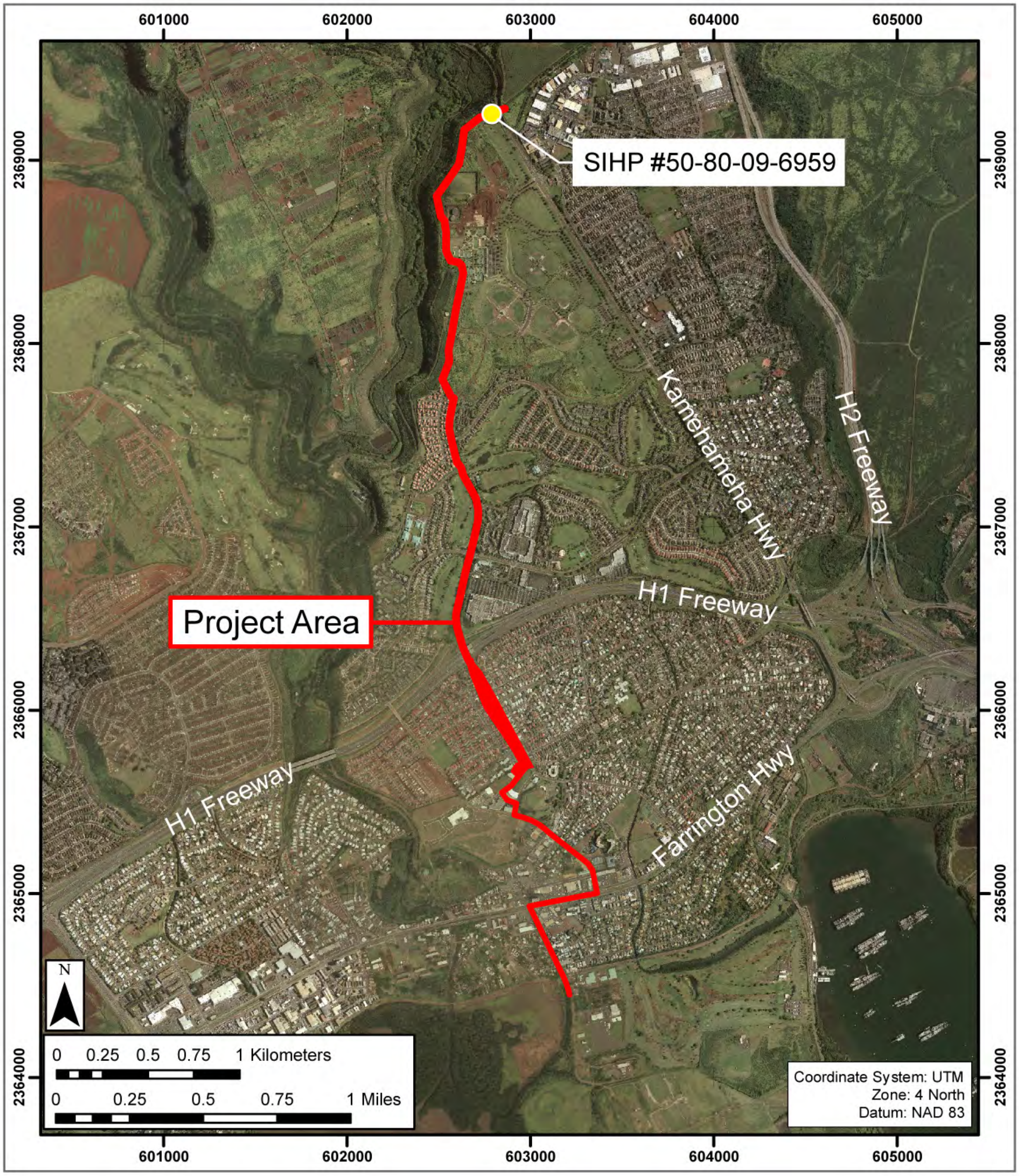

Figure 36. Aerial photograph showing the location of SIHP #50-80-09-6959 (source: USGS Orthoimagery 2005)

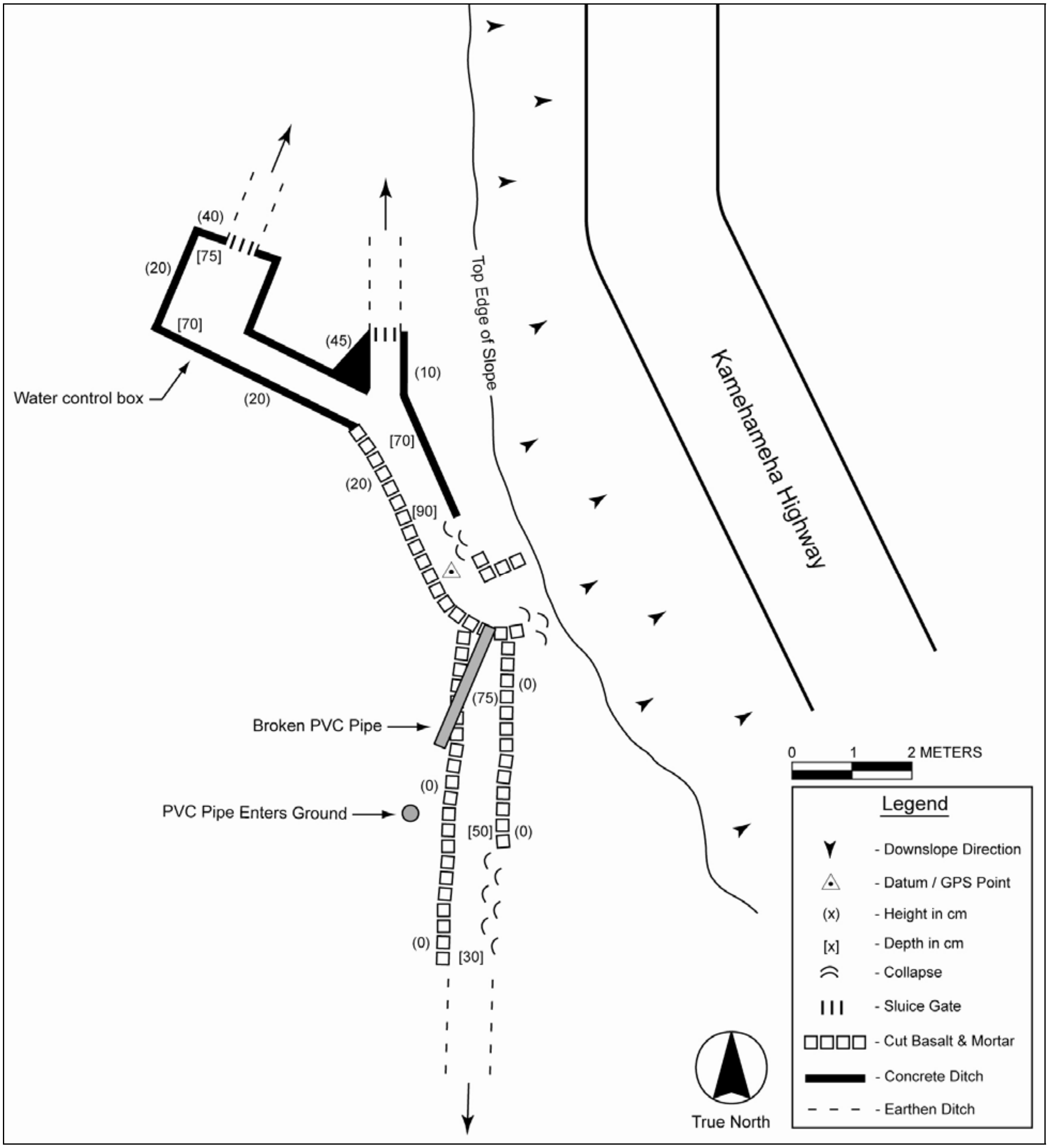

Figure 37. Plan map of SIHP # 50-80-09-6959, irrigation infrastructure related to pineapple or sugar cultivation

Figure 38. Photograph of the southern end of SIHP # 50-80-09-6959, rock and mortar construction, view to north

Figure 39. Photograph of sluice gate grooves observed at northern end of irrigation ditch, view to east

Figure 40. Photograph of a water control gate at the end of the west branch of SIHP # 50-80-09-6959, facing southeast

Figure 41. Photograph of concrete ditch leading to water control box (upper left had corner), view to north

intersects with the primary irrigation ditch (Figure 41). This ditch would have funneled water from the primary ditch into the water control box.

SIHP #50-80-09-6959 is determined to be of post-contact origin. This is based on the construction techniques utilized to construct the historic property as well as its location within an area documented as being utilized for post-contact agriculture. These factors also indicate that SIHP -6959 likely functioned as an irrigation ditch in support of Plantation Era agriculture.

SIHP #50-80-09-6959, a Plantation Era irrigation ditch and water control box, has integrity of location and materials, and is recommended eligible to the Hawai‘i Register under criteria D.

Section 6 Summary and Interpretation

In compliance with and to fulfill applicable Hawai‘i state historic preservation legislation, CSH completed this archaeological inventory survey investigation for the proposed trunk sewer line alignment planned as part of the off-site improvements for the proposed Koa Ridge Makai Community Development.

Per the Hawai‘i state requirements for archaeological inventory surveys [HAR Chapter 13-276], this inventory survey investigation includes the results of cultural, historical, and archaeological background research and fieldwork. The background research focused on summarizing the project area’s pre-contact and post-contact land use, cultural significance, and types and locations of potential historic properties within the project area and its vicinity.

Pedestrian inspection of the 15-acre project area identified one historic property, SIHP #50-80-09-6959. SIHP #50-80-09-6959 is located at the northern tip of the project area, approximately 6 m southwest of Kamehameha Highway, along the upslope edge of a road cut. It is of post-contact origin, and consists of a Plantation Era irrigation ditch and water control box utilized for agriculture.

The current archaeological inventory survey investigation also confirmed extensive post-contact and modern disturbances throughout the project area. A majority of the project area is situated within either asphalt paved or dirt roads that would have involved grading, cutting, and/or filling during road construction. The remainder of the project area is situated within fallow fields that were being cultivated for decades prior to abandonment. The presence of only a single surface historic property within the entire project area can be attributed to these observed land modifications.

These findings are largely in keeping with expectations, based on background research. The majority of the project area, from Kamehameha Highway to the southern tip of the bus parking facility (i.e. the *mauka* project area), is situated within an area that lacked the resources necessary for extensive indigenous Hawaiian settlement and agriculture, as evidenced by an absence of LCAs in the area. During the post-contact period, the entire *mauka* project area was utilized for the cultivation of sugarcane and pineapple. Historic maps indicate that the *mauka* project area was under cultivation from the early 20th century through modern times. Following post-contact agriculture the *mauka* project area was subjected to extensive land modifications associated with modern development including the construction of asphalt paved roads, housing developments, and the Patsy T. Mink Central Oahu Regional Park. Due to the absence of pre-contact Hawaiian settlement, the extensive post-contact land disturbance via sugar/pineapple cultivation, and modern development, the likelihood of subsurface historic properties within the *mauka* project area is minimal.

The *makai* project area, from Koaki Street to the Waipahu Wastewater Pump Station, is situated within an area that contained abundant marine resources and arable land. These lands would have been extremely favorable to pre-contact Hawaiian populations for the development of large scale taro cultivation and the implementation of aquaculture in the form of large fish ponds or *loko*. LCA documentation indicates that by the mid-eighteenth century the *makai* project area was located within a complex network of irrigation ditches, agricultural fields, fish ponds, and habitations, probably developed over many centuries. Previous archaeological research has identified pre-contact subsurface cultural layers, human burials, and petroglyphs in the immediate vicinity of the *makai* project area (Perzinski et al. 2004; Ostroff et al. 2001; and Hammatt et al. 2000), providing further evidence of the pre-contact Hawaiian occupation of the area.

During the late nineteenth century the northern portion of the *makai* project area was developed by the Oahu Sugar Company. Historic maps indicate extensive sugar transport (railroad stations), harvesting (field workers quarters) and processing (sugar mill) infrastructure within and in the immediate vicinity of the *makai* project area. Previous archaeological research has identified remnants of Oahu Sugar Company infrastructure, in the form of abandoned plantation camps and sugar mill architecture and machinery, within and in the immediate vicinity of the *makai* project area (Hammatt et al. 2000; Cleghorn 1996; and Spear 1993).

Based on background research, it is very likely that subsurface historic properties, associated with both pre- and post-contact land use, are present within the *makai* project area in the form of cultural layers and/or structural remnants buried by modern and/or historic fill layers. Evidence of pre-contact land use could be in the form of human burials, midden deposits, artifacts (i.e. stone tools), *lo‘i* deposits (organically enriched sediment indicative of taro cultivation), as well as buried *lo‘i* or fishpond walls. Evidence of post-contact land use could be in the form of human burials, trash pits, privies, and building foundations.

Section 7 Significance Assessments

The inventory survey investigation and documentation of the project area's single historic property has provided sufficient information for significance evaluations. Significance is determined after evaluation of the historic property in light of the five broad criteria used by the Hawaiʻi State Register of Historic Places (HAR 13-284-6). The criteria are the following:

A. Site reflects major trends or events in the prehistory or history of the state or nation.

B. Site is associated with the lives of persons significant in our past.

C. Site is an excellent example of a site type.

D. Site has yielded or is likely to yield information important to prehistory or history.

E. Site has traditional cultural significance to an ethnic group.

SIHP #50-80-09-6959, a Plantation Era irrigation ditch and water control box, has integrity of location and materials, and is recommended eligible to the Hawaiʻi Register under criteria D.

Section 8 Project Effect and Mitigation Recommendations

8.1 Project Effect

CSH's project specific effect recommendation is "effect, with proposed mitigation commitments." The proposed trunk sewer line has the potential to adversely affect subsurface cultural resources, including human burials, which may be located within the project's APE. The recommended mitigation measures will reduce the project's effect to any cultural resources that may be located within the alignment of the proposed trunk sewer line and be pro-active in addressing possible community concerns.

8.2 Mitigation Recommendations

Background research has indicated that the *makai* section of the project area, from Koaki Street to the Waipahu Wastewater Pump Station, was intensively utilized by pre-contact Hawaiians for agriculture, aquaculture, and habitation; and by the Oahu Sugar Company as a transport hub, a sugar processing facility, and residences for field workers and supervisors. Thus it is very likely that subsurface historic properties, associated with both pre- and post-contact land use, are present within the *makai* project area in the form of cultural layers and/or structural remnants buried by modern and/or historic fill layers. In order to mitigate the potential damage to these potential historic properties within the *makai* project area, it is recommended that project construction proceed under an archaeological monitoring program. This monitoring program will facilitate the identification and proper treatment of any burials that might be discovered during project construction, and will gather information regarding the project's non-burial archaeological deposits, should any be discovered. It is understood that much or all of the sewer line work in the *makai* area may be conducted by micro-tunneling. It may be appropriate to limit archaeological monitoring to the excavation of the micro-tunneling pits. Such specifics will be addressed in the archaeological monitoring plan to be reviewed and approved by the State Historic Preservation Division.

No further historic preservation work is recommended for SIHP # 50-80-09-6959. Sufficient information regarding the location, function, age, and construction methods of SIHP # 50-80-09-6959 have been generated by the current inventory survey investigation to mitigate any adverse effect caused by proposed development activities.

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Appendix A LCA Documentation

Waihona ʻAina
Your ultimate resource for hawaiian history and land use

Review Cart & Checkout

DOCUMENT DELIVERY Change password Log out

Mahele Database Documents

Number: 01021

Claim Number:	**01021**
Claimant:	**Maawe**
Other claimant:	
Other name:	
Island:	**Oahu**
District:	**Ewa**
Ahupuaa:	**Waikele**
Ili:	**Auiole**

Apana:	**2**	Awarded:	**1**
Loi:	**3**	FR:	
Plus:		NR:	**594v2**
Mala Taro:		FT:	**413v2**
Kula:		NT:	**183v3**
House lot:		RP:	**858**
Kihapai/Pakanu:		Number of Royal Patents:	**1**
Salt lands:		Koele/Poalima:	**No**
Wauke:		Loko:	**No**
Olona:		Lokoia:	**No**
Noni:		Fishing Rights:	**No**
Hala:		Sea/Shore/Dunes:	**No**
Sweet Potatoes:		Auwai/Ditch:	**No**
Irish Potatoes:		Other Edifice:	**No**
Bananas:		Spring/Well:	**No**
Breadfruit:		Pigpen:	**No**
Coconut:		Road/Path:	**No**
Coffee:		Burial/Graveyard:	**No**
Oranges:		Wall/Fence:	**No**
Bitter Melon/Gourd:		Stream/Muliwai/River:	**No**
Sugar Cane:		Pali:	**No**
Tobacco:		Disease:	**No**

Koa/Kou Trees:		Claimant Died:	No
Other Plants:		Other Trees:	
Other Mammals:	No	Miscellaneous:	

No. 1021, Maawe
N.R. 594v2

I, Maawe, hereby tell you of my claim for three patches, under a certain man.
MAAWE

F.T. 413v2
Cl. 1021, Maawe, August 4 [1848]

Kalawaia, sworn, Tlhis land is in Waikele, Ewa, Kalo land in 2 pieces.

1. Two patches, bounded:
Mauka by Kukoele & others
Honolulu by Paheau's
Makai by Kuauli's
Waianae by Puupuu's land.

2. Second 1 kalo patch, bounded:
Mauka by Kukueke's
Honolulu by Makue's
Makai also
Waianae by Kakaiili's land.

Claimant had these two lands from Kukueke in 1845, who got them from Makue long ago. They have never been disputed to this time, Kukueke is sick.

Akaakaa, sworn, and confirmed all the particulars above given and knew of no counter claim.

N.T. 183v3
No. 1021, Maawe, August 4

Kalawaia, sworn and stated, "I have seen this land in Waikele. It has patches in two sections.

Kukoeke's land is mauka, also Nameai's land
Paheau's land, Honolulu here
Kuauli's land, makai
Puupuu's land, Waianae.
There are two patches.

Section II:
Kukoeke's land, mauka
Makue's land, Honolulu and makai
Kakaihili's land, Waianae.

These two sections of Maawe are from Rukoeke in the year 1845 and it was given free of cost. Kukoeke's land is from Makue. No one has objected."

Akaakaa, sworn and stated, "I have seen this property exactly as Kalawaia has just related here."

[Award 1021; R.P. 858; Auiole Waikele Ewa; 1 ap.; .54 Ac.]

Number: 01613

Claim Number:	**01613**
Claimant:	**Kaihunana**
Other claimant:	
Other name:	
Island:	**Oahu**
District:	**Ewa**
Ahupuaa:	**Waikele**
Ili:	**Kahakuohia**

Apana:	**1**	Awarded:	**1**
Loi:	**4**	FR:	
Plus:		NR:	**186v3**
Mala Taro:		FT:	**100v9**
Kula:		NT:	**245v9**
House lot:		RP:	**840**
Kihapai/Pakanu:		Number of Royal Patents:	**1**
Salt lands:		Koele/Poalima:	**No**
Wauke:		Loko:	**No**
Olona:		Lokoia:	**No**
Noni:		Fishing Rights:	**No**
Hala:		Sea/Shore/Dunes:	**No**
Sweet Potatoes:		Auwai/Ditch:	**No**
Irish Potatoes:		Other Edifice:	**No**
Bananas:		Spring/Well:	**No**
Breadfruit:		Pigpen:	**No**
Coconut:		Road/Path:	**No**
Coffee:		Burial/Graveyard:	**No**
Oranges:		Wall/Fence:	**No**
Bitter Melon/Gourd:		Stream/Muliwai/River:	**No**
Sugar Cane:		Pali:	**No**
Tobacco:		Disease:	**No**
Koa/Kou Trees:		Claimant Died:	**No**
Other Plants:		Other Trees:	
Other Mammals:	**No**	Miscellaneous:	**claimant has a son who attended hearing in his place**

No. 1613, Kaihunana
N.R. 186v3

I, Kaihunana, hereby tell of my claims: first, a mo`o claim, second, a house lot claim.
KAIHUNANA

F.T. 100v9
No. 1847!, See 1613, Kaihunana, claimant, his claim is found.

[Margin note: No. 1613 in the Index before]

Claimant, being sick, Pakeau & Kikualiilii made oath that the claim of Kaihunana had been duly made out by Kuapanio in their presence, & as they suppose was presented. The claimant's son was therefore admitted to an audience.

Pakeau, sworn, says he knows the land of claimant & it is a mau loi in the ili of Kahakuohia, Waikele, Ewa. It conatins 4 lois and is bounded:

Mauka by the land of Kekualiilii
Honoluu by koele of konohiki
Makai by Painaole
Waianae by land of Kuauli.

Claimant received his land from Mahuna in the time of Kaahumanu & has held quiet possession of it until now.

Kekualiilii, sworn, confirms the above testimony of Pakeau & says it is true.

N.T. 245-246v9
No. 1847!, Kaihunana (court action) Late
[should be 1613]

Pakeau and Kekualiilii, sworn, they had seen Kuaipanio write Kaihunana's claim. It was made delinquent by Kuaipaino perhaps but it has been filed in Honolulu.

No return documents have arrived, approval has been granted.

Pakeau, sworn, he has seen claimant's land of 4 patches in the ili of Kahakuohia in Waikele, Ewa, Oahu, in 1 section.

Mauka, Kekualiilii's land
Honolulu, Konohiki's koele
Makai, Painaole konohiki
Waianae, Kuauli's land.

Land from Mahune in the time of Kaahumanu I. No one objected to him.

Kekualiilii, sworn, he has seen in the same way as Pakeau.

[Award 1613; R.P. 840; Kahakuohia Waikele Ewa; 1 ap.; 1.38 Acs]

Number: 01614B

Claim Number:	**01614B**
Claimant:	**Hookaamomi**
Other claimant:	
Other name:	
Island:	**Oahu**
District:	**Ewa**
Ahupuaa:	**Waikele**
Ili:	**Ahualii, Mikiokai, Keahupuaa°**

Apana:	3	Awarded:	1
Loi:	4	FR:	
Plus:		NR:	
Mala Taro:		FT:	103v9
Kula:		NT:	249,304v9
House lot:	1	RP:	1282
Kihapai/Pakanu:		Number of Royal Patents:	1
Salt lands:		Koele/Poalima:	No
Wauke:		Loko:	No
Olona:		Lokoia:	No
Noni:		Fishing Rights:	No
Hala:		Sea/Shore/Dunes:	No
Sweet Potatoes:		Auwai/Ditch:	No
Irish Potatoes:		Other Edifice:	No
Bananas:		Spring/Well:	No
Breadfruit:		Pigpen:	No
Coconut:		Road/Path:	No
Coffee:		Burial/Graveyard:	No
Oranges:		Wall/Fence:	Yes
Bitter Melon/Gourd:		Stream/Muliwai/River:	No
Sugar Cane:		Pali:	No
Tobacco:		Disease:	No
Koa/Kou Trees:		Claimant Died:	No
Other Plants:		Other Trees:	
Other Mammals:	No	Miscellaneous:	

Cl. 1614B, Hookaamomi, claimant
F.T. 103v9

Claimant appeared & took oath that his claim had been duly made out by Momona & presented, the same was therefore admitted to a hearing.

Mauna, sworn, says the land of claimant is a mooaina called Mikiokai in the ili Keahupuaa, Waikele, Ewa. It contains 4 lois in one piece, and a kahuahale in another.

Apana 1st, 4 lois, is bounded:
Mauka by the loi Kumukukui & Nio
Honolulu by moo Kapakahi
Makai by moo Kapakahi
Waianae by moo Kapakahi.

Apana 2: kahuahale, bounded:
Mauka the kula of Kaholo
Honolulu by kula of Kaholo
Makai by paaina of Keanupoo
Waianae by paaina.

Claimant received the land from Makue in the time of Kaomi & has held quiet possession ever since.

Kalawaia, sworn, confirms the testimony of Hauna as true.

N.T. 249v9
No. 1614B, Hookaamomi (court action) (SEE pg. 304)

Claimant, sworn, says Mamana wrote his claim and probably has it filed in Honolulu, but no receipt has been sent back, approval has been granted.

Hauna, sworn, he has seen his land Mikiokai, a taro moo in the ili of the ahupuaa in Waikele, Ewa, Oahu - 4 patches in 1 section and a house lot is the second section.

Section 1:
Mauka by Kumukukui patch
Honolulu by Kapakahi ili land
Makai by Kapakahi ili land
Waianae by Kapakahi ili land.

Section 2:
Mauka and Honolulu by Kaholo's pastures
Makai by Keanupoo's land fence
Waianae by Government's land fence.

Land from Makue to Hookaamomi at the time of Kaahumanu I. No one objected to him.

Kalawaia, sworn, he has known in the same way as Hauna.

N.T. 304v9
No. 1614B, Hookaamomi Vs. Kaholo, the konohiki (from page 249)

(?)Honua, sworn, he has seen Hookaamomi's house lot in the ili of Ahualii, Waikele, Oahu. It has been enclosed.

House lot received at the time of Poki before 1829, from Kaeleele. Life there since has been pleasant to a very recent objection. It is believed the objection arose at the time the claim was being filed.

It is true Hookaamomi's land was from Kieleele at the time of Poki and he has lived there continuously to the present time. I have not known the house site to be the reason the tenants have left the land.

Kaholo, sworn, it is true he had taxed the farming tenants on that land except for the house site.

Kalanao, sworn, the above statements are true, he has known in the same way. Life has been pleasant up to a very recent time, the konohiki has made an opposition; the reason is not known to Kalanao.

[Award 1614B; R.P. 1282; Aualii Waikele Ewa; 1 ap.; .598 Ac.; Mikiokai Waikele Ewa; 1 ap. 1.405 Acs]

Number: 01712C

Claim Number:	**01712C**
Claimant:	**Nuuanu**
Other claimant:	
Other name:	

Island:	**Oahu**		
District:	**Ewa**		
Ahupuaa:	**Waikele**		
Ili:	**Kapuna, Keahupuaa°**		
Apana:	**2**	Awarded:	**1**
Loi:	**4**	FR:	
Plus:		NR:	
Mala Taro:		FT:	**127v9**
Kula:		NT:	**274v9**
House lot:	**1**	RP:	**853**
Kihapai/Pakanu:		Number of Royal Patents:	**1**
Salt lands:		Koele/Poalima:	**No**
Wauke:		Loko:	**No**
Olona:		Lokoia:	**No**
Noni:		Fishing Rights:	**No**
Hala:		Sea/Shore/Dunes:	**No**
Sweet Potatoes:		Auwai/Ditch:	**No**
Irish Potatoes:		Other Edifice:	**No**
Bananas:		Spring/Well:	**No**
Breadfruit:		Pigpen:	**No**
Coconut:		Road/Path:	**No**
Coffee:		Burial/Graveyard:	**No**
Oranges:		Wall/Fence:	**No**
Bitter Melon/Gourd:		Stream/Muliwai/River:	**No**
Sugar Cane:		Pali:	**No**
Tobacco:		Disease:	**No**
Koa/Kou Trees:		Claimant Died:	**No**
Other Plants:		Other Trees:	
Other Mammals:	**No**	Miscellaneous:	

Cl. 1712C, Nuuanu, claimant
F.T. 127-128v9]

Claimant appeared and made oath that his claim was made out by Kaopanio & as he supposes was duly presented by the same he is therefore admitted to a hearing.

Ohule, sworn says, the land of claimant is a moo aina called Kalai in the ili of Keahupuaa, Waikele, Ewa, Oahu. Apana 1 contains 4 lois & 2d apana contains a pahale in the kula of Auiole.

Apana 1 is bounded:
Mauka by the ili Waikele
Honolulu by Nio
Makai by moo Kauhaikui
Waianae by ili Kahakuohia.

Apana 2 is bounded: on all sides by the kula of Auiole, except Makai is the sea shore.

Claimant received the land from Makue in the time of Kaahumanu & has held it in quiet ever since.

Heulu, sworn, confirms the above testimony as correct & says it is his own.

N.T. 274-275v9
No. 1712C, Nuuanu (court action)

Claimant, sworn, Kuaipanio wrote this claim and has probably sent it to Honolulu.

Ohule, sworn, he has seen his land Kalai, a moo land in the ili of the ahupuaa of Waikele, Ewa, Oahu - 4 patches in 1 section. Section 2 is a garden in the pasture, of Aniole on the Makai by side of Kapuna.

Section 1:
Mauka by Waikele, a "ku" ili
Honolulu by Nio a "ku" ili
Makai by Kauhaikui moo land
Waianae by Kahakuohia ili.

Section 2 - A garden.
Makai by of Kapuna in the pasture of Aniole, this pasture is surrounded by a fence except for the Makai by side.

Nuuanu's land from Makue at the time of Kaahumanu I. No one objected to him.

Heulu, sworn, he has known in the same way as Ohule.

[Award 1712C; R.P. 853; Kapuna Waikele Ewa;; 1 ap.; .518 Ac.]

Number: 10512*O

Claim Number:	**10512*O**
Claimant:	**Nahuina**
Other claimant:	
Other name:	
Island:	**Oahu**
District:	**Ewa**
Ahupuaa:	**Waipio**
Ili:	**Kauaka**

Apana:	**1**	Awarded:	**1**
Loi:	**3**	FR:	
Plus:		NR:	**561v4**
Mala Taro:		FT:	**121v9**
Kula:		NT:	**289v9, 193v10**
House lot:		RP:	**7528**
Kihapai/Pakanu:		Number of Royal Patents:	**1**
Salt lands:		Koele/Poalima:	**No**
Wauke:		Loko:	**No**
Olona:		Lokoia:	**No**
Noni:		Fishing Rights:	**No**
Hala:		Sea/Shore/Dunes:	**No**

Sweet Potatoes:		Auwai/Ditch:	No
Irish Potatoes:		Other Edifice:	No
Bananas:		Spring/Well:	No
Breadfruit:		Pigpen:	No
Coconut:		Road/Path:	No
Coffee:		Burial/Graveyard:	No
Oranges:		Wall/Fence:	No
Bitter Melon/Gourd:		Stream/Muliwai/River:	No
Sugar Cane:		Pali:	No
Tobacco:		Disease:	No
Koa/Kou Trees:		Claimant Died:	No
Other Plants:	1	Other Trees:	
Other Mammals:	**No**	Miscellaneous:	**bounded by Akaakai (bulrushes)**

No. 10512*O, Nahuina
N.R. 561v4

Kauaka `ili, Waipio, Ewa, Oahu. Kindly award the claim.
NAHUINA

F.T. 121v9
No. 10512, Nahuina, claimant (7262 Index)

Naone, sworn, says the land of claimant is a moo aina called Kauaka in the ili Kauaka, Waipio, Ewa, Oahu. Contains 3 lois in one piece,

And is bounded:
Mauka by the koele Keoki
Honolulu by ili of Ulu
Mauka by Waikele
Waianae by Akaakai.

Claimed his land from the King in 1847, when his people's land was apportioned out to them by His Majesty.

Ehu, sworn, says his testimony corresponds with that of Naone.

N.T. 268v9
No. 10512, Nahuina (court action)

Naone, sworn, he has seen his land Kanaka, a moo land in the ili of Kanaka in Waipio, Ewa, Oahu - 3 patches in 1 section.

Mauka by Keoki, big koele
Honolulu by Ulu, an ili
Makai by Waikele
Waianae by Sea onions.

Land from King Kamehameah III, in 1847. No one objected to Nahuina.

Ehu, sworn, he has known in the same way as Naone.

N.T. 193v10
No. 10512, Nahuina, 4 February 1843

COPY
Nahuina's land in the Mahele Book.
Kanaka ili of Waipio, Ewa, Oahu.
1 Keaa 2 ahupuaa, Koolau, Maui.
TRUE COPY
A.G. Thruston, Secretary K.K.
Department of Interior, 4 February 1853

[Award 10512; (Oahu) R.P. 7528; Kauaka Waipio Ewa; 1 ap.; 3.64 Acs; See also 7262; (Maui) R.P. 2356 & 4488; Keaa Koolau; 1 ap.; 140 Acs]

Number: 05531

Claim Number:	**05531**
Claimant:	**Keawe**
Other claimant:	
Other name:	
Island:	**Oahu**
District:	**Ewa**
Ahupuaa:	**Waikele**
Ili:	**Kapakahi**

Apana:	**2**	Awarded:	**1**
Loi:	**4**	FR:	
Plus:		NR:	**66v5**
Mala Taro:		FT:	**110v9**
Kula:	1	NT:	**256v9**
House lot:	**1**	RP:	**859**
Kihapai/Pakanu:		Number of Royal Patents:	**1**
Salt lands:		Koele/Poalima:	**No**
Wauke:		Loko:	**No**
Olona:		Lokoia:	**No**
Noni:		Fishing Rights:	**No**
Hala:		Sea/Shore/Dunes:	**No**
Sweet Potatoes:		Auwai/Ditch:	**No**
Irish Potatoes:		Other Edifice:	**No**
Bananas:		Spring/Well:	**No**
Breadfruit:		Pigpen:	**No**
Coconut:		Road/Path:	**No**
Coffee:		Burial/Graveyard:	**No**
Oranges:		Wall/Fence:	**No**
Bitter Melon/Gourd:		Stream/Muliwai/River:	**Yes**
Sugar Cane:		Pali:	**No**

Tobacco:		Disease:	No
Koa/Kou Trees:		Claimant Died:	No
Other Plants:		Other Trees:	
Other Mammals:	No	Miscellaneous:	also a kula moku

No. 5531, Keawe, Waikele, December 4, 1847
N.R. 66-67v5

To the Honorable Land Commissioners of the Hawaiian Islands, Greetings: I hereby state my claim for land at Kapakahi in Waikele, Ewa, Island of Oahu. It is bounded on the north by the mo'o of Kamakalolohe, on the east by the mo'o of Ai, on the south by the mo'o of Puhi, on the west by the lo'i of Kaele. The house claim is at Kopuna in Waikele. It is bounded on the north, east, south and west by kula.
KEAWE

F.T. 110v9
No. 5531, Keawe, claimant

Puhi, sworn says, the land of Keawe is a moo aina in the ili of Kapakahi, Waikele, Ewa. It contains 4 lois & a kula moku in one piece & a kahuahale in another.

Bounded:
Mauka by Holomanu of Waipio
Honolulu by a loi Ananakini of Puhi
Makai by river
Waianae by moo aina of Kua, son of Makalolohi.

Claimant received the land from Kauliokamoa in the time of Kinau & has had quiet possession until now.

Kuapuu, sworn says, the testimony of Puhi is as his own & is true.

N.T. 256v9
No. 5531, Keawe (court action)

Puhi, sworn, he has seen Keawe's land a taro moo in Kapakahi ili, Waikele, Ewa, Oahu - 4 patches and a dividing pasture in 1 section.

[It is bounded]:
Mauka by Holoamauu ili
Honolulu by Ananakini patch
Makai by River
Waianae by Kua's land.

Land from Kauliokamoa, during Kinau's time, title good.

Kaupuaa, sworn, testimony same as Puhi.

[Award 5531; R.P. 859; Kapakahi Waikele Ewa; 2 ap.; 1.07 Acs]

Number: 05989

Claim Number: **05989**

Claimant:	**Makole**		
Other claimant:	Paulua, brother-in-law; heir		
Other name:			
Island:	**Oahu**		
District:	**Ewa**		
Ahupuaa:	**Waikele**		
Ili:	**Kapakahi**		
Apana:	**2**	Awarded:	**1**
Loi:	**3**	FR:	
Plus:		NR:	**201v5**
Mala Taro:		FT:	**114v9**
Kula:	**1**	NT:	**261v9**
House lot:	**1**	RP:	**855**
Kihapai/Pakanu:		Number of Royal Patents:	**1**
Salt lands:		Koele/Poalima:	**Yes**
Wauke:		Loko:	**Yes**
Olona:		Lokoia:	**No**
Noni:		Fishing Rights:	**No**
Hala:		Sea/Shore/Dunes:	**No**
Sweet Potatoes:		Auwai/Ditch:	**Yes**
Irish Potatoes:		Other Edifice:	**No**
Bananas:		Spring/Well:	**No**
Breadfruit:		Pigpen:	**No**
Coconut:		Road/Path:	**No**
Coffee:		Burial/Graveyard:	**No**
Oranges:		Wall/Fence:	**Yes**
Bitter Melon/Gourd:		Stream/Muliwai/River:	**Yes**
Sugar Cane:		Pali:	**No**
Tobacco:		Disease:	**No**
Koa/Kou Trees:		Claimant Died:	**Yes**
Other Plants:		Other Trees:	
Other Mammals:	**No**	Miscellaneous:	

No. 5989, Makole, Waikele, December 3, 1847
N.R. 201v5

To the Honorable Land Commissioners of the Hawaiian Islands, Greetings: I hereby state my claim for land at Kapakahi, Ewa, Island of Oahu. It is bounded on the north by the lo`i of Uuku, on the east by the lo`i of Kualu, on the south by a lo`i ko`ele, on the west by the lo`i of Lono. My second claim is bounded on the north by the lo`i of Maio, on the east by the mo`o of Keawa, on the south by the lo`i of Kamakalolohe, on the west by the lo`i of Maio. My house claim is at Kaohai in Waikele and is bounded on the north by the pond of Kahalehili, on the east by a watercourse, on the south by a Muliwai, on the west by a Muliwai.
MAKOLE X

F.T. 114-115v9
No. 5989, Makole, claimant, died in 1844

Claim presented by his heir, Paulua.

Ohule, sworn says, the land of claimant is a moo kalo called Kooka in the ili Kapakahi, Waikele, Ewa, Oahu, [It] contains 3 lois & a kula moku in one piece & a kahuahale in another.

Apana 1 is bounded:
Mauka by the moo aina Mikiokai
Honolulu by the moo aina Kaalaau
Makai by the koele Kumukukui
Waianae by lois Kamooiki.

Apana 2, Kahuahale is situated in a part of Kapakahi near Kaohai, bounded:
Mauka by a loko called Kaikai
Honolulu by a kahuahale of Kaliola
Makai by Paaina & the river
Waianae by Kahuahale of Keawe.

Claimant received the land from Kauliokamoa in the time of Kinau & has held &c.

Koliola, sworn says the testimony of Ohule is true & is also his own.

N.T. 261v9
No. 5989, Makole (court action)

This interest has been bequested to Paulua, Makole's brother-in-law and heir.

Ohule, sworn, he has seen his land Kookama, a moo land in the ili of Kapakahi in Waikele, Oahu - 3 patches, a dividing pasture in 1 section. A house site is the second section.

[Section 1]:
Mauka by Mikiokai moo land
Honolulu by Kualaau moo land
Makai by Kumukukui koele
Waianae by Kamooiki moo land.

Section 2:
Mauka by Kaohai
Honolulu by Kaliola's house site
Makai by Land enclosure
Waianae by Keawe's house site.

Land from Kauliokamoa to Makole, from Makole upon death to Paulua at the time of Kinau, no disputes.

Koliola, sworn, testimony similar to Ohule.

[Award 5989; R.P. 855; Kapakahi Waikele Ewa; 2 ap.; .66 Ac.; Makaole for Paulua]

Number: 07260*O

Claim Number:	**07260*O**
Claimant:	**Namakeha, B**
Other claimant:	

Other name:
Island: **Oahu**
District: **Kona, Ewa**
Ahupuaa: **Honolulu, Waikele**
Ili: **Kaalaaluna, Kaolipea**

Apana:	**6**	Awarded:	**1**
Loi:		FR:	
Plus:		NR:	**311v5**
Mala Taro:		FT:	**88v16**
Kula:		NT:	**169v10**
House lot:		RP:	**4370, 4371, 4372, 4398**
Kihapai/Pakanu:		Number of Royal Patents:	**4**
Salt lands:		Koele/Poalima:	**No**
Wauke:		Loko:	**No**
Olona:		Lokoia:	**No**
Noni:		Fishing Rights:	**No**
Hala:		Sea/Shore/Dunes:	**No**
Sweet Potatoes:		Auwai/Ditch:	**No**
Irish Potatoes:		Other Edifice:	**No**
Bananas:		Spring/Well:	**No**
Breadfruit:		Pigpen:	**No**
Coconut:		Road/Path:	**No**
Coffee:		Burial/Graveyard:	**No**
Oranges:		Wall/Fence:	**No**
Bitter Melon/Gourd:		Stream/Muliwai/River:	**No**
Sugar Cane:		Pali:	**No**
Tobacco:		Disease:	**No**
Koa/Kou Trees:		Claimant Died:	**No**
Other Plants:		Other Trees:	
Other Mammals:	**No**	Miscellaneous:	

No. 7260*O, B. Namakeha
N.R. 311/v5

Greetings to the Land Commissioners: I hereby state my claims for land at Waikele, Ewa, and at Kaalaa luna in Honolulu. Those are my claims for my two lands from the Mo`i. I have a little claim at Lahaina, on Maui, one small lo`i at Waianae.
NAMAKAEHA
February 11, 1848

F.T. 86v16
No. 7260, B. Namakeha, 23 June 1854

P. Nahaolelua, sworn, says he knows the kalo patch of claimant in Waianae, Lahaina.

It is bounded as follows:
Mauka by Kahikona's lot

Olowalu by Haalelea's land
Makai by King's land
Kaanapali by Foot path.

Claimant has held this patch since the year 1845, without dispute (Namakeha says he received this patch from Asa Kaeo.)

N.T. 169v10
No. 7260, Namakeha, B.

Copy, B. Namakeha's land in the Mahele Book.
Kaalaa, ili of Honolulu, Kona, Oahu.
Waikele, ili of Waikele, Ewa, Oahu.
Department of Interior
29 October 1852
True Copy, A.G. Thruston, Secretary K.K.

[Award 7260; R.P. 4371; Kaalaaluna Honolulu Kona; 1 ap.; 17.28 Acs; R.P. 4372; Kaolipea Waikele Ewa; 1 ap.; 252.18 Acs; R.P. 4370; Waikele Ewa; 4 ap.; 39.13 Acs; R.P. 4398; Waianae-uka; 1 ap.; 1 rood 4 rods; R.P. 4373; Waianae Lahaina(cancelled)]

Appendix B UTM Information for Historic Property

SIHP 50-80-09-6959, UTM NAD 83, Zone 4 North (m)

NORTHING	EASTING
2369269.89	602809.37

LINDA LINGLE
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES

STATE HISTORIC PRESERVATION DIVISION
601 KAMOKILA BOULEVARD, ROOM 555
KAPOLEI, HAWAII 96707

LAURA H. THIELEN
CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES
COMMISSION ON WATER RESOURCE MANAGEMENT

RUSSELL Y. TSUJI
FIRST DEPUTY

KEN C. KAWAHARA
DEPUTY DIRECTOR - WATER

AQUATIC RESOURCES
BOATING AND OCEAN RECREATION
BUREAU OF CONVEYANCES
COMMISSION ON WATER RESOURCE MANAGEMENT
CONSERVATION AND COASTAL LANDS
CONSERVATION AND RESOURCES ENFORCEMENT
ENGINEERING
FORESTRY AND WILDLIFE
HISTORIC PRESERVATION
KAHOOLAWE ISLAND RESERVE COMMISSION
LAND
STATE PARKS

December 2, 2008

Mr. David Shideler
Cultural Surveys Hawai'i.
P. O. Box 1114
Kailua, Hawai'i 96734

LOG NO: 2008. 5359
DOC NO: 0812WT01
Archaeology

Dear Mr. Shideler:

SUBJECT: Chapter 6E-42 Historic Preservation Review--
An Archaeological Field Inspection and Literature Review for Proposed Improvements to the Waipi'o Interchange, Waipi'o Ahupua'a, 'Ewa District, O'ahu, Hawai'i
TMK: (1) 9-4-006: 11, 27, 28, 29, and 31

Thank you for the opportunity to review the aforementioned project, which we received on November 24, 2008. This project was carried out prior to proposed highway improvements including the construction of a northbound loop off-ramp to westbound Ka Uka Boulevard in the northeast quadrant of the Waipi'o Interchange. The proposed project lies primarily within existing roadways maintained by the City and County of Honolulu and the Hawai'i State Department of Transportation.

We determine that **no historic properties will be affected** by this project because:

- ☐ Intensive cultivation has altered the land
- ☒ Residential development/urbanization has altered the land
- ☐ Previous grubbing/grading has altered the land
- ☐ An accepted archaeological inventory survey (AIS) found no historic properties
- ☐ SHPD previously reviewed this project and mitigation has been completed
- ☐ Other:

We accept this report as meeting the minimum qualifications for HAR Chapter §13-13-284: *Rules Governing Procedures for Historic Preservation Review to Comment on Section 6E-42, HRS Projects.*

In the event that historic resources, including human skeletal remains, are identified during the construction activities, all work needs to cease in the immediate vicinity of the find, the find needs to be protected from additional disturbance and please contact the State Historic Preservation Division at (808) 692-8015.

Aloha,

Nancy A. McMahon

Nancy McMahon, Deputy SHPO/State Archaeologist
and Historic Preservation Manager

An Archaeological Field Inspection and Literature Review for Proposed Improvements to the Waipio Interchange, Waipio Ahupuaʻa, ʻEwa District, Oʻahu TMK: [1] 9-4-006:11, 27, 28, 29, 31

Prepared for

Wilson Okamoto Corporation

Prepared by

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and

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Cultural Surveys Hawaiʻi, Inc.

Kailua, Hawaiʻi

(Job Code: WAIPIO 3)

March 2008

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Management Summary

Reference	An Archaeological Field Inspection and Literature Review for Proposed Improvements to the Waipio Interchange, Waipio Ahupuaʻa, ʻEwa District, Oʻahu TMK: [1] 9-4-006:11, 27, 28, 29, 31 (Yucha and Hammatt 2008)
Date	March 2008
Project Number	Cultural Surveys Hawaiʻi Inc. (CSH) Job Code: WAIPIO 3
Investigation Permit Number	The fieldwork component of the archaeological literature review and field inspection study was carried out under CSH's annual archaeological permit # 08-14 issued by the Hawaiʻi State Historic Preservation Division/Department of Land and Natural Resources (SHPD/DLNR), per Hawaiʻi Administrative Rules (HAR) Chapter 13-282.
Project Location	The project area is located in Waipio at the intersection of Interstate Highway 2 (I-H2), Ka Uka Boulevard, and Mililani Cemetery Road. The proposed road improvements project extends east to near the bottom of Pānakauahi Gulch, north along I-H2, west along the I-H2 south-bound Ka Uka Boulevard exit ramp and portions of Ka Uka Boulevard, and south along portions of Ka Uka Boulevard, Moaniani Street, and Mililani Cemetery Road. This area is depicted on the 1998 USGS 7.5-Minute Series Topographic Map, Waipahu Quadrangle.
Land Jurisdiction	The proposed highway improvements project is primarily located within existing road rights-of-way maintained by the City and County of Honolulu (C&C) and the Hawaii State Department of Transportation (DOT). The eastern portion of the project area is located within TMK [1] 9-4-006:011 and 031 owned by the Waiawa Ridge Development LLC. The western and central portions of the project area are located within TMK [1] 9-4-006:027 and 028 owned by the Thomas H. Gentry Trust.
Project Description	The proposed highway improvements include the construction of a northbound loop off-ramp to westbound Ka Uka Boulevard in the northeast quadrant of the Waipio Interchange.
Historic Preservation Regulatory Context	The project is subject to Hawai'i State environmental and historic preservation review legislation [Hawai'i Revised Statutes (HRS) Chapter 343 and HRS Chapter 6E-42 and HAR Chapter 13-284]. This investigation does not fulfill the requirements of an archaeological inventory survey investigation (per HAR Chapter 13-276); however, through detailed historical, cultural, and archaeological background research, and a field inspection of the area, this investigation identifies the likelihood that historic properties may be affected by the project.

Document Purpose	This archaeological literature review and field inspection study was to assess if there are any major archaeological concerns within the study area and to develop data on the general nature, density, and distribution of the archaeological resources. This document was prepared in response to the Department of Transportation’s (DOT) comments for the draft environmental impact statement, which called for an assessment of the environment where improvements to the freeway interchange are made to mitigate traffic concerns created by the proposed Castle and Cooke Waiawa project.
Fieldwork Effort	The fieldwork component of the archaeological literature review and field inspection study was accomplished February 15, 2007, by two CSH archaeologists, Jon Tulchin, B.A., and Trevor Yucha, B.S., under the general supervision of Hallett H. Hammatt, Ph.D (principal investigator). The fieldwork required approximately 2 person-days to complete.
Results Summary	No historic properties were observed within the project area. Based on observations during the field inspection and from background research, it seems likely that past land use and modern development has significantly disturbed or destroyed any historic properties that were present in the project area.
Recommendations	Within the project area itself, no historic properties were observed during the field inspection. The combination of previous pineapple or cane cultivation and modern highway development has likely significantly disturbed or destroyed any surface or subsurface historic properties that may have existed within the project area. Based on the results of this study, it appears unlikely that significant historic properties will be affected by the proposed interchange improvements. No further cultural resource management work is recommended for the project. It is recommended that this investigation be used to support consultation with SHPD to obtain SHPD’s concurrence with this recommendation for no further project-related cultural resource management work.

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Section 1 Introduction

1.1 Project Background

At the request of the Wilson Okamoto Corporation, Cultural Surveys Hawai‘i, Inc. (CSH) completed this archaeological literature review and field inspection study for the proposed improvements to the Waipio Interchange, Waipio Ahupua‘a, ‘Ewa District, O‘ahu TMK: [1] 9-4-006:11, 27, 28, 29, 31. The project area (Figure 1-3) is located in Waipio Ahupua‘a at the intersection of Interstate Highway 2 (I-H2), Ka Uka Boulevard, and Mililani Cemetery Road. The eastern portion of the project area includes a portion of Pānakauahi Gulch and Mililani Cemetary Road, while the western portion consists of a section of Ka Uka Boulevard and a Hawaii Department of Transportation (DOT) infrastructure staging area.

The proposed highway improvements project is primarily located within existing road rights-of-way maintained by the City and County of Honolulu (C&C) and DOT. The eastern portion of the project area is located within TMK [1] 9-4-006:011 and 031 owned by the Waiawa Ridge Development LLC. The western and central portions of the project area are located within TMK [1] 9-4-006:027 and 028 owned by the Thomas H. Gentry Trust. The proposed project consists of the construction of a northbound loop off-ramp to westbound Ka Uka Boulevard in the northeast quadrant of the Waipio Interchange.

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1.2 Scope of Work

The agreed upon scope of work for the archaeological literature review and field inspection was as follows:

1. Historical research including study of archival sources, historic maps, Land Commission Awards and previous archaeological reports to construct a history of land use and to determine if archaeological sites have been recorded on or near the project area.

2. Field inspection of the project area to identify any surface archaeological features and to investigate and assess the potential for impact to such sites. This assessment identifies

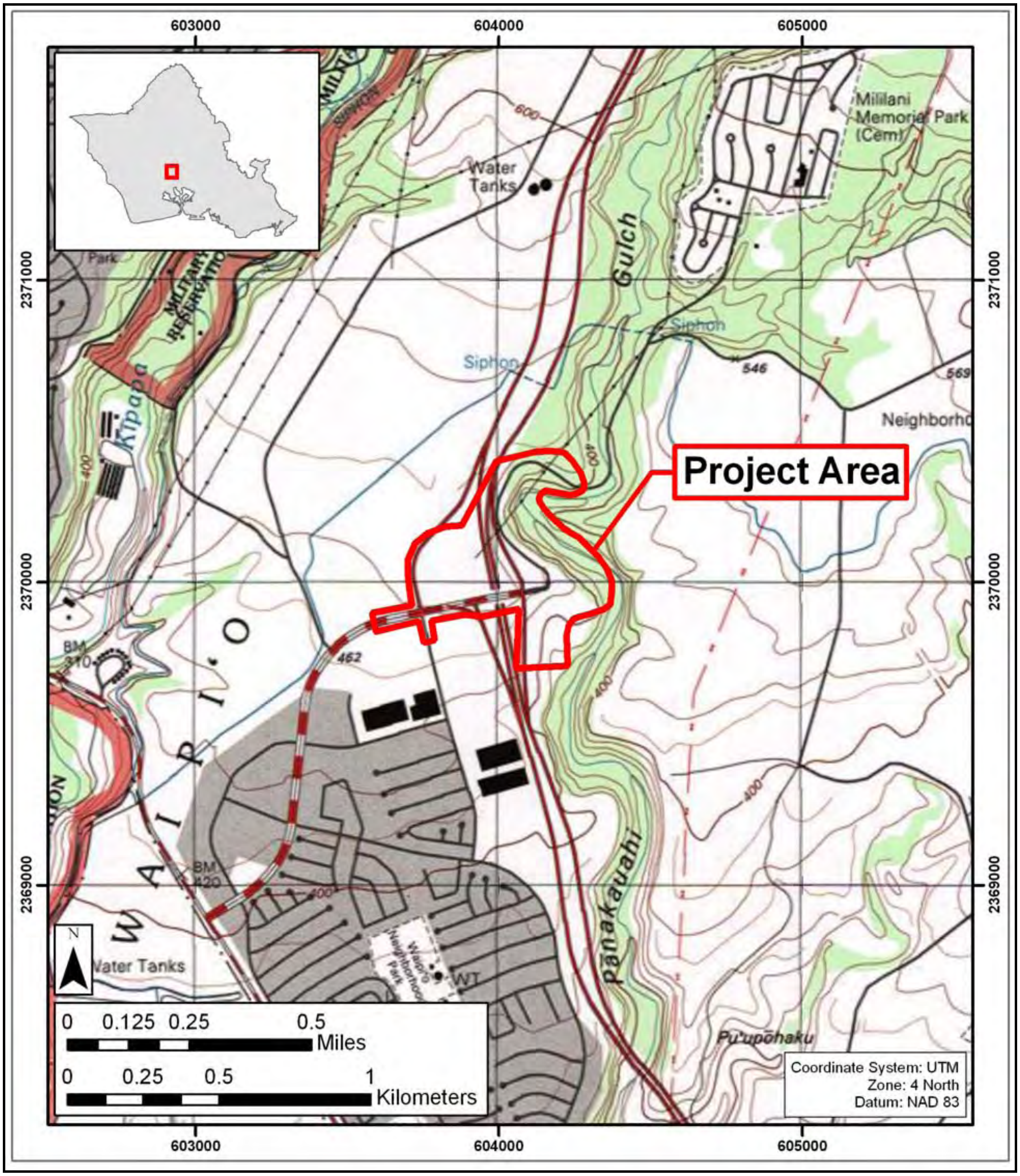

Figure 1. Portion of U.S. Geological Survey 7.5-Minute Series Topographic Map, Waipahu Quadrangle (1998), showing the location of the project area

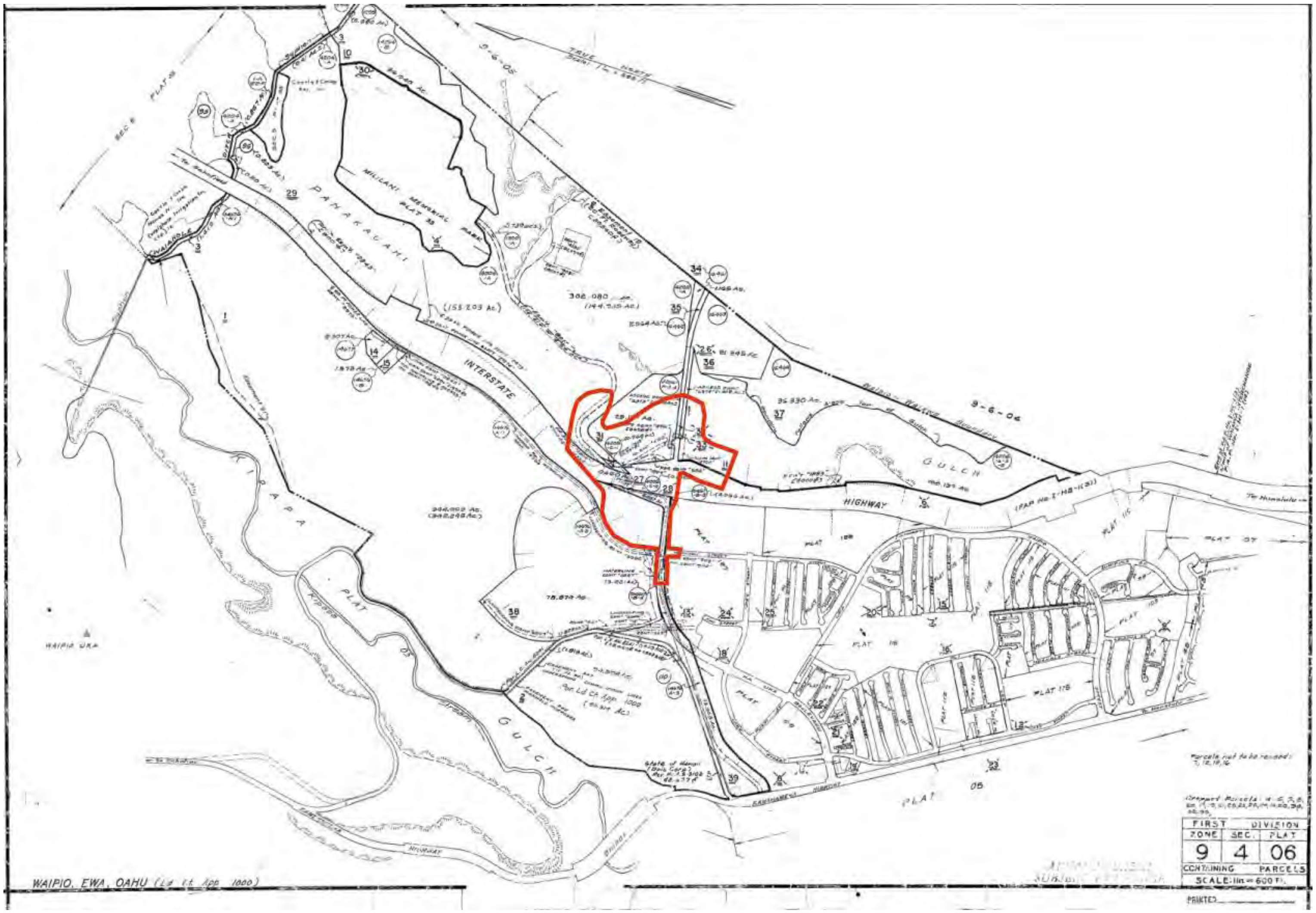

Figure 2. Portion of Tax Map Key 9-4-06, showing the location of the project area

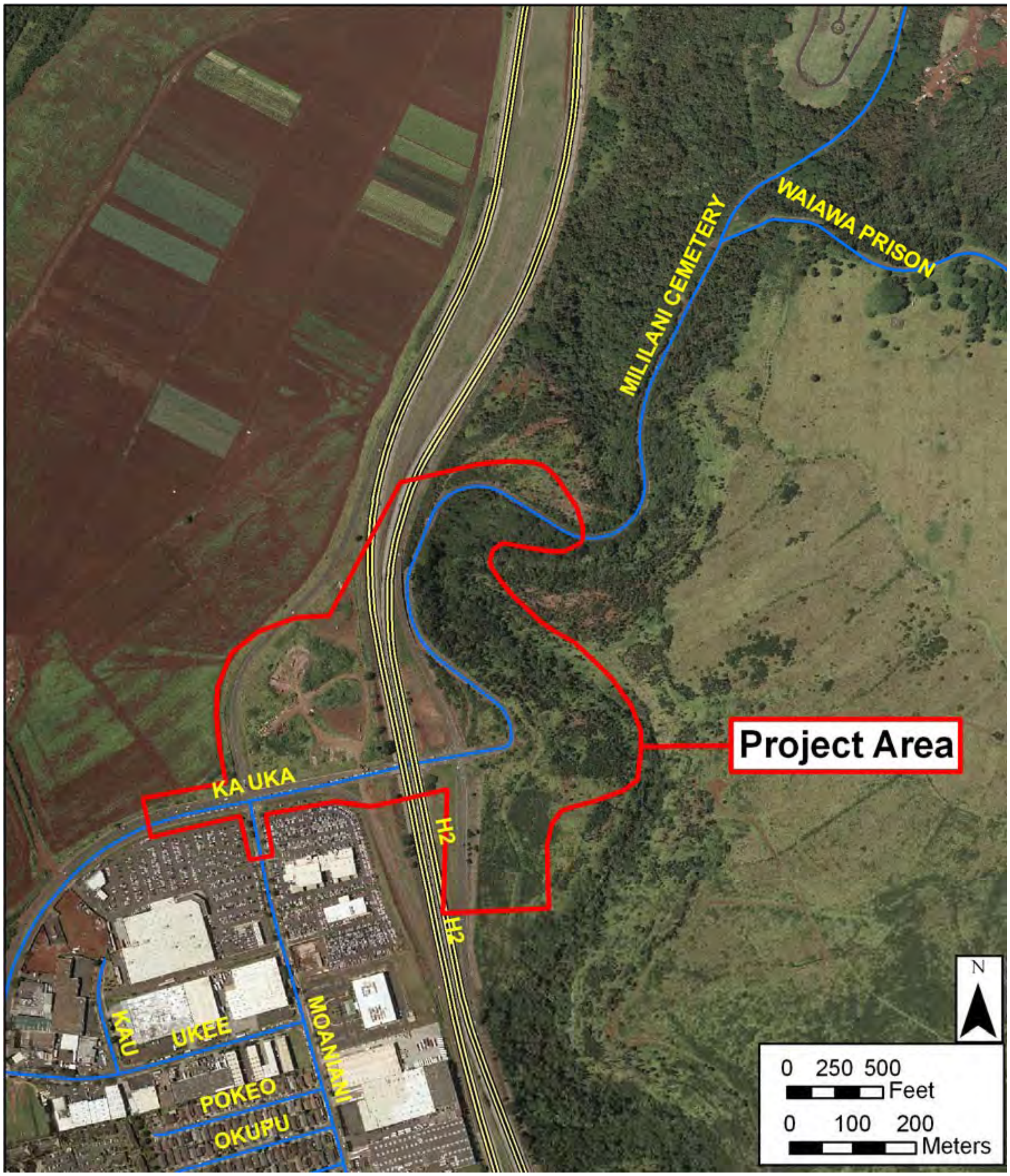

Figure 3. Aerial photograph showing the location of the project area (source: U.S.G.S Orthoimagery 2005)

sensitive areas that may require further investigation or mitigation before the project proceeds.

3. Preparation of this report, including the results of the historical research and the field inspection, with an assessment of archaeological potential based on that research and recommendations for future archaeological work. The report also provides mitigation recommendations for archaeologically sensitive areas that need to be taken into consideration.

1.3 Environmental Setting

1.3.1 Natural Environment

The project area extends from the base of Pānakauahi Gulch at the east to the Schofield Plateau to the west. The topography within the project area is level to steeply sloping, with elevations ranging from approximately 90-150 m (300-500 ft.) above mean sea level. The average annual rainfall in the vicinity of the project area is approximately 1000 mm (39.4 in.) (Giambelluca et al. 1986). The perennial flow of Waiawa Stream within Pānakauahi Gulch has continually modified and transformed the low-lying areas of the gulch during heavy rains. During field inspection, the Waiawa streambed was dry with signs of recent over-bank flooding.

Soils within the project corridor primarily consist of Wahiawa Silty Clay (WaA), Helemano Silty Clay (HLMG), and Manana Silty Clay (MpD2) (Figure 4). Soils of the Wahiawa Series consist of “well-drained soils on uplands…developed in residuum and old alluvium derived from basic igneous rock” (Foote et al. 1972). Soils of the Helemano Series consist of “well-drained soils on alluvial fans and colluvial slopes on the sides of gulches…developed in alluvium and colluvium derived from basic igneous rock” (Foote et al. 1972). Soils of the Manana Series consist of “well-drained soils on uplands…developed in material weathered from basic igneous rock” (Foote et al. 1972). Vegetation in the project area predominantly consists of exotic grasses with areas of *koa haole* (*Leucaena leucocephala*) and ironwood (*Casuarina equisetifolia*).

1.3.2 Built Environment

The proposed improvement to the Waipio Interchange is primarily located within asphalt-paved highway rights-of-way. The majority of the project area consists of disturbed and modified developments associated with the construction of Ka Uka Boulevard, I-H2, and Mililani Cemetery Road. Additionally, a large Department of Transportation staging area occupies most of the undeveloped land west of I-H2. The area located east of Mililani Cemetery Road is largely undeveloped with the exception of an asphalt road surface that runs parallel to I-H2.

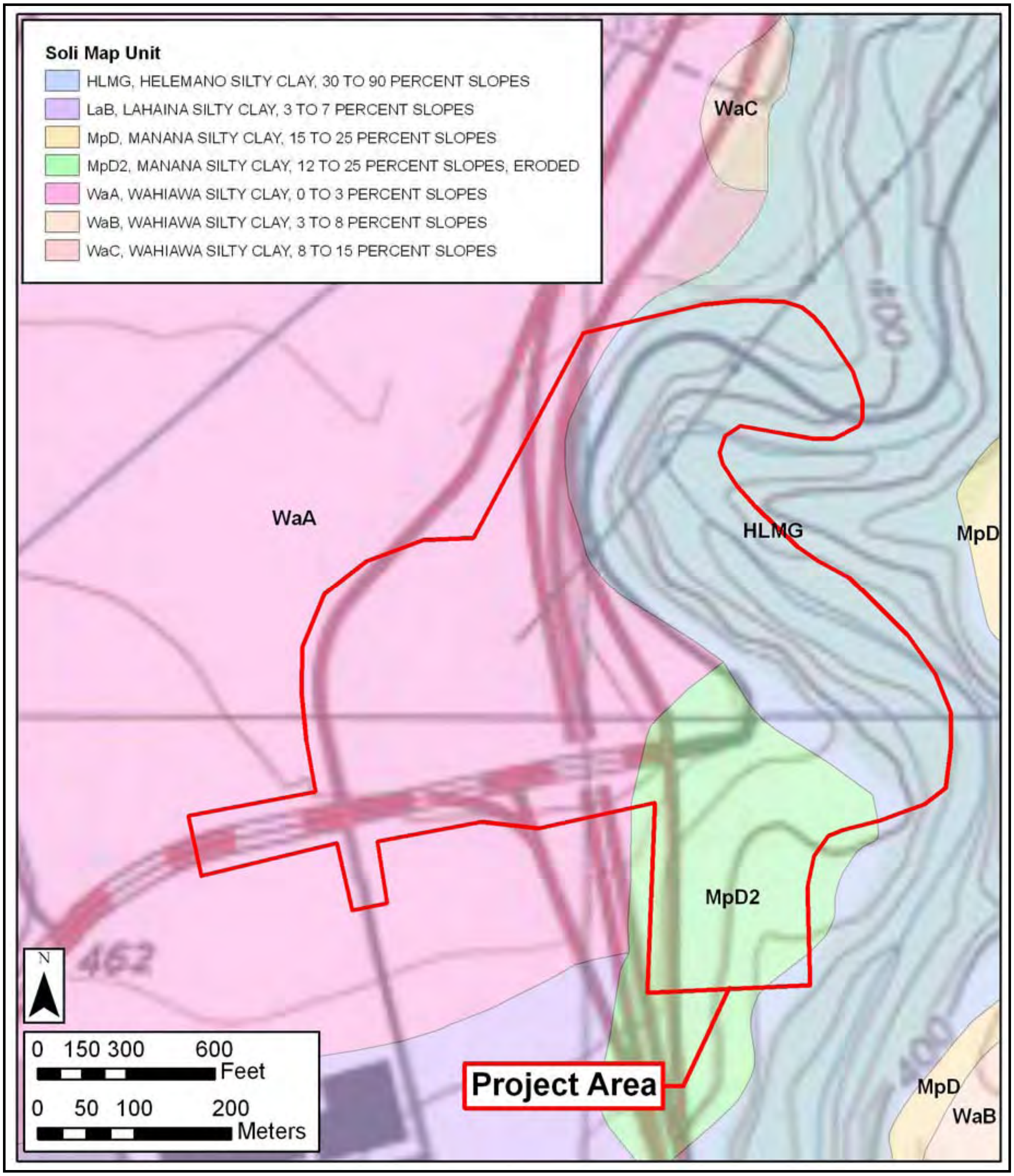

Figure 4. Overlay of Soil Survey of the State of Hawai'i (Foote et al. 1972), indicating sediment types within the project area

Section 2 Methods

2.1 Document Review

Historic and archival research included information obtained from the UH Hamilton Library, the State Historic Preservation Division Library, the Hawaiʻi State Archives, the State Land Survey Division, and the Archives of the Bishop Museum. Previous archaeological reports for the area were reviewed, as were historic maps and primary and secondary historical sources. Information on Land Commission Awards was accessed through Waihona Aina Corporation's Mahele Data Base (<www.waihona.com>).

2.2 Field Methods

The fieldwork component of the archaeological literature review and field inspection study was accomplished February 15, 2008, by two CSH archaeologists, Jon Tulchin, B.A., and Trevor Yucha, B.S., under the general supervision of Hallett H. Hammatt, Ph.D (principal investigator). The fieldwork required approximately 2 person days to complete. The fieldwork component of the archaeological literature review and field inspection study was carried out under CSH's annual archaeological permit # 08-14 issued by the State Historic Preservation Division (SHPD), per (HAR) Chapter 13-282.

In general, the purpose of the field inspection was to develop data on the nature, density, and distribution of archaeological sites within the study area, and also to develop information on the degree of difficulty that vegetation and terrain create for future archaeological studies. As the majority of the project area appeared to be disturbed, with little potential for surface archaeological deposits, the field inspection focused on areas that were less disturbed. Although this field inspection was not 100% coverage of the project area, representative portions of the entire project area were covered. The spacing between the archaeologists was generally 10-20 m. Potential archaeological sites or site areas were documented with brief written descriptions, and photographs, and were located with Garmin GPS survey technology (accuracy 3-5 m). A track log of the area covered was also implemented (see section 4).

Section 3 Background Research

3.1 Traditional and Historical Background

3.1.1 Waipi‘o Uka and Kūkaniloko

It is difficult to write of the traditions of ‘Ewa or Waialua, O‘ahu without mentioning Kūkaniloko (the location of the royal birthing stones). Located in the uplands of Kamananui, Waialua, Kūkaniloko was thought to have been established in the twelfth century “by Nanakaoko and his wife, Kahihiokalani, whose son Kapawa, heads the list of important *ali‘i* born there” (McAllister 1933:135). A child born to a *kapu* chiefess at Kūkaniloko was considered to be a “child with the highest *mana* (spiritual or divine power) and revered as a god that could not be touched” (Alameida 1993:19). Part of Kūkaniloko’s significance lay in its location at the crossroads of the Wai‘anae, Waialua and ‘Ewa Districts. One of the major traditional trails receiving traffic from Kona and portions of ‘Ewa leading to Kūkaniloko passed through Waipi‘o Uka.

Even long after Kūkaniloko had been abandoned and the seat of Hawaiian political power had moved from ‘Ewa to Kona, the memory of Kūkaniloko is still revered. The oral tradition of Kūkaniloko lives on today as one of our informants relayed to us. Kalama Makaneole’s mother, who grew up in Waikele, kept the tradition alive when she shared the history of Kūkaniloko with her son, Kalama.

3.1.2 Kīpapa and Mā‘ilikūkahi

Born *ali‘i kapu* at Kūkaniloko, Mā‘ilikūkahi became *mō‘ī* of O‘ahu in the late fourteenth century (Kamakau 1991: 54). Mā‘ilikūkahi was popular during his reign and was remembered for initiating land reforms, which brought about peace, and for encouraging agricultural production, which brought about prosperity. He also prohibited the chiefs from plundering the *maka‘āinana* with punishment of death (Kamakau 1991: 55).

Mā‘ilikūkahi’s peaceful reign was interrupted by an invasion which would change Waipi‘o ‘Uka forever. The following is a description of the Battle of Kīpapa by Fornander:

> I have before referred to the expedition by some Hawaii chiefs, Hilo-a-Lakapu, Hilo-a-Hilo-Kapuhi, and Punaluu, joined by Luakoa of Maui, which invaded Oahu during the reign of Mailikukahi. It cannot be considered as a war between the two islands, but rather as a raid by some restless and turbulent Hawaii chiefs... The invading force landed at first at Waikiki, but for reasons not stated in the legend, altered their mind, and proceeded up the Ewa lagoon and marched inland. At Waikakalaua they met Mailikukahi with his forces, and a sanguinary battle ensued. The fight continued from there to the Kipapa gulch. The invaders were thoroughly defeated, and the gulch is said to have been literally paved with the corpses of the slain, and received its name “Kipapa”, from this circumstance. Punaluu was slain on the plain which bears his name, the fugitives were pursued

> as far as Waimano, and the head of Hilo was cut off and carried in triumph to Honouliuli, and stuck up at a place still called Poo-Hilo (Fornander Vol.II:89).

Apparently, Kīpapa Gulch located approximately 950 m west of the project area, was named after this particular battle, or more likely renamed. In old Hawaiʻi, places were often given names based on historic events. In this case, Kīpapa Gulch was the location of an historic battle in which a very popular *mōʻī*, Māʻilikūkahi, was victorious in battle.

3.1.3 Waipiʻo Uka and the Legend of Kalelealuaka

In the *mauka* regions of Waipiʻo, legend speaks of Kalelealuaka, who lived during the reign of the Oʻahu chief, Kākuhihewa (Thrum 1998). Blessed with supernatural powers, Kalelealuaka travels to Oʻahu from his home on Kauaʻi and settles in the *mauka* regions of Waipiʻo with his two companions Kaluhe and Keinohoomanawanui. This place is called Keahumoe and here they build their mountain house Lelepua, named after Kalelealuaka's magic arrows. One night, Kalelealuaka makes known his wish:

> The beautiful daughters of Kakuhihewa to be my wives; his fatted pigs and dogs to be baked for us; his choice *kalo*, sugar cane, and bananas to be served up for us; that Kakuhihewa himself send and get timber and build a house for us; that he pull the famous *awa* of Kahuone; that the King send and fetch us to him; that he chew the *awa* for us in his own mouth, strain and pour it for us, and give us to drink until we are happy, and then take us to our house (Thrum 1998: 89).

Upon hearing such a request, the *mōʻī* Kākuhihewa confers with his priests and instead of killing Kalelealuaka, decides to test him in battle with Kūaliʻi. Kalelealuaka proves worthy in battle and is given charge of Kākuhihewa's kingdom.

Several place names are noted in the legend of Kalelealuaka and Keinohoomanawanui including Keahumoe (sic. Keahumoa), Kahuone, Lelepua, and Kuaikua in Helemano. Fornander describes Keahumoa as the "plain before reaching Kipapa gulch" (Fornander Vol. V, Part II, p. 274). However, in the legends of the Battle of Keahumoa, the place seems to be closer to Honouliuli, near Līhue, Kualiʻi's fort (in Sterling and Summers, 1978:38). Kahuone is noted as a place of choice ʻ*awa*, ʻ*awa* fit for a king, however its location is unknown. According to Thrum, Lelepua is the home of Kalelealuaka and his companions (Thrum 1998: 88). In Fragments of Hawaiian History, ʻĪʻī mentions several places in Waipiʻo ʻUka including Lelepua, however he associates Kalelealuaka to a place called Kahalepoai and not to Lelepua.

> From there it extended to the digging place of Kahalo, then went below to Paupalai, thence Lelepua, and to Kahalepoai, where the legendary characters Kalelealuaka and Keinohoomanawanui lived (ʻĪʻī 1959:99).

The Indices of Awards lists four LCAs which claim portions of Lelepua and Kahalepoai as land. Lelepua is described as an *ʻili* or a land section within Waipiʻo ʻUka and Kahalepoai (sic. Walepoai) is described as a ravine. Kahalepoai appears again in association with Kalelealuaka and Keinohoomanawanui in a Hawaiian newspaper article recalling "*Na Wahi Pana o Ewa*".

> Kahalepoai is another noted place which those who had not seen but heard of ask about. They ask, “Where is the place where Kalelelaluaka and Keinohoomanawanui lived?” Then the native points it out, “It is there at the *hau* grove standing above Waipi‘o. That is Kahalepoai.” I do not believe that this year will be gone before that *hau* grove will be gone. Gold and diamonds are going to make it into nothing and the generations to come will not know about it (*Ka Loea Kalaiaina*, June 3, 1899).

At the time these articles were written (1899), Oahu Sugar Company had just purchased land in upper Waipi‘o, and land was being converted to sugar cane fields at a rapid rate (Condé and Best 1973). After years of sugar cane and pineapple cultivation during the twentieth century, Kahalepoai and Lelepua are no longer commonplace names in the Waipi‘o/Mililani area.

3.1.4 Waipi‘o Uka and the Māhele (mid – 1800s)

The earliest recorded information on land use in Waipi‘o Uka is in the Land Commission Awards. During the Māhele period, or mid-1800s, the land tenure changed from traditional use rights to private ownership. With the exception of the Land Commission Awards, or *kuleana* lands, most of the *ahupua‘a* of Waipi‘o was granted to John Papa ‘Ī‘ī. During the time of the Māhele, there were 13 applications for quiet title to lands in Waipi‘o Uka (Waihona ‘āina, 2000) (Table 1). The LCAs lie well to the north (*mauka*) of the current project area, which is on a plain that would have been difficult to water.

The *kuleana* claims, whether awarded or not awarded, give much insight into the land use in Waipi‘o Uka during this time period. The LCAs tell us that Waipi‘o Uka extended from the Waikakalaua Gulch on the northwest side of the Waipi‘o Ahupua‘a to the Kīpapa Gulch on the east side of Waipi‘o. Resident of Waipi‘o Uka, Koikoi (no LCA number), claims a land called Kamanuiki, “an entire portion of the Valley Waipi‘o uka of Waikaka laua Stream” (Waihona ‘āina, 2000). The boundaries of Kamanuiki include a neighbor Lanai who lives on a piece of land called Kahooneananui, the Waikele Stream (often called the Waikakalaua Stream) and the Alanui Aupuni, or Government Road.

Thirteen *‘okipu‘u* were claimed in the Waipi‘o ‘Uka LCAs. *‘Okipu‘u* is a rare term in the Land Commission Awards and seems to be utilized only by Hawaiians residing in Waipi‘o and Waialua Ahupua‘a (Waihona ‘āina, 2000). *‘Okipu‘u* is described as a forest clearing (Lucas, 1995: 82), and may have been used for growing dry land taro. Given the numbers of *‘okipu‘u* and *mo‘o*, the major crops of Waipi‘o ‘Uka were probably dry land taro and sweet potatoes. There is little mention of *lo‘i* and associated features, which suggests that conditions were not entirely favorable for wetland taro cultivation.

Several pieces of land were claimed in mountains or *pali*. One translation of *pali* is “steep hill or slope suitable for *olonā* or *wauke*” (Pukui and Elbert, 1986:312). Along the Kīpapa Gulch were numerous tributary gulches. These steep, moist areas which were sheltered from the wind may have provided excellent conditions to cultivate *wauke* (*Broussonetia papyrifera*) and *olonā* (*Touchardia latifolia* Gaud.) plants known to grow in the ‘Ewa uplands (Handy and Handy 1972: 209, 227). A third plant, *mamaki* (*Pipturus spp*.), may have been cultivated in conjunction with the *wauke* and *olonā*. The *mamaki tapa* which was made in Waipi‘o, ‘Ewa was known to be of high quality (‘Ī‘ī 1959:83).

Table 1. Māhele Claims And Awards in Waipi‘o ‘Uka

Claimant	Claim No.	Name of Land Claimed	Land Use	Land Awarded
Koikoi	No number	Kamanuiki in Waipi‘o Uka (entire portion of valley of Waikakalaua Stream)	1 house, no other land use indicated	unknown
Ukeke	8241N	Maheu, Lelepua in Waipi`o `Uka	1 *mo`o*, 1 *kula*, house lot, house, 2 *`okipu`u* of mountain taro	Maheu 1 ap., 5.507 Acs.; Waipi`o `Uka 1 *‘āp*., .9 Acs.
Kamakahi	8241Q	Kuana, Waianeki in Waipi`o `Uka	1 *mo`o*, 1 *kula*, house lot, 1 house, 2 *okipu`u* in 1 piece	Kuana 1 *‘āp*. 2.217 Acs.; Waianeki 1 *‘āp*. .256 Acs.
Kauluoaiwi/ Kaulewaiwi	8241V	Honowaka in Waipi`o `Uka	1 *mo`o*, 1 *kula*, houselot, 1 house	Hanauaka 1 *‘āp*. .256 Acs.; Waipiouka 1 ap. 5.475 Acs.
Kaneakauhi	8241W	Kaohai in Waipi`o `Uka, Wailele	1 *mo`o*, 1 *kula*, houselot, 1 house	Waipi`o `Uka Kaohi 1 *‘āp*. 8.162 Acs.
Kaioe	8241Z	Moakea, Puulu, Palikea in Waipi`o `Uka	1 *mo`o*, 1 *kula*, houselot, 1 house	Puulu 1 *‘āp*. 18.72 Acs.
Kalaiku	8241UU	Lelepua in Waipi`o `Uka	1 *mo`o*, 1 *kula*, houselot, 1 house, *`okipu`u*	Lelepua Waipi`o Ewa 1 *‘āp*. 13.15 Acs.
Kaualelehuna	8241XX	Walepoai in Waipi`o `Uka	*mo`o, kula*, house lot, 1 house, a ravine, 2 *`okipu`u*	Not Awarded
Kaimileihonua	9361B	Waipi`o `Uka	1 *mo`o*, 1 *kula*, houselot, 2 houses	Not Awarded

Naniu	11207	Liloa, Kamae in Waipi`o `Uka	1 *mo`o*, 1 *kula*, houselot, 1 house, mountain *kalo* land	Not Awarded
Kaopuana	11208	Kahalo, Kepooakaholu in Waipi`o `Uka	1 *mo`o*, 1 *kula*, houselot, 1 house	Not Awarded
Kawaihae	11209	Kaluahine, Kanewahine in Waipi`o `Uka	1 *mo`o*, 1 *kula*, houselot, 1 house, *`okipu`u*	Not Awarded
Kaluehinue	11210	Kauloa, Waipi`o `Uka	1*`okipu`u*	Not Awarded

3.1.5 Waipi‘o Uka in the 1900s

3.1.5.1 Independent Pineapple Growers

Before the turn of the century, sugar and pineapple were already beginning to transform the landscape of ‘Ewa and Wahiawā. The newly organized Oahu Sugar Company leased 3,400 acres of the *mauka* portion of Waipi‘o from the ‘Ī‘ī estate in 1897. A few years earlier, the Oahu Railway and Land Co. (O.R. & L.) had leased a tract through Kīpapa Gulch to transport sugar and pineapple from Wahiawā to Honolulu. A 1925 map of the Oahu Sugar Company indicates that approximately 60% of the project area (west of Pānakauahi Gulch) was utilized occasionally for cultivation (Figure 5). The railway up the Gulch may have been the impetus for small independent farmers to move in and begin growing pineapple in the upper reaches of Kīpapa Valley.

Land records document Japanese farmers acquiring lands in Waipi‘o *mauka* for pineapple cultivation in the first decade of the twentieth century. An unrecorded lease from the John ‘Ī‘ī Estate, Ltd. to Yoshisuke Tanimoto and Kintaro Izumi in 1908 led to the formation of the Waipi‘o Pineapple Company who cleared and cultivated approximately 223 acres in portions of the Kīpapa Gulch (Bureau of Land Conveyances 434: 228-235). This was probably the beginning of pineapple cultivation in the uplands of Waipi‘o, and likely extended into the western portion of the project area (see Figure 5).

In 1915, Libby McNeil & Libby took over Waipi‘o Pineapple Company’s leases and continued to cultivate pineapple in the area. The area the two farmers leased was known as the Leoiki and Panihakea Gulches, two small gulches within Kīpapa. The place name Leoiki was also recorded in the Land Commission documents as a valley with one boundary being Waiawa and surrounded by *pali* (LCA #8241CC).

Unrecorded leases for land in Waipi‘o were probably fairly common in that early stage of land transactions. As pineapple and sugar became more viable and profitable crops, and transportation to the sugar mills and pineapple canneries became available, it is likely that more

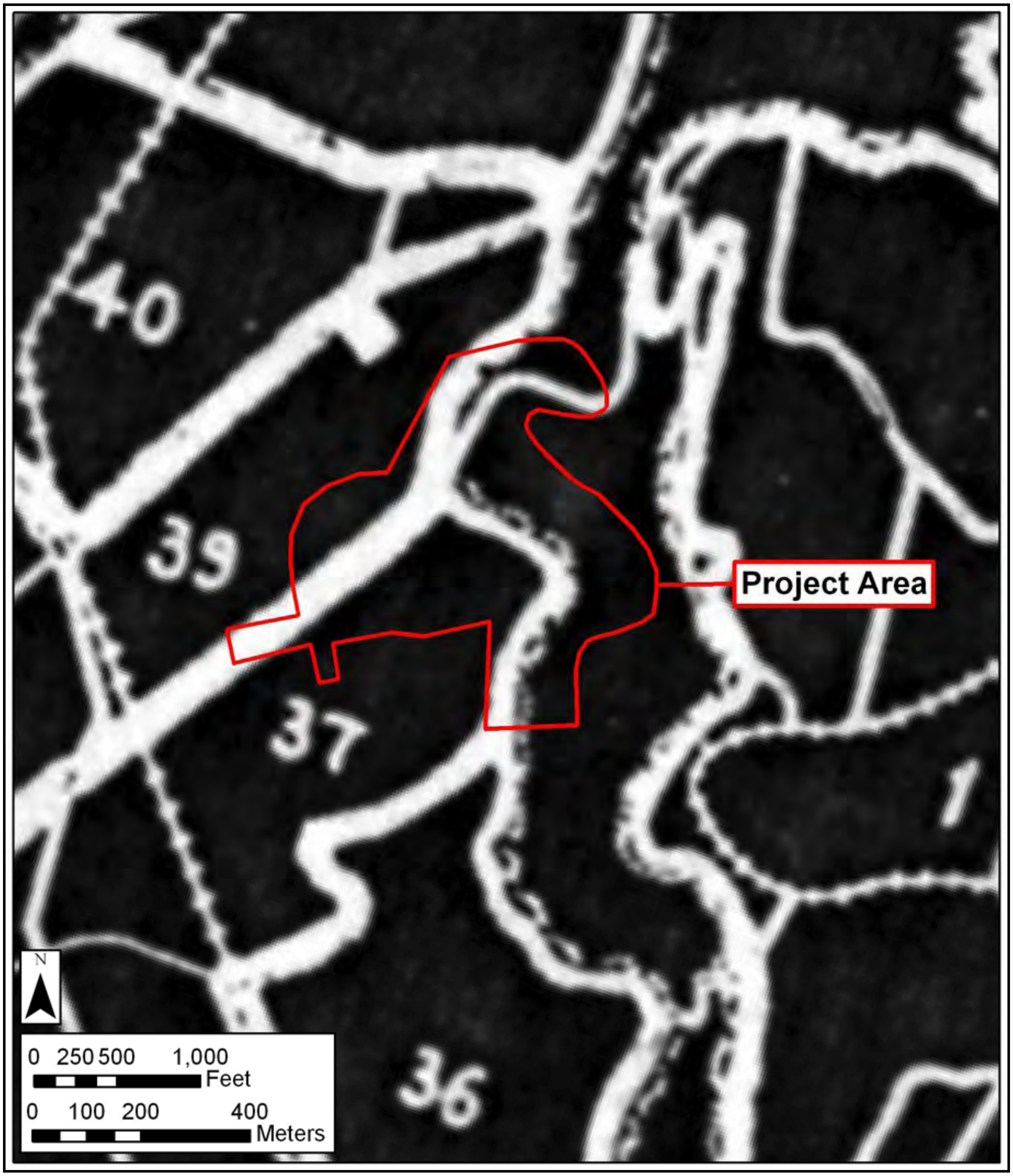

Figure 5. A 1925 map of the Oahu Sugar Company lands showing the project area

and more land was placed into cultivation, including the less arable lands within Kīpapa such as the swales and small gulches.

3.1.5.2 The Waiahole Ditch

The Oahu Sugar Company began work on the Waiahole Ditch in 1913 and the water system was "an engineering feat of epic proportion for those times" (Condé and Best 1973: 37). The objective was to bring water from the windward side of Oʻahu to the fields and mill of Oahu Sugar Company in ʻEwa. The original system included 27 tunnels and connecting 37 stream intakes, with a ditch running for nearly 22 miles, stretching from windward to leeward O`ahu.

Mr. Arakaki, a former plantation worker, remembers when the ditch was operated by families that lived strategically along the ditch. One family in particular, the Shibuya family, stood out for Mr. Arakaki:

> The Shibuya Family actually lived adjacent to the Waiahole Ditch, a little distance from the Camp [Shohata Camp]. They worked for the Waiahole Ditch Company and were in charge of opening and closing the locks and managing the water...When there was too much water, the excess was dumped into Waiawa Stream...Mr. Arakaki relates that sometimes as kids, when visiting the Shibuya family, they would go swimming in the Waiahole Ditch near the Shibuya house. Near the house, the main ditch flowed into a small reservoir, approximately 20' x 20' or 30' x 30'. A wooden gate was maneuvered to adjust the flow into the reservoir and at the opposite end of the reservoir, where the reservoir once again became a ditch, there was a flat area with a measuring stick. Based on the measuring stick, one could tell how many thousands of gallons were flowing per day and thus how much water was being sent to central Oʻahu (Bushnell and Hammatt 2001).

A 1928-29 USGS map indicates numerous irrigation ditches and reservoirs within the vicinity of the project area (Figure 6), which may be associated with the diversion of excess water into Waiawa Stream.

3.1.5.3 World War II in Waipi'o Uka

The military began the appropriation of Kīpapa Gulch around 1938 and during World War II used the rail system to "haul large quantities of ammunition" (Condé and Best 1973:315). Kīpapa Gulch was used for underground gas storage and underground ammunition storage (Allen, 1950: 229).

The War had a great impact on those living in the Kīpapa Gulch, particularly those living in the lower gulch. The families were evicted from their truck farms in lower Kīpapa when the military condemned the land during World War II (Bushnell and Hammatt 2001).

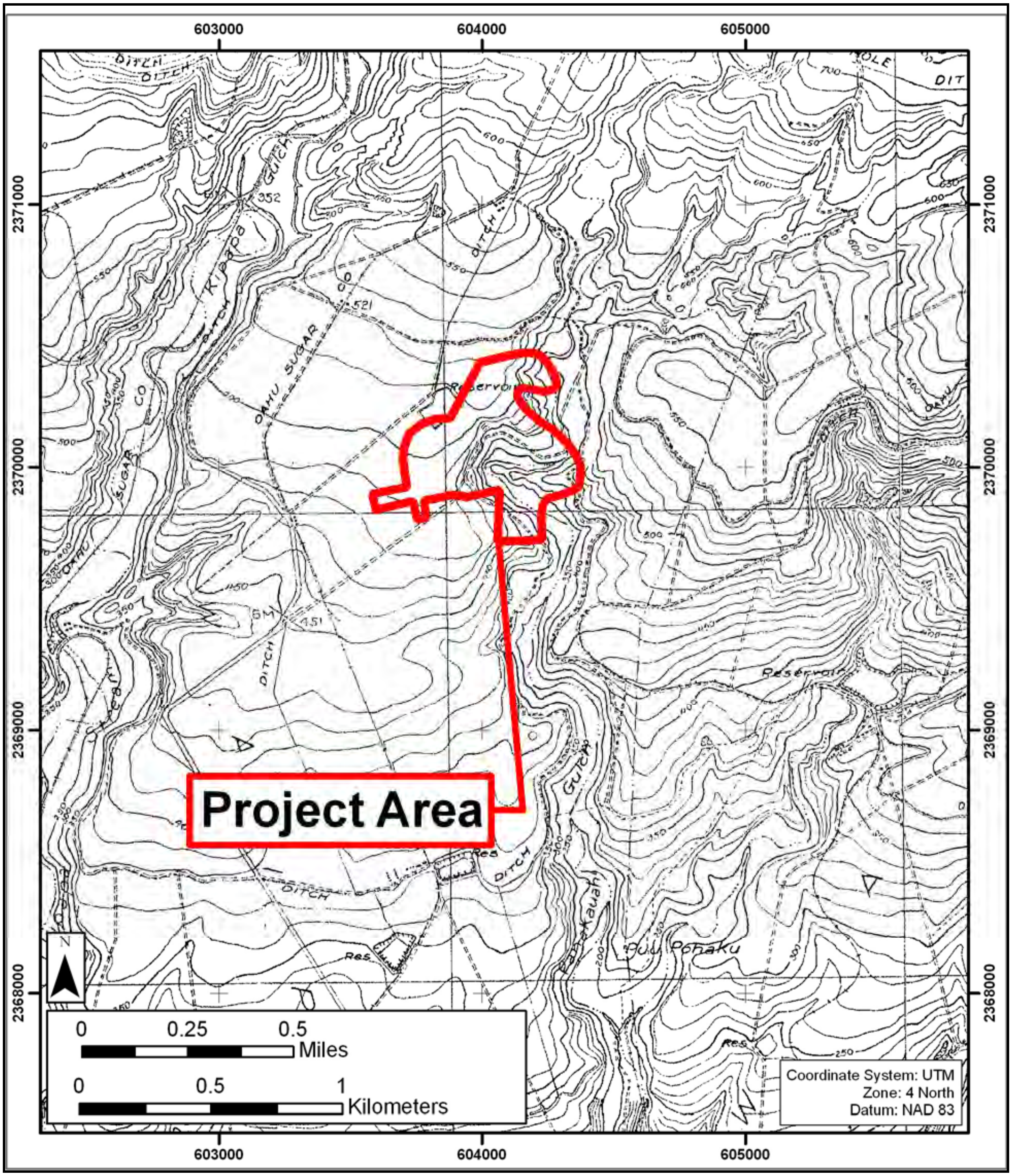

Figure 6. Portion of 1927-1928 U.S. Geological Survey 7.5-Minute Series Topographic Map, Waipahu Quadrangle, showing the location of the project area

3.2 Previous Archaeological Research

There have been several archaeological investigations in the vicinity of the current project area. The studies establish that this area of Waipio was continuously used, pre- and post-Contact, for a number of functions. They also establish that much of the pre-contact archaeology of the area was disturbed by sugar and pineapple cultivation. The locations of the previous archaeological investigations can be found in Figure 7 and a summary is presented in Table 2.

Hammatt and Borthwick (1988) conducted an archaeological reconnaissance and subsurface testing of approximately 371 acres in the upper and lower Kīpapa Gulch. Three previously identified sites (Rosendahl 1977) were encountered, which included a laborers’ camp (SIHP 50-80-09-9529), an Oahu Sugar Company Weir Station (SIHP 50-80-09-0530), and a stockpile of rocks (SIHP 50-80-09-9534) associated with the Oahu Sugar Company.

A crew from the Applied Research Group, Bishop Museum (Goodman and Nees 1991) carried out a reconnaissance survey of 3600 acres in Waiawa and Waipio Ahupua’a (TMK 1-9-4-006:11, 026; and 1-9-6-004:001, 004, 016). Seventeen sites were reported from the project area (SIHP 50-80-09-1469 to 1472; 2261 to 2273). Four pre-contact sites were recorded: a rock-shelter complex, a mound complex, a trail, and a lithic scatter. Post contact features, such as irrigation ditches, a railroad system, and a cannery, were described. Four features associated with WWII military training were also found.

Sinoto and Pantaleo (1994) conducted an archaeological data recovery of two sites as a requested supplement to the Goodman and Ness (1991) inventory survey. SIHP 50-8009-2271, located approximately 2.5 km northeast of the current project area, was described as a historic complex containing a pineapple cannery, remains of the Pine Ridge Farms Dairy, and a historic cemetery (Sinoto and Pantaleo 1994). A lithic scatter (SIHP 50-80-09-2262) was also observed beyond the vicinity of the current project area.

In 1996, Cultural Surveys Hawaii conducted and archaeological inventory of four discrete parcels in Waipi‘o and Waiawa covering a total area of 1,339 acres (Hammatt et al 1996). All four parcels were either in active pineapple cultivation, were lying fallow, or were cultivated in the recent past. One isolated artifact – the tang section of a finished basalt adz – was observed in the Koa Ridge Makai parcel, however it was not assigned an SIHP number. Two previously identified state sites were located. SIHP 50-80-09-2268, The Waiahole Ditch, runs approximately 3600 feet in the Koa Ridge Makai and Mauka areas. It is constructed of concrete and mortar with pipes that have been continuously maintained. SIHP 50-80-09-5929, The Kipapa Ditch, is associated with historic sugar cultivation.

Although several archaeological studies have identified both pre- and post-contact historic properties in the Waipio Uka area, no historic properties have been identified within or in the immediate vicinity of the project area.

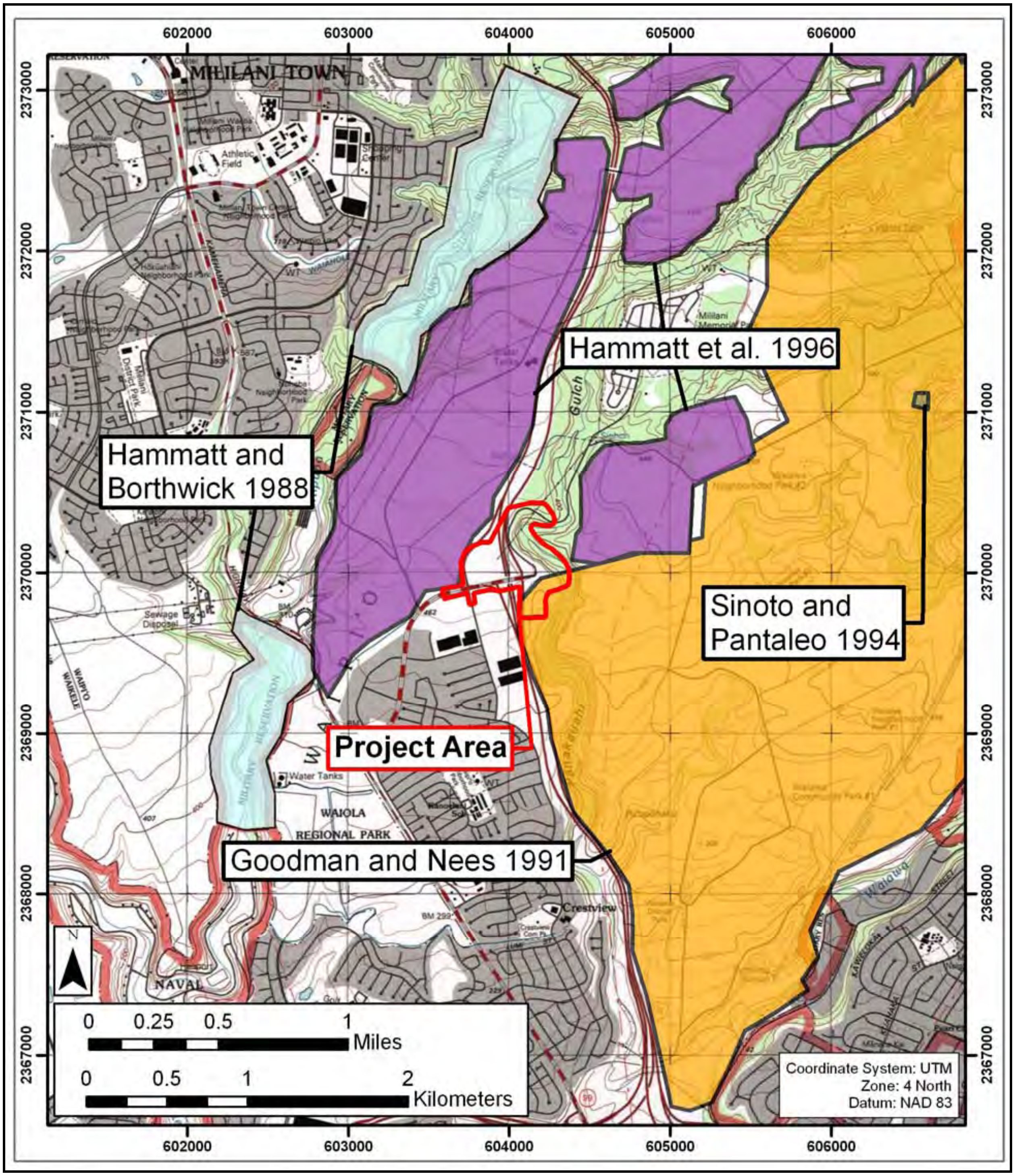

Figure 7. Previous archaeological investigations in the vicinity of the project area

Table 2. Previous Archaeological Studies in the Vicinity of the Project Area

Source	Type of Investigation	General Location	Findings
Hammatt and Borthwick 1988	Reconnaissance Survey and Subsurface Testing	Kīpapa Gulch	A laborer’s camp (SIHP 50-80-09-9529), an Oahu Sugar Company Weir Station (SIHP 50-80-09-0530), and a stockpile of rocks (SIHP 50-80-09-9534) associated with the Oahu Sugar Company
Goodman and Nees 1991	Inventory Survey	3,600 acres bounded by H-1, H-2, and Waiawa Stream	17 historic properties, among them are: a prehistoric rockshelter complex with petroglyphs, historic plantation infrastructure, a small cemetery, a road and railroad system, historic fire pits and trash dumps.
Sinoto and Panteleo 1994	Data Recovery	East of Pānakauahi Gulch	A historic complex (SIHP 50-80-09-2271) consisting of a pineapple cannery, remnants of the Pine Ridge Farms Dairy, and a historic cemetery. A lithic scatter (SIHP 50-80-09-2262)
Hammatt et al. 1996	Inventory Survey	*mauka* areas of Waipiʻo and Waiawa Ahupuaʻa	Recorded previously identified Waiahole Ditch (SIHP 50-80-09-2268) and Kīpapa Ditch (SIHP 50-80-09-5929)

3.3 Background Summary and Predictive Model

While background research indicates that pre-contact populations in Waipio were concentrated in the coastal (*makai*) portion of the *ahupua’a*, a review of Land Commission Awards indicates the presence of upland settlements in Waipio Uka far *mauka* of the project area. Previous archaeological studies (Goodman and Nees 1991) have also documented the presence of at least four pre-contact historic properties in the vicinity of the project area.

The use of the land in and around the project area for cultivation is well documented throughout the beginning of the 20th century. The Oahu Sugar Company leased 3,400 acres of the *mauka* portion of Waipiʻo from the ʻĪʻī estate in 1897. A few years earlier, the O.R. & L. leased a tract through Kīpapa Gulch to transport sugar and pineapple from Wahiawā to Honolulu. A 1925 map of the Oahu Sugar Company indicates that approximately 60% of the project area (west of Pānakauahi Gulch) was utilized occasionally for cultivation (see Figure 5).

At present, the majority of the project area consists of modern developments including the I-H2, Ka Uka Boulevard, Mililani Cemetery Road, and a large DOT staging area. While background research suggests that pre- and post-contact land use occurred in the vicinity of the project area, significant disturbances and land modification associated with pineapple cultivation and modern roadway development have likely destroyed any surface sites that may have been present. Accordingly, the expectation of encountering historic properties during this survey is low.

Section 4 Results of Field Inspection

Field inspection of the project area confirmed the findings and information provided in the background research. The majority of the project area showed signs of modern and historic disturbance. No historic properties were observed within the project area. The pedestrian survey involved a general inspection of the 70.6-acre project area targeting undeveloped areas. The spacing between the archaeologists was generally 10-20 m. A GPS track log to document pedestrian coverage within the project area was recorded (Figure 8).

The western portion of the project area including portions of Ka Uka Blvd., Mililani Cemetery Rd., and I-H2 were situated within modern asphalt-paved roadway rights-of-way (Figure 9). Additionally, a large Department of Transportation staging area, located to the west of the I-H2, was observed to be disturbed by recent activities including paving, bulldozer push, and the dumping of construction fill and modern debris (Figure 10). The eastern portion of the project area, situated between Mililani Cemetery Rd. and the bottom of the Pānakauahi Gulch, was observed to be undeveloped. The steeply sloping gulch edges adjacent to Mililani Cemetery Rd. were inaccessible to pedestrian inspection (Figure 11). A large quantity of modern garbage was observed along Mililani Cemetery Rd. and extending down the slope of the gulch to Waiawa stream including a large cement mixing apparatus (Figure 12 and Figure 13). The southern portion of the project area, situated adjacent to the margins of I-H2 consisted of several cleared or paved areas (Figure 14 and Figure 15). These areas contained an abundance of modern materials including plastic sheeting, glass, metal, and all-terrain vehicle (ATV) parts. An overgrown gravel-paved road oriented parallel to I-H2 and visible on aerial photographs was also identified (see Figure 3). The road and cleared areas may be attributable to the plantation era or modern development.

The only undisturbed portion of the project area consisted of the land along the Waiawa streambed at the base of Pānakauahi Gulch. This area would have been the most likely location of historic properties due to level topography and access to a fresh water source. No sites were observed. It seems likely that any historic properties or subsurface cultural material existing within the flat or gently sloping portions of the gulch were destroyed by intermittent flooding of the stream or outwash flows from the Schofield Plateau (Figure 16).

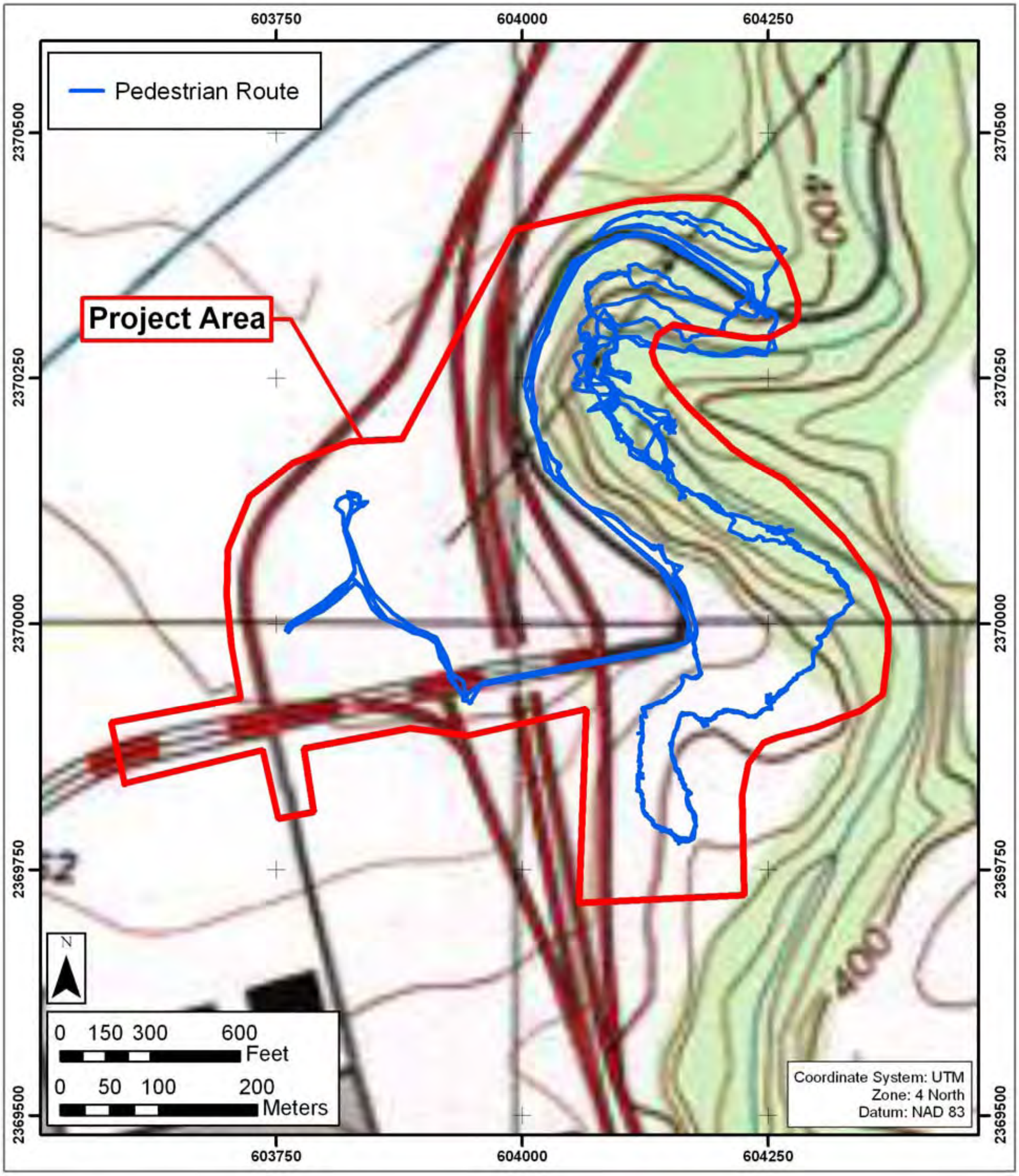

Figure 8. Portion of U.S. Geological Survey 7.5-Minute Series Topographic Map, Waipahu Quadrangle (1998), showing the location of the project area and pedestrian route

Figure 9. Ka Uka Boulevard showing I-H2 overpass facing southeast

Figure 10. Portion of the Department of Transportation staging area showing degree of disturbance facing west

Figure 11. View of the steeply sloping portion of Pānakauahi Gulch showing Mililani Cemetery Road facing west

Figure 12. Cement mixing apparatus near the bottom of Pānakauahi Gulch facing west

Figure 13. View of the extent of modern garbage along Mililani Cemetery Rod facing east

Figure 14. View of cleared area near the intersection of Mililani Cemetery Road and Ka Uka Boulevard showing modern garbage facing south

Figure 15. View of gravel-paved area near the I-H2 Ka Uka Boulevard northbound onramp facing west

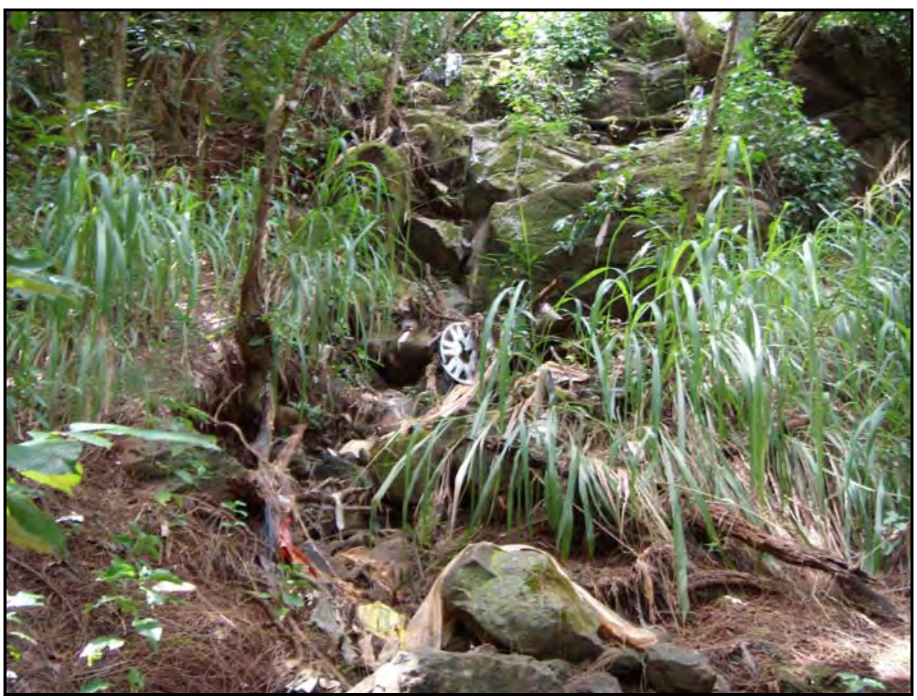

Figure 16. View of an outwash channel near the bottom of Pānakauahi Gulch showing modern garbage facing south

Section 5 Summary and Recommendations

Background research indicated that pre-contact populations in Waipio were concentrated in the coastal (*makai*) portion of the ahupua'a, but a review of previous archaeological studies identified the presence of at least four pre-contact historic properties in the vicinity of the project area. These historic properties included a rock-shelter complex, a mound complex, a trail, and a lithic scatter located within 2 kilometers of the current project area (Goodman and Nees 1991). A supplement to this study conducted by Sinoto and Pantaleo (1994) also observed a lithic scatter (SIHP 50-80-09-2262) located slightly beyond the vicinity of the current project area.

The use of the land in and around the project area for cultivation is well documented throughout the beginning of the 20th century. A 1925 map of the Oahu Sugar Company indicates that approximately 60% of the project area (west of Pānakauahi Gulch) was utilized occasionally for cultivation (see Figure 5). Previous archaeological research has identified numerous plantation era historic properties in the vicinity of the current project area. During a reconnaissance survey of the nearby Kīpapa Gulch, Hammatt and Borthwick (1988) observed three previously identified sites (Rosendahl 1977), which included a laborers' camp (SIHP 50-80-09-9529), an Oahu Sugar Company Weir Station (SIHP 50-80-09-0530), and a stockpile of rocks (SIHP 50-80-09-9534) associated with the Oahu Sugar Company. In addition to several pre-contact sites, Goodman and Nees (1991) encountered irrigation ditches, a railroad system, and a cannery likely associated with the production, packaging and transport of sugar and pineapple. Sinoto and Pantaleo (1994) also located a historic complex (SIHP 50-80-09-2271) containing a pineapple cannery, remains of the Pine Ridge Farms Dairy, and a historic cemetery during a supplemental data recovery of the area. Portions of previously described irrigation infrastructure associated with cane and pineapple cultivation were identified as the Waiahole Ditch (SIHP 50-80-09-2268) and the Kīpapa Ditch (SIHP 50-80-09-5929) during a previous inventory survey (Hammatt et al. 1996).

Within the project area itself, no historic properties were observed during the field inspection. The combination of previous pineapple or cane cultivation and modern highway development has likely significantly disturbed or destroyed any surface or subsurface historic properties that may have existed within the project area. Based on the results of this study, it appears unlikely that significant historic properties will be affected by the proposed interchange improvements. No further cultural resource management work is recommended for the project. It is recommended that this investigation be used to support consultation with SHPD to obtain SHPD's concurrence with this recommendation for no further project-related cultural resource management work.

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November 22, 2002

Alan K. Arakawa
Vice President
Castle & Cooke Homes Hawaii, Inc.
P. O. Box 898900
Mililani, HI 96789-8900

LOG NO: 31158 ✓
DOC NO: 0211EJ10

Dear Mr. Arakawa:

SUBJECT: **Chapter 6E-42 Historic Preservation Review – Environmental Impact Statement Preparation Notice: Koa Ridge a Master Planned Community**
Waipi`o and Waiawa, `Ewa, O`ahu
TMK: (1) 9-4-006:001, 002, por.003, por.029; 9-5-003: por.001, por.004; 9-6-004:021

Thank you for the opportunity to comment on the EISPN submitted in support of an application to amend the City & County of Honolulu Central Oahu Development Plan Land Use Map and Zoning Designations for the Koa Ridge Makai and Castle & Cooke Waiawa Development Areas. Our review is based on historic reports, maps, and aerial photographs maintained at the State Historic Preservation Division; no field inspection was made of the project areas. We received the EISPN for comment on November 8, 2002, and provide the following comment.

We provided the State Department of Business, Economic Development & Tourism Land Use Commission comments on the Koa Ridge Project in August 2001 (attached SHPD Log 27976). We also provided the City & County of Honolulu Department of Planning and Permitting comment on the proposed Health Center (attached SHPD Log 030911). Our previous comments have been summarized and included in the EISPN.

An acceptable archaeological survey verified that aside from the two historic ditches (Waiahole Ditch and the Kipapa Ditch), the remaining lands contained within this action were commercially cultivated in sugar and pineapple for many years and no other historic sites were found. The Waiahole Ditch is clearly likely to be significant under multiple criteria of the Hawaii Register of Historic Places, as it played a significant role in the early 1900s agricultural history of O`ahu. Our previous comments stated that that appropriate mitigative measures will need to be agreed upon should future development have the potential to have an adverse effect on this site. The EISPN has stated that development is not expected to alter the Waiahole Ditch and that the SHPD will be consulted prior to any work that may impact the ditch. The Kipapa Ditch lies outside but adjacent to the application area and could be impacted by project's off-site improvements, such as drainage structures. The EISPN commits to additional site-specific archaeological survey for any project-related improvements outside the application area.

Therefore, we believe that the proposed actions in areas other than the historic ditches will have "no effect" on significant historic sites. We also concur that mitigative measures will need to be agreed upon should future development have the potential to have an adverse effect on the Waiahole or Kipapa Ditch.

Should you have any questions about archaeology, please feel free to call Sara Collins at 692-8026 or Elaine Jourdane at 692-8027. Should you have any questions about architecture, including treatment of the historic ditches, please feel free to contact Tonia Moy at 692-8030.

Aloha,

Don Hibbard, Administrator
State Historic Preservation Division

EJ:jk

Attachments: SHPD Log 27976, 29403, 30911

c: OEQC, 235 S. Beretania Street, Suite 702, Honolulu, HI 96813
Matt Higashida, Planner, Dept. of Planning and Permitting, City & County of Honolulu, 650 S. King St., 7th Fl., Honolulu, HI 96813
✓Gail Renard, Project Planner, Helber Hastert & Fee, Planners, Inc.733 Bishop Street, Suite 2590, Honolulu, HI 96813

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March 18, 2002

David Shideler
O`ahu Office Manger
Cultural Surveys Hawaii
733 N. Kalaheo Ave.
Kailua, Hawaii 96734

LOG NO: 29403
DOC NO: 0203EJ09

Dear Mr. Shideler:

SUBJECT: Archaeological Inventory Survey of a 1339-Acre Parcel at Castle and Cooke Lands within Portions of Waipi`o and Waiawa Ahupua`a, O`ahu
Waipi`o and Waiawa,, `Ewa, O`ahu
TMK: 9-4-006:001, 003, 010por.; 9-5-003:001por. 004, 007 and 9-6-004:021

Thank you for the submission of a report on an archaeological inventory survey of Castle and Cooke Lands in Waipi`o and Waiawa, O`ahu [*Archaeological Inventory Survey of a 1339-Acre Parcel at Castle and Cooke Lands within Portions of Waipi`o and Waiawa Ahupua`a, O`ahu* (Hammatt et al, June 1996)]. We received the report in June 2001.

We believe that the survey was performed acceptably, finding one site, portions of Waiahole Ditch (State Site No. 50-80-09-2268) within the subject parcels. One other site, portions of Kipapa ditch (State Site No. 50-80-09-9529), were identified outside of the project area. The Waiahole Ditch is clearly likely to be significant under multiple criteria of the Hawaii Register of Historic Places, as it played a significant role in the early 1900s agricultural history of O`ahu. We agree that appropriate mitigative measures will need to be agreed upon should future development have the potential to have an adverse effect on this site.

We have placed the CSH report in the SHPD library where it will be available for the public's use and benefit.

Should you have any questions, please feel free to call Sara Collins at 692-8026 or Elaine Jourdane at 692-8027.

Aloha,

Don Hibbard, Administrator
State Historic Preservation Division

EJ:jk

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GOVERNOR OF HAWAII

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March 2, 1995

LOG NO: 13981
DOC NO: 9502TD20

Ms. Patrice Tottori Liu, Vice President
Waiawa Gentry Hawaii, Ltd.
P.O. Box 295
Honolulu, Hawaii 90809

Completion of work at WRD March 2, 1995

Dear Ms. Liu:

SUBJECT: **Supplemental Data Recovery Report for Site 50-80-09-2271: Feature 3 Waiawa, `Ewa, O`ahu TMK: 9-6-5: 3**

Thank you for the opportunity to review this report, which successfully completes the tasks set out in the approved Data Recovery Plan for site 2271.

We concur with the significance evaluations noted in your letter and included on page 44 of the report entitled Archaeological Data Recovery at Sites 50-80-09-2262 and 2271, Phase I Development Area (Sinoto and Pantaleo, January 1994). Three significant sites remain within the 3600 acre Waiawa development area, including sites 50-80-09-2263, -2265, and -2266. Site -2263, a petroglyph site, is significant for multiple criteria and we strongly recommend that the mitigation plan for this site involve its interpretive display. We look forward to reviewing a mitigation plan for these three sites when development is planned for this portion of the Waiawa development area.

Thank you for your interest in historic preservation and your efforts to ensure that relatives of the individuals buried at the site 2271, feature 3 cemetery were identified.

If you have any questions please call Tom Dye at 587-0014.

Sincerely yours,

DON HIBBARD, Administrator
State Historic Preservation Division

TD:amk

ARCHAEOLOGICAL INVENTORY SURVEY OF A 1339-ACRE PARCEL AT CASTLE AND COOKE LANDS WITHIN PORTIONS OF WAIPI'O AND WAIAWA *AHUPUA'A*, O'AHU (TMK 9-4-06:01, 03 & 10 port.; and 9-5-03:01 port., 04 & 07; and 9-6-04:21)

by

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ABSTRACT

An archaeological inventory survey was conducted in a 1,339-Acre project area in central O'ahu, within the *ahupua'a* of Waipi'o and Waiawa. This survey included four separate parcels planned for residential development, designated as Koa Ridge *Makai*, Koa Ridge *Mauka*, Kīpapa Ridge, and Waiawa. Virtually all of these lands have been used for pineapple cultivation within the recent past. This, combined with the settlement pattern showing concentrated habitation in coastal areas and inland only in stream valleys - such as Kīpapa Gulch - explains the absence of evidence of former habitation in the project area. These lands were grassy plains with forests in the upper regions, probably used for gathering of medicinal plants, cutting of *koa* trees, and other uses.

A portion - including a ditch and two siphons - of the extensive Waiāhole Ditch System (State site 50-80-09-2268) cross approximately 3600 feet of the project area. If this portion is ever to be impacted by future development, the State Historic Preservation Division should be notified beforehand, so that appropriate mitigative measures, if necessary, can be established.

A well-constructed and well-preserved historic site, Kīpapa Ditch (State site 50-80-09-9529), lies adjacent to the Koa Ridge *Makai* parcel and runs 8,000 ft. along the eastern slope of Kīpapa Gulch. Steps should be taken to avoid impacting this site, even though it is outside the project area.

ACKNOWLEDGEMENTS

Cultural Surveys Hawaii would like to acknowledge the assistance of Mark Hastert and Gail Uyetake of Helber, Hastert and Fee, Planners. Mr. Wally Miyahara, the project director for Castle and Cooke properties provided local information and useful maps. Ms. Beverly Kaku, land agent for Castle and Cooke assisted in providing essential information for us to conduct field work. Mr. Ken Teruya, also of Castle and Cooke, gave up his time to serve as a guide for access to Kīpapa Ridge. Dr. Evangeline Funk, the botanist for the project, provided valuable information on the native plants of the area. Special appreciation is extended to Ms. Linda Mahoe Gallano for generously sharing her knowledge of the area. Field work was conducted by David Shideler, William Folk and Hal Hammatt. Mr. Folk donated his skill as a pilot to enable taking of aerial photographs of the project area.

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I. INTRODUCTION

A. Project Description

At the request of Helber Hastert & Fee, Planners, Cultural Surveys Hawaii has completed an inventory survey of four relatively discrete parcels - totalling 1,339 acres - in the *ahupua'a* of Waipi'o and Waiawa in Central O'ahu just east of Mililani Town (Figures 1-4). The four parcels - located on gentle sloping flats between deeply dissected gulches at elevations between 420ft. and 1100ft. - are designated: "Koa Ridge Makai" (571 acres), "Koa Ridge Mauka" (485 acres), "Kipapa Ridge" (92 acres), and "Waiawa" (191 acres) (See Figure 1). All four of these parcels occupy former commercial sugar cane and pineapple plantation lands.

Koa Ridge Makai (including TMK 9-4-06: 1 & 2 and portions of 9-5-03:1 and 9-5-03:4) is bounded to the west by the steep slopes of Kīpapa Gulch, is bounded on the north by a small tributary gulch to Kīpapa Gulch, is bounded on the east by the easement for the H-2 Freeway and is bounded on the south by a Pineapple Road and Kamehameha Highway.

Koa Ridge Mauka (including portions of TMK 9-5-03:1 and 9-5-03:4) is adjacent to the northernmost portion of Koa Ridge Makai but is separated from it by the H-2 easement. Koa Ridge Mauka is bounded on the north by steep tributary gulches of Kīpapa Gulch and is bounded on the south by steep tributary gulches of Panakauahi Gulch. These deeply dissected gulches virtually meet at a "knife-edge" ridge on the east corner of Koa Ridge Mauka. The H-2 easement forms the west boundary of Koa Ridge Mauka.

The parcel of the project area designated Kīpapa Ridge (TMK 9-5-03:7) lies immediately north of Koa Ridge Mauka and is bounded on the south, west and north sides by deeply dissected tributary gulches of Kīpapa Gulch. These gulches are in close

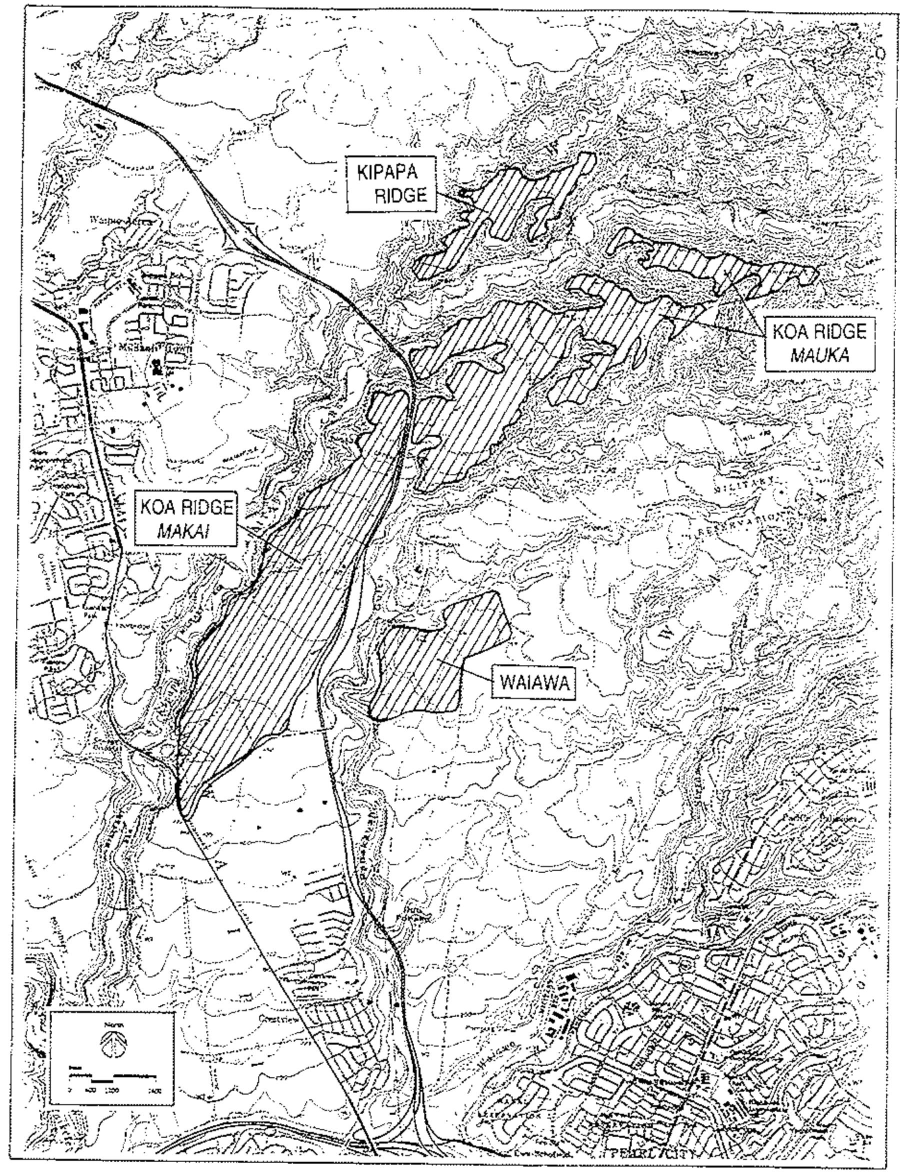


Figure 1 Portion of USGS 7.5 Minute Series Topographical Map, Waipahu Quadrangle, Showing Project Area With Parcel Names Identified

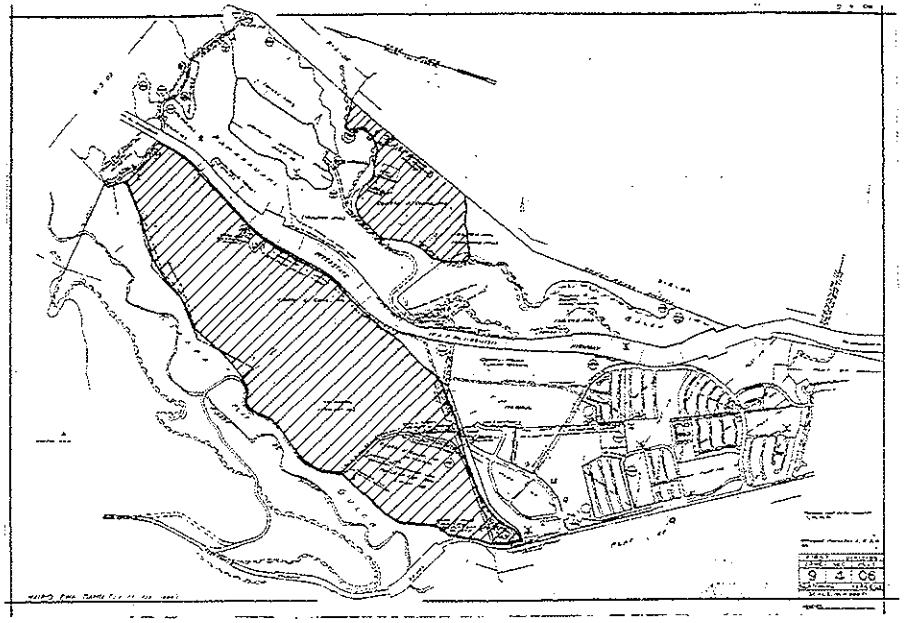


Figure 2 Tax Map of the General Area Showing Affected Lands (TMK 9-4-06:01, 03 & 10 por.)

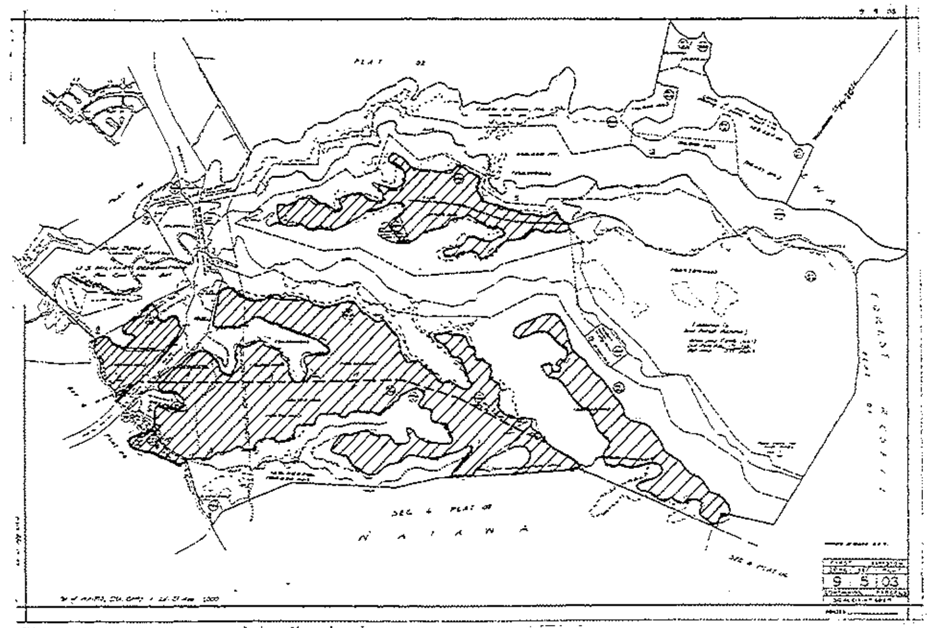


Figure 3 Tax Map of the General Area Showing Affected Lands (TMK 9-5-03:01 (portion), 04, & 07).

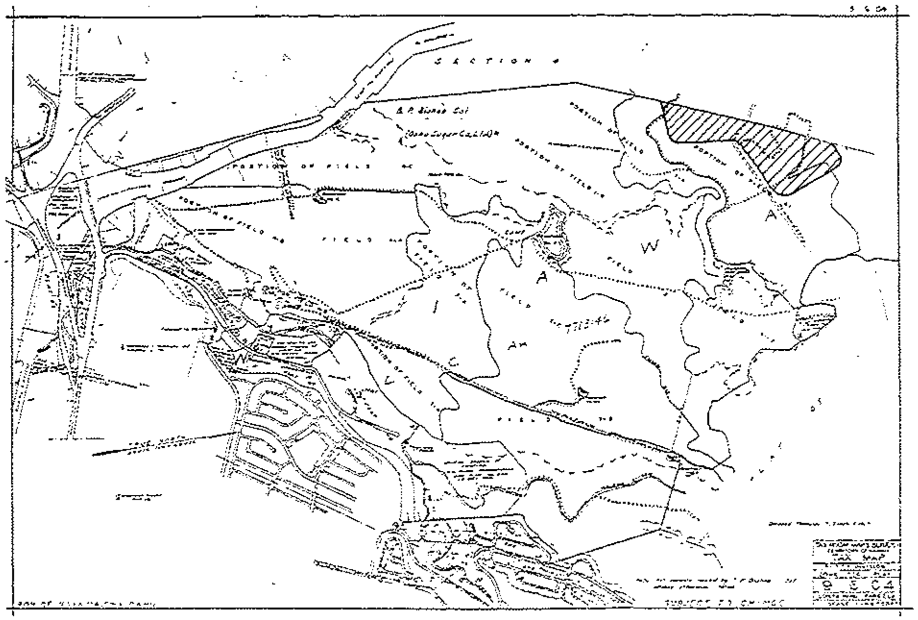


Figure 4 Tax Map of the General Area Showing Affected Lands (TMK 9-6-04:21)

proximity at the northeast corner of Kīpapa Ridge and this parcel is effectively pinched out by these gulches on the east side.

The parcel designated Waiawa (TMK 9-4-06:10 port. and 9-6-04:21) lies just east of Koa Ridge Makai across Panakauahi Gulch. The Waiawa parcel is bounded on the west by Panakauahi Gulch, on the north by a small tributary of Panakauahi Gulch, on the east by the road to the Waiawa Correctional Facility and on the southeast and south by old Pineapple Roads.

B. Scope of Work

The scope of work included:

1. A complete ground survey of the entire project area for the purpose of site inventory. All sites would be located, described, and mapped with evaluation of function, interrelationships, and significance. Documentation will include photographs and scale drawings of selected sites and complexes. All sites will be assigned State site numbers.

2. Limited subsurface testing to determine depth and quantity of cultural materials within archaeological sites and to obtain datable samples for chronological information if none is available for sites in the immediate area from previous studies.

3. Research on historic and archaeological background, including search of historic maps, written records, Land Commission Award documents. This research will focus on the specific area with general background on the *ahupua'a* and district and will emphasize settlement patterns.

4. Preparation of a survey report to include the following:

   a. A topographic map of the survey area showing all archaeological sites and site areas;

   b. Description of all archaeological sites with selected photographs, scale drawings, and discussions of function;

   c. Historical and archaeological background sections summarizing prehistoric and historic land use as they relate to the archaeological features;

   d. A summary of site categories, their significance in an archaeological and historic context;

e. Recommendations based on all information generated which will specify what steps should be taken to mitigate impact of development on archaeological resources - such as data recovery (excavation) and preservation of specific areas. These recommendations will be developed in consultation with the client and the State agencies.

C. Work Accomplished

Background research included: a review of previous archaeological studies on file at the State Historic Preservation Division of the Department of Land and Natural Resources; studies of documents at Hamilton Library of the University of Hawai'i, the Hawai'i State Archives, the Mission Houses Museum Library, the Hawai'i Public Library, and the Archives of the Bishop Museum; and study of maps at the Survey Office of the Department of Land and Natural Resources.

Inventory survey fieldwork was accomplished over a period of four days and included March 14, 20, 21, and April 17, 1996. Eleven person days were expended on the survey. The survey generally proceeded from *makai* to *mauka*, the first area examined being the Koa Ridge *Makai* parcel of the study area, followed by the *makai* portion of Koa Ridge *Mauka*, then Kipapa Ridge, and the Waiawa parcel. On the last day of fieldwork, the upslope portion of Koa Ridge *mauka* was surveyed. This day also included a hike up Kīpapa Ridge Trail to the crest of the Ko'olaus for the purpose of assessing possible former Hawaiian use of these forest lands.

On the afternoon of March 21, an aerial reconnaissance of the entire project area was conducted through the courtesy of William Folk of Cultural Surveys Hawaii. This aerial survey provided an overall view of land use in the project area and an opportunity for aerial photographs of the area (see Photo Appendix).

Given the active pineapple cultivation throughout most of the project area, the survey was confined to roads and all open uncultivated areas, with special emphasis on

the edges of fields at the rims of gulch slopes. The archaeologists were aware of possibility of finding basalt flake or midden scatters which could indicate presence of an archaeological site disturbed by plowing.

In some cases, uncultivated land at the upslope ends of tributary gullies were part of the survey area. These uncultivated lands were given 100% coverage by pedestrian survey with archaeologists spaced 50 feet apart.

Although no archaeological sites were found in the project area, field notes were taken on general conditions, with photographs documenting present land use (see Photo Appendix).

During the course of fieldwork, the survey crew made the acquaintance of Mrs. Linda Mahoe Gallano who, along with her husband, is the caretaker of the ranch property located at the upslope portion of Koa Ridge *Mauka*. Mrs. Gallano is also a teacher of Hawaiian language at Wai'anae High School, an avid hunter and a student of Hawaiian culture. She expressed a willingness to share her knowledge of the area and was interviewed on May 8, 1996 (see Section IIIF below).

II. NATURAL SETTING

A. Waipi'o *Ahupua'a*

The *ahupua'a* of Waipi'o, ("curved waters" [Pukui *et al*:1981) is in the 'Ewa District of the island of O'ahu. Its southern boundary is at Pearl Harbor at sea level, encompassing most of Waipi'o Peninsula. Pearl Harbor is a large inland embayment essentially composed of drowned river valleys formed by erosion during a lower stand of the sea.

The *ahupua'a* continues inland in a northerly direction upslope onto the Schofield Plateau. "Lava flows from the Ko'olau volcano banked against the already-eroded slope of the Wai'anae volcano to form the gently sloping surface of the Schofield Plateau" (Macdonald and Abbott 1983:420). The *ahupua'a*'s western border is Waikele Stream. Leaving the stream the boundary turns northeast and then east, following a tributary of Waikele Stream, the Waikakalaua Stream, and follows this gulch/stream/valley to the summit of the Ko'olau Range. This is a distance of about 21 kilometers.

To the west lies the *ahupua'a* of Waikele, to the north, the Wahiawā and Ko'olaupoko Districts, and along its eastern border lies the *ahupua'a* of Waiawa. Some of the project area extends across the Waipi'o border into Waiawa.

Elevation of the *ahupua'a* ranges from sea level at Pearl Harbor, slowly rising to the gently sloping central plains and Schofield Plateau, up to the foothills and valleys of the Ko'olau Range and on up steeply to the summit of the Ko'olaus at around 2700 ft. At about 1,000 ft elevation, it enters the 'Ewa Forest Reserve.

There are 4 basic topographic zones in Waipi'o: the slopes of Schofield Plateau, the gulches, the coastal plain at Pearl Harbor, and the leeward ridges and valleys of the *Ko'olau* Summit.

The soils in the Pearl Harbor coastal section of Waipi'o are: 1) Lualualei-Fill land-Ewa association, 2) Helemano-Wahiawa association in Central O'ahu, and 3) Rough mountainous land-Kapaa association on the leeward ridges and valleys of the Koolaus. The first two are deep, nearly level to moderately sloping, well-drained soils that have a fine textured subsoil. The third is very steep land broken by numerous drainageways and deep, well-drained soils that have a fine textured or moderately fine textured subsoil; in gulches and on narrow ridges (Foote *et al.*: 6-7; & General Soil Map, O'ahu).

Waipi'o *ahupua'a* is deeply dissected up through its center by Kīpapa Gulch, a tributary of the Waikele Stream. Another gulch, Pānakauahi, comes in from the east (Waiawa *ahupua'a*) along the lower southeast border of Waipi'o *ahupua'a*. Kipapa Stream is a permanently flowing stream in the "lower section, below the forest, which occasionally dries up after a long drought" (Hosaka 19937:178). The entire watershed of Pearl Harbor and Waiawa and Waipi'o in particular is one of the largest watersheds on O'ahu. (Dugan 1990; in Goodman and Nees, 1991:3).

Waipi'o enjoys a climate characterized by equable temperatures ranging from an average mean minimum of 60° to an average mean maximum of 85° near Pearl Harbor (Armstrong 1973:58). Rainfall varies between 20" in the Pearl Harbor region to a maximum of 200 inches at the summit of the Ko'olaus (Armstrong, 1973:56).

B. The Soils of the Project Parcels

All four project parcels have Wahiawa silty clay, 0 to 3% slopes. "This soil occurs on smooth, broad interfluves" Foote *et al.*:124. "Wahiawa Series consists of well-drained soils on uplands on the island of O'ahu. These soils developed in residuum and old alluvium derived from basic igneous rock. They are nearly level to moderately steep. Elevations range from 500 to 1,200 feet. Rainfall amounts to 40 to 60 inches annually;

most of it occurs between November and April ... These soils are used for sugarcane, pineapple, pasture and homesites" (*Ibid.*:124).

Three of the project parcels - Koa Ridge Makai, Koa Ridge Mauka and Waiawa - have Wahiawa silty clay, 3 to 8% slopes. " On this soil, runoff is slow and the erosion hazard is slight. Included in mapping were small areas of nearly level soil" (*Ibid.*:125).

Only one parcel, Koa Ridge Makai, has Wahiawa silty clay, 8 to 15% slopes. On this soil, runoff is medium and the erosion hazard is moderate. Included in mapping were small areas that are stony and eroded. This soil is used for sugarcane and pineapple" (*Ibid.*:125)

The Waiawa Parcel only has these two Wahiawa Series of soils.

Three of the project parcels, Koa Ridge Makai and Mauka, and Kipapa Ridge, have Manana Series. "Manana Series consists of well-drained soils on uplands on the island of O'ahu. These soils developed in material weathered from basic igneous rock. They are gently sloping to steep. Elevations range from 500 to 1,200 feet. The annual rainfall amounts to 40 to 60 inches. It is well distributed throughout the year ... These soils are used for sugarcane, pineapple, and pasture". (*Ibid.*:94) All three have Manana silty clay, 3 to 8% slopes. On this soil, runoff is slow and the erosion hazard is slight. The depth to the panlike sheet is 30 to 50 inches. This soil is used for sugarcane and pineapple" (*Ibid.*:94-95).

Two of the project areas, Koa Ridge Mauka and Makai, have " Manana silty clay loam, 6 to 12% slopes. "This soil is on smooth slopes in the uplands ... This soil is used for sugarcane, pineapple, and pasture" (*Ibid.*:94).

Koa Ridge Mauka Parcel has three additional soil types: Manana silty clay loam, 2 to 6% slopes; Manana silty clay loam, 12 to 25% slopes, eroded; and Paaloa silty clay, 3 to 12% slopes. On Manana silty clay loam, 2 to 6% slopes, "runoff is slow and the erosion

hazard is slight" (*Ibid.*:94). Manana silty clay loam, 12 to 25% slopes, eroded "is similar to Manana silty clay loam, 6 to 12% slopes, except that it is moderately steep "(*Ibid.*:94). Both these soil types "were used for sugarcane, pineapple, and pasture" (*Ibid*:94). Paaloa silty clay, 3 to 12%. The Paaloa Series "consists of well-drained soils on uplands on the island of O'ahu. These soils developed in old alluvium and residuum derived from basic igneous rock. They are gently to moderately sloping. Elevations range from 1,000 to 1,700 feet. The annual rainfall amounts to 70 to 90 inches and is fairly well distributed throughout the year... These soils are used primarily for pasture and sugarcane. Small areas are used for homesites and pineapple" (*Ibid.*:106). " Paaloa silty clay, 3 to 12% slopes "occurs as narrow areas bounded by steep gulches. The slope range is 3 to 12%, but in most places it is 3 to 8%. The slopes are smooth...Permeability is moderately rapid. Runoff is slow to medium, and the erosion hazard is slight to moderate" (*Ibid.*:106).

Koa Ridge Makai, at its lower edge, has a small area of Lahaina silty clay, 7 to 15% slopes, severely eroded, at the lower edge of the parcel. Lahaina series "consists of well-drained soils on uplands on the islands of Lanai, Maui, Molokai, and Oahu. These soils developed in material weathered from basic igneous rock. They are nearly level to steep. Elevations range from 10 to 1,500 ft. The annual rainfall amounts to 20 to 35 inches, most of which occurs in fall and winter" (*Ibid.*:79). "Lahaina silty clay, 7 to 15% slopes, severely eroded "has a profile like that of Lahaina silty clay, 3 to 7% slopes, except that most of the surface layer and, in places, part of the subsoil have been removed by erosion. Runoff is medium, and the erosion hazard is severe. Included in mapping were small blowout spots and gullies and small, very stony areas that are eroded to weathered rock" (*Ibid.*:79).

C. Vegetation

Edward V. Hosaka's research "Ecological and Floristic studies in Kipapa Gulch, Oahu" divides the vegetation of Kipapa Gulch, which runs the length of Waipio Ahupua'a into 6 plant zones: maritime zone, *haole koa* zone, guava zone, *koa* zone, *'ōhi'a* zone, and cloud zone. (Hosaka:1937).

The project parcels fall mostly in the *haole koa* zone, and guava zone. The uppermost portion of the Koa Ridge Mauka Parcel touches the *koa* zone. Plants in the haole koa zone are "predominately xeophytic" and include *Opuntia megacantha* (*Panini*, prickly pear cactus), *Acacia farnesiana* (klu), *Heteropogon contortus* (*pili*), *Lantana camara*, *Psidium guajava* (guava), *Cassia lechenaultiana* and *Stachytarpheta jamaicensis* (*'oi*), *Leucaena leucocephala* (*koa haole*) and *Waltheria indica* (*'uhaloa*). At the upper end of the zone is the native *Dodonaea viscosa* (*'a'ali'i*). (Hosaka 1937:201-2) "The vegetation of this zone is quite uniform, due to the dominance of the four common species; it may be classified as an Opuntia-Acacia-Heteropogon-Leucaena Community" (*Ibid.*:202). This zone can be compared with the *Lowland Dry Forest* of the *Manual of Flowering Plants* by Wagner, Herbst and Sohmer. "Virtually all of the native Lowland Dry Forests have been variously degraded or impacted by cattle and feral herbivores. As a consequence the more mesic examples have been invaded by alien shrubs such as lantana (*Lantana camara*), Christmas berry (*Schinus terebinthifolius*), and *koa haole* (*Leucaena leucocephala*)" (Wagner, *et al*, 1990:75).

The Guava Zone consists of a Psidium-Lantana Community with a uniform cover of *Psidium guajava* and *Lantana camara* which are found in mixtures and in pure stands. In the bottoms of some side gullies, one to five *Aleurites moluccana* (*kukui*) trees grow. At elevations above 152 meters in the Guava Zone, there is a difference of vegetation between north and the south facing slopes. Mentioned in the list of native plants found on

the north facing slope are *Pipturus albidus* (*mamaki*), *Dianella sandwicensis* (*'uki 'uki*), and *Santalum freycinetianum* (*'iliahi*), the native sandalwood.

The most characteristic features of the Koa Zone are the presence of pure stands of *Acacia koa* and *Dicranopteris linearis* (*uluhe*) which occupy the slopes and ridges, and *Aleurites moluccana* which occupies the bottom of the gulch and side gullies. *Syzygium malaccensis* (*'ohi'a 'ai*, or Mountain apple) is the most common associate of *Aleurites moluccana*. In areas where the *Dicranopteris linearis* has not spread, *Cordyline fruiticosa* (ti) and *Psidium guajava* are the common species. Under the tall trees, where the ground is moist, *Oplismenus hirtellus* (basketgrass), *Zingiber zerumbet* (shampoo ginger), and the ferns: *Marattia douglasii* (*pala*), *Dryopteris cyatheoides* and *Cibotium chamissoi* (*hāpu'u 'i'i*) are common. Under the *Psidium guajava* shrubs is the grass *Paspalum conjugatum*, and the fern *Nephrolepis exaltata*.

The guava zone and the koa zone equate to the *Koa (Acacia) Mesic Forest* of the *Manual of Flowering Plants* (Wagner *et al* 1990:81). "On Kaua'i, O'ahu, Moloka'i, Lāna'i, and West Maui, forests dominated by *koa* (*Acacia koa*) generally occur below *'Ōhi'a Lowland Wet Forests*, usually on leeward slopes...A dry to mesic subtype occurs on drier ridges of the Ko'olau Mountains, O'ahu, at 130-300 m elevation." (Wagner, et al:81) and it follows that the 'ohi'a zone falls in the Manual's *'Ōhi'a Lowland Wet Forest* (*ibid.*:90).

The vegetation of the Ohia Zone is predominantly mesophytic with *Metrosideros collina* (*'ōhi'a*) as the dominant and most characteristic species. Many other mesophytic native plants grow in this zone including *Touchardia latifolia* (*ōlonā*).

The Cloud Zone is above 600 meters in the cloud area and an open low scrubby moss-covered vegetation is found. One of the plants listed is *Pritchardia martii* (*loulu*).

The upper vegetation zones are interesting in regards to the subsistence patterns of the *ahupua'a* and the possible impact by the sandalwood trade. We find the following accounts in traditional sources regarding use of plants from the upper ridges and valleys of Waipio:

> The lowlands, bisected by ample streams, were ideal terrain for the cultivation of irrigated taro. The hinterland consisted of deep valleys running far back into the Ko'olau range. Between the valleys were ridges, with steep sides but a very gradual increase of altitude. The lower parts of the valley sides were excellent for the culture of yams and bananas. Farther inland grew the *'awa* for which the area was famous. The length or depth of the valleys and the gradual slope of the ridges made the inhabited lowlands much more distant from the *wao* here, or upland jungle, than was the case on the windward coast. Yet the *wao* here was more extensive, giving greater opportunity to forage for wild foods in famine time.
>
> The people needed this resource because 'Ewa, particularly its western part, got very little rain in the summer months when the trade winds dropped their moisture in the interior. Stream water for irrigation, however, was always abundant. (Handy 1972:469)
>
> ...In the interior was the same avifauna, including the birds whose feathers were prized for feather capes, helmets, and lei making. In fact this, with its spacious *wao* inland, was the region where these birds were most numerous. There were more extensive areas also where *wauke* and *mamaki*, which supplied bast for the making of tapa, grew in abundance. In fact, 'Ewa was famous for its *mamaki*. There was too, much *ōlona* grown in the interior, and wild bananas and yams flourished. (Handy:1972:470)
>
> Among the places where the *'o'o*, *'i'iwi* and other indigenous birds were caught was at Puuloa on Oahu. There the *'ō'ō*, *'i'iwi* and other birds gathered when the *noni* fruit ripened. They came down to feed and when the season was over the birds returned to the mountains. (Lahilahi Webb, Collection on Kahilis, Ms cited in Sterling & Summers 1978:45)
>
> Here is a wonderful thing about the land of Waipi'o. After a famine had raged in that land, the removal of new crops from the taro patches and gardens was prohibited until all of the people had gathered and the farmers had joined in thanks to the gods. This prohibition was called kapu *'ōhi'a* because, while the famine was upon the land, the people had lived on mountain apples (*'ōhi'a*), tis, yams, and other upland foods. ('Ī'ī:1959:76-77)
>
> ...From Waipi'o in 'Ewa and from some lands of Hawaii came tapas made of *mamaki* bark and 'ouholowai tapas from Ola'a and so forth... ('Ī'ī:1959:83)

Sandalwood must have had its impact on the people in the early 1800s. Remnants of the trees are still found today in these leeward slopes of 'Ewa District. "On the central plain of O'ahu (and perhaps elsewhere), large areas of grassland and dry forest were

burned to make the standing or fallen Sandalwood easier to find" (St. John 1947:18). "Sandalwood harvesters were often gone for several days, sometimes for weeks, in the mountains collecting sandalwood. Many died of exposure and other misfortunes in the cold, often damp uplands" (Merlin & VanRavenswaay 1990).

III. WAIPI'O *AHUPUA'A*: CULTURAL AND HISTORIC DOCUMENTATION WITH A NOTE ON WAIAWA *AHUPUA'A*

A. Pre-Contact to 1800

The greater portion of the present study area is located in the *ahupua'a* of Waipi'o which was a focus of Hawaiian settlement and activity on O'ahu during the centuries preceding western contact. "The populous dwelling place of the alii was formerly located on an east point of Waipio Peninsula known as Lepau" (McAllister 1933:106). The *ali'i* at Waipi'o - and the centrality of the 'Ewa district - are documented in the traditions of O'ahu, stretching back to the reign of Maweke during twelfth or thirteenth century:

> Maweke's three sons each controlled major districts of Oahu...One, Keaunui, was the most powerful, controlling Ewa and its satellite districts of Waianae and Waialua. At this time the island apparently was not unified...
>
> However, the descendants of the eldest of Maweke's sons (Mulielealii) did unify and become kings of the island. Mulielealii controlled Kona. Of his three eldest sons, Fornander...says Kumuhonua could have become *Moi* (king) of the entire island. If he did not, his immediate descendants did. His great-great-grandson Kapae-a-Lakona (or Lakona) was *Moi* of the island. Kumuhonua himself, controlled the vital Ewa District (and Waianae and Waialua); thus the power base of Oahu seems to have stayed in Ewa. (Cordy 1981:204)

The settlement of the *ali'i* of the 'Ewa district on the Waipi'o Peninsula likely paralleled the Hawaiians' development of the surrounding coastal resources; according to Handy and Handy:

> The salient feature of 'Ewa, and perhaps its most notable point of difference, is its spacious coastal plain, surrounding the deep bays ("lochs") of Pearl Harbor, which are actually the drowned seaward valleys of 'Ewa's main streams, Waikele and Waipi'o...
>
> These bays offered the most favorable locality in all the Hawaiian Islands for the building of fishponds and fish traps into which deep-sea fish came on the inflow of tidal waters...
>
> The primary reason for 'Ewa's prominence in history and as an *ali'i* stronghold was undoubtedly the existence of the great number of fishponds at different points around Pearl Harbor, which was 'Ewa territory. Two of the largest were on the [Waipio] peninsula, and another was at its northwest corner...(Handy and Handy 1972:470)

Other resources of the 'Ewa *ahupua'a*, including Waipi'o, were available to promote their settlement by an expanding population:

> The lowlands, bisected by ample streams, were ideal terrain for the cultivation of irrigated taro. The hinterland consisted of deep valleys running far back into the Ko'olau range. Between the valleys were ridges, with steep sides, but a very gradual increase of altitude. The lower parts of the valley sides were excellent for the culture of yams and bananas. Farther inland grew the *'awa* for which the area was famous. The length or depth of the valleys and the gradual slope of the ridges made the inhabited lowlands much more distant from the *wao*, or upland jungle, than was the case on the windward coast. Yet the *wao* here was more extensive, giving greater opportunity to forage for wild foods in famine time. (*Ibid.*:469)

The Handys characterize Waipi'o and its peninsula as "an ali'i stronghold" and traditions of the *ahupua'a* focus on it as the scene of battles by the *ali'i* from other islands for political control and conquest of O'ahu. Several accounts relate the "Battle of Kipapa" during the reign of the 15th century *mo'i* Mailikukahi, explaining how the gulch and stream in Waipi'o got their name; according to Abraham Fornander:

> I have before referred to the expedition by some Hawaii chiefs, Hilo-a-Lakapu, Hilo-a Hilo-Kapuhi, and Punaluu, joined by Luakoa of Maui, which invaded Oahu during the reign of Mailikukahi. It cannot be considered as a war between the two islands, but rather as a raid by some restless and turbulent Hawaii chiefs, whom the pacific temper of Mailikukahi and the wealthy condition of his island had emboldened to attempt the enterprise, as well as the eclat that would attend them if successful...The invading force landed at first at Waikiki, but, for reasons not stated in the legend, altered their mind, and proceeded up the Ewa lagoon and marched inland. At Waikakalaua they met Mailikukahi with his forces, and a sanguinary battle ensued. The fight continued from there to Kipapa gulch. The invaders were thoroughly defeated, and the gulch is said to have been literally paved with the corpses of the slain, and received its name, "Kipapa", from this circumstance. Punaluu was slain on the plain which bears his name, the fugitives were pursued as far as Waimano, and the head of Hilo was cut off and carried in triumph to Honouliuli, and stuck up at a place still called Poo-Hilo. (cited in Sterling and Summers 1978:20)

During the second half of the 18th century, Waipi'o again became a focus of political intrigue and warfare on O'ahu. In 1783, forces of the Maui chief Kahekili gained control of the island of O'ahu by defeating the *mo'i* Kahahana, "from the powerful Ewa chiefs' line" (Cordy 1981:207). According to the pioneer 19th-century Hawaiian historian

Samuel Kamakau, the defeated O'ahu chiefs laid

> a plot...to murder the chiefs of Maui. . .Those in the plot were the chiefs Elani, Pupuka, Maka'i-oulu, Kona-manu, Ka-lake-o'o-nui, and a great many others. Waipi'o in 'Ewa as the center of the plot got the name of "Waipi'o of secret rebellion" (Waipi'o *kimopo*). (Kamakau 1961:138)

The plot failed

> ...and when Ka-hekili learned that Elani of 'Ewa was one of the plotters, the districts of Kona and 'Ewa were attacked and men, women, and children were massacred, until the streams of Makaho and Niuhelewai in Kona and of Kahoa'ai'ai in 'Ewa were choked with the bodies of the dead, and their waters became bitter to the taste, as eyewitnesses say, from the brains that turned the water bitter. All the Oahu chiefs were killed and the chiefesses tortured. (*Ibid.*:138)

If Kamakau is correct, the population of Waipi'o would have been decimated during the 1780s. "The Oahu society never rose again" (Cordy 1981:208).

Kahekili and the Maui chiefs retained control of O'ahu until the 1790s. Kahekili died at Waikiki in 1794. His son, Kalanikapule, was defeated the following year at the battle of Nu'uanu by Kamehameha, who distributed the O'ahu lands - including Waipi'o *ahupua'a* among his favorites: "...land belonging to the old chiefs was given to strange chiefs and that of old residents on the land to their companies of soldiers, leaving the old settled families destitute" (Kamakau 1961:376-377).

B. 1800s to 1850

During much of the 19th century, Waipi'o *ahupua'a* is associated with John Papa 'Ī'ī, a significant figure and chronicler of the Hawaiian kingdom. In an account of his birth, 'Ī'ī records the establishment of his family at Waipi'o after the ascendancy of Kamehameha on Oahu:

> John Papa Ii was born in Kumelewai, Waipio, in Ewa, Oahu, on the third day of August (Hilinehu in the Hawaiian calendar) in 1800, on the land of Papa Ii, whose namesake he was. Papa ['Ī'ī's uncle] was the owner of the pond of Hanaloa and two other pieces of property, all of which he had received from Kamehameha, as did others who lived on that *ahupua'a*, or land division, after the battle of Nuuanu. He gave the property to his *kaikuahine*, who was the mother of the aforementioned boy. ('Ī'ī 1959:20)

'Ī'ī's writings, collected in *Fragments of Hawaiian History*, provide glimpses of life within Waipi'o *ahupua'a* during 'Ī'ī's lifetime. 'Ī'ī records that in "late 1803, or early 1804," Kamehameha was "living with the chiefs at Halaulani, Waipio, Ewa"; during that time the king "became ill" but "recovered under the treatment of Papa, his medical Kahuna [and] returned to Honolulu, having boarded the canoe at Miki in Waikele" (*Ibid.*:33). Kamehameha also appears in an account of a journey with his heir Liholiho and their entourage which describes the *ahupua'a* resources that could be procured at the behest of the *ali'i*:

> It was at this time [during 'Ī'ī's youth] that the king, chiefs, and court members left Honolulu and sailed by canoe to Waianae. Liholiho, the heir to the kingdom, went overland with Papa and others from Honolulu and spent the night at Kumelewai in Ewa. Before the company arrived for the night, Ii was sent with a message to the dwellers of the land [Waipio] to be ready with fish, dogs, vegetable food, and clothing that would be of help to the travelers. Thus were all things supplied from upper Waipio to the sea. There was enough for the traveling company of the young chief, who was spending the night there. (*Ibid.*:23)

'Ī'ī mentions the "family [going] to Kīpapa from Kumelewai by way of upper Waipio to make ditches for the farms" (*Ibid.*:28) and recalls that, during the visit to O'ahu by the Kauai chief Kaumualii and his entourage, the chief's attendants were provided with gifts that included "from Waipio in Ewa and from some lands of Hawaii came tapa made of *mamaki* bark" (*Ibid.*:83). 'Ī'ī notes how a period of famine was managed in Waipio and what resources were available during the famine:

> Here is a wonderful thing about the land of Waipio. After a famine had raged in that land, the removal of new crops from the taro patches and gardens was prohibited until all of the people had gathered and the farmers had joined in thanks to the gods. This prohibition was called *kapu 'ohi'a* because, while the famine was upon the land, the people had lived on mountain apples (*'ohi'a 'ai*), tis, yams, and other upland foods. On the morning of Kane an offering of taro greens and other things was made to remove the *'ohi'a* prohibition, after which each farmer took of his own crops for the needs of his family. (*Ibid.*:77)

Also during the first half of the 19th century, western visitors begin to describe the 'Ewa landscape at Pearl Harbor as it had been developed by the Hawaiians by the early decades of western contact. Archibald Campbell, travelling through 'Ewa in 1809, recorded:

> We passed by footpaths winding through an extensive and fertile plain, the whole of which is in the highest state of cultivation. Every stream was carefully embanked, to supply water for taro beds. Where there was no water, the land was under crops of yams and sweet potatoes. The roads and numerous houses are shaded by cocoa-nut trees, and the sides of the mountains are covered with wood to a great height. (Campbell 1967:103)

The botanist F.J.F. Meyen, visiting in 1831, confirms the profusion - that surely included the *makai* lands of Waipi'o - described by Campbell:

> At the mouth of the Pearl River the ground has such a slight elevation, that at high tide the ocean encroaches far into the river, helping to form small lakes which are so deep, that the long boats from the ocean can penetrate far upstream. All around these water basins the land is extraordinarily low but also exceedingly fertile and nowhere else on the whole island of Oahu are such large and continuous stretches of land cultivated. The taro fields, the banana plantations, the plantations of sugar cane are immeasurable. (Meyen 1981:63)

A contrasting picture of 'Ewa is recorded in the missionary William Ellis' description from 1823-24 of the 'Ewa lands away from the coast:

> The plain of Eva is nearly twenty miles in length, from the Pearl River to Waiarua, and in some parts nine or ten miles across. The soil is fertile, and watered by a number of rivulets, which wind their way along the deep water-courses that intersect its surface, and empty themselves into the sea. Though capable of a high state of improvement, a very small portion of it is enclosed or under any kind of culture, and in travelling across it, scarce a habitation is to be seen. (Ellis 1963:7)

Despite Ellis' impression of a desuetude and lack of people in the more *mauka* reaches of 'Ewa, there is evidence that the population of Waipi'o during the early 19th century was not focused solely amidst the abundance at the coast; Kamakau notes, in an inventory of advances in education during the reign of Kamehameha III (from 1825 to 1854):

> Schools were built in the mountains and in the crowded settlements. Waipi'o had school houses near the coast and in the uplands. (Kamakau 1961:424)

The placement of a school "in the uplands" of Waipi'o suggests that some portion of the *ahupua'a's* population was settled there.

Censuses taken by Protestant missionaries throughout the Hawaiian islands beginning in 1831 provide the earliest record of the size of the native population after the first decades of western contact. In the 1831-32 census of O'ahu, a population of 913 is recorded within Wahiawa and Waipi'o *ahupua'a*. Three years later, in 1835, 513 individuals were recorded in Waipi'o alone (Schmitt 1973:19,22).

By the late 1840s, approximately 300 persons were listed as living in Waipi'o *ahupua'a*. This population figure is documented in records of the 1840s for the Great *Mahele*. The Organic acts of 1845 and 1846 initiated the process of the *mahele* - the division of Hawaiian lands - which introduced private property into Hawaiian society. In 1848 the crown and the *ali'i* (royalty) received their land titles. The common people received their *kuleana* (individual parcels) in 1850. It is through records for Land Commission Awards (LCAs) generated at the *mahele* that the first specific documentation of life in Waipi'o *ahupua'a*, as it had evolved up to the mid-19th century, come to light.

John Papa 'Ī'ī was awarded most of the *ahupua'a* of Waipi'o - in LCA 8241 - comprising approximately 20,540 acres. Included in the documentation for 'Ī'ī's award is a list of "the people living on the land of Waipio Ewa" in 1848 (Native Register vol.5:512-517).

A substantial award within the *ahupua'a* went to Abenera Pākī, the father of Bernice Pauahi Bishop. Part of LCA 10613 to Pākī comprised the 350 acres of the *'ili* of Hanaloa:

> Abenera Pākī (age forty) as a grandson of Kamehamehanui, a former Māui *Mō'ī*, and brother of the great Kahekili, was an *Ali'i Nui* by Māui standards, but he was not closely related to Kamehameha. Therefore, he held only 9 *'Āina* before the *Māhele*: 6 on O'ahu [including Hanaloa *'ili*], 1 on Māui, 1 on Moloka'i, and 1 on Kaua'i...

Pākī was treated very well by the *Mōʻī*: only 33 percent of his *ʻĀina* were taken. His remaining property included valuable Oʻahu *ʻĀina*: the entire *ahupuaʻa* of Heʻeʻia in Koʻolaupoko, the *ʻili* of Waialae in Waikīkī, and the *ʻili* of Hanaloa in Waipiʻo, ʻEwa. (Kameʻeleihiwa 1992:267)

Also receiving a land award (LCA 2937) in Waipiʻo was William Harbottle who claimed 2 acres at Hanapouli *ʻili*.

The remaining land claims - totalling 99 (not all of which were awarded) - documented in the records are for *kuleana* worked and lived upon by the Hawaiians of Waipiʻo. Predominant among the claimed land usages in Waipiʻo are 312 *loʻi*, irrigated taro patches, of various sizes; and 43 *moʻo* or fields comprising indeterminate numbers of *loʻi*. Clearly, wetland taro cultivation was the primary agricultural pursuit within the *ahupuaʻa* at mid-19th century, likely reflecting a long history of taro farming. At the coast, 4 fishponds are claimed. In the more *mauka* reaches of Waipiʻo, 53 claims were made for portions of *kula* (pasture land) and 25 for "*okipu*" or *ʻokipuʻu* (forest clearing).

Historic maps and modern tax maps show the great majority of the awarded land parcels located in the *makai* portions of Waipiʻo, at or just above the peninsula. However, there were 19 claims describing land use in upper Waipiʻo or "Waipio Uka". Eleven of these claims were awarded. Locations of these awards are shown on a modern tax map which also shows the locations of the present study parcels (Figure 5). All of the awards are located in Kīpapa Gulch. Table 1 below presents, among other information, the land usages indicated for these *mauka* parcels - or *apana* - from all 19 claims. Clearly, the *moʻo* claims and the 1 *loʻi* claim (LCA 8241T) are associated with the parcels shown on the map located along Kīpapa Stream in the gulch. The "house lot" and "house" claims indicate that Hawaiians continued to live in *mauka* Waipiʻo during the mid-19th century. Also noteworthy are the claims for "*kula*" or pasture land; exact locations of these *kula* have not been identified.

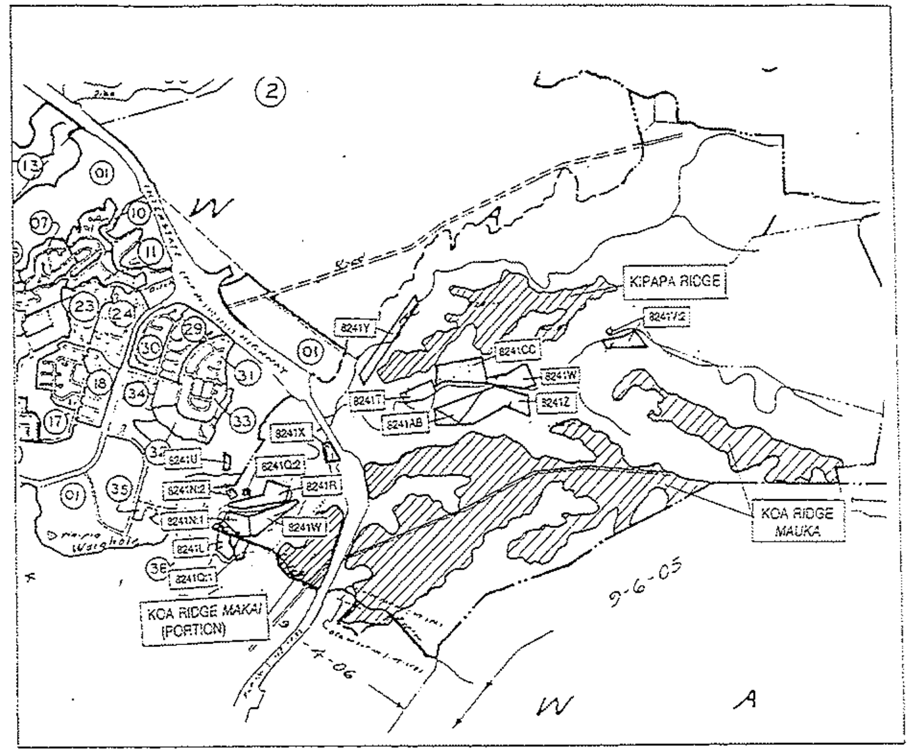


Figure 5 Tax map showing locations of Land Commission Awards and present study parcels in Upper Waipiʻo

Table 1: Waipio Uka Land Use in Land Commission Award Records

LCA#	Claimant	Ili of Waipio	Land Use	Apana in claim	Apana & Acreage awarded
No number [por 8241 N.R.]	Kaualelehuna	Walepoai in Waipio uka	Moo, kula, house lot, 1 house, a ravine & 2 okipu	3	not awarded
No number	Koikoi	Kamanuiki in Waipio uka	portion of valley and stream	1	not awarded
8241L	Mokunui	(no Foreign Testimony found)	1 mo'o, 1 kula, 1 house lot, 1 house	1?	Waipiouka Kamalokauhola 1 ap. .54 Acs.
8241N	Ukeke	Maheu Waipio uka	1 mo'o, 1 kula, house lot, house 2 okipu of mountain taro	3	Maheu 1 ap. 5.507 Acs; Waipiouka 1 ap. .9 Acs.
8241R	Meahale	Waipio uka	1 mo'o, 1 kula, house lot, 2 houses	1?	Waipio uka Waiakapuaa 1 ap. 6.882 Acs.
8241Q	Kamakahi	Waianeki in Waipio uka	1 mo'o, 1 kula, house lot, 1 house, 2 okipu in 1 piece	1	Waianeki 1 ap. .256 acs.
8241T	Kailio	Waipio uka	1 mo'o, 1 lo'i, houselot, 2 houses	1	Waipio Uka Kaneulupo 1 ap. 5.665 Acs.
8241U	Kailihao	Waipio uka	1 mo'o, 1 kula, houselot, 1 house	1	Pupuka 1 ap. 3.804 Acs.
8241V	Kauluoaiwi	Honowaka in Waipio uka	1 mo'o, 1 kula, houselot, 1 house	1	Hanauaka 1 ap. .256 Acs.; Waipiouka 1 ap. 5.475 Acs
8241W	Kaneakauhi	Waipio uka	1 mo'o, 1 kula, houselot, 1 house	1	Waipio uka Kaohi 1 ap. 8.162 Acs.

LCA#	Claimant	Ili of Waipio	Land Use	Apana in claim	Apana & Acreage awarded
8241Z	Kaioe	Moakea & Puulu & Palikea in Waipio uka	1 mo'o, 1 kula, houselot, 1 house	3	Puulu 1 ap. 18.72 acs
8241AB	Kaioe				see 8241Z
8241CC	Poupou	Waipio uka	1 mo'o, 1 kula, houselot, 1 house	1	Waipio uka Papa 1 ap. 14.38 acs.
8241UU	Kalaiku	Kelepua in Waipio uka	1 mo'o, 1 kula, houselot, 2 houses (okipu)	1	Lelepua 1 ap. 13.15 Acs.
9361B	Kaimileihonua	Waipio uka	1 mo'o, 1 kula, houselot, 2 houses	1	not awarded
11205	Kalaiku	Waipio uka			not awarded; See 8241UU
11206	Kanealu/ Kanealii	land in the mountain called Kahaikei & Luanui	1 mo'o, 1 kula, houselot, 1 house	2	not awarded
11207	Naniu	Liloa & Kamae Waipio uka	1 mo'o, 1 kula, houselot, 1 house, mountain kalo land	2	not awarded
11208	Kaopuana	Kahalo & Kepooakaholu a Waipio uka	1 mo'o, 1 kula, houselot, 1 house	2	not awarded
11209	Kawaihae	Kaluahine & Kanewahine, Waipio uka	1 mo'o, 1 kula, houselot, 1 house, okipu	2	not awarded
11210	Kaluehinue	Kauloa, Waipio uka	1 okipu	2	not awarded
11211	Poupou	Papa in Waipio uka	1 mo'o, 1 kula, 1 houselot, 1 house	2	not awarded; See 8241CC

A document of the 1840s suggests that portions of the present study parcels were then used for grazing of livestock. In a petition dated June 2, 1847 to John Young, Minister of the Interior, some of these residents of Waipi'o Uka "who have held the land since time of Kamehameha" requested action "against stray animals" (Hawai'i State Archives). These strays were likely from herds of cattle and goats being grazed on the flat *kula* lands of Waipi'o which would have included portions of the present study parcels (see Figure 6 below). The raising of cattle in 'Ewa, begun in the 1830s, would have consequences during the remainder of the 19th century beyond the aggravation of stray animals disturbing the farm lands of people like the Waipi'o Uka residents; as the surveyor Serrano Bishop noted in a memoir of 'Ewa:

> The subsequent occupation of the uplands by cattle denuded the country of herbiage, and caused vast quantities of earth to be washed down by storms into the lagoons, shoaling the water for a long distance seaward. Bishop 1901:87)

C. 1850s to 1900

During most of the second half of the 19th century, new developments in Waipi'o would be confined to the flat lands of and just above the peninsula. Beginning in the 1860s, rice cultivation would displace taro upon the Waipi'o landscape, reflecting the influx of Chinese immigrants to the Hawaiian Islands.

As sugar plantations were developed and expanded in the islands during the middle decades of the 19th century, the need for increased numbers of field laborers prompted passage of contract labor laws. By mid-century, the first Chinese contract laborers arrived in the Hawaiian kingdom. Contracts were for five years and pay was $3 a month plus room and board. Upon completion of their contracts, a number of the immigrants remained in the islands, many becoming merchants or rice farmers.

The Hawaiian islands were well-positioned for rice cultivation. A market for rice in California had developed as increasing numbers of Chinese laborers immigrated there. Similarly, as Chinese immigration to the islands also accelerated, a domestic market opened. Typically, groups of Chinese began leasing or purchasing former taro lands for conversion to rice farming. Sadly, the taro lands' availability throughout the islands in the second half of the 19th century reflected the declining demand for taro as the native Hawaiian population diminished. At Halawa *ahupua'a* in 'Ewa, most of the taro *lo'i* had already been replaced by rice fields in the 1860s (Klieger 1995:78) and it is likely that a similar displacement was taking place at Waipi'o during that period.

An 1877 map of Waipi'o *ahupua'a* (Figure 6), compiled by J.F. Brown, shows the fishponds still present at Waipi'o peninsula and the *mauka* lands, including the present study parcels, are labelled "smooth grassy plain" and "grassy plain," suggesting suitable areas for the grazing of livestock. After John Papa 'Ī'ī's death in 1870, his estate - including the Waipi'o lands - was inherited by his daughter Irene 'Ī'ī Brown. Shortly after, small parcels within the *ahupua'a* were sold off, "including a portion to James Robinson and Co. in September 1871" (in Riford 1986:22). It would not be until the late 1890s that large tracts of Waipi'o land would be leased for large-scale commercial agriculture.

The newly organized Oahu Sugar Company, an "annexation plantation, a direct promotion of Benjamin F. Dillingham" (Conde and Best 1973:313), leased 3,400 acres of the *mauka* portion of Waipi'o from the 'Ī'ī estate in 1897. A few years earlier, the Oahu Railway and Land Co. (O.R. & L.) had leased a tract through Kīpapa Gulch to transport sugar and pineapple from Wahiawā to Honolulu. The growth of sugar and pineapple in Waipi'o would comprise the major transformation of the present study parcels during the 20th century.

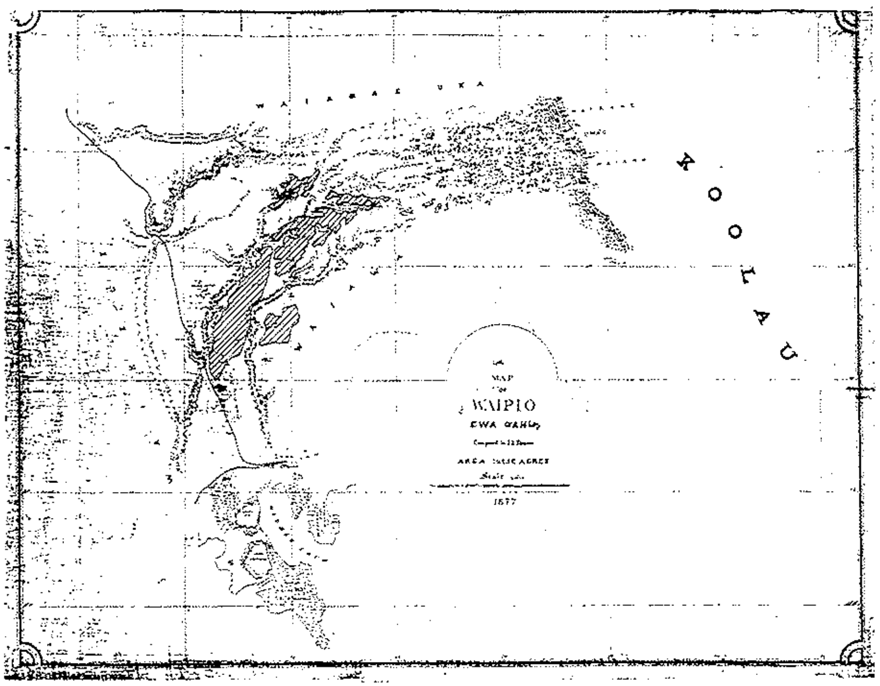


Figure 6 1877 map of Waipi'o *Ahupua'a* showing approximate locations of present study parcels

D. 1900s to Present

The beginning of the century saw the continuing growth of the Chinese presence in Waipi'o; an account of the period suggests the co-existence of rice and sugar fields upon the Waipi'o landscape:

> Hanaloa fishpond was operated as a family business by the Loo family from early in the twentieth century when they leased this property from the Ii Estate. Loo Chit Sam was the original lessee and he later transferred the lease and management of the fishpond to his younger brother Loo Goon...[Loo Goon's] wife, Loo Luke Sun, was born at Halawa, Hawaii...Oi Yung [Loo Luke Sun's daughter] remembers that her mother learned to drive a car out of necessity in order to get to the fishpond from Honolulu and recalls riding there with her younger sister through the cane and rice fields that grew between the pond and the end o Depot Road in Waipahu. (Loo in Char and Char 1988:204)

At the start of the century, the U.S. Government commenced acquiring the coastal lands of 'Ewa for the development of a naval base at Pearl Harbor. In 1909 the government obtained Waipi'o peninsula by condemnation from the 'Ī'ī estate; the land was valued at $10,000.

During the next decade, the *mauka* lands of Waipi'o would be the site of a portion of a major undertaking. In 1913 a project began to transport water from the windward side of O'ahu through the Ko'olau Range to irrigate the fields and mill of the Oahu Sugar Company in 'Ewa. The Waiāhole Water Company, a subsidiary of Oahu Sugar, created the Waiāhole Ditch System that was "an engineering feat of epic proportion for those times" (Conde and Best 1973:37). The original system, when completed, included 27 tunnels connecting with 37 stream intakes on the north side of the Ko'olau, with the main bore through Waiāhole Valley, then connecting it to the 14 tunnels on the southern side of the Ko'olau, and thence by ditch westward to Honouliuli, covering a total of 13.6 kilometers (*Ibid.*). The ditch system was completed in 1916, and with some modifications is still in use. It is included on the state inventory of archaeological sites as State site no.

50-80-09-2268. (The ditch crosses Waipi'o *ahupua'a* through the present "Koa Ridge *Makai*" and "Koa Ridge *Mauka*" parcels.)

Two maps of the 1920s show the development of sugar and pineapple within Waipi'o and the present study parcels. A 1925 map shows the extent of the Oahu Sugar Company fields of the Oahu Sugar Company fields within Waipi'o and the neighboring *ahupua'a* (Figure 7). Indicated on the map is the portion of the present "Koa Ridge *Makai*" parcel and the "Waiawa" parcel then planted in sugar cane. Also from the 1920s, a Fire Control Map of 1922 shows structures and transportation networks within the entire *ahupua'a* of Waipi'o (Figures 8 & 9). Indicated on the map are the approximate locations of the present study parcels.

A photograph (*ca.* 1920s) from the Bishop Museum Archives is labelled "Aerial view of upper Kipapa Gulch, Oahu" (Figure 10). Although it is difficult to determine the precise Waipi'o locations shown in the photograph, it does show flat plateaus almost completely planted in pineapple.

In the 1930s, use of Waipi'o by the U.S. military extended well *mauka* of the peninsula at Pearl Harbor. The military began the appropriation of Kīpapa Gulch around 1938 and during World War II used the rail system to "haul large quantities of ammunition" (Conde and Best 1973:315). Also, in 1941, "on the day after the bombing of Pearl Harbor, Hanaloa fishpond was seized by the U.S. Navy and filled in" (Loo in Char and Char 1988:209). At the end of World War II, the military condemned the southern portions of Kīpapa Gulch for fuel and ammunition storage tunnels.

During the second half of the 20th century, growth in Waipi'o *ahupua'a* has focused on the development of Mililani Town by Castle & Cooke, Inc. through its subsidiary, Oceanic Properties, Inc. In 1964, the state Land Use Commission redesignated for urban use 705 acres of agricultural land in Waipi'o. The first increment

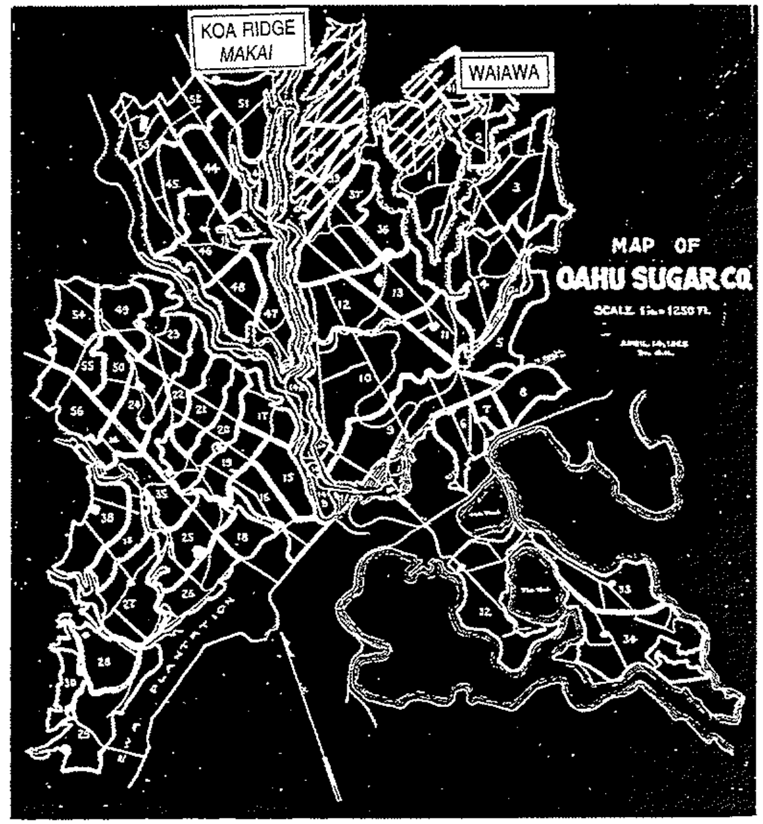


Figure 7 1925 map (in Conde and Best 1973:316) of Oahu Sugar Co. land showing fields comprising "Waiawa" and a portion of "Koa Ridge *Makai*" parcels (hatched)

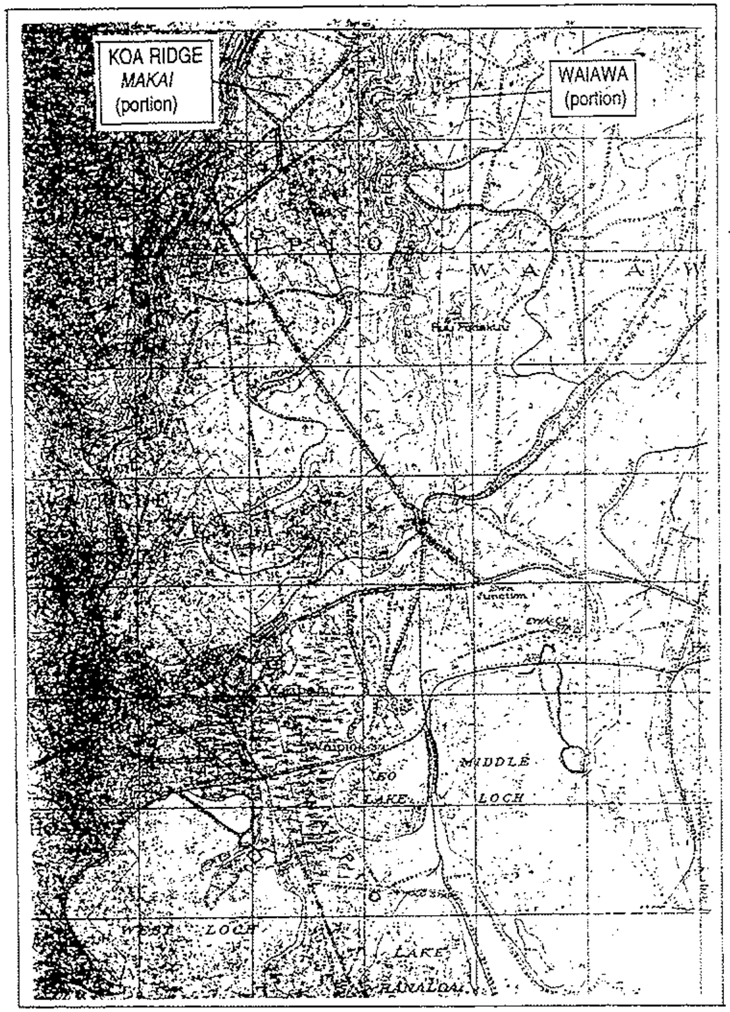


Figure 8 Portion of 1922 U.S. Army Corps of Engineers Fire Control Map (Pearl Harbor Sheet) showing locations of study parcels in *makai* portion of Waipi'o *ahupua'a*

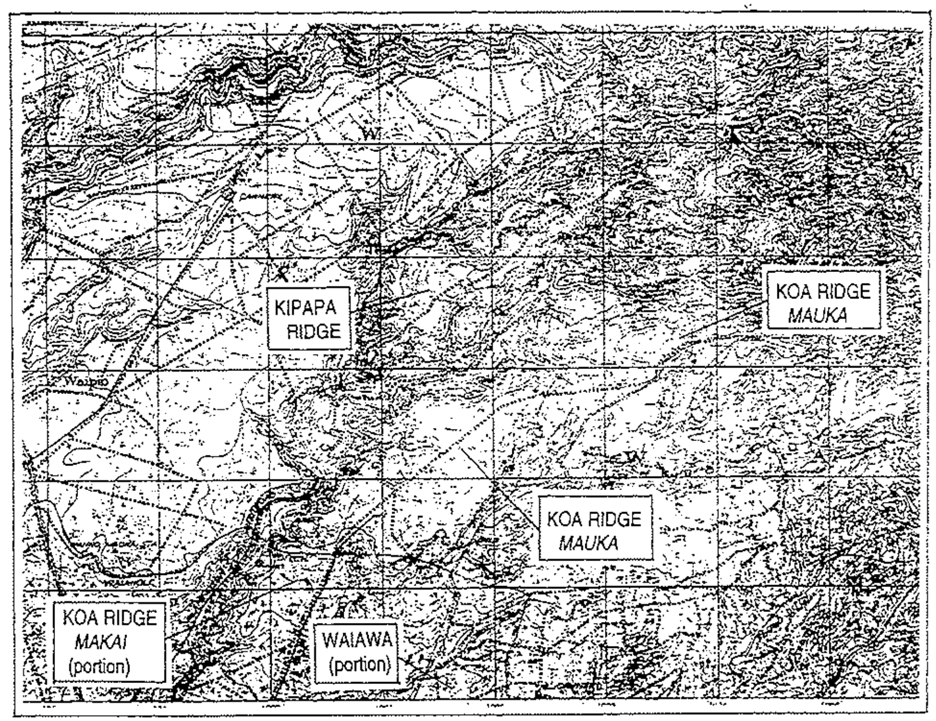


Figure 9 Portion of 1922 U.S. Army Corps of Engineers Fire Control Map (Wahiawa Sheet) showing locations of study parcels in *mauka* portion of Waipi'o *ahupua'a*

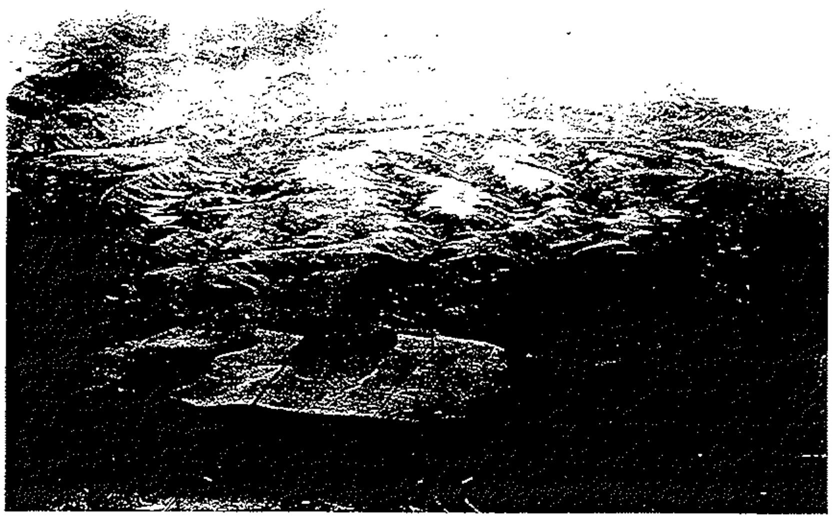


Figure 10 *Ca.* 1920s "Aerial view of upper Kipapa Gulch, Oahu" (Bishop Museum)

of Mililani Town opened in June 1968. In 1973 construction began on the H-2 freeway across Waipi'o, connecting Mililani to the H-1 freeway.

E. Waiawa *Ahupua'a*

A portion of one of the present study parcels - "Waiawa" - is located in Waiawa *ahupua'a* which bounds Waipi'o to the east. There are few traditional accounts related to Waiawa. One of these suggests that Waiawa may have been acknowledged in early times as the site of a special variety of *'awa*:

> ...When the wondrous maiden [Ke-ao-melemele] arrived at the entrance to the mountain of Konahuanui, all the offerings were in charge of Ke-anuenue, a puko'a or reddish brown pig, a clump of dark 'awa [pu'awa popolo] which was not common in these islands. This variety of 'awa now grows in the upland of Waiawa, down there in Ewa. (cited in Sterling and Summers 1978:19)

'Awa is also associated with Waiawa in another legend:

> ...it was here in 'Ewa that Kane and Kanaloa were invoked by a planter of sweet potatoes, taros, and *'awa* named Maihea. This man, living in the upland of Wai'awa, when he had prepared his meal and his *'awa*, would pray:
>
> O unknown gods of mine,
> Here are *'awa*, taro greens and sweet potatoes
> Raised by me, Maihea, the great farmer.
> Grant health to me, to my wife and to my son.
> Grant us *mana*, knowledge and skill.
> Amama. It is freed. (Handy and Handy 1972:472)

The first documentation specific to Waiawa appears in the records of the *Mahele* during the mid-19th century. Victoria Kamamalu was awarded the *ahupua'a* (LCA 7713). Also claiming and receiving land in Waiawa was the American Board of Commissioners for Foreign Missions: LCA 387 comprised 4.13 acres in the *makai* portion of Waiawa and included a salt pond, a *mo'o* for the church, and a house lot. Making the application was Artemis Bishop, the Protestant missionary stationed at 'Ewa from 1836-1856. Another claim by a non-Hawaiian was made by William Wallace in LCA 10942 which comprised

3.238 acres including a houselot, 2 *mo'o*, and 6 *lo'i*. The remaining 50 claims by 29 claimants in Waiawa were for *kuleana*; the claims included: 28 houselots, 176 taro *lo'i*, 20 fishponds, 23 *kula* or pasture, 8 *pauku 'auwai* [length of ditch], and 7 banana *kula*. Modern tax maps show the 30 claims actually awarded all located in the *makai* portion of the *ahupua'a*.

During the second half of the 19th century, Waiawa was passed on to successive members of the *ali'i*:

> Victoria Kamāmalu died in 1866 at the age of twenty-seven. Her entire estate was inherited by her father, Kekūanao'a. He died two years later and the estate went to Kekūanao'a's son Lota Kapuāiwa, who by that time reigned as Kamehameha V...Kapuāiwa died intestate in 1872, whereupon Ruta Ke'elikōlani, Kapuāiwa's half-sister, petitioned for and received in 1873 the entire estate...By 1883, Ruta Ke'elikōlani died, leaving all of her estate to her cousin Bernice Pauahi Bishop. (Kame'eleihiwa 1992:309-310)

(The Bernice Pauahi Bishop Estate presently retains ownership of most of the *ahupua'a*.)

Similar to neighboring Waipi'o, Waiawa in the twentieth century became the site of military and agricultural developments. As was indicated on the map above (see Figure 7), by the 1920s the "Waiawa" parcel of the present study area comprised fields of the Oahu Sugar Company.

F. Interview with Linda Mahoe Gallano

Mrs. Linda Mahoe Gallano, a teacher of the Hawaiian language at Wai'anae High School, and her husband have been caretakers since 1986 of the ranch house and grounds in the *mauka* portion of the Koa Ridge *Mauka* parcel. Mrs. Gallano, an avid hunter and student of Hawaiian culture, has hunted and hiked throughout the *mauka* reaches of Waipi'o and Waiawa *ahupua'a*, and has learned from long-time hunters and farmers of the area. She shared her knowledge of the area during an interview at the ranch on May

8, 1996 and, later, provided approximate locations of some of places mentioned during the interview on a map of upper Waipi'o and Waiawa *ahupua'a* (Figure 11).

Mrs. Gallano described her activities in the uplands and her sources of information:

> I first came up here in 1979. I've been here steady [as caretaker] since 1986. This was a ranch. [Randolph] Crossley had a working ranch here. So this was all levelled and then replanted with all these foreign trees because he had this aviary...But if you walk just a few steps back there, you're in *koa*, thick *koa*, and *'ōhi'a lehua*. [The ranch house and grounds are presently recreation center for Castle and Cooke employees.]
>
> I know the area but I'm always asking questions of other people. My two links to the past are Mr. Claude Ortiz of Pupukea and Sonny Nelson. Sonny Nelson of Wai'anae is an old time hunter of this area and he's hunted here from the 1930s on or the '40s at least.
>
> I started out hiking, but on my own, and then [learned from] listening to hunters. So I found my way up to the [Waiāhole] ditch from the old trail behind the houses...where you come up the hard way and you come out and there you are on top of the ditch trail from here, the Waiāhole ditch trail. And then I found my way across Kīpapa and some of the old trails back there. I've been to the summit a couple of times. We've been all over: Waiawa, Waiāhole, all the way back to the CCC [Civilian Conservation Corps] trail, the Swamp Gulch on the Waiawa side, all of Kīpapa, across from what they call Small Kīpapa, which probably has another name.

Noting that the hunters of the Kīpapa she knows reside elsewhere on O'ahu, Mrs. Gallano mentioned:

> You know once you hunt a ground, you feel comfortable hunting that ground because you know where all the *puka* and all the danger places are. I should ask Sonny why does he still come here and hunt. But these are known as his grounds. You talk to young hunters coming up: "Oh, Sonny Nelson, yeah this his grounds." He doesn't live here but they all have this respect: "Oh this is Sonny Nelson's territory."

Mrs. Gallano described some of the trees and plants she's noted in the gulches and on the ridges:

> I went with a botanist so I learned the names. There's *'iliahi* and there are tons of them on that Small Kīpapa Ridge over there. Of course there's *koa*, *'ōhi'a*, *lama*, and *'ahakea*, the one they make the gunnels of the canoe with. [The botanist] found an endemic *noni* that's supposed to be rare, because the Hawaiians brought the indigenous *noni* but this is the

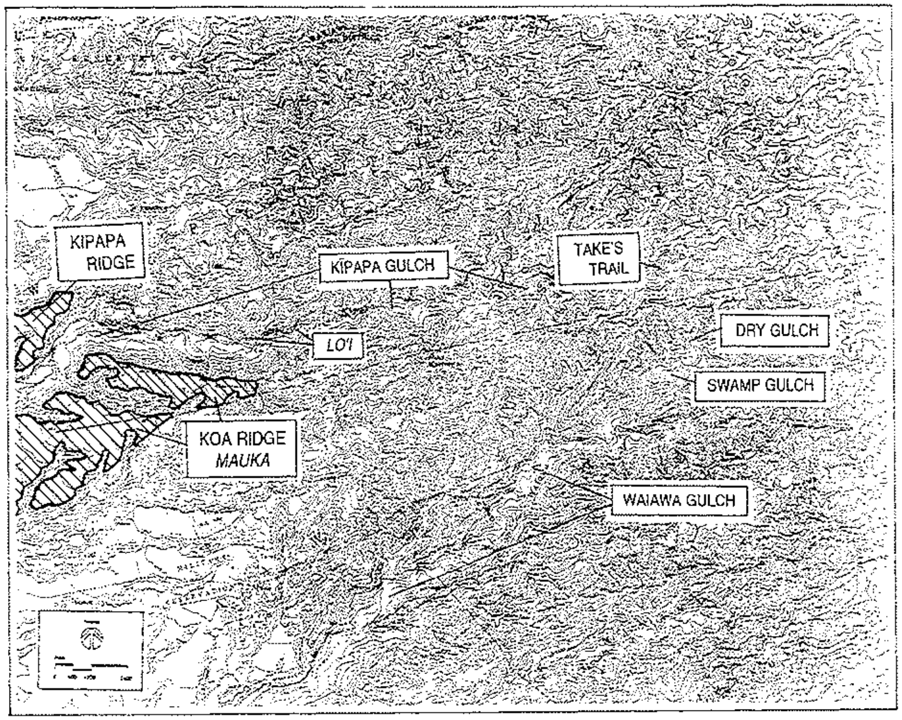


Figure 11 *Mauka* portion of Waipi'o and Waiawa *ahupua'a* showing locations of areas mentioned in interview with Mrs. Linda Mahoe Gallano

rare kind that was already here before the Hawaiians got here, so he's pretty excited about that. *Pepeiao*, of course. *'Ōhi'a 'ai*, rose apples. Pretty much everything that you'd find in a rain forest.

There's *'awa* in Waiawa.

[On the flats are] *pili* grass, *alahe'e*, *'a'ali'i*.

There is evidence of earlier 20th-century activity in upper Waiawa and Kīpapa gulches; in Waiawa Gulch:

There were bootleggers on the Waiawa side; you can still see the structures; you can still find bottles. I remember going in the 1970s and finding bottles but the bottle craze came in and a lot of stuff [disappeared]. I found a bottle not too long ago after a big rain.

Mrs. Gallano gave an account of a hermit who lived in the back of Kīpapa Gulch until the 1930s and mentioned the presence of taro *lo'i* in upper Kīpapa:

There was a Japanese man they called Old Man Take who had to have been born in the 1800s. He died around the 1930s. He lived in the back [of Kīpapa Gulch]. They called him a hermit; he was totally self-sufficient. He planted bananas, *'uala*.

They have a trail named after him: Take's Trail. The hunters say "Oh, I'll meet you at Take's." That's a trail about an hour in: you go in along the main CCC [Civilian Conservation Corps] trail - the ridge trail, the Kīpapa summit trail - you go along and all of a sudden there's a sharp left downhill and that's Take's Trail. And if you go down to the bottom it's all lush and you know it had a lot of stuff before. It's getting overgrown with some kind of foreign berry. But you can see where it's levelled off and flat and there's all kinds of good things to eat down there. So they say that's his trail, he made that trail, and that trail used to not come down this way, it used to straight over to this other big area where there are *lo'i*. So it's like he would go over this hill and there's big wide bowl that later farmers or somebody used as a reservoir because you can see where there are rocks. And then you can see *lo'i* all the way out. The only name I know for that is Swamp Gulch. [From here] it's an hour walking in and then it's a hard hike...Not really, to go into Swamp it's a hard *drop*. It's a hard hike coming back out, especially if you're packing pig.

There's a place way in the back they call "Buddha House" probably because it was his house. I don't know and I've never been there. That is really hard walking in; it's almost to the summit wall. He was a real hermit. They say he used to hunt boar with a club because he didn't have a gun. I don't think he wanted to do too much with society, only when he wanted to come down to the [plantation] camp, maybe to get coffee and sugar, or something like that.

Claude Ortiz used to go up there and bring him presents around the holiday time. Now Mr. Ortiz is in his 80s or late 70s and he remembers him from that time, 1930, but nobody remembers after that so they pretty much think he died [in the 1930s].

The discussion of Take's Trail brought up the question of the age of the Kīpapa trails:

I would think that the CCC trail was built on an old trail. And Take's Trail: if you look at that mountain the fern is horrendous so I wouldn't imagine he just set out and said "I'm going to hack a trail over this mountain"; probably there was something existing.

Mrs. Gallano has observed other taro *lo'i* in Kīpapa besides those mentioned in the account of the hermit:

In Kīpapa is where I found these little pockets...it looks they had to have *lo'i* in there. I asked some *kupuna* from Wai'anae, "Why would the Hawaiians put their *kalo* up there?" It is so hard to get to, especially some of the places way in. They said it was like an insurance policy, that if something killed off all their plants or if they had war they would have *kalo* in the mountains, they could always go and restore. They didn't have to care for it because it grew so well in the mountains. But the last time I went through this big *kalo* patch they had up there, it was all trampled by the pigs. I guess the pigs got hungry. So I guess it wasn't totally safe.

Mrs. Gallano discussed possible former habitation areas in Kīpapa and Waiawa gulches:

[One of the farmers in Kīpapa Gulch] was telling me that all these places up here along this river [in the gulch] where there are big mango trees that there were houses before. And there are not too many, the mango trees don't go far up. But they go far up in Waiawa, they go way in, because it's wider. But over here, Kīpapa, it just gets really narrow and then it splits and it's narrow on both sides. He just said there were houses, I don't know if he meant Hawaiian houses.

Kīpapa is narrow and there are places where it's narrow with these big rock walls so there'd be no escaping [a flood] if you lived in that kind of place but then there are other places where you find these mango trees that are on a bluff, about four or five feet high, and then it's flat for a while, not huge.

Mrs. Gallano described one such possible habitation area nearby in Kīpapa Gulch:

It's right down here, you drop down, you go right down across the river and there's this big mango tree and right next to it is an orange tree

and then there's this wide area that only has *'awapuhi* growing there. And there are rocks; you just know somebody lived there before. I had a *kupuna* come up once and he said they probably made *kapa* on this rock right there because it's right by this river so they could easily work on it but it's high enough the river that it's not going to get flooded.

Mrs. Gallano was told about other nearby evidence of Hawaiian activity in Kīpapa Gulch:

[One of the farmers] said they found (and I didn't ask him who is "they") *ulumaika* right down in that little pocket [of the gulch]. He said: "Oh, yeah, had plenty of Hawaiians living there before."

Summarizing the character of the area, Mrs. Gallano concluded:

Kīpapa is a very rough place. We always try to reciprocate so we tell the people we hunt with on the Big Island to come and hunt with us. And they'll hunt with us once and they'll go home and say: "We're never coming back." Because it's just too hard, it's very rugged. A lot of times we spend hanging on trees or just climbing and climbing.

Sometimes we have droughts. I have pictures of Kīpapa dry. Hunting pictures with the dogs standing in the river with big boulders all around them just looking like "Where's the water?"

IV. PREVIOUS ARCHAEOLOGICAL RESEARCH

A. Waipi'o *ahupua'a*

During a 1930 survey of O'ahu for the B.P. Bishop Museum, J. Gilbert McAllister identified seven sites in Waipi'o *ahupua'a* (McAllister 1933). Two of the sites comprise significant land areas: Site 124 ("the populous dwelling place of the alii...formerly located on an east point of Waipio Peninsula known as Lepau") and Site 132 (Waikakalaua and Kīpapa gulches). Two sites are fishponds at Waipi'o peninsula: Loko Eo (Site 123) and Hanaloa (Site 125). The remaining three sites are *heiau*: Site 122 - Ahuena *heiau* ("...just seaward of the Experiment Station of the Hawaiian Sugar Planters' Association"), Site 131 - *Heiau* o Umi ("just northeast of the government road at the bottom of Kipapa Gulch on the slight elevation at the foot of the pali on the Honolulu side"), and Site 130 - Moaula *heiau* ("on the Honolulu side of Kipapa Gulch just above the Heiau o Umi to which it is said to be a companion structure").

Since the 1970s, archaeological study in Waipi'o has focused on portions of Kīpapa Gulch. The Bishop Museum conducted a reconnaissance level survey of "all lands owned or controlled by the Army within the State of Hawai'i" (Rosendahl 1977). This survey included 118.56 acres of the total 659.54 acres of the Kīpapa Ammunition Storage Installation. The survey located three previously unrecorded sites:

Site 50-80-09-9529:	"Kīpapa Historic Occupation Complex"
Site 50-80-09-9530:	"Kīpapa Platform and Terraces, consisting of a crude platform, of stacked stone and terraces, which are possibly of the dryland agricultural type
Site 50-80-09-9534:	"a large platform"

The survey also confirmed the destruction of the two *heiau* sites in Kīpapa Gulch recorded by McAllister.

In 1977, during construction of the new H-2 Kīpapa Bridge, a bulldozer operator

noticed rock terracing. William Kikuchi investigated and reported that the terracing appeared to be "probable historic agricultural features." The site, designated 50-80-09-531, was identified as "Kīpapa *Kuleana*." Construction of footing for the bridge destroyed the features (State Historic Preservation Division files).

In 1985 the Bishop Museum, under contract with the Department of the Navy, conducted an archaeological survey of portions of the Waikele Branch of the Lualualei Naval Magazine" (Riford 1986). This survey covered portions of Kīpapa and Waikakalaua Gulches. No sites were recorded in the Kīpapa portion of the survey, though "three shelters were observed and examined along the eastern cliff face of Kīpapa Gulch...None of the examined shelters contained cultural material" (*Ibid.*:52). Three shelters, outside the project area, were also observed on the western cliff face of the gulch.

In 1988, Cultural Surveys Hawaii conducted a reconnaissance survey of approximately 371 acres within the Kīpapa Military Reservation (Hammatt and Borthwick 1988). Three sites - those previously recorded in the Bishop Museum inventory of military lands (above) - were documented:

> All three are assigned to the historic era. Upper Kīpapa site, State site 50-80-09-9529 is considered to be a laborers' camp associated with construction of a nearby Waiahole Water Company Siphon. Subsurface testing showed no earlier buried cultural layers. Upper Kīpapa Site 2 (9530) is the remains of the O'ahu Sugar Co. Weir Station and is the intake for a dressed stone ditch constructed during the 1930's...The one site located in Lower Kīpapa (9534) a platform shaped structure is considered a sugar company stone pile. (Hammatt and Borthwick 1988:i)

In 1989 Cultural Surveys Hawaii conducted an archaeological reconnaissance survey of a 1,700-foot long and 100-foot wide proposed drainage channel route along the northwestern slopes of Kīpapa Gulch, immediately north of the Kīpapa Military Reservation (Hammatt *et al.* 1989). The area had been heavily impacted by construction of the H-2 Highway Bridge and no archaeological remains were observed.

B. Waiawa *ahupua'a*

During McAllister's 1930 survey of O'ahu for the B.P. Bishop Museum, four sites were identified in Waiawa *ahupua'a* (McAllister 1933). The sites included three fishponds at Pearl City Peninsula and, *mauka*, Puoiki *heiau* (Site 121) "at the juncture of Manana and Waiawa gulches" of which "there are no remains" (*Ibid.*:105).

In the 1970s, the Bishop Museum conducted a reconnaissance level survey of "all lands owned or controlled by the Army within the State of Hawai'i" (Rosendahl 1977). This survey included 6.18 acres of the total *ca.* 13 acres comprising the Waiawa Gulch National Guard Storage Area. No sites were inventoried.

In 1986 William Barrera conducted a reconnaissance level survey "along the right-of-way of a proposed golf course on Waiawa Ridge" (Barrera 1987). Four sites were identified, all apparently of historic-era construction; they included boulder alignments, a dump site, and an area identified as a Cannery on a 1922 War Department map.

In the early 1990s the Bishop Museum conducted reconnaissance and inventory level surveys of a 3600-acre parcel within Waiawa bounded by the H-2 Freeway, Waiawa Gulch, Dole pineapple fields, and Kīpapa Gulch (Goodman and Nees 1991). Historic era sites recorded during the survey

> ...include the remnants of an extensive irrigation system, represented by 29 features and two main irrigation ditches (State sites 50-80-09-2268 and 2269...), a road/railroad system..., two camps and a cannery complex..., and a military reservation...(Goodman and Nees 1991:i)

State site 50-80-09-2268 is the Waiāhole Ditch which also crosses two parcels of the present study area. Goodman and Nees discuss the significance and construction of the Waiāhole Ditch:

> The entire irrigation system would not exist without the constant water source provided by the Waiāhole Ditch (State Site 2268...). Constructed between 1913 and 1915 bt the Waiāhole Water Company (a subsidiary of the Oahu Sugar Company) at a cost of $2,500,000.00, this ditch was designed to draw water from windward streams and subterranean lava

> tubes. It begins in the Ko'olau Range *mauka* of Waiawa, and extends 21 miles across the 'Ewa Plain through Honouliuli, terminating near Barber's Point. The ditch delivers an average of 25 to 30 million GPD of water via a tunnel, the main ditch, and connecting ditches to marginal lands in Central O'ahu...
>
> ...The construction technique of the main ditches appears to have changed over time and may reflect the size and wealth of the plantation, the availability of ditch technology and materials, and the terrain. Some main ditches were constructed of unmodified basalt cobbles stacked and embedded in the trench sides. This trench appears as U-shaped in cross section with its base wider than its sides. Another style is a trench excavated into the soil with a raised berm. This trench is unlined and sometimes raised above the level of the fields to promote gravity drainage across uneven terrain. This trench appears as a U-shape in cross section. (*Ibid.*:64)

Pre-contact sites were also located during the Waiawa survey:

> Four pre-Contact sites were found including a complex of rockshelters with terraces and associated petroglyphs (State site 50-80-09-2263...), which dated between A.D. 1460-1600, a complex of six rock mounds (State site 2265...), which dated between A.D. 1650-1955, an aboriginal trail (State site 2264...), and a lithic scatter (State site 2262...). (Goodman and Nees 1991:i)

No permanent habitation or agricultural sites were located and the survey report concludes that the types of pre-contact sites recorded "suggests that gulch bottoms and upland portions [of Waiawa] were utilized for travel and resource procurement" (*Ibid.*:i).

V. SURVEY RESULTS

In spite of the thorough survey coverage of the project area with special emphasis on the boundaries at the rims of tributary gulches, no archaeological sites were encountered. The four parcels of the project area are either in active pineapple cultivation (Koa Ridge *Makai*), lie fallow (Koa Ridge *Mauka*), or were cultivated in the recent past (Kīpapa Ridge and Waiawa). The Kīpapa Ridge parcel appears to be returning to native *koa* forest since the abandonment of pineapple cultivation. The upslope portion of Koa Ridge *Mauka* which, as was noted in the informant interview above, was developed into a ranch during the 1950s and continues in use as horse pasture today.

A. The Surface Find of an Isolated Adz

One isolated artifact - the tang section of a finished basalt adz - was observed in the Koa Ridge *Makai* parcel of the project area. This adz was located within a pineapple road, on the edge of a steeply sloping tributary of Kīpapa Gulch (Figure 12); it is described and shown in Figure 13.

The area of the find was carefully examined for other artifacts or any indication of a cultural layer or archaeological materials. The find appears to be completely isolated. Its occurrence at the top of a tributary of Kīpapa Gulch, as well as the fact that it is a finished adz, may associate it with tree cutting activities. Perhaps the tang portion of the adz was broken off in the process of tree-felling. This isolated find was not assigned an archaeological site number.

B. The Waiāhole Ditch (State site 50-80-09-2268)

The Waiāhole Ditch runs across the upslope portion of the Koa Ridge *Makai* parcel as well as the downslope portion of the Koa Ridge *Mauka* parcel for a length of

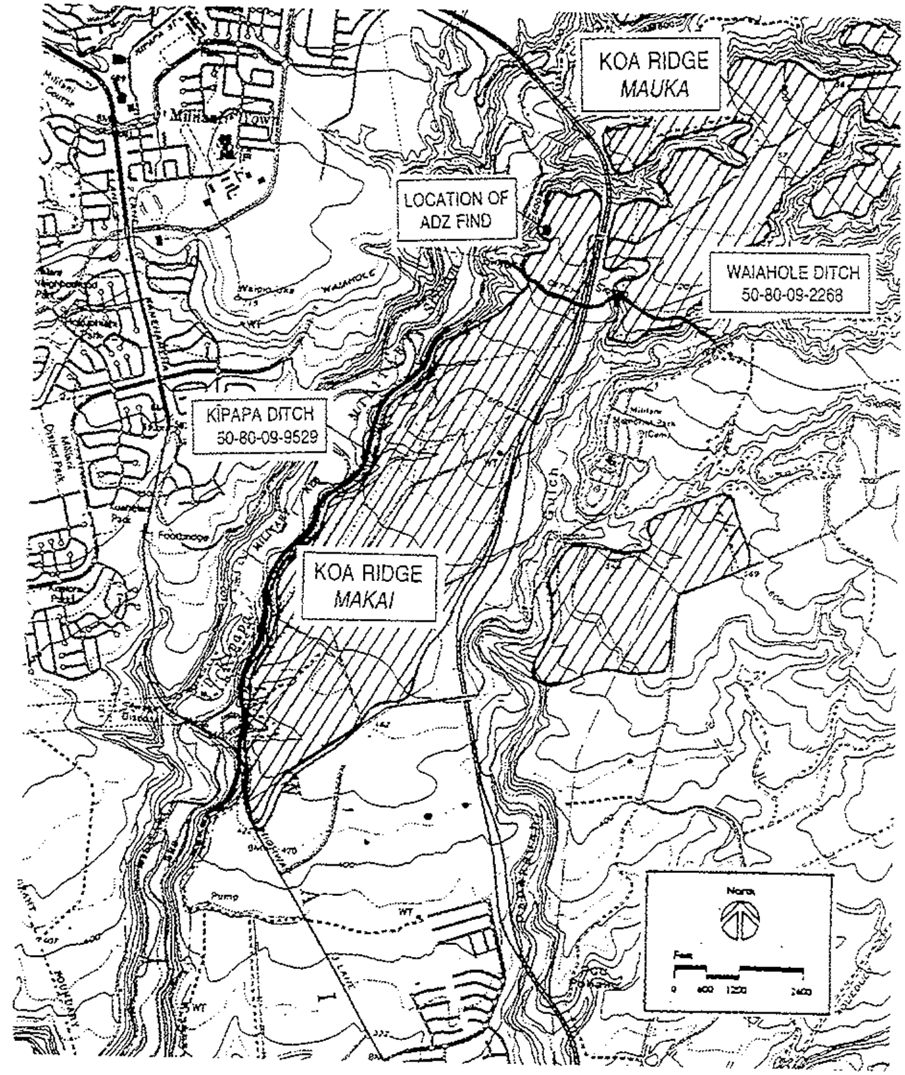
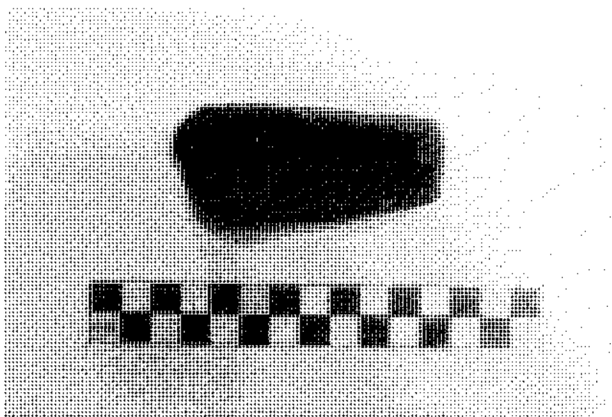


Figure 12 Portion of project area showing location of adz find, Kīpapa Ditch and Waiahole Ditch



Project Central Oahu INDIGENOUS ARTIFACT

Location	# of pcs	Length cm	Width cm	Thickness cm	Weight gm	Material Type	Function	Comments
Roadway surface in pineapple field	1	8.4	3.5	3.4	215.9	Basalt	Adz	Tang section

Figure 13 Basalt adz collected in Koa Ridge *Makai* parcel

approximately 3600 feet (see Figure 12). Along this length the ditch is constructed of concrete and mortar; it averages 2 to 3 feet wide and 3 feet high, and rises approximately 1 foot above the surrounding terrain. The ditch is open except where crossed by road bridges, and there are two metal pipe siphons which pass the water across two steep gullies in the southern portion of Koa Ridge *Mauka*. At the western end of Koa Ridge *Makai* the ditch enters a large siphon where water is transported down and up Kīpapa Gulch. This siphon is a closed metal pipe approximately 6 feet in diameter. An historic photograph shows the siphon under construction *ca.* 1915 (Figure 14). Although the ditch - within the project area - was constructed during that same period, it has been continuously maintained and improved up to the present time.

The Waiāhole Ditch is part of an extensive water system which was built between 1913 and 1916 (see Sections III and IV above). It has been described as "an engineering feat of epic proportion..."(Conde and Best 1973:37). This system included 27 tunnels connecting with 37 stream intakes, with a ditch running for nearly 22 miles, stretching from windward to leeward O'ahu. The ditch has been designated State site 50-80-09-2268.

C. The Kīpapa Ditch (State site 50-80-09-5929) (not within present project area)

An archaeological site associated with historic sngar cultivation - Kīpapa Ditch, State site 50-80-09-5929 - is located outside the project area, on the western side of Koa Ridge *Makai* (see Figure 12). Although this site is not of direct concern, it is mentioned here because it runs adjacent to the parcel for a length of approximately 8000 feet and could be directly impacted by off-site improvements of the proposed development. For this reason, the ditch was examined and photographed as part of the present survey (Figures 15 & 16).

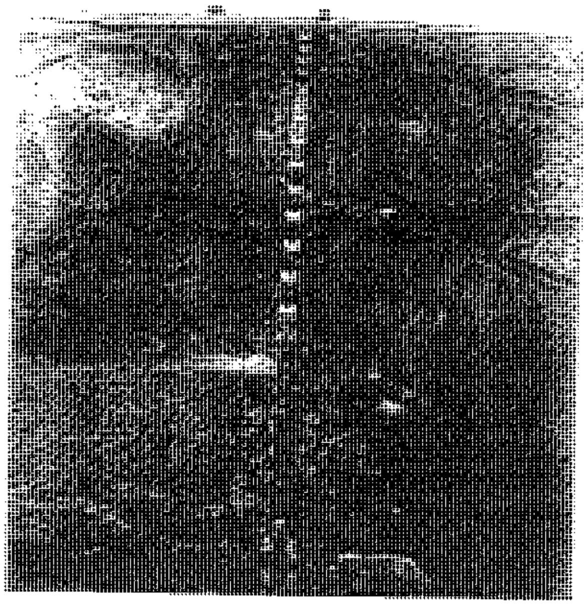


Figure 14 Waiāhole Ditch siphon in Kīpapa Gulch under construction *ca.* 1915 (Bishop Museum Archives)

Figure 15 View of Kīpapa Ditch (interior) showing three courses of quarried shaped basalt boulders

Figure 16 Kīpapa Ditch overflow flume showing date 1938 incised in mortared bridge

The ditch site was briefly described in a Bishop Museum report (Rosendahl 1977) and described in more detail in a later survey of Kīpapa Gulch (Hammatt and Borthwick 1988). The ditch was constructed in the 1930s as part of the Oahu Sugar Co. water delivery system. It formerly tapped water from Kīpapa Stream at a specially constructed dam just *makai* of the Waiāhole Siphon. The ditch, which generally averages three feet wide, was lined on both sides with quarried shaped basalt boulders, two to six courses high. The ditch enters a 400-foot long tunnel within the gulch and then continues to climb the east slope of Kīpapa Gulch, where it irrigated former cane fields in the *makai* area of Waipi'o.

Although at present the ditch only carries excess water during rains, along much of its length it is still in workable condition. It was observed to be a major work of engineering for its time. The use of quarried shaped basalt boulders along its entire length is particularly impressive.

VI. SUMMARY AND RECOMMENDATIONS

A. Summary

Historical research, and particularly the locations of the Land Commission Awards within the *ahupua'a* of Waipi'o and Waiawa, show early settlement to have been concentrated on the coast. Within Waipi'o, some settlement extended into the uplands, confined to Kīpapa Gulch (see Figure 5). The project area parcels would have been used for traditional gathering of forest resources, including gathering of medicinal plants, cutting of *koa* trees for canoes, and other uses. The settlements along Kīpapa Gulch would have had access to this area for such uses. But permanent settlement would not have been located here.

This settlement pattern, in combination with long-term use of the project parcels for commercial cultivation (pineapple and sugar), accounts for the complete lack of prehistoric archaeological sites within the project area. Not only have the flat lands been modified by plowing but even many of the slopes and gullies adjacent to the fields have been graded and terraced for erosion control.

The single historic-era archaeological site present in the project area is a portion of the Waiāhole Ditch System, State site 50-80-09-2268, constructed between 1913 and 1916. The ditch, with two siphons crossing steep gullies, runs across approximately 3600 feet of the Koa Ridge *Makai* and the Koa Ridge *Mauka* parcels.

B. Recommendations

For the project area apart from the portions crossed by the Waiāhole Ditch, no further archaeological investigation is recommended. There is little or no chance of archaeological finds during construction and archaeological monitoring would not be appropriate. If findings are encountered during ground disturbing activities, work should be halted in the immediate area and the State Historic Preservation Division of the Department of Land and Natural Resources should be contacted (Ph.587-0047).

If the portion of the Waiāhole Ditch which crosses the two parcels of the project area is ever to be impacted by future development, the State Historic Preservation Division should be notified beforehand, so that appropriate mitigative measures, if necessary, can be established.

It should be pointed out that a known archaeological site of the historic era - Kīpapa Ditch, State site 50-80-09-5929 - runs adjacent to the western boundary of the Koa Ridge *Makai* project parcel for a length of approximately 8000 feet. This site is outside the project area but could be impacted by off-site improvements, particularly for drainage. This concern can be addressed if separate surveys are conducted for any improvements outside the immediate project area. An additional concern is the avoidance of pushing of graded materials over the slopes of the project parcel to prevent damage to the site.

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PHOTO APPENDIX

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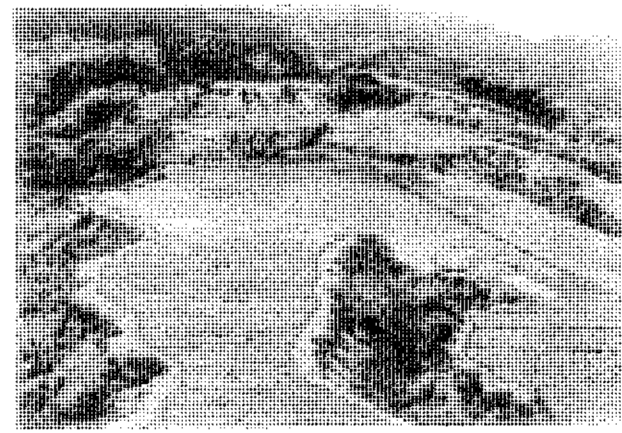

Figure 21 Aerial View of Koa Ridge *Mauka*, Showing Koʻolau

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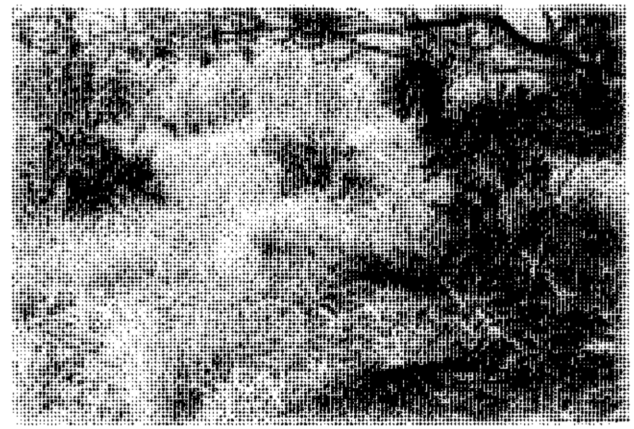
Figure 23 Koa Ridge *Mauka*, Showing Kipapa Gulch and H2 Highway Bridge

Figure 24 Kipapa Ridge Aerial View



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F | Cultural Impact Assessment

Cultural Impact Assessment for Off-Site Detention Basins, Traffic Interchanges, and Sewer Line Work Related to the Koa Ridge Makai Development Waipiʻo and Waikele Ahupuaʻa, ʻEwa District, Island of Oʻahu

TMK: [1] 9-3, 9-4 & 9-5, various plats and parcels

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Management Summary

Reference	Cultural Impact Assessment for Off-Site Drainage Detention Basins, Traffic Interchanges, and Sewer Line Work Related to the Koa Ridge Makai Development, Waipiʻo and Waikele Ahupuaʻa, ʻEwa District, Island of Oʻahu TMK: [1] 9-3, 9-4 & 9-5, various plats and parcels
Date	November 2008
Project Number(s)	WAIPIO 6
Project Location	The project area is located in Waipiʻo and Waikele Ahupuaʻa, ʻEwa District, on the island of Oʻahu. The project area includes four discreet sections, generally located east of Mililani Town and Mililani Mauka. Most of the project lands are situated within Kīpapa Gulch or its tributaries. Portions of the project area are located on tablelands adjacent to Kīpapa Gulch, and one section of the project area is located within a tributary of Pānakauahi Gulch. The underground sewer line portion of the proposed project extends approximately 5.6 km. (3.5 miles) from the southernmost portion of the Koa Ridge Makai Development south to the City and County wastewater treatment facilities in Waipahu. The project areas are depicted on the U.S. Geological Survey 7.5-Minute Series Topographic Map, Waipahu Quadrangle (1998).
Land Jurisdiction	Government, U.S. Army; and Private, Castle & Cooke Homes Hawaiʻi, Inc. Portions of the project area is under the land jurisdiction of the City and County of Honolulu. Of note is the short segment where the project area crosses Kamehameha Highway, which is under the land jurisdiction of the Hawaii State Department of Transportation.
Agencies	State of Hawaiʻi Department of Health/Office of Environmental Quality Control (DOH/OEQC)
Project Description	The proposed project consists of off-site infrastructure improvements supporting the proposed Koa Ridge Makai and Waiawa Development areas located in Waipiʻo and Waikele Ahupuaʻa, ʻEwa District, in south central Oʻahu. These improvements are: **Off-site Drainage Facilities:** Four off-site drainage detention basins (one of which is an alternate) totaling approximately 20 acres are proposed, which would be located in Kīpapa Gulch along tributaries of Waikele Stream. **H-2 Freeway Interchange Improvements:** Improvements are proposed at the Waipiʻo Interchange and a new freeway interchange is proposed near the existing Pineapple Road overpass. The improvements may involve loop or other type of ramps on the east and west sides of the H-2 Freeway at the existing Waipiʻo Interchange

	and a proposed new interchange near Pineapple Road. **Underground Sewer Line:** A new trunk sewer line is required to convey wastewater from the Koa Ridge Makai Development to City and County wastewater treatment facilities. An approximately 5.6 km. (3.5-miles) underground sewer trunk line would extend from the southernmost portion of the Koa Ridge Makai development area, under Kamehameha Highway, southward along the western boundary of the Patsy T. Mink Central Oʻahu Regional Park, continue in a southerly direction along Pāiwa Street, Kōʻaki Street, Kōpākē Street, Pūkō Street, and Mokuola Street to Farrington Highway. The line would extend west along Farrington Highway to Waipahu Depot Road, where it would run southward, terminating at the Waipahu Wastewater Pump Station.
Project Acreage and Linear Miles	The footprint of the proposed ground disturbance measures approximately 20 acres for the drain detention basins. The sewer line from Waipiʻo to Waipahu is approximately 5.6 km. (3.5-miles) in length.
Area of Potential Effect (APE)	The Area of Potential Effect (APE) for this Cultural Impact Assessment (CIA) includes the project area in the context of Waipiʻo and Waikele Ahupuaʻa and other places on Oʻahu that may be traditionally associated or connected with Waipiʻo and/or the project area.
Document Purpose	The project requires compliance with the State of Hawaiʻi environmental review process [Hawaiʻi Revised Statutes (HRS) Chapter 343], which requires consideration of a proposed project's effect on cultural practices and resources. At the request Castle & Cooke Homes Hawaiʻi, Inc., Cultural Surveys Hawaiʻi Inc. is undertaking this CIA. Through document research and (ongoing) cultural consultation efforts this draft report document provides information compiled to date pertinent to the assessment of the proposed project's impacts to cultural practices (per the State Department of Health, Office of Environmental Quality Control's *Guidelines for Assessing Cultural Impacts*). The document is intended to support the project's environmental review and may also serve to support the project's historic preservation review under HRS Chapter 6E-42 and Hawaiʻi Administrative Rules Chapter 13-284.
Community Consultation	Hawaiian organizations, agencies and community members were contacted in order to identify potentially knowledgeable individuals with cultural expertise and/or knowledge of the project area and the vicinity. The organizations consulted included the State Historic Preservation Division (SHPD), the Office of Hawaiian Affairs (OHA), the Oʻahu Island Burial Council (OIBC), and community and cultural organizations including Hui Mālama I Nā Kūpuna ʻO Hawaiʻi Nei, Hui Pū and the Hawaiian Civic Club of Wahiawā.

Results of Background Research	Background research shows: 1. Portions of the project area are located in Kīpapa Gulch, which includes the Kīpapa Stream channel. Kīpapa, which translates as "placed prone" refers to corpses slain in the victory of Oʻahu forces over those of Hawaiʻi Island in the fourteenth century (Alexander 1891:96). Kīpapa was a well-known place of native Hawaiian activity from pre-Contact times. Waipiʻo was the scene of many battles between local and invading *aliʻi* for the political control of Oʻahu (Handy & Handy 1972:470). 2. Historic records indicate that a major trail which formerly connected ʻEwa to the Waialua District through the Central Oʻahu Plains, as well as to Waiʻanae over Kolekole Pass crossed Kīpapa Gulch within or very close to the southernmost drainage detention basin. One community participant mentions a Night Marcher or *Huakaʻi Pō* trail located in Kīpapa Gulch under the Kamehameha Highway bridge extending south to the waters of Pearl Harbor. 3. Prior cultural impact studies reveal that there were hunting and gathering activities in the Waipiʻo ʻUka area (before Kīpapa Gulch was cut off from public access). Hawaiian gathering practices seem to have been concentrated within the Kīpapa and Waikakalaua Gulches, particularly along Gulch walls. One *kupuna*, who grew up as a practitioner of *lāʻau lapaʻau* (healing with plants) and *lomi lomi* (massage), collected medicinal plants and minerals in Kīpapa Gulch for many years The Waikakalaua and Kīpapa Gulches were especially noted for their sources of *ʻalaea* (red earth mixed with salt for medicinal and other purposes)—unique to this area. Other items collected were medicinal plants such as the native, indigenous species *ʻaʻaliʻi* (*Dodonaea viscose*). Hunting of pigs in the vicinity of the project area has been documented as far back as the 1930s. Popular access points to hunting on Koa Ridge in the Koʻolau Mountains used to be up by Shohata Camp, through the pineapple fields. 4. The project area is also closely associated with early 1900s commercial sugar cane and pineapple agriculture on Oʻahu; in particular, the project area retains archaeological features related to water-management and transport facilities, including the famous Waiāhole Ditch. By the late 1920s, James Dole's Hawaiian Pineapple Company, incorporated in 1901, was cultivating pineapple on thousands of acres leased from the ʻĪʻī estate in the *mauka* area of Waipiʻo. 5. During the 1930s, U.S. military use of Waipiʻo extended well *mauka* of the peninsula at Pearl Harbor. The military began the

	appropriation of Kīpapa Gulch about 1938 and by 1941; Pacific Naval Air Bases expenditures for new construction at Pearl Harbor were in the hundreds of millions of dollars (Woodbury 1946). In 1942, the U.S. military began constructing bunkers inside Kīpapa Gulch to house munitions and other war related equipment. 6. Given its location within Waipiʻo Ahupuaʻa, the project area is generally associated with a wide variety and extensive number of *moʻolelo* (oral histories), including legends, mythological accounts, stories, parables and sayings. These include, for example, the exploits of gods and demigods such as Maui and Peʻapeʻamakawalu (the octopus god) in which the eight-eyed Peʻapeʻa kidnapped Maui's wife Kumulama (Beckwith 1951:136).
Results of Community Consultation	Twenty-seven community contacts (government agency or community organization representatives, or individuals such as long-time area residents and cultural practitioners) were contacted for the purposes of this Cultural Impact Assessment. 10 people have responded and 5 *kūpuna* (elders) and/or *kamaʻāina* (native-born) were interviewed for more in-depth contributions to the cultural impact survey. Community consultation has yielded the following cultural concerns: 1. Four participants stressed the importance of not losing any additional Hawaiian cultural features of the landscape, such as trails, *ahu* (rock altars), petroglyphs and rock walls that may possibly be pre- or early post -Contact, to development in and around the project area, which has experienced substantial losses due to commercial agriculture and other development in more recent times. 2. One *Kupuna*, Tane Inciong, mentioned the existence of a "Night Marcher Trail" or "*Huakaʻi Pō*" located under the Kamehameha Bridge in Kīpapa Gulch. According to Hawaiian legends, Night Marchers are ghosts of ancient Hawaiian warriors who roam large sections of the island chains usually in areas that were once large battlefields, such as Kīpapa Gulch. 3. One participant is concerned about plant gathering practices for lei and medicinal purposes in Kīpapa Gulch that may be restricted as a result of the proposed development. One participant (*kupuna* Tane Inciong) mentioned his past use of the Kīpapa area (before there was restricted access) for gathering of plants for lei-making, medicinal and other ethnobotanical purposes. Gathering for native plants (some indigenous or endemic species) such as *kūkaenēnē* (*Coprosma*

	sp.), *maile* (*Alyxia oliviformis*) and *ʻieʻie* (*Freycinetia arborea*), as well as non-native plants such as purple *lilikoʻi* (*Passiflora edulis*), were part of the traditional practices of his *ʻohana*. To this day, Mr. Inciong passes along the gathering techniques he has learned from his *kūpuna* to younger members of his extended family, close friends and hula groups as well. 4. Those who responded are also concerned about the numerous caves in Kīpapa Gulch that may contain *iwi*. During the excavation for the underground sewer line inside the lower portion of Kīpapa Gulch, consultation members feel that construction workers may inadvertently discover these caves and highly recommend these caves not be disturbed by construction crews. 5. Two members contributing to this study are concerned with the untreated wastewater traveling approximately 5.6 km. (3.5-miles) from the Kamehameha Highway bridge in Waipiʻo to the wastewater treatment facility in Waipahu. Their concerns focus on a potential rupture or breakage of the sewer line, thus releasing untreated sewer in the gulch area. They mention the 6.7 magnitude earthquake that hit Hawaiʻi on October 15, 2006. Community members recommended a wastewater treatment facility should be planned for a location in Waipiʻo to service the Wahiawā, Mililani and Waipiʻo communities instead of having more and more untreated wastewater traversing from the uplands of Waipiʻo, Mililani and Wahiawā to the wastewater treatment facility in Waipahu. 6. Four community consultation members are also concerned with flooding in the gulch. They mentioned the rising waters of Kīpapa Stream over the years as various projects, such as Mililani Mauka, were developed upstream. It was noted that after these development projects were completed, the water levels in the stream would significantly rise. Cultural consultants are concerned that if this trend continues, cultural and natural resources may be negatively impacted by the rising waters. For instance, Mr. Inciong is concerned that potential flooding in the Kīpapa Gulch as a result of future developments in the area surrounding Kīpapa Gulch could negatively impact native and non-native ethnobotanical plants enumerated above.
Recommendations	Based on all available information to date, including background research and community consultation, the proposed project will have minimal impact on Hawaiian culture, practices and traditions if the following measures are addressed in a good faith manner: 1. Based on site visits with community consultants Shad Kane

	and Pono Kealoha, a specific rock formation or *ahu* (Figure 19) and its companion wall structures located in Kīpapa Gulch near the northern-most drain detention basin should be preserved in its entirety and protected from harm during project construction. 2. Caves in Kīpapa Gulch, which may contain *iwi* and other burial *moepū* or funerary objects, should be preserved in their entirety and protected from potential harm during project construction. 3. Three community consultants recommended that early 1900s structures associated with the sugar cane and pineapple plantation era, such as bridge supports and drainage systems, should be preserved in their entirety and protected from potential harm during project construction where possible. 4. Concerns expressed by two study participants regarding potential flooding in Kīpapa Gulch should be addressed with community members, particularly in regard to measures taken to protect natural and cultural resources from adverse impacts due to potential flooding. Additionally, project proponents might consider consulting with Mr. Inciong and other cultural consultants about the presence of native and non-native species in the area of ethnobotanical significance. Project proponents should consult with a botanist in order to help identify if the ground-disturbance area includes these native and non-native plant species.

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Section 1 Introduction

1.1 Project Background

At the request of Castle & Cooke Homes Hawaiʻi, Cultural Surveys Hawaiʻi, Inc. (CSH) has prepared this supplemental Cultural Impact Assessment (CIA) for off-site infrastructure improvements supporting the proposed Koa Ridge Makai and Waiawa Development (the "Development") located in the Waipiʻo and Waikele Ahupuaʻa, ʻEwa District, Oʻahu Island, TMK: (1) 9-3, 9-4 & 9-5, various plats and parcels. As discussed further below (see Section 1.4), earlier cultural studies were conducted for the *on-site* development of the Koa Ridge Makai and Waiawa Development (Hammatt and Shideler 1996; Bushnell and Hammatt 2001). The Development is the subject of a State Land Use District Boundary Amendment Petition for the reclassification of 766 acres (Figures 1 through 4) from the Agricultural District to the Urban District and an Environmental Impact Statement under preparation.

The Development will require supporting infrastructure improvements, some of which will be located off-site (i.e., outside the Petition and/or Development Areas). Areas affected by these off-site improvements are also shown on the U.S. Geological Survey map (Figures 1 & 2) and aerial photographs (Figures 3 & 4) and labeled as "Improvement Area." For the purposes of this CIA, the project area includes all of the proposed improvements—both within and outside of the Petition and/or Development areas—indicated in Figures 1 through 4. The Area of Potential Effect (APE) for this CIA includes the project area in the context of Waipiʻo and Waikele Ahupuaʻa and other places on Oʻahu that may be traditionally associated or connected with Waipiʻo, Waikele and/or the project area. The APE also considers the potential cumulative impacts of the entire Development on traditional and ongoing Hawaiian practices and resources.

The off-site improvements include:

> **Off-site Drainage Facilities:** Four off-site drainage detention basins (one of which is an alternate) totaling approximately 20 acres are proposed, which would be located in Kīpapa Gulch along tributaries of Waikele Stream. The basins would meet City & County drainage standards and regulate the storm water runoff rate flowing into the stream from developed areas during major storm events. The basins would consist of earthen bermed areas that would detain storm water runoff and release the flows through drainage outlets at pre-development rates. There will also be construction staging areas, construction and maintenance access roads, drainage culverts and erosion control improvements associated with the off-site drainage facilities.
>
> **H-2 Freeway Interchange Improvements:** Improvements are proposed at the Waipiʻo Interchange and a new freeway interchange is proposed near the existing Pineapple Road overpass. The improvements may involve loop or other type of ramps on the east and west sides of the H-2 Freeway at the existing Waipiʻo Interchange and a proposed new interchange near Pineapple Road.
>
> **Underground Sewer Line:** A new trunk sewer line is required to convey wastewater from the Koa Ridge Makai Development to City & County

wastewater treatment facilities. An approximately 5.6 km. (3.5-mile) underground sewer trunk line would extend from the southernmost portion of the Koa Ridge Makai development area, under Kamehameha Highway, southward along the western boundary of the Patsy T. Mink Central O‘ahu Regional Park, continue in a southerly direction along Pāiwa Street, Kō‘aki Street, Kōpākē Street, Pūkō Street, and Mokuola Street to Farrington Highway. The line would extend west along Farrington Highway to Waipahu Depot Road, where it would run southward, terminating at the Waipahu Wastewater Pump Station.

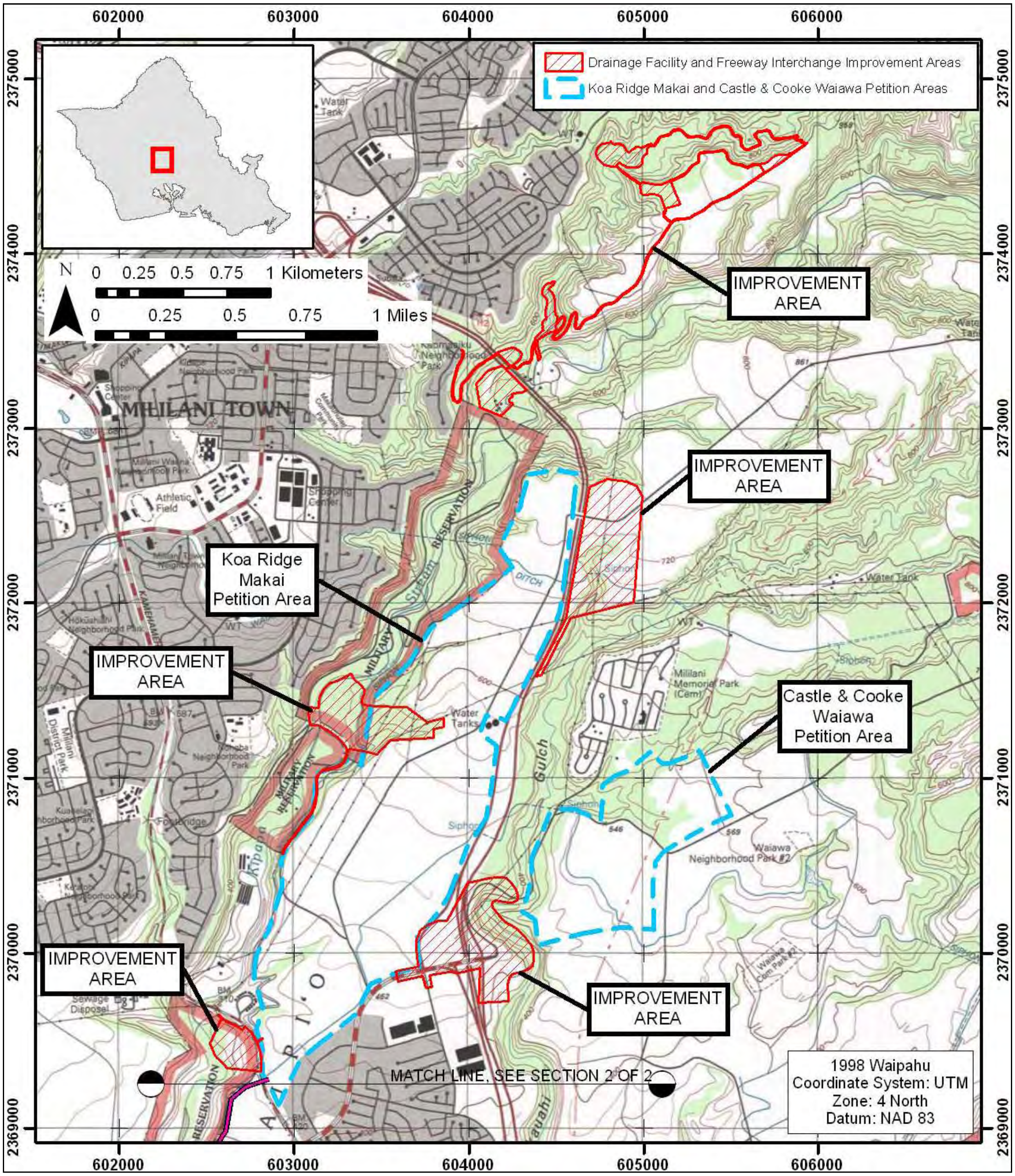

Figure 1. Northern portion of the project area depicted on the 1998 USGS Waipahu quadrangle 7.5-minute topographic map

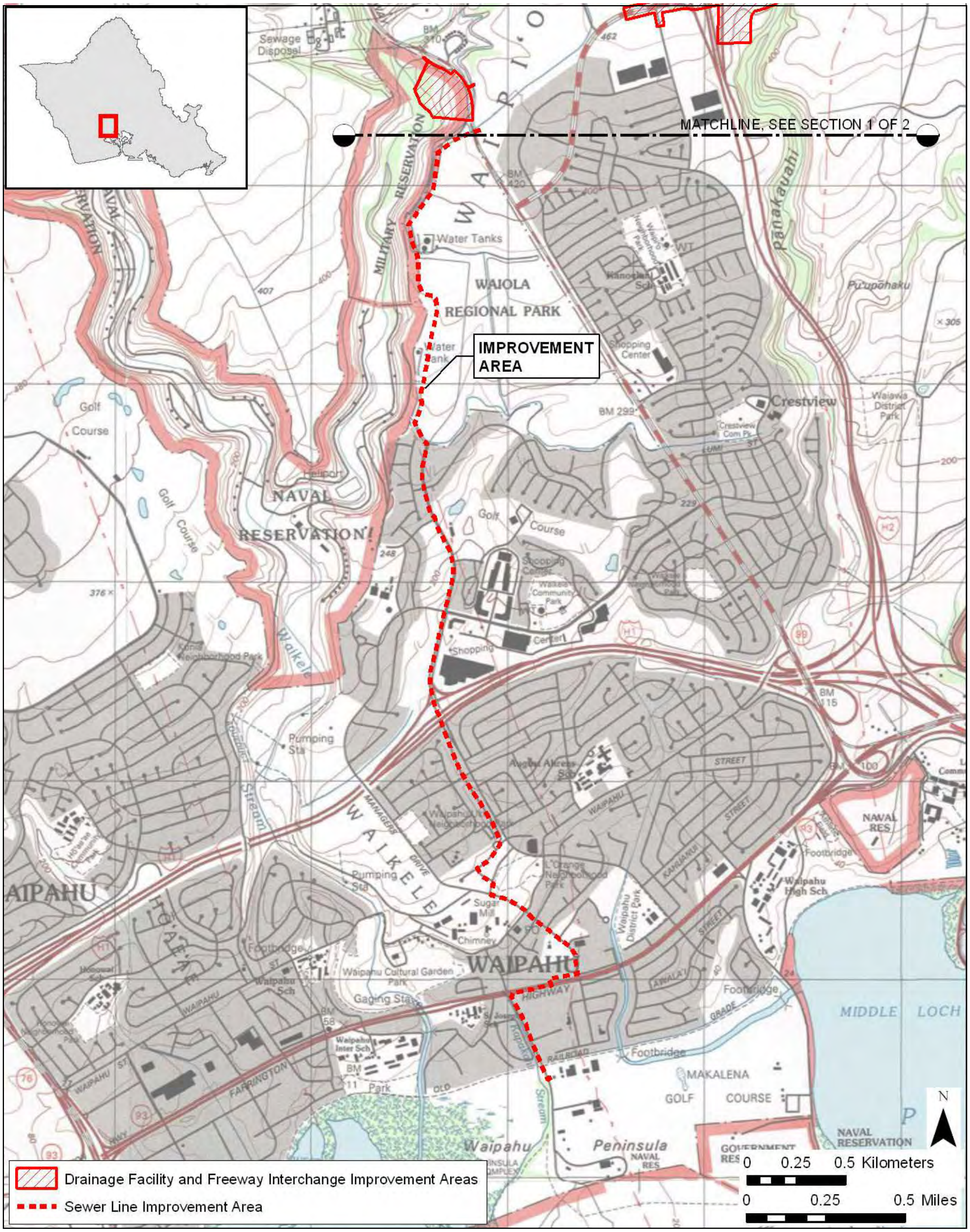

Figure 2. Southern portion of the project area depicted on the 1998 USGS Waipahu quadrangle 7.5-minute topographic map

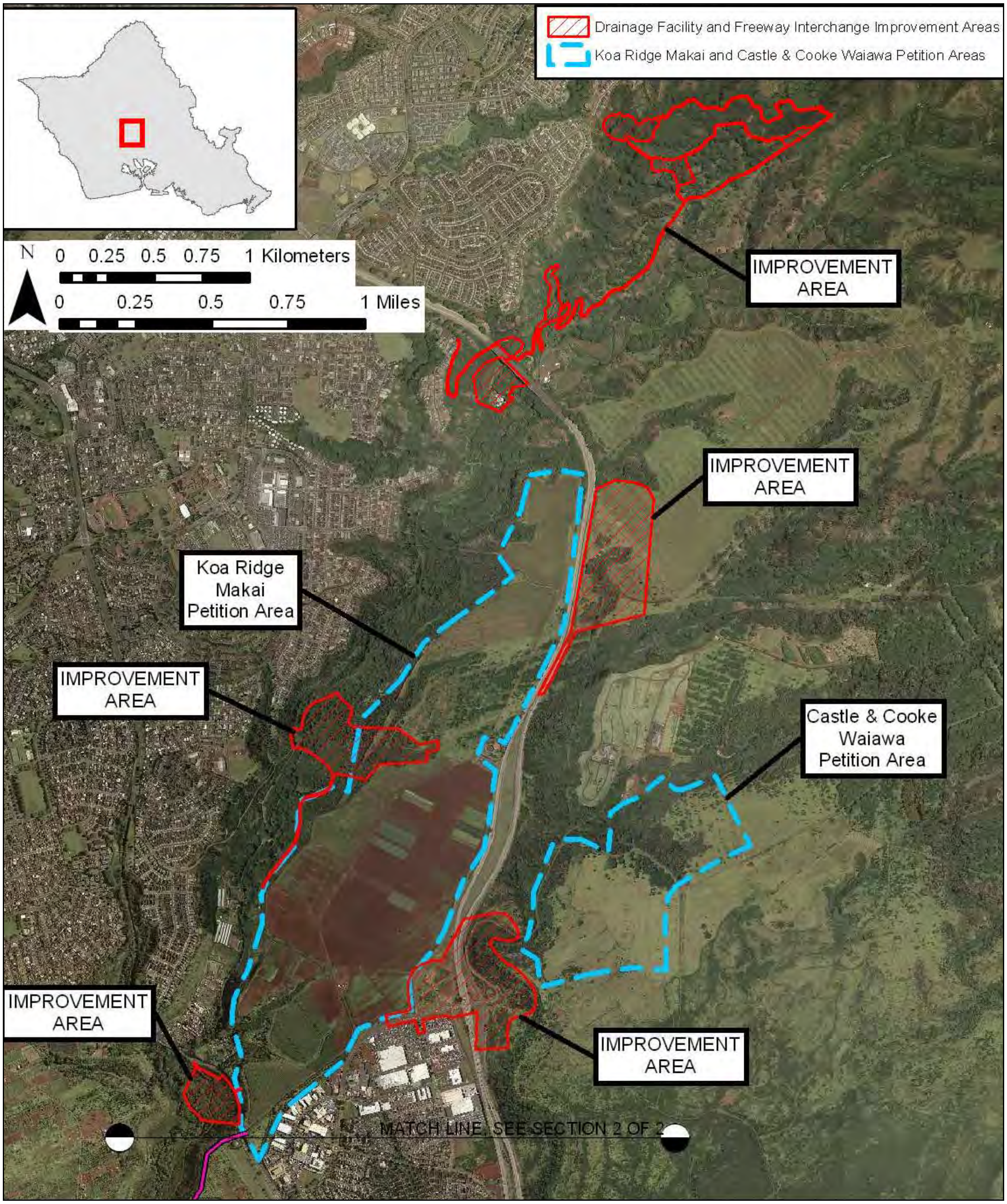

Figure 3. Northern portion of the project area depicted on an aerial image (Orthoimagery 2005)

Figure 4. Southern portion of the project area depicted on an aerial image (Orthoimagery 2005)

1.2 Document Purpose

The project requires compliance with the State of Hawaiʻi environmental review process [Hawaiʻi Revised Statutes (HRS) Chapter 343], which requires consideration of a proposed project's effect on cultural practices. CSH is conducting this CIA at the request of Castle & Cooke Homes Hawaiʻi. Through document research and (ongoing) cultural consultation efforts this report provides information pertinent to the assessment of the proposed project's impacts to cultural practices and resources (per the Office of Environmental Quality Control's *Guidelines for Assessing Cultural Impacts*). The document is intended to support the project's environmental review and may also serve to support the project's historic preservation review under HRS Chapter 6E-42 and Hawaiʻi Administrative Rules Chapter 13-284.

1.3 Scope of Work

The scope of work for this CIA includes:

1. Examination of cultural and historical resources, including Land Commission documents, historic maps, and previous research reports, with the specific purpose of identifying traditional Hawaiian activities including gathering of plant, animal, and other resources or agricultural pursuits as may be indicated in the historic record.
2. A review of previous archaeological work at and near the subject parcel that may be relevant to reconstructions of traditional land use activities; and to the identification and description of cultural resources, practices, and beliefs associated with the parcel.
3. Consultation and interviews with knowledgeable parties regarding traditional cultural practices at or near the parcel; present uses of the parcel; and/or other (non-Hawaiian) practices, uses, or traditions associated with the parcel.
4. Preparation of a report summarizing the results of these research activities.

1.4 Prior Archeological and Cultural Studies in the Project Area

Previously, CSH produced two studies germane to this project including: a *Hawaiian Traditional Customs and Practices Impact Assessment for the Development of a 1339-Acre Parcel at Castle and Cooke Lands Within Portions of Waipiʻo and Waiawa Ahupuaʻa, Oʻahu (TMK 9-4-06:01, 03 & 10 por. and 9-5-03:01 por. 04 & 07 and 9-6-04:21)* (Hammatt and Shideler 1996) and *A Supplement to the Hawaiian Traditional Customs and Practices Impact Assessment for the Development of a 1339-Acre Parcel at Castle and Cooke Lands Within Portions of Waipiʻo and Waiawa Ahupuaʻa, Oʻahu (TMK 9-4-06:01, 03 & 10 por. and 9-5-03:01 por. 04 & 07 and 9-6-04:21)* (Bushnell and Hammatt 2001).

The prior two studies have attempted to give due consideration to the effects which the proposed development activity may have on the specific practices, culture and traditions of native Hawaiians. Specific areas which have been examined have included the issue of burials (there are not believed to be any), the issue of access to Hawaiian trails, other archaeological/historical concerns including *heiau* and a battle field in the vicinity, Hawaiian hunting practices and Hawaiian gathering practices. The conclusion of these two studies is that the impact of the development of this specific parcel per se on Hawaiian culture would be minimal. However, in the 2001 study, the Wahiawā Hawaiian Civic Club has expressed its concern over several cultural sites they identify to be in the vicinity of the project area. These sites include a spring, *heiau*, *kā‘anani‘au* or boundary markers, navigational *pōhaku*, native Hawaiian plants, other culturally significant *pōhaku*, burials and other cultural sites. The description and location of these sites was not disclosed to CSH.

The lack of impact documented previously is a reflection largely of the geographic location of the parcel, set well back from the coast, with no surface water and no unique topographic features. While the absence of significant cultural impacts in the project area studied does not necessarily mean an absence of Hawaiian activity, the patterns of land use in this area are relatively clear, and Hawaiians did not utilize this *kula* land nearly as intensively as they utilized coastal areas, well-watered areas, and forest zones.

Another significant cultural issue worth noting for the purpose of this CIA derived from both prior reports would seem to be the importance of access to the Kīpapa Ridge Trail for purposes of hunting and native gathering practices in adjacent gulches and farther upslope areas which lie outside of the Koa Ridge Makai and Waiawa Development project areas. Sections 7 and 8 include interview excerpts from past CSH reports pertinent to the current proposed development.

1.5 Current Archeological Work in the Project Area

An archaeological inventory survey including a surface survey and subsurface testing was conducted for the project area. The results of the archaeological study are presented in a companion report titled: *Archaeological Inventory Survey of Proposed Detention Basins, Associated Appurtenances, and an H-2 Freeway Interchange Associated with the Koa Ridge Makai Development Project, Waipi‘o Ahupua‘a, ‘Ewa District, Island of O‘ahu (TMK: [1] 9-4-005: 006 por., 008 por.; 9-4-006:001 por., 029 por. ; 9-5-003:001 por., 002, 011 por. 014 por.)* (Tulchin, Yucha, Shideler and Hammatt 2008). A discussion of the findings is presented in Section 5 of the present study.

1.6 Environmental Setting

1.6.1 Physical Environment

This brief subsection is primarily based on Handy and Handy (1972), Foote et al. (1972), Hammatt et al. (1996), and Juvik and Juvik (1998).

The project area, which is located between Kīpapa Gulch (and within portions of Kīpapa Gulch) and Pānakauahi Gulch, immediately east of Mililani Town, extends from approximately 900 feet elevation (east of Mililani Mauka) to near sea level (near the Farrington Highway and the Ted Makalena Golf Course in Waipahu) in Waipi‘o and Waikele Ahupua‘a, ‘Ewa District, south-central O‘ahu Island. Overall, the drainage detention basin improvement areas are spread over a distance of approximately 4.8 km. (3 miles) *mauka* to *makai*, and the sewer connection to Waipahu covers an additional 5.6 km. (3.5-miles). The upper project area is located in the piedmont zone (i.e., transition between the mountains and the coastal plain) leading up to the elevated central plain of O‘ahu between its two mountain ranges (the younger Ko‘olau to the east and the older Wai‘anae to the west); the lower project area is located at the upper Waipi‘o Peninsula.

Rainfall in the vicinity of the project area is relatively modest, on the order of 25-35 inches per year, but it rains much more upslope and *mauka* (inland) of the project area. Through-flowing water in this area is mostly confined to steep-sided, deep gulches that native Hawaiians in traditional times did not generally divert for cultivation up on the plains (“interfluves”) between these drainages. Portions of Kīpapa Gulch were probably planted for wet-taro and other types of gardens by native Hawaiians living a subsistence lifestyle. Some “Dry land” (non-irrigated) cultivation was likely practiced on the interfluvial area between Kīpapa and Pānakauahi Gulches prior to the historic era. According to Hosaka (1937), Kīpapa has been a permanently flowing stream for some time, although in the “lower section, below the forest…[it] occasionally dries up after a long drought.” An ephemeral (seasonal) drainage, Pānakauahi, is located to the east of the project area.

The volcanic soils in this general area are typically excellent for agriculture when irrigation is possible; and commercial agricultural activities in this area—most notably sugar cane, was especially active starting in the 1890s. These commercial agricultural activities substantially modified the ground surface of the project area and surrounding lands such that any historic properties and/or structures in the project area—other than the modern highway and its associated infrastructures—are likely to represent sugar-cane era and later features. Conspicuous evidence of native Hawaiian landscape modifications, in particular, have generally been eliminated from the project area by historic activities.

Given the historic clearing of native and Polynesian-introduced vegetation, and commercial agricultural use of the project area, to the knowledge of CSH the project area and vicinity is dominated by alien, introduced species with few natives or Polynesian-introductions. Common plant species in this area are part of the xeophytic *haole koa* zone (Hosaka 1937), and include: non-native naturalized species such as *haole koa* (*Leucaena leucocephala*), *pānini* (prickly pear cactus, *Opuntia megacantha*), *klu* (*Acacia farnesiana*), guava (*Psidium guajava*), lantana (*Lantana camara*). The natives *‘uhaloa* (*Waltheria indica*) and *pili* grass (*Heteropogon contortus*) are found in the area and have ethnobotanical applications as do most of the alien naturalized species enumerated above. Community consultation for this CIA indicates that there were — and possibly are — native (indigenous and/or endemic) species in or near the project area such as, *kūkaenēnē* (*Coprosma* spp.), *maile* (*Alyxia oliviformis*) and *‘ie‘ie* (*Freycinetia arborea*) all of which are valuable *hula* and *lei* plants (see Section 7.1). Prior native vegetation, which would have originally (before the arrival of the first Polynesians) consisted of lowland forest and scrub lands, was probably partially cleared by native Hawaiians for dry-land garden plots. Native Hawaiian uses and management of native and Polynesian-introduced vegetation in the and around the project area, is discussed in detail in Section 3 (below).

1.6.2 Built Environment

Small portions of the project area include highways, infrastructure and other associated appurtenances. Most of the rest of the project area consists of now-undeveloped lands that were previously in commercial agricultural pursuits (e.g., sugar cane); old railroad tracks previously crossed parts of the project area in one or two places. Small retention basins and small reservoirs have also been built in historic times in the general area.

Section 2 Methods

Historical documents, maps and existing archaeological information pertaining to the sites in the vicinity of this project were researched at the CSH library. Information on Land Commission Awards was accessed through Waihona ‘Aina Corporation’s Māhele Data Base (www.waihona.com). The State Historic Preservation Division, Office of Hawaiian Affairs, O‘ahu Island Burial Council, and community and cultural organizations on O‘ahu were contacted in order to identify potentially knowledgeable individuals with cultural expertise and/or knowledge of the project area and the surrounding vicinity. The names of potential community contacts were also provided by colleagues at CSH and from the authors’ familiarity with people who live in or around the project area. The cultural specialist conducting research on this assessment employed snowball and judgment sampling methods, an informed consent process and semi-structured interviews according to standard ethnographic methods (as suggested by Bernard 2005). Some of the prospective community contacts were not available to be interviewed as part of this project. A discussion of the consultation process can be found in Section 6 on Community Consultations. Please refer to Table 3, Section 6 for a complete list of individuals and organizations contacted.

Section 3 Traditional Background

3.1 Overview

Specific references and citations for information contained in this overview are provided, where applicable, in the subsections that follow (i.e., Sections 3.2 onward).

The project area is located in Waipiʻo with a small *makai* portion in Waikele Ahupuaʻa, ʻEwa District, on the island of Oʻahu. This section (and the following Historical Background, Section 4) will focus on Waipiʻo Ahupuaʻa with a summary discussion of Waikele Ahupuaʻa. Waipiʻo Ahupuaʻa is in the *moku* (traditional district) of Ke- ʻĀpana-o-ʻEwa, now simply known as ʻEwa. Waipiʻo Ahupuaʻa is bounded on the south by Ke-awa-lau-o-Puʻuloa (or simply Puʻuloa), known in modern times as Pearl Harbor. Puʻuloa, which has been a natural resource of enormous importance to native Hawaiians living a subsistence lifestyle for well over a thousand years, is a large inland embayment of the Pacific Ocean essentially composed of drowned river valleys formed by erosion during a lower stand of the sea (Macdonald et al. 1983). The *ahupuaʻa* continues inland in a northerly direction upslope into the Līhuʻe uplands, known in modern times as the Schofield Plateau. The western boundary of the *ahupuaʻa* is Waikele Stream into which flows Waipiʻo's primary drainage, Kīpapa Gulch (or Stream). Leaving Waikele Stream, the western boundary turns northeast and then east, following another, more *mauka* tributary of Waikele, known as Waikakalaua Stream, and follows this drainage to the summit of the Koʻolau mountains some 21 kilometers distant. Waikele Ahupuaʻa (to the west) and Waiawa Ahupuaʻa (to the east) border Waipiʻo.

The upper portions of the project area are located within Kīpapa Gulch and on the gently-sloping interfluvial plain (between Kīpapa and Pānakauahi) known as either Keahumoa or Kanoenoe, depending on the source. As illustrated below, there is a large body of specific oral-historical information associated with Kīpapa and Keahumoa. Lower portions of the project area, including the upper Waipiʻo Peninsula, were permanently settled in pre-Contact and early historic times; these areas were also prime gardening locations. Upper portions of the project area away from the Kīpapa Gulch were unlikely to be a location of either permanent native Hawaiian settlement or traditional-style irrigated cultivation (e.g., *kalo,* or taro). Kīpapa Gulch, itself, was likely a place of small scattered living sites and gardens.

In the upper project area away from Kīpapa Gulch, native Hawaiians almost certainly maintained ʻ*okipu* or ʻ*okipuʻu* gardens, that is, dry-land (non-irrigated) forest clearings, of sweet potatoes and other suitable crops interspersed among the native lowland forest and scrublands of this area. In traditional style, these gardens would have been tended periodically as people traveled from the coastal lowlands of Puʻuloa to the upper plateau of Līhu'e and beyond to the mountains for gathering purposes. The upper portion of the project area is close to the location of an old native Hawaiian trail connecting ʻEwa to the Waialua District through the Central Oʻahu Plains, as well as to Waiʻanae over Kolekole Pass.

Documented *heiau* were located (Ahuʻena Heiau) down slope at Hālaulani (south of the H-1 highway), near the old Loko ʻEo (Eo Fishpond), and upslope at the headwaters of Kīpapa Stream (Moaʻula Heiau and Heiau o ʻUmi).

By virtue of its location in Waipiʻo and Waikele, the subject project area is generally associated with many *moʻolelo* (oral histories and legends) and *wahi pana* (storied or legendary places) from such areas as Puʻuloa, ʻEwa Moku and the uplands of Līhuʻe. Legendary connections to the lowland areas of Waipiʻo include the famous gaming and competition sites of Pueohulunui and Hālaulani, fresh water springs and *loko* (fishpond) and the old village of Waipahu. Numerous other *moʻolelo* and *wahi pana* are associated with the Kula o Keahumoa, including the demi-god/hero figures of Palila, Pikoi and Maui; the goddess Hiʻiaka; and other legendary individuals (e.g., Kalelealuakā and Nāmakaokapaʻo). There are also many references to battles in this area, which was also (especially the lowlands around Puʻuloa) home to many hereditary elites (*aliʻi*).

In late pre-Contact and early historic times, the project area is also associated with intra- and inter-island struggles for control over Oʻahu Island and with the Hawaiian Kingdom's entrance into the world market economy (i.e., the sandalwood trade). Later, the area was used for ranching and for various commercial agricultural crops, most notably sugar cane (Oahu Sugar Company) and later pineapple. The prominent 19th century Hawaiian, John Papa ʻĪʻī, was born at Hālaulani (near Loko ʻEo) and provided several historic descriptions of life and times in Waipiʻo at the dawn of the historic era.

3.2 Place Names

Translations presented without attribution in this subsection are from Pukui et al. (1974), unless indicated otherwise. Many of the place names listed below are associated with specific *moʻolelo* and *wahi pana*, which are presented in Section 3.3 (below).

Waipiʻo means "curved water" or "curved, winding water" (Sterling and Summers 1978:1), which presumably refers to the curving shorelines of the middle loch of Pearl Harbor, with its many adjacent fishponds.

Kīpapa, in the western project area, translates literally as "placed prone (referring to corpses slain in the victory of Oʻahu forces over those of Hawaiʻi in the fourteenth century)" (Pukui et al. 1974:113). Two *heiau* were once located at the headwaters of Kīpapa, Moaula (or Moaʻula) Heiau and Heiau o ʻUmi. The seasonal drainage to the east of the project area is known as Pānakauahi, which translates as "touched by smoke."

Pueohulunui, a famed gaming place (where various traditional competitions such as *ʻulu maika* rolling and spear throwing took place), located in the south project area, is not described by Pukui et al. (1974) as an Oʻahu place name (but rather one in Kāʻu, Hawaiʻi Island). Regardless, Pueohulunui translates as "well-feathered owl." Another such nearby place, Hālaulani, which was the location of Ahuʻena Heiau, is not translated by Pukui et al. (1974). Ahuʻena is translated as "red-hot heap," and apparently refers to the human sacrifices that were carried out here. Both of these places (Pueohulunui and Hālaulani) and the *heiau* are associated with several different *moʻolelo* (see below).

Puʻu Pōhaku (literally, "Rock Hill"), 705 feet elevation, is located just east of the project area along the eastern margins of the Pānakauahi drainage.

Kanoenoe and **Keahumoa** appear to be variant names for the same broad plain leading up to Kīpapa Stream, and including the subject project area. Keahumoa is associated with multiple *mo‘olelo* (see below).

Waipahu village and spring, located immediately southwest of the project area, translates as “bursting water (water burst forth from underground)” or “pushing water, said to be named for water that forced its way out of the earth…” Pukui et al. (1974:227) also state: “…said to have been originally Wai-pahū. The shark goddess Ka-‘ahu-pāhau lived here.” According to Pukui and Elbert (1986), *pahū* means “to explode, burst,” or “explosive,” or “outburst,” thus reinforcing the meaning(s) of this place name.

Loko (Fishpond) Eo, located in the south project area, is not translated by Pukui et al. (1974), whose entry for “Loko-‘eo” says simply “Fishpond, Pearl Harbor, O‘ahu.” They do provide another similar name, Loko ea, translated as “rising pond,” and located near Waialua and Waipahu. The word *‘eo* is translated by Pukui and Elbert (1986) as “full of food,” and perhaps this is one of the meanings of the name Loko Eo (or ‘Eo).

3.3 Mo‘olelo Associated with Place Names

3.3.1 Waipi‘o Uka and the Legend of Kalelealuakā

In the *mauka* regions of Waipi‘o, legend (Thrum 1998:74-106) speaks of Kalelealuakā, who lived during the reign of the O‘ahu chief, Kākuhihewa (i.e., late 16th century to early 17th century). Kalelealuakā was the son of Kaopele, who was born in Waipi‘o, O‘ahu. Kaopele had a tendency to fall into deep trances for months at a time. While awake, he would create plantations of supernatural proportions. However, he was never able to enjoy the fruits of his labors because he would always fall into another deep sleep.

During one profound slumber when Kaopele was believed to be dead, he was taken to Wailua, Kaua‘i to be offered as a sacrifice. Upon awakening, he married a woman named Makalani and stayed on Kaua‘i. They had a son named Kalelealuakā, who was also blessed with supernatural powers. Kaopele instructed the boy in the arts of war and combat, which Kalelealuakā exhibited during two challenges with kings of Kaua‘i. One day, Kalelealuakā decided to travel to O‘ahu. A boy, Kaluhe, accompanied him and they paddled to Wai‘anae. There, he met another companion who he later named Keinoho‘omanawanui, the sloven. The three traveled toward the old plantation called Keahumoe (Keahumoa), in the *mauka* regions of Waipi‘o, that were formerly planted by Kaopele.

> . . . the three turned inland and journeyed till they reached a plain of soft, whitish rock, where they all refreshed themselves with food. They kept on ascending, until Keahumoe lay before them, dripping with hoary moisture from the mist of the mountain, yet as if smiling through its tears. Here were standing bananas with ripened, yellow fruit, upland *kalo*, and sugar cane, rusty and crooked with age, while the sweet potatoes had crawled out of the earth and were cracked and dry. (Thrum 1998:86-87)

To determine the best settlement location, Kalelealuakā shot an arrow to see where it would land. He then built a mountain house and called it "Lelepua" (meaning "arrow flight"), after his magic arrows.

3.3.2 Nāmakaokapaʻo and the Kula o Keahumoa (Plains of Keahumoa)

In the legend of Nāmakaokapaoʻo, one lowland area was called the "*kula o Keahumoa*" ("plain of Keahumoa"), which was the plain before reaching Kīpapa Gulch. As stated above (Section 3.2), an alternative name for this area may be Kaoneone. Nāmakaokapaoʻo's mother was Pokai and his father was Kaulukahai, a great chief of Kahiki (the ancestral home of the Hawaiians). The father returned to his home before the birth of his son, leaving his Oʻahu family destitute. Nāmakaokapaoʻo is described as a small, brave child who disliked his stepfather, Pualiʻi, and pulled up the sweet potatoes Pualiʻi had planted at their home in Keahumoa. When Pualiʻi chased Nāmakaokapaoʻo with an axe, Nāmakaokapaoʻo delivered his death prayer and killed Pualiʻi, hurling his head to a cave in Waipouli, near the beach at Honouliuli (Fornander 1919 V:274).

According to other versions of the legend of Nāmakaokapaʻo (Fornander Vol. 5, part 2, p.274):

> Pokai then assented and went to live with her husband Pualii, and resided at the plains of Keahumoa (the plain below Kipapa Gulch). They lived there tilling the soil, Pualii had two large taro patches which remain to this day. They are called Namakaokapaoo. (in Handy 1940:82)

The plains of Keahumoa are also mentioned in other Hawaiian stories. The goddess, Hiʻiaka, a sister of the volcano goddess Pele, passed through ʻEwa and met some women wearing flower *lei* (published in *Ka Hōkū o Hawaiʻi*, translated by Kepā Maly):

E lei ana ke kula o Keahumoa i ka maʻo	The plain of Keahumoa wears the *maʻo* blossoms as its lei
ʻOhuʻohu wale nā wahine kui lei o ke kanahele	Adorning the women who string garlands in the wild.
	(from Jensen and Head 1997:17)

Pikoi was a legendary hero, the son of a crow (*ʻalalā*) and brother to five god-sisters in the form of rats. He was famous for his ability to shoot arrows, and often made bets that he could hit rats from a long distance (Fornander 1917, Vol. IV, Part III:450-463). Pikoi's skill was commemorated in a saying (Pukui 1983:200):

Ku aku la i ka pana a	Shot by the arrow of Pikoi-[son]
Pikoi-a-ka-ʻalalā, keiki pana	of-the-crow, the expert rat-shooter
ʻiole o ke kula o Keahumoa.	Of the plain of Keahumoa.

In the legend of the hero Palila, the warrior uses his supernatural war club to carry himself to Kaʻena Point at Waiʻanae.

After leaving Kaʻena, he came to Kalena, then on to Pōhākea, then to Manuauna, then to Kānehoa, then to the plain of Keahumoa and looked toward ʻEwa. At this place he stood and looked at the dust as it ascended into the sky caused by the people who had gathered there; he then pushed his war club toward Honouliuli. When the people heard something roar like an earthquake they were afraid and they all ran to Waikele. When Palila arrived at Waikele he saw the people gathered there to witness the athletic games that were being given by the king of O‘ahu, Ahupau by name. His palace was situated at Kalaepōhaku, close to Wailuakio at Kapālama (Fornander 1918, Vol. V, part I:142).

3.3.3 Maui and Keahumoa

In the stories of the Maui-kupua (i.e., Maui-the-demi-god), Keahumoa is the home of Maui‘s grandfather, Kū-olokele (Kū-honeycreeper). One day, Maui’s wife, Kumu-lama, was stolen by the chief Pe‘ape‘amakawalu, called eight-eyed-Pe‘a-Pe‘a, who is identified in the creation chant Kumulipo, as the octopus god (Beckwith 1951:136). The chief disappeared with Kumulama in the sky beyond the sea, and escaped so quickly that Maui could not catch him. To recover his wife, Maui’s mother advised him to visit the hut of his grandfather at Keahumoa:

> Maui went as directed until he arrived at the hut; he peeped in but there was no one inside. He looked at the potato field on the other side of Pōhā-kea, toward Hono-uli-uli, but could see no one. He then ascended a hill, and while he stood there looking, he saw a man coming toward Waipahu with a load of potato leaves, one pack of which, it is said, would cover the whole land of Keahumoa. (Thrum 1923:253-254)

Kū-olokele made a *moku-manu* (“bird-ship”) for Maui, who entered the body of the bird and flew to Moanaliha, the land of the chief Pe‘ape‘amakawalu. This chief claimed the bird as his own when it landed on a sacred box, and took it with him into the house he shared with Maui’s wife, Kumulama. When Pe‘ape‘amakawalu fell asleep, Maui killed him, cut off his head, and flew away back to O‘ahu with his wife and the chief’s head (Thrum 1923:252-259; see also Kawaharada 1996).

3.3.4 Kaoneone Plain

As stated above, it is possible that Keahumoa and Kaoneone are variant names for the same plain that leads up to the headwaters of Kīpapa. A piece from the Hawaiian language newspaper *Ka Loea Kalaiaina* contains a few poetic lines that clearly associate Kaoneone with other old O‘ahu place names:

> The icy wind of Lihue plied its spurs,
> Pulling up the bridle of Haleauau,
> Speeding headlong over Kalena
> And running over the plain of Kaoneone.

3.3.5 The Battles of Kīpapa

Waipi‘o was the scene of more than one battle between local and invading *ali‘i* for political control of O‘ahu (Handy and Handy 1972:470). One of these was apparently fought during the reign of the 15th century *mō‘ī* (king) Ma‘ilikūkāhi. Fornander’s telling of this *mo‘olelo* also explains how Kīpapa gulch and stream in Waipi‘o were named:

> I have before referred to the expedition by some Hawaii chiefs, Hilo-a-Lakapu, Hilo-a Hilo-Kapuhi, and Punaluu, joined by Luakoa of Maui, which invaded Oahu during the reign of Mailikukahi. It cannot be considered as a war between the two islands, but rather as a raid by some restless and turbulent Hawaii chiefs, whom the pacific temper of Mailikukahi and the wealthy condition of his island had emboldened to attempt the enterprise, as well as the éclat that would attend them if successful, a very frequent motive alone in those days. The invading force landed at first at Waikiki, but, for reasons not stated in the legend, altered their mind, and proceeded up the ʻEwa lagoon and marched inland. At Waikakalaua they met Mailikukahi with his forces, and a sanguinary battle ensued. The fight continued from there to Kipapa gulch. The invaders were thoroughly defeated, and the gulch is said to have been literally paved with the corpses of the slain, and received its name, "Kipapa," from this circumstance. Punaluu was slain on the plain which bears his name, the fugitives were pursued as far as Waimano, and the head of Hilo was cut off and carried in triumph to Honouliuli, and stuck up at a place still called Poo-Hilo. (Fornander 1996:89-90)

A second "Battle of Kīpapa," from the Hawaiian language newspaper *Hoku o Hawaii*, involves different main characters and, unlike the previous one, has the Oʻahu side losing to the Hawaiʻi Island *koa* (warriors):

> Mr. Kahikulani was a war leader of Puna, Hawaii. He came to battle against the [famous Oʻahu] chief Halemano whose cannibal meat dish became famous. He went inland and up to the very top of the mountain. He looked down on Kipapa stream where his warriors fought those of Chief Halemano in a great battle. The sun had not set when all of Halemano's warriors were destroyed. The land and stream of Kipapa was reddened with the blood shed in this battle. That was the first time that the public highway became peaceful in that period that is gone. Kakikulani was a man of power in Puna, Hawaii. (Na Anoai o Oahu nei, *Hoku o Hawaii*, Jan. 28, 1930, "Place Names," in Sterling and Summers 1978:20)

3.3.6 Spearing-throwing Contest at Pueohulunui and Hālaulani

An excerpt of a fragment of unfinished material authored by one Donald Angus Coll from the Hawaiian language newspaper *Kuokoa* describes a spear-throwing competition in and around the project area:

> The chief [Piliwale, ruling chief of ʻEwa at the time] had declared that if any man be found who was skilled in spear throwing and could out-match his instructor then the reward would be his daughter [Kohepalaoa]. The chief's spear throwing instructor was Awa. He could hold ten spears in his right hand and ten in his left. He could, with two thrusts send ten at the back, two to trip his opponent and two at the navel…
>
> The spear throwing contest lasted two days at Pueohulunui but none dared to challenge the instructor. As for Lo-Kaholialale, he observed the manner in which the expert instructor thrust and parried and he also knew how his own instructor

> fought. Ake-pao-a-na-ihe (Eager-to-thrust-with-spears) was the name of his own teacher.
>
> On the third day the contest was taken down to Halaulani. It was there the chief heard that a certain young chief of the upland of Lihue challenged Awa-hauna-laʻau-nui.
>
> There the young chief of Lihue showed his unequalled skill in parrying. The strokes by which he won was the pane (skull top) from above and the huʻalepo (dust scattering) from below. Two places were then named Ka-pahu (The thrust) and Hana-pouli (making-a-darkness) and they are at Waipio in Ewa. (in Sterling and Summers 1978:23).

3.3.7 Waipahu Pūnāwai (Spring)

There are several variations of *moʻolelo* associated with this *pūnāwai* (fresh water spring) located southwest of the project area in the lowlands of Waikele. The spring was described by McAllister (1933) as “famous in tradition as the place at which the tapa mallet appeared after having been lost in Kahuku. A pump has been placed over the site” (Sterling and Summers 1978:25). There are several variations of this particular legendary connection between Kahuku and Waipahu by way of this spring (see, e.g., Sterling and Summers 1978:25-26).

Referring to this same spring, an entry in the Hawaiian language newspaper, *Kuokoa* (August 11, 1899) reads: “Saw the river in which Madam Kaahupahau [Kaʻahupāhau] (a shark goddess) swam up from the sea at Puuloa to the upland to bathe in the fresh water of the gushing spring of Waipahu.” (Sterling and Summers 1978:25).

3.3.8 Pānakauahi

The seasonal stream drainage located to the east of the project area is associated with an interesting character named Ke-akua-ʻōlelo, as described by Pukui et al. (1974:178):

> A talkative local god, Ke-akua-ʻōlelo (the speaking god), lived here. According to some accounts he betrayed secrets. In another story he saw a chiefess hide a *lei palaoa* (whale-tooth pendant) in a stone called Pōhaku-hūnā-palaoa (stone hiding whale-tooth pendant); he promised to tell only her descendants.

3.3.9 Waikele Background Summary and Predictive Model

A small makai portion of the project area lies in Waikele Ahupuaʻa. The *makai* portion of Waikele including the Waipiʻo Peninsula and the surrounding loch waters of Pearl Harbor contained abundant marine resources and arable land which would have been extremely favorable to pre-contact Hawaiian populations for the development of large scale taro cultivation and the implementation of aquaculture in the form of large fish ponds or *loko*. A 1889 J. F. Brown map of the *makai* portion of Waikele shows the *makai* portion of the project area crossing thru 8 LCAs and completely surrounded by others. LCA documentation indicates that by the mid-eighteenth century the entire *makai* portion of the project area was in an extensive network of irrigation ditches, agricultural fields, fish ponds, and habitations, developed over many centuries. Previous archaeological research has also documented pre-contact subsurface cultural layers, human burials, and petroglyphs in the immediate vicinity of the *makai* project area (Perzinski et al. 2004; Ostroff et al. 2001; and Hammatt et al. 2000), providing further evidence of the pre-contact Hawaiian occupation of the area.

During the late nineteenth century the Oahu Sugar Company established sugarcane operations in Waikele. A 1925 Oahu Sugar Company map indicates that the entire *makai* portion of the project area was within the boundaries of Oahu Sugar Company operations. The *makai* portion of the project area does not appear to have been planted with cane, but is situated within the heart Oahu Sugar Company operations. Extensive sugar transport (railroad stations), harvesting (field workers quarters) and processing (sugar mill) infrastructure are indicated within and in the immediate vicinity of the *makai* portion of the project area. Previous archaeological research has identified remnants of Oahu Sugar Company infrastructure, in the form of abandoned plantation camps and sugar mill architecture and machinery, within and in the immediate vicinity of the *makai* project area (Hammatt et al. 2000; Cleghorn 1996; and Spear 1993).

Land modifications within the *makai* portion of the project area associated with historic sugar agriculture, as well as modern urban development (i.e. asphalt paved roads) have caused extensive land disturbances (i.e. grading, leveling, filling, etc.) which would have destroyed and/or buried any evidence of both pre- and post-contact land use. However, it is very likely that subsurface historic properties, associated with both pre- and post-contact land use, are present within the *makai* project area in the form of cultural layers and/or structural remnants buried by modern and/or historic fill layers. Evidence of pre-contact land use could be in the form of human burials, midden deposits, artifacts (i.e. stone tools), *lo‘i* deposits (organically enriched sediment indicative of taro cultivation), as well as buried *lo‘i* or fishpond walls. Evidence of post-contact land use could be in the form of human burials, trash pits, privies, and building foundations.

3.4 Settlement and Subsistence

Waipi‘o Ahupua‘a was a locus of Hawaiian settlement and activity on O‘ahu during the centuries preceding western contact. “The populous dwelling place of the *alii* was formerly located on an east point of Waipi‘o Peninsula known as Lēpau” (McAllister 1933:106). The *ali‘i* (chiefly class) at Waipi‘o were no doubt attracted to the great abundance the region offered. “The primary reason for ‘Ewa’s prominence in history and as an *ali‘i* stronghold was undoubtedly the existence of the great number of fishponds at different points around Pearl Harbor, which was ‘Ewa territory. Two of the largest [Loko Eo and Loko Hanaloa] were on the peninsula, and another was at its northwest corner” (Handy and Handy 1972:470). The district of ‘Ewa also contained other resources that were attractive to an expanding population:

> The lowlands, bisected by ample streams, were ideal terrain for the cultivation of irrigated taro. The hinterland consisted of deep valleys running far back into the Ko‘olau range. Between the valleys were ridges, with steep sides, but a very gradual increase of altitude. The lower parts of the valley sides were excellent for the culture of yams and bananas. Farther inland grew the *‘awa* for which the area was famous. The length or depth of the valleys and the gradual slope of the ridges made the inhabited lowlands much more distant from the *wao*, or upland jungle, than was the case on the windward coast. Yet the *wao* here was more extensive,

> giving greater opportunity to forage for wild foods in famine time. (Handy and Handy 1972:469)

Handy described the character and extent of the lowland cultivation areas in the Waipiʻo area:

> Between the West Loch of Pearl Harbor and Loko Eo the lowlands were filled with terraces which extended for over a mile up into the flats of Waikele Stream. The lower terraces were formerly irrigated partly from Waipahu Stream, which Hawaiians believe came all the way through the mountains from Kahuku. It is said that terraces formerly existed on the flats in Kipapa Gulch for at least 2 miles upstream above its junction with Waikele. Wild taros grow in abundance in upper Kipapa Gulch… (Handy 1940:82)

Writing in the mid-19th century, John Papa ʻĪʻī described how a period of famine was managed in Waipiʻo and what resources were available during the famine. These comments stress importance of upland resources to the *kamaʻāina* (commoners) of Waipiʻo:

> Here is a wonderful thing about the land of Waipio. After a famine had raged in that land, the removal of new crops from the taro patches and gardens was prohibited until all of the people had gathered and the farmers had joined in thanks to the gods. This prohibition was called *kapu ʻohiʻa* because, while the famine was upon the land, the people had lived on mountain apples (*ʻohiʻa ʻai*), tis [i.e., *kī* or *tī*], yams, and other upland foods. On the morning of Kane an offering of taro greens and other things was made to remove the *ʻohiʻa* prohibition, after which each farmer took of his own crops for the needs of his family. (ʻĪʻī 1959:77)

ʻĪʻī also talked about supplying a royal party connected with Liholiho (Kamehameha II, who ruled from 1819 to his death in 1824), including the King, himself, who were journeying overland from Honolulu and staying the night at Kūmelewai (near Hanaloa Fishpond, in the south project area in Waipiʻo). ʻĪʻī's description suggests that all necessary resources for this purpose were obtained from Waipiʻo Ahupuaʻa, including most especially its upland areas:

> Before the company arrived for the night, Ii was sent with a message to the dwellers of the land [i.e., the *makaʻāinana* of Waipiʻo Ahupuaʻa] to be ready with fish, dogs, vegetable food, and clothing that would be of help to the travelers. Thus were all things supplied from upper Waipio to the sea. There was enough for the traveling company of the young chief [Liholiho], who was spending the night there. (ʻĪʻī 1959:23)

3.5 Heiau

Located at Hālaulani, in the immediate vicinity of the south project area, Ahuʻena Heiau (State Inventory of Historic Properties [SIHP] No. 50-80-09-122) was described in the 1930s by McAllister (1933) of the Bishop Museum as follows:

> Ahuʻena Heiau (Destroyed)…Only a small portion of paving of very small waterworn stone at the edge of the 25 foot elevation remains of what must have been an important heiau, for the site is known and remembered by all the old

> Hawaiians (kamaaina) in the district. There is a vague memory that this heiau was formerly located in the mountains in Honouliuli at Punahawele. Thrum states "Hon. John [Papa] Ii [the 19th century historian, member of the Land Commission and prominent citizen] used to be the custodian of its idols." (Sterling and Summers 1978:19)

McAllister (1933) described two other *heiau* (both "destroyed" by the time of his 1930s survey) located at the *mauka* headwaters of Kīpapa Stream. Moaula Heiau (SIHP No. 50-80-09-130) was described as: "…on the Honouliuli side of Kīpapa Gulch just above Heiau o ‘Umi, to which it is said to be a companion structure…" Pukui et al. (1974) translate Moa‘ula (their preferred spelling for this *heiau*) as "red chicken." Heiau o ‘Umi (SIHP No. 50-80-09-131) "…was just northeast of the government road in the bottom of Kipapa Gulch on the slight elevation at the foot of the pali on the Honolulu side. The level elevation can still be seen, though planted in cane." ‘Umi presumably refers to the 16th century supreme ruler of Hawai‘i Island; therefore, this name—if this not the entire *heiau*, may be a relatively recent (i.e., Later Pre-Contact) phenomenon.

Two other nearby *heiau* were documented by McAllister in the lowlands of Waikele, southwest of the project area: Mokoula Heiau (SIHP No. 50-80-09-127) "has [by the 1930s] been completely destroyed for building purposes of the neighborhood" (McAllister 1933:106). Mokoula Heiau was pointed out to McAllister (around 1930) by *kama‘āina* Kaluawai, who was "undoubtedly [according to McAllister] more than 100 years old."

Hapupu Heiau (SIHP No. 50-80-09-129) was also reported by McAllister as destroyed. According to Thrum's earlier description of this temple, Hapupu Heiau was a "Heiau pookanaka [human sacrifice temple], where the chief Hao was surprised during temple worship and slain with his priest and attendant chiefs by direction of the moi [king] of Oahu, about 1650." The site was pointed out to McAllister (around 1930) by *kama‘āina* Kapano.

3.6 Loko (Fishponds)

Much of ‘Ewa District *makai* of the south project area environs is traditionally well-known for its many *loko* (fishponds), both large and small. The closest major *loko* to the project area was Loko ‘Eo, described in the *Dictionary of Hawaiian Localities* (*Saturday Press*, August 11, 1883) as a "…large fishpond in Ewa, well known for superior flavor of fishes" (Sterling and Summers 1978:20). As stated above, *‘eo* is translated as "full of food" (Pukui and Elbert 1986:42). A nineteenth century visitor to Loko ‘Eo described it in the Hawaiian newspaper *Ka Nupepa Kuokoa* (Aug. 11, 1899):

> We rode and reached Waipio. Saw Halaulani House; only the house stood there for the inhabitants had gone to Mana. The bubbling waster of the pond Eo rippled on the left. There a recollection came of the bundles of fat eel from that place and the delicious mullet of Makahanaloa. It was delicious clean and that is why the very juice in the ti leaves was sucked up by Kohala's son (cited in Sterling and Summers 1978:20).

Just south of this *loko*, still on the Waipi‘o Peninsula, was Loko Hanaloa, reportedly very near to the actual birthplace of John Papa ‘Ī‘ī.

3.7 Trails

Portions of the project area are in the immediate vicinity of a well-documented traditional trail, which formerly connected ʻEwa to the Waialua District through the Central Oʻahu Plains, as well as to Waiʻanae over Kolekole Pass (see the often-reproduced map on p. 96 in ʻĪʻī 1959 and Figure 5. below). As reconstructed in the Rockwood map (present Figure 5), the eastern-most of the two main trails passing up through central Oʻahu would have passed on the west side of the present study area.

3.8 Other Traditional Resources of Waipiʻo

Several well-known sources, including Handy (1940), Handy and Handy (1972), Sterling and Summers (1978) and ʻĪʻī (1959), mention other traditional resources for which Waipiʻo is famous. These include: its extensive *wao* (upland jungle) and its diverse and abundant wild foods (e.g., *ʻōhiʻa ʻai* or Mountain apple), birds such as *ʻōʻō* (a black honey eater, *Moho nobilis*) and *ʻiʻiwi* (Scarlet Hawaiian honey creeper, *Vestinaria coccinea*) for making feather capes, helmets and *lei*) and tapa-making plants such as *wauke* (paper mulberry, *Broussonetia papyrifera*) and *māmaki* (*Pipturis* spp.); and, a local variety of the mildly narcotic plant, *ʻawa* (also known as ʻkava,ʼ *Piper methysticum*).

Waipahu Spring (Site 128), located in the lowlands of adjacent Waikele, southwest of the project area, was described as being "famous in tradition as the place at which the tapa mallet appeared after having been lost in Kahuku" (McAllister cited in Sterling and Summers 1933:25).

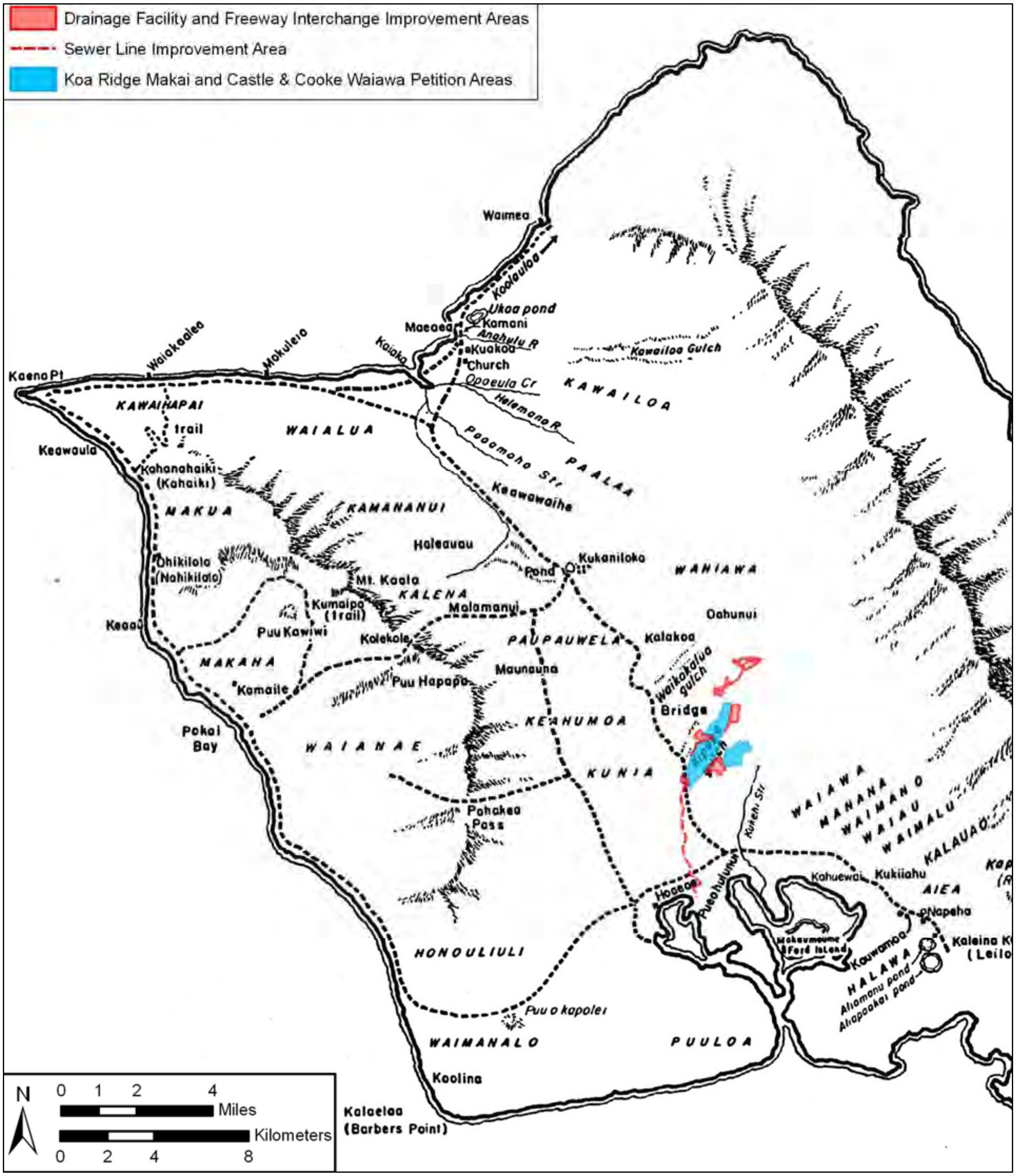

Figure 5. Map showing trails of leeward O‘ahu (source: Rockwood in ‘Ī‘ī 1959: 96), in relation to the project area)

Section 4 Historical Background

4.1 Late Pre-Contact and Early Historic Eras

In the first half of the eighteenth century, the island of Oʻahu was ruled by a chief named Kūaliʻi who consolidated his supreme power over the entire island by defeating the chiefs of ʻEwa (Cordy 2002:32). Kūaliʻi met the competing army on the plains of Keahumoa, but the ʻEwa chiefs surrendered when they saw Kūaliʻi's overwhelming forces, and they ceded the lands of Koʻolau Loa, Koʻolau Poko, Waialua, and Waiʻanae to him (Fornander 1917, Volume IV (2):366, 400).

During the second half of the eighteenth century, Waipiʻo again became a focus of political intrigue and warfare. In 1783, the forces of the Maui chief Kahekili gained control of the island of Oʻahu by defeating the *mōʻī*, Kahāhana, "from the powerful ʻEwa chiefs' line" (Cordy 1981:207). According to the 19th Hawaiian historian Samuel Kamakau, the defeated Oʻahu chiefs plotted to kill the Maui chiefs. Waipiʻo was given the name "Waipiʻo *kīmopō*," or "Waipiʻo of the secret rebellion," due to all the covert planning (Kamakau 1992:138). Pukui (1983) comments on this name:

> An epithet for the people of Waipiʻo, Oʻahu. After the death of Kahāhana, the chiefs of Waipiʻo plotted to murder the chiefs of Maui, who were then in ʻEwa. Someone warned the Maui chiefs and all but one escaped. To throw off suspicion, the Waipiʻo chiefs claimed that the one was killed by someone from Kauaʻi. Later Kahekili learned that Elani, chief of ʻEwa, was in the plot, so he launched a massacre that choked the streams of Niuhelewai and Makāhi in Palama with the bodies of the dead. (Pukui 1983:319)

Kamakau adds some additional details. Following the plan's failure, Kahekili took revenge on the ʻEwa and Kona districts:

> . . . and when Ka-hekili learned that Elani of ʻEwa was one of the plotters, the districts of Kona and ʻEwa were attacked and men, women, and children were massacred, until the streams of Makaho and Niuhelewai in Kona and of Kahoaʻaiʻai in ʻEwa were choked with the bodies of the dead, and their waters became bitter to the taste, as eyewitnesses say, from the brains that turned the water bitter. All the Oʻahu chiefs were killed and the chiefesses tortured. (Kamakau 1992:138)

If Kamakau is correct, the population of Waipiʻo would have been decimated during the 1780s. Kahekili and the Maui chiefs retained control of Oʻahu until the 1790s. In 1794, Kahekili died at Waikīkī. His son, Kalanikūpule, was defeated the following year at the battle of Nuʻuanu by Kamehameha, who distributed the Oʻahu lands - including Waipiʻo Ahupuaʻa - among his favorite followers which resulted in the displacement of many families. "Land belonging to the old chiefs was given to strange chiefs and that of old residents on the land to their companies of soldiers, leaving the old settled families destitute" (Kamakau 1992:376-377).

4.2 1800s to 1850

John Papa ʻĪʻī—one of the Hawaiian Kingdom's most prominent citizens in the 19th century, and a member of the Land Commission that oversaw the distribution of lands during the Māhele—was placed in the household of Liholiho (Kamehameha II) when he was ten years old; he became Liholiho's personal attendant and also maintained records of life in the Hawaiian Kingdom. ʻĪʻī was born in Waipiʻo Ahupuaʻa in 1800; an autobiographical account of his birth details the establishment of ʻĪʻī's family at Waipiʻo after the ascendancy of Kamehameha I on Oʻahu:

> John Papa Ii was born in Kumelewai, Waipio, in Ewa, Oahu, on the third day of August (Hilinehu in the Hawaiian calendar) in 1800, on the land of Papa Ii , whose namesake he was. Papa [ʻĪʻī's uncle] was the owner of the pond of Hanaloa and two other pieces of property, all of which he had received from Kamehameha, as did others who lived on that *ahupuaʻa*, or land division, after the battle of Nuuanu. He gave the property to his *kaikuahine* [cousin] who was the mother of the aforementioned boy. Her names were Wanaoa, Pahulemu, and Kalaikane. (ʻĪʻī 1959:20)

ʻĪʻī's writings provide glimpses of life within Waipiʻo Ahupuaʻa during ʻĪʻī's lifetime. ʻĪʻī mentions the "family [going] to Kīpapa from Kūmelewai by way of upper Waipiʻo to make ditches for the farms" (ʻĪʻī 1959:28) and recalls that, during the visit to Oʻahu by the Kauaʻi chief Kaumualiʻi and his entourage, the chief's attendants were provided with gifts: "From Waipio in Ewa and from some lands of Hawaii came *tapa* made of *mamaki* bark" (ʻĪʻī 1959:83).

ʻĪʻī also described witnessing the activities and ceremonies associated with the Makahiki, the annual traditional celebration (somewhat akin to New Years, but lasting about four months) including sports and competition, religious observances and prohibitions of warfare. Traditionally, the Makahiki festival moved around the island, and ʻĪʻī witnessed and described it as it came through Waipiʻo. Given that he was moved to Waikīkī when approximately 10 years old, the following description probably comes from his memories before that age:

> Many people followed the procession on its tour over the land, among them the boxers, and all partook of the foods that were contributed by the people of each place. Ii followed the procession of the gods as far as Waipio in Ewa, and thus learned the customs of the *makahiki* period.
>
> In imitation of what he saw on his journey from Honolulu with the god of play, the boy made two images that looked very much like the *makahiki* gods. Beside them he placed ferns and a clump of bananas bearing fruit.
>
> For four days there was boxing with the boys from Waikele. The matches were held in front of the images, starting about four o'clock in the afternoon. Then, because the visiting boys plotted to take the images, they were put away in a safe place.
>
> At noon of the fifth day the battlers met at a designated place and fought back and forth with stones. One of the Waipio boys was struck by a Waikele boy, and so the battle was postponed until evening. Then those of both sides gathered.

> Kaapuiki, wearing his dark red shoulder covering, was on the side of the opponents, and when Ii threw his stone, it struck Kaapuiki on the eyebrow and made him cry. This ended their devilish behavior; but Ii, having been told that the other was the son of a sorcerer, was frightened. Later he learned that the report was not true.
>
> After this “battle” of the children a sham battle between adults took place on the southwestern side of Kupapaulau at Waikele. Two chiefs who had gone from Honolulu to Puuloa with some chiefs of that locality landed at Aioloolo in Waikele, and the battle was staged between them and residents of Waikele that very afternoon. The two sides gathered at a place above Aioloolo on the slope of the hill leading down to Kupapaulau.
>
> The spectators noticed that both sides were equally skilled in stone throwing and in dodging the stones that flew back and forth. No one was hurt or harmed, and the skill of the participants and the chiefs who arranged the sham battle was praised. It seems that the chiefs watched to see how skilled their people were in battle.
>
> At about the time of the sham battle, a proclamation came from Kawelo, the overseer of the land at Waikele, for the men of the land to fetch the double canoe beached at Kupahu, on the northeastern side of Halaulani in Waipio. Because this proclamation came from Kawelo, who said the order was from Kalanimoku, the men of Waipio made ready to detain the canoe. They felt that the command should have come from their own leader, Papa.
>
> When Kawelo and the men of Waikele had taken their places from prow to stern of the canoe and the command, “Go ahead,” was given, the canoe did not budge. It was being held back by the men of Waipio, Kawelo’s men tried again to make it go forward, but to no avail, so Kawelo asked the Waipio men why they held on. Kaimihau answered, “You cannot do this, for we were not told of it by our leaders. If Kalanimoku had made this request through our own leaders, we should have heard of it and therefore done nothing to prevent the removal of the canoe. If you persist in the idea of taking the canoe, day may change to night and night to day without its budging from its resting place. All things left here at Waipio are protected, from the sea to the upland, and we shall not let them go unless we hear from our own leaders.” O companions, see how well the people served their leader. The peace of the land of Waipio was well known while the high chiefs were in charge and up to the time of Papa’s death.

The end of the eighteenth century and beginning of the nineteenth century marked Hawai‘i’s entry into world trade networks. One of the chief exports at this time was sandalwood (*Santalum* spp.) or *‘iliahi*, which was prized in China for its unique fragrance and was used in the manufacture of household items, and as incense, perfume, and medicine (St. John 1947). The central plains of ‘Ewa supplied the Hawaiian Kingdom with *‘iliahi*. One of the first generation missionaries, Sereno Bishop (1901), described his memories of the central O‘ahu region in the 1830s:

> Our family made repeated trips to the home of Rev. John S. Emerson at Waialua during those years. (Bishop Family moved to Ewa in 1836.) There was then no road save a foot path across the generally smooth upland. We forded the streams. Beyond Kipapa gulch the upland was dotted with occasional groves of Koa trees. On the high plains the ti plant abounded, often so high as to intercept the view. No cattle then existed to destroy its succulent foliage. According to the statements of the natives, a forest formerly covered the whole of the then nearly naked plains. It was burned off by the natives in search of sandalwood, which they detected by its odor when burning. (cited in Sterling and Summers 1933:89)

The dry forests formerly covering this region probably never came back, particularly considering the harm done to the *ʻiliahi* seedlings with the introduction of cattle soon thereafter (Judd 1933). It is also important to point out that other types of hardwood were in great demand as Honolulu was built up during the 19^{th} century.

Native Hawaiian activity and habitation at the middle of the nineteenth century clustered in the *makai* lowlands and the fishponds near the coast. The *ahupuaʻa's makai* landscape was dominated by an extensive network of taro *loʻi* (irrigated fields), as indicated by Land Commission Award (LCA) documents from the mid-nineteenth century Māhele.

4.3 The Māhele

The Organic Acts of 1845 and 1846 initiated the process of the Māhele, the division of Hawaiian lands, which introduced private property into Hawaiian society. In 1848, the crown, the Hawaiian government, and the *aliʻi* (royalty) received their land titles. The common people (*makaʻāinana*) received their *kuleana* awards (individual land parcels) in 1850. It is through Land Commission records generated during the Māhele that the first specific documentation of life in Waipiʻo Ahupuaʻa, as it had evolved up to the mid-nineteenth century, comes to light.

The majority of awarded land parcels were located in the *makai* portions of Waipiʻo, at or just above the peninsula (Table 1). John Papa ʻĪʻī was awarded most of the *ahupuaʻa* of Waipiʻo in LCA 8241, comprising approximately 20,540 acres. Included in the documentation for ʻĪʻī's award is a list of "the people living on the land of Waipiʻo ʻEwa in 1848" (Barrere 1994:73).

A substantial grant within the *ahupuaʻa* was awarded to Abner Pākī, Bernice Pauahi Bishop's father. Part of LCA 10613 given to Pākī comprised the 350 acres of the *ʻili* of Hanaloa. William Harbottle also received a land award (LCA 2937) in Waipiʻo; he claimed two acres at Hanapouliʻili.

The remaining land claims documented in the records, a total of 99 (not all of which were awarded), are *kuleana* claims, where the commoners of Waipiʻo worked and lived. Predominant among the claimed land usages in Waipiʻo are 312 *loʻi* (irrigated taro patches) of various sizes; and 43 *moʻo*, or fields, comprising indeterminate numbers of *loʻi*. Wetland taro cultivation was the primary agricultural pursuit within the *ahupuaʻa* at the mid-nineteenth century, and likely reflects a long history of taro farming. At the coast, four fishponds are claimed. In the *mauka* reaches of Waipiʻo, 53 claims were made for portions of *kula* (pasture land) and 25 for "*okipu*" or *ʻokipuʻu* (forest clearings). The fact that several claims were made in the *mauka* regions suggests that Waipiʻo residents had particular locales that they traveled to repeatedly. This also confirms other accounts (e.g., see Handy and Handy 1972:469-470) suggesting this area had especially abundant and diverse uplands. Kula land is a general term for open fields, pastures, uncultivated fields, or fields for cultivation, and upland (drier), which is distinct from meadow or wetland (Lucas 1995:60). Kula lands were often used for opportunistic plantings such as bananas, sugar cane, sweet potatoes, dry land taro, and others that did not depend heavily on a consistent source of water. Okipuʻu is defined as a forest clearing (Lucas 1995:82), a place that was presumably used to gather forest products and medicinal herbs and or for pasturage.

In contrast to the well-populated *makai* lands of Waipiʻo, the *mauka* regions were often described in 19th century accounts as virtually uninhabited. The missionary William Ellis described the interior regions of ʻEwa in 1823-24:

> The plain of Eva is nearly twenty miles in length, from the Pearl River to Waialua, and in some parts nine or ten miles across. The soil is fertile, and watered by a number of rivulets, which wind their way along the deep water-courses that intersect its surface, and empty themselves into the sea. Though capable of a high state of improvement, a very small portion of it is enclosed or under any kind of culture, and in traveling across it, scarce a habitation is to be seen. (Ellis 1963:7)

Despite Ellis' impressions, there is evidence that during the early nineteenth century, the Waipiʻo population was not solely focused on the fertile coast. In an inventory of advances in education during the reign of Kamehameha III (from 1825 to 1854), "schools were built in the mountains and in the crowded settlements. Waipiʻo had school houses near the coast and in the uplands" (Kamakau 1992:424). The placement of a school "in the uplands" of Waipiʻo suggests that some portion of the *ahupuaʻa* population had settled there.

During the 1830s, cattle grazing began in the *mauka* regions of Waipiʻo (Bishop 1901:87). In 1847, residents of more *makai* land petitioned the Minister of the Interior, John Young, to resolve the problem of stray animals. These stray animals may have been from herds of cattle and goats grazing on Waipiʻo's *kula* lands. In addition to damage from stray animals on the lands of Waipiʻo, the impact of grazing animals was noted several kilometers away at Puʻuloa (Pearl Harbor) and likely near the present project area. Stray cattle continued to be a problem until large-scale agriculture was introduced just prior to the beginning of the twentieth century. The occupation of the uplands by cattle denuded the countryside of ground cover, and caused vast quantities of earth to be washed down by storms into the lagoons, shoaling the water for a long distance seaward (Bishop 1901:87).

Table 1. Māhele Claims and Awards in Waipiʻo Uka

Claimant	Claim No.	Name of Land Claimed	Land Use	Land Awarded
Koikoi	No number	Kamanuiki in Waipiʻo Uka (Waikakalaua Stream)	1 house, no other land use indicated	unknown
Mokunui	8241L	Kamalokauhola	1 *moʻo*, 1 *kula*, 1 house lot, 1 house	Waipiʻo Uka Kamalokauhola 1 *ʻāp*. 0.54 Acs.
Ukeke	8241N	Maheu, Lelepua, Waipiʻo Uka	1 *moʻo*, 1 *kula*, house lot, house, 2 *ʻokipuʻu* of mountain taro	Maheu 1 *ʻāp*., 5.507 Acs.; Waipiʻo Uka 1*ʻāp*., 0.9 Acs.
Kamakahi	8241Q	Kuana, Waianeki in Waipiʻo Uka	1 *moʻo*, 1 *kula*, house lot, 1 house, 2 *ʻokipuʻu* in 1 piece	Kuana 1 *ʻāp*. 2.217 Acs.; Waianeki 1 *ʻāp*. 0.256 Acs.
Keahale	8241R	Waiakapuaa	1 *moʻo*, 1 *kula*, house lot, 2 houses	Waipiʻo Uka Waiakapuaʻa 1 *ʻāp*. 6.882 Acs.
Kailio	8241T	Kaneulupoo	1 *moʻo*, 1 *loʻi*, houselot, 2 houses	Waipiʻo Uka Kaneulupoo 1 *ʻāp*. 5.665 Acs.
Kailihao	8241U	Kapoipuka	1 *moʻo*, 1 *kula*, houselot, 1 house	Pupuka 1 *ʻāp*. 3.804 Acs.
Kauluoaiwi/ Kaulewaiwi	8241V	Honowaka in Waipiʻo Uka	1 *moʻo*, 1 *kula*, houselot, 1 house	Hanauaka 1 *ʻāp*. 0.256 Acs.; Waipiouka 1 *ʻāp*. 5.475 Acs.
Kaneakauhi	8241W	Kaohai in Waipiʻo Uka Wailele	1 *moʻo*, 1 *kula*, houselot, 1 house	Waipiʻo Uka, Kaohi 1 *ʻāp*. 8.162 Acs.
Halelaau	8241X	Kopilau, Hokapiele	1 house, 2 *ʻokipuʻu*	Awarded, but no description
Hepa	8241Y	Kīpapa	1 house, 4 *ʻokipuʻu*	Kepapa 1 *ʻāp*. 12.25 Acs.

Claimant	Claim No.	Name of Land Claimed	Land Use	Land Awarded
Kaioe	8241Z	Moakea, Puulu, Palikea in Waipiʻo Uka	1 *moʻo*, 1 *kula*, houselot, 1 house	Puulu 1 *ʻāp.* 18.72 Acs.
Palekaluhi	8241AB	Kamuku, Lapili	1 house, 9 *loʻi*, 1 *kula*, 1 *moʻo*	Kamuku 1 *ʻāp.* 6.363 Acs.
Poupou	8241CC	Papa, Leoiki	1 *moʻo*, 1 *kula*, houselot, 1 house	Waipiʻo Uka Papa 1 *ʻāp.* 18.72 Acs
Kalaiku	8241UU	Lelepua in Waipiʻo Uka	1 *moʻo*, 1 *kula*, houselot, 1 house, *ʻokipuʻu*	Lelepua Waipiʻo Ewa 1 *ʻāp.* 13.15 Acs.
Kaualelehuna	8241XX	Walepoai in Waipiʻo Uka	*Moʻo*, *kula*, house lot, 1 house, a ravine, 2 *ʻokipuʻu*	Not Awarded
Kahuluhulu	8241YY	Waipiʻo Valley	2 houses, 2 *ʻokipuʻu*	Not Awarded
Kaimileihonua	9361B	Waipiʻo Uka	1 *moʻo*, 1 *kula*, houselot, 2 houses	Not Awarded
Kalaiku	11205	Lelepua	1 *ʻokipuʻu*	Not Awarded; See 8241UU
Kanealu	11206	Kahaikei, Luanui	1 *moʻo*, 1 *kula*, houselot, 1 house	Not Awarded
Naniu	11207	Liloa, Kamae in Waipiʻo Uka	1 *moʻo*, 1 *kula*, houselot, 1 house, mountain *kalo* land	Not Awarded
Kaopuana	11208	Kahalo, Kepooakaholu in Waipiʻo Uka	1 *moʻo*, 1 *kula*, houselot, 1 house	Not Awarded
Kawaihae	11209	Kaluahine, Kanewahine in Waipiʻo Uka	1 *moʻo*, 1 *kula*, houselot, 1 house, *ʻokipuʻu*	Not Awarded
Kaluehinue	11210	Kauloa, Waipiʻo Uka	1*ʻokipuʻu*	Not Awarded

Notes: *ʻāp.* = *ʻāpana* (piece or portion), Acs. = acres, see text for definition and discussion of other Hawaiian land use terms in this table (e.g., *ʻokipuʻu, moʻo, kula*).

4.4 1850s to 1900

During the late 1800s, taro fields in the *makai* areas of Waipiʻo were converted to rice fields as Chinese immigrants began to lease and purchase land. Mauka lands were cultivated in sugar and pineapple. Extensive tracts of Waipiʻo land were leased for large-scale commercial agriculture in the late 1890s.

After John Papa ʻĪʻī's death in 1870, his estate—including the Waipiʻo lands—was inherited by his daughter Irene ʻĪʻī Brown. Shortly after, small parcels within the *ahupuaʻa* were sold off. The majority of the project area lands are within the James Robinson estate property, sold to James Robinson and Co. in September 1871 (Barrere 1994:75).

In 1889, Benjamin Dillingham organized the Oahu Railway and Land (O.R.&L.) Company; his rail line connected outlying areas of Oʻahu to Honolulu. By 1890, the railroad reached from Honolulu to Pearl City and continued on to Waiʻanae in 1895, to Waialua Plantation in 1898, and to Kahuku in 1899 (Kuykendall 1967:100). O. R. & L. transported sugar and pineapple from Wahiawā through Waipiʻo to Honolulu. In 1897, the newly organized Oahu Sugar Company leased 3,400 acres of Waipiʻo land from the ʻĪʻī estate (Condé and Best 1973:313). Sugarcane cultivation in Waipiʻo directly affected and transformed the present project area during the twentieth century. The 1899 Government Surveys map (Figure 6) and the ʻEwa Plantation and Oahu Sugar Company map (Figure 7) show the project area lands within the sugar company property. Based on the presence of rail lines and roads within the vicinity, the lands were under commercial agricultural development.

4.5 1900s to Present

By the early decades of the twentieth century, rice farming in Waipiʻo, and throughout the Hawaiian Islands, was in decline, beset by crop diseases and cheaper prices for rice from the Mainland. Sugar dominated commercial agriculture, particularly due to the founding and development of the Oahu Sugar Company. The Oahu Sugar Co. was established in 1897 with over 900 field workers, composed of 44 Hawaiians, 473 Japanese, 399 Chinese, and 57 Portuguese. The first sugar crop was harvested in 1899, ushering in the sugar plantation era in Waipahu (Ohira 1997).

In 1901, the U.S. Congress formally ratified the annexation of the Territory of Hawaiʻi, and the first 1,356.01 acres of Pearl Harbor land were transferred to U.S. ownership. The U.S. Navy began a preliminary dredging program, which created a 30-foot deep entrance channel measuring 200 feet wide and 3,085 feet long. In 1908, money was appropriated for five miles of entrance channel dredged to an additional 35 feet down (Downes 1953).

At the same time, lands in *mauka* Waipiʻo were being acquired for pineapple cultivation. A 1908 lease from the John ʻĪʻī Estate, Ltd. to Yoshisuke Tanimoto and Kintaro Izumi led to the formation of the Waipiʻo Pineapple Company, which cleared and cultivated approximately 223 acres in portions of Kīpapa Gulch. In 1909, the government appropriated the Waipiʻo peninsula from the ʻĪʻī estate. The land was valued at $10,000 for purposes of fair compensation (Dept. of Land and Natural Resources Land Record Books 1909:228-235). In 1915, Libby, McNeill & Libby took over Waipiʻo Pineapple Company's leases and continued to cultivate pineapple in the

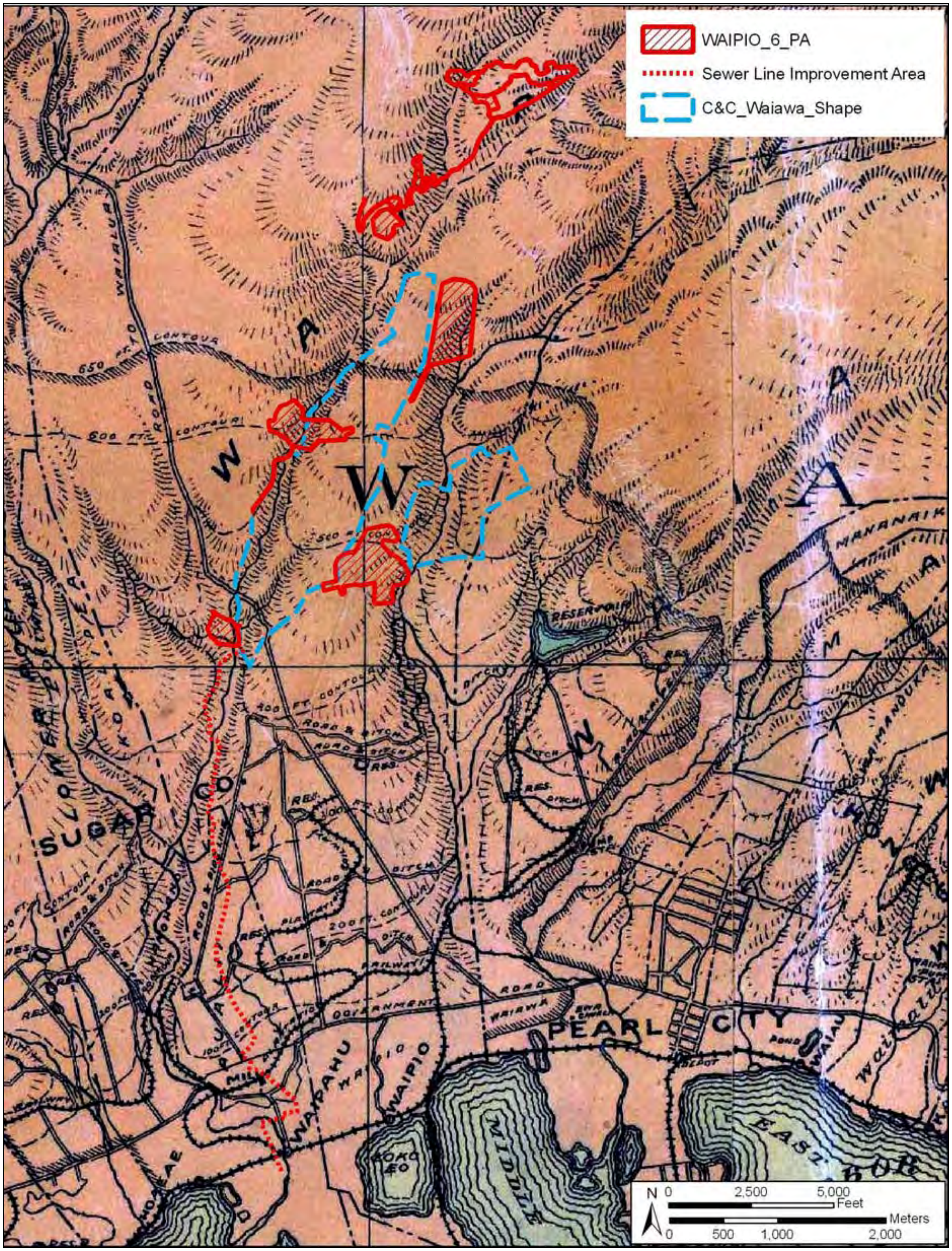

Figure 6. Portion of 1899 compiled Government Surveys showing project area

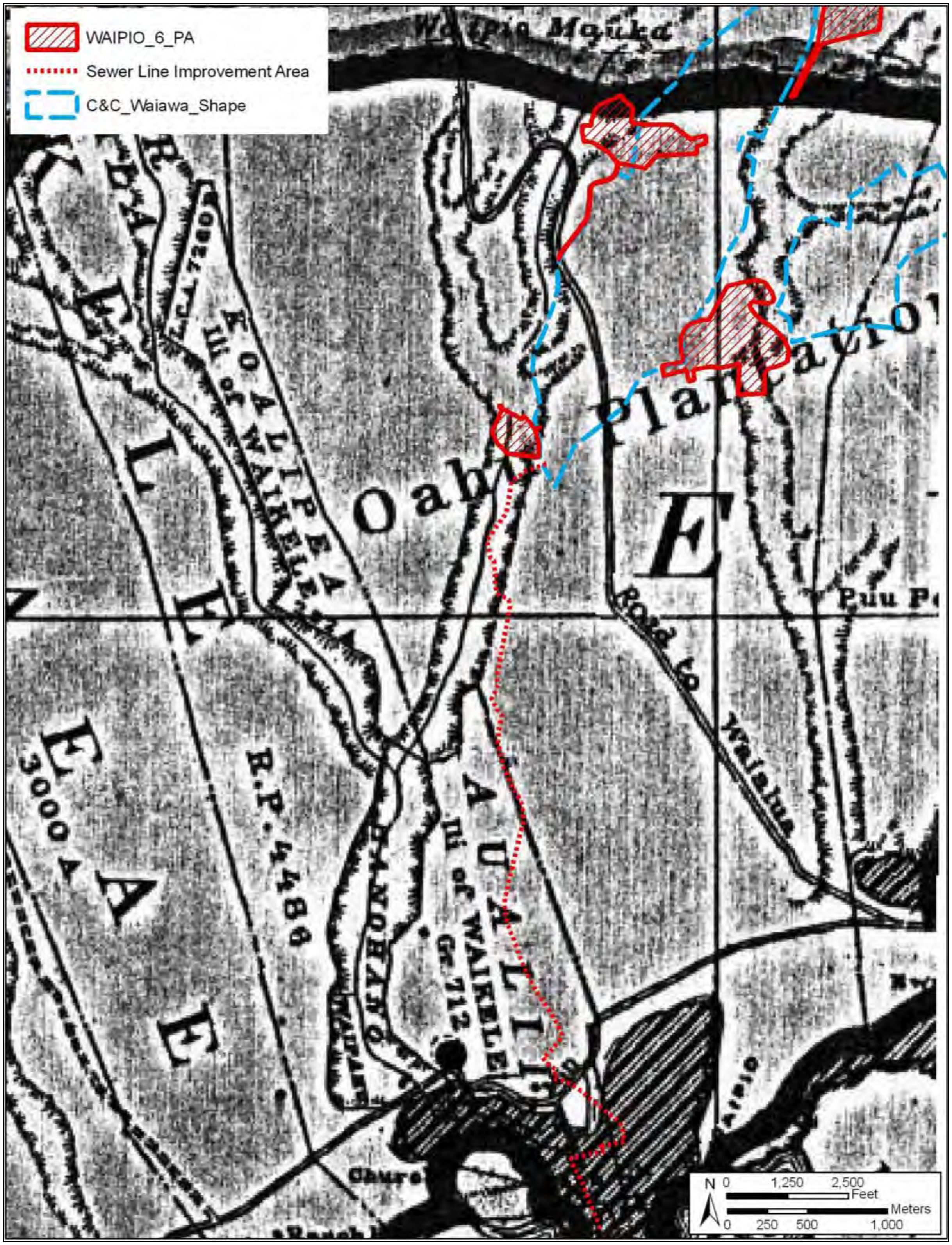

Figure 7. Portion of 1902 'Ewa Plantation and Oahu Sugar Company Map with project area

area. By the late 1920s, James Dole’s Hawaiian Pineapple Company, incorporated in 1901, was cultivating pineapple on thousands of acres leased from the ‘Ī‘ī estate in the *mauka* area of Waipi‘o.

The Oahu Sugar Company had difficulty obtaining sufficient water to cultivate sugar. The Waiāhole Water Company, a subsidiary of Oahu Sugar, created the Waiāhole Ditch System. In 1913 the project began transporting water from the windward side of O‘ahu through the Ko‘olau Range to irrigate the fields and provide water for the Oahu Sugar Company mill in ‘Ewa. The water system was declared “an engineering feat of epic proportion for those times” (Condé and Best 1973:37). The ditch system was completed in 1916 and, with some modifications, is still in use. The 1919 US War Department map (Figure 8) and the 1925 Oahu Sugar Company map (Figure 9) show the project area within the commercial cultivation and its association with roads and railroad tracks.

During the 1930s, U.S. military use of Waipi‘o extended well *mauka* of the peninsula at Pearl Harbor. The military began the appropriation of Kīpapa Gulch about 1938, although the 1938 USGS topographic map (Figure 10) shows little change directly within and adjacent to the project area at that time. By 1941, Pacific Naval Air Bases expenditures for new construction at Pearl Harbor were in the hundreds of millions of dollars. The Japanese attack on Pearl Harbor, December 7, 1941, damaged or destroyed much of the new construction. Reconstruction was instituted to double the Pearl Harbor’s war capacity. Military planners approved a new ammunition depot in the mountainside of Waipahu, a large new hospital in ‘Aiea, and thousands of additional changes to the Navy Yard to accommodate the new aircraft carrier task forces (Woodbury 1946). During World War II, the military used the sugar cane rail system to “haul large quantities of ammunition” (Condé and Best 1973:315). The military modifications during WWII appear to have had little impact on the present project area as shown on the 1943 United States War Department map (Figure 11)

After WWII, roads replaced railroads within the sugar plantation as shown on the 1956 USGS topographic map (Figure 12). The map shows little other change in and within the vicinity of the project area. During the second half of the twentieth century, growth in Waipi‘o Ahupua‘a focused on the development of Mililani Town by Castle & Cooke, Inc. through its subsidiary, Oceanic Properties, Inc. (Hammatt et al. 2004). In 1964, the state Land Use Commission re-designated 705 acres of agricultural land in Waipi‘o for urban use. The first section of Mililani Town opened in June 1968. In 1973, construction began on the H-2 freeway across Waipi‘o, connecting Mililani to the H-1 freeway. The current Town Center of Mililani is a relatively recent construction dating to the 1990s (Hammatt et al. 2004).

By the 1960s, construction of residential developments began on Waipi‘o lands. Sugar plantations gave way to residences in the 1970s and 1980s (Anon. 2008). East of the proposed underground sewer line project area, the 133,500 sq. ft. Waipi‘o Shopping Area was established in the mid-1980s to serve the residents of Waipi‘o (Anon. 2005). To the south and west of the project area, the Waikele Golf Club was established in 1993. In 2001, the Central O‘ahu Regional Park near the project area was opened for public use. With over 269 acres, the park has baseball fields as well as areas for soccer, football, rugby and other sports such as archery and tennis (Pang 2001).

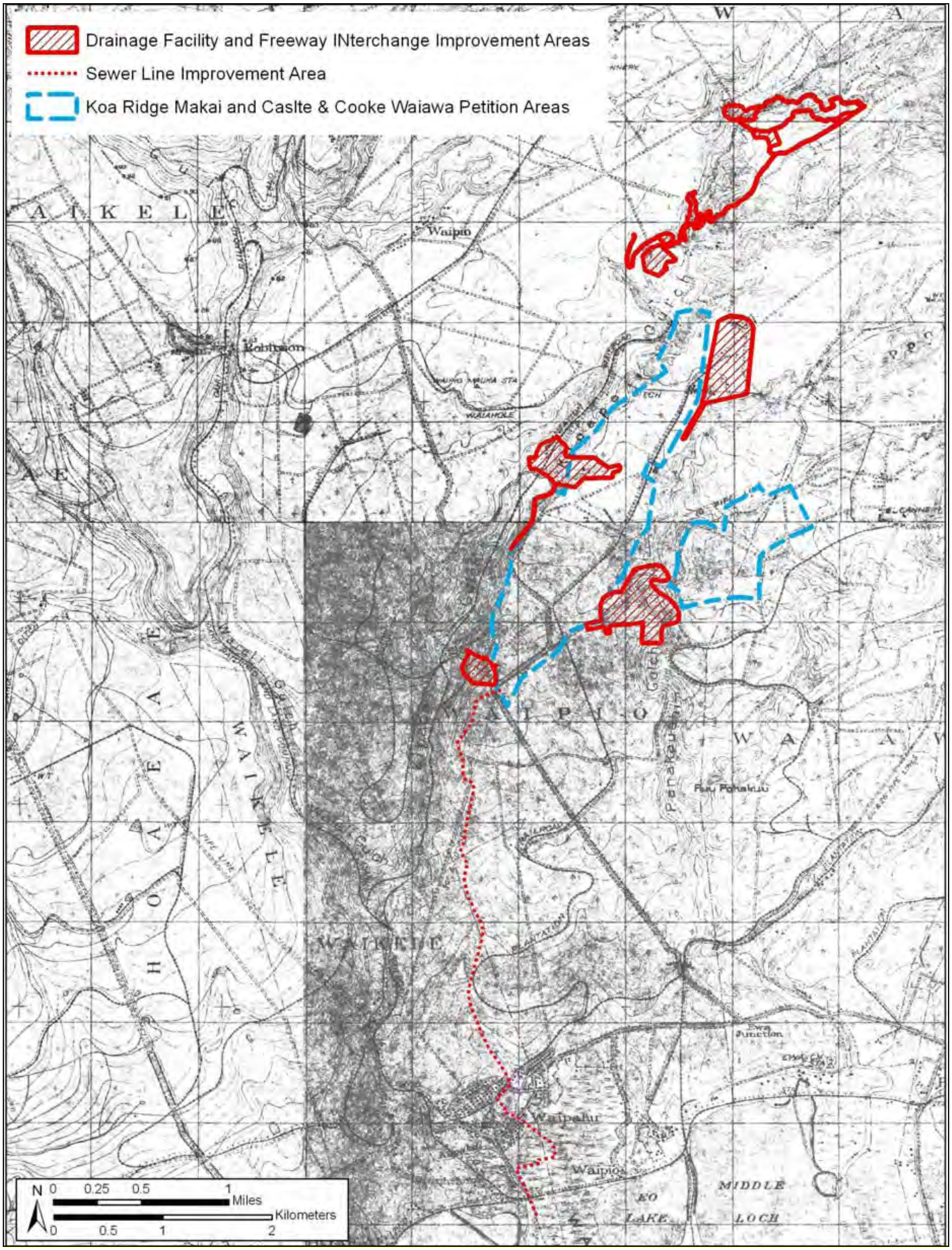

Figure 8. Portion of 1919 United States War Department map showing project area

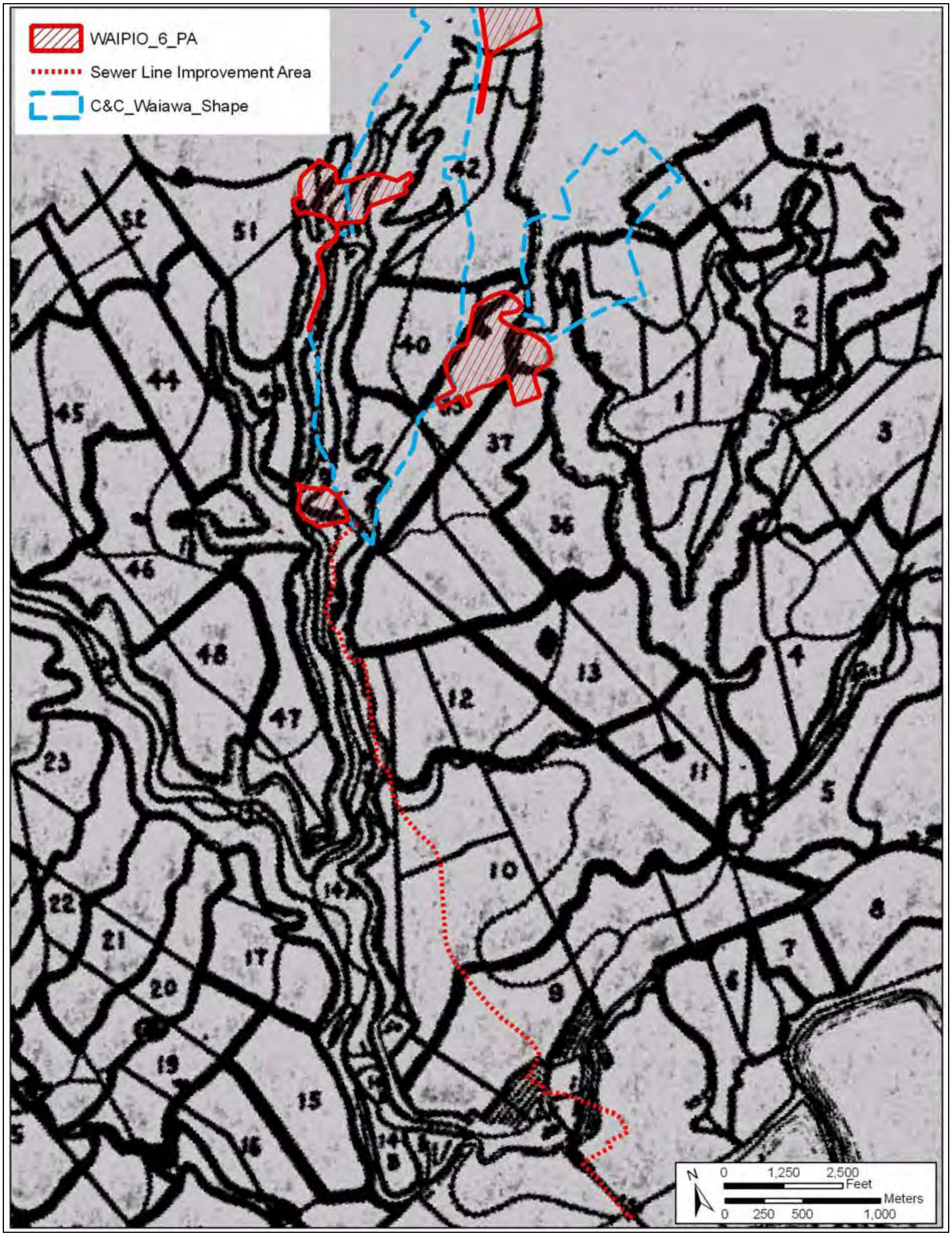

Figure 9. Portion of 1925 Oahu Sugar Company map showing project area

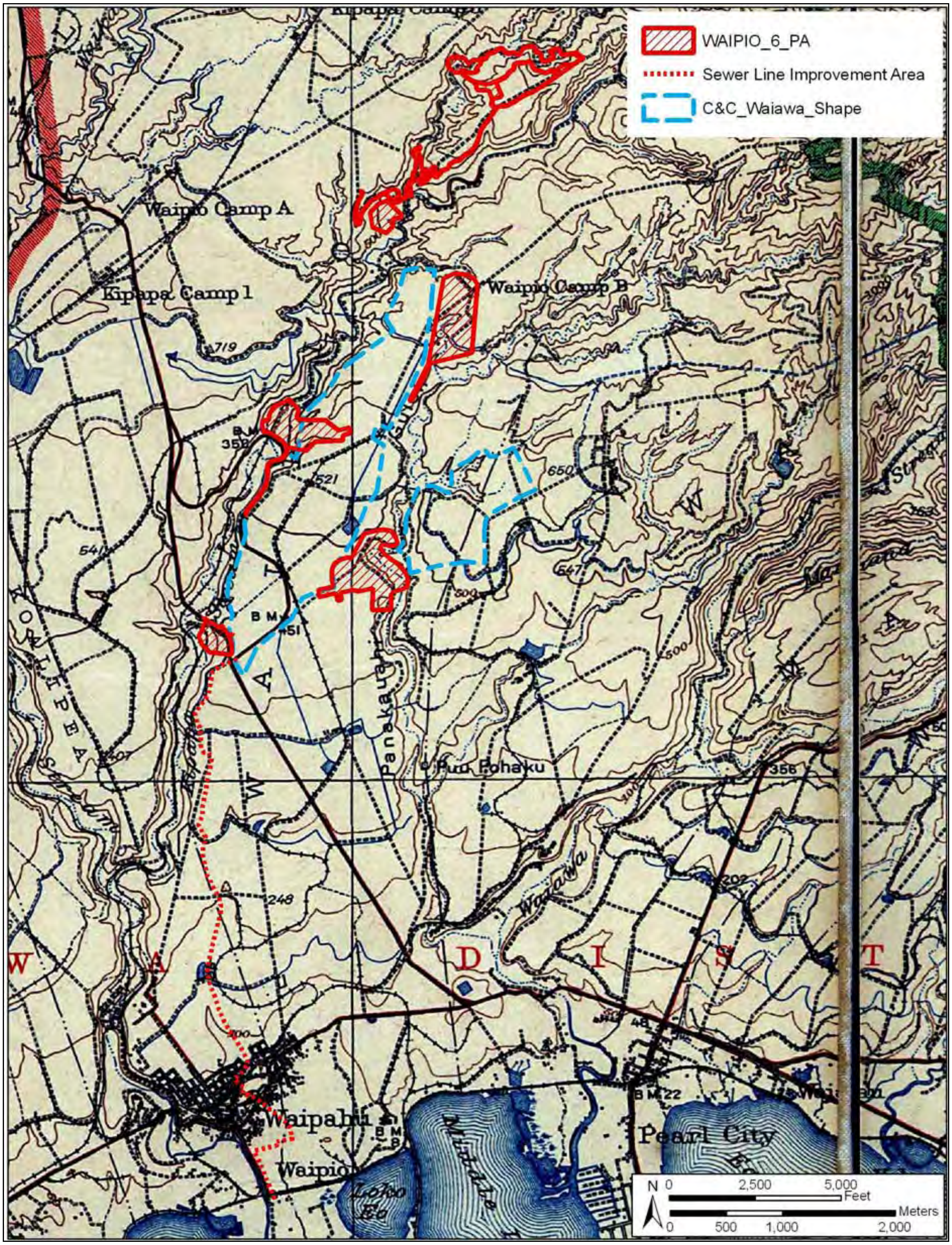

Figure 10. Portion of 1938 USGS topographic map showing project area

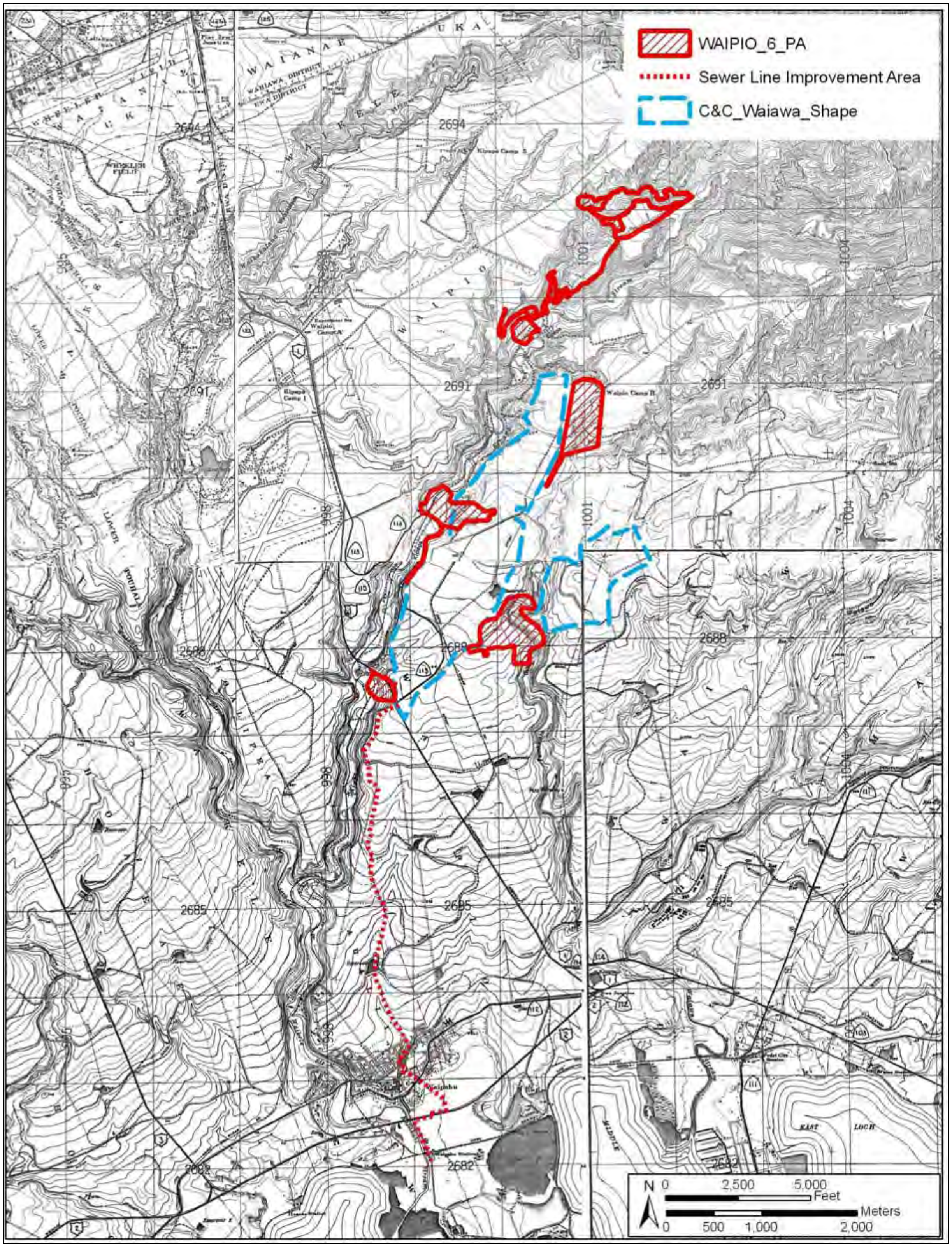

Figure 11. Portion of 1943 United States War Department map showing project area

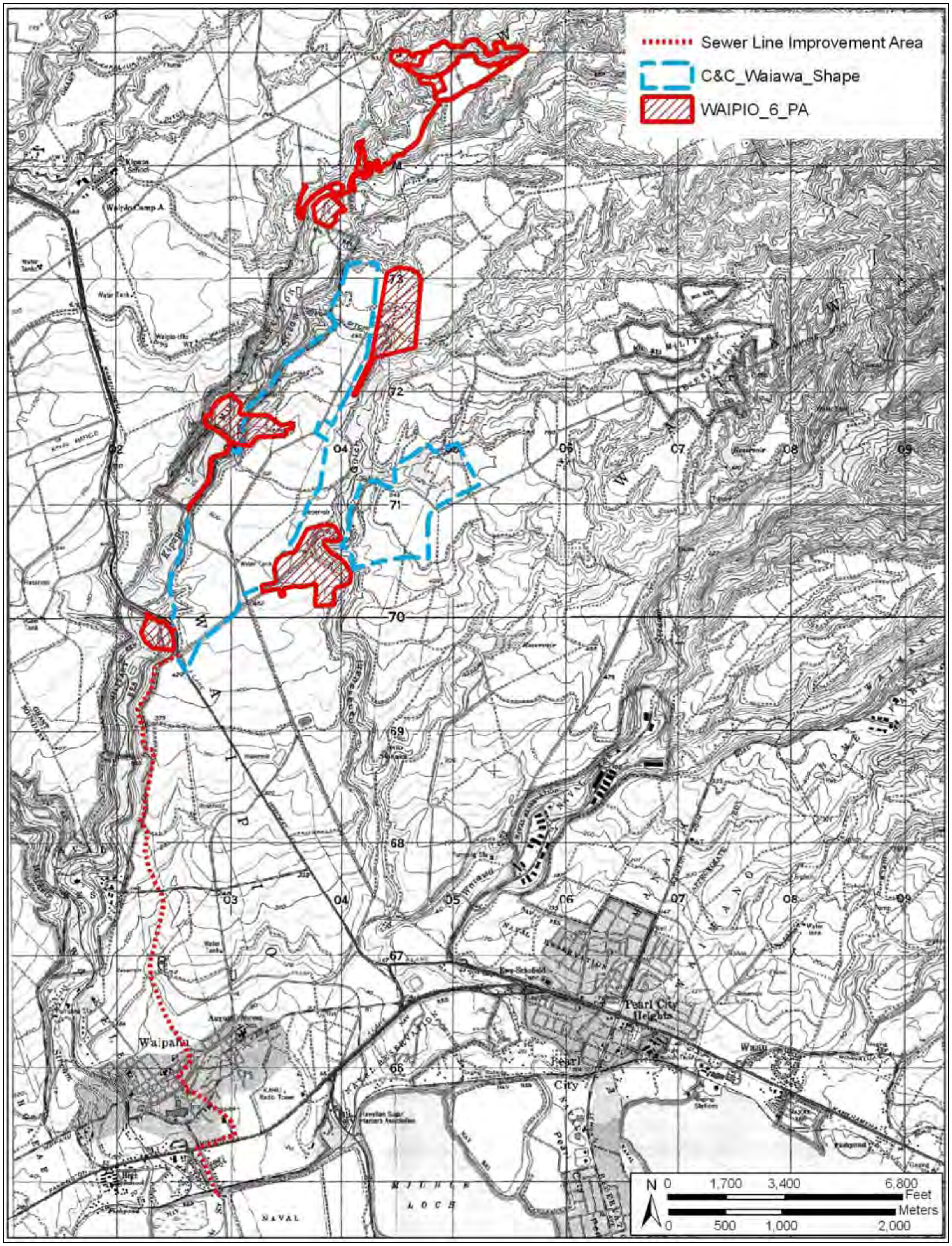

Figure 12. Portion of 1956 USGS topographic map showing project area

Section 5 Previous Archaeological Research

Table 2 lists and briefly describes previous archaeological studies in the vicinity of the project area. Figure 13 shows archaeological sites nearby the project area identified in early surveys of the area. Figure 14 shows the location of more recent archaeological work in the vicinity of the project area.

The earliest archaeological work in Waipi‘o Ahupua‘a was conducted by J. Gilbert McAllister in the 1930s. He described several sites in Waipi‘o, most of which were located near the Pearl Harbor’s marine resources and fishponds or on the wide coastal plain with its excellent taro lands in proximity to the Waipi‘o Peninsula. These sites include: Ahuena Heiau (Site 122), which was described as “destroyed” by the time of McAllister’s (1930s) work, located just northwest of the *pā* (fence or enclosure) between Loko Eo and Middle Loch; and Loko Eo fishpond (Site 123). Three other traditional native Hawaiian sites were documented in the vicinity of the south project area in the adjacent Waikele Ahupua‘a. Mokoula Heiau (Site 127) “has [by the 1930s] been completely destroyed for building purposes of the neighborhood” (McAllister 1933:106). Waipahu Spring (Site 128) was described as being “famous in tradition as the place at which the tapa mallet appeared after having been lost in Kahuku” (McAllister cited in Sterling and Summers 1933:25). Hapupu Heiau (Site 129) was also reported by McAllister as destroyed.

Four other sites located in Waipi‘o Ahupua‘a are McAllister’s numbers 130, 131, 132 and 204. Two *heiau*, sites 130 and 131, are located in the immediate vicinity of the north project area along Kīpapa Gulch. Site 130, Moa‘ula Heiau, is located on the east side of Kīpapa Gulch and described as being a companion *heiau* to Heiau o Umi (Site 131), located at the bottom of Kīpapa Gulch (McAllister 1933:107). McAllister claimed both *heiau* were covered in cane during the time of his survey. In a reconnaissance survey of military lands in Kīpapa Gulch conducted by the Bishop Museum, both *heiau* were documented as located inside Kīpapa Gulch and were listed as destroyed sites (Rosendahl 1977). During a reconnaissance survey and sub-surface testing in Kīpapa Gulch in 1988, CSH searched for the Moa‘ula Heiau and Heiau o Umi. No structures were observed, but a fairly level area with some *kī* (*tī*) plants was noted (Hammatt and Borthwick 1988:31). Site 132 is described as Waikakalaua and Kīpapa Gulches, which were made famous by a battle between Hawai‘i and the chief of O‘ahu, Mailikākahi (McAllister 1933:107). Site 204 is named O‘ahunui and is described as a stone “whose outline is said to resemble that of O‘ahu” (McAllister 1933:132). The location of the O‘ahunui stone (by traditional accounts) is in the gulch near the ‘Ewa-Waialua District boundary, presumably Waikakalaua Gulch.

No archaeological resources were documented in the area for many years. In 1983, an archaeological reconnaissance survey of 300 acres was conducted for the proposed Hawai‘i High Technology Park (Hommon and Ahlo 1983). One archaeological site was identified during the survey (SIHP No. 50-80-09-3401). This site consisted of a terrace measuring 17 m long, 2-4 m wide, and 0.3-0.6 m high with one stacked retaining wall. One interpretation of the terrace was as an agricultural plot used for non-irrigated crops. No further archaeological work was recommended based on the small size of the site, its simple form, and the lack of surface artifacts encountered.

Table 2. Previous Archaeological Research in Waipi‘o Ahupua‘a

Reference	Location	Nature of Study	Findings
McAllister (1933)	Island of O‘ahu	Island Archaeological Survey	Identifies Ahuena Heiau (Site 122), Mokoula Heiau (Site 127), Moa‘ula Heiau (Site130), Heiau o Umi (Site 131), and O‘ahunui Stone (Site 204)
Rosendahl (1977)	Kīpapa Gulch	Archaeological Reconnaissance Survey	Documents Moa‘ula Heiau (Site 130) and Heiau o Umi (Site 131) as located inside Kīpapa Gulch and listed as destroyed sites
Hommon and Ahlo (1983)	Hawai‘i High Technology Park	Archaeological Reconnaissance Survey of 300 acres	Identifies terrace with one stacked retaining wall identified as SIHP No. 50-80-09-3401
Barrera (1985)	Mililani Town (Mililani Mauka)	Archaeological Inventory Survey	No evidence of structural remains of an archaeological or historical nature. No further archaeological work was recommended
Kennedy (1985)	Waikakalaua Gulch	Archaeological Reconnaissance Survey of 70 acres	One site was identified, an un-irrigated terrace and 1 small piece of *kukui* nut, too small for radiocarbon testing. No additional archaeological work recommended.
Sinoto (1990)	Waikakalaua Gulch	Archaeological Reassessment Survey of above (Kennedy 1985)	Identified SIHP Nos. 50-80-08-4662 and 50-80-08-4663, historic habitation platforms, retaining walls and excavated catchments associated with Japanese plantation workers. Recommendations included possible preservation of some features.
Riford and Cleghorn (1986)	Waikele Branch of the Lualualei Naval Magazine	Archaeological Inventory Survey	Documents five archaeological sites (SIHP Nos. 50-80-08-2919 to -2923). 21 overhang caves and crawl spaces were identified in Waikakalaua Gulch including one modified cave and 11 with pre-Contact material. Further archaeological testing was recommended for one site, SIHP No. 50-80-08-2919.

Reference	**Location**	**Nature of Study**	**Findings**
Rosendahl (1987)	Mililani Town	Archaeological Reconnaissance Survey of 2.75 acres	No archaeological resources were identified and no further archaeological work recommended.
Hammatt and Borthwick (1988)	Waikakalaua Gulch	Archaeological Reconnaissance Survey of 422 acres.	Two small agricultural terraces were recorded, associated with sugar cane cultivation. No further archaeological work recommended.
Goodman and Nees (1991)	3,600 acres bounded by H-1, H-2, and Waiawa Stream	Archaeological Inventory Survey	17 historic properties, among them are: a prehistoric rock shelter complex with petroglyphs, historic plantation infrastructure, a small cemetery, a road and railroad system, historic fire pits and trash dumps
Cleghorn et al. (1992)	Mililani Summit	Archaeological Inventory Survey	Identified three sites (SIHP Nos. 50-80-08-4436 to -4438). A complex of World War II military structures and two historic charcoal ovens linked to Japanese pineapple workers.
Stride and Hammatt (1993)	A tributary of Kīpapa Gulch	Archaeological Inventory Survey	No archaeological finds, no further archaeological work recommended.
Moore and Kennedy (1994)	Waikakalaua Gulch	Archaeological Test Excavations, and Reconnaissance Survey	Information gathered on two documented archaeological sites (SIHP Nos. 50-80-08-4812 & -4813); suggest sites are historic. Members of the community claimed all or portions of Site -4812 constituted the O‘ahunui Stone. It was concluded that the O‘ahunui Stone was probably never located within the Waikakalaua Gulch.
Hammatt et al. (1996)	*Mauka* areas of Waipi‘o and Wai‘awa Ahupua‘a	Archaeological Inventory Survey of 1339 acres	No evidence of historic settlement was found. A portion of the Waiāhole Ditch System (SIHP No. 50-80-09-2268) was identified within project area. Recommendations made to take appropriate mitigative measures if the site was to be impacted during development of area. No further archaeological work recommended.

Reference	Location	Nature of Study	Findings
Rechtman and Henry (1998)	West of Leeward Community College	Archaeological Reconnaissance Survey	No historic properties identified.
Hammatt et al. (2002)	Mililani Transit Center	Archaeological and Cultural Impact Assessment	Study concludes that Mililani Transit Center project would have no adverse impact to historical or cultural resources. No further archaeological work recommended.
Hammatt et al. (2004)	Waipahu Drainage Improvements Project	Archaeological and Cultural Impact Assessment	No cultural resources or ongoing traditional cultural practices were found within the project area; no additional work was recommended.
Perzinski et al. (2004)	Queen Emma Foundation Parcel, Waipiʻo Ahupuaʻa	Archaeological Inventory Survey of 13.219 acres	Three sites recorded including the historic remnants of the Brown Estate (SIHP No. 50-80-09-6671), three buried cultural layers (SIHP No. -6672), and a cultural layer with two associated burials (SIHP No. -6673).
Tulchin, Yucha, Shideler and Hammatt (2008)	Proposed Detention Basins, Associated Appurtenances, and an H-2 Freeway Interchange Associated with the Koa Ridge Makai Development Project	*Archaeological Inventory Survey*	The archaeological inventory survey investigation identified thirteen cultural resources within and in the immediate vicinity of the project area including historic road and stream channel improvements; plantation-era retaining walls, clearing platform:, agricultural terrace complexes, a plantation-era charcoal kiln; a portion of the historic Waiāhole Ditch System; military-related components of the U.S. Army Upper and Lower Kīpapa Ammunition Storage facility; and a historic roadbed and associated features of the Old Kamehameha Highway alignment

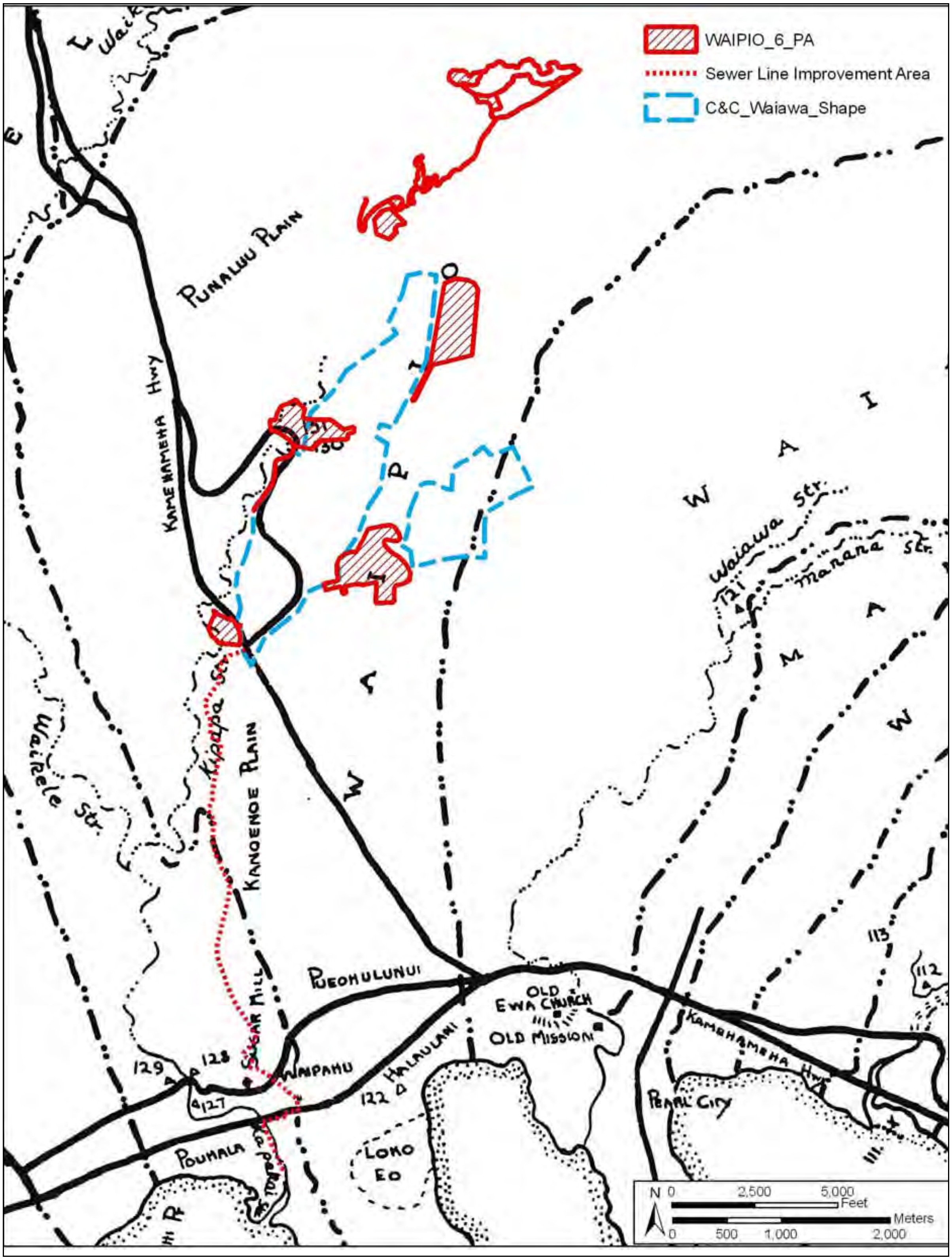

Figure 13. Sterling and Summers (1978) map showing project area and site locations

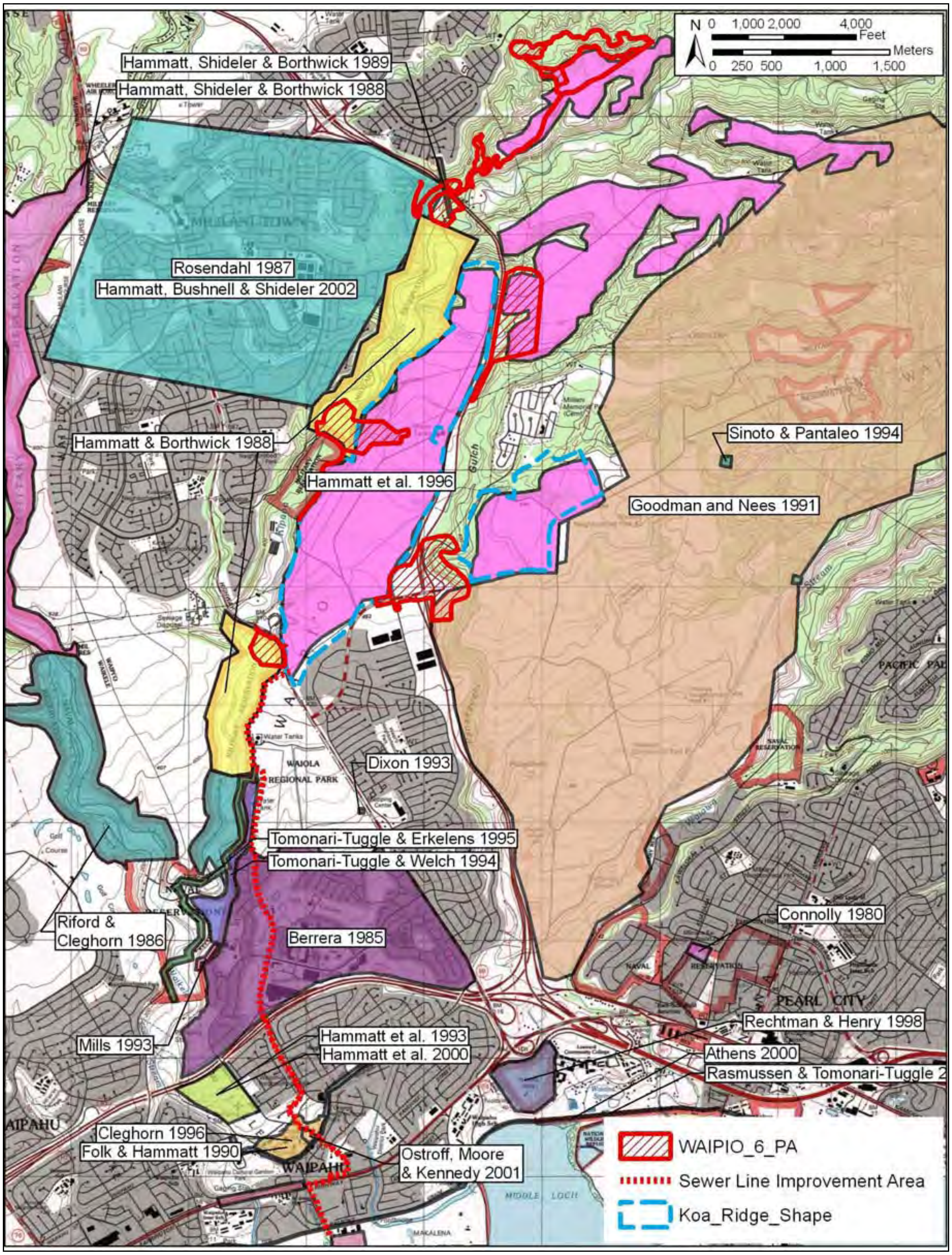

Figure 14. USGS topographic map, showing a sample of previous archaeological survey areas in Waipi‘o and within the vicinity of the project area

One site was identified during a 70-acre reconnaissance survey of Waikakalaua Gulch (Kennedy 1985). The site was described as “an un-irrigated terrace-most likely for the cultivation of dry taro or sweet potato” (Kennedy 1985:4). Subsurface testing produced one small piece of *kukui* nut, too small for radiocarbon testing. It was concluded the property needed no additional archaeological work. In 1990, a reassessment of the 70 acres was undertaken because the original survey was considered deficient and failed to “meet the minimum guidelines set by the Historic Preservation Program of the State Department of Land and Natural Resources” (Sinoto 1990:1). Due to the lack of a site location map, the single terrace recorded during the first survey was not relocated. During the 1990 resurvey, four areas of structural remains were located including areas of historic habitation platforms, retaining walls, water catchments, bridge remains, historic roadbeds and associated retaining walls. Areas 1 and 2 were assigned SIHP Nos. 50-80-08-4662 and 50-80-08-4663, respectively. The Area 2 structures, including historic habitation platforms, retaining walls and excavated catchments, were associated with Japanese plantation workers who probably lived at the Pine Spur Camp, an early twentieth century plantation camp. Recommendations included possible preservation of some Site -4662 features and further archaeological work on this site (Sinoto 1990).

A survey of the Waikele Branch of the Lualualei Naval Magazine documented five archaeological sites, SIHP Nos. 50-80-08-2919 to 50-80-08-2923 (Riford and Cleghorn 1986). This study area consisted of 264 acres along Kīpapa and Waikakalaua streams near their confluence. Twenty-one overhang caves and crawl spaces were identified in Waikakalaua Gulch including one modified cave and eleven caves containing pre-Contact material. Several historic features were also recorded (although not deemed archaeological sites) in Waikakalaua Valley, including cement boulders, portions of an old roadbed, boulder and cobble paving associated with an abandoned railroad berm, scattered boulder mounds and facings connected to historic agricultural clearing activities, and boulder rock tailings associated with road construction or ammunition storage facility excavation. In Kīpapa Gulch, three rock shelters, segments of a railroad berm, remains of a railroad cane-hauling car, and rock tailings were observed. The rock shelters along Waikakalaua Gulch were interpreted as temporary habitation sites for a possible travel route from Pu‘uloa over Kolekole Pass and into Wai‘anae. Many historic references indicate a transportation route was present between the south coast and central and western O‘ahu. SIHP No. 50-80-08-2922, situated on an intermittent tributary of Waikakalaua Stream, was recorded as a historic basalt rock quarry, but may have been used in pre-Contact times. Further archaeological testing was recommended for Site -2919.

An archaeological reconnaissance survey was conducted for a 2.75-acre parcel of land in Mililani Town, west of Mililani High School (Rosendahl 1987). No archaeological resources were identified and no further archaeological work was recommended.

Some 422 acres of the Waikakalaua Gulch were surveyed during an archaeological reconnaissance of Waikakalaua Ammunition Storage Tunnels Site (Hammatt and Borthwick 1988). Two small agricultural terraces situated parallel to the stream were recorded. The dimensions of the terraces were 12 m long and 0.3 m wide. The two terraces were associated with sugar cane cultivation based on their low height and their location in a former cane field. The land within the study area had been heavily modified due to the grading and filling required during the construction of the 1905 railroad line and during World War II excavation of the ammunition storage tunnels. No further archaeological work was recommended for the area.

A 23-acre inventory survey investigated the Oahu Sugar Mill in Waipahu and its surroundings. The mill and associated buildings comprised 60% of the project area; the remainder comprised Skill Village, a plantation supervisors’ residential area. No surface archaeological sites were observed within that project area (Cleghorn 1996).

CSH conducted an inventory survey of approximately 40 acres along Manager’s Drive in Waipahu for Castle and Cook Homes. Two historic properties were found: SIHP No. 50-80-09-0530, pre-Contact petroglyphs; and SIHP No. 50-80-09-4660, a former Oahu Sugar Company plantation camp named Higashi Camp (Hammatt et al. 2000).

The proposed stream clearing of Melemanu Woodlands Phase III was given archaeological clearance in a letter by Joseph Kennedy (March 16, 1992) who stated “it was in our opinion that no further work was necessary on the subject property or, by extrapolation, any lands *mauka* here due to topographic conditions” (Kennedy 1992:1). Kennedy also based his decision on a field inspection of the study parcel by Dr. Tom Dye (at that time) of the State Historic Preservation Division who maintained “the depositional environment is inhospitable to the preservation of historic deposits...there is no reason to conduct an archaeological survey for this project” (in Kennedy 1992: 1). No map was included in the letter report and the exact location of the subject property is unknown.

An archaeological inventory survey of the proposed Mililani Summit project area produced three sites (SIHP Nos. 50-80-08-4436 to -4438) consisting of two historic charcoal ovens linked to Japanese pineapple workers and a World War II military structure complex (Cleghorn et al. 1992). Large-scale land modifications were noted in the subject property commencing with pineapple cultivation, continuing with the military construction of storage facilities during World War II, and most recently with lime and lychee orchard activities. The two historic charcoal ovens were considered significant under Criteria A and D of the National Register and would be avoided during development. No further archaeological work was recommended for the study area.

An archaeological inventory survey conducted for the proposed drainage of the Mililani Mauka Subdivision produced no archaeological finds (Stride and Hammatt 1993). The project area location was in a tributary gully of Kīpapa Gulch, which showed no signs of inhabitation or agricultural modification in the pre-Contact period and seemed to have been utilized only as drainage for the pineapple fields. No further archaeological work was recommended.

Archaeological investigations were carried out for the Launani Valley Townhouse Development in 1994 (Moore and Kennedy 1994). This development is situated inside the Waikakalaua Gulch, *mauka* and a distance from the project area. The objective of the study was to gather more information on two documented archaeological sites (SIHP Nos. 50-80-08-4812 and -4813) before development construction began. Site -4812 consists of 19 *ahu* (stone markers) and a capped stone flume and terrace. The capped stone flume is associated with historic agricultural modifications. After test excavation in the terrace revealed no cultural material, it was suggested this feature was a historic modification from an old foot trail, which led up the Waikakalaua Stream to a horse crossing. The *ahu* complex was interpreted as possible historic growing mounds for sweet potatoes and gourds due to their position in the ravine, which would optimize water catchments and soil retention. SIHP No. 50-80-08-4813 consists of the collapsed structures and walls associated with a former nursery that is known to have been in use until the 1960s. Additionally, this study briefly addressed community members' concerns regarding the Oʻahunui Stone. This study indicates that members of the community claimed all or portions of SIHP No. 50-80-08-4812 constituted the "Oʻahunui Stone" (Moore and Kennedy 1994:1). It was concluded that because none of the *ahu* in Site -4812 resembled the shape of Oʻahu, and the two referenced maps depicted the location of the Oʻahunui Stone outside of Waikakalaua Gulch, that the Oʻahunui Stone was probably never located within the Waikakalaua Gulch.

In 1996, an archaeological inventory survey was completed for 1339 acres of Castle and Cooke lands slated for residential development in the *mauka* areas of Waipiʻo and Waiawa Ahupuaʻa (Hammatt et al. 1996). No evidence of historic settlement was found; this was attributed to the fact that the majority of the project area lands had been cultivated in pineapple in the historic-to-modern periods. A portion of the Waiāhole Ditch System (SIHP No. 50-80-09-2268) was identified while traversing a portion of the project area. Recommendations were made to take appropriate mitigative measures if the site was to be impacted during development. Also, the Kīpapa Ditch Site (SIHP No. 50-80-098-9529) is located *mauka* of the project area.

CSH conducted an archaeological assessment of the H-1 Highway from Hālawa to the H1-H2 interchange at Waiawa (Hammatt and Chiogioji 1998). No archaeological sites have been previously recorded within any portion of the study area or its immediate vicinity; no surface archaeological sites were observed during a reconnaissance survey of the lands adjacent to the highway study area corridor. Adjacent to the highway corridor at First and Second Streets in Pearl City are several buildings older than fifty years. Recommendations included consultation with the SHPD to ascertain if the buildings over 50 years old are of historical concern if future highway improvement activities will impact these structures. No further archaeological investigation was recommended due to the urban development along the H-1 Highway study area and prehistoric surface or subsurface archaeological remains were determined to be unlikely (Hammatt and Chiogioji 1998:20).

Rechtman and Henry (1998) conducted an archaeological reconnaissance survey of the ʻEwa Drum Filling and Fuel Storage area, west of Leeward Community College. No significant historic properties were identified.

CSH completed an archaeological inventory survey of 13.219 acres in Waipiʻo Ahupuaʻa, ʻEwa District, Island of Oʻahu, TMK 9-4-38:83 and 9-4-50:59 (Perzinski et Al. 2004). Fieldwork included a pedestrian survey, documentation of surface sites, and subsurface testing. Three sites were recorded in the project area: (SIHP No. 50-80-09-6671) the remnants of the Brown Estate with six features constructed in the early 1950s and demolished in 1998; (SIHP No. 50-80-09-6672) three buried cultural layers in the southeast portion of the project area; and (SIHP No. 50-80-09-6673) a cultural layer and associated burials in the north central portion of the project area.

Hammatt et al. (2004) conducted an archaeological and cultural assessment of an approximately 38-acre area in the immediate vicinity of the August Ahrens School in the environs of urban Waipahu town. The project area is a developed residential neighborhood, with evidence of commercial sugar cane cultivation and housing development dating to 1919. No cultural resources or ongoing traditional cultural practices were found within the project area, and no additional work was recommended.

A companion archaeological study titled: *Archaeological Inventory Survey of Proposed Detention Basins, Associated Appurtenances, and an H-2 Freeway Interchange Associated with the Koa Ridge Makai Development Project, Waipi‘o Ahupua‘a, ‘Ewa District, Island of O‘ahu (TMK: [1] 9-4-005: 006 por., 008 por.; 9-4-006:001 por., 029 por. ; 9-5-003:001 por., 002, 011 por. 014 por.)* (Tulchin, Yucha, Shideler and Hammatt 2008) has been undertaken for this project. The archaeological inventory survey investigation identified thirteen cultural resources within and in the immediate vicinity of the project area including historic road and stream channel improvements; plantation-era retaining walls, clearing platform:, agricultural terrace complexes, a plantation-era charcoal kiln; a portion of the historic Waiāhole Ditch System; military-related components of the U.S. Army Upper and Lower Kīpapa Ammunition Storage facility; and a historic roadbed and associated features of the Old Kamehameha Highway alignment.

Section 6 Community Consultations

Throughout the course of this assessment, an effort was made to contact and consult with Hawaiian cultural organizations, government agencies, and individuals who might have knowledge of and/or concerns about cultural resources and practices specifically related to the project area in the context of the Waipiʻo and Waikele Ahupuaʻa and other places on Oʻahu that may be traditionally associated or connected with Waipiʻo and/or the project area. The community consultation effort was made by letter, e-mail, telephone and in person. In the majority of cases, letters with a detailed description of the proposed action- including project acreage, a conceptual plan provided by Castle & Cooke Homes Hawaiʻi, a map and an aerial photograph of the project area—was mailed with the following text:

> At the request of Castle & Cooke Homes Hawaiʻi (CCHH), Cultural Surveys Hawaiʻi, Inc. (CSH) is conducting a supplemental Cultural Impact Assessment (CIA) for off-site infrastructure improvements supporting the proposed Koa Ridge Makai and Waiawa Development (the "Development") located in the Waipiʻo Ahupuaʻa, ʻEwa District, on the island of Oʻahu. (Note: An earlier CIA was conducted for the on-site development of the Koa Ridge Makai and Waiawa Development.) The Development is the subject of a State Land Use Boundary Amendment Petition for the reclassification of 766 acres from the Agricultural District to the Urban District and an Environmental Impact Statement under preparation. The Petition Area is shown on the attached USGS map and aerial photograph.
>
> The Development will require supporting infrastructure improvements, some of which will be located off-site (i.e., outside the Petition and/or Development Areas). Areas affected by these off-site improvements are also shown on the USGS map and aerial photograph and labeled as "Improvement Area." These off-site improvements include:
>
> **Off-site Drainage Facilities:** Four off-site drainage detention basins (one of which is an alternate) totaling approximately 20 acres are proposed, which would be located in Kīpapa Gulch along tributaries of Waikele Stream. The basins would meet County drainage standards and regulate the storm water runoff rate flowing into the stream from developed areas during major storm events. The basins would consist of earthen bermed areas that would detain storm water runoff and release the flows through drainage outlets at pre-development rates. There will also be construction staging areas, construction and maintenance access roads, drainage culverts and erosion control improvements associated with the off-site drainage facilities.
>
> **H-2 Freeway Interchange Improvements:** Improvements are proposed at the Waipiʻo Interchange and a new freeway interchange is proposed near the existing Pineapple Road overpass. The improvements may involve loop or other type of ramps on the east and west sides of the H-2 Freeway at the existing Waipiʻo Interchange and a proposed new interchange near Pineapple Road.

Underground Sewer Line: A new trunk sewer line is required to convey wastewater from the Koa Ridge Makai Development to County facilities. An approximately 3.5-mile underground sewer trunk line would extend from the southernmost portion of the Koa Ridge Makai development area, under Kamehameha Highway, southward along the western boundary of the Patsy T. Mink Central Oʻahu Regional Park, continue in a southerly direction along Pāiwa Street, Kōʻaki Street, Kōpākē Street, Pūkō Street, and Mokuola Street to Farrington Highway. The line would extend west along Farrington Highway to Waipahu Depot Road, where it would run southward, terminating at the Waipahu Wastewater Pump Station.

The purpose of this cultural study is to assess potential impacts to cultural practices and resources as a result of proposed development of the off-site infrastructure improvements in the Waipiʻo Ahupuaʻa. We are seeking your *kōkua* and guidance regarding the following aspects of our study:

- **General history and present and past land use of the project area.**
- **Knowledge of cultural sites which may be impacted by future development of the project area - for example, historic sites, archaeological sites, and burials.**
- **Knowledge of traditional gathering practices in the project area, both past and ongoing.**
- **Cultural associations of the project area, such as legends and traditional uses.**
- **Referrals of *kūpuna* or elders and *kamaʻāina* who might be willing to share their cultural knowledge of the project area and the surrounding *ahupuaʻa* lands.**
- **Any other cultural concerns the community might have related to Hawaiian cultural practices within or in the vicinity of the project area.**

Several (3-5) attempts were made by mail, email and telephone to contact individuals, organizations, and agencies apposite to the Cultural Impact Assessment for Waipiʻo and Waikele Ahupuaʻa. The results of all consultations are presented in Table 3. The review letter from the Office of Hawaiian Affairs (Figures 15 & 16) follows Table 3. The review letter from the State Historic Preservation Division is presented in Figure 17.

Parties consulted that at least partially addresses OHA's stated concerns include Mr. Tom Lenchanko, Ms. Phyllis "Coochie Cayan (former OIBC ʻEwa District representative), Mr. Shad Kane (present OIBC ʻEwa District representative) Mr., Kawika McKeague (present OIBC ʻEwa District representative), and Mr. Jace McQuivey (OIBC chairperson).

Table 3 Results of Community Consultation

Name	Background, Affiliation	Comments
Alegado, Dean	Ethnic Studies, University of Hawaii	Sent letter August 14, 2008.
Ailā, William	Hui Mālama I Nā Kūpuna ʻO Hawaiʻi Nei	Sent letter August 14, 2008.
Arakaki, Masanobu	Waipiʻo resident, former plantation worker	Sent email October 28, 2008. Phoned November 17, 2008, In a phone conversation on November 18, 2008, Russell Arakaki, Masanobu Arakaki's son, stated that Mr. Arakaki has given his permission to include his 2001 interview for Koa Ridge Makai Development project in this CIA. Mr. Arakaki has no specific comments for the current proposed project. See section 7 and Appendix A for 2001 interview summary and transcript.
Ayau, Halealoha	Hui Mālama I Nā Kūpuna ʻO Hawaiʻi Nei	Sent email August 14, 2008. Will forward community outreach information to other members.
Balaz, Keahialaka	Waipiʻo resident	Sent letter August 14, 2008.
Brown, DeSoto	Bishop Museum Archivist, John Papa ʻĪʻī Descendant	Sent email November 18, 2008.
Burke, Marty	Waipahu Neighborhood Board Secretary	Sent email October 28, 2008.
Cayan, Phyllis "Coochie"	State Historic Preservation Division, History & Culture Branch Chief	Sent email request for review October 16, 2008. See Figure 17 below for response.
Ching, Arlene	Aiea Public Library	Sent letter September 11, 2008.
Fujita, Mitsuko "Penny"	Waiawa resident	Sent letter September 11, 2008.
Higa, Jeffery	Waipahu resident	Sent letter August 14, 2008.
Inciong, Tane	Hui Pū Hawaiian Group	See section 7 for interview.
Kalahiki, Mel	Hui Mālama ʻO Kaniakapūpū	See section 7 for interview.

Name	Background, Affiliation	Comments
Kane, Shad	ʻAha Siwila Hawaiʻi ʻO Kapolei Hawaiian Civic Club	See section 7 for interview.
Kapeliela, Kanaʻi	Hawaiian Cultural Practitioner	Sent letter October 28, 2008. He replied on November 14, 2008 but had no comment.
Kealoha, Pono	Hui Pū Hawaiian Group	See section 7 for interview.
Lee, Lurline	Hawaiian Civic Club of Wahiawā	Sent letter August 14, 2008.
Lenchanko, Tom	Hawaiian Civic Club of Wahiawā	See section 7 for interview.
McKeague, Kawika	Oʻahu Island Burial Council	Sent letter August 14, 2008.
McQuivey, Jace	Chair, Oʻahu Island Burial Council	Sent letter August 14, 2008.
Nāmuʻo, Clyde	Office of Hawaiian Affairs	See OHA response below table (Figures 15 &16)
Oba, Ron	*Kamaʻāina* of Waimano, Author and Historian	Sent letter September 11, 2008.
Paik, Linda Kaleo	State Historic Preservation Division, Cultural Specialist	Sent letter August 14, 2008.
Paglinawan, Richard	Queen Emma Trust	Sent letter October 28, 2008.
Poirier, Richard	Mililani/Waipio/Melemanu Neighborhood Board Chair	Sent email October 28, 2008.
Slater, Lovey	*Kamaʻāina* of Pearl City, Hawaiian Practitioner, Program Manager for Alu Like	Sent letter September 11, 2008.
Stagner, Ishmael	*Kamaʻāina* of ʻAiea and Pearl City, Historian and Author, Hawaiian Practitioner, Program Specialist for Alu Like	Sent letter September 11, 2008.

PHONE (808) 594-1888 FAX (808) 594-1865

STATE OF HAWAI'I
OFFICE OF HAWAIIAN AFFAIRS
711 KAPI'OLANI BOULEVARD, SUITE 500
HONOLULU, HAWAI'I 96813

HRD08/3121E

October 6, 2008

Brian Cruz, Cultural Research Specialist
Cultural Surveys Hawai'i
P.O. Box 1114
Kailua, Hawai'i

Re: Cultural Impact Assessment
Koa Ridge Makai and Waiawa Development
Waipi'o Ahupua'a, 'Ewa District, Island of O'ahu

Aloha e Mr. Cruz,

The Office of Hawaiian Affairs (OHA) is in receipt of your August 14, 2008 letter initiating consultation for a cultural impact assessment (assessment) ahead of off-site infrastructure improvements supporting the proposed Koa Ridge Makai and Waiawa Development (development). Based on the information contained within your letter, it is our understanding that an assessment has already been conducted for the development area. Off-site improvements will include: drainage detention basins (with associated staging areas, access roads, drainage culverts and erosion control improvements), H-2 Freeway interchange improvements and an approximately 3.5 mile underground sewer line.

The proposed drainage detention basins will be situated within Kīpapa Gulch, for which there are certain traditional accounts which provide some insight to the cultural significance of the area. It is said that invading chiefs from Hawai'i Island met the forces of O'ahu under Mailekukahi near Waikakalaua and the battle continued from there into Kīpapa Gulch. The invading warriors were soundly defeated and it is said the gulch was literally paved with the dead. Thus, the gulch received the name Kīpapa, or "paved" from this event.

OHA seeks assurances that an comprehensive archaeological review for the undeveloped areas which will be subject to the proposed off-site improvements has been conducted. If warranted, an archaeological inventory survey should be submitted to the Department of Land and Natural Resources-State Historic Preservation Division for review and approval. In the event cultural resources are identified during any phase of the improvement project, all design

Figure 15. October 6, 2008 Response from the Office of Hawaiian Affairs; page 1

Brian Cruz, Cultural Research Specialist
Cultural Surveys Hawai'i
October 6, 2008
Page 2

and engineering concepts which would allow the identified resources to preserved in place in a respectful manner should be fully explored and considered.

OHA recommends that consultation occur with Mr. Tom Lenchenko, Mr. Kana'i Kapeliela, Members of the Brown Family (descendants of Papa I'i who was awarded certain lands in Waipi'o by Kamehameha I) and Members of the O'ahu Island Burial Council. Please remember that this list is not all encompassing, and we are sure additional individuals and/or organizations will be identified as you move forward with your consultation process.

Thank you for initiating consultation at this early stage and we look forward to the opportunity to review the completed cultural impact assessment. Should you have any questions, please contact Keola Lindsey, Lead Advocate-Culture at (808) 594-1904 or keolal@oha.org.

ʻO wau iho nō me ka ʻoiaʻiʻo,

Clyde W. Nāmuʻo
Administrator

Figure 16. October 6, 2008 Response from the Office of Hawaiian Affairs; page 2

LINDA LINGLE
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES

STATE HISTORIC PRESERVATION DIVISION
601 KAMOKILA BOULEVARD, ROOM 555
KAPOLEI, HAWAII 96707

LAURA H. THIELEN
CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES
COMMISSION ON WATER RESOURCE MANAGEMENT

RUSSELL Y. TSUJI
FIRST DEPUTY

KEN C. KAWAHARA
DEPUTY DIRECTOR - WATER

AQUATIC RESOURCES
BOATING AND OCEAN RECREATION
BUREAU OF CONVEYANCES
COMMISSION ON WATER RESOURCE MANAGEMENT
CONSERVATION AND COASTAL LANDS
CONSERVATION AND RESOURCES ENFORCEMENT
ENGINEERING
FORESTRY AND WILDLIFE
HISTORIC PRESERVATION
KAHOOLAWE ISLAND RESERVE COMMISSION
LAND
STATE PARKS

October 24, 2008

MEMORANDUM

Log No: 2008.4733
Doc No: 0810PC05

TO: Brian Kawika Cruz, Cultural Impact Assessment Specialist
Cultural Surveys Hawaii, P.O. Box 114, Kailua, HI 96734

FROM: Phyllis Coochie Cayan, History and Culture Branch Chief Phyllis Coochie Cayan

Subject: WAIPIO 6 Supplemental Cultural Impact Assessment (CIA) for proposed Koa Ridge Makai and Waiawa Development, Wapi'o Ahupua'a, 'Ewa District, Island of O'ahu

Mahalo for the email copy of your letter dated August 14, 2008 to our office for comments on the WAIPO 6 Supplemental Cultural Impact Assessment (CIA) for proposed Koa Ridge Makai and Waiawa Development. Although it looks like the surrounding areas are developed or have been impacted by earlier agricultural uses, it is the people who remember the area that may best help you in identifying any significant sites or cultural practices.

The SHPD recommends you make a serious effort to contact as many community leaders, na kupuna and groups in the project area of the Wapi'o Ahupua'a to get a sense of this place and the people who once were there. For example, making a presentation and asking for information at the neighborhood board at Waipio –Gentry may lead you to older residents with historical and cultural knowledge of the area. Other groups such as the O'ahu Pig Hunters Association or the lessees (i.e. ranchers, farmers) on Bishop Estate parcels in that area may know about cultural and/or historical sites or resources. Many of the old folks have retired and may live in the general vicinity of Mililani-Waipio-Pearl City. The inclusion of oral history that may address culturally significant practices will add to your report.

Other groups or individuals you may want to speak with are as follows:

Mr. Richard Paglinawan, Queen Emma Trust
Ms. Momi Kamahele, Hawaiian Studies, Leeward Community College
Waipahu Senior Citizens Group
Mililani Senior Citizens Group
Waipio-Gentry Neighborhood Board
Waipahu Neighborhood Board
Pearl City Neighborhood Board
Residents who continue to farm in area below Leeward Community College
Residents in the 'patch' across from Sam's Club, Pearl City

c: Nancy McMahon, Deputy SHPO, Archaeology Branch Chief

Figure 17. October 24, 2008 Response from the State Historic Preservation Department

Section 7 Summaries of *Kama‘āina* “Talk Story” Interviews

Kama‘āina and *kūpuna* with knowledge of Waipi‘o and Waikele Ahupua‘a and the area in the vicinity of the proposed project participated in “talk-story” sessions for this assessment. The approach of Cultural Surveys Hawai‘i Inc. to cultural impact studies affords those community contacts an opportunity to review transcriptions and/or interview notes and to make any corrections, deletions or additions to the substance of their testimony.

Cultural Surveys Hawai‘i Inc. employs snowball and judgment sampling, an informed consent process and semi-structured interviews (Bernard 2005). To assist in discussion of natural and cultural resources and any cultural practices specific to the project area, CSH initiates the “talk-story” sessions with questions from the five broad categories. The categories include: Gathering Practices, Marine and Freshwater Resources, Burials, Trails and Historic Properties. Presented below are brief backgrounds of participants’ “talk-story” sessions and their comments and concerns about the proposed project area.

As provided in the Management Summary, land jurisdiction for portions of the project area is held by the U.S. Government (U.S. Army) and private owners (Castle & Cooke Homes Hawai‘i, Inc.). For the most part, Kīpapa Gulch has been off-limits to the public for many years following the appropriation of the area by the military and the building of bunkers beginning in 1942, and subsequent private ownership of some parcels by Castle & Cooke. The plant gathering, and other cultural, activities and resources reported in the following statements refer to an earlier time before access was cut off to Kīpapa Gulch for Native Hawaiians and *kama‘āina* who may have frequented the area. It is important to note here that the 1995 Public Access Shoreline Hawaii (PASH) ruling by the Hawai‘i Supreme Court states that traditional and customary practices are not extinguished by non-use. A footnote (26) to the PASH ruling regarding customary gathering states that, “…as to the right versus exercise thereof, i.e., continuous exercise is not required: ‘the custom is not destroyed, though they do not use it for ten years; it only becomes more difficult to prove’” (Public Access Shoreline Hawai‘i v. Hawai‘i County Planning Commission, 79 Hawai‘i 425, 1995).

7.1 Tane Inciong

Mr. Tane Inciong was born in 1943 and grew up in Wahiawā, O‘ahu as one of 11 children. Mr. Inciong spent many days as a youth in Kīpapa Gulch for both fun and gathering practices. Relatives and close associates taught Mr. Inciong proper gathering techniques for both lei-making and medicinal purposes. Mr. Inciong is concerned about potential flooding in the Kīpapa Gulch as a result of future developments in the area surrounding Kīpapa Gulch. In an interview by CSH at his home in Pearl City on September 22, 2008, Mr. Inciong the following concerns:

> Every time there was development around or near Kīpapa Gulch, the water levels of Kīpapa Gulch would get higher and higher. What’s going to happen to these plants that we use for gathering purposes if the stream rises and wipes them out? This area in known for *kūkaenēnē* (*Coprosma* sp.), some *maile (Alyxia oliviformis*), purple *liliko‘i* (*Passiflora edulis*), *paha* (possibly, *Sicyos pachycarpa*), *‘ie‘ie* (*Freycinetia arborea*) and guava. If the water rises, it will

> definitely affect these gathering practices. Not just the plants themselves but maybe even accessing the plants. It could be more dangerous.

When Mr. Inciong reviewed the figures showing the Sewer Line extending approximately 3 miles from Waipiʻo to the wastewater treatment plant in Waipahu, He was concerned about the untreated waste traveling through the sewer line in Kīpapa Gulch:

> Why don't the put a [wastewater] treatment plant in Waipiʻo or Mililani? That line will be right inside the lower portion of Kīpapa Gulch. What if it breaks from an earthquake or something? All that untreated waste will wipe out our plants and pollute the *aina*. There's no way they can guarantee that it will not rupture of break. Look at Kapiʻolani Boulevard, look how many times that thing broke. If they treated the sewage waste in Waipiʻo or Mililani, then they could use the treated water for crop irrigation downstream. But this plan has the untreated sewage waste going through not only portions of Waipahu, but also Kīpapa Gulch and if it breaks, there goes our natural and cultural resources.

Another concern Mr. Inciong pointed out was the projects potential impact on sacred sites in the Kīpapa Gulch area:

> I am concerned about *ka huakaʻi pō* trail or the night marchers trail. Are they going to run over it? I hope not. The night marcher trail is right where Kam highway crosses over Kīpapa Gulch just below the bridge. I've seen that trail and I hope they protect it. The trail follows along the floor of the gulch towards the lower portion of Waipahu. Also inside the gulch, there are many caves containing burials. Will descendants of these *iwi* still have access to these caves? When they run the sewer line, I know they are going to come across these caves. Got plenty things inside there. I hope they don't disturb them. Not too many people know the exact location of their ancestors. Usually only one member per family knew the location of their ancestors. That person passed it on to one other person to carry on the tradition of caring for the *iwi*. Got some families till this day don't know where their ancestors are because maybe the guy caring for the *iwi* passed away before he could pass on the responsibility to the next person. This tradition of caring for their ancestors in these caves still exists today. In some families, when a family *kūpuna* passes away, they have a funeral and they bury the elderly in a coffin and then the family goes home. Then the person responsible for the ancestor's iwi would go at night and exhume the body from the grave and take the remains to the family cave so the *kūpuna* could join their ancestors. I hope the workers on this project do not disturb these caves and its contents.

7.2 Tom Lenchanko

Mr. Tom Lenchanko is a member of the Hawaiian Civic Club of Wahiawā and a caretaker of the Kūkaniloko Birthstones located in Wahiawā. He is a Hawaiian practitioner in both language and Hawaiian spirituality centered on the Kūkaniloko Birthstones. Mr. Lenchanko was interviewed by CSH on August 29, 2008 at the Kūkaniloko Birthstones. Because the project is located close to the birthstones, he is concerned about the protection of the Kūkaniloko Birthstones and its companion sites:

> Kūkaniloko is the center, it is the *piko*. This is the beginning, the umbilical cord for all Hawaiians. This site is closely associated with every site on this island. One of the companion sites is less than a half mile from the project area. It is called O‘ahu Nui Pōhaku. This pōhaku is in the Waikakalaua Gulch stream bed just north of the proposed drain. This stone is shaped just like the island of O‘ahu. Legend says that Chief O‘ahu Nui was executed in the gulch along with his sister Kilikiliula by their father because he had Kilikiliula’s two sons sacrificed so he could eat them. O‘ahu Nui’s headless body became petrified as well as his sister’s. That place where the *pōhaku* is has been cursed ever since. One of my main concerns is this *pōhaku*. I hope the development of the drain detention basins does not submerge O‘ahu Nui. We have many ceremonies at the O‘ahu Nui Pōhaku and we need to protect it for our children and their children.

7.3 Shad Kane

Shad Kane, member of ‘Ahahui Siwila Hawai‘i ‘O Kapolei Hawaiian Civic Club, grew up in Wahiawā, 2 miles from the project area. Mr. Kane is a cultural historian and a Hawaiian cultural practitioner in the art of making *kāhili* (Feather standard, symbolic of royalty). In an interview with CSH on September 26, 2008 in Waipi‘o, Mr. Kane expressed the following concerns:

> I’m really concerned about this project. All these drain basins. What exactly are they going to look like and how will it affect the natural and cultural resources in the area? I mean is it going to be a big reservoir in the gulch and all the natural and cultural resources be underwater and lost forever? Will we no longer have access to these resources? I know this area has burial caves, petroglyphs (see Figure 18 below) and many cultural and historical sites in Kīpapa Gulch. So I am very concerned about the preservation and protection of these sites.

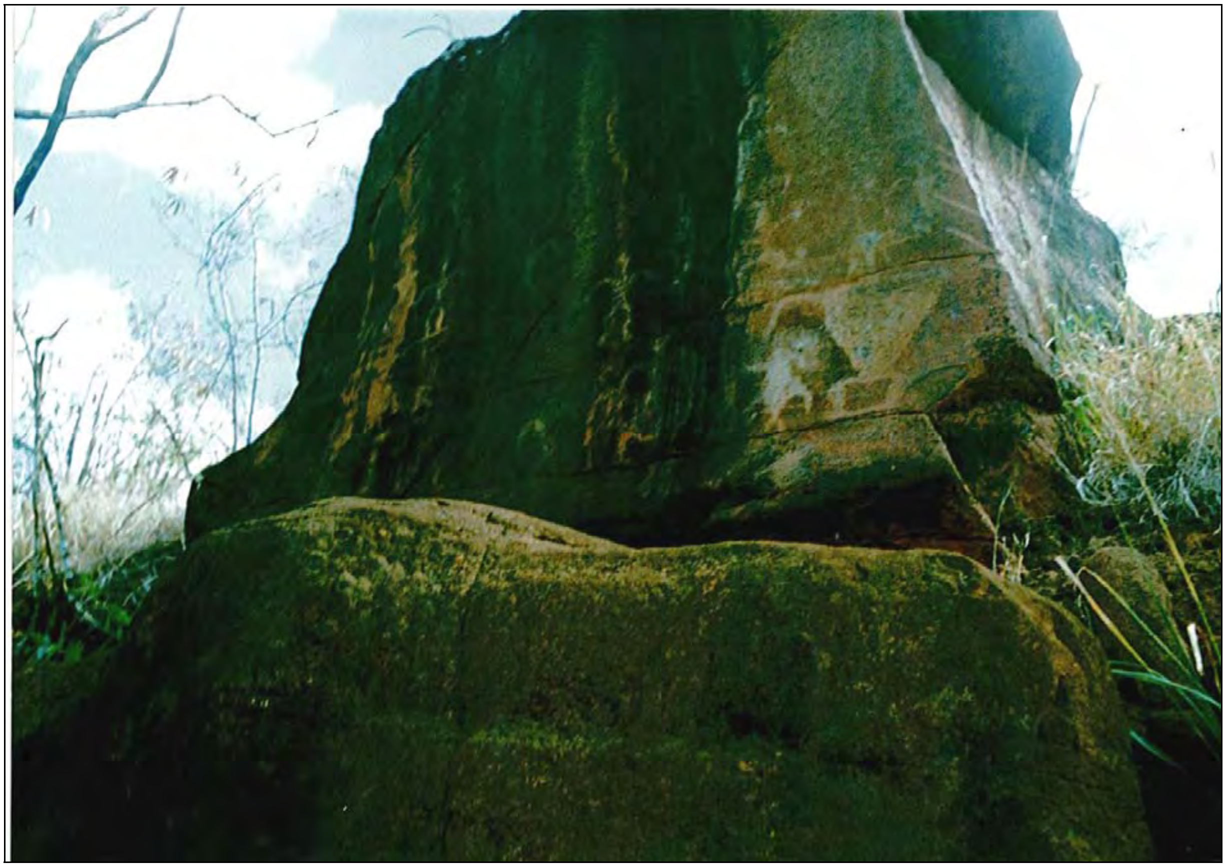

Figure 18. Mr. Kane expressed concern for these petroglyphs located near the project area in Waipahu (this petroglyph site 50-80-09-530 safely lies 700 m to the southwest)

On September 26, 2008, Mr. Kane toured the project area with members of CSH. While in Kīpapa Gulch, several structures were examined and studied by Mr. Kane and CSH. These structures included terraces, rock walls and a rock formation called an *ahu* or shrine. This *ahu* is the most impressive feature located in the project area in Kīpapa Gulch (See Figure 19). Figure 19 below is also presented in the Cultural Surveys Hawai‘i’s companion Archeological Inventory Survey (Tulchin and Hammatt 2008) as State Inventory of Historic Property (SIHP No. 50-80-09-7046 (CSH 3). Although the companion AIS lists the probable age of this structure as post-Contact, Mr. Kane believes there is great historical and cultural significance to this *ahu*:

> I believe there is some kind of cultural significance to this *ahu*. This, in my opinion, is a burial marker or some kind of important marker. This area in here [Kīpapa Gulch] was a major battle field with O‘ahu forces fighting against the forces from the big island [Hawai‘i Island]. This *ahu* is probably a marker of an important battle or there is an important high chief buried here in this area. Being that the *ahu* is in the lower flood area of the gulch, I don’t believe a burial is under the *ahu*, but perhaps it marks that a burial is very near by, maybe in a cave above the *ahu*. I believe this site is pre-Contact and should be preserved.

Mr. Kane also expressed his concern with the drain basin structures:

> You know…these drain basins, what exactly are they? What is their capacity? How many feet high will it be? Will the bottom be concrete or will it be natural? Can we have more information about these structures because I think these basins may have the biggest impact to our cultural and natural resources in the area?

Figure 19. During a visit to the project area, community consultants Shad Kane and Pono Kealoha indicated that this rock structure or *ahu*, located in Kīpapa Gulch, should be preserved and protected

7.4 Pono Kealoha

Mr. Pono Kealoha is a member of Hui Pū, a Hawaiian activist group, and Ka Lei Maile Ali‘i Hawaiian Civic Club. Mr. Kealoha lives near the proposed underground sewer line in the southern portion of the project area. He was interviewed by CSH on September 26, 2008 after touring the project area with CSH and shared his concerns about cultural sites located in Kīpapa Gulch:

> I live downstream from the project area and I am very concerned about this project. There are many historic sites located in the Kīpapa Gulch area. Some of

> which I have seen today. I hope that the *ahu* we saw today will not be disturbed. I believe the terraces and the different rock formations we saw today are all pre-Contact definitely. I believe more studies should be done to them to determine their age. I highly recommend the developers avoid disturbing these areas because we [Hawaiian people] have lost so much already and I want to try to preserve what we can. That's our history in there and we shouldn't erase it.

Mr. Kealoha also expressed his concerns over the proposed underground sewer line extending 3.5 miles from Waipiʻo to the Waipahu wastewater treatment plant:

> I can't believe they are going to run the untreated sewer through Kīpapa Gulch! I think they should have planned for a waste [water] treatment plant in Waipiʻo. If the sewer line ever breaks for whatever reason, I live downstream from Waipiʻo, all that waste is going to flood the gulch, destroying our plants and then end up in our back yard. I also hope that the sewer line does no disturb the petroglyphs near the H-1 Freeway by Manager's Drive overpass. When they get close to the petroglyphs during excavations, I hope a cultural monitor will be present to make sure those petroglyphs are protected.

7.5 Mel Kalahiki

Mr. Mel Kalahiki was born June 25, 1925 to parents Kamaka Kalahiki of Kahaluʻu and Elisabeth Akau of Kohala. He worked within the Council of Hawaiian Organizations in forming the legislation that formed OHA. Mr. Kalahiki formed the group Hui Mālama ʻo Kaniakapūpū to help preserve and care for the summer home of Kamehameha III. Mr. Kalahiki was interviewed by CSH at his home in Kāneʻohe on October 6, 2008.

When Pearl Harbor was attacked in 1941, Mr. Kalahiki, a high school student at the time, left school to work for the United States Engineering Department based at Fort Shafter in Kalihi, Oʻahu. During his tenure with U.S.E.D., he participated in the excavation project for the military bunkers in Kīpapa Gulch in 1942:

> I remember working in Kīpapa Gulch after the war; it was during the "Blackout" period. I was a truck driver and I was getting $1.50 an hour and that was big bucks. One of my uncles was working on the docks and he was getting $1.00 an hour and I used to brag about my $1.50. There was only one way to get in Kīpapa and that was Kam Highway. We were working right on the bridge in the gulch. The engineers would stick dynamite in these holes and they would blast them off and I would back my truck in there and they would load the muck into my truck. I would take the muck a short ways away to unload and then go back for more. As I remember each of the bunkers were 25 yards in and about 10 feet wide by 10 feet high. None of the bunkers connected together because if one blew up, they didn't want the others to be affected.

The military bunkers Mr. Kalahiki is referring to are still present today in Kīpapa gulch (Figure 20). There are over 30 bunkers approximately 100 meters apart along the sides of Kīpapa. These bunkers are sealed shut with metal brackets welded to the doors to keep people out. When asked about the sealed doors to the bunkers and its possible contents, Mr. Kalahiki shared this story:

> When I was working in the Kīpapa area excavation, I had been there for about a year and a half. My coworker, his name was Jim Albertini, and I were standing on the bridge over Kīpapa stream and we were watching the military load and unload equipment in the bunkers. As we watched them from above, we saw what we believed was an Atomic bomb. Jim had heard rumors circulating in the area that the atomic bomb was being stored in the bunkers that we built. I was convinced that what we were seeing was an atomic bomb. Of course by now, the talks around the job site was all about the Atomic bomb in the bunker. Everyone believed on our job site was a serious weapon stuffed in the bunker we built. The sad part about this whole thing was that when we bomb Japan and we heard about all the people that died, we felt bad for the people who had lost their lives. It was as if we were a part of the bombing because we had it stored in our bunkers. It was a real uneasy feeling.

Mr. Kalahiki was asked about his concerns for the proposed project in Waipiʻo and the potential impacts it may have on Hawaiian culture:

> I know inside the gulch has lots of structures from old Hawaiʻi. My main concern is that these sites are unharmed. We should respect *Ka Poʻe Kahiko* [The ancient people of Hawaiʻi] even if there are not here today we should still show respect to them. I ask that the developers please avoid damage to any historical sites in the area.

Figure 20. Mr. Kalahiki participated in the construction of this military bunker in Kīpapa Gulch

7.6 Masanobu Arakaki

In a phone conversation with CSH on November 18, 2008, Russell Arakaki, Masanobu Arakaki's son, stated that Mr. Arakaki has given his permission to include his 2001 interview for the Koa Ridge Makai Development project in this CIA (Bushnell and Hammatt 2001). Mr. Arakaki has no specific comments for the current CIA for the proposed Off-Site Drainage Detention Basins, Traffic Interchanges, and Sewer Line Work Related to the Koa Ridge Makai Development. The 2001 study provides the following biographical information and interview summary (see Appendix A for complete interview transcript):

> Masanobu Arakaki was born in Kīpapa Valley, Waipi‘o, O‘ahu to Seiboku Arakaki and Nae Nakamatsu in 1929. Mr. Arakaki has lived most of his life in Kīpapa Valley. He grew up in the Valley where his parents were truck farmers and he has continued to farm on the leased family land in Kīpapa ever since.
>
> Both his parents had come from Okinawa to work in the sugar plantations in the early 1900s. Mr. Arakaki believes his parents met at the Kekaha Sugar Plantation on Kaua‘i and later moved to O‘ahu. They found work at a private plantation farm in Kunia which is where his two older siblings were born. Sometime during the 1920s, the Arakakis began to lease land in Kīpapa. They began to grow vegetables such as sweet potatoes, corn, beans, bananas, Chinese cabbage and irish potatoes. They were one of many Japanese families who became known as the "truck farmers" of Kīpapa.
>
> During his school days, first at Kīpapa School and later at Leilehua High School, most of his classmates and friends came from the neighboring pineapple plantation camps including the Dole Camps, K-1, K-5, Robinson 1 and 2 and the Libby, McNeil, Libby Camps, Waipi‘o and Shohata. The tablelands above Kīpapa Valley surrounding the camps were all planted in pineapple.
>
> Although from the outside Kīpapa Valley may look very similar to what it looked like for much of the twentieth century, Mr. Arakaki has witnessed many changes to the Kīpapa Valley throughout his life. During World War II, the U.S. military condemned the lower portion of Kīpapa Gulch and relocated the truck farmers to the mauka portion of the Kīpapa Valley. Here, the Arakaki family had to start over with the farm. At about this time also, Mr. Arakaki's father died leaving the rest of the family to run the farm. In the 1950s, Dole Pineapple Company bought the Kīpapa Valley from the ‘Ī‘ī Estate.
>
> The Arakaki family has always had the hope of buying their leased land in Kīpapa. However, this has never become a reality for them (Bushnell and Hammatt 2001: 6).

Section 8 Cultural Landscape of the Project Area

8.1 Overview

Discussions of specific aspects of traditional Hawaiian culture as they may relate to the project area are presented below. This section examines cultural resources and practices identified within or in proximity to the subject project area in the broader context of the encompassing Waipiʻo and Waikele Ahupuaʻa landscape. Excerpts from talk story sessions from past and the present cultural stuides are incorporated throughout this section where applicable.

8.1.1 Growing and Gathering of Plant and other Mauka Resources

As indicated by the LCAs in Waipiʻo Ahupuaʻa, the majority of awarded land parcels were located in the *makai* portions of Waipiʻo, at or just above the peninsula (Table 1). John Papa ʻĪʻī was awarded most of the *ahupuaʻa* of Waipiʻo in LCA 8241, comprising approximately 20,540 acres. Included in the documentation for ʻĪʻī's award is a list of "the people living on the land of Waipiʻo ʻEwa in 1848" (Barrere 1994:73).

A substantial grant within the *ahupuaʻa* was awarded to Abner Pākī, Bernice Pauahi Bishop's father. Part of LCA 10613 given to Pākī comprised the 350 acres of the *ʻili* of Hanaloa. William Harbottle also received a land award (LCA 2937) in Waipiʻo; he claimed two acres at Hanapouliʻili.

The remaining land claims documented in the records, a total of 99 (not all of which were awarded), are *kuleana* claims, where the commoners of Waipiʻo worked and lived. Predominant among the claimed land usages in Waipiʻo are 312 *loʻi* (irrigated taro patches) of various sizes; and 43 *moʻo*, or fields, comprising indeterminate numbers of *loʻi*. Wetland taro cultivation was the primary agricultural pursuit within the *ahupuaʻa* at the mid-nineteenth century, and likely reflects a long history of taro farming.

Past cultural studies conducted in the vicinity of the current project area include information on plant resources in Kīpapa Gulch (see Hammatt and Shideler 1996, Bushnell and Hammatt 2001). In particular, an interview with Somerset Kalama Makaneole included considerable discussion of plant and mineral gathering activities in Kīpapa Gulch (see Bushnell and Hammatt 2001: Appendix B for complete transcript): Following is an excerpt from Bushnell and Hammatt (2001) regarding gathering activities (prior to restricted access to the area):

> A good discussion on native gathering practices in the Waipiʻo Uka region is included in the 1996 Traditional Practices Assessment (Hammatt and Shideler, 1996:15-19). The objective in this [Bushnell and Hammatt 2001] supplement is to discuss native gathering practices in the context of the information shared through the interviews and the additional research conducted.
>
> Gathering in the uplands of Waipiʻo is specifically discussed by John Papa ʻĪʻī (1959:77) who was born in Waipiʻo in 1800 when he describes a famine: "This prohibition was called kapu ʻohiʻa because, while the famine was upon the land, the people lived on mountain apples *(ʻohiʻa ʻai*), tis, yams and other upland

foods”. The Hawaiians dried the *ʻohiʻaʻai* first before eating it, thus avoiding a stomach ache (Handy and Handy, 1972:235). Even in the 1930s and 1940s, the mountain apple or *ʻohiʻaʻai* was used to stave off hunger in a small boy from the pineapple camp. Nobukichi Toyama recalls picking mountain apples in the valleys surrounding Shohata Camp (personal communication, July 24, 2001). Long ago, during hunting trips in the far reaches of Kīpapa Valley, Senichi Tanisue recalls collecting bamboo shoots, the tree fungus *pepeiao* (*Auricularia auricula*) and *hōʻiʻo* (*Diplazium [Athyrium] arnottii*) fern shoots. All of these were collected outside of the [Bushnell and Hammatt 2001] project area.

Gathering in the Waipiʻo uplands was not just limited to times of famine. Certain resources only found in the upland areas were targeted for particular uses. One interview documents traditional gathering of plants and minerals in the Waikakalaua and Kīpapa Gulches (Interview with K. Makaneole, July 28, 2001). Kalama’s mother, Esther Pahuanui Kauhane, grew up in Waikele near where the Waipahu Cultural Garden is today. It was she and her mother, Kalama’s grandmother, who passed on the family knowledge of *lāʻau lapaʻau* and *lomi lomi* as well as other modes of healing to Kalama. When visiting family in Wahiawā, Kalama would accompany his mother and aunts and uncles on their collecting trips. One of the things the Kauhane family sought in Central Oʻahu was the four o’clock plant (*Mirabilis jalapa* L.) or what they called *pelekane.*

> It’s blue or white tubular flowers that everybody knows that studied botany, it blooms, it opens up at four o’clock. It gives out–it has this black seed that they use it for making rattles inside Hawaiian instruments, kind of like *ʻiliʻili*. And, that see, black seed is what they used to extract the oils from, all the property from and they mix ‘em in the ointment...And that’s what gives it its penetrating property to go into the muscle and gives out this heat, you know, this four o’clock plant. And they used to go up there because used to grow wild up there (Interview with K. Makaneole, July 28, 2001).

The four o’clock plant grew more in the vicinity of Wahiawā. Another Hawaiian name given to the four o’clock plant was *nani-ahiahi* and is recorded to be a popular lei flower for the evening (Neal, 1965: 336). Other medicinal properties are given for the plant including the use of the kernel in the black seeds as a cosmetic.

Some of the plants Kalama’s family collected for medicine in the Waikakalaua and Kīpapa Gulches were the *ʻaʻaliʻi* (*Dodonaea viscosa*) and the *lauaʻe* (Phymatosorus scolopendria). In addition to their uses in lei and decoration, Kalama is aware of how *ʻaʻaliʻi* and *lauaʻe* were utilized medicinally. According to Kalama, the bark of the *ʻaʻaliʻi* was smoked for its narcotic effect.

> KM: ... And then when people was sick, people was sick, thy used to blow ‘em into them, the *ʻaʻaliʻi.* And then what it does, it has this–

> CSH: Blow the smoke?
>
> KM: Yeah, the smoke, and have them breathe or burn ʻem in our room. They burn ʻem up, burn ʻem in our room and let the patient breathe that because what it has, it has a narcotic effect, you know, on the person. And then it numbs the whole body. It's like a painkiller, that maybe say like marijuana. It's like marijuana, the *ʻaʻaliʻi*. Not too many people know that.(Interview with K. Makaneole, July 28, 2001).

Traditional gathering of *ʻaʻaliʻi* and its use in *lei* making is also documented in the Waikakalaua Gulch (Bushnell and Hammatt, 2001). Kalama describes the *lauaʻe* as useful in controlling blood sugar when taken as a tea (Interview with K. Makaneole, July 28, 2001). In treating advanced stages of diabetes, Kalama uses *lauaʻe* to draw out infections of the leg.

During the period Kalama and his mother and family collected in the Kīpapa Gulch in the 1950s and 1960s, access issues with the military and contamination of the lower gulch limited their collection to the upper gulch, *mauka* of the H-2 bridge. In fact, Kalama and his family collected in the vicinity of the truck farms of Kīpapa. As a young, agile boy, it was Kalama's job to descend the ravines and side gulches and harvest the *ʻaʻaliʻi* and *lauaʻe* while his mother and aunts and uncles waited for him on top. Based on his description of collecting localities, much of the gathering occurred on the sides of Kīpapa Gulch, probably adjacent to the Koa Ridge Mauka parcel and possibly in the upper limits of Koa Ridge Makai in the vicinity of the H-2 Bridge. According to Kalama, the *ʻaʻaliʻi* and *lauaʻe* grew in great profusion along the gulch sides.

Although Kalama and his family spent their days gathering medicinal plants and snacking on available, fresh fruits, one of their primary motives in visiting the Waikakalaua and Kīpapa Gulches was to collect *ʻalaea* [water-soluble colloidal ocherous earth used for coloring salt, for medicine, for dye and purification ceremonies (Pukui and Elbert 1986)]. In *Māhele* documents, "Pualaea" appears as the name of a piece of land used as the *mauka* boundary of the *ʻili* of Hanauaka in LCA 8241V. This suggests that *ʻalaea* was a noteworthy resource in Waipi'o ʻUka. More than likely, Hawaiians living there gathered *ʻalaea* for their use. Traditionally, *ʻalaea* has been used in purification rituals and in conjunction with fishing protocol (Malo, 1951:163;208). Mixed with other herbs, *ʻalaea* was a very common form of medicine (Gutmanis, 1989:47). "*ʻalaea*, by itself, was added to medicines and foods for all kinds of hemorrhages and menstrual disorders, as well as for the general building-up of the patient" (*Ibid*). Such is the case for Kalama who uses *ʻalaea* to treat AIDS and cancer patients in order to build up their energy.

> I get people that get AIDS. That's what I give ʻem besides they gotta watch their diet, take their medication. I give them something extra that kick ʻem in gear for make their life better. You know, I cannot save them.

> But I can make that life perform better for them and be more active and being more aware of his surroundings, be able to enjoy your life and not being tired. This helps them. That's what I do. I give them that [gold *‘alaea*] (Interview with K. Makaneole, July 28, 2001).

Kalama uses several different types of *‘alaea* in his practice, but he prefers the gold *‘alaea*, which he says is unique to central O'ahu. He claims the gold *‘alaea* is stronger than the "Kaua‘i *‘alaea*" (or red *‘alaea*) and attests to its ability to build up red blood cells.

> CSH: Now tell me again, you already told me, but just to have it on tape. What do you do with the gold *‘alaea*?

> KM: Okay. This is a gift [referring to the gold *‘alaea* he is holding]. I get this one student. He's--they got him on the mainland, he's researching this, in the mainland, for cancer. Because he gives it [gold *‘alaea*] to the patient who has cancer. And then, because when they go through chemo [therapy] and they go through radiation, they don't eat. They lose their appetite. And if people don't eat, they die. And, he gives them that [gold *‘alaea*] and then it stimulates the appetite. It brings up, builds up red blood cells... Because what it does is that if you take it full strength of that, it's like a methamphetamines. It create the body to come alive. It's like a rush (laugh). You know, it's like a rush. And, make it active. The old Hawaiians used to take that to stay up.

Two types of *‘alaea* were found along the stream banks of both Waikakalaua and Kīpapa Streams, the gold *‘alaea* and the white *‘alaea*. The Kīpapa area also has the orange *‘alaea*. The uses of the gold *‘alaea* have already been outlined in previous paragraphs. The white *‘alaea* is used externally for skin irritations and was traditionally used by Hawaiian women as a deoderant (Interview with K. Makaneole, July 28, 2001). Kalama explained that one of the most important factors in producing the *‘alaea* is the stream water. The stream water gives strength to the *‘alaea*. Before collecting *‘alaea*, Kalama studies the stream from the roadway to judge the water level and see if the *‘alaea* is submerged or not. Although he collects *‘alaea* more often at Waikakalaua because access is easier, he does sometimes also go to Kīpapa.

In Kīpapa, orange *‘alaea* is gathered from veins on gulch sides after landslides. According to Kalama, that is the best time to collect because the *‘alaea* is in its cleanest, purest form (K. Makaneole, personal communication, August 16, 2001). Purity of *lā‘au lapa‘au* is important to traditional practitioners because much of the foundation of Hawaiian medicine is based on detoxifying the body. Kalama discusses the effects of development on gathering localities in Waikakalaua:

> CSH: You mentioned that Waikakalaua was a place that you really like to get the gold *‘alaea*.

> KM: Yeah, but now hard ‘cause you gotta go more further up. Because, they get the run off from the housing into the stream. When they do that, it’s gone already. You going get rubbish, you going get oil that comes off from the curbing when they wash their car, they working in their yard, oil leaks. They going be run down by the storm and they deposit inside of the stream bed. You going see a lot of development, they running ‘em off into the stream. So, you gotta go more higher [into the mountains] because the contaminants (Interview with K. Makaneole, July 28, 2001).

In addition to the wild medicinal plants collected, Kalama remembers that his mother knew where all the fruit orchards were in the Kīpapa Valley. During collecting trips, they would help themselves to avocado, mango, banana (*Musa* sp.), sugarcane (*Saccharum officinarum* L.), Hawaiian oranges, wild guava, and *‘ōhelo* (*Vaccinium* spp.) berries. Many of the fruits were found on what Kalama described as old farms, however these may have included old *kuleana* lands as well. Linda Mahoe Gallano, caretaker for the Koa Ridge Ranch in the 1980s, was interviewed during the Archaeological Inventory Survey of this same project area. She remembered seeing fruit trees in association with what she described as Hawaiian homesites:

> It’s right down here, you drop down, you go right down across the river and there’s this big mango tree and right next to it is an orange tree and then there’s this wide area that only has *‘awapuhi* growing there. And there are rocks; you just know somebody lived there before. I had a *kupuna* come up once and he said they probably made *kapa* on this rock right there because it’s right by this river so they could easily work on it but it’s high enough the river that it’s not going to get flooded (Interview with Linda Mahoe Gallano, June 1996).

All the fruit picking occurred within the Kīpapa Valley and not in the project area. Kalama also reported collecting ginseng (*Panax quinquefolias*) on the valley floor, probably a remnant of the Japanese or Chinese independent pineapple growers or truck farmers.

Māhele land documents indicate that there was *‘iliahi* (*Santalum* spp.) or sandalwood in the Kīpapa Valley in the mid nineteenth century. A chief export to China in the early nineteenth century, *‘iliahi* was prized for its unique fragrance and used in making chests, as incense, in perfumes and as medicine (St. John, 1947). A first generation missionary of ‘Ewa, Sereno Bishop, recalls hearing of a dry forest on the ‘Ewa plain which was burned off in the search for sandalwood (Bishop in Sterling and Summers, 1978:89). In LCA #8241YY, Kahuluhulu claimed an *‘okipu‘u* called Ahanaanaa in Waipi‘o Valley. The western boundary of the *‘okipu‘u* is described as “kailiahi of konohiki”, or the konohiki’s ‘iliahi. That the sandalwood was claimed by the konohiki indicates it was of value. Also noted as a boundary in LCA #8241YY is *hau* (*Hibiscus tiliaceus* L.) claimed by

> the *konohiki*. *Hau* was a very useful plant, particularly its inner bark for making cordage (Summers, 1990:20). (Bushnell and Hammatt:34-37)

One participant in this cultural assessment mentioned the use of the Kīpapa area for gathering of plants for both lei and medicinal purposes. Kupuna Tane Inciong was taught plant gathering techniques by close relatives and family friends. He learned how to properly gather various plants without doing damage to the plants themselves. Mr. Inciong was instructed by his *kūpuna* to only pick what you need and to use all that you gather. Also, he learned the importance of picking items carefully so the same plants can continue to provide needed resources in the future. Plant gathering for items such as *kūkaenēnē* (*Coprosma* sp.), *maile (Alyxia oliviformis*), purple *lilikoʻi* (*Passiflora edulis*), *paha* (possibly, *Sicyos pachycarpa*) and *ʻieʻie* (*Freycinetia arborea*) were part of the traditional practices of his *ʻohana*. To this day, Mr. Inciong passes along the gathering techniques he has learned from his *kūpuna* to younger members of his extended family as well as close friends.

8.1.2 Marine and Freshwater Resources

Waipiʻo Ahupuaʻa was a focus of Hawaiian settlement and activity on Oʻahu during the centuries preceding western contact. "The populous dwelling place of the *alii* was formerly located on an east point of Waipiʻo Peninsula known as Lēpau" (McAllister 1933:106). The *aliʻi* (chiefly class) at Waipiʻo were no doubt attracted to the great abundance the region offered. "The primary reason for ʻEwa's prominence in history and as an *aliʻi* stronghold was undoubtedly the existence of the great number of fishponds at different points around Pearl Harbor, which was ʻEwa territory. Two of the largest [Loko Eo and Loko Hanaloa] were on the peninsula, and another was at its northwest corner"

Much of ʻEwa District *makai* of the south project area environs is traditionally well-known for its many *loko* (fishponds), both large and small. The closest major *loko* to the project area was Loko ʻEo, described in the *Dictionary of Hawaiian Localities* (*Saturday Press,* August 11, 1883) as a "…large fishpond in Ewa, well known for superior flavor of fishes" (Sterling and Summers 1978:20). As stated above, *ʻeo* is translated as "full of food" (Pukui and Elbert 1986:42). A nineteenth century visitor to Loko ʻEo described it in the Hawaiian newspaper *Ka Nupepa Kuokoa* (Aug. 11, 1899):

> We rode and reached Waipio. Saw Halaulani House; only the house stood there for the inhabitants had gone to Mana. The bubbling waster of the pond Eo rippled on the left. There a recollection came of the bundles of fat eel from that place and the delicious mullet of Makahanaloa. It was delicious clean and that is why the very juice in the ti leaves was sucked up by Kohala's son (cited in Sterling and Summers 1978:20).

Today, fishing in Pearl Harbor still exist, however, due to restrictions imposed by the U.S. military, access is very limited. Also, water quality in Pearl Harbor has adversely impacted not only fishing practices but also *limu* (seaweed, algae) gathering. The area south of the project area once was abundant with different types of *limu* such as the popular *limu kohu* (*Asparagopsis taxiformis*) and *limu manauea* or *ogo (Gracilaria coronopifolia).* These two types of *limu* are commonly use in *poke,* a local Hawaiian raw-fish dish that is a favorite delicacy for many island residents. Participants for this cultural assessment mention that the gathering of *limu* and extensive fishing are very rare these days to the point of non-existence. The two major fishponds in Waipiʻo Ahupuaʻa, Loko Eo and Loko Hanaloa, no longer exist. Both have been filled in, one is a grassy field and the other, a golf course. *Aku* (skipjack tuna) boats used for commercial fishing still use the waters in Pearl Harbor for bait-catching prior to going out in the deep waters off Oʻahu to catch *aku*. The *aku* boats, such as the *Orion* and the *Kula Kai*, lay nets in Pearl Harbor to catch *nehu* (*Encrasicholina purpurea* or anchovy) which are plentiful in the Pearl Harbor waters. Once these boats have their saltwater wells filled with *nehu*, they would head out to sea in search of *aku*.

Participants in the current CIA study did not discuss marine and freshwater resources. One participant in the 2001 cultural study described past fishing practices in Kīpapa Stream:

> Masanobu Arakaki talks about going fishing in the Kīpapa Stream as a boy. However, back then, the stream was different:
>
> > Mr. Arakaki remembers when he was a child, Kīpapa Stream used to dry up just once in a while, perhaps once every two or three years. He believes that the increased development keeps Kīpapa Stream dry a lot of the time nowadays, because much of the groundwater is being tapped by wells. Before, the children used to catch fish in the stream and when it did dry up, there were little pools which maintained the fish, until the stream filled up again. Some of the fish they used to catch were gold fish, dojo-catfish, mosquito fish (guppies) and *ʻoʻopu*. Mr. Arakaki felt that no fish could survive in Kīpapa Stream today (Interview with M. Arakaki, July 27, 2001).
>
> *ʻOʻopu* is the only native fish mentioned which may have been gathered traditionally in Kīpapa Stream, however there is no known documentation of this. (Bushnell and Hammatt 2001: 38).

8.1.3 Hunting Practices

Participants in this CIA did not mention past or ongoing hunting in the project area and environs. The following excerpt from Bushnell and Hammatt (2001) provides an overview of hunting before the area was closed to the public:

> The 1996 Traditional Practices Assessment reported evidence of pigs from the Koa Ridge Mauka, Waiawa, and Kīpapa Ridge portions of the project area (Hammatt and Shideler, 1996: 15). Pigs were probably a part of the local fauna for centuries. The place name Waiakapuaʻa (LCA #8241R) in the *Māhele* documents suggests pigs were in the Kīpapa Valley in the mid 1800s. Traditionally, pig may have been an attractive source of meat considering Waipiʻo ʻUka residents lived some distance from the coast and did not have daily access to fish. In addition, pigs may have been a nuisance when food shortages forced them down to lower elevations where Hawaiians were cultivating dryland *kalo* and sweet potato. Such was the case when Masanobu Arakaki's family was farming in Kīpapa Valley in the 1940s. The Arakaki's *mauka* farm was situated up the

Kīpapa Valley, adjacent to the Koa Ridge Mauka parcel of the study area. The sweet potatoes would lure the pigs into the fields. "To deal with the pigs which sometimes frequented the fields at night time when nobody was watching, they would tie a dog at the edge of the field who would start barking when they smelled the pig and scare it away. As kids, they would shoot the pigs with rifles" (M. Arakaki, July 27, 2001).

Hunting of pigs in the immediate vicinity of the project area has been documented as far back as the 1930s (Hammatt et al., 1996: 38-39). When he was a child in the thirties and forties, Mr. Arakaki would see many hunters hunting up in the valleys. "Back then, there were many hunters, of all nationalities. Hunters came from Kalihi, hunters came from Wai‘anae to hunt in the Ko‘olaus" (Interview with M. Arakaki, July 27, 2001). Apparently, hunting had already become a tradition by the time Mr. Arakaki was growing up in the 1930s.

Mr. Arakaki explained that one of the most popular access points to hunting in this part of the Ko‘olaus used to be up by Shohata Camp, through the pineapple fields. A younger generation hunter who was interviewed for another traditional practices assessment in the Mililani Mauka area also described this route as an access route to prime hunting grounds (Bushnell and Hammatt, 2001, Appendix B). This access route is through the Koa Ridge Mauka parcel of the project area, following Pineapple Road *mauka*. This route has been closed to hunters and the general public for several years. (Bushnell and Hammatt 2001:34-35)

8.1.4 Cultural and Historic Properties and Burials

As described in Section 3, there are numerous sites in Waipi‘o and Waikele Ahupua‘a of historic and cultural significance. O‘ahu Nui Pōhaku, a stone shaped like the island of O‘ahu, lies approximately 200 meters north of the northern-most proposed drain detention basin in Kīpapa Gulch. In an interview with Tom Lenchanko, he explains that the stone is the remnants of Chief O‘ahu Nui, who after being beheaded, was petrified in Kīpapa Gulch where it remains today.

There are also numerous cultural and historic sites in Waipi‘o and Waikele Ahupua‘a that no longer exist today. These include the Ahu‘ena Heiau which was described in the 1930s by McAllister (1933) of the Bishop Museum as follows:

> Ahu‘ena Heiau (Destroyed)…Only a small portion of paving of very small waterworn stone at the edge of the 25 foot elevation remains of what must have been an important *heiau*, for the site is known and remembered by all the old Hawaiians (*kamaaina*) in the district. There is a vague memory that this *heiau* was formerly located in the mountains in Honouliuli at Punahawele. Thrum states "Hon. John [Papa] Ii [the 19th century historian, member of the Land Commission and prominent citizen] used to be the custodian of its idols." (Sterling and Summers 1978:19)

In an interview with Tane Inciong, he describes the numerous caves in Kīpapa Gulch that may contain *iwi* (bones) and *moepū* (funerary objects). He explained the Hawaiian traditions practiced by people of old Hawai‘i in which ancestral remains were taken to these caves in secrecy to protect the ancestors *iwi* from being stolen. It was believed by the ancient Hawaiian practitioners that their ancestor’s *iwi* contained *mana* or power by those who possess them. This is still believed today by contemporary Hawaiian traditionalist.

8.1.5 Trails

Portions of the project area are in the immediate vicinity of a well-documented traditional trail, which formerly connected ‘Ewa to the Waialua District through the Central O‘ahu Plains, as well as to Wai‘anae over Kolekole Pass (see the often-reproduced map on p. 96 in ‘Ī‘ī 1959).

Tane Inciong also mentions the existence of the night marchers (*Huaka‘i Pō*) trail located in Kīpapa Gulch. Although portions of the trail have been destroyed by prior developments over the years, he recommended that the portions of the trail that still exist today be protected and preserved. Remains of this trail can be seen under the Kamehameha Highway Bridge at Kīpapa Gulch heading south toward Waipahu.

8.1.6 Wahi Pana (Storied Places)

The project area is associated with specific *mo‘olelo* (oral history, stories, legends) about the famous battles of Kīpapa Gulch. Kīpapa translates literally as “placed prone (referring to corpses slain in the victory of O‘ahu forces over those of Hawai‘i in the fourteenth century)” (Pukui et al. 1974:113).

Pearl Harbor, located south of the project area, was named after the pearl oysters formerly found there. The Hawaiian name for Pearl Harbor is Pu‘uloa which translates to “long hill” (Pukui et al. 1974:182). Pu‘u also translates to “throat”. Hawaiian *kākau* (expert tattooist) Keone Nunes believes the true meaning of Pu‘uloa translates to “long throat” making reference to the entry waterway of Pearl Harbor. Besides being the site if the infamous attack on Pearl Harbor by the Japanese on December 7, 1941, Pearl Harbor was also known to contain several fishponds and a fishery operation. Loko Eo located in the south project area, is not translated by Pukui et al. (1974), whose entry for “Loko-‘eo” says simply “Fishpond, Pearl Harbor, O‘ahu.” They do provide another similar name, *Loko ea*, translated as “rising pond,” and located near Waialua and Waipahu. The word ‘*eo* is translated by Pukui and Elbert (1986) as “full of food,” and perhaps this is one of the meanings of the name Loko Eo (or ‘Eo). Today, Loko Eo has been filled in and is now the Ted Makalena Golf Course. South of Loko Eo was Loko Hanaloa, reportedly very near to the actual birthplace of John Papa ‘Ī‘ī. At the entrance to Loko Hanaloa was the Homaika‘i Fishery.

Section 9 Summary and Recommendations

Cultural Surveys Hawaiʻi, Inc. (CSH) is conducting a supplemental Cultural Impact Assessment (CIA) for off-site infrastructure improvements supporting the proposed Koa Ridge Makai and Waiawa Development projects at the request of Castle & Cooke Homes Hawaiʻi. The cultural survey includes both the Waipiʻo and Waikele Ahupuaʻa, and more specifically Kīpapa Gulch located in the Waipiʻo Ahupuaʻa, ʻEwa District, on the island of Oʻahu. The underground sewer line portion of the infrastructure improvements project crosses over into the Waikele Ahupuaʻa in the Waipahu area.

9.1 Results of Background Research

Background research on the project area and surrounding *ahupuaʻa* of Waipiʻo and Waikele demonstrates:

1. Portions of the project area are located in the Kīpapa Gulch, which includes the Kīpapa Stream channel. Kīpapa, which translates as “placed prone” referring to corpses slain in the victory of Oʻahu forces over those of Hawaiʻi in the fourteenth century (Alexander 1891:96), was a well-known place of native Hawaiian activity from pre-Contact times. Waipiʻo was the scene of many battles between local and invading *aliʻi* for the political control of Oʻahu (Handy & Handy 1972:470).
2. Historic records indicate that a major trail which formerly connected ʻEwa to the Waialua District through the Central Oʻahu Plains, as well as to Waiʻanae over Kolekole Pass crossed Kīpapa Gulch within or very close to the southernmost drainage detention basin. One community participant mentions a Night Marcher or *Huakaʻi Pō* trail located in Kīpapa Gulch under the Kamehameha Highway bridge extending south to the waters of Pearl Harbor.
3. Past cultural impact studies reveal that there were hunting and gathering activities in the Waipiʻo ʻUka area (before Kīpapa Gulch was cut off from public access). Hawaiian gathering practices seem to have been concentrated within the Kīpapa and Waikakalaua Gulches, particularly along Gulch walls. One *kupuna*, who grew up as a practitioner of *lāʻau lapaʻau* (healing with plants) and *lomi lomi* (massage), collected medicinal plants and minerals in Kīpapa Gulch for many years The Waikakalaua and Kīpapa Gulches were especially noted for their sources of *ʻalaea* (red earth mixed with salt for medicinal and other purposes)—unique to this area. Other items collected were medicinal plants such as the native, indigenous species *ʻaʻaliʻi* (*Dodonaea viscose*). Hunting of pigs in the vicinity of the project area has been documented as far back as the 1930s. Popular access points to hunting in Koʻolau Mountains (Koa Ridge) used to be up by Shohata Camp, through the pineapple fields.
4. The project area is also closely associated with commercial sugar cane and pineapple agriculture on Oʻahu; in particular, the project area retains archaeological features related to water-management and transport facilities, including the famous Waiāhole Ditch. By the late 1920s, James Dole’s Hawaiian Pineapple Company, incorporated in 1901, was

cultivating pineapple on thousands of acres leased from the ʻĪʻī estate in the *mauka* area of Waipiʻo.

5. During the 1930s, U.S. military use of Waipiʻo extended well *mauka* of the peninsula at Pearl Harbor. The military began the appropriation of Kīpapa Gulch about 1938 and by 1941; Pacific Naval Air Bases expenditures for new construction at Pearl Harbor were in the hundreds of millions of dollars (Woodbury 1946). In 1942, the U.S. military began constructing bunkers (Figure 20) inside Kīpapa Gulch to house ammunitions and other war related equipment.
6. Given its location within Waipiʻo Ahupuaʻa, the project area is generally associated with a wide variety and extensive number of *moʻolelo* (oral histories), including legends, mythological accounts, stories, parables and sayings; these include, for example, the exploits of gods and demigods such as Maui and Peʻapeʻamakawalu (the octopus god) in which the eight-eyed Peʻapeʻa kidnapped Maui's wife Kumulama (Beckwith 1951:136).

9.2 Results of Community Consultation

For this draft CIA, twenty-seven community contacts (government agency or Hawaiian cultural community organization representatives, or individuals such as long-time area residents and cultural practitioners) were contacted for the purposes of this cultural impact assessment. Ten people have responded and 5 *kūpuna* (elders) and/or *kamaʻāina* (native-born) were interviewed for more in-depth contributions to the cultural impact survey.

Although portions of the project area and environs has been restricted to the public for many years because of U.S. government and private ownership (U.S. Army, Castle & Cooke), community consultation for this assessment provided testimony of former use and knowledge of natural and cultural resources in and around the project area in addition to information provided on historic properties observed during the site visit by CIA study participants (see Section 7). It is worth noting for the purpose of this CIA that the Public Access Shoreline Hawaii (PASH) ruling by the Hawaiʻi Supreme Court states that traditional and customary practices are not extinguished by non-use. As such, it is likely that the project area and environs hold natural and cultural resources of value and potential use to Native Hawaiians and *kamaʻāina*.

Community consultation yielded the following cultural concerns:

1. Four participants stressed the importance of not losing any additional Hawaiian cultural features of the landscape, such as trails, *ahu* (rock altars), petroglyphs and rock walls that may possibly be pre- or early post -Contact, to development in and around the project area, which has experienced substantial losses due to commercial agriculture and other development in more recent times.
2. One *kupuna*, Tane Inciong, mentioned the existence of a "Night Marcher Trail" or "*Huakaʻi Pō*" located under the Kamehameha Bridge in Kīpapa Gulch. According to Hawaiian legends, Night Marchers are ghosts of ancient Hawaiian warriors who roam large sections of the island chains usually in areas that were once large battlefields, such as Kīpapa Gulch.

3. One participant is concerned for the plant gathering practices for lei and medicinal purposes in Kīpapa Gulch that may be restricted as a result of the proposed development. One participant (*kupuna* Tane Inciong) mentioned his past use of the Kīpapa area (before there was restricted access) for gathering of plants for lei-making, medicinal and other ethnobotanical purposes. Plant gathering for native (some indigenous or endemic species) such as *kūkaenēnē* (*Coprosma* sp.), *maile (Alyxia oliviformis*) and *ʻieʻie* (*Freycinetia arborea*), as well as non-natives such as purple *lilikoʻi* (*Passiflora edulis*), were part of his ʻohana's traditional practices. To this day, Mr. Inciong passes along the gathering techniques he has learned from his *kūpuna* to younger members of his extended family, close friends and hula groups.
4. Those who responded are also concerned about the numerous caves in Kīpapa Gulch that may contain *iwi*. During the excavation for the underground sewer line inside the lower portion of Kīpapa Gulch, consultation members feel that construction workers may inadvertently discover these caves and highly recommend these caves not be disturbed by construction crews.
5. Two members contributing to this study are concerned with the untreated waste traveling approximately 3.5 miles from the Kamehameha Highway bridge in Waipiʻo to the wastewater treatment facility in Waipahu. Their concerns focus on a potential rupture or breakage of the sewer line, thus releasing untreated sewer in the gulch area. They mention the 6.7 magnitude earthquake that hit Hawaiʻi on Oct 15, 2006. Community members recommended a wastewater treatment facility should be planned for a location in Waipiʻo to service the Wahiawā, Mililani and Waipiʻo communities instead of having more and more untreated waste traversing from the uplands of Waipiʻo, Mililani and Wahiawā to the wastewater treatment facility in Waipahu.
6. Four community consultation members are also concerned with flooding in the gulch. They mentioned the rising waters of Kīpapa Stream over the years as various development projects, such as Mililani Mauka, occurred upstream. After these development projects were completed, the water levels in the stream would significantly rise. Consultants are concerned that if this trend continues, cultural and natural resources may be negatively impacted by the rising waters. For instance, Mr. Inciong is concerned that potential flooding in the Kīpapa Gulch as a result of future developments in the area surrounding Kīpapa Gulch could negatively impact native and non-native ethnobotanical plants enumerated above.

9.3 Recommendations

Based on all available information to date, including background research and community consultation, the proposed project will have minimal impact on Hawaiian culture, practices and traditions if the following measures are addressed in a good faith manner:

1. Based on site visits with community consultants Shad Kane and Pono Kealoha, the rock formation or *ahu* (Figure 19) and its companion wall structures located in Kīpapa Gulch near the northern-most drain detention basin should be preserved in its entirety and protected from harm during project construction.

2. Caves in Kīpapa Gulch, which may contain *iwi* and other burial *moepū* or funerary objects, should be preserved in its entirety and protected from potential harm during project construction.
3. Three community consultants recommended that early 1900s structures associated with the sugar cane and pineapple plantation era, such as bridge supports and drainage systems, should be preserved in their entirety and protected from potential harm during project construction where possible.
4. Concerns expressed by two study participants regarding flooding in Kīpapa Gulch should be addressed with community members, particularly in regard to measures taken to protect natural and cultural resources from adverse impacts due to flooding. Additionally, project proponents might consider consulting with Mr. Inciong and other cultural consultants about the presence of native and non-native species in the area of ethnobotanical significance. Project proponents should consult with a botanist in order to help identify if the ground-disturbance area includes these native and non-native plant species.

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Appendix A Arakakai Interview (2001)

Interview notes with: Masanobu Arakaki

Project: Supplement to Hawaiian Traditional Practices Assessment of Koa Ridge Lands

Interviewed by: Tina Bushnell for Cultural Surveys Hawaii (CSH)

Place of Interview: Kīpapa Valley, O’ahu

Date: July 27 and August 13, 2001

Mr. Arakaki was born in Kīpapa Valley, O’ahu in 1929. The third child of five, Masanobu spent the first twelve years of his life in the lower part of Kīpapa Gulch near where the Waiahole Ditch spans the Gulch. His father’s name was Seiboku Arakaki and his mother’s name was Nae Makamatsu. They were originally from Okinawa and had traveled to Hawaii to work in the sugar plantations. Mr. Arakaki thought they had met on Kaua’i at the Kekaha Plantation because he remembers his great uncles talking about Mānā and Kekaha and going fishing there. He remembers his mother telling him she had come to Hawai’i from Okinawa in 1919 with her brother and father to work in the sugar plantations. Nae Nakamatsu also had uncles who came to Hawaii. Masanobu’s maternal grandfather lived with the Arakaki Family until he went back to Okinawa sometime in the 1930s. Masanobu remembers his grandfather as a healthy, husky man who surprised his family when he passed away of pneumonia about five years after returning to Okinawa. Masanobu doesn’t know much of his father’s history because his father died in 1944 when Nobu was a boy. He does recall that the Arakaki family was close with his uncles, two of his father’s brothers.

Mr. Arakaki’s parents moved to O’ahu and began to work for a private plantation farm in Kunia. At that time, the Arakaki Family lived at Leilehua Camp which Mr. Arakaki describes as a camp run by the private Kunia plantation farm. It was here that Masanobu’s older siblings were born. Plantation farm work was hard work and the pay was not too good, 75¢ per day. During the Depression, his parents decided to be independent or maybe the Kunia plantation farm let them go. Mr. Arakaki doesn’t know for sure. They became truck farmers. They began to lease land from the ‘Ī‘ī Estate in the 1920s. Mr. Arakaki doesn’t know exactly when. The Arakaki family actually took over the lease of a farmer who was previously farming in Kīpapa. The Arakaki’s grew sweet potatoes, corn, beans, bananas, chinese cabbage and sometimes irish potatoes. They sold their produce to wholesalers from Honolulu who would send up trucks to pick up the fresh vegetables and fruits. When asked of the origin of the term “Truck Farmer”, Mr. Arakaki explained that when the State would come to survey them, the farmers had to fill out a form and tell what kind of farmers they were, whether sugar, pineapple, hog, chicken, etc... Truck farmer ended up referring to farmers who cultivated small vegetable crops with maybe some fruit on the side. There were several other truck farmers in the valley whose farms were scattered about ½ mile apart. Some of the names of the old time truck farming families are: Nakata, Shiroma, Asato, Kiyabu, Shiraishi, Higa, Harada, Kobashigawa, Abe, Konishi and Miyasato. Mr. Arakaki remembers a few Filipino families who also operated as truck farmers out of Kīpapa Valley but does not recall their names.

Mr. Arakaki related that he and his brothers and sisters used to help with the farm. On weekends and after school, the kids would help harvest and would take care of the chickens and rabbits. The chickens and rabbits were mostly kept for the family use. Mr. Arakaki describes his parents as “old-fashioned”. They would farm with mules and irrigate with rain water. Prior to the 1940s, all the farm work was done by hand and with mules. Planting was seasonally, according to the crop and rainfall. During the summer, the family would go up the valley to a leased piece of land they had there and plant where it was wetter (80-90 inches per year). During the rainy period, they would move to their leased land in lower Kīpapaand plant there (40-50 inches per year). For fun, the Arakaki children would hike in the mountains and swim in the stream. Mr. Arakaki remembers when he was a child, Kīpapa Stream used to dry up just once in a while, perhaps once every two or three years. He believes that the increased development keeps Kīpapa Stream dry a lot of the time nowadays, because much of the groundwater is being tapped by wells. Before, the children used to catch fish in the stream and when it did dry up, there were little pools which maintained the fish, until the stream filled up again. Some of the fish they used to catch were gold fish, dojo-catfish, mosquito fish (guppies) and ʻoʼopu. Mr. Arakaki felt that no fish could survive in Kīpapa Stream today.

In the 1940s, the extension agents [Agriculture Extension Agents] visited the Arakaki Farm and helped them to modernize. The family bought a tractor and a water pump. The Arakaki kids were the ones who learned to use all the mechanized equipment. They drove the tractor and ran the pump. The extension agents helped teach the Arakaki children to use the new equipment.

The Arakaki children attended KīpapaSchool. Mr. Arakaki related that KīpapaSchool was built by Libby McNeil Libby for $50,000.00, a project which would cost millions today. All the children from the surrounding pineapple camps would attend the school. Some of the camps included Kīpapa5 (K-5) located near where Ola Loa Retirement Community in Mililani Mauka is today (where the grove of Eucalyptus trees is located), Kīpapa1 (K-1) located below where the Mililani McDonalds along Kamehameha Highway is today, Robinson 1 and Robinson 2 located between Waikakalaua and Kunia, Waipio (located where Mililani Town is today) and Shohata (located above Kīpapa Valley, up Pineapple Road). The kids would walk two miles to school and two miles back everyday.

In 1942, the Arakaki Family was evicted from their farm in lower Kīpapawhen the military condemned the land during World War II. They were relocated to the mauka part of their lease in Kīpapa Valley along with six of the other farming families. Mr. Arakaki described the move as a “set back” in the farm, where the family had to start over. He claims that the military compensated them a few hundred dollars, but it wasn’t too much. Some of the crops grown in the lower valley didn’t do too well in the mauka regions and there were lots of wild animals that got into the fields, especially the sweet potatoes. The pigs would come, the rats would come, the birds knew exactly where the sweet potatoes were growing. To deal with the pigs which sometimes frequented the fields at night time when nobody was watching, they would tie a dog at the edge of the field who would start barking when they smelled the pig and scare it away. As kids, they would shoot the pigs with rifles. One good thing about the relocation was that the farms were closer and the families weren’t so isolated.

At about the same time the Arakaki Family was being relocated, Masanobu was sent to work for Libby, for the plantation. This was due to the labor shortage caused by the War. Only Masanobu worked in the fields. His older brother helped the family move the farm up the valley. When asked about Shohata Camp [Waipio B Camp], Mr. Arakaki described it “was like any other plantation camp”. It was smaller than Waipio Camp [Waipio A Camp]. Mr. Arakaki remembers about 20-25 homes in the camp. He claims Shohata Camp had many trees and looked something like what Kaumakani Camp on Kaua'i looks like today. The Shohata Camp residents were of mixed ethnicity, but the majority were Japanese. Shohata Camp gets its name from one of the supervisors from Libby, McNiel & Libby, Mr. Shohata. The Arakaki kids would ride their bikes up a road which followed a small gulch up to the pineapple fields and Shohata Camp where they would play with their friends. When asked if he remembered particular names of friends or classmates from Shohata Camp, Mr. Arakaki recalled Nobukichi Toyama and the Fujio Shibuya. The Shibuya Family actually lived adjacent to the Waiahole Ditch, a little distance from the Camp. They worked for the Waiahole Ditch Company and were in charge of opening and closing the locks and managing the water. The Waiahole Ditch Company had families living strategically along the ditch. There was even one family which lived way up in the mountains. When there was too much water, the excess was dumped into Waiawa Stream.

Mr. Arakaki relates that sometimes as kids, when visiting the Shibuya family, they would go swimming in the Waiahole Ditch near the Shibuya house. Near the house, the main ditch flowed into a small reservoir, approximately 20'x20' or 30'x30'. A wooden gate was maneuvered to adjust the flow into the reservoir and at the opposite end of the reservoir, where the reservoir once again became a ditch, there was a flat area with a measuring stick. Based on the measuring stick, one could tell how many thousands of gallons were flowing per day and thus how much water was being sent to central O'ahu. The Waiahole Ditch was the main artery which supplied water from Waiawa to Kunia. From the area near the Shibuya House, there were four pipelines which directed the flow to distinct areas. One pipeline went near the O'ahu Correctional Facility in Waiawa, one was near the Shibuya home, one went across Kīpapa Gulch and the fourth went across the Waikakalaua Gulch, in those days called the ‘Robinson Gulch’ (probably because of its proximity to Robinson Camp) to water the Kunia area. For fun, the Arakaki children would sometimes run up and down the pipeline in Kīpapa Valley. Mr. Arakaki believes the Waiahole Ditch still supplies the Kunia area farmers with water.

The Arakaki children continued to go to KīpapaSchool until the eighth grade. From there they went to Leilehua Highschool. When asked about transportation to school from the Kīpapamauka farm, Mr. Arakaki spoke of a neighbor who worked for the military and had a military truck. He would pile the kids into the truck and haul them off to school. After highschool, Masanobu took over the farm. His father had passed away in 1944 from complications after surgery to remove a kidneystone and his mother had run the farm with the help of her children. When the ‘Ī‘īFamily sold their estate to Dole sometime in the 1950s, the Arakaki Family wanted to buy the land they were living on. Dole considered it, but then decided not to sell the Kīpapa Valley land. The land was later taken over by Castle & Cooke.

In the early sixties, the Arakaki Family moved to Wahiawā. Mr. Arakaki could not remember why exactly they moved there. The Arakaki's spent three years in Wahiawā. In 1966, the family moved to Waipio [now Mililani Town] and lived in an old plantation house that once belonged to a Libby McNeil Libby manager. They lived there for only a year when Mililani Town Association notified them they were going to tear down the house so they could construct all new homes for the new Mililani Town. Because they couldn't buy the lot, the Arakaki's decided to buy the house and move it down to a leased piece of land in Kīpapa Valley. The house was moved in 1966 and the Arakaki's have lived there since then.

Mr. Arakaki related that there have been many proposed ideas for developing the land inside Kīpapa Gulch including a golf course, however none of the proposals has gone through. In 1976, the H-2 Freeway Bridge was constructed by Hawaiian Dredging Company. This altered forever the peace the Arakaki home enjoyed. Now, during the *kona* wind, the noise from the bridge is really bad, especially when the big trucks drive by. There are also problems with people throwing things over the bridge. Once, someone threw a heavy piece of metal over the bridge and it fell on the roof of the house causing damage. Another time, someone threw a driveshaft from a large truck over the bridge in the middle of the night. It hit the highwires and fell to the ground making a loud noise waking Mr. Arakaki up. A more disturbing thing that has happened several times are suicides from the H-2 Bridge over Kīpapa Valley (personal communication, Mrs. Arakaki, July 27, 2001).

Over the years, farming has changed. The truck farmers used to sell a variety of vegetables to the Honolulu wholesalers. Now, the farmers concentrate on just a few crops, mostly bananas and papayas. These are less labor intensive and require less toxic chemicals and less chemicals in general. The papayas of Kīpapa Valley used to be really sweet. Mr. Arakaki claims that at farmer’s markets around the area, some people still ask for the Kīpapapapapayas (personal communication, Mr. Arakaki, July 27, 2001).

When asked about Kīpapa Valley prior to truck farming era, Mr. Arakaki recalls his parents talking about the independent pineapple growers. These were farmers who grew pineapples independently and sold them to the larger plantations. Many of them grew pineapples inside Kīpapa Gulch. Mr. Arakaki remembers his parents saying how the independent growers lost out during and after the Depression if they didn’t have a contract with the Plantations because the Plantations quit buying from the independent growers. If the growers had a contract, the Plantations were obligated to buy their pineapples, even if the pineapples were left to rot. As a child, Masanobu has memories of traveling up the valley and seeing stands of abandoned pineapple fields. There were even some scattered pineapple plants up on the gulch sides. One old timer told Mr. Arakaki that there was once a camp of independent pineapple growers about ½ mile mauka of Arakaki’s leased houselot in Kīpapa Valley.

Mr. Arakaki used to hunt in the back of Kīpapa Valley and in the Ko’olau Mountains. Back then, there were many hunters, of all nationalities. Hunters came from Kalihi, hunters came from Wai’anae to hunt in the Ko’olaus. Even when Masanobu Arakaki was growing up, he recalls seeing many hunters. The Arakaki Family actually had problems with many hunters because they would steal everything from vegetables to the gasoline and oil which was stored near the family water pump. Eventually the Arakaki Family asked the hunters not to go through their farm land. Some hunters continued to sneak through though. In those days, most people hunted for the game and there were lots of pigs. They would use dogs to flush the pig and then kill the pig with a knife. Not too many people used guns to hunt because they might mistakenly shoot their dogs. Besides coming up through Kīpapa Valley, hunters would also access the Ko’olaus from up by Shohata Camp. They followed the pineapple roads up past the camp and left their vehicles there. Many of the trails in the mountains were created by hunters. Mr. Arakaki explained that back during the Depression, the WPA and CCC were up on Koa Ridge and cleared the trails and planted many trees including Norfolk Pine, Palm Trees, Strawberry Guava and travelers’s plant (travelers tree). He believes that the CCC workers cleared the Kīpapa Ridge Trail, but that currently the trail is not being maintained.

When asked if Shohata Camp had a cemetery, Mr. Arakaki does not recall a cemetery there. He said that Oriental people would have their dead family members taken to the mortuary to be cremated. The families would then put the ashes in an urn and store the urn in the back of the church. Sometimes there was a separate building to store the urns. Masanobu’s parents attended the Wahiawa Hongwanji Church and Nobu remembers that there were lots of old urns stored in the back of the church.

The road on the side of Kīpapa Gulch which led up to Shohata Camp upon which Mr. Arakaki and his brothers and sisters used to ride their bikes up to the camp, this same road was used to transport pineapples from the fields surrounding Shohata Camp down to the last train station in Kīpapa Gulch. The pineapples were then transported out of Kīpapa Gulch to the Libby Cannery. Mr. Arakaki recalls the railroad was run by Oahu Railroad Co. and thinks the line was used exclusively for pineapple, but doesn’t know for sure. There was sugar cane being cultivated in the lower portion of Kīpapa Gulch, but Mr. Arakaki doesn’t remember how it was transported out of the Gulch. Libby used the railroad track until about 1941 when the military took Kīpapa Valley over.

When asked of stories from Kīpapa Valley, Mr. Arakaki mentioned worshiping stones. He spoke of a half-moon shaped stone with cobble sized stones circling the half-moon, located on the side of the stream approximately 500 feet makai of the H-2 Freeway Bridge. One day when he was out looking for bamboo, he came upon the stone and “got a funny feeling”. Near the stone there were mountain apple trees, bamboo and other trees. Mr. Arakaki says that after talking to a Hawaiian woman who worked for Kamokila Campbell, she said the stone was a worshiping stone used for asking for abundance of fish and water. Mr. Arakaki also remembers long ago, a neighbor farmer had a similar half-moon shaped stone in one his fields that the farmer wanted to move. The farmer tried and tried to move the stone, but could not move it.

Another story Mr. Arakaki related was of the headless and appendageless corpse who used to wander up and down the Kīpapa Valley swinging a lantern (M. Arakaki, personal communication 7/27/01). The lantern was described as one they used to use in the trains.

One of the final stories both Mr.and Mrs. Arakaki told was about a visit from an old Hawaiian women. When the Arakakis first moved back down to Kīpapa Valley in 1967, Mr. Arakaki’s mother lived with them. Apparently, she was the one who received a visit from an elderly Hawaiian women who told Mrs. Arakaki that she used to live there fifty years ago. This would have been in the early part of the 1900s.

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February 6, 2003

Mr. Mark H. Hastert
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Subject: Review and Summary of the Status of the Koa Ridge/Waiawa Castle and Cooke Homes Hawaii Project - Cultural Impact Assessment

Dear Mark Hastert:

At your request Cultural Surveys Hawai'i (CSH) is presenting here a brief review and summary of the status of the Koa Ridge/Waiawa Castle and Cooke Homes Hawaii Project - Cultural Impact Assessment work. While CSH has conducted subsequent Cultural Impact Assessment work in the vicinity, our initial findings still stand. The only significant native practices issue would seem to be access to the Kīpapa Ridge Trail for purposes of hunting and native gathering in adjacent gulches and farther upslope areas which lie outside of the project area.

CSH carried out a two phase Cultural Impact Assessment in support of the Koa Ridge/Waiawa Castle and Cooke Homes Hawaii Project. Back in August 1996, CSH (Hammatt and Shideler 1996) completed a study entitled "*Hawaiian Traditional Customs and Practices Impact Assessment for the Development of a 1339-Acre Parcel at Castle and Cooke Lands Within Portions of Waipi'o and Waiawa Ahupua'a, O'ahu (TMK 9-4-06:01, 03, & 10 por. and 9-5-03:01 por. 04 & 07 and 9-6-04:21)*". This study was a good faith effort to assess the likelihood and nature of any potential cultural impacts of the project on the basis of background historical research and an assessment of the potential resources present. This 1996 study had a rather modest interview component.

Subsequently, in September 2001, CSH (Bushnell and Hammatt 2001) carried out a *Supplement to Hawaiian Traditional Customs and Practices Impact Assessment for the Development of a 1339-Acre Parcel at Castle and Cooke Lands Within Portions of Waipi'o and Waiawa Ahupua'a, O'ahu (TMK 9-4-06:01, 03, & 10 por. and 9-5-03:01 por. 04 & 07 and 9-6-04:21).*

The purpose of this work was to serve as a supplementary study and supportive amendment or exhibit for the Land Use Commission including community consultations, interviews of knowledgeable parties and studies to address Office of Environmental Quality Control guidelines that had been written after the initial study. This effort involved consultation with thirty-two potentially knowledgeable informants. Organizations contacted included: Friends of Kūkaniloko, the Mililani/Waipi'o/Melemanu Neighborhood Board, the Mililani Town Association, the Pu'uloa Hawaiian Civic Club, the Wahiawā Hawaiian Civic Club, the 'Ewa Hawaiian Civic Club, the Sierra Club, the State Historic Preservation Division and the Office of Hawaiian Affairs. Individuals contacted included a farmer of K□papa Valley, pig hunters, leases of Koa Ridge Ranch, *kumu hula*, former Pineapple Camp residents, former Oahu Sugar Company employees, and a number of *kūpuna*.

The assessments attempted to give due consideration to the effects that the proposed development activity may have on the specific practices, culture and traditions of native Hawaiians. Specific areas which have been examined have included the issue of burials (there are not believed to be any), the issue of access to Hawaiian trails, other archaeological/historical concerns including *heiau* and a battle field in the vicinity, Hawaiian hunting practices and Hawaiian gathering practices. The conclusion of this study is that the impact of the development of this specific parcel *per se* on Hawaiian culture would be minimal.

The lack of impact is a reflection largely of the geographic location of the parcel, set well back from the coast, with no surface water and no unique topographic features. There were no commoner land claims within the project area. While the absence of *kuleana* land claims does not necessarily mean an absence of Hawaiian activity, the patterns of land use in this area are relatively clear, and Hawaiians did not utilize this *kula* land nearly as intensively as they utilized coastal areas, well-watered areas, and forest zones.

One of the recommendations of our Bushnell and Hammatt study (2001:40) was that there be consultation between Castle and Cooke and the Wahiawā Hawaiian Civic Club regarding their concerns. As a result of our recommendation, Castle and Cooke subsequently met with Wahiawā Hawaiian Civic Club members in September 2001 to discuss their concerns, which involved potential impacts to cultural sites outside the project limits and the potential for the project to improve native biota in the surrounding gulch areas. Castle and Cooke agreed to update the Civic Club and work with them on issues of concern as the project proceeded.

Dr. Hallett H. Hammatt of CSH gave testimony before the Land Use Commission in October of 2001 presenting the archaeological and cultural impacts. No additional concerns were raised.

CSH has recently completed four other cultural impact studies in the vicinity including:

> *A Traditional Practices Assessment for the Proposed Mililani Mauka Phase III Development in Waipi'o Ahupua'a, 'Ewa District, Island of O'ahu (TMK 9-05-49:portion of 27)* (Bushnell and Hammatt 2001)

A Cultural Impact Assessment for the Approximately 175-Acre, Phase 2 Portion of Lands Within Waiawa and Waipi'o Ahupua'a, O'ahu (TMK 9-4-06:11, 9-6-04:4 and 9-6-5:3) (Bushnell, Shideler and Hammatt 2002)

An Archaeological and Cultural Impact Evaluation for the Proposed Mililani Community Transit Center, Waipi'o Ahupua'a, 'Ewa District, Island of O'ahu (TMK 9-5-53: por. 2) (Hammatt, Bushnell, and Shideler 2002)

An Archaeological and Cultural Impact Evaluation for the Proposed Wahiawā Community Transit Center, Wahiawā Ahupua'a, Wahiawā District, Island of O'ahu (TMK 7-4-06: por. 2 and por 12) Hammatt, Shideler and Mann 2002)

None of these studies have developed any additional concerns for the Koa Ridge/Waiawa Castle and Cooke Homes Hawaii Project. The one cultural impact concern remains access through the project area to lands further upslope.

It is our understanding that as a part of the Land Use Commission reclassification, Castle & Cooke has agreed to preserve any established access rights of native Hawaiians who have customarily and traditionally used the reclassified area for access to other areas in order to exercise subsistence, cultural and religious practices. This will be stated in the DEIS.

If I may provide any further clarification please call.

Sincerely,

David W. Shideler
O'ahu Office Manager
Cultural Surveys Hawai'i, Inc.

A Supplement to the Hawaiian Traditional Customs and Practices Impact Assessment for the Development of 1339 Acres of Castle and Cooke Lands Within Portions of Waipi'o and Waiawa *Ahupua'a*, O'ahu (TMK 9-4-06:01, 03 & 10 port. And 9-5-03:01 port., 04 & 07 and 9-6-04:21)

by

K.W. Bushnell, B.A.,
and
Hallett H. Hammatt, Ph.D.

Prepared for

Helber, Hastert, and Fee

Cultural Surveys Hawaii, Inc.
September 2001

ACKNOWLEDGEMENTS

Cultural Surveys Hawai'i, Inc. would like to thank Masanobu Arakaki of Kīpapa Valley, O'ahu and Kalama Makaneole of Nānākuli, O'ahu who were so generous and helpful in sharing information about their families, their lives and Waipi'o. Their aloha was transparent throughout the interview process. We would also like to acknowledge all the individuals we contacted who were so helpful in leading us to other useful sources. In particular, there were several people who went out of their way to help. We would like to thank Richard Estoesta, Senichi Tanisue, Dan Au, Tom Lenchanko, Arlene Eaton, Billy Nakagawa, Joe Seteno, Lani Nedbalek, Richard DeLima Jr., and Yvonne Toma.

ABSTRACT

A supplemental Hawaiian Traditional Customs and Practices Impact Assessment was completed for 1339 acres of Castle and Cooke lands in Waipi`o and Waiawa *Ahupua`a*. The objective of this supplementary report was to address current OEQC guidelines not addressed during the completion of the original report in 1996. Principally, this consisted of searching for and interviewing more informants who may have information on Hawaiian Traditional Customs and Practices in or near the project area. Other issues addressed include an *ahupua`a* focus, an assessment of the impact of proposed action, and an examination of prior land use decisions.

A considerable effort was made to contact knowledgeable informants in the area and two persons agreed to interviews. During one of the interviews, information was gained regarding traditional gathering practices in the Waipio `Uka area.

Most of the Hawaiian traditional practices in the Waipio `Uka area seem to be concentrated within the Kīpapa and Waikakalaua Gulches and alongside Gulch walls, adjacent to the project area. One interviewee, who grew up as a practitioner of *la`au lapa`au* and *lomi lomi* has collected medicinal plants and minerals in the Waikakalaua and Kīpapa Gulches for many years. The Waikakalaua and Kīpapa Gulches were especially noted for their sources of *`alaea* which was unique to this area. Other items collected were the medicinal plants *`a`ali`i* and *laua`e*. The interviews did not shed light on any Hawaiian traditional custom or practice within the proposed area of development.

In other consultations and preliminary interviews with community members, two other issues have come to light, hunting access and cultural sites within the project area. In the past, one of the popular points of access to traditional hunting grounds in the Ko`olau Mountains *mauka* of the project area has been through the study parcel. Recommendations made regarding impact to the traditional hunting grounds were made based on information gathered from hunters in the Waipi`o community.

The Wahiawā Hawaiian Civic Club has identified several cultural sites in the vicinity of the area for proposed development. No further information has been forthcoming regarding the description and location of the sites. Cultural Surveys Hawaii has not found any supportive evidence of such cultural sites within the area of proposed development. Recommendations were made for the client to consult with the Wahiawā Hawaiian Civic Club.

Note: As much as possible, throughout this report the spelling of Hawaiian vocabulary and place names has been standardized to present orthography, except those Hawaiian words used in quotations.

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I. INTRODUCTION

A. Project Background

In 1996, a Hawaiian Traditional Customs and Practices Impact Assessment was conducted for 1339 acres of Castle and Cooke lands proposed for development (Hammatt and Shideler, 1996). This report was submitted to Helber, Hastert and Fee in August of 1996. The development of the 1339 acres was then placed on hold. Recently, plans for the proposed development have moved forward. Since the initial cultural impact assessment report was written in 1996, the Office of Environmental Quality Control (OEQC) has published new guidelines for assessing cultural impacts. Based on the more recent OEQC guidelines, the 1996 report is considered limited in scope. As contracted by Helber, Hastert and Fee, this supplementary report is an attempt to address those issues which were not included in the initial cultural impact assessment.

The purpose of this Traditional Practices Assessment is to consider the effects the proposed development may have on native Hawaiians as it pertains to the culture and their right to practice traditional customs. The Hawai`i State Constitution, Article XII, Section 7 protects "all rights" of native Hawaiians that are "customarily and traditionally exercised for subsistence, cultural and religious purposes". The Scope of Work (SOW) was designed to meet the cultural impact assessments of the Office of Hawaiian Affairs (OHA), the Office of Environmental and Quality Control (OEQC) and any other state and county agencies involved in the review process for the proposed project. The process for evaluating cultural impacts is evolving. There continue to be gray areas and unresolved issues pertaining to traditional access and gathering rights for native Hawaiians. Act 50 is an attempt to balance the scales between traditional lifestyles and development and economic growth.

B. Scope of Work

The following Scope of Work was proposed for satisfying requirements related to Native Hawaiian Gathering Rights and their applicability to the project area. This document is considered a supplementary study and supportive amendment to the *Hawaiian Traditional Customs and Practices Impact Assessment for the Development of a 1339-Acre Parcel at Castle and Cooke Lands Within Portions of Waipi`o and Waiawa Ahupua`a, O`ahu (TMK 9-4-06:01, 03 & 10 port. And 9-5-03:01 port., 04 & 07 and 9-6-04:21).*

1. A good faith effort to gain 3-4 additional interviews. This process involves the identification of appropriate parties, interviews, transcription, sending transcripts back to the interviewees for review and release and preparation of synopses and synthesis.

2. Address or expand on the following areas as outlined by OEQC guidelines:

   a) an *ahupua`a* focus

b) an assessment of the impact of the proposed action, alternatives and mitigation measures

c) examination of prior land use proposals, decisions, and rulings which pertain to the area

C. Methodology

Historical documents and maps were researched at the Hawai`i State Archives, Hawai`i State Survey Office, Hawai`i State Library, Bureau of Land Conveyances, and the Cultural Surveys Hawai`i library.

Hawaiian organizations, agencies and community members were contacted in order to identify potentially knowledgeable individuals with cultural expertise and/or knowledge of the project area and the surrounding vicinity. A discussion of the consultation process can be found in the following section on "Community Consultations". Please refer to Table 1 for a complete list of individuals and organizations contacted.

D. Identification of Knowledgeable Interview Informants

Community Consultations

As partial fulfillment for the Scope of Work (SOW), consultation with organizations and the community were conducted to identify knowledgeable *kūpuna* and participants to be interviewed, as well as others who could inform on the history of the subject parcel and previous land use. The organizations consulted were the State Historic Preservation Division, the Office of Hawaiian Affairs and the O`ahu Island Burial Council, the Wahiawā, Pu`uloa and `Ewa Hawaiian Civic Clubs, the Mililani/Waipi`o/Melemanu Neighborhood Board, Koa Ridge Ranch, Friends of Kūkaniloko and Kīpapa Elementary School.

A substantial effort was made to locate 3-4 knowledgeable informants for the Waipi`o area. Thirty two individuals were contacted as possible leads, however we were successful in locating only two knowledgeable informants. The individuals contacted ranged from local pig hunters to *kumu hula*, to *kūpuna* to civic leaders to former pineapple plantation camp residents. The difficulty in locating old *kama`āina* families in the Waipi`o `Uka area may reflect the history of land use in that area. Many of the Hawaiian families who were granted *kuleana* land in Waipi`o `Uka probably sold their land in the late 1800s and early 1900s when vast tracts of sugar cane and pineapple began to transform the landscape. The Hawaiian families were largely replaced with immigrant laborers who brought stories of far-off lands. After identifying an old Libby, McNeil, Libby Pineapple Camp in the project area (Shohata Camp), an attempt was made to find former camp members in hopes they may have information on the project area. But even this proved to be challenging as many of the camp members have passed away or dispersed. Most of the old timers who are originally from the Mililani/Waipi`o area are associated with the other historic pineapple camps "Waipi`o", "K-1" and "K-5", all formerly located in the general vicinity of Mililani Town.

Through the consultation process, two individuals, Masanobu Arakaki and Kalama Makaneole, were identified as potential informants. Both interviewees proved to be knowledgeable of the area, though in somewhat different ways. Mr. Arakaki grew up in Kīpapa Valley in the vicinity of the project area and has farmed in the Valley for most of his life. He was aware of much of the twentieth century history of the Kīpapa Valley. Mr. Arakaki was interviewed and notes taken from this interview appear in Appendix A. Kalama Makaneole gained his knowledge of the Kīpapa area from his mother who grew up in the adjacent *ahupua`a*, Waikele. Raised in the Hawaiian *la`au lapa`au* tradition, Mr. Makaneole's knowledge includes gathering areas for medicinal herbs and minerals and the traditional Hawaiian lore and history of that area. Kalama Makaneole was formally interviewed and the interview transcript is available in Appendix B of this report.

The following table shows the results of the community consultations which were conducted by Tina Bushnell for Cultural Surveys Hawai`i.

TABLE I: Results of Community Consultations
Results of Community Consultations

Key:
Y=Yes
N=No
A=Attempted (at least 3 attempts were made to contact individual, with no response)
S=Some knowledge of the project area
D=Declined to comment
U=Unable to contact, i.e., no phone or forwarding address, phone number unknown

Name	Affiliation	Contacted	Knowledge of Project Area	Comments
Arakaki, Masanobu	Long time farmer of Kīpapa Valley	Y	Y	Interviewed 7/27/01 at Kīpapa Valley home, O`ahu
Au, Dan	Friends of Kūkaniloko	Y	S	Made Referrals
Balaz, Keahialaka	Nature Conservancy-Kunia and local Pig Hunter	Y	S	Made Referrals
Bass, William	Vice Chair of Mililani/ Waipi`o/ Melemanu Neighborhood Board	Y	N	Made Referral
Behrens, Doug	Leases Koa Ridge Ranch	Y	N	Made referral
DeLima, Richard Jr.	Kīpapa Ridge Hunter	Y	S	Made referrals

Name	Affiliation	Contacted	Knowledge of Project Area	Comments
DeRego, Hokulani	Kumu Hula of Wahiawā	A	—	—
Dole (Whitmore Office)	Pineapple Plantation Camps in Waipi'o 'Uka	Y	N	Made referral
Eaton, Darlene	Pu'uloa Hawaiian Civic Club	Y	N	Made referral
Estoesta, Richard	Waipi'o Valley Pig Hunter	Y	S	Helped to search for informants
Gallano, Linda	Former Caretaker for Koa Ridge Ranch	A	Y	Gave interview for first TCP Report
Hirota, John	Dole employee	Y	N	Made referrals
Horiuchi, Ann	Coordinator of Kupuna Program for Mililani Public Schools	A	—	—
Iszard, Peter	Mililani Town Association	Y	N	—
Ka'eo, Francis	Kūpuna resident of Waipi'o	Y	S	Made referral
Kaeliwai, George N. Jr.	'Ewa Hawaiian Civic Club	Y	N	Made referral
Keala, Jalna	Office of Hawaiian Affairs	Y	N	Made referral
Kim, Ferry	Grew up in K-5 (former Dole Pineapple Camp)	Y	N	—
Kippen, Collin	Office of Hawaiian Affairs	Y	N	Made referrals
Kodayama, Mitsuo	Grew up in K-5 Camp (former Dole Pineapple Camp)	Y	S	Made referral
Lenchanko, Tom	Friends of Kūkaniloko and Wahiawā Hawaiian Civic Club	Y	S	Made referrals
Lee, Lurline	Hawaiian Civic Club of Wahiawā	A	—	—
Makaneole, Kalama	Friends of Kūkaniloko	Y	Y	Interviewed 7/28/01 in Nānākuli home
Mikiluna, Jeff	Sierra Club	Y	N	—

Name	Affiliation	Contacted	Knowledge of Project Area	Comments
Nakagawa, Billy	Former Dole Field Superintendent	Y	N	Made referrals
Nāpoka, Nathan & Holly McEldowney	DLNR/ Culture and History Branch	Y	S	—
Nedbalek, Lani	Author of 'Wahiawa' and familiar with former Pineapple Camps	Y	S	—
Nihipali, Kūnani	Hui Mālama I Nā Kūpuna o Hawai'i Nei	U	—	—
Paty, Bill	Former manager of large plantation in Waialua	Y	N	—
Porier, Dick	Chair of Mililani/ Waipi'o/ Melemanu Neighborhood Board	Y	N	—
Sato, Kinya	Grew up in Waipi'o Camp	Y	N	Made referrals
Sato, Richard	Grew up in Waipi'o Camp	Y	N	Made referrals
Seteno, Joe	Former employee of O'ahu Sugar Co. and lived Waiawa Sugar Camp	Y	N	—
Shirai, Thomas Jr.	O'ahu Island Burial Council	A	—	—
Tanisue, Senichi	Old time pig hunter of Kipapa Valley	Y	S	Pre-interviewed
Toma, Yvonne	Kipapa Elem. School Employee	Y	N	Made referrals
Toyama, Nobukichi	Grew up in Shohata Camp (Waipi'o B Camp)	Y	S	—
Tseu, Iwalani	Hula Teacher in Mililani	Y	N	Made referral

E. The Interview Process

Once the participants were identified, they were contacted and appointments were set-up to conduct the interviews. The interviews were conducted on July 27 and July 28, 2001. The interviews lasted approximately 2-2½ hours. The first interview was not taped (Masanobu Arakaki), but extensive notes were taken during the interview. The second interview was taped and transcribed (Kalama Makaneole). Both participants were allowed the opportunity to review the typed transcript and/or notes for corrections, editing and to approve the final transcript. Both informsnts signed an "Authorization for Release" form giving permission for the interview to be used as part of this study. Excerpts from the interviews are used throughout this report, wherever applicable. The full transcript and notes of both interviews are appended to this report.

F. Biographical Sketches of the Interview Informants

The following biographical sketches of the two interviewees (listed in alphabetical order) serve to introduce the reader to the informants.

Masanobu Arakaki

Masanobu Arakaki was born in Kīpspa Valley, Waipi`o, O`ahu to Seiboku Arakaki and Nae Nakamatsu in 1929. Mr. Arakaki has lived most of his life in Kīpapa Valley. He grew up in the Valley where his parents were truck farmers and he has continued to farm on the leased family land in Kīpapa ever since.

Both his parents had come from Okinawa to work in the sugar plantations in the early 1900s. Mr. Arakaki believes his parents met at the Kekaha Sugar Plantation on Kaua`i and later moved to O`ahu. They found work at a private plantation farm in Kunia which is where his two older siblings were born. Sometime during the 1920s, the Arakakis began to lease land in Kīpapa. They began to grow vegetables such as sweet potatoes, corn, beans, bananas, chinese cabbage and irish potatoes. They were one of many Japanese families who became known as the "truck farmers" of Kīpapa.

During his school days, first at Kīpapa School and later at Leilehua High School, most of his classmates and friends came from the neighboring pineapple plantation camps including the Dole Camps, K-1, K-5, Robinson 1 and 2 and the Libby, McNeil, Libby Camps, Waipi`o and Shohata. The tablelands above Kīpapa Valley surrounding the camps were all planted in pineapple.

Although from the outside Kīpapa Valley may look very similar to what it looked like for much of the twentieth century, Mr. Arakaki has witnessed many changes to the Kīpapa Valley throughout his life. During World War II, the U.S. military condemned the lower portion of Kīpapa Gulch and relocated the truck farmers to the *mauka* portion of the Kīpapa Valley. Here, the Arakaki family had to start over with the farm. At about this time also, Mr. Arakaki's father died leaving the rest of the family to run the farm. In the 1950s, Dole Pineapple Company bought the Kīpapa Valley from the `Ī`ī Estate.

The Arakaki family has always had the hope of buying their leased land in Kīpapa. However, this has never become a reality for them.

Somerset Kalama Makaneole

Kalama, as he likes to be called, was born in Honolulu on August 17, 1948. He was raised by his parents and his maternal grandmother in Papakōlea, Pūowaina (Punchbowl). Kalama and his family spent many years in Wahiawā, but now live in Nānākuli where they recently built a house on Hawaiian homestead land.

Kalama is pure Hawaiian. His father's family is originally from Kaua`i and his mother's family is from the Waipi`o and Waikele area in central O`ahu. Kalama is a lineal descendant of John Papa `Ī`ī who was granted the majority of Waipi`o *Ahupua`a* during the *Māhele*. According to Kalama, `Ī`ī gave Waipi`o lands to his mother's family.

From a very young age, Kalama began to practice the traditional medicine taught to him by his mother, Esther Pahuanui Kauhane, father, William Makaneole and maternal grandmother, Kuahalahala Kuali`i. Kalama comes from a long line of traditional healers who practiced laying of hands, holistic medicine, *la`au lapa`au* and *lomi lomi*. As a yong boy, Kalama would assist his mother and grandmother in caring for the sick and the elderly of the community. Kalama's father worked as a nurse at Queen's Hospital and taught Kalama about First Aid, CPR, anatomy and home remedy.

After Kalama attended high school, the Vietnam War broke out. Kalama joined the U.S. Navy in order to avoid being drafted into the Army. He served four years then returned to Hawai`i where he worked for a few years in the trucking business. Later, he returned to school to study mechanical engineering. Currently, Kalama works as Chief Engineer for Hālawa Correctional Facility.

In his spare time, Kalama continues to practice healing in the forms of *la`au lapa`au, lomi lomi, ho`oponopono*, spiritual blessing and working with the dying and the dead through spirituality. Through the years, Kalama has studied under Papa Kalua Kaiahua of Maui, David Kealakea of Maui and Auntie Napeahi of Hawaii. Two of Kalama's greatest teachers in life have been God and his mother.

It was through his mother's family that Kalama learned of the gathering localities in central O`ahu. The Makaneole family would make weekly visits to Wahiawā where Kalama's mother would make collecting excursions with her brothers and sisters. Waikakalaua and Kīpapa Gulches were two of the places the family would frequent to gather medicinal materials and restock supplies.

G. Description of the Traditional Cultural Practices Region

The study area consists of four relatively discrete parcels located in the *ahupua`a* of Waipi`o and Waiawa in Central O`ahu just east of Mililani Town (Figure 1). These four parcels have been named "Koa Ridge Makai" (571 acres), "Koa Ridge Mauka" (485 acres), "Kipapa Ridge" (92 acres), and "Waiawa" (191 acres) (See Figure 1). A good physical description of these lands is contained within the 1996 Traditional Cultural Practices Impact Assessment (Hammatt and Shideler, 1996).

In assessing the cultural impact to a proposed development, the geographic boundaries of study area are often extended beyond those of the proposed development. The reason for this is to "ensure that cultural practices which may not occur within the boundaries of the project area, but which may nonetheless be affected, are included in the assessment"(OEQC Guidelines for Assessing Cultural Impacts, 1997). For this project, the upland area of Waipi`o *Ahupua`a* or the Waipi`o `Uka area was considered to be the general traditional practices region, although a specific focus was placed on the Kīpapa Gulch (often called the Kīpapa Valley). The Kīpapa Gulch is adjacent to much of the land which is proposed for development.

The traditional practices study area was defined mostly by examining Land Commission Award documents dating from the *Māhele* in the mid nineteenth century. These documents give us a sense of the traditional names of places and areas. Most individuals in the area describe themselves living in a certain *`ili* in the area of Waipi`o `Uka in the district of `Ewa. Waipi`o `Uka extended from Kīpapa Gulch to the Waikakalaua Gulch, adjacent to the Waipi`o-Waikele *Ahupua`a* boundary. The majority of Hawaiians who applied for quiet land titles in Waipi`o `Uka lived in what is today known as Kīpapa Gulch. Because of its proximity to the land proposed for development, Kīpapa Gulch is considered an important area of traditional land use which may give us great insight into the land use of the area proposed for development.

H. Natural Setting

The area of proposed development comprises approximately 1,339 acres in the *ahupua`a* of Waipi`o and Waiawa. The lands are located on gently sloping flats between deeply dissected gulches at elevations ranging from 420' to 1100'. The lands of the project area typically receive approximately 150 cms of rainfall annually, mostly falling between October and March. The soil within the project area is mostly silty clay falling within the Wahiawa and Manana soil series.

Virtually the entire project area has been under commercial cultivation since at least as early as the 1920s. Many of these pineapple fields have been taken out of production and the fields have been replaced largely by exotic weeds.

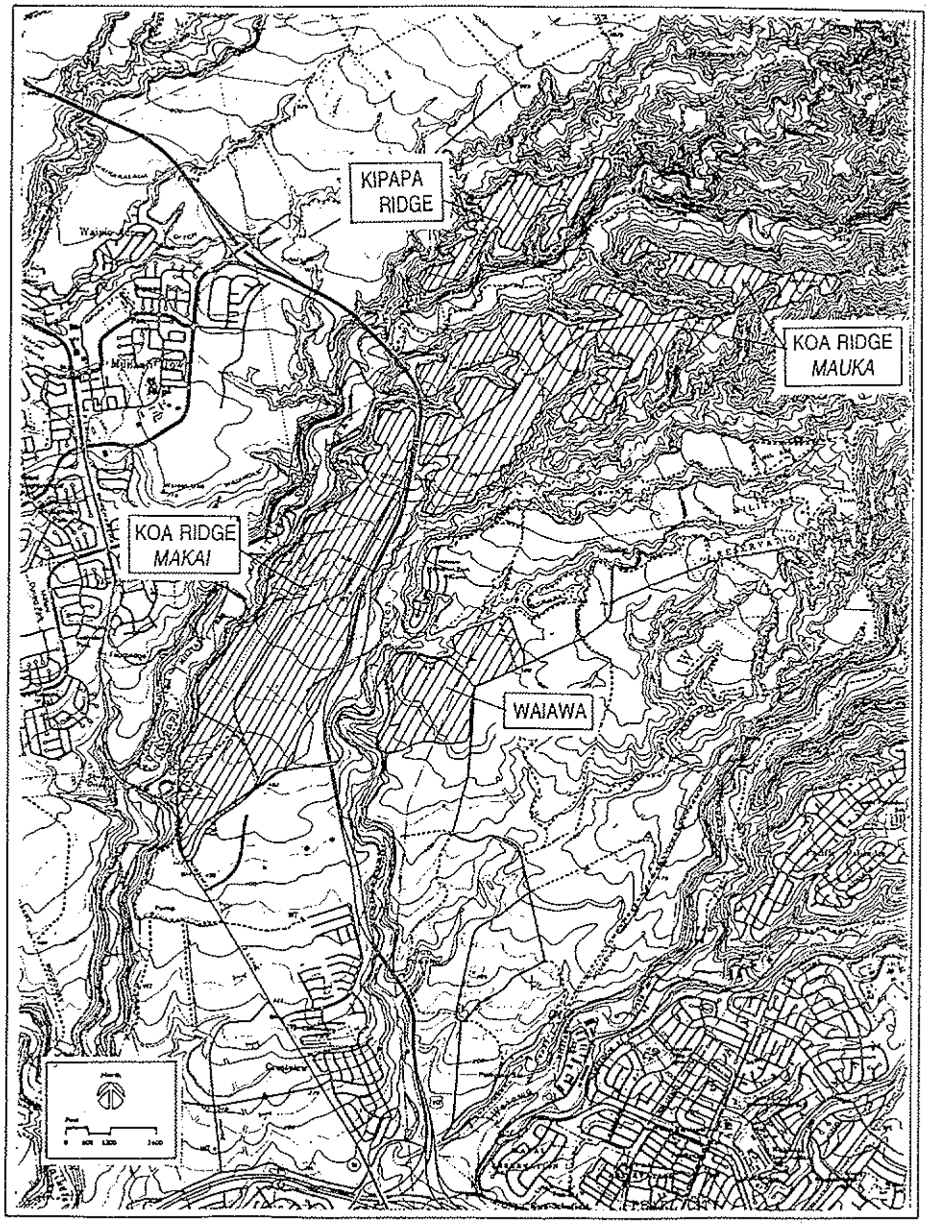

Figure 1 Portion of USGS 7.5 Minute Series, Waipahu Quad, Showing Study Area

II. CULTURAL SETTING

A. Legends Associated with Waipi`o `Uka

The following sections attempt to look at the greater Waipi`o `Uka area in the context of documented legends and oral histories gained from knowledgeable informants. The significance of Waipi`o `Uka in the legendary sense can often lead to information regarding traditional practices.

1. Waipi`o `Uka and Kūkaniloko

It is difficult to write of the traditions of `Ewa or Waialua, O`ahu without mentioning Kūkaniloko, located approximately 10 km to the northwest. Located in the uplands of Kamananui, Waialua, Kūkaniloko was thought to have been established in the twelfth century "by Nanakaoko and his wife, Kahihiokalani, whose son Kapawa, heads the list of important alii born there" (McAllister, 1930:135). A child born to a *kapu* chiefess at Kūkaniloko was considered to be a "child with the highest *mana* (spiritual or divine power) and revered as a god that could not be touched" (Alameida, 1993:19). Part of Kūkaniloko's significance lay in its location at the crossroads of the Wai`anae, Waialua and `Ewa Districts. One of the major traditional trails receiving traffic from Kona and portions of `Ewa leading to Kūkaniloko passed through Waipi`o `Uka.

Even long after Kūkaniloko had been abandoned and the seat of Hawaiian political power had moved from `Ewa to Kona, the memory of Kūkaniloko is still revered. The oral tradition of Kūkaniloko lives on today as one of our informants relayed to us. Kalama Makaneole's mother, who grew up in Waikele, kept the tradition alive when she shared the history of Kūkaniloko with her son, Kalama.

> **CSH: Did you used to go out with your mother when she went on her collecting trips?**
>
> KM: Yeah, I did. As a matter of fact, she took me to the birth site [Kūkaniloko] and she gave me one oral history of the place, why it's so important, the birth site is. She says now, we gotta respect this place because it's the place of your ancestors. That's the birth site [looking at two prints of Kūkaniloko hanging on Kalama's wall]. That's Mount Ka`ala, that's the birth site...
>
> **CSH: And who made those, who created those drawings?**
>
> KM: This is actually how the place look like. All the stones. It was actually a photograph and the artist, Parks, Jim Parks, sketched that. But, this, it's related to what the "Sites of O`ahu" described the birthing process, a hollow place somewhere in Wahiawā known as Kūkaniloko, birth place of the *ali`is*, observing by 36 warrior chiefs. But then what they say is the birthing process was never, ever been disclosed because they call it the tabu of Līloa and they never knew how the high chiefess actually gave birth on the stone. No one knew this, to this day. Historians didn't know, leading senior Hawaiian historians, they didn't know. No one really knew it, except me (laugh). And, I showed them how they gave birth--why they selected this particular *pōhaku*, that the stone was actually an equipment, an instrument to assist the practitioners in the proper means of giving birth of someone that has the highest *mana* or the highest ranking of that order at that time.

For those who have cultural ties to the land of Waipi`o and have been fortunate enough to receive the stories of their *kūpuna*, Kūkaniloko has always played a spiritual role in the foundation of `Ewa.

2. Kīpapa and Mā`ilikūkahi

Born *ali`i kapu* at Kūkaniloko, Mā`ilikūkahi became *mō`ī* of O`ahu in the late fourteenth century (Kamakau, 1991: 54). Mā`ilikūkahi was popular during his reign and was remembered for initiating land reforms which brought about peace and for encouraging agricultural production which brought about prosperity. He also prohibited the chiefs from plundering the *maka`āinana* with punishment of death (Kamakau, 1991: 55).

Mā`ilikūkahi's peaceful reign was interrupted by an invasion which would change Waipi`o `Uka forever. The following is a description of the Battle of Kīpapa by Fornander:

> I have before referred to the expedition by some Hawaii chiefs, Hilo-a-Lakapu, Hilo-a-Hilo-Kapuhi, and Punaluu, joined by Luakoa of Maui, which invaded Oahu during the reign of Mailikukahi. It cannot be considered as a war between the two islands, but rather as a raid by some restless and turbulent Hawaii chiefs... The invading force landed at first at Waikiki, but for reasons not stated in the legend, altered their mind, and proceeded up the Ewa lagoon and marched inland. At Waikakalaua they met Mailikukahi with his forces, and a sanguinary battle ensued. The fight continued from there to the Kipapa gulch. The invaders were thoroughly defeated, and the gulch is said to have been literally paved with the corpses of the slain, and received its name "Kipapa", from this circumstance. Punaluu was slain on the plain which bears his name, the fugitives were pursued as far as Waimano, and the head of Hilo was cut off and carried in triumph to Honouliuli, and stuck up at a place still called Poo-Hilo (Fornander, Vol.II:89).

Fornander's version of the Battle of Kīpapa sounds very much like the version told to Kalama Makaneole by his mother:

> **CSH: Did she ever tell you any stories about those gulches?**
>
> KM: ..And she tells me stories about Kīpapa, when they had the battle there, that they had this Hawaiian chief that is part of your ancestral line by the name of Mā`ilikūkahi. He took on the invaders that wanted to rule O`ahu and they came up through Pearl Harbor way and the enemy forces all with the full armor and weapons, travel up from Pearl Harbor and work their way up through Waipi`o Valley going into Kīpapa and then--they was looking for the *mō`ī*, Mā`ilikūkahi because he lives in central O`ahu. He stayed in the uplands because of much more protection and then she tells me about there

was a battle there. The warrior chiefs slaughtered the invaders there and Kīpapa is known as a place paved with corpse because of the battle was done there between the O`ahu chief and the invaders from Maui and from the Big Island.

Apparently, Kīpapa Gulch was named after this particular battle, or more likely renamed. In old Hawai`i, places were often given names based on historic events. In this case, Kīpapa Gulch was the location of an historic battle in which a very popular *mō`ī*, Mā`ilikūkahi, was victorious in battle. Although most people today do not know it, the name Kīpapa is a remnant of the glorious reign of Mā`ilikūkahi. The plain of Punalu`u refers to the tablelands between Kīpapa Gulch and Waikakalaua Gulch, in the vicinity of Mililani Mauka. Although people living in Waipi`o today are still familiar with the name Kīpapa as referring to the Valley, the plains of Punalu`u have long been covered over by pineapple and sugar cane and the place name is all but forgotten.

3. Waipi`o `Uka and the Legend of Kalelealuaka

In the *mauka* regions of Waipi`o, legend speaks of Kalelealuaka, who lived during the reign of the O`ahu chief, Kākuhihewa (Thrum, 1998). Blessed with supernatural powers, Kalelealuaka travels to O`ahu from his home on Kaua`i and settles in the *mauka* regions of Waipi`o with his two companions Kaluhe and Keinohoomanawanui. This place is called Keahumoe and here they build their mountain house Lelepua, named after Kalelealuaka's magic arrows. One night, Kalelealuaka makes known his wish:

> The beautiful daughters of Kakuhihewa to be my wives; his fatted pigs and dogs to be baked for us; his choice kalo, sugar cane, and bananas to be served up for us; that Kakuhihewa himself send and get timber and build a house for us; that he pull the famous awa of Kahuone; that the King send and fetch us to him; that he chew the awa for us in his own mouth, strain and pour it for us, and give us to drink until we are happy, and then take us to our house (Thrum, 1998: 89).

Upon hearing such a request, the *mō`ī* Kākuhihewa confers with his priests and instead of killing Kalelealuaka decides to test him in battle with Kūali`i. Kalelealuaka proves worthy in battle and is given charge of Kākuhihewa's kingdom.

Several place names are noted in the legend of Kalelealuaka and Keinohoomanawanui including Keahumoe (*sic.* Keahumoa), Kahuone, Lelepua, and Kuaikua in Helemano. Fornander describes Keahumoa as the "plain before reaching Kipapa gulch" (Fornander, Vol. V, Part II, p. 274). However, in the legends of the Battle of Keahumoa, the place seems to be closer to Honouliuli, near Līhue, Kuali`i's fort (in Sterling and Summers, 1978:38). Kahuone is noted as a place of choice *`awa*, *`awa* fit for a king, however its location is unknown. According to Thrum, Lelepua is the home of Kalelealuaka and his companions (Thrum, 1998: 88). In *Fragments of Hawaiian History*, `Ī`ī mentions several places in Waipi`o `Uka including Lelepua, however he associates Kalelealuaka to a place called Kahalepoai and not to Lelepua.

> From there it extended to tbe digging place of Kahalo, then went below to Paupalai, thence Lelepua, and to Kahalepoai, where the legendary characters Kalelealuaka and Keinohoomanawanui lived (`Ī`ī, 1959:99).

The *Indices of Awards* lists four LCAs which claim portions of Lelepua and Kahalepoai as land. Lelepua is described as an *`ili* or a land section within Waipi`o `Uka and Kahalepoai (*sic.* Walepoai) is described as a ravine. Kahalepoai appears again in association with Kalelealuaka and Keinohoomanawanui in a Hawaiian newspaper article recalling "*Na Wahi Pana o Ewa*".

> Kahalepoai is another noted place which those who had not seen but heard of ask about. They ask, "Where is the place where Kalelelaluaka and Keinohoomanawanui lived?" Then the native points it out, "It is there at the hau grove standing above Waipi`o. That is Kahalepoai." I do not believe that this year will be gone before that hau grove will be gone. Gold and diamonds are going to make it into nothing and the generations to come will not know about it (*Ka Loea Kalaiaina*, June 3, 1899).

Ironically enough, this prophecy seems to have been fulfilled. At the time these articles were written around 1899, Oahu Sugar Company had just purchased land in upper Waipi`o, and land was being converted to sugar cane fields at a rapid rate (Condé and Best, 1973). After years of sugar cane and pineapple cultivation during the twentieth century, Kahalepoai and Lelepua are no longer common place names in the Waipi`o/Mililani area.

4. Waipi`o `Uka, Kīpapa and the Legend of Kaupe

During an interview with a knowledgeable informant, it came forward that Kaupe, the legendary half-man, half-dog was the guardian of Waipi`o Valley. This is what Kalama Makaneole's mother told him about Kaupe:

> **CSH: Did she [Kalama's mother] ever tell you any stories about those gulches [Kīpapa and Waikakalaua] ?**
>
> KM: Well, she told me this story about Kaupe–half man, half dog. That Kaupe still roams Kīpapa. That—and she says not to be afraid if you go in there and if you see a white dog with red eyes. She says not to be afraid over there. And she says Kaupe roam all up in the valley there because he's the guardian of Waipi`o Valley that extend all the way to Mount Ka`ala. Kaupe.

Kaupe is often associated with Nu`uanu and is said to rest in the back of the valley, often in the shape of a cloud formation (Westervelt, 1983:90-96). According to the legend, Kaupe overthrew Kahanaiakeakua and his temple Kaheiki which had been built for Kahanaiakeakua by the Menehune. The temple was located in what is known today as Pacific Heights. In this version of the legend, Kaupe is a cannibal dog and eats many people. Finally, after receiving instruction from Kahanaiakeakua's priest, Kaupe is killed by the families of the victims (Westervelt, 1983: 90-96). In the written legend, Kaupe is described as a *kupua*, a demi-god with the ability to possess multiple forms. He originally resided in Līhue in `Ewa where he had his own *heiau*. This may be his connection to Waipi`o.

B. Waipi`o `Uka in the Nineteenth Century

Waipi`o was a particularly desirable *ahupua`a* of the `Ewa District in former times. The majority of the inhabitants lived in close proximity to the rich fisheries and fishponds of the Waipi`o peninsula. The coastal plains also afforded ideal land for wetland taro cultivation (Handy and Handy, 1972:470). This explains why during the *Māhele*, the great majority of the awarded land parcels were located in the *makai* portions of Waipi`o, at or just above the peninsula. However, there were 25 claims describing land use in upper Waipi`o or "Waipi`o `Uka". A significant figure and chronicler of the Hawaiian kingdom, John Papa `Ī`ī, recalls that the uplands of Waipi`o were once a fertile and well populated region (`Ī`ī, 1959: 99). By the time `Ī`ī began to write in the mid nineteenth century, the uplands had been largely abandoned and `Ī`ī asks, "Who has 'closed' these places today? We don not know enough to say, 'It was so-and-so.'" (*Ibid*). It seems that events had occurred, even during the lifetime of John Papa `Ī`ī in the 1800s, to significantly reduce and perhaps even destroy the villages which once thrived in Waipi` `Uka.

1. Waipi`o `Uka and the *Māhele*

The earliest recorded information on land use in Waipi`o `Uka is in the Land Commission Awards. During the *Māhele* period, or mid-1800s, the land tenure changed from traditional use rights to private ownership. With the exception of the Land Commission Awards or *kuleana* lands, most of the *ahupua`a* of Waipi`o was granted to John Papa `Ī`ī. During the time of the *Māhele*, there were 25 applications for quiet title to lands in Waipi`o `Uka (Waihona `Āina, 2000). Of the twenty five claims made, thirteen were awarded (Table 2, Figure 2). No *kuleana* lands were claimed in the proposed area of development.

The *kuleana* claims, whether awarded or not awarded, give much insight into the land use in Waipi`o `Uka during this time period (Table 2, Figure 2). The LCAs tell us that Waipi`o `Uka extended from the Waikakalaua Gulch on the northwest side of the Waipi`o *Ahupua`a* to the Kīpapa Gulch on the east side of Waipi`o. Resident of Waipi`o `Uka Koikoi (no LCA number) claims a land called Kamanuiki, "an entire portion of the Valley Waipi`o uka of Waikaka laua Stream" (Waihonaaina.com, 2001). The boundaries of Kamanuiki include a neighbor Lanai who lives on a piece of land called Kahooneananui, the Waikele Stream (often called the Waikakalaua Stream) and the *Alanui Aupuni* or Government Road.

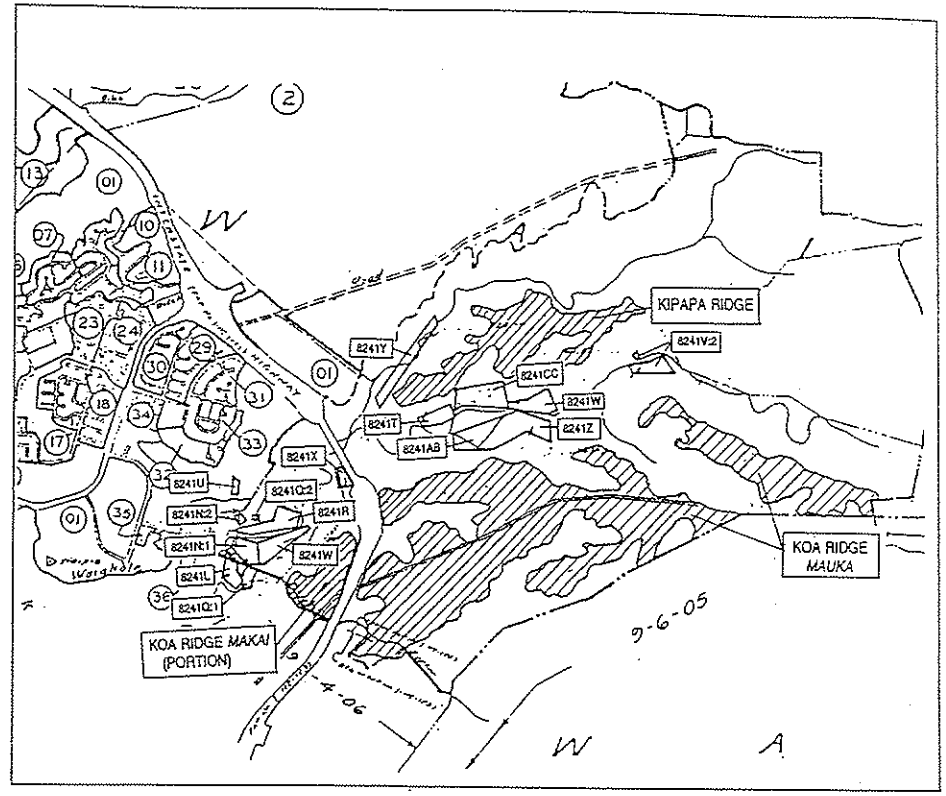

Figure 2 Tax Map Showing Location of Land Commission Awards and present study area in Waipi`o `Uka

TABLE 2: MÂHELE CLAIMS AND AWARDS IN WAIPI'O 'UKA (Also See Figure 2)

Claimant	Claim No.	Name of Land Claimed	Land Use	Land Awarded
Koikoi	No number	Kamanuiki in Waipi'o 'Uka (entire portion of valley of Waikakalaua Stream)	1 house, no other land use indicated	unknown
Mokunui	8241L	Kamalokauhola	1 *mo'o*, 1 *kula*, 1 house lot, 1 house	Waipi'o 'Uka Kamalokauhola 1 ap. .54 Acs.
Ukeke	8241N	Maheu Lelepua Waipi'o 'Uka	1 *mo'o*, 1 *kula*, house lot, house, 2 *okipu'u* of mountain taro	Maheu 1 ap., 5.507 Acs.; Waipi'o 'Uka 1ap., .9 Acs.
Kamakahi	8241Q	Kuana, Waianeki in Waipi'o 'Uka	1 *mo'o*, 1 *kula*, house lot, 1 house, 2 *okipu'u* in 1 piece	Kuana 1 ap. 2.217 Acs.; Waianeki 1 ap. .256 Acs.
Keahale	8241R	Waiakapuaa	1 *mo'o*, 1 *kula*, house lot, 2 houses	Waipi'o 'Uka Waiakapua'a 1 ap. 6.882 Acs.
Kailio	8241T	Kaneulupoo	1 *mo'o*, 1 *lo'i*, houselot, 2 houses	Waipi'o 'Uka Kaneulupoo 1 ap. 5.665 Acs.
Kailihao	8241U	Kapoipuka	1 *mo'o*, 1 *kula*, houselot, 1 house	Pupuka 1 ap. 3.804 Acs.
Kauluoaiwi/ Kaulewaiwi	8241V	Honowaka in Waipi'o 'Uka	1 *mo'o*, 1 *kula*, houselot, 1 house	Hanauaka 1 ap. .256 Acs.; Waipiouka 1 ap. 5.475 Acs.

Claimant	Claim No.	Name of Land Claimed	Land Use	Land Awarded
Kaneakauhi	8241W	Kaohai in Waipi'o 'Uka, Wailele	1 *mo'o*, 1 *kula*, houselot, 1 house	Waipi'o 'Uka Kaohi 1 ap. 8.162 Acs.
Halelaau	8241X	Kopilau, Hokapiele	1 house, 2 *'okipu'u*	Awarded, but no description
Hepa	8241Y	Kīpapa	1 house, 4 *'okipu'u*	Kepapa 1 ap. 12.25 Acs.
Kaioe	8241Z	Moakea, Puulu, Palikea in Waipi'o 'Uka	1 *mo'o*, 1 *kula*, houselot, 1 house	Puulu 1 ap. 18.72 Acs.
Palekaluhi	8241AB	Kamuku, Lapili	1 house, 9 *lo'i*, 1 *kula*, 1 *mo'o*	Kamuku 1 ap. 6.363 Acs.
Poupou	8241CC	Papa, Leoiki	1 *mo'o*, 1 *kula*, houselot, 1 house	Waipi'o 'Uka Papa 1 ap. 18.72 Acs
Kalaiku	8241UU	Lelepua in Waipi'o 'Uka	1 *mo'o*, 1 *kula*, houselot, 1 house, *'okipu'u*	Lelepua Waipi'o Ewa 1 ap. 13.15 Acs.
Kaualelehuna	8241XX	Walepoai in Waipi'o 'Uka	*mo'o*, *kula*, house lot, 1 house, a ravine, 2 *'okipu'u*	Not Awarded
Kahuluhulu	8241YY	Waipi'o Valley	2 houses, 2 *'okipu'u*	Not Awarded
Kaimileihonua	9361B	Waipi'o 'Uka	1 *mo'o*, 1 *kula*, houselot, 2 houses	Not Awarded
Kalaiku	11205	Lelepua	1 *'okipu'u*	Not Awarded; See 8241UU
Kanealu	11206	Kahaikei, Luanui	1 *mo'o*, 1 *kula*, houselot, 1 house	Not Awarded
Naniu	11207	Liloa, Kamae in Waipi'o 'Uka	1 *mo'o*, 1 *kula*, houselot, 1 house, mountain *kalo* land	Not Awarded
Kaopuana	11208	Kahalo, Kepooakaholu in Waipi'o 'Uka	1 *mo'o*, 1 *kula*, houselot, 1 house	Not Awarded
Kawaihae	11209	Kaluahine, Kanewahine in Waipi'o 'Uka	1 *mo'o*, 1 *kula*, houselot, 1 house, *'okipu'u*	Not Awarded
Kaluehinue	11210	Kauloa, Waipi'o 'Uka	1 *'okipu'u*	Not Awarded

Thirteen *`okipu`u* were claimed in the Waipi`o `Uka LCAs. *Okipu`u* is a rare term in the Land Commission Awards and seems to be a term utilized only by Hawaiians residing in Waipi`o and Waialua *Ahupua`a* (Waihonaaina, 2001). *`Okipu`u* is described as a forest clearing (Lucas, 1995: 82), and may have been used for growing dry land taro. Given the numbers of *`okipu`u* and *mo`o*, the major crops of Waipi`o `Uka were probably dry land taro and sweet potatoes. There is little mention of *lo`i* and associated features which suggests that conditions were not entirely favorable for wet land taro cultivation.

Several pieces of land were claimed in mountains or *pali*. One translation of *pali* is "steep hill or slope suitable for *olonā* or *wauke*" (Pukui and Elbert, 1986:312). Along the Kīpapa Gulch were numerous tributary gulches. These steep, moist areas which were sheltered from the wind may have provided excellent conditions to cultivate *wauke* (*Broussonetia papyrifera*) and *olonā* (*Touchardia latifolia* Gaud.) plants known to grow in the `Ewa uplands (Handy and Handy, 1972: 209, 227). A third plant, *mamaki* (*Pipturus* spp.), may have been cultivated in conjunction with the *wauke* and *olonā*. The *mamaki* tapa which was made in Waipi`o, `Ewa was known to be of high quality (`Ī`ī, 1959:83).

2. Place Names of Waipi`o `Uka

Place names or *wahi pana* ("legendary place" Pukui and Elbert, 1968: 376) are an integral part of Hawaiian culture. "In Hawaiian culture, if a particular spot is given a name, it is because an event occurred there which has meaning for the people of that time. (Mc Guire, 2000: 23)." The *wahi pana* were then passed on through language and the oral tradition, thus preserving the unique significance of the place. Hawaiians named all sorts of objects and places, points of interest which may have gone unnoticed by persons of other cultural backgrounds.

> Hawaiians named taro patches, rocks and trees that represented deities and ancestors, sites of houses and *heiau* (places of worship), canoe landings, fishing stations in the sea, resting places in the forests, and the tiniest spots where miraculous or interesting events are believed to have taken place. (Pukui and Elbert, 1974:x)

The following is a list of place names for Waipi`o `Uka and Kīpapa found during research for this report. This list is by no means considered to be complete. Place names were gathered from traditional literature (*mo`olelo*, chants) historical sources and the *Māhele* records. All the names of the *`ili* and *`okipu`u* were taken from Land Commission Award records. Sadly, none of these *`ili* and *`okipu`u* names were documented on historic maps researched for this project and their meanings and cultural associations appear to be lost and forgotten.

An attempt was made to include the proper diacritical marks for all known and generally accepted translations of place names. Making incorrect assumptions about the pronunciation and where to place the diacritical marks in a name can entirely change the meaning of a name, (e.g. *pūʻāʻā*: "scattered; to flee in disorder and fright"; *pua`a*: "pig, pork"). Therefore, in cases where the pronunciation of a name was uncertain, diacritical marks were not used and no attempt was made to translate the name. In some cases, cultural relationships were made based on the literal translation of the root word.

Place Names of Hawai`i (Pukui *et al.*, 1974) was used as the primary source for all place name translations. Where there were no known translations, a literal translation of the place name was made using the *Hawaiian Dictionary* (Pukui and Elbert, 1986). The intent of the author is to merely present the available information and let the reader come to his own conclusions.

One of the beauties of the Hawaiian language is the dualism in names and the double meanings – the literal meaning and the *kaona* or hidden meaning. It should be remembered that the true significance of a place name lies only with the people who use them and know their history.

The following abbreviations are used throughout the Place Names section for ease and efficiency. Please refer to the References section for complete citations.

LCA = Land Commission Award
PE = *Hawaiian Dictionary* by Pukui and Elbert, 1986
PEM = *Place Names of Hawai`i* by Pukui, Elbert and Mookini, 1974

Place Names List

Ahanaanaa:	The name of an *`okipu`u* described to be in Waipi`o Valley and bounded by Pauku Valley and the *`Ili* of Lelepua (LCA #8241YY).
Aikapu:	The name of an *`okipu`u* in the *`ili* of Kaluahine, Waipi`o `Uka. The exact location of the *`okipu`u* is unknown.
Eo:	The name of an *`okipu`u* in Waipi`o `Uka claimed in LCA #8241CC/ LCA 11211 and in LCA #8241XX. The location of the LCA is in Kīpapa Valley. Also the name of a fishpond (*loko*) in the Waipi`o peninsula.
Hokapiele:	*Pali* of Waipi`o `Uka where an *`okipu`u* was claimed in LCA #8241X. Also listed as the *makai* boundary of a piece of land claimed in the mountain Palikea (*Apana* 3 of LCA #8241Z). *Piele* may possibly refer to a pudding made from grated taro, sweet potato, yam, banana or breadfruit mixed with coconut cream (PE: 326).
Homawaka/Hanauaka:	An *`ili* in Waipi`o `Uka (LCA #8241V). Location of LCA is unknown.
Inuwai:	The name of a breeze noted in a chant about Kahuiki Spring (Waipi`o). Ka Loea Kalaiaina, "Na Wahi Pana o Ewa", June 3, 1899.
Kahaikei/Kahuikoi:	A mountain in Waipi`o `Uka in which was claimed an *`okipu`u* (LCA #11206).
Kahalo:	Described in LCA #11208 as an *`ili `aina* in Waipi`o `Uka.

Location of LCA is unknown although it may have been on the plains above Kīpapa Gulch. `Ī`ī (1959: 99) calls Kahalo "the digging place" and describes it as a place that once had a large population with lots of trees located off the main trail which led from Waiawa in `Ewa to Waialua.

Kahooneananui: Described as "a land" bounding Kamanuiki in Waikakalaua (LCA no number to Koikoi).

Kahuaiki: A refreshing pool created by a spring located on the plain of Kanoenoeo and made famous in chants (See p.12) Ka Loea Kalaiaina, "Na Wahi Pana o Ewa", June 3, 1899.

Kaluahine: An *`ili* in Waipi`o `Uka (LCA #11209). Location of LCA is unknown. *Lit.*, the old lady (PEM: 78).

Kamae: An *`ili* in Waipi`o `Uka (LCA #11207). Location of LCA is unknown. Claimants refer to mountain *kalo* land. The eastern boundary of the *pali* Kamae is noted as the *ahupua`a* boundary of Waiawa.

Kamuku: An *`ili* in Waipi`o `Uka (LCA 8241AB). Location of LCA is in Kīpapa Valley.

Kamalokauhola: An *`ili* in Waipi`o `Uka (LCA #8241L). LCA #8241L is located in Kīpapa Valley near where the Waiāhole Ditch now crosses the Gulch. One meaning of *kauhola* is "to open, unfold, as a tapa" (PE: 135).

Kamanuiki: An *`ili* in Waipi`o `Uka (No LCA #). Claimant describes land as a portion of valley and stream in Waikakalaua. One boundary of this LCA is noted as the Waikele Stream and another is "*alanui aupuni*" as the government road. A possible reference to *manu*, bird.

Kaneulupo/Kaneulupoo: An *`okipu`u* in Waipi`o `Uka (LCA #8241T). Location of LCA is in Kīpapa Valley. One translation of *ulupo* is *ulupō* or *Lit.*, night inspiration (PEM: 215).

Kanewahine: A *pali* in Waipi`o `Uka in which a piece of land was claimed (LCA #11209). Location of LCA is unknown.

Kaniukulou?: An *`okipu`u* in Waipi`o `Uka forming the *makai* boundary of Papa *`okipu`u* (LCA #8241C/ 11211).

Kanoenoe: A plain in Waipi`o. Purportedly located west of the plain of Punahawele. (Ka Loea Kalaiaina, "Na Wahi Pana o Ewa", June 3, 1899). On the plain Kanoenoe was situated the home of the legendary figures Kalelelaluaka and Keinohoomanawanui, Kahalepohai/Kahalepoai. Also located on the Kanoenoe plain was Kahuaiki spring and pool.

Kaohai/ Kaohi: An *`ili* in Waipi`o `Uka (LCA #8241Z). Location of LCA is inside Kīpapa Valley. May indicate presence of *`ohai, Sesbania tomentosa* (PE:276).

Kapapala: The name of a *pali* and land used as a boundary for Hokapiele Pali. May refer to *pāpala*; *Lit.*, the *Charpentiera* shrub (PEM: 88).

Kapoipuka: An *`okipu`u* in Waipi`o `Uka (LCA #8241T). The location of this *`okipu`u* is in Kīpapa Valley.

Kauloa: An *`ili* in Waipi`o `Uka (LCA #11210). Location of LCA is unknown.

Keanaloa: The name of an *`okipu`u* of Waipi`o `Uka claimed in LCA #8241XX. The location of the *`okipu`u* is uncertain although it was used as the *makai* boundary of Hokapiele (LCA #8241X).

Kekoena: The name of a land used as a boundary for the mountain Kahaikei/Kahuikoi (LCA #11206). *Lit.*, the remainder, residue, remnant, surplus, scraps, leftovers, balance, etc... (PEM: 158).

Kepa: The name of an *`okipu`u* in Kauloa `Ili, Waipi`o `Uka (LCA #11210). The location of this *`okipu`u* is unknown.

Kepoookuholua/ Kepoookaholua: An *`ili* in Waipi`o `Uka (Lca #11208). Location of LCA is unknown.

Kīpapa: A gulch and stream in Waipi`o. *Lit.*, placed prone (referring to corpses slain in the victory of O`ahu forces over those of Hawai`i in the fourteenth century; Alexander, 1891:96) (PEM: 113). Also an *`ili* in Waipi`o in which four *`okipu`u* were claimed in LCA #8241Y. The location of the LCA is in Kīpapa Valley, west of the Kīpapa Ridge parcel.

Koakukaua: A *kula* in Waipi`o (LCA #8241AB). The location is thought to be in Kīpapa Valley.

Kopilau: An *`okipu`u* located in Kīpapa Valley (LCA #8241X). One of the boundaries of Kopilau was noted as Kipapa Stream. May refer to *kō*, sugarcane.

Kumuipali: A *mo`o `āina* in the *`ili* Lapili, Waipi`o claimed in LCA #8241AB. The location of this *mo`o `āina* is in Kīpapa Valley.

Lapili: An *`ili* in Waipi`o `Uka (LCA #8241AB). The location of this *`ili* is in Kīpapa Valley.

Lauli: The name of a land used as a boundary for the *mo`o `āina* Kumuipali (LCA #8241AB).

Lelepua/Kelepua: An *`ili* in Waipi`o `Uka (LCA #8241UU, LCA #11205, LCA #8241N). Location of Lelepua is unknown. Lelepua was noted as the mountain home of the legendary charactera Kalelealuaka and Keinohoomanawanui (Thrum, 1998: 88). Thrum translates *lelepua* to "arrow flight", possibly referring to Kalelealuaka's method of shooting an arrow to choose a house site (*Ibid*: 88). `Ī`ī (1959: 99) mentions Lelepua as one of several much visited places off of the main trail (`Ewa to Waialua) which at one time was a rich land with many trees and more people.

Leoiki: A gulch within Kīpapa Gulch, location unknown though probably adjacent to Panihakea Gulch. In LCA 8241CC/ 11211, Poupou claims Leoiki Valley in Waipi`o `Uka. One boundary of Leoiki is noted as Waiawa. This portion of Kīpapa was leased out to Japanese farmers in 1908 to cultivate pineapple (Bureau of Land Conveyances, Liber 434: 228-235). *Lit*,. A low voice; to speak softly (PE: 203).

Liloa: An *`ili* in Waipi`o `Uka (LCA #11207). Location of LCA is unknown.

Luanui: An *`ili* in Waipi`o `Uka (LCA #11206). Possibly refers to *lua*, crater (PE: 213).

Maheu: An `ili in Waipi`o `Uka (LCA #8241N). Location of LCA is in Kīpapa Valley. May refer to digging the earth for cultivation (PE: 219).

Mailiula Makai: An *`okipu`u* in Waipi`o `Uka claimed in LCA #9361B. The location of this *okipu`u* is unknown. Mailiula may refer to Mā`ili–*Lit.*, pebbly (PEM: 139) and *`ula*, red (PE: 367).

Maloi/Malu: The name of an *`okipu`u* in Kauloa `Ili, Waipi`o `Uka (LCA #11210). The location of this *`okipu`u* is unknown.

Maluakele: The name of a wind noted in a chant about Kahuiki Spring, Waipi`o (Ka Loea Kalaiaina, "Na Wahi Pana o Ewa", June 3, 1899).

Moakea: An *`ili* in Waipi`o `Uka (LCA #8241Z). Location of LCA is in Kīpapa Valley. A possible reference to the chicken, *moa*. Moaula is the name of a destroyed *heiau* purported to be formerly located on the Honolulu side of Kīpapa Gulch, Site 130 (McAllister, 1933:107).

Nuimuka?: An *`ili* in Waipi`o `Uka listed as the *mauka* boundary of the *`ili* of Kīpapa (LCA #8241Y).

Omai: The name of a mountain in which an *`okipu`u* was claimed in LCA #8241YY. The location of Omai is unknown however it lists as its boundaries a *kahawai* and two *pali*, one noted as "pali Kamoi of Nahiu". This may refer to *pali* Kamae of Naniu (LCA #11207, Apana 2) which borders the Waiawa *ahupua`a* boundary.

Palaele: The name of an *`okipu`u* in Waipi`o `Uka claimed in LCA #9361B. The exact location of the *`okipu`u* is unknown. May refer to *pala* as a variety of sweet potato or taro (PEM: 307).

Palikea: A *pali* in Waipi`o `Uka where a piece of land was claimed in LCA #8241Z. A portion of LCA 8241Z is in Kīpapa Valley although it is uncertain which *apana* this refers to. *Lit.*, white cliff (PEM: 177). May refer to a steep gulch side suitable for planting *olonā* or *wauke* (PE: 312). Also the name of a sweet potato (Handy, 1985:142).

Panihakea: A gulch within Kīpapa Gulch, location unknown though probably adjacent to Leoiki Gulch. This portion of Kīpapa was leased out to Japanese farmers in 1908 to cultivate pineapple (Bureau of Land Conveyancea, Liber 434: 228-235).

Papa: An *`okipu`u* in Waipi`o `Uka (LCA #8241CC). The location of LCA ia in Kīpapa Valley.

Pua: The name of a land used as a boundary for the *mo`o `āina* Kumuipali (LCA #8241AB).

Pualaea: The name of a land used as a boundary for *Apana* 2 in LCA 8241V located in Kīpapa Valley. Possible reference to the presence of *`alaea*.

Punahawele: A plain whose exact location is unknown but that is thought to be in Waip`io (Sterling and Summers, 1978: 21). One meaning of *hāwele* is "a type of tapa" (PE: 62). One description would place its location straddling the Waipi`o-Waiawa *ahupua`a* boundary and encompassing portions of Pānakauahi Stream (Ka Loea Kalaiaina, "Na Wahi Pana o Ewa", June 3, 1899).

Punaluu:	A plain in Waipi`o `Uka. Named after a Hawai`i Chief killed during a Hawai`i invasion of O`ahu during the reign of Mā`ilikūkahi (Fornander, Vol.II:89).
Pupuka:	An *`ili* in Waipi`o `Uka (LCA #8241U). Location of LCA is in Kīpapa Valley. Also the name of an `Ewa chief who helped plot the murder of the Maui Chiefs who had taken over O`ahu after the death of Kahahana (Kamakau, 1992: 138).
Puulu:	An *`ili* in Waipi`o `Uka (LCA #8241Z). Location of LCA is in Kīpapa Valley. May refer to the *`ulu (Artocarpus altilis).*
Waiakapuaa:	An *`ili* in Waipi`o `Uka (LCA #8241R). Location of LCA is in Kīpapa Valley. Possibly reference to the presence of *pua`a*, pig.
Waianeki:	An *`ili* in Waipi`o `Uka (LCA #8241Q). Location of LCA is in Kīpapa Valley.
Wailele:	The name of a mountain in Waipi`o `Uka in which an *`okipu`u* was claimed in LCA 8241W. This LCA is located in Kīpapa Valley. *Lit.*, waterfall (PEM: 224).
Waimahu:	A land used as a boundary for Kaohai *`okipu`u* in Waipi`o `Uka (LCA #8241W). Indicates presence of water.
Waimuka:	Land used as *mauka* boundary of Kopilau *`okipu`u* in Kīpapa Valley (LCA #8241X).
Walepoai/Halepoai Kahalepoai/Kahalepohai:	Described as a "ravine" in Waipi`o `Uka (LCA #8241XX). Location of LCA is unknown. *Pō`ai-hale*: *Lit.*, surrounding house (PE:333). `Ī`ī (1959: 1959) describes Kahalepoai as the home of the legendary characters Kalelealuaka and Keinohoomanawanui. In the Hawaiian newspaper Ka Loea Kalaiaina, Kahalepoai is described as the plain where Kalelealuaka and Keinohoomanawanui lived. It is marked by a *hau* grove.

Of the 59 place names, all but 5 refer to lands in Waipi`o `Uka. Most of the place names are associated with *`ili* or land sections and *`okipu`u* or forest clearings throughout Waipi`o `Uka which were used as reference points to quiet land claims during the *Māhele*. Although many of the interpretations are tentative, there does seem to be tendency towards cultivation. Several place names suggest the range of sustenance activities including appropriate places to cultivate such as *Palikea* which may infer a steep gulch for planting *wauke* or *olonā* to preparation of the soil which is one of the meanings of *maheu* to types of cultivars of sweet potato or taro which implies *pala* of the *`okipu`u* Palaele to food preparation which may include *piele*, a type of pudding (in Hokapiele).

In addition, there are several place names which contain the root word of plants, minerals or animals suggesting their presence. The plant, animal and mineral names include *kō* or sugarcane, *Saccharum officinarum* L. (Kōpilau), *`ohai* or *Sesbania tomentosa* (Ka`ohai), *pāpala* or *Charpentiera* spp. (Kapāpala), *`ulu*/breadfruit or *Artocarpus altilis* (Pu`ulu), *moa*/chicken or *Gallus gallus* (Moakea), *pua`a*/pig or (Waiakapua`a), *manu*, general term for bird (Kamanuiki) and *`alaea* or red ocherous dirt (Pu`alaea). Only two of the four plants are cultivated plants, the *kō* or sugarcane and the *`ulu* or breadfruit and the *`ulu* is more of an opportunistic plant which once planted needs very little care. In fact, *`ulu* was called *`ai kameha`i*, "meaning that it is a food (*`ai*) that simply reproduces itself 'by the will of the gods,' that is, by sprouting" (Handy and Handy, 1972:152). *Kō* was often planted around dwellings of Hawaiians.

> But as an element in the systematic horticulture of the old natives, it had a fixed place in relation to taro and sweet potatoes. In wet-taro farming, cane was planted along the embankments separating the flooded terraces and flats. In dry-taro and sweet-potato fields on the sloping *kula* or in the lower forest zone, cane was planted as hedges along the lines of stone and rubbish thrown up between the fields. Thus it helped the planter to utilize to the maximum his soil and water, and acted as a windbreak against the gusty breezes which blow in most valley bottoms, along the coasts, and on the uplands where taro is grown (Handy and Handy, 1972: 186).

In addition to its use as a condiment food and a famine food, sugar cane was used as medicine, and the leaves were sometimes used as thatching for houses. The *kaona* or double meaning of *kō* made its use popular as well. "*Kō* 'sugarcane' was important as medicine and to bring success to any undertaking because *kō* also means success" (Pukui *et. al*, 1974: 261). One of our interviewees, Kalama Makaneole remembers eating sugarcane up in Kīpapa when he was out gathering *la`au lapa`au* with his mother in the 1950s and 1960s (Interview with K. Makaneole, July 28, 2001).

The *`ohai* is a native shrub associated with low elevation dry shrubland and may have been found in the lower reaches of the Kīpapa Valley before alien species became dominant in that elevation zone (Wagner *et. al*, 1990: 72). The flowers have been used for making *lei* (Krauss, 1993: 77). *Pāpala* is most often associated with the Hawaiian sport *`ōahi* in which dry *pāpala* branches were collected to be lit on fire and tossed over high cliffs. The effect was something like fireworks (Krauss, 1993: 96).

As was mentioned in the earlier sections, there are several place names associated with legends pertaining to Waipi`o and Waiawa. Kīpapa, Punalu`u, Kahalepoai, Lelepua, Kanoenoe, and Punahawele are all place names which have survived through the times. Three of the place names also appear in the Land Commission Awards including Kīpapa, Kahalepoai (*sic.* Walepoai) and Lelepua.

C. Waipi`o `Uka in the 20th Century–Sugar Cane and Pineapple

1. Independent Pineapple Growers

Before the turn of the century, sugar and pineapple were already beginning to transform the landscape of `Ewa and Wahiawā. The newly organized O`ahu Sugar Company leased 3,400 acres of the *mauka* portion of Waipi`o from the `Ī`ī estate in 1897. A few years earlier, the Oahu Railway and Land Co. (O.R. & L.) had leased a tract through Kīpapa Gulch to transport sugar and pineapple from Wahiawā to Honolulu. The railway up the Gulch may have been the impetus for small independent farmers to move in and begin growing pineapple in the upper reaches of Kīpapa Valley. One of our informants, Masanobu Arakaki, born and raised in Kīpapa Valley, recalls vestiges of the independent pineapple growers.

> When asked about Kīpapa Valley prior to the truck farming era, Mr. Arakaki recalls his parents talking about the independent pineapple growers. These were farmers who grew pineapples independently and sold them to the larger plantations. Many of them grew pineapples inside Kīpapa Gulch. Mr. Arakaki remembers his parents saying how the independent growers lost out during and after the Depression if they didn't have a contract with the Plantations because the Plantations quit buying from the independent growers. If the growers had a contract, the Plantations were obligated to buy their pineapples, even if the pineapples were left to rot. As a child, Masanobu has memories of traveling up the valley and seeing stands of abandoned pineapple fields. There were even some scattered pineapple plants up on the gulch sides. One old timer told Mr. Arakaki that there was once a camp of independent pineapple growers about ½ mile *mauka* of Arakaki's leased houselot in Kīpapa Valley (Interview with M. Arakaki, July 27, 2001).

Mr. Arakaki's memories are substantiated by research conducted at the Bureau of Land Conveyances. Land records document Japanese farmers acquiring lands in Waipi`o *mauka* for pineapple cultivation in the first decade of the twentieth century. An unrecorded lease from the John`Ī`ī Estate, Ltd. to Yoshisuke Tanimoto and Kintaro Izumi in 1908 led to the formation of the Waipi`o Pineapple Company who cleared and cultivated approximately 223 acres in portions of the Kīpapa Gulch (Liber 434: 228-235). This was probably the beginning of pineapple cultivation in the uplands of Waipi`o, probably adjacent to or within the project area. In 1915, Libby McNeil & Libby took over Waipi`o Pineapple Company's leases and continued to cultivate pineapple in the area. The area the two farmers leased was known as the Leoiki and Panihakea Gulches, two small gulches within Kīpapa. The place name Leoiki was also recorded in the Land Commission documents as a valley with one boundary being Waiawa and surrounded by *pali* (LCA 8241CC).

Unrecorded leases for land in Waipi`o were probably fairly common in that early stage of land transactions. As pineapple and sugar became more viable and profitable crops, and transportation to the sugar mills and pineapple canneries became available, it is likely that more and more land was placed into cultivation, including the less arable lands within Kīpapa such as the swales and small gulches.

> There is also documentation of early pineapple cultivation in neighboring Waiawa Ahupua`a. There is record of attempted pineapple irrigation utilizing water from shallow wells in Waiawa Gulch in 1893; and prior to 1913, most of the plateaus in the Waiawa project area [makai of the Waiawa parcel of the current area of proposed development] were planted in pineapple (Goodman and Nees, 1991: 59).

Shortly thereafter, pineapple was abandoned and by 1935, the area south of the Waiawa parcel was planted in sugar cane (*Ibid.*)

2. The Waiāhole Ditch

O`ahu Sugar Company began work on the Waiahole Ditch in 1913 and the water system was "an engineering feat of epic proportion for those times" (Condé and Best, 1973: 37). The objective was to bring water from the windward side of O`ahu to the fields and mill of O`ahu Sugar Company in `Ewa. The original system included 27 tunnels and connecting 37 stream intakes, with a ditch running for nearly 22 miles, stretching from windward to leeward O`ahu. Portions of the ditch run across the Koa Ridge Makai and the Koa Ridge Mauka parcels of the project area (Figure 3). Mr. Arakaki remembers when the Ditch was operated by families which lived strategically along the ditch. One family in particular stood out for Mr. Arakaki, the Shibuya Family.

> The Shibuya Family actually lived adjacent to the Waiahole Ditch, a little distance from the Camp [Shohata Camp]. They worked for the Waiahole Ditch Company and were in charge of opening and closing the locks and managing the water...When there was too much water, the excess was dumped into Waiawa Stream...Mr. Arakaki relates that sometimes as kids, when visiting the Shibuya family, they would go swimming in the Waiahole Ditch near the Shibuya house. Near the house, the main ditch flowed into a small reservoir, approximately 20' x 20' or 30' x 30'. A wooden gate was maneuvered to adjust the flow into the reservoir and at the opposite end of the reservoir, where the reservoir once again became a ditch, there was a flat area with a measuring stick. Based on the measuring stick, one could tell how many thousands of gallons were flowing per day and thus how much water was being sent to central O`ahu (Interview with M. Arakaki, July 27, 2001).

As Mr. Arakaki describes it, the Shibuya house was most likely near the southern edge of the Koa Ridge Mauka parcel of the project area, adjacent to the Waiahole Ditch (Figure 3). Mr. Arakaki also described the pipelines or siphons which were found near the Shibuya house and across the Kīpapa Gulch. The siphon which crosses the Kīpapa Gulch was used for the fun of the Arakaki children who would run up and down the pipeline (Interview with M. Arakaki, July 27, 2001).

3. Pineapple and Camps

In the first part of the twentieth century, there were many sugar and pineapple camps in the Waipi`o `Uka area (Figure 3). One such camp was located in the Koa Ridge Mauka parcel of the project area (Figures 3 & 4). On the map, the camp is shown as "Waipi`o B", however after talking to residents who grew up in the outlier camps, it was found that most people knew the camp as "Shohata Camp". Apparently the name Shohata is derived from one of the supervisors of Libby, McNeiL& Libby (Interview with M. Arakaki, July 28, 2001). Shohata Camp was a pineapple camp operated by Libby McNeil and Libby along with "Waipi`o A" Camp, better known as Waipi`o Camp. Waipi`o Camp was located near today's Mililani Town. Our informant, Mr. Arakaki, discussed some of the camps when he talked of going to Kīpapa School, which was located near Waipi`o Camp.

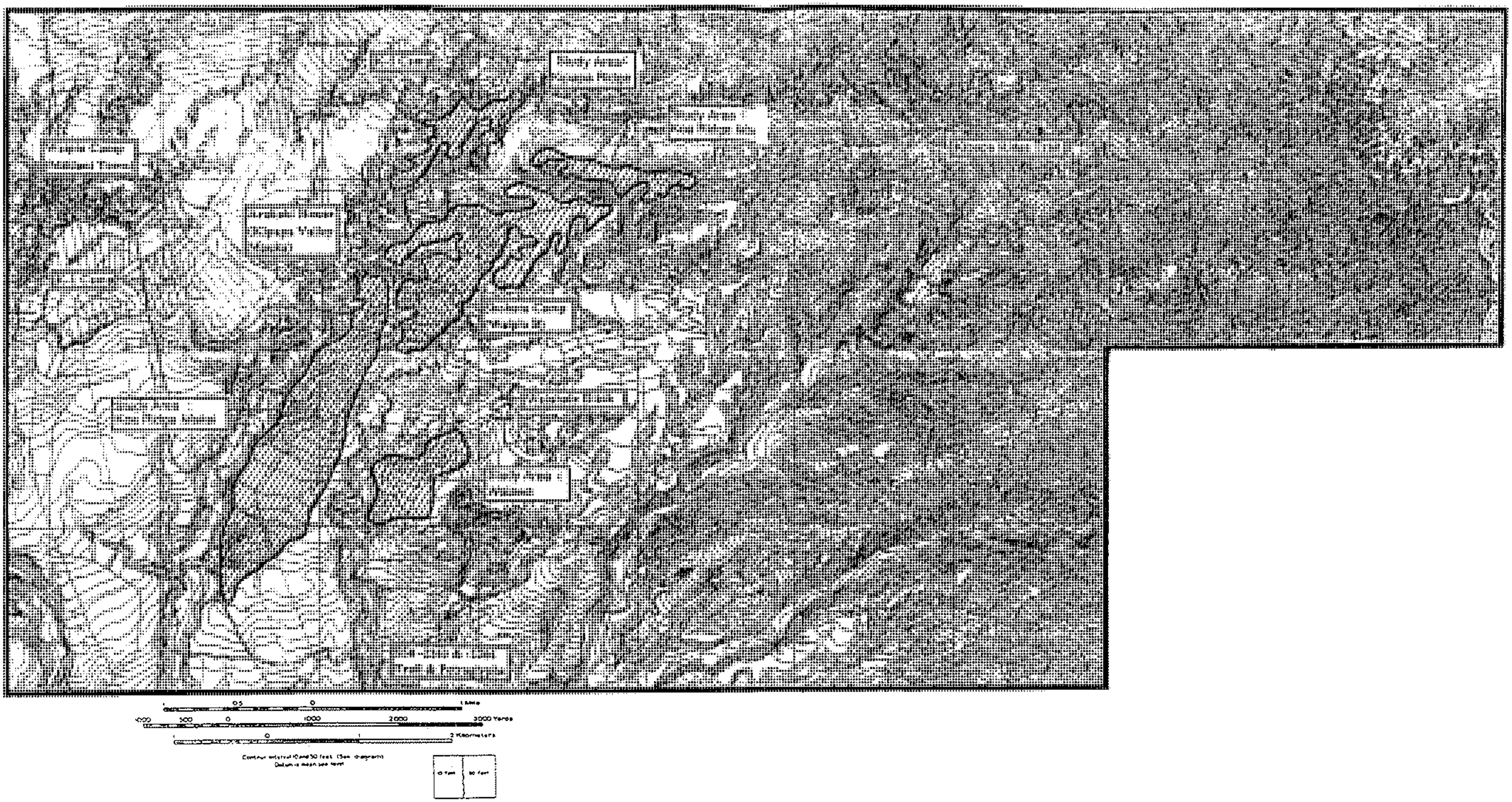

Figure 3 Portions of 1927-1929 U.S. Coast and Geodetic Survey and Air Corps US Army Map, Waipahu, Wahiawa and Kaawa Quads.

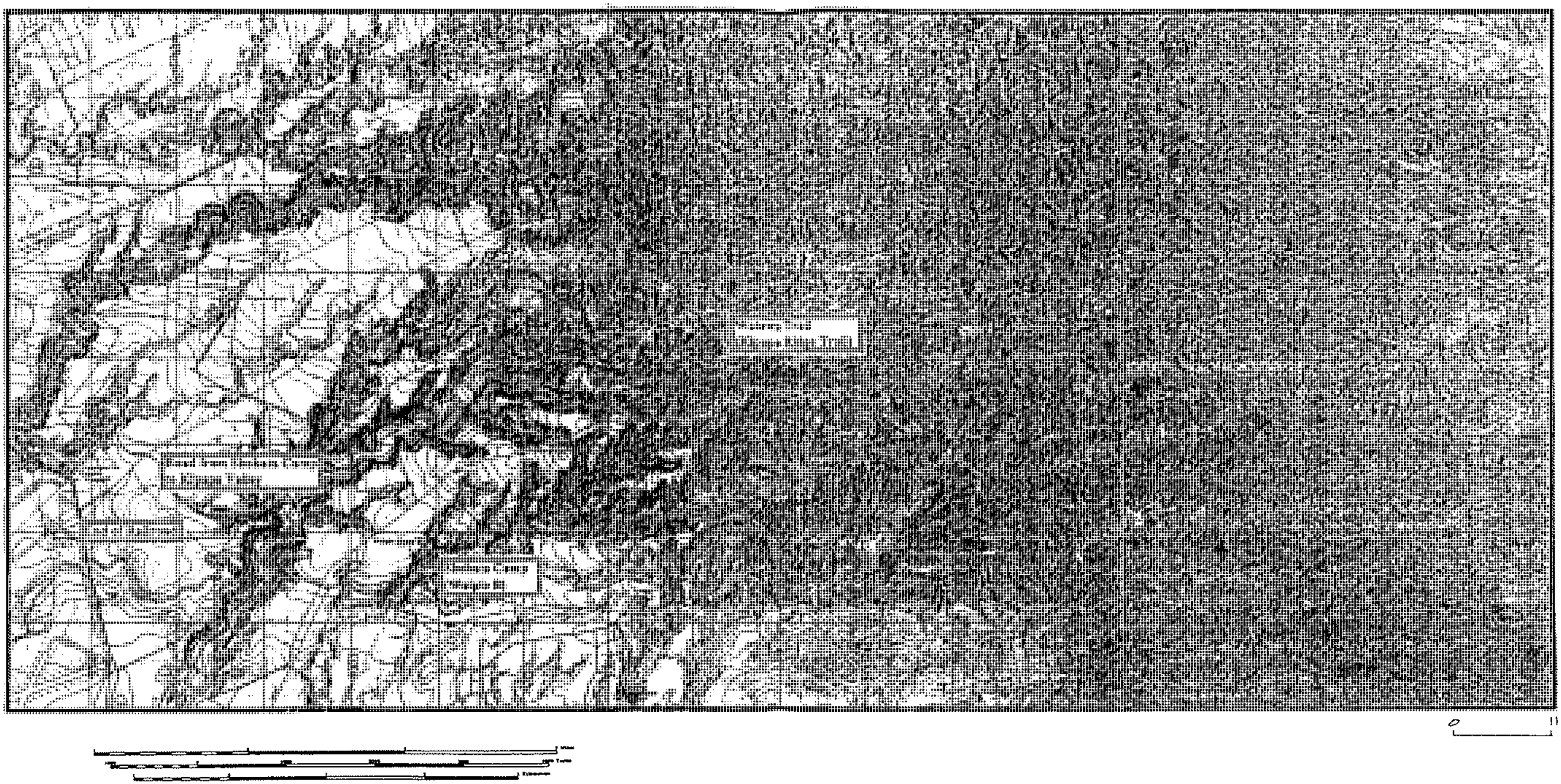

Figure 4 Portions of 1943 U.S. Coast and Geodetic Survey and US Army Map, Waikane, Kaukonahua and Aiea Quads.

All the children from the surrounding camps would attend the school. Some of the camps included Kīpapa 5 (K-5) located near where Olaloa Retirement Community is in Mililani Mauka today (where the grove of Eucalyptus trees Kamehameha Highway is today, Robinson 1 and Robinson 2 located between Waikakalaua Gulch and Kunia, Waipi'o (located where Mililani Town is today) and Shohata (located above Kīpapa Valley, up Pineapple Road). The kids would walk two miles to school and two miles back everyday (Interview with M. Arakaki, July 27, 2001).

K-1, K-5, Robinson 1 and Robinson 2 Camps were Dole Co. operated camps (Nedbalek, 1984).

The pineapple camp in the project area, Shohata Camp, is described as a small camp. One former resident, now in his seventies, recalls the camp had approximately 30 houses which had no electricity (personal communication, N. Toyama, July 24, 2001). Water was provided by a water tank. Our interviewed informant, Mr. Arakaki used to visit Shohata Camp to play with his classmates.

It was smaller than Waipi'o Camp [Waipi'o A Camp]. Mr. Arakaki remembers about 20-25 homes in the camp. He claims Shohata Camp had many trees and looked something like what Kaumakani Camp on Kaua'i looks like today. The Shohata Camp residents were of mixed ethnicity, but the majority were Japanese...The Arakaki kids would ride their bikes up a road which followed a small gulch up to the pineapple fields and Shohata Camp where they would play with their friends...This same road was used to transport pineapples from the fields surrounding Shohata Camp down to the last train station in Kīpapa Gulch. The pineapple were then transported out of Kīpapa Gulch to the Libby Cannery [see Figure 4] (Interview with M. Arakaki, July 27, 2001).

The date of the construction of Shohata Camp is unknown although based on the historic events occurring at the time, it was probably built sometime in the early 1920s. There is evidence that Libby, McNeil & Libby was accumulating land near or in the area of proposed development around 1915 (Liber. 434:228-235). Like the surrounding Dole plantation camps, Shohata Camp was disbanded in the 1940s. Most of the Dole pineapple camp members were relocated to Whitmore community near Wahiawā (Nedbalek, 1984). It is uncertain what happened to the Shohata Camp members who worked for Libby, McNeil & Libby. The only former resident of Shohata who was consulted left the camp before it was disbanded.

4. World War II in Waipi'o 'Uka

The military began the appropriation of Kīpapa Gulch around 1938 and during World War II used the rail system to "haul large quantities of ammunition" (Condé and Best 1973:315). Kīpapa Gulch was used for underground gas storage and underground ammunition storage (Allen, 1950: 229). The War had a great impact on those living in the Kīpapa Gulch, particularly those living in the lower gulch. The Arakaki family was evicted from their truck farm in lower Kīpapa when the military condemned the land during World War II.

They were relocated to the *mauka* part of their lease in Kīpapa Valley along with six of the other families. Mr. Arakaki described the move as a "set back" in the farm, where the family had to start over. He claims the military compensated them a few hundred dollars, but it wasn't too much. Some of the crops grown in the lower valley didn't do too well in the *mauka* regions and there were lots of wild animals that got into the fields, especially the sweet potatoes. The pigs would come, the rats would come, the birds knew exactly where the sweet potatoes were growing...One good thing about the relocation was that the farms were closer and the families weren't so isolated (Interview with M. Arakaki, July 27, 2001).

Even those who would use Kīpapa occasionally for such things as gathering plants, like the Makaneole family, needed to search for new areas to gather *mauka* of the military reservation. In addition to problems of access into Kīpapa, the greater problem was the potential contamination of the plants and water due to the types of military activities occurring in the area. Kalama described the lower portion of the Kīpapa Gulch as "contaminated" from use by the military (personal communication, K. Makaneole, July 19, 2001).

But, then the place over there, had it already. The soil no good, the run off no good because all above that is the fuel dumps. And they build that during the war days. Kind of wasted already (Interview with K. Makaneole, July 28, 2001).

III. TRADITIONAL CULTURAL PRACTICES

A. Burials

Neither of the additional two informants was aware of any burials in the project area. When asked about any possible cemetery in association with Shohata Camp, Mr. Arakaki did not recall a cemetery there.

He said that Oriental people would have their dead family members taken to the mortuary to be cremated. The families would then put the ashes in an urn and store the urn in the back of the church. Sometimes there was a separate building to store the urns. Masanobu's parents attended the Wahiawā Hongwanji and Nobu remembers that there were lots of old urns stored in the back of the Hongwanji (Interview with M. Arakaki, July 27, 2001).

No evidence of burials was found during the inventory survey and no burials are believed to exist within the project area.

B. Trails

A trail which ran from Pueohulunui in Waiawa to Kūkaniloko in Wahiawā was a major route connecting the 'Ewa District to the Waialua District; the alignment of this pre-contact trail is thought to have been situated southwest of the project area, near the present Kamehameha Highway (Hammatt and Shideler, 1996:12). John Papa 'Ī'ī also discusses a secondary trail branching from this 'Ewa-Waialua main trail:

> A trail ran from this main trail to Kalakoa, Oahunui, and other places much visited, such as Kukaniloko. From there it extended to the digging place of Kahalo, then went below to Paupalai, thence Lelepua, and to Kahalepoai, where the legendary characters Kalelealuaka and Keinohoomanawanui lived. Then it reached Kekuolelo, the stone in which the *niho palaoa* was hidden, then went on to Puunahawele and Puechulunui, where it met with the Waialua trail (`Ī`ī, 1959: 99).

`Ī`ī goes on to say that these places were once well populated, with fertile land and a wealth of trees. Kahalo, Lelepua, and Kahalepoai are place names mentioned in the *Māhele kuleana* claims. In the foreign testimony, LCA 8241XX, Walepoai (*sic.* Halepoai) is referred to as a ravine and Kahalo is called an *`ili `āina* which suggests it is a rather significant land division. The Land Commission Awards document Lelepua as an *`okipu`u* or forest clearing and an *`ili*. There is also record of *kalo `auwai* and an *alanui* or trail in Lelepua. The Lelepua trail may correlate to the one recorded by `Ī`ī. The exact location of these place names is not known however they are thought to be in the small gulches along the *kula* Punaluu (personal communication, D. Au, August 30, 2001).

A second reference to an upland trail beyond the `Ewa-Waialua trail appears in the Hawaiian newspaper *Ka Loea Kalaiaina*, this time in association with the legendary rock, *Pohaku-huna-palaoa* or what `Ī`ī referred to as Kekuolelo:

> On the plain [of Punahawele] was a famous rock, famed in the olden days as Pohaku-huna-palaoa (Ivory-hiding-stone). This stone was by the old road going from Ewa to Waialua, but not the road used now, this is the new road. This road (that I am speaking of) was farther up about a mile from the new road. The old road was inland (*Ka Loea Kalaiaina*, July 14, 1899).

If the "old" (pre-1899) trail was aligned a mile further *mauka* of what is now considered Kamehameha Highway, than this trail may have traversed the *makai* portion of the Koa Ridge Makai Parcel of the project area. No evidence of this trail was found during the inventory survey and more than likely no vestige of the trail remains in the project area after so many years of sugar cane cultivation on the tablelands.

In the 1996 Traditional Practices Assessment, there is a discussion on the possible *mauka/makai* trending trails. One such trail is documented as a foot path through the plain of Kanoenoe which led from the `Ewa-Waialua government road near Kīpapa Stream down to Waipi`o (*Ka Loea Kalaiaina*, July 22, 1899). It is uncertain if this old footpath crossed any portion of the project area, although it is possible considering the location of the "old" `Ewa-Waialua Trail.

A second *mauka/makai* trail in the vicinity of the project area was recorded in a study of 3,600 acres in Waiawa and was called a "possible aboriginal trail" [Site -2264] (Goodman and Nees, 1991:37). This site is outside the project area (Figure 3). The trail was found in the Pānakauahi Gulch and is described as 0.5 m wide and not paved, but worn from use. Part of what makes this site so significant is the associated complex of rockshelters, terraces and "possibly the largest concentration of petroglyphs (Site -2263) with the most varied motifs..." on O`ahu (Goodman and Nees, 1991: 129). Based on its

location and `Ī`ī's description of trails, this site is interpreted as a portion of the Waialua trail which was used to connect the coastal area of Pearl Harbor with the central plain surrounding Wahiawā. A similar interpretation is given for a complex of rockshelters and petroglyphs in the Waikele Gulch (Riford, 1986).

Goodman and Nees (1991: 130) also note the importance of the petroglyphs and trail at the location of the Waipi`o Waiawa *ahupua`a* boundary. They suggest the petroglyphs were made as travelers crossed from one boundary to another. There is a possibility the trail in Pānakauahi Gulch also served as a *mauka/makai* trail to mark the *ahupua`a* boundary from Pu`uloa up to the Ko`olau mountains. The Kīpapa Ridge Trail, which begins just beyond the Koa Ridge Mauka parcel, parallels the *ahupua`a* boundary almost up to the summit (See Figures 3 & 4). The Kīpapa Ridge Trail (called Waiawa Trail in a 1943 map), appears on maps as early as 1927 (Figure 3) and may have been based on an older *ahupua`a* boundary trail although it is also known the Civilian Conservation Corps was involved with the Kīpapa Ridge Trail in the 1930s (Interview with M. Arakaki, July 27, 2001). The Waipi`o-Waiawa *ahupua`a* boundary traverses the Waiawa parcel of the study area, however no sign of a trail was found during the archaeological inventory survey.

C. Native Hunting Practices

The 1996 Traditional Practices Assessment reported evidence of pigs from the Koa Ridge Mauka, Waiawa, and Kīpapa Ridge portions of the project area (Hammatt and Shideler, 1996: 15). Pigs were probably a part of the local fauna for centuries. The place name Waiakapua`a (LCA #8241R) in the *Māhele* documents suggests pigs were in the Kīpapa Valley in the mid 1800s. Traditionally, pig may have been an attractive source of meat considering Waipi`o `Uka residents lived some distance from the coast and did not have daily access to fish. In addition, pigs may have been a nuisance when food shortages forced them down to lower elevations where Hawaiians were cultivating dryland *kalo* and sweet potato. Such was the case when Masanobu Arakaki's family was farming in Kīpapa Valley in the 1940s. The Arakaki's *mauka* farm was situated up the Kīpapa Valley, adjacent to the Koa Ridge Mauka parcel of the study area. The sweet potatoes would lure the pigs into the fields. "To deal with the pigs which sometimes frequented the fields at night time when nobody was watching, they would tie a dog at the edge of the field who would start barking when they smelled the pig and scare it away. As kids, they would shoot the pigs with rifles" (M. Arakaki, July 27, 2001).

Hunting of pigs in the immediate vicinity of the project area has been documented as far back as the 1930s (Hammatt et al., 1996: 38-39). When he was a child in the thirties and forties, Mr. Arakaki would see many hunters hunting up in the valleys. "Back then, there were many hunters, of all nationalities. Hunters came from Kalihi, hunters came from Wai`anae to hunt in the Ko`olaus" (Interview with M. Arakaki, July 27, 2001). Apparently, hunting had already become a tradition by the time Mr. Arakaki was growing up in the 1930s.

Mr. Arakaki explained that one of the most popular access points to hunting in this part of the Ko`olaus used to be up by Shohata Camp, through the pineapple fields. A younger generation hunter who was interviewed for another traditional practices assessment in the Mililani Mauka area also described this route as an access route to prime hunting grounds (Bushnell and Hammatt, 2001, Appendix B). This access route is through the Koa Ridge Mauka parcel of the project area, following Pineapple Road *mauka*. This route has been closed to hunters and the general public for several years.

D. Native Gathering Practices

A good discussion on native gathering practices in the Waipi`o `Uka region is included in the 1996 Traditional Practices Assessment (Hammatt and Shideler, 1996:15-19). The objective in this supplement is to discuss native gathering practices in the context of the information shared through the interviews and the additional research conducted.

Gathering in the uplands of Waipi`o is specifically discussed by John Papa `Ī`ī (1959:77) who was born in Waipi`o in 1800 when he describes a famine: "This prohibition was called kapu `ohi`a because, while the famine was upon the land, the people lived on mountain apples(`ohi`a `ai), tis, yams and other upland foods". The Hawaiians dried the *`ohi`a`ai* first before eating it, thus avoiding a stomach ache (Handy and Handy, 1972:235). Even in the 1930s and 1940s, the mountain apple or *`ohi`a `ai* was used to stave off hunger in a small boy from the pineapple camp. Nobukichi Toyama recalls picking mountain apples in the valleys surrounding Shohata Camp (personal communication, July 24, 2001). Long ago, during hunting trips in the far reaches of Kīpapa Valley, Senichi Tanisue recalls collecting bamboo shoots, the tree fungus *pepeiao*(*Auricularia auricula*) and *hō`i`o* (*Diplazium [Athyrium] arnottii*) fern shoots. All of these were collected outside of the project area.

Gathering in the Waipi`o uplands was not just limited to times of famine. Certain resources only found in the upland areas were targeted for particular uses. One interview documents traditional gathering of plants and minerals in the Waikakalaua and Kīpapa Gulches (Interview with K. Makaneole, July 28, 2001). Kalama's mother, Esther Pahuanui Kauhane, grew up in Waikele near where the Waipahu Cultural Garden is today. It was she and her mother, Kalama's grandmother, who passed on the family knowledge of *la`au lapa`au* and *lomi lomi* as well as other modes of healing to Kalama. When visiting family in Wahiawā, Kalama would accompany his mother and aunts and uncles on their collecting trips. One of the things the Kauhane family sought in Central O`ahu was the four o'clock plant (*Mirabilis jalapa* L.) or what they called *pelekane*.

> It's blue or white tubular flowers that everybody knows that studied botany, it blooms, it opens up at four o'clock. It gives out–it has this black seed that they use it for making rattles inside Hawaiian instruments, kind of like *`ili `ili*. And, that see, black seed is what they used to extract the oils from, all the property from and they mix `em in the ointment...And that's what gives it its penetrating property to go into the muscle-and gives out this heat, you know, this four o'clock plant. And they used to go up there because used to grow wild up there (Interview with K. Makaneole, July 28, 2001).

The four o'clock plant grew more in the vicinity of Wahiawā. Another Hawaiian name given to the four o'clock plant was *nani-ahiahi* and is recorded to be a popular *lei* flower for the evening (Neal, 1965: 336). Other medicinal properties are given for the plant including the use of the kernel in the black seeds as a cosmetic.

Some of the plants Kalama's family collected for medicine in the Waikakalaua and Kīpapa Gulches were the *`a`ali`i* (*Dodonaea viscosa*) and the *laua`e* (*Phymatosorus scolopendria*). In addition to their uses in *lei* and decoration, Kalama is aware of how *`a`ali`i* and *laua`e* were utilized medicinally. According to Kalama, the bark of the *`a`ali`i* was smoked for its narcotic effect.

> KM: ... And then when people was sick, people was sick, thy used to blow `em into them, the *`a`ali`i*. And then what it does, it has this–
>
> CSH: Blow the smoke?
>
> KM: Yeah, the smoke, and have them breathe or burn 'em in our room. They burn 'em up, burn 'em in our room and let the patient breathe that because what it has, it has a narcotic effect, you know, on the person. And then it numbs the whole body. It's like a painkiller, that maybe say like marijuana. It's like marijuana, the *`a`ali`i*. Not too many people know that.(Interview with K. Makaneole, July 28, 2001).

Traditional gathering of *`a`ali`i* and its use in *lei* making is also documented in the Waikakalaua Gulch (Bushnell and Hammatt, 2001). Kalama describes the *laua`e* as useful in controlling blood sugar when taken as a tea (Interview with K. Makaneole, July 28, 2001). In treating advanced stages of diabetes, Kalama uses *laua`e* to draw out infections of the leg.

During the period Kalama and his mother and family collected in the Kīpapa Gulch in the 1950s and 1960s, access issues with the military and contamination of the lower gulch limited their collection to the upper gulch, *mauka* of the H-2 bridge. In fact, Kalama and his family collected in the vicinity of the truck farms of Kīpapa. As a young, agile boy, it was Kalama's job to descend the ravines and side gulches and harvest the *`a`ali`i* and *laua`e* while his mother and aunts and uncles waited for him on top. Based on his description of collecting localities, much of the gathering occurred on the sides of Kīpapa Gulch, probably adjacent to the Koa Ridge Mauka parcel and possibly in the upper limits of Koa Ridge Makai in the vicinity of the H-2 Bridge. According to Kalama, the *`a`ali`i* and *laua`e* grew in great profusion along the gulch sides.

Although Kalama and his family spent their days gathering medicinal plants and snacking on available, fresh fruits, one of their primary motives in visiting the Waikakalaua and Kīpapa Gulches was to collect *`alaea*. In *Māhele* documents, "Pualaea" appears as the name of a piece of land used as the *mauka* boundary of the *`ili* of Hanauaka in LCA 8241V. This suggests that *`alaea* was a noteworthy resource in Waipi`o `Uka. More than likely, Hawaiians living there gathered *`alaea* for their use. Traditionally, *`alaea* has been used in purification rituals and in conjunction with fishing protocol (Malo, 1951:

163:208). Mixed with other herbs, *`alaea* was a very common form of medicine (Gutmanis, 1989:47). "*`Alaea*, by itself, was added to medicines and foods for all kinds of hemorrhages and menstrual disorders, as well as for the general building-up of the patient" (*Ibid*). Such is the case for Kalama who uses *`alaea* to treat AIDS and cancer patients in order to build up their energy.

> ...I get people that get AIDS. That's what I give 'em besides they gotta watch their diet, take their medication. I give them something extra that kick 'em in gear for make their life better. You know, I cannot save them. But I can make that life perform better for them and be more active and being more aware of his surroundings, be able to enjoy your life and not being tired. This helps them. That's what I do. I give them that [gold *`alaea*] (Interview with K. Makaneole, July 28, 2001).

Kalama uses several different types of *`alaea* in his practice, but he prefers the gold *`alaea*, which he says is unique to central O`ahu. He claims the gold *`alaea* is stronger than the "Kaua`i *`alaea*" (or red *`alaea*) and attests to its ability to build up red blood cells.

> CSH: Now tell me again, you already told me, but just to have it on tape. What do you do with the gold *`alaea*?
>
> KM: Okay. This is a gift [referring to the gold *`alaea* he is holding]. I get this one student. He's--they got him on the mainland, he's researching this, in the mainland, for cancer. Because he gives it [gold *`alaea*] to the patient who has cancer. And then, because when they go through chemo [therapy] and they go through radiation, they don't eat. They lose their appetite. And if people don't eat, they die. And, he gives them that [gold *`alaea*] and then it stimulates the appetite. It brings up, builds up red blood cells... Because what it does is that if you take it full strength of that, it's like a methamphetamines. It create the body to come alive. It's like a rush (laugh). You know, it's like a rush. And, make it active. The old Hawaiians used to take that to stay up.

Two types of *`alaea* were found along the stream banks of both Waikakalaua and Kīpapa Streams, the gold *`alaea* and the white *`alaea*. The Kīpapa area also has the orange *`alaea*. The uses of the gold *`alaea* have already been outlined in previous paragraphs. The white *`alaea* is used externally for skin irritations and was traditionally used by Hawaiian women as a deodorant (Interview with K. Makaneole, July 28, 2001). Kalama explained that one of the most important factors in producing the *`alaea* is the stream water. The stream water gives strength to the *`alaea*. Before collecting *`alaea*, Kalama studies the stream from the roadway to judge the water level and see if the *`alaea* is submerged or not. Although he collects *`alaea* more often at Waikakalaua because access is easier, he does sometimes also go to Kīpapa.

In Kīpapa, orange *`alaea* is gathered from veins on gulch sides after landslides. According to Kalama, that is the best time to collect because the *`alaea* is in its cleanest, purest form (K. Makaneole, personal communication, August 16, 2001). Purity of *la`au lapa`au* is important to traditional practitioners because much of the foundation of Hawaiian medicine is based on detoxifying the body. Kalama discusses the effects of development on gathering localities in Waikakalaua:

> CSH: You mentioned that Waikakalaua was a place that you really like to get the gold *`alaea*.
>
> KM: Yeah, but now hard 'cause you gotta go more further up. Because, they get the run off from the housing into the stream. When they do that, it's gone already. You going get rubbish, you going get oil that comes off from the curbing when they wash their car, they working in their yard, oil leaks. They going be run down by the storm and they deposit inside of the stream bed. You going see a lot of development, they running 'em off into the stream. So, you gotta go more higher [into the mountains] because the contaminants (Interview with K. Makaneole, July 28, 2001).

In addition to the wild medicinal plants collected, Kalama remembers that his mother knew where all the fruit orchards were in the Kīpapa valley. During collecting trips, they would help themselves to avocado, mango, banana (*Musa* sp.), sugarcane (*Saccharum officinarum* L.), Hawaiian oranges, wild guava, and *`ōhelo* (*Vaccinium* spp.) berries. Many of the fruits were found on what Kalama described as old farms, however these may have included old *kuleana* lands as well. Linda Mahoe Gallano, caretaker for the Koa Ridge Ranch in the 1980s, was interviewed during the Archaeological Inventory Survey of this same project area. She remembered seeing fruit trees in association with what she described as Hawaiian homesites:

> It's right down here, you drop down, you go right down across the river and there's this big mango tree and right next to it is an orange tree and then there's this wide area that only has *`awapuhi* growing there. And there are rocks; you just know somebody lived there before. I had a *kupuna* come up once and he said they probably made *kapa* on this rock right there because it's right by this river so they could easily work on it but it's high enough the river that it's not going to get flooded (Interview with Linda Mahoe Gallano, June 1996).

All the fruit picking occurred within the Kīpapa Valley and not in the project area. Kalama also reported collecting ginseng (*Panax quinquefolias*) on the valley floor, probably a remnant of the Japanese or Chinese independent pineapple growers or truck farmers.

Māhele land documents indicate that there was *`iliahi*(*Santalum* spp.) or sandalwood in the Kīpapa Valley in the mid nineteenth century. A chief export to China in the early nineteenth century, *`iliahi* was prized for its unique fragrance and used in making chests, as incense, in perfumes and as medicine (St. John, 1947). A first generation missionary of `Ewa, Sereno Bishop, recalls hearing of a dry forest on the `Ewa plain which was burned off in the search for sandalwood (Bishop in Sterling and Summers, 1978:89). In LCA #8241YY, Kahuluhulu claimed an *`okipu`u* called Ahanaanaa in Waipi`o Valley. The western boundary of the *`okipu`u* is described as "kailiahi of konohiki", or the konohiki's *`iliahi*. That the sandalwood was claimed by the *konohiki* indicates it was of value. Also noted as a boundary in LCA #8241YY is *hau* (*Hibiscus tiliaceus* L.) claimed by the *konohiki*. *Hau* was a very useful plant, particularly its inner bark for making cordage (Summers, 1990:20).

Besides plants and minerals, there is little mention of other resources gathered from Kīpapa. Masanobu Arakaki talks about going fishing in the Kīpapa Stream as a boy. However, back then, the stream was different:

> Mr. Arakaki remembers when he was a child, Kīpapa Stream used to dry up just once in a while, perhaps once every two or three years. He believes that the increased development keeps Kīpapa Stream dry a lot of the time nowadays, because much of the groundwater is being tapped by wells. Before, the children used to catch fish in the stream and when it did dry up, there were little pools which maintained the fish, until the stream filled up again. Some of the fish they used to catch were gold fish, dojo-catfish, mosquito fish (guppies) and *`o`opu*. Mr. Arakaki felt that no fish could survive in Kīpapa Stream today (Interview with M. Arakaki, July 27, 2001).

`O`opu is the only native fish mentioned which may have been gathered traditionally in Kīpapa Stream, however there is no known documentation of this.

E. Other Cultural Concerns

Very recently, Cultural Surveys Hawaii, Inc. was contacted by the Wahiawā Hawaiian Civic Club with several cultural concerns. Although they were contacted early on in this research, no cultural concerns were expressed until recently. According to representatives of the club, there are several cultural sites in the vicinity of the project area including: "spring, *heiau*, *kā`anani`au* [boundary markers], navigational *pōhaku*, a wealth of native Hawaiian plants, other culturally significant *pōhaku*, burials and other cultural sites" (Personal communication, Dan Au, August 30, 2001). The representatives of the Wahiawā Hawaiian Civic Club did not wish to disclose the descriptions or locations of the aforementioned sites preferring that the client consult directly with them. The archaeological inventory survey conducted by Cultural Surveys Hawaii, Inc. produced no evidence that such sites exist within the project area per se. Castle and Cooke has previously consulted with the Wahiawā Hawaiian Civic Club regarding the culturally sensitive site, O`ahu nui located in the Waikakalaua Gulch, adjacent to the Mililani Mauka Phase III development.

IV. SUMMARY AND RECOMMENDATIONS

A supplement to a Hawaiian traditional cultural practices assessment has been conducted for a 1339-Acre parcel of Castle and Cooke lands in Waipi`o and Waiawa. Thirty two individuals were contacted regarding the project. Two additional interviews of knowledgeable informants of the Waipi`o `Uka area were conducted and further research was carried out on the place names and the Māhele Land Commission Awards.

The results of the analysis of the place names indicate there were several plants and some animals that were present in Waipi`o `Uka, mostly in Kīpapa that were traditionally utilized by Hawaiians. Their presence infers their traditional use. These plants include *`ulu* or breadfruit, sugarcane or *kō*, *pāpala*, *`ohai* and probably at least one variety of sweet potato. The animals included birds or *manu*, *pua`a* or pig and possibly the *moa* or chicken. In general, the place names suggest that cultivation was important although it is not readily apparent what exactly was cultivated. Several place names are

associated with legendary or historic figures or chants. These place names include the *`ili* and *`okipu`u* of Lelepua, the ravine Kahalepoai, the Gulch Kīpapa, the *kula* or plain of Punaluu, the *kula* Punahawele, and the *kula* Kanoenoe. Only the *kula* of Punahawele and Kanoenoe can be associated with the project area. Different sources document an old trail to Waialua which traversed the uplands of Waipi`o and crossed through the plains of Punahawele and Kanoenoe. The exact location of the trail is unknown, however it could possibly have been in the lower portion of the Koa Ridge Makai parcel. There is no sign of this early trail today. The trail was most likely destroyed in the early twentieth century when those lands were converted to sugarcane.

The *Māhele* documents suggest that dryland taro and sweet potato were probably the principal crops cultivated in the Waipi`o `Uka area. The numerous *`okipu`u* claimed suggests forests were being cleared to cultivate plants which would do well without irrigation, such as dryland taro and sweet potato. In addition, the multiple claims for *pali* and "*`okipu`u* in mountains" is a good indication that the steep tributary gulches and swales along the Kīpapa Gulch were being cultivated, possibly with *wauke*, *olonā* and *māmaki*. These plants were known to grow in the Waipi`o uplands. *Kuleana* lands were found to be located mostly in Kīpapa Gulch, in Waikakalaua Gulch and possibly in the small gulches in between the two main gulches. There is no indication there were any *kuleana* in the project area and none of the plants mentioned were found in the project area. However, it is very likely that many of the smaller gulches and tributary gulches adjacent to the project area, particularly adjacent to Koa Ridge Mauka parcel, were used to cultivate plants.

One of the individuals interviewed, Masanobu Arakaki, grew up in Kīpapa Valley and has lived there most of his life. He was very knowledgeable regarding the twentieth century history of the area and was able to give us some information on the early twentieth century independent pineapple farmers and the later truck farmers who farmed the Kīpapa Valleys. As a youngster, the Arakaki kids would fish in Kīpapa Stream and catch several fish, one of which was the *`o`opu*. No doubt, *`o`opu* was used traditionally by Hawaiians living in the area, particularly when the stream was cleaner and had not been affected by large scale agriculture. Mr. Arakaki was also able to inform us on the pineapple camp that was formerly located in the Koa Ridge Mauka parcel, Shohata Camp. A trail which led from the Camp and pineapple fields on the plateau land down to the gulch may have been built over an old trail, however there is no record of traditional use of this trail. As a boy, Masanobu knew the family which maintained the Waiāhole Ditch near the Camp and he was able to give us information on the historic Ditch (State Site #50-80-09-2268). Mr. Arakaki is aware of Hawaiian cultural sites in the Kīpapa Valley and he knows that the Hawaiians once lived there, however he has had little exposure to the Hawaiian traditions specific to Kīpapa Valley.

Our second interviewee, Kalama Makaneole does have traditional Hawaiian knowledge of Waipi`o `Uka which he gained from his mother who grew up in Waikele. His mother shared many stories connected to Waipi`o including stories of Kūkaniloko, Mā`ilikūkahi and the invasion of Kīpapa Gulch, and Kaupe, the legendary half-man, half-dog. During visits to his mother's family in Wahiawā, the family would go on collecting excursions; their collecting localities included Waikakalaua and Kīpapa in Waipi`o. Two medicinal herbs found growing wild on the sides of Kīpapa Gulch were gathered. These include the *laua`e* and the *a`ali`i*. The highly prized gold *`alaea* (earth) was also found in these gulches. Although Waikakalaua was favored as a collecting site due to easier access, `alaea was also collected from Kīpapa. The white `alaea and the orange `alaea were also collected from these areas. The gold `alaea is normally collected from the stream bed and the orange `alaea is collected from the gulch side after a landslide. Kalama and his family continue to collect in these locales, including in the gulches adjacent to the project area.

Based on the interviews, no traditional practices were recorded for the project area per se. However, the tributary gulches adjacent to the project area have been used traditionally for the gathering of a unique variety of *`alaea*, called gold *`alaea* as well as other varieties of *`alaea*. In addition, the medicinal plants *laua`e* and *a`ali`i* are also collected from the gulch sides. Use of the gulch sides for cultivation has been documented in the *Māhele*. Mr. Makaneole has expressed a general concern regarding how development has contaminated collecting sites and has forced practitioners to travel further into the mountains to gather. However, he did not feel the development would impact his collecting sites.

Contact with the hunting community during this project and the Mililani Mauka project suggests that access for pig hunting is an issue in the Waipi`o `Uka area in general. Two of the most popular hunting spots are located *mauka* of Koa Ridge and *mauka* of the Mililani Mauka community. Although the land within the project area is not known to be a traditional hunting ground, the project area has provided access to the traditional hunting grounds of the Ko`olaus in the Waipi`o `Uka region for the good part of one century, perhaps even longer. When the project area was formerly planted in pineapple, access was not a problem. Hunters of all ages who were consulted expressed regret and frustration at the loss of access to their hunting grounds. Many have stopped hunting or go to other hunting areas where access is not so difficult. Others try to sneak into their hunting ground one way or another. Although modern pig hunting is often not considered a "traditional cultural practice", it is associated with sustenance for many Hawaiians. Based on the input from hunters, we would like to encourage Castle and Cooke to work with the hunting community to try to create a safe access to traditional hunting grounds in Waipi`o `Uka.

The Wahiawā Hawaiian Civic Club has expressed its concern over several cultural sites they identify to be in the vicinity of the project area. These sites include a spring, *heiau*, *kā`anani`au* or boundary markers, navigational *pōhaku*, native Hawaiian plants, other culturally significant *pōhaku*, burials and other cultural sites. The description and location of these sites was not disclosed to Cultural Surveys Hawaii and our recommendation would be to consult with the Wahiawā Hawaiian Civic Club regarding their concerns.

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VI. APPENDICES

Preface to Interview Transcriptions

As part of this project, two interviews – one formal and one informal – were conducted by Tina Bushnell for Cultural Surveys Hawai`i. The formal interview was taped and transcribed. For the informal interview, detailed notes were taken during the interview process. The notes were written up, reviewed for accuracy and approved by the informant. Both the full transcript of the formal interview and the notes of the informal interview are included below.

The reader is reminded that the information shared in the interviews are the express opinions and views of the informants, much of which relates to their personal experiences, knowledge and family traditions. These are their words, their experiences and their stories. Please respect them by not using portions of the interviews out of context or quoting from the interviews without giving proper credit to the interviewees. These interviews may not be used in their entirety in any publications unless the written authorization of the interviewee is obtained.

Cultural Surveys Hawai`i is very grateful to both interviewees, Masanobu Arakaki and Kalama Makaneole, for sharing their thoughts and for giving so willingly of their time. It is hoped that the value of documenting their *mana`o* (thoughts) will be understood and appreciated by future generations of Hawaiians and that it will serve to perpetuate the Hawaiian culture, not only for Hawaiians, but also for those who seek to understand the depth and wealth of this rich, cultural heritage.

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APPENDIX A: Interview Notes with Masanobu Arakaki

Interview notes with: Masanobu Arakaki
Project: Supplement to Hawaiian Traditional Practices Assessment of Koa Ridge Lands
Interviewed by: Tina Bushnell for Cultural Surveys Hawaii (CSH)
Place of Interview: Kīpapa Valley, O`ahu
Date: July 27 and August 13, 2001

Mr. Arakaki was born in Kīpapa Valley, O'ahu in 1929. The third child of five, Masanobu spent the first twelve years of his life in the lower part of Kīpapa Gulch near where the Waiahole Ditch spans the Gulch. His father's name was Seiboku Arakaki and his mother's name was Nae Makamatsu. They were originally from Okinawa and had traveled to Hawaii to work in the sugar plantations. Mr. Arakaki thought they had met on Kaua'i at the Kekaha Plantation because he remembers his great uncles talking about Mānā and Kekaha and going fishing there. He remembers his mother telling him she had come to Hawai`i from Okinawa in 1919 with her brother and father to work in the sugar plantations. Nae Nakamatsu also had uncles who came to Hawaii. Masanobu's maternal grandfather lived with the Arakaki Family until he went back to Okinawa sometime in the 1930s. Masanobu remembers his grandfather as a healthy, husky man who surprised his family when he passed away of pneumonia about five years after returning to Okinawa. Masanobu doesn't know much of his father's history because his father died in 1944 when Nobu was a boy. He does recall that the Arakaki family was close with his uncles, two of his father's brothers.

Mr. Arakaki's parents moved to O`ahu and began to work for a private plantation farm in Kunia. At that time, the Arakaki Family lived at Leilehua Camp which Mr. Arakaki describes as a camp run by the priv. te Kunia plantation farm. It was here that Masanobu's older siblings were born. Plantation farm v ork was hard work and the pay was not too good, 75¢ per day. During the Depression, his parents decided to be independent or maybe the Kunia plantation farm let them go. Mr. Arakaki doesn't know for sure. They became truck farmers. They began to lease land from the `I`ī Estate in the 1920s. Mr. Arakaki doesn't know exactly when. The Arakaki family actually took over the lease of a farmer who was previously farming in Kīpapa. The Arakaki's grew sweet potatoes, corn, beans, bananas, chinese cabbage and sometimes irish potatoes. They sold their produce to wholesalers from Honolulu who would send up trucks to pick up the fresh vegetables and fruits. When asked of the origin of the term "Truck Farmer", Mr. Arakaki explained that when the State would come to survey them, the farmers had to fill out a form and tell what kind of farmers they were, whether sugar, pineapple, hog, chicken, etc... Truck farmer ended up referring to farmers who cultivated small vegetable crops with maybe some fruit on the side. There were several other truck farmers in the valley whose farms were scattered about ½ mile apart. Some of the names of the old time truck farming families are: Nakata, Shiroma, Asato, Kiyabu, Shiraishi, Higa, Harada, Kobashigawa, Abe, Konishi and Miyasato. Mr. Arakaki remembers a few Filipino families who also operated as truck farmers out of Kīpapa Valley but does not recall their names.

Mr. Arakaki related that he and his brothers and sisters used to help with the farm. On weekends and after school, the kids would help harvest and would take care of the chickens and rabbits. The chickens and rabbits were mostly kept for the family use. Mr. Arakaki describes his parents as "old-fashioned". They would farm with mules and irrigate with rain water. Prior to the 1940s, all the farm work was done by hand and with mules. Planting was seasonally, according to the crop and rainfall. During the summer, the family would go up the valley to a

leased piece of land they had there and plant where it was wetter (80-90 inches per year). During the rainy period, they would move to their leased land in lower Kīpapa and plant there (40-50 inches per year). For fun, the Arakaki children would hike in the mountains and swim in the stream. Mr. Arakaki remembers when he was a child, Kīpapa Stream used to dry up just once in a while, perhaps once every two or three years. He believes that the increased development keeps Kīpapa Stream dry a lot of the time nowadays, because much of the groundwater is being tapped by wells. Before, the children used to catch fish in the stream and when it did dry up, there were little pools which maintained the fish, until the stream filled up again. Some of the fish they used to catch were gold fish, dojo-catfish, mosquito fish (guppies) and *`o`opu*. Mr. Arakaki felt that no fish could survive in Kīpapa Stream today.

In the 1940s, the extension agents [Agriculture Extension Agents] visited the Arakaki Farm and helped them to modernize. The family bought a tractor and a water pump. The Arakaki kids were the ones who learned to use all the mechanized equipment. They drove the tractor and ran the pump. The extension agents helped teach the Arakaki children to use the new equipment.

The Arakaki children attended Kīpapa School. Mr. Arakaki related that Kīpapa School was built by Libby McNeil Libby for $50,000.00, a project which would cost millions today. All the children from the surrounding pineapple camps would attend the school. Some of the camps included Kīpapa 5 (K-5) located near where Ola Loa Retirement Community in Mililani Mauka is today (where the grove of Eucalyptus trees is located), Kīpapa 1 (K-1) located below where the Mililani McDonalds along Kamehameha Highway is today, Robinson 1 and Robinson 2 located between Waikakalaua and Kunia, Waipio (located where Mililani Town is today) and Shohata (located above Kīpapa Valley, up Pineapple Road). The kids would walk two miles to school and two miles back everyday.

In 1942, the Arakaki Family was evicted from their farm in lower Kīpapa when the military condemned the land during World War II. They were relocated to the *mauka* part of their lease in Kīpapa Valley along with six of the other farming families. Mr. Arakaki described the move as a "set back" in the farm, where the family had to start over. He claims that the military compensated them a few hundred dollars, but it wasn't too much. Some of the crops grown in the lower valley didn't do too well in the *mauka* regions and there were lots of wild animals that got into the fields, especially the sweet potatoes. The pigs would come, the rats would come, the birds knew exactly where the sweet potatoes were growing. To deal with the pigs which sometimes frequented the fields at night time when nobody was watching, they would tie a dog at the edge of the field who would start barking when they smelled the pig and scare it away. As kids, they would shoot the pigs with rifles. One good thing about the relocation was that the farms were closer and the families weren't so isolated.

At about the same time the Arakaki Family was being relocated, Masanobu was sent to work for Libby, for the plantation. This was due to the labor shortage caused by the War. Only Masanobu worked in the fields. His older brother helped the family move the farm up the valley. When asked about Shohata Camp [Waipio B Camp], Mr. Arakaki described it "was like any other plantation camp". It was smaller than Waipio Camp [Waipio A Camp]. Mr. Arakaki remembers about 20-25 homes in the camp. He claims Shohata Camp had many trees and looked something like what Kaumakani Camp on Kaua`i looks like today. The Shohata Camp residents were of mixed ethnicity, but the majority were Japanese. Shohata Camp gets its name from one of the supervisors from Libby, McNiel & Libby, Mr. Shohata. The Arakaki kids would ride their bikes up a road which followed a small gulch up to the pineapple fields and Shohata Camp where they would play with their friends. When asked if he remembered particular names of friends or classmates from Shohata Camp, Mr. Arakaki recalled Nobukichi Toyama and the Fujio Shibuya. The Shibuya Family actually lived adjacent to the Waiahole Ditch, a little distance from the Camp. They worked for the Waiahole Ditch Company and were in charge of opening and closing the locks and managing the water. The Waiahole Ditch Company had families living strategically along the ditch. There was even one family which lived way up in the mountains. When there was too much water, the excess was dumped into Waiawa Stream.

Mr. Arakaki relates that sometimes as kids, when visiting the Shibuya family, they would go swimming in the Waiahole Ditch near the Shibuya house. Near the house, the main ditch flowed into a small reservoir, approximately 20'x20' or 30'x30'. A wooden gate was maneuvered to adjust the flow into the reservoir and at the opposite end of the reservoir, where the reservoir once again became a ditch, there was a flat area with a measuring stick. Based on the measuring stick, one could tell how many thousands of gallons were flowing per day and thus how much water was being sent to central O`ahu. The Waiahole Ditch was the main artery which supplied water from Waiawa to Kunia. From the area near the Shibuya House, there were four pipelines which directed the flow to distinct areas. One pipeline went near the O`ahu Correctional Facility in Waiawa, one was near the Shibuya home, one went across Kīpapa Gulch and the fourth went across the Waikakalaua Gulch, in those days called the 'Robinson Gulch' (probably because of its proximity to Robinson Camp) to water the Kunia area. For fun, the Arakaki children would sometimes run up and down the pipeline in Kīpapa Valley. Mr. Arakaki believes the Waiahole Ditch still supplies the Kunia area farmers with water.

The Arakaki children continued to go to Kīpapa School until the eighth grade. From there they went to Leilehua Highschool. When asked about transportation to school from the Kīpapa *mauka* farm, Mr. Arakaki spoke of a neighbor who worked for the military and had a military truck. He would pile the kids into the truck and haul them off to school. After highschool, Masanobu took over the farm. His father had passed away in 1944 from complications after surgery to remove a kidneystone and his mother had run the farm with the help of her children. When the `Ī`ī Family sold their estate to Dole sometime in the 1950s, the Arakaki Family wanted to buy the land they were living on. Dole considered it, but then decided not to sell the Kīpapa Valley land. The land was later taken over by Castle & Cooke.

In the early sixties, the Arakaki Family moved to Wahiawā. Mr. Arakaki could not remember why exactly they moved there. The Arakaki's spent three years in Wahiawā. In 1966, the family moved to Waipio [now Mililani Town] and lived in an old plantation house that once belonged to a Libby McNeil Libby manager. They lived there for only a year when Mililani Town Association notified them they were going to tear down the house so they could construct all new homes for the new Mililani Town. Because they couldn't buy the lot, the Arakaki's decided to buy the house and move it down to a leased piece of land in Kīpapa Valley. The house was moved in 1966 and the Arakaki's have lived there since then.

Mr. Arakaki related that there have been many proposed ideas for developing the land inside Kīpapa Gulch including a golf course, however none of the proposals has gone through. In 1976, the H-2 Freeway Bridge was constructed by Hawaiian Dredging Company. This altered forever the peace the Arakaki home enjoyed. Now, during the *kona* wind, the noise from the bridge is really bad, especially when the big trucks drive by. There are also problems with people

throwing things over the bridge. Once, someone threw a heavy piece of metal over the bridge and it fell on the roof of the house causing damage. Another time, someone threw a driveshaft from a large truck over the bridge in the middle of the night. It hit the highwires and fell to the ground making a loud noise waking Mr. Arakaki up. A more disturbing thing that has happened several times are suicides from the H-2 Bridge over Kīpapa Valley (personal communication, Mrs. Arakaki, July 27, 2001).

Over the years, farming has changed. The truck farmers used to sell a variety of vegetables to the Honolulu wholesalers. Now, the farmers concentrate on just a few crops, mostly bananas and papayas. These are less labor intensive and require less toxic chemicals and less chemicals in general. The papayas of Kīpapa Valley used to be really sweet. Mr. Arakaki claims that at farmer's markets around the area, some people still ask for the Kīpapa papayas (personal communication, Mr. Arakaki, July 27, 2001).

When asked about Kīpapa Valley prior to truck farming era, Mr. Arakaki recalls his parents talking about the independent pineapple growers. These were farmers who grew pineapples independently and sold them to the larger plantations. Many of them grew pineapples inside Kīpapa Gulch. Mr. Arakaki remembers his parents saying how the independent growers lost out during and after the Depression if they didn't have a contract with the Plantations because the Plantations quit buying from the independent growers. If the growers had a contract, the Plantations were obligated to buy their pineapples, even if the pineapples were left to rot. As a child, Masanobu has memories of traveling up the valley and seeing stands of abandoned pineapple fields. There were even some scattered pineapple plants up on the gulch sides. One old timer told Mr. Arakaki that there was once a camp of independent pineapple growers about ½ mile *mauka* of Arakaki's leased houselot in Kīpapa Valley.

Mr. Arakaki used to hunt in the back of Kīpapa Valley and in the Ko`olau Mountains. Back then, there were many hunters, of all nationalities. Hunters came from Kalihi, hunters came from Wai`anae to hunt in the Ko`olaus. Even when Masanobu Arakaki was growing up, he recalls seeing many hunters. The Arakaki Family actually had problems with many hunters because they would steal everything from vegetables to the gasoline and oil which was stored near the family water pump. Eventually the Arakaki Family asked the hunters not to go through their farm land. Some hunters continued to sneak through though. In those days, most people hunted for the game and there were lots of pigs. They would use dogs to flush the pig and then kill the pig with a knife. Not too many people used guns to hunt because they might mistakenly shoot their dogs. Besides coming up through Kīpapa Valley, hunters would also access the Ko`olaus from up by Shohata Camp. They followed the pineapple roads up past the camp and left their vehicles there. Many of the trails in the mountains were created by hunters. Mr. Arakaki explained that back during the Depression, the WPA and CCC were up on Koa Ridge and cleared the trails and planted many trees including Norfolk Pine, Palm Trees, Strawberry Guava and travelers's plant (travelers tree). He believes that the CCC workers cleared the Kīpapa Ridge Trail, but that currently the trail is not being maintained.

When asked if Shohata Camp had a cemetery, Mr. Arakaki does not recall a cemetery there. He said that Oriental people would have their dead family members taken to the mortuary to be cremated. The families would then put the ashes in an urn and store the urn in the back of the church. Sometimes there was a separate building to store the urns. Masanobu's parents attended the Wahiawa Hongwanji Church and Nobu remembers that there were lots of old urns stored in the back of the church.

The road on the side of Kīpapa Gulch which led up to Shohata Camp upon which Mr. Arakaki and his brothers and sisters used to ride their bikes up to the camp, this same road was used to transport pineapples from the fields surrounding Shohata Camp down to the last train station in Kīpapa Gulch. The pineapples were then transported out of Kīpapa Gulch to the Libby Cannery. Mr. Arakaki recalls the railroad was run by Oahu Railroad Co. and thinks the line was used exclusively for pineapple, but doesn't know for sure. There was sugar cane being cultivated in the lower portion of Kīpapa Gulch, but Mr. Arakaki doesn't remember how it was transported out of the Gulch. Libby used the railroad track until about 1941 when the military took Kīpapa Valley over.

When asked of stories from Kīpapa Valley, Mr. Arakaki mentioned worshiping stones. He spoke of a half-moon shaped stone with cobble sized stones circling the half-moon, located on the side of the stream approximately 500 feet *makai* of the H-2 Freeway Bridge. One day when he was out looking for bamboo, he came upon the stone and "got a funny feeling". Near the stone there were mountain apple trees, bamboo and other trees. Mr. Arakaki says that after talking to a Hawaiian woman who worked for Kamokila Campbell, she said the stone was a worshiping stone used for asking for abundance of fish and water. Mr. Arakaki also remembers long ago, a neighbor farmer had a similar half-moon shaped stone in one his fields that the farmer wanted to move. The farmer tried and tried to move the stone, but could not move it. Another story Mr. Arakaki related was of the headless and appendageless corpse who used to wander up and down the Kīpapa Valley swinging a lantern (M. Arakaki, personal communication 7/27/01). The lantern was described as one they used to use in the trains.

One of the final stories both Mr.and Mrs. Arakaki told was about a visit from an old Hawaiian women. When the Arakakis first moved back down to Kīpapa Valley in 1967, Mr. Arakaki's mother lived with them. Apparently, she was the one who received a visit from an elderly Hawaiian women who told Mrs. Arakaki that she used to live there fifty years ago. This would have been in the early part of the 1900s.

APPENDIX B: Transcript of Interview with Somerset Kalama Makaneole

Interview with: Somerset Kalama Makaneole (KM)
Project: Supplement to Koa Ridge Hawaiian Traditional and Cultural Practices Assessment
Interviewed by: Tina Bushnell for Cultural Surveys Hawaii (CSH)
Date: July 28, 2001

CSH: So here we are at Kalama Makaneole's house. And we're gonna talk about the Koa Ridge Project and also Kalama's life. Kalama, can you tell me about where you grew up?

KM: I was born and raised in Honolulu. Our residence was on the slope of Punchbowl. And I grew up in the Punchbowl, Tantalus area. Public school, Pauoa Elementary, Kawānanakoa Intermediate, Roosevelt High School. I'm the son of William Makaneole whose father is Harry William Makaneole and Harry William Makaneole is the son of Makaneole and Makaneole is the son of Keoua Pe`eale all originally from O`ahu. My mother is Esther Pahuanui Kauhane. She's the daughter of Solomon Kauhane. Solomon Kauhane is the son of Solomon Kauhane Ha`o and Solomon Kauhane Ha`o is the son of Kukai Ha`o of Waipi`o and as well as Waikele who is the descendent line of John Papa `Ī`ī. And, as we know who has the Royal Patent for the valley of Waipi`o on O`ahu. And they were cousins and we have land documents in the archives that-- which was awarded to our family by John Papa `Ī`ī, who worked as-- who at one time had the land entitlements just prior before the overture of the monarchy government. He was the-- at one time a retainer for Kamehameha Great's first born son and later in life, he became a noble with Kauikeaouli as well as Kalakaua as well as Liliuokalani. My mother's family, originally has always been in central O`ahu. They are descendant of high chiefess Kalanimanuia who is the mother of three sons, whose sons are Kuamanuia, Kilikapumanuia51 and Ha`o, which is my mother's descendant line. And, a sister by the name of Kekela. Traditional medicine and practice has always been a part of our ancestral lines as traditional healers. My mother and grandmother did laying of hands. They also did work with holistic medicine and my father was a nurse with Queen's Hospital. He taught me basic CPR, First Aid, anatomy and as well as home remedy. I began to practice as a traditional Hawaiian practitioner at the age of five. I worked with a lot of elderlies and members of the church that were unable to care for themselves. It was my mother and grandmother's kind generosity to help the elderly as far as feeding, home care and dressing their wounds and preparing them, at least on a daily basis. And my job was to bathe them, prepare them and massage them and that was instructed to me by my grandmother who showed me the way as far as techniques. And as I grew, I needed to be a teenager, needed to continue my education, move on, into the military. I've done four years with the United States Navy. I'm a veteran of Vietnam War. I served one tour in Southeast Asia Chulai. And I was discharged from the United States Navy with an honorable discharge. I continued my education on a university level using the G.I. Bill and I hold a mechanical engineer [degree]. [I'm] presently employed with the Department of Public Safety as a General Construction Maintenance Superintendent. I'm Chief Engineer for Halawa Corrections. I also continue doing traditional practitioner. I mastered the arts of traditional *lomilomi* as well as *la`au lapa`au*. I also do consultation through *ho`oponopono*. I also do spiritual blessing which is the power of the prayer and I've dealt with the dying as well as the dead through spirituality. I continue to do this work and were taught by several individuals that have contributed to the alternative healing. I was student and assistant to Papa Kalua Kaiahua of Maui which I've studied with for five years. I've studied under David Kealakea of Maui in *la'au lapa'au*. I've studied with Auntie Napeahi of the Island of Hawai'i in *ho'oponopono* who is relatives of my mother and a close friend as they grew. I attend many health conference pertaining to the native Hawaiian health care. I've done numerous engagements with Ke Ola Mamo, numerous workshops with Papa Olokahi. I've continued to use God's means as his instrument to help those to be able to help themselves. I resided in the Wahiawā District for the past 25 years. I have taken numerous hikes and outdoor throughout Central O'ahu. I have identified with a native species plants in that area and it's such a beautiful place, real close to God, away from the hustle and bustle of downtown Honolulu. It's very centralized, tranquility, a means to be by yourself, to be able to meditate and to release the stress, a way to find yourself again and to be in tune with Mother Nature. I have always asked permission to be able to gather plants. I've always thanked Him for this blessing that be able to use this as an instrument of Your healing and I continue to do this work. Presently, I reside at the Nānākuli Homestead. I've been residing at Pohakupalena for the last two years. I still serve those who are in need of help and continue to do God's work.

CSH: Wait, I only asked one question.

KM: That was a short introduction. OK (laugh).

CSH: Thank you. So, what, can we go back to your childhood? Can I ask you about how you grew up in Pūowaina and what you did with your brothers and sisters when you were a little kid?

KM: I'm the youngest of twelve children, as far as the boys. Five brothers and six girls and the twelfth was actually *hanai*. Mama took her, because she was born out of wedlock of my older sister. Instead of give her up, Mama adopt her. She grew up as one of our own sisters, yet she was my niece. This is what we call *hanai*. Growing up with my brothers and sisters was a battle. It's like, when time for supper comes, you better be there (laugh). It was really great growing up with my brothers and sisters because we kind of outnumbered everybody else in school. We always had someone from the sixth grade down to kindergarten-- there was Makaneole and we always look out for each other. And we all went to school together and we made sure that the younger ones always would come home. Growing up in Punchbowl area was a life experience because it was like, it was people that you grow up with and some became very famous. For example like, I grew up with people like Eddie Akau who was the big board surfer, one of the members of crew of the Hokule'a and he had some complications and Eddie decided to seek help with his surfboard, but apparently, he was never seen again.

CSH: This was Clyde?

KM: No, this was Eddie. Clyde was his younger brother. Clyde was my classmate (laugh). They had, the Akau family also had a lot of brothers and sisters that was from the sixth grade to kindergarten (laugh). So, we were really close.

CSH: With the Akau Family?

KM: Yeah. Well, the other kids in the neighborhood, we was really close. Their parents and our parents share a lot of things. They didn't have to go doctors 'cause my mother and grandmother were midwives. All my sisters and brothers was born in home.

CSH: You too?

KM: No, I was born in Kuakini Hospital.

CSH: Oh yeah, how come?

KM: Because my grandmother didn't have the hands anymore, she was getting too old.

CSH: She lived with you guys?

KM: Yeah, my grandmother lived with us. And, my mother did all the midwife work for the rest of the neighbors and there were other women there that does midwife so, kind of grew up and we observe and watch this process. We had a lot of sick people come over our house and mom and grandma used to help them. And, there were lots of people (laugh).

CSH: Your house was always full.

KM: Yeah, was always full. Yeah, and we were taught more in the English because there weren't Hawaiian language spoken at school. We were growing up in a way where English was the first language. Didn't really learn about Hawaiian culture until we was in High School. We were forbidden to speak Hawaiian when we was going to school. A lot of times we would speak Hawaiian with our neighbors and church members, but we were forbidden to speak Hawaiian language at school. I went to English Standard School so-- that makes any difference.

CSH: But your grandma and your mom spoke to you in Hawaiian?

KM: Yes, my dad, my mother, my grandmother. They spoke fluent Hawaiian. Aunts and Uncles, friends and neighbors that were Hawaiians spoke Hawaiian in the house. That was the language as we were growing up. Apparently, they really didn't want us guys to hear what they were talking about. It was like my older brothers and sisters spoke Hawaiian 'cause--so did I because we was cared by our grandmother, so. Grandmother only spoke Hawaiian.

CSH: What did you call your Grandma?

KM: Auntie Ku, I mean Grandma Ku. Her name was Kuahalahala, Kuahalahala Kuali'i.

CSH: And, I forgot to ask you, what year were you born?

KM: I was born in August 17, 1948. And presently, I'm gonna make 53. Fifteen years ago, I was documented by this research group as being one of the youngest traditional practitioners in the State of Hawaii. And they were 25 practitioners interviewed on the Island of O'ahu and I was one of them. And I was the youngest Hawaiian practitioner on the Island of O'ahu.

CSH: So, you grew up with a lot of activity around you. You said you went to church. Which church did you go to?

KM: We were members of the Latter Day Saints, Church of Jesus Christ, Latter Day Saints. I was baptized as a Mormon. My father was a high priest. At the age of twelve, baptism as far as to manhood was at the tabernacle which is at Lā`ie. And it was forbidden for many foreigners from entering this sacred baptism ground. Today, now it's open to the public. But, when I was growing up, was forbidden that anyone outside of the high priests and those that have been baptized, be able to enter. But, it was forbidden to the public and different beliefs. My father instructed me and taught, that I need to recite it, I need to recite my family genealogy line, prior before baptism. So, for months I would practice the recital and it is forty nine lines, forty nine lines of my genealogy that I needed to recite because for each name from the beginning--I am the way, that he be able to enter the Kingdom of Heaven, because he wasn't baptized. So, I baptized for the dead so that the spirit no longer be able to walk the land and be able to enter the Kingdom in Heaven through me and baptism. So, I needed to baptize forty nine times in order to complete the baptism. And, it was a very wet experience (laugh).

CSH: That's when you were twelve?

KM: That's when I was twelve. I attended primary. I attended seminary classes growing up and the classes was conducted at six in the morning. So, I needed to get up to attend seminary class, so I could be able to go to school and continue my education as well as in high school. But then, I worked, I was supposed to go on my mission, but other things happened in life. They had the war going on in Vietnam. And, on my eighteenth birthday, I got my draft notice. I didn't want to the Army, so I notified the draft that I going volunteer to join the United States Navy. But, it didn't work out the way I wanted it to work out.

CSH: You wanted to or didn't want to?

KM: I didn't want to go to Vietnam. And if you get drafted, we all knew that you're going to Vietnam. So, to avoid the draft, they gave me thirty days to join any branch of service outside of being drafted in the United States Army. So, I chose the United States Navy. But, eventually, two years passed by I wind up going to Southeast Asia, stationed in Chulai in the United States Navy, in PBRs. That's Patrol River Crafts. We were known as Brown Water Sailors. I cannot mention what I had to do. And (pause), it was an experience that I will never forget, but you know, it really helped in later life as far as financial aid, as far as my education as well as for financial help for, as far as the loan to construct my home. So, it was beneficial. I attended numerous Veteran's meetings in the neighbor islands. I'm not suffering from post trauma stress disorder because I really in tuned with my higher power and move on in life. I don't try to reflect on my past.

CSH: That was a tough experience. How do you communicate that to your children? How do you tell them about those kind of experiences?

KM: Well, my kids, they understand that I've served in the United States military as well as all of my five brothers. As a matter of fact, all of them retired from the military. My uncles were all retired from the military. I come from a family of warriors, whether the United States Government or the warrior chiefs of O`ahu. We were warriors, always have

been. I identify themselves with that. I explain to them, 'you come from a line of warriors'. It was honorable to serve our country, though I didn't get the respect when I got out of the service. But, it's okay. That's life. We need to identify the sacrifice that was given so that we all be able to enjoy the freedoms that we have today. And, they made the ultimate sacrifice; they gave their life whether they were of all different ethnic race. They were the sacrifice, so that we would be able to live in a more peace environment. I mean a lot of folks back home, they don't really understand until they actually walk the mile, walk the edge to see the third world and undeveloped countries are really being denied by their government and why there are so much wars because people out there, they're starving. And when you starving, you get angry and frustrations set in and people destroy people because they hungry. And, we participate in a war that wasn't too favorable and thank President Nixon for bringing us guys out although we all know what happened to him, yeah.

CSH: So, what happened when you came back from the war. What did you do?

KM: When I returned home, I (pause). I wanted to take care of my parents. But I wasn't too fortunate for that because about a week later, my father died.

CSH: A week after you got home?

KM: Yeah, he had a heart condition. He had a heart attack at work and he never recovered. So, that ends my relationship with my father. He just abruptly had a heart attack and passed away and so it's a matter of me to take care of myself and started working and find me a job and in about a month time, found a job working in the trucking industry. That was where the big money was at (laugh). Yeah trucking. It was a teamster job. I got work there through a neighbor that grew up with us, James Lau. He was Operations Manager. He approached me at the funeral of my father and he asked me and he says, 'you take some time off, and when you ready, you come see me and you start working for me'. And so, I stayed with him, worked for him for about three years. So, I decided ey, save up some money and decided 'what I going do, I think I better go school' (chuckle). Can't be doing this all my life, it's hard work. So, took advantage of the education bill from the VA. And it was good for about ten years. You can use it up, ten years. So, I took advantage of that. So, financial help was there.

CSH: Where did you study?

KM: I studied at Leeward College and I went on to the University of Hilo, I went to Hilo. I got my Associates Degree. And, I needed to get a job (laugh). And, so I went into the Carpenter's Union and eventually went into the Plumber's Union and worked as an apprenticeship. Went on to work into other areas, Paradise Estate, Mr.Goodman was a multi-millionaire, hotel developer, condominiums developer. I was his engineer, maintenance, upkeep, landscaping, pools, electrical, plumbing, and later on I went into the Mililani Town Association and did all of their pool equipment pumps, worked with all of the electrical, plumbing throughout Mililani Town Association, all of the Rec facility.

CSH: When was that?

KM: This was in the eighties. Then I started into the State of Hawaii which I'm presently there today. I moved up through the ladder to where I'm the Chief Engineer. I take care, maintenance, upkeep, all the refrigeration, air conditioning, all of the generator system, backup system, all of the boiler units that provide hot water and maintenance of all of the security systems throughout the facility, and major capital improvements and try to review with the consultants that are hired out by the state and how to fit my program, * facility program that would deal with on-going repairs to minimize the cost efficiency, energy savings and as much as possible to generate work that may he cost effective. Certain capital improvement work can be used with a joint venture with the facility and private industry where we utilize the inmate labor force to reduce the cost as far as the tax payers dollars. And, it's on-going, it's a city of its own. What's important is the welfare, and the safety and the health condition of the ward as well as the employees there. It's never-ending, on-going city that needs to be maintained.

CSH: What year did you start working for Halawa?

KM: I started working at Halawa Corrections back in 1986.

CSH: And you've been working there ever since.

KM: Yes, since 1986. I started on the bottom as a maintenance worker and then eventually, developed to be Chief Engineer. I'm very well respected among my peers and the wards and other staff members in different sections, divisions as far as getting the job done.

CSH: Do you ever have much contact with the wards?

KM: Contact witb the wards is a daily thing for me because I need to create jobs, need to stimulate on-the-job training, classroom work that concerns safety and health in the workshop. Also, need to develop their skills so they would be able to take that with them and use it and be more productive into the community aa they leave their mandatory time. Hopefully, they will continue to use these gifts as a means to provide some source of income, or some source of good handyman around the house (laugh). It's a learning experience for them in providing job skills for them, providing consultation, providing them with a supervisor knowledge they be able to understand orders, how to deal with command, voice command, be able to understand the difference between right and wrong, and be able bring out their skills and their knowledge and to have a good relationship with their peers as well as their immediate supervisor, care of government equipment. These on-going need to be evaluated, need to be praised, where they need improvements, whether their learning skills needs improvements, need to counsel them and show them their areas, their wrongs and then to give them instruction so that they will be able to improve the discrepancies that doesn't fit the needs so that he needs to be monitored for at least thirty days and see what kind of improvements that he has and then if he does make improvements, than hey, give him praise, because he earned it. Don't reprimand him or counsel him if it's--because it's not done correctly, but then, ey, if you monitor, observe, explain that you will be monitored, that this will be for thirty days, and looking for improvements and if its satisfactory that he learn. Then by all means, give him praise. He deserves it.

CSH: So, tell me about how you met Auntie Ruth.

KM: I met her in a nightclub (laugh). And, I was single. I was with a friend of mine and she was with a friend of hers. Met in a nightclub.

CSH: In Waikīkī?

KM: No, it was. There used to be this place by Pi`ikoi. Used to be Stardust Lounge, there used to also he Stardust Lanes, it was a bowling alley. I used to like to go that Stardust Lounge because they had Nephi Hanneman, Kalani Young. They were entertaining there. And they had Paulette Sai, she was also entertaining too. I kind of grew up with them and I grew up with Kalani, Kalani Young as well as with Paulette Sai. They were all entertainers and Makawa Brothers also grew up with us at Punchbowl, Papakōlea. They all was in the entertainment field and one other girl, Kalua also was in the entertainment field. So, kind of grew up. A lot of the guys I grew up with became professional entertainers. Kind of support them, Hawaiian music, contemporary music. They had a nice atmosphere and you know, local people and it suits me and my friend. And another place we like to go to—not to get off the track where I first met Ruth, Auntie Ruth—there was another place by the old HRT bus terminal, also another nightclub there, Billy Gonzalves, they all from Punchbowl. So, we used to like to go there a lot and then we used to go down to Stardust Lanes later on. Well, we used to start off by HRT and wind up by the Stardust Lanes. That's where I met my wife. It was very electrifying from my experience. I knew she was the one. It just, wow,** It was like thunder and lightning, felt this huge energies when she walked through the door and it was like 'WOW' and I could see this huge aura, this energy, it was like a rainbow, just glowing over her and I knew that she was the one. I got very attracted to her, I didn't want it to end, that one dance (laugh), or that one drink. You know, it usually comes with the drink. You know 'go order this girl some drinks over there'. Start off like that and then you gotta walk up to them and say 'how about dance', get to know each other, feel each other out and see if it fits. And, things just caught on that night, and I refused to end it there.

CSH: So, then you just kept calling her up and meeting each other.

KM: I didn't ask for a telephone number, I asked her where she lived (laugh). 'Cause the next day, I was up the house. I went visit her. I met her family, father, sisters and brothers.

CSH: Did, she have big family too?

KM: Yeah, she had a large family. Small, she had a small family. But her aunts and uncles, wow, they were quite a bit. For, her sisters and brothers, they were small. They were three sisters and one brother. There were only four in the family, compared to my twelve.

CSH: And where did they live?

KM: She was born and raised in `Aiea, up in the Heights, `Aiea Heights. Her father was a former, retired pipe fitter from Pearl Harbor. He's Irish-Hawaiian. Her mother is from the Island of Maui, Kepoho, Kepohakukimohewa. Her mother's parents were the principal of Lahainaluna. They were all in education. Her dad is from, originally from Mākua [tape reversed].

CSH: That was what war time, World War II?

KM: That's before World War II. The parents were Hawaiian, Irish, Hawaiians. His father was Portuguese. His mother was Hawaiian.

CSH: This is Ruth's father you're talking about.

KM: Ruth's Dad. And, his name was McShane and McShane married a Phillips who was from Portugal. No, his, his...Yeah, he was a Phillips, but they changed his name. And, they were also from Mākua, hired as-they came for the sugar industry, but then they was hired as *lunas*. They were all camp police. So, my wife's side, father's side was camp policemans. They married Hawaiians and they eventually–the McShanes married Phillips and Phillips before was, his name was Emanuel, so actually his name was Phillip Emanuel. So, he changed his name to Phillip. Then, Phillip's daughter married McShane. So, it was like Emanuel came from Portugal, he changed his name to Phillip which is Portugal and Phillip's daughter married McShane. And then from there, thus we got my wife's father. He married Hawaiian. His wife was pure Hawaiian. Phillips-McShane, my wife's father was half Hawaiian. His mother pure Hawaiian, his father was Hawaiian-Irish and then it goes back all the way to Phillips, all Portuguese. So, my wife is Hawaiian, Portuguese, Irish. I'm pure Hawaiian. I'm 100% Hawaiian. Then, that's how I met my wife in, the nightclub.

CSH: So, you folks married and moved to Wahiawā?

KM: No, we got married, we lived in town.

CSH: When did you get married?

KM: I got married in 1974, 1974.–and, lived in town. Then, I think about a year or two, I started 'ey, you know, we go live Wahiawā, we go move out Wahiawā' 'cause it's a place that I always loved. We used to go there a lot, weekends, with my parents. My aunts and uncles, they bought residence up in the California Avenue back in the fifties, early fifties. My aunts and uncles, they bought place up there. We used to go up there every week (emphasized). And then I had another uncle and aunt, they were in the Army. My uncle was serving with the Wolf Hounds at Scholfield Barracks and they lived on base, at Schofield Barracks. So, we had a lot of my aunties and uncles on my mother's side all living up in Wahiawā, central O`ahu. At that time, it was nothing but pineapple fields. You know, the road used to come off by Farrington and where Waipi`o, used to be nothing but pineapple fields. And then, you looking one side and you coming up by Waipahu, you get sugar cane. Then when you pass the sugar cane, you get nothing but pineapples which is Waipio Gentry today. You going, and all you see is pineapples, nothing but pineapples. And then, you got a little, small homesite down at Waikakalaua. Not very much homes over there. Was mostly all–

CSH: There was a homesite down there?

KM: Yeah there was a homesite over there, they had one small residence yeah, in Waipi`o, very small residence. Then, they used to get this bar over there.

CSH: Over where?

KM: Over, in Waipi`o. It was like one country bar.

CSH: You mean, where the camp stay?

KM: No, you know when you coming down by–you know where today, now the Mililani Golf Course? You know the main drag, you come down, eh? You come down the hill, you get that Korean store over there. That place right there, used to be one bar. Used to be one old water hole. And all up in that area, was all camp sites. Used to be all pineapple camps. We used to go up, pass through there and go to Wahiawā every week, spend the week, at least three times a week, we used to go up there.

CSH: And what did you do up there when you went to your aunty and uncles'?

KM: I build canoes, sail all of where is known as Lake Wilson. Paddle canoes all up there, all in the stream beds and whatnot. Went all the way up to East Range. But, a lot of activities, Army activities going on over there, 'cause of the East Range. Went up there. My mother and auntie them used to go get plants and medicine. And apparently, I think this is why my mom went up there for, to get medicine to bring home, because she always brought home something. The gold *`alaea*, she always had 'em in the cabinet. And then, she used to take me with her and some of my aunts and uncles, we used to go get some medicines, all around in that area.

CSH: What kind of things did they collect over there? This is in the back of Wahiawā or all over-?

KM: All central O`ahu. Yeah, all of central O`ahu. She knew exactly where all the fruit orchards was anyway. 'Cause a lot of the sites there, it was one time residential, like farmers. But, then the place was abandoned. So, you get a lot of fruit trees, avocado, sugar cane, they had mangos, had banana just growing wild. So, we never starved, oranges or whatnot.

CSH: This was up in the valleys?

KM: Yeah, all in the valleys.

CSH: Even in Kīpapa and Waikakalaua?

KM: Yeah, it was all inside there. Had a lot of vegetation inside there. A lot of earlier sites of truck farmers, or makeshift farmers at one time. But then, a lot of guys go there, used to, back in the sixties, they go dirt bike riding inside there. And half the time, they don't even see you because they too busy looking at the ground. They focusing too much on the trail, you can stand ten feet in front of them, as they coming up the trail, they never see you because they too busy looking at the ground.

CSH: Did they run you over?

KM: No, you just gotta watch them. They don't even see you. Because they too busy looking at the ground so that they no fall off the bike, oh hit one hole, [unintelligible]. You know, I like it up there. I really liked it. I moved there because I liked it, I like the place.

CSH: Did you used to go out with your mother when she went on her collecting trips?

KM: Yeah, I did. As a matter of fact, she took me to the birth site [Kūkaniloko] and she gave me one oral history of the place, why it's so important, the birth site is. She says now, we gotta respect this place because it's the place of your ancestors. That's the birth site [looking at two prints of Kūkaniloko hanging on Kalama's wall]. That's Mount Ka`ala, that's the birth site. And this one here is actually how they gave birth. It's a form of assistance for the high chiefs, observed by the young warrior chiefs that bear witness to the birthing. So, this is this one. That's the proof print of today, now they have what you call an interpretation sign on the historical site.

CSH: And who made those, who created those drawings?

KM: This is actually how the place look like. All the stones. It was actually a photograph and the artist, Parks, Jim Parks, sketched that. But, this, it's related to what the "Sites of O`ahu" described the birthing process, a hollow place somewhere in Wahiawā known as Kūkaniloko, birth place of the *ali`is*, observing by 36 warrior chiefs. But then what they say is the birthing process was never, ever been disclosed because they call it the tabu of Līloa and they never knew how the high chiefess actually gave birth on the stone. No one knew this, to this day. Historians didn't know, leading senior Hawaiian historians, they didn't know. No one really knew it, except me (laugh). And, I showed them how they gave birth--why they selected this particular *pōhaku*, that the stone was actually an equipment, an instrument to assist the practitioners in the proper means of giving birth of someone that has the highest *mana* or the highest ranking of that order at that time. And, it was defiant for this *kapu* princess to have her feet even touch the ground. She was always escorted with a retainer either on a *mānele*, or they carried her on their shoulders where ever she went. A *mānele* is a litter, carriage. It was tabu to have her feet touch the ground and the only time she would place her feet on the ground would be in this sacred enclosement which is her compound, her living quarters. She lives a really secluded life with so many restrictions. She was like a very precious thing to them. And all their means was to continue the line of this pure breed of the same line because they believed that they actually were descendants of the gods. They always seem to mate with their own line of lineages yet they never came out physically deformed or have mental disability or any kind of down syndromes. They were well cared for by a line of priests that they constantly showered her with this special attention because of her highest rank. They took care of her, raised her, fed her, educated her just for the means of the next ruling chief and they are responsible for the lineages, the connections as they would mature and develop and then the enclosement which is known as *kapalama*, *kapa* is enclosure, *lama* is the sacred wood of the *lama*, so its enclosement of *lama*, which is tabu. She lived in an enclosement. She did the connections and for several hours or maybe a day or two and then after the connection, they would go on their separate ways and until they have signs of pregnancy and there would be rejoice, there would be song writings, most of all, these practitioners cared for her, make sure she ate the correct foods, gave her consultations so that her mind was in the right frame and exercise, physical condition, manipulation, *lomi lomi*, medicine if she needs to and prepare her for this one particular birth--and to give birth without pain. And,

they did their part. It plays, in giving childbirth, it plays a lot of medical knowledge and dietician knowledge, food knowledge so that she gave birth without any kind of pains. Because, these practitioners is really knowledgeable in giving birth. So, I try to, even today, I try to practice their techniques through consultations, through foods, through *lomi lomi* and I have patients that pregnant; they give birth without pain. And they didn't have to walk around with backaches during the whole pregnancy. And, they had easy time giving birth. I have helped women that were breech--if baby would not descend in five days, they gonna C-section her. When they look to the ultrasound, they see that baby hasn't positioned himself yet and she's overdue by one week and they gonna C-section her. So, I get a call and they come and set it up and I put baby into the descent position. And then three days later, she gave birth. She didn't have to C-section, thank goodness. And, I help women that couldn't give birth, give birth. Got it connected. And some women tell me that, 'you not going rub me no more'. I had women that they menopause, they no longer menstruate. A week later, the husband comes screaming at me and the wife's smiling and he tells me 'what you did to my wife?'. And the wife says, we was talking, she says 'you know she was just joking last week', but then she got her period back, she got her *ma`is* back, so, I don't know.

CSH: So, your mother told you all about Kūkaniloko.

KM: Yeah. She really was instrumental in what I do today. My sister does what I do but then she passed away.

CSH: Is there anybody else in your family, any other brothers and sisters?

KM: No, only me. Hopefully, my kids. They all grew up with this. So, they always--we was living Wahiawā, they always used to–, patients always look, my kids just go in and out of the house. So, I told myself, I told myself, 'if I going get one place, if I build one house, the kids going be upstairs and I going do this downstairs and no interruptions', which is what I have now. Suits me for now.

CSH: That's good. So, coming back to Waipi`o and Central O`ahu, when you used to go collecting with your mother, was just the two of you that went out?

KM: No, was her brothers and sisters. See, they was looking for this plant, they used to mix 'em with ointment. They used to make ointment 'cause they used to do massage work. And they used to extract the oils out of this, it was known as the four o'clock plant. And this four o'clock plant is tubulant, it's a tubulant plant and but then, they used to call it, oh what is this, get one Hawaiian name for that. Ah, *pelekane*, it's known as *pelekane*, but then it's known as the four o'clock plant. It's blue or white tubular flowers that everybody knows that studied botany, it blooms, it opens up at four o'clock. It gives out--it has this black seed that they use it for making rattles inside Hawaiian instruments, kind of like *'ili 'ili*. And, that seed, black seed is what they used to extract the oils from, all the property from and they mix 'em in the ointment. (Cough)

CSH: You like drink water?

KM: No, no. They mix them in the ointment. And that's what gives it it's penetrating property to go into the muscle and gives out this heat, you know, this four o'clock plant.

And they used to go up there because used to grow wild up there. And, it was like, all you do is just picking up black seed and you pick 'em up by the buckets of 'em because that's what they wanted.

CSH: That's what, an endemic plant?

KM: An endemic plant, actually that's an introduced plant. But then, it used to grow wild up there. It was brought over by Admiral Vancouver. He brought the plant over. The thing just went propagate. But at that time, only central O`ahu had 'em. I get practitioners that knew of this plant. They used to ask me if you know this plant known as the *pelekane*. And then, my mother, --they come from a line of practitioners too and he comes up to me and he says he heard about this formula they use in the old days for putting into ointments, for make ointments out of. And this was the *pelekane*. And they been looking high and low searching for this plant. And I says, 'they grow like wild weeds in central O`ahu, it's just a weed'. And they would ask they only grow only one place in central O`ahu, all in the Wahiawā area, because of the elevation and the cool climate. So, I says- and then he never saw the plant, but if I could go get 'em. Yeah, no problem. So, I go get 'em and brought it the plant. I took a couple starters, made a couple starter plants and just told him, says 'ey, just give 'em a lot of water, mulch, good soil, dig 'em deep, put some gravel, put some mulch in it, good soil and go about three feet deep and make 'em wide so that way when she roots, she just go. And all you gotta do is give 'em water, that's all, that's all it requires and she just go crazy. And I gave him about a gallon of the seed and he never got back with me again. To this day and that was couple years ago. And, he's a--his name was [looking through a binder] Arthur Uyesugi, they call him Hatsu. He's Hawaiian Japanee. His mother is [looking through the binder]. His mother was blind, his mother was Annie Uyesugi and she was the wife of this man, he used to own Kalihi Poi, down at Kalihi Street. She was a minister for Kamakuamauloa Church, Annie Uyesugi. She was Hawaiian. She's blind. She did laying of hands, she done herbal medicine and she made her own ointment. And the son, Arthur, went approach me because the herbal book that his mother had, that was handed down. It disappeared. And he remembered one of the ingredients that she used in the ointment was the *pelekane* which is the four o'clock plant. He asked me about the use, I mean how to find it. So, I went go get 'em for him and he does the extraction from the seed. And he mix 'em with his ointment so he like to get the kind, old traditional herbs and plants and then put 'em into his ointment.

CSH: But, you never heard from him again?

KM: Oh, once in a while, I see him. The last time I saw him was at the World Indigenous Healers Conference, Convention held at Waimanalo Conference Health Center. They had 'em at Bellows Air Force Base. Was three days. Had all the healers from all around the world, traditional healers. And Hawaii was the host sponsored by the Conference of Health Center which is Frank Kalani Hewett. He's the cultural director for the Waimanalo Health Clinic. And, I was there as a presenter. I went there to do one workshop too. So, I did the *la`au lapa`au* workshop for the conference. And they had people like Papa Auwai, Margaret Machado, Malia Craver, Abby Napeahi, they had healers from Alaska, Navajo, Arizona. They came from Louisiana, those that do black magic, they were voodoos, do voodoo work; they came too. They had people from Tennessee, mountain people that do home remedy. They came from Tennessee. People came from Tonga, Fiji, New Zealand, Samoa. They flew in from Japan, from Taiwan. So, had all of this healers from, even from

Ugandi came. They all came to share their traditional medicine for three days. And I was there as a representative, more as a presenter. I did what they call one full blown *la`au lapa`au* and in the life of plants, minerals--gotta gather all up in central O`ahu, Ko`olauloas, Tantalus, Downtown. So like me, I travel right around the whole island. 'Cause, my mom and my grandmother and auntie them, they knew where all clean one [herbs] was at.

CSH: Where all the what was?

KM: Plants, you know go gather plants. They went around the island. So, there's much times, I go all the way up to--for example. I give you one example: by the Hawaiian Memorial Park [Kaneohe]. If you take the stoplight as you're coming off from H-3, you cut off, you go up, you get off, you coming up by Hawaiian Memorial Park and then you hit the first stoplight. Now, you go down to that stoplight. Go further about halfway, before they had the housing over there, they used to get one *heiau* you know, on the top. That *heiau* over there, and then on the ridge over there, they get what you call, they get this, choke *laua`e*. People used to go there, just go make decorations. They usually use the *laua`e* for medicine, you know. You can use 'em as a--it's real good for controlling blood sugar. You can have it as a tea, the *laua`e* tea. They use that compound as a solution for people that has infections of the leg or of the feet or possibly detectment of amputation because of--if he's a diabetic, it became an ulcer, they looking at the worse scenario it's gonna turn into gangrene, possibly amputation. The *laua`e* is one of the plants that are used for pulling extractions of the matter. Use other extractions, the *maile hohono*, but then the *laua`e* is one of them. Another one we use, combination with that, is the *kauna`oa*. But then you don't use the *kauna`oa* that is the *pe`u** one which is that grows alongside the *naupakas* along the coastal area, the beach. You use the one that dominate the *kiawe* trees. So, you get--that's the *kuka`akai** which is the stronger ones, more thicker ones. We find them dominate the *kiawe* trees, all alongside `Ewa Beach, all Barber's Point or by-. Another area is by Campbell Industrial Park. So, if you go down Campbell Industrial Park, the last road that there, you go, and then you go into Germaine Luau* Parking Lot and get this bunch of *kiawe* trees just dominating *kauna`oa*. So, it's there, dominated down in Naval Air Station, Barber's Point, a lot of *kauna`oa* over there. Mā`ili Beach side, you get--certain season, when it's abundance of rain that flows through here, you going find the *kauna`oa* growing all alongside on the beach, choke *kauna`oa*. And I go there, pick 'em up, can make medicine out of that, use 'em as a pulp, pound 'em. Because when you done with the soak, you take the *kauna`oa* and the *maile hohono* and you pound that and use that internally as a pulp to, planted into the wound and you wrap 'em. After the soak, yeah, and that should draw 'em all out. The *kauna`oa* and the--but the *pe`u** one, but then when you soak 'em, you soak 'em with the *kauna`oa*, the *laua`e* and the *maile hohono*, all combined together. You cook 'em all up and you soak the feet. And then, you take out the *pehu**, the softer ones and then the *kauna`oa*--you pound 'em up with the *maile hohono*, already cooked now in the pot. You just smash 'em and then stick 'em in the wound and you wrap 'em up and the thing draw right out.

CSH: Coming back to the Waipi`o area in central O`ahu, you showed me all the *`alaea* you gathered from that area. That's something your mother showed you?

KM: Yeah. Still there, not going be target [referring to the Koa Ridge Development], no problem (laugh).

CSH: Where do you find it, just to have it on tape. Where do you find that kind *`alaea?*

KM: Okay, what can I say. [Searching for *'alaea*-pause in recording]. The gold *`alaea*, you going find 'em all here, they get one stream in here.

CSH: Kīpapa Stream?

KM: Yeah, the Kīpapa Stream.

CSH: Up above--this is H-2 yeah. Up above there?

KM: All above, all in the stream. You going find the gold one and the white. And they usually situated all on the banks. They gotta get water. Because—

CSH: On the banks of the stream, not further outside along the gulch?

KM: Not outside on the gulch; all on the stream bank area because what's unique about that is that what makes the gold of its quality. It has to be constantly flowing with water, because the water coming off from the Ko`olauloas. So, the Ko`olauloas, when they coming out from the flumes, when it comes on the flumes, it has this clean mineral extractions. And they doing is just going into the *`alaea*. So, it's actually coming from the water. The water is creating this composition through erosion and compression and putting the minerals into the gold *`alaea*. That's the key. And without the water, it ain't gonna work. So, the thing is, when you see 'em. That thing is, you gotta be very careful for take 'em out, because the thing just break apart. So what I do is that I try to carefully spoon 'em out and then wash 'em. The trick is to dry 'em. The object is to get it home and then I put 'em in the pans. I get these kind big pans and I just let it dry because when she dries, she get harder. And then, when she's completely dry and now I just scrape off whatever of the matter's off. I try to wash 'em in the stream if I can too, usually one strainer, move as much of the mud as I can get out of that. And then, I bring 'em out, dry 'em and the rest, I just shave 'em off. You know, come all, come across [showing me different types of *`alaea*]. What happens is that this thing is so soft--

CSH: Looking at the gold *`alaea*. You just break `em with your fingers. This, you do at home when you bring 'em home?

KM: Yeah, that's why I don't want to [break the *`alaea* when I gather `em]. You just * with them and they just break up.

CSH: Now tell me again, you already told me, but just to have it on tape. What do you do with the gold *`alaea*?

KM: Okay. This is a gift [referring to the gold *`alaea* he is holding]. I get this one student. He's--they got him on the mainland, he's researching this, in the mainland, for cancer. Because he gives it [gold *`alaea*] to the patient who has cancer. And then, because when they go through chemo [therapy] and they go through radiation, they don't eat. They lose their appetite. And if people don't eat, they die. And, he gives them that [gold *`alaea*] and then it stimulates the appetite. It brings up, builds up red blood cells. And, he says 'how

come the blood build back?' You know, he's wondering, how can the blood went build back. And then, he gave it to about four cancer patients. They--some in remission now. They go to chemo, they go to radiation. He gives 'em that [gold *`alaea*] and he's just very positive about this and now he told--he says. He's got it on the mainland, they're researching this in the mainland in one of the universities, 'how this one particular gold *`alaea* stimulate the cancer victim?'. Because what it does is that if you take it full strength of that, it's like a methamphetamines. It create the body to come alive. It's like a rush (laugh). You know, it's like a rush. And, make it active. The old Hawaiians used to take that to stay up. Say they get one meeting that gonna take couple days 'cause we gonna build one fishpond. We going to have to bring in about four thousand manual labor. We're looking at providing shelter, we're looking at providing food. We're looking at providing for the families that going come. We need all of this to make this project, the engineers and the labor force, to do it in a certain period of time so that everybody can return back home. It's gonna need enormous foodstuff, going to have enormous area so where they can sleep, rest because they gotta do manual labor. And about a thousand going come in and construct this, 'cause that time they didn't have any machinery. So, the construction was done more on labor. And these engineers and the consultants, they needed to stay up, make decisions and they took that [gold *`alaea*], they ate 'em so that they could stay up. And they burned oil lamps nighttime. And to come up with strategy, to make sure that this project can be done on time, before the rainy season come up or whatevahs, to be constructed for one dedication because this *heiau* is gonna be for the god Lono, for cultivations or we're gonna build this for one chief that needs this as part of his complex, whatevahs. So, it requires mass amount of people. It requires mass amount of time to pull all this thing together, organize and they needed to make decision and they needed to stay up. They took that. They took that. And, no place else on the island has 'em, but central O`ahu. Because why? It has to connect with the water resource that comes down from the hill. And that's what makes it potent. It's the water. You find 'em on different islands, you going see--like Maui, when you go Maui, you see this, ho this huge yellow vein. And that's that [*`alaea*], but that's not what you want. You want 'em in a bed stream. You don't want 'em on the cliffs or the ravine because it lose its strength because it's not fed by water. It's only was fed by rain water, by erosion, by winds, but not constantly in water. So, like for example, I give you one example. I go up, all I gotta do is just look at the stream bed from the roadway, I just look at the stream bed. And I says, ahh cannot go up, because it's under water. You follow? Now, when the water drop, now is the time I can go get. I can get. It's not every time I can go up there get it. Because, I gotta watch when it rain heavy, going get plenty water come down, you know what I mean, and the stream going raise up. Now, when the stream raise up, its gonna--after the storm--it's gonna stay like that for a while. It's gonna balance out. Then, eventually it's going decrease, drop. I look at that, I say, 'oh, the water is down, now I can go up get it'. But, still get water. I know the level mark because I judge the flow on the water bed, going down, from the road. Because I know when I get up there, it's gonna show. It's gonna be below the water mark where I can get it. Now, if the thing is high, forget it. Sometimes stay high for about one year. One time, was high for three years. I couldn't get inside there and the things was going low, low, low [Kalama's supply of *`alaea*]. All of a sudden, the water just went drop. Drop. I went up and I got, I took out. And then, people they ask, especially my students. They like this. But then I give 'em Kauai [Kauai *`alaea*], I give 'em Kauai one. And then--, but like the gold one. They like mix `em, that's why. Because they know what the potency does and they like the gold because they use 'em already. It has that real adrenalin rush, you know. Using this, you get one rush. But then, they know how to tame 'em down, control 'em. So what they do, they mix 'em. And that way, the body don't get the rush. Just kind of mellow 'em out with Kauai [`alaea]. You know Kauai, we enhance Kauai `alaea. They always says, 'what kind of `alaea this?' We says, 'oh, Kauai'. 'Oh', he says. 'I tried Kauai'. But we didn't tell him that it's been mixed. We mix 'em so it downtune the gold `alaea. The gold `alaea is strong.

CSH: So, what's the difference between the different kinds of `*alaea*? I saw you got white `*alaea*, you got brown `*alaea*, you got gold `*alaea*.

KM: The gold one; I give that for people who get AIDS. I give 'em that straight up, just gold. Cancer victims and those that get what you call, connective tissue disorder–which is AIDS. I give 'em the gold. And then, they resume normal lives, you know, besides their medication, besides not being active. They tired, they run down. I give 'em that, I work on them. When they call, I give 'em that and they walking the streets, living normal lives. Cancer, AIDS patients. I get people that get AIDS. That's what I give 'em besides they gotta watch their diet, take their medication. I give them something extra that kick 'em in gear for make their life better. You know, I cannot save them. But I can make that life perform better for them and be more active and being more aware of his surroundings, be able to enjoy your life and not being tired. This helps them. That's what I do. I give them that.

CSH: What about the other different types of `*alaea*, the different colors?

KM: The white one is actually used for external–the white `*alaea* was used for external for women that get rash around the groin area. You can use that for skin irritations, but they're very rare [the white `*alaea*]. But, in the ancient days, they used to use that when they used to come out of the *hale ma`i*. They used to powder themselves with that because the white `*alaea* is like a—it's a deodorant. It has a nice smell to 'em. Smell like–it has a nice, pleasant fragrance, you know. And it's really sweet. And then, when they rub it on their body and they return home. So, it's like a stimulant for her husband. Because when she came back home after she had her period, she would powder herself with this and she would send this fragrance out [interruption in recording].

CSH: [Smelling the white `*alaea*] It smells like soap. So, you collect the white one over there too, at Kīpapa, Waikakalaua?

KM: Yeah.

CSH: You mentioned that Waikakalaua was a place that you really like to get the gold `*alaea*.

KM: Yeah, but now hard 'cause you gotta go more further up. Because, they get the run off from the housing into the stream. When they do that, it's gone already. You going get rubbish, you going get oil that comes off from the curbing when they wash their car, they working in their yard, oil leaks. They going be run down by the storm and they deposit inside of the stream bed. You going see a lot of development, they running 'em off into the stream. So, you gotta go more higher [into the mountains] because the contaminants. It's like you going get something not knowing that what leads off into the stream, that you going take from there and you going give somebody this. They may die or they may get one side effect because now they making their body toxic, because you actually taking in toxin

from chemicals that accumulate in household, automobiles, plantation and it's gone already. You just gotta chalk it off already, just cannot go already. You gotta go more higher and higher.

CSH: So, where did you used to go to collect the `*alaea* when you used to go with your mom? You used to go further down into the valley?

KM: Yeah, never had housing. Was closer, off from the road, yeah was closer. Now, you gotta go more higher 'cause all the development coming up.

CSH: So, how far down, in Kīpapa, how far down you guys used to go to collect

KM: We try to stay away from the–you see, when we was going there, when I was going there, at the time they had those military reserve. We couldn't go inside there because of the, they had the fuel storage dump and ammunition dump. They had the railroad tracks over there. They used to use the tracks and they had couple warehouses inside there. So, the place was on guard, military police was up in that area. So, we went above that. And, try to stay away from them.

CSH: Above the truck farmers.

KM: Yeah, above the truck farmers, but within that zone where all the truck farmers. Within that area. But, then they never build anymore bunkers past the bridge. They had end the bunkers over there.

CSH: Which bridge you talking about. The Roosevelt Bridge, Kamehameha Highway or more up? Which bridge?

KM: Just before you get into the bridge overpass for Mililani Mauka.

CSH: You mean the H-2 Bridge.

KM: Yeah, yeah, the H-2. And then, they went end them there as far as the bunkers. And it goes down all the way to just before Peterson's Farm. You know, the dairy, chicken farm over there, just before that. But, then the place over there, had it already. The soil no good, the run off no good because all above that is the fuel dumps. And they build that during the war days. Kind of wasted already.

CSH: Did your mom used to tell you stories of how that place looked when she was growing up?

KM: There was mostly farmers up there. We kind of get a glimpse of it but there was some truck farmers up on the top, just above–in the fifties, but no more nobody there already, all gone already.

CSH: But what about when she was young? Because your mother grew up what, in the early part of the 1900s?

KM: The early 1900s.

CSH: Did she tell you what Kīpapa and Waikakalaua and that area looked when she was–where did she grow up.

KM: She actually grew up in Waikele. And then she had relatives up in Wahiawā. It was smaller town, you know, really small. And her uncle, he was the janitor for Leilehua High School and the Leilehua High School was where Wheeler Elementary School is at, not where it's at now. That's the new Leilehua High School. But the old one used to be by Kunia, Kunia Road. They all live Wahiawā so she traveled a lot over there, with them. And they all played–they all ran around. They had friends and families that all live in Kīpapa, Kīpapa area. And then they got relocated. A lot of them got relocated.

CSH: During the war?

KM: Yeah, during the war. Because the military was making a lot of camps around gulch. They was making a lot of military camps, fuel-storage fuel camps, ammunition camps. Especially–including where the Central Park is at, the Central Regional Park in Mililani. All in that gulch over there was all, at one time, all military installations, you know, pockets.

CSH: That' s Waikele Gulch, yeah?

KM: Yeah, Waikele Gulch, right. So, she kind of grew up with that, seeing all this during the war days.

CSH: But, she had family that lived up Kīpapa Gulch?

KM: Yeah, she had family that lived up Kīpapa Gulch?

CSH: And they all got evicted?

KM: Yeah, they all got evicted out, relocated?

CSH: So, where did they all go?

KM: They went to, they actually got located, some were located to Waipahu. They went to Kawa`akoa. They got relocated by, where the elementary school–Waipahu Elementary School is at. There was homesteading over there so the relocating was over there. Some went to–some of the farmers joined the plantation and worked for the plantation–a lot of them joined the plantation. Because it was all leased land, so they provided work for them on the plantation. They went to the plantation camp. They had this Japanee man. He passed away. He actually was living in the valley but then got relocated to the camps. You know, he grew up and the parents would work for the industry.

CSH: Did your mother grow up inside Waikele Gulch or up above?

KM: My mom grew up where, she grew up by–you know where the Waipahu Cultural Garden is at?

CSH: Yeah.

KM: Well, they used to own all the land over there, my mom, my parents. They owned the lands over by Kawa`akoa. They owned the lands where the Waipahu, the old Waipahu Library was at, all the cemetery used to be over there. They used to own all that land. They used to own the lands where Pearl Harbor park is at, all the lands over there was on my mom thems side. My mother had plenty lands. They had land around the island. And my mother was the executive of the estate. She's the one went around, collect the rent. And I used to go down to Arakawa Store and collect rent from Mr. Arakawa 'cause where Arakawa Store is at over there, that's all my mother's land.

CSH: So, what happened to all that land?

KM: My mom sold 'em. She sold it all because her brothers and sisters went take her to court claiming that they weren't getting their royalties. So, they couldn't agree. So what the court did was that they put–they had to force to liquidate the assets so that everyone get their equal share. She was forced into this because one of her sisters took the royalties which my mom gave her to give the brother. You know, 'send it to your brother'. He was in Germany at that time, in the service. But, apparently the sister wasn't sending the royalties to the brother for couple years. She was keeping 'em. And then when she came back home, she–his wife–well, when he came back home, his wife, a German lady went seek court actions as far as entitlement on the place and took my mother to court 'cause my mother was the executive. She was the oldest one. And, when came down to liquidation, my mother went comply. Even they couldn't settle it, with the brothers and sisters. So, my mom did, she settle off with them and then she says to every one of them at the meeting, 'cause I was there and my mother–see–told all her brothers and sisters and sisters-in-laws and brother-in-law, she said this, she says, 'I going live to see the day that the land going consume all of you, that I going bury every one of you'. And my mom lived to see the day that the land went consume all of her brothers and sisters, all of her brother-in-laws, all of her sister-in-laws. My mom buried every one of them.

CSH: Is your mom still alive?

KM: No, she just passed away, recently, she passed away. And then, my mother's liquidation. She went to the Big Island, she bought lands up there. Today, I own all the titles to all her land. We were fortunate. I'm the one got 'em.

CSH: All your brothers and sisters fight with you?

KM: No, no, they don't. I asked my mom this in front of my brothers and sisters, 'cause they knew already. And I asked my mother, I asked my mother, I says, 'Mom, why me?' Why me of all your children? I'm sure my brothers and sisters are much more worthy than I am.' She says, 'You know Kalama, of all my children, you're the only one not going sell the land.' (Laugh). She tells me that. So, today, I get all the land, maintenance the land, pay the property tax, upkeep, maintenance, lease out, pay the insurance.

CSH: So, none of your aunties or uncles are still alive?

KM: No, they all gone, they all passed away. They all passed away.

CSH: Okay, so coming back to the land; if she [Kalama's mom] grew up right in that area (Waikele), she probably frequented that gulch yeah, Waikele Gulch, Waikakalaua, Kīpapa.

KM: Yeah, she went all the way up to–they used to go all the way up to Wheeler. They used to walk all the way up to Wheelers.

CSH: And what else besides the four o'clock plant and the *'alaea*. the gold *'alaea* and the white *'alaea* you said they collected up there, what other kind of herbs and plants did they collect over there?

KM: Okay, up *mauka* [Kīpapa]. They get a lot of ginseng, that's for sure. That's where I usually get 'em from, from–it used to grow wild up there. It still do today.

CSH: And where you think that came from?

KM: It was introduced by the farmers. But when they went abandon there, the thing just went wild. So, in there, you cannot miss 'em. It's all over the place, just growing all over, just like wild weeds.

CSH: Where more or less is that found?

KM: It's more on the bottom, right by–just offset of the stream, the stream area.

CSH: So around–above Kamehameba Highway and below H-2?

KM: Yeah, below H-2. It's almost off center from the stream bed, because the stream bed c[illegible] there is about, at some point maybe about fifteen feet drop. Some areas, it's more rocky, lower. But then, all alongside–I say, it's about from a mile–it's all ginseng.

CSH: A mile from where?

KM: From the stream, right up from the Freeway.

CSH: So around where the Waiahole Ditch spans the gulch?

KM: Yeah, all nothing but ginseng, yeah.

CSH: Can you remember any other plants your mom used to gather up there?

KM: We went there to gather fruits, you know, something for eat.

CSH: What kind fruits?

KM: Avocado, banana. They had sugar cane up there. They had orange trees, Hawaiian orange over there. They had wild guava. They had *'ōhelo* and one other plant they used to get over there; they used to go get, they used to make leis with that over there. It's the *'a'ali'i*. They get the *'a'ali'i* over there. And then, the –my Mom used that. They used to get the–they used to smoke 'em.

CSH: The *'a'ali'i*?

KM: Yeah, they used to dry out the–they used to scrape the bark, you know scrape the bark and dry it out and they used to smoke 'em.

CSH: Oh, I've never heard of that.

KM: And, they used to get loaded on that (laugh).

CSH: This is your mom's family?

KM: Yeah, they used to get loaded on that. They used to get loaded on the *'a'ali'i*. And then when people was sick, people was sick, thy used to blow 'em into them, the *'a'ali'i*. And then what it does, it has this–

CSH: Blow the smoke?

KM: Yeah, the smoke, and have them breathe or burn 'em in our room. They burn 'em up, burn 'em in our room and let the patient breathe that because what it has, it has a narcotic effect, you know, on the person. And then it numbs the whole body. It's like a painkiller, that maybe say like marijuana. It's like marijuana, the *'a'ali'i*. Not too many people know that.

CSH: Yeah, I never knew that.

KM: And they used to go crazy up there. They used to go get 'em. And then, they used to administer the pain relief.

CSH: That's interesting.

KM: (Laugh)

CSH: So, you guys went to Wahiawā plenty yeah?

KM: Yeah.

CSH: Several times a week?

KM: Yeah.

CSH: How frequently would you say you went up into these gulches?

KM: Maybe, I'd say maybe about once a month. Maybe, once every three months, depending how often we gotta go, yeah–for get more supplies for bring home. And my job was to —the *'a'ali'i*. It used to grow right alongside the embankment, had loaded. Loaded *'a'ali'i* up there. And then, one other place you get where–.

CSH: That's up Kīpapa or Waikakalaua?

KM: Waikakalaua. You get 'em by also growing alongside by–they get this nother–(pause)–it's another area that grows that. But now--it used to be the old military fuel depot that feeds off to Wheelers Air Force Base. You know, you get one on top of the hill or something up there, on the top of the hill. When you're going down past the golf course, you coming down, you get one stoplight over there. You go down 'Ewa end, they get one road, right up from the stoplight. They get this, sound like one column, you know, this cement column, like they blocking off the road. They get one fence over there. All inside there, all get–we went go–we went go *niele* one time inside there. Came across this abandoned fuel dump, underground fuel dump overlooking Wheelers Base. I think that was a fuel dump the war, they made to funnel off the fuel. But, nobody's over there no more now. All inside there, get *'a'ali'i*–then you can find 'em down in Kīpapa, the *'a'ali'i*, alongside the ridge and all in that area. Go right up, choke *'a'ali'i*.

CSH: So, what was your job you said?

KM: I gotta go down in the ravine.

CSH: So, everybody stayed on top and you went down.

KM: Yeah, they just gave me instructions. They sent me down. I'm the guy gotta go get 'em. I was the mountaineer, the mountain goat.

CSH: The mountain donkey (laugh).

KM: I used to go down there, pick 'em up and come back up–'cause I was agile, light. I was real agile.

CSH: So, if you guys went maybe once a month for go pick stuff in those valleys, your mother, who grew up there, probably went more often yeah?

KM: If she did, she would call me for help her.

CSH: But I mean before you guys were born when she was growing up?

KM: I guess so, yeah, I guess so. Because she was a traditional practitioner for a long–forever.

CSH: Did she ever tell you any stories about those gulches?

KM: Well, she told me this story about Kaupe–half man, half dog. That Kaupe still roams Kīpapa. That—and she says not to be afraid if you go in there and if you see a white dog with red eyes. She says not to be afraid over there. And she says Kaupe roam all up in the valley there because he's the guardian of Waipio Valley that extend all the way to Mount Ka'ala. Kaupe. And she tells me stories about Kīpapa, when they had the battle there, that they had this Hawaiian chief that is part of your ancestral line by the name of Mā'ilikūkahi. He took on the invaders that wanted to rule O'ahu and they came up through Pearl Harbor way and the enemy forces all with the full armor and weapons, travel up from Pearl Harbor and work their way up through Waipio Valley going into Kīpapa and then–they was looking for the *mō'ī*, Mā'ilikūkahi because he lives in central

O'ahu. He stayed in the uplands because of much more protection and then she tells me about there was a battle there. The warrior chiefs slaughtered the invaders there and Kīpapa is known as a place paved with corpse because of the battle was done there between the O'ahu chief and the invaders from Maui and from the Big Island. And where Mililani Mauka stay, it's in an old map, it says 'the plains of Punaluu'. The Plains of Punaluu is the actual site where Chief Punaluu was slayed by the Hawaiian warriors–O'ahu warriors. He was killed there. So, the old maps show the Plains of Punaluu.

CSH: That was where Punaluu was slain. Do you know where the Battle of Kīpapa was?

KM: The Battle, the Battle took place up by Kīpspa. Actually there–when the main battle group, the main battle group was in Kīpapa, so what they done was that they started by–the battle started up in Waikakalaua, you know the battle started up in Waikakalaua and then they went push 'em, push 'em into Kīpapa. And then they was breaking up the armies. But they didn't go beyond Kīpapa because they went close 'em in, the gap. And they went slaughter them there. And they was just running array, yeah you know array. Some ran up to *mauka* area and sooner or later, they getting lost. Sooner or later, the people living over there started hauling them out where they at. And they just killed them as they went. They destroyed them as they went. No one escaped from over there. They were slaughtered right in that peninsula because they came from all different entrapments. It's like a wedge, they coming in, they close in on the wedge and no where to go but just chaos, no generals to lead them, no way how they going overgroup, they just was going–just running wild with no means of control. They don't know how to control themselves and that's how they lost. They really lost because they didn't know how to organize themself when they got caught. And when their back was against the wall. They just was going any old ways. They had no means of restructuring, back up, make a defensive line and stand. They just was going crazy. Because they was just overwhelmed where all these people coming from different angle. I go this way, get hit, run that way. I want to give up. And there was no giving up because Mā'ilikūkahi just slaughtered them all, just killed 'em all, right up Kīpapa.

CSH: And he was from your ancestral line?

KM: Yeah, yeah. He was from my ancestral line.

CSH: What else did your mother tell you about Kīpapa and Waikakalaua and Waipio?

KM: Don't travel over there nighttime (laugh). There's too much–she tell me the stories over there about this, this Hawaiian lady in a white garment, white hair--that she frequents Kīpapa, Kīpapa area in search of her, of her lover. So, it's a lady, Hawaiian lady dressed in white garment, with white hair in search of her lost lover. And she says that she has this–because she has this jealousy to her lover and-she's very jealous. She's very violent to him because he never gave her the attention so she's always in search and actually tell her because–she tells us that she actually slayed her lover and she dove off the bridge over there, you know the ravine and killed herself. She threw her lover and then she committed suicide. My mom, she tells us that. So, if you ever walk, don't walk around

Kīpapa at night. You might see this lady, wearing a white garment, with white hair asking if you ever saw, 'have you ever seen a man walk by here at night', you know what I mean. 'I'm looking for my husband, my lover', you know she telling us the story that. Whooo, you know.

CSH: Did she have a name, the lady in white?

KM: No, she never had a name. She never bad a name.

CSH: Just lady in white?

KM Just the lady in white. And she says, she tells us, she says, she tells us the story that a lot of people used to go there, travel and commit suicide.

CSH: Kīpapa?

KM: Kīpapa, just jump over the bridge.

CSH: Which bridge you talking about?

KM: The old Kīpapa Bridge.

CSH: The one down at Kamehameha Highway?

KM: Yeah. She tells us that people committed suicide, they jumped over the bridge, especially during the war. People were jumping off the bridge. I said, 'now what, they go up the Pali?' (Laugh).

CSH: There were *kuleana* lands up in Kīpapa. Do you know if your family had *kuleana* lands up there?

KM: I know there had a lot of *kuleana* lands up there because they was all farmers yeah. But, I not sure; I don't really think so, because all our *kuleana* lands was all down in Waikele.

CSH: Oh, down by Pearl Harbor?

KM: Yeah, that's all *kuleana* lands.

CSH: [searching for a list of *kuleanas* in Kīpapa Valley]. I want to show it to you to see if you recognize any of those names.

KM: 'Cause I get my whole genealogy over here.

CSH: I like ask you for the spellings of the names-'cause I not going be able for write 'em down.

KM: This goes back many lines. This is the line I gotta remember, when I baptism. This one.

CSH: You got plenty generations. You mentioned one time, last time we talked about it that you and your mom had come down from Kīpapa Trail and come down into Kīpapa Valley from the Ko'olaus. Did you travel that route often? Like, up the summit trail?

KM: Yeah, that's the Summit Trail you talking about. Yeah. Went up there. See, my mama was da kine, one hiker. She really outdoor hiker. And, we took a lot of walks around the islands, and a lot of times we would go around by–there's another way you can get inside there too, the other way. More convenient today than now because now the trail goes up by–who what that place at by? You know the maze? You know the maze?

CSH: Dole?

KM: The Dole. They got one dirt road over there. You can go up to the summit, go up through there.

CSH: That's Poamoho Trail?

KM: Pōmoho. One other one you can go up, you can go up one other trail, you can go through Helemano. Helemano.

CSH: That goes up to the summit?

KM: That goes up to the summit, yeah. One other way you can get up to the summit is by, on the last road up by Wahiawā Heights. You can go to the summit up there. And one other you can go up to there is the old pineapple road, you pass up by the camp to get to the top.

CSH: That's Kīpapa Ridge.

KM: That's Kīpapa Ridge, yeah.

CSH: You know how old that trail is?

KM: I haven't been there in years, you know.

CSH: Did your mother say anything about how that trail was, if it was older than–'cause some of those trails are CCC era trail.

KM: Yeah, a lot of them are CCC.

CSH: Do you know anything about that trail?

KM: No, no. Because when we went up there, was all CCC. Had a lot of trails being done by the hunters, you know, people who live in the village and then. A lot of them made their own trails, a lot of the campers did because they went over there–they went up there for get game. Plenty games up there.

CSH: Plenty pig.

KM: A lot of pig, so they brought 'em home to the camp. And, a lot of this elders, wow, they either in convalescent or they in the senior citizens home or else they passed away already. But, you know, up that area up there, not too often we went up. If you get--any time you do, you gotta get transportation, as far as can go. You gotta bring along food, equipment and most of all you gotta be able to watch the mosquitoes. We try to do early in the morning, go in and come out. Or else, we go another route, depending. See, the islands is structured in one way. You look at where there's a lot of rainfall, you get abundance of plants, you know, consistent. Certain plants grow certain elevation, certain time of the year as the weather progress. So, as a gatherer, you gather, you go right around the island, consistent. One area--like I'm looking for the *kōko`olau*. One area doesn't suit because it's seasonal, because the weather change. It grows, like say certain time of the year central O`ahu get dry. So, you lose 'em. She [the plant] start-- goes into dormant, start dying out 'cause of the weather change or you get bush fire. So, you reroute your Ko`olauloa, you know, Ko`olauloa. You can go Kahana, you go to, by the Kualoa, Hakipu`u. So, I reroute myself, in that area because the climate's almost the same. And then, because I go there constantly, I target the area what kind plants I like. And then, I looking at the vegetation, I looking at the streamfall, I look at the least amount of developments so that I know where it's at and I even used to go down to Sacred Falls, you know Hau`ula side. I go over there and I used to gather all inside there too because nobody bother over there, they're just going up the trail, clean and then it's public access. So, I get no problem. I can go someplace, public access--get no problem. And you want to gather where-- you gotta get backup because first of all, you gotta look at safety. Most of all, you want to go in and be out before nightfall because it's gonna get a problem. So, you want to start your day off early in the morning, get your provisions ready, be there before sunbreak. That way, you get one early start and then because you gotta look at the time involved, you gotta look at the preservation, preserving of the plant or we want to take plants home. How long is gonna be able to bring him down and depending on the elevation, the thing might shock the plant. If you taking plants from the higher elevation, we gotta look at how we going bring 'em down without shocking the plant. So, it's a means of--we utilize the land, we'll take, remove, get some ti leaves whatnot, bundle 'em all up, wrap 'em, cover 'em, insulate 'em, put water on 'em and gradually bring 'em down with us. I stay coming down, we watering 'em, watering, watering, come down so that by the time we take it home, hopefully it don't go into shock or we lose the plant.

CSH: Yeah, that's important.

M: And then, usually I will teach people that you looking for one indigenous plant only ows in the higher elevation. If you find 'em, and it grows up only on the top. Bring 'em wn. Bring 'em down, I'd say about a hundred feet, two hundred feet. Plant 'em over re. Plant 'em. Then come back six months, two months, six months to a year--see if ore *keikis* there. Replant. And then now, you take 'em down one other two, three hundred feet. Because what you doing is changing the climate, you adjusting 'em to the elevations and maybe luckily in four years from now, you might get 'em inside your back yard. And then--in a controlled environment. But, if you cannot, then it's not meant for bring down--but it takes years. You can't do it--but then you gotta change the climate so that the plant doesn't go into shock by just bringing slowly from the highlands and then gradually getting 'em adjusted to the climate change and so you can be able to bring it to your back yard. If you can't do that, then it's not meant for your back yard. Simple as that.

CSH: You gotta think about a lot of things, yeah?

KM: Yeah. You gotta look at all that. You know—you don't learn this in a book. Like my cousin, he grow taro. That's the time had the--they had this--they had this bacteria that was contaminating all of his taro patch. The guy was wiping 'em all out so I says, 'fine--ey, just don't grow'. I says, 'just shut 'em down, let the land heal and then we grow again'. I tell, we going do that. Ey simple. We go get mulch, anything, old kind chopped wood, burn 'em, burn 'em in the ground. Just empty 'em all out the *lo`i*, let 'em dry up and just throw rubbish inside there, just burn 'em up, you know just burn 'em. Get mulch, everything inside there, mix 'em all up. Burn again if you have to and then we go down the beach, we go get the seaweed, you know seaweed. We get 'em by the bags, you know. Bring 'em all up, load 'em on the truck, chop 'em all up and just throw 'em all in the patch. Let the thing mulch, you know one year, two year. Then you going replant again. Then, you no more problems. All you gotta do is just back up, clean up the system, even though take two years now, clean up the system and start all over again. That's it. You can get rid of all the contaminants, you get rid of all the toxin, you get rid of all the disease and you start all over again. That's what the Hawaiians--they smart--you go look when they make *lo`is*. They get one side, they grow, one side no more. They had huge taro patch, but they kept one side wild so the land recover and then all they do is transfer over. You get the kind of disease, whatnot, they just transfer over. You just want to make all year round, 24 hours around the day and you ask yourself why--sometimes you just gotta back up. So what it tells you cousin. You no more enough land. You no more enough land for grow your stuff.

CSH: So, do you go up to Kīpapa anymore to go gather or do you mostly go to Waikakalaua?

KM: I don't now, go there that often, only when I run low. If I run low, I get the signal already. I says, 'okay, we going up--' --that jar I show you [jar of *`alaea*]. Well, the thing was full. And now, I get some more. Get one other bottle inside there, I never crush 'em yet. I get enough in there for last me one year. So, I only gonna go--if I pass in the neighborhood, I might look. I might stop, I might look. I say, 'oh, the water's low, I going take advantage'. Because, that's the only time, if when I need 'em or I'm in the neighborhood and I going check. And if I check it's okay, I going make time for go 'cause you don't really need much. You got sticks over there, you can make 'em for dig 'em out. You get leaves, whatnot. You can throw 'em in. You really don't need much for gather. And, because you get all your tools out in the open and now if I look at it, I see the water is low, then I going tell myself, 'okay, I going come back. I going come back in about maybe two days and each time I going bring the proper--my tools, shovel, I going bring my strainers, I going bring bucket, I bringing my two sons with me 'cause I never bring my students. I never bring my students because as a teacher, you don't tell 'em where they [the *`alaea* and *la`au lapa`au*] at. They themselves gotta go look for themselves. I never give out any of my plants, disclose 'em to them but you know the thing is I'll talk about it with them. But it's up to you to go find 'em yourself. I'm not gonna take them over there and show because 'ey, where's the fun? You know what I mean. Where's the fun? And I just going over there, take you with me and go like 'here, right here'. No. That's not the idea, the idea is to 'ey, make time for yourself, prepare yourselves spiritually, what I want to do, here the *kumu* says, the teacher says, 'it's there. All you gotta do is open yourself up and then you'll be able to receive them'. And, I want them to find out for themself so that they understand as a gatherer, there's more to life than just go get it. You know, the idea is that you by yourself, I can find peace for myself, I get time for myself. I can meditate, I can do imaging, I can get very resourceful what's around me. I can heal myself which myself really needs it. I need to put time for myself and this is the time for them to help heal themself if they only know how to prepare themself to go gather. Because they not gathering for them, they gathering for helping people. So, it's an all around thing. It helps you, it helps them and it maintains the balance. The practitioner need healing to. The sick need healing, but the practitioner need healing so it's a form a healing as they practice their lessons and keep a balance with what's around them and heal themself as well. Let me show you this [looking at Kalama's binder]. Me, I like collect articles. Here's Papa Auwai, traditional healer. This is his obituary.

CSH: Was he part of your family?

KM: He's my mother's cousin. He's actually from the Big Island. My mother's mother is from the Big Island. My mother's father is from Waikele. Papa Auwai's mother is my grandmother's cousin. My mother and him are cousins. So, it's two sisters, different fathers. Was two sisters that married, his father and then my mother's father. They the Kuali'i lines. I keep a record of him. He was 94.

CSH: And he died the last day of 2000.

KM: New Year's Eve.

CSH: I'm going to turn this off now. This is good. Thank you.

Hawaiian Traditional Customs and Practices Impact Assessment for the Development of a 1339-Acre Parcel at Castle and Cooke Lands Within Portions of Waipi'o and Waiawa *Ahupua'a*, O'ahu (TMK 9-4-06:01, 03 & 10 port. and 9-5-03:01 port., 04 & 07 and 9-6-04:21)

by

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Prepared for
Helber, Hastert, and Fee

Cultural Surveys Hawai'i
August 1996

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I. INTRODUCTION

The Purpose of this Hawaiian Traditional Customs and Practices Impact Assessment is to give due consideration to the effects that the proposed development activity may have on the traditions and customs of native Hawaiians and to give due consideration to appropriate measures to ensure the protection thereof. This is meant to be an informational document disclosing the impacts on native Hawaiian culture of proposed development within this specific project area. This document is prepared for possible submission to any state agency that might require such an assessment as a condition for the issuing of a permit or other approval.

II. PROJECT AREA DESCRIPTION

A. Project Area Location and Boundaries

The project area (Figures 1-4) consists of four relatively discrete parcels located in the *ahupua'a* of Waipi'o and Waiawa in Central O'ahu just east of Mililani Town. These four parcels have been named "Koa Ridge Makai" (571 acres), "Koa Ridge Mauka" (485 acres), "Kipapa Ridge" (92 acres), and "Waiawa" (191 acres) (See Figure 1). All four of these parcels occupy former commercial pineapple plantation lands.

Koa Ridge Makai (including TMK 9-4-06: 1 & 2 and portions of 9-5-03:1 and 9-5-03:4) is bounded to the west by the steep slopes of Kīpapa Gulch, is bounded on the north by a small tributary gulch to Kīpapa Gulch, is bounded on the east by the easement for the H-2 Freeway and is bounded on the south by a Pineapple Road and Kamehameha Highway.

Koa Ridge Mauka (including portions of TMK 9-5-03:1 and 9-5-03:4) is adjacent to the northernmost portion of Koa Ridge Makai but is separated from it by the H-2 easement. Koa Ridge Mauka is bounded on the north by steep tributary gulches of Kīpapa Gulch and is bounded on the south by steep tributary gulches of Panakauahi Gulch. These deeply dissected gulches virtually meet at a "knife-edge" ridge on the east corner of Koa Ridge Mauka. The H-2 easement forms the west boundary of Koa Ridge Mauka.

The parcel of the project area designated Kīpapa Ridge (TMK 9-5-03:7) lies immediately north of Koa Ridge Mauka and is bounded on the south, west and north sides by deeply dissected tributary gulches of Kīpapa Gulch. These gulches are in close proximity at the northeast corner of Kīpapa Ridge and this parcel is effectively pinched out by these gulches on the east side.

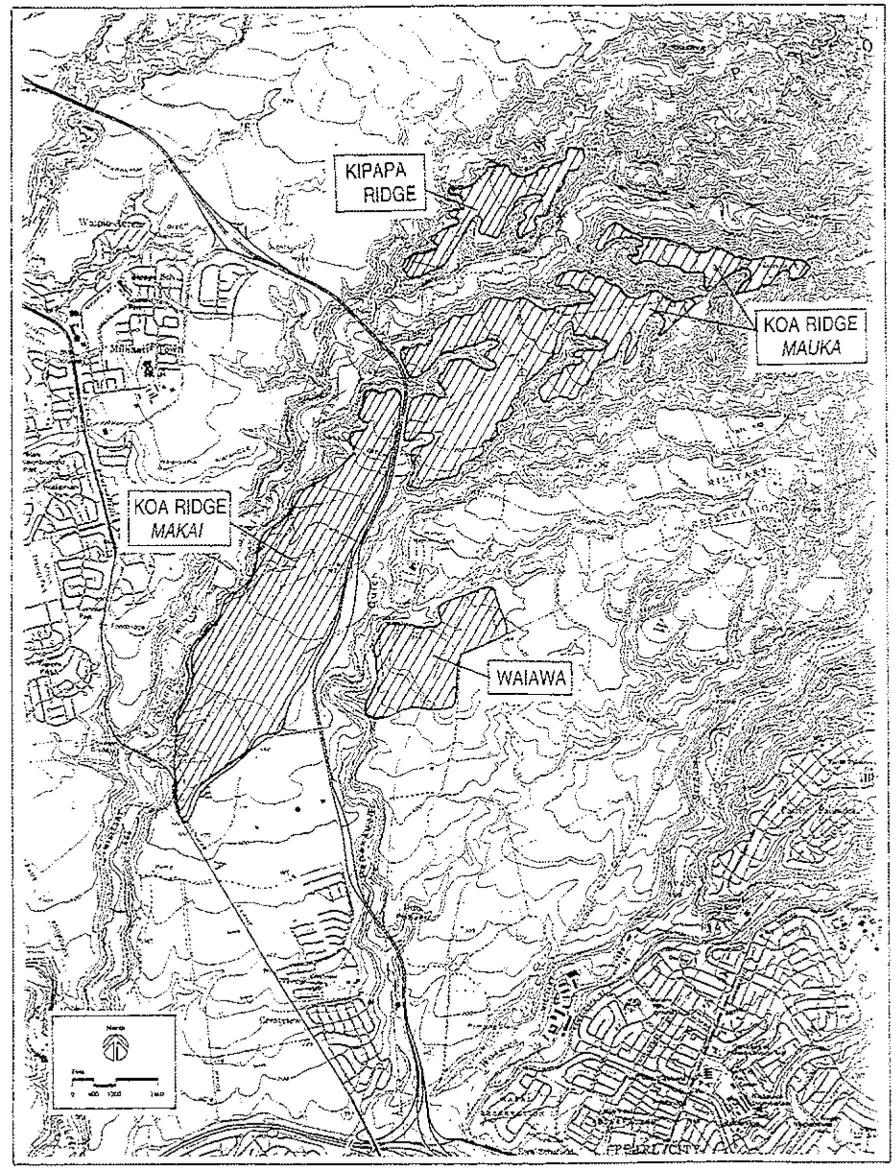

Figure 1 Portion of USGS Waipahu Quadrangle Map, Showing Project Area With Parcel Names Annotated

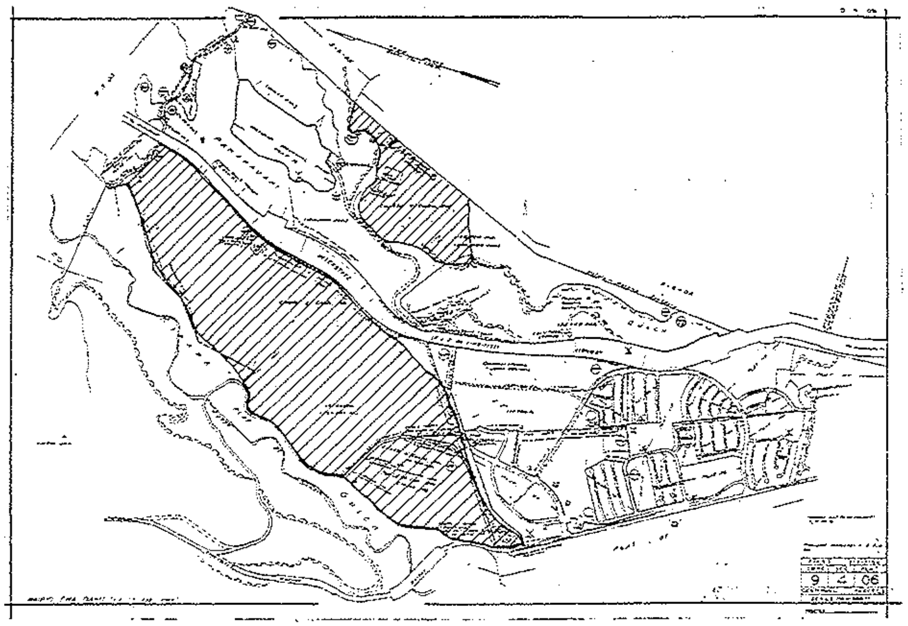

Figure 2 Tax Map of the General Area Showing Affected Lands (TMK 9-4-06:01, 03 & 10 por.)

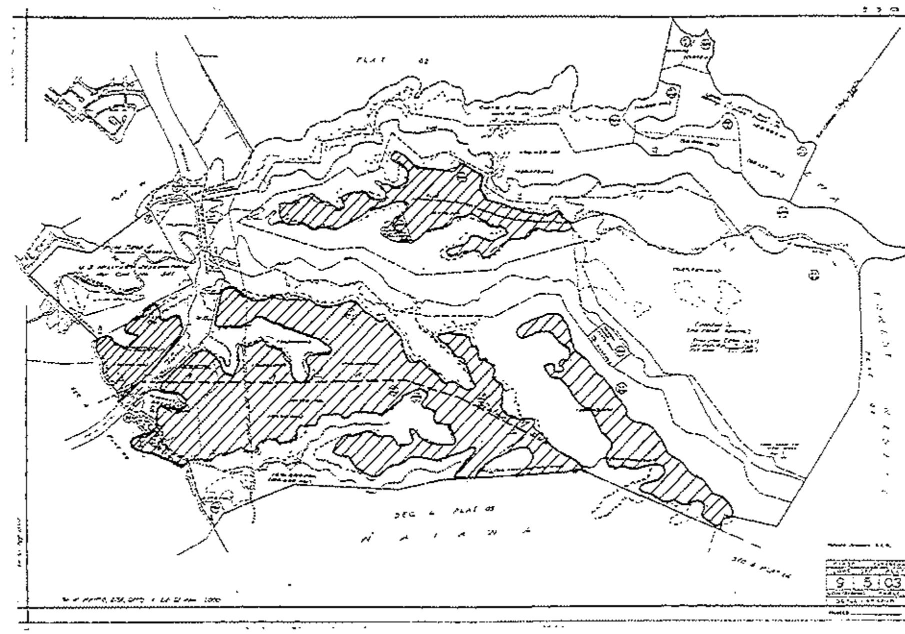

Figure 3 Tax Map of the General Area Showing Affected Lands (TMK 9-5-03:01 (portion), 04, & 07).

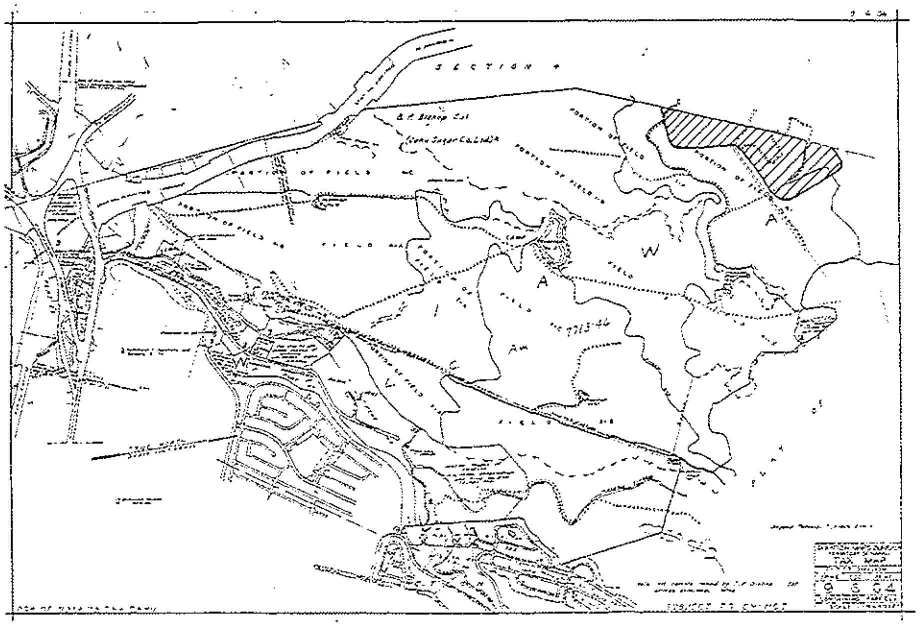

Figure 4 Tax Map of the General Area Showing Affected Lands (TMK 9-6-04:21)

The parcel designated Waiawa (TMK 9-4-06:10 port. and 9-6-04:21) lies just east of Koa Ridge Makai across Panakauahi Gulch. The Waiawa parcel is bounded on the west by Panakauahi Gulch, on the north by a small tributary of Panakauahi Gulch, on the east by the road to the Waiawa Correctional Facility and on the southeast and south by old Pineapple Roads.

B. Description of the Affected Land

The project area comprises approximately 1,339 acres in the *ahupua'a* of Waipi'o and Waiawa. The lands are located on gentle sloping flats between deeply dissected gulches at elevations between 420' and 1100'. The deeply dissected Kīpapa Gulch and Panakauahi Gulch and their substantial tributary gulches are excluded from the project area (See Figure 1). The lands of the project area typically receive around 150 cms. of rainfall annually, mostly falling between October and March.

The soil within the project area is mostly silty clay falling within the Wahiawa and Manana soil series.

Virtually the entire project area has been under commercial cultivation since at least as early as the 1920s. Many of these pineapple fields have been taken out of production and the fields have been replaced largely by exotic weeds.

III. DESCRIPTION OF THE TRADITIONAL CULTURAL PRACTICES REGION

Waipi'o was a particularly desirable *ahupua'a* of the 'Ewa District in former times. The majority of the inhabitants of Waipi'o lived in close proximity to the rich fisheries and fishponds of the Waipi'o peninsula as did Waipi'o's most famous resident, John Papa 'Ī'ī. The *māhele* of 1848 listed 110 awardees within "Waipi'o" and eight in "Waipi'o-Uka." This probably was the traditional pattern of residence. Those who lived in towards the mountains in Waipi'o Uka were spread out along the bottom lands in the base of Kīpapa Gulch (Figure 5). The well-watered gulches typically had a much higher diversity of plant species than the relatively dry exposed flats of the project area. The project area by 1887 (Figure 6) appears to have been a "grassy Plain." At the time of Polynesian arrival, such lower leeward slopes as the project area are understood to have been a more appealing open forest or mixed savanna but the introduction of pigs, dogs, and rats, the collecting of firewood and construction materials, deliberate and accidental burning and historic animal introductions would have pushed desired resources farther into the uplands (Cuddihy and Stone 1990:14ff).

The project area lay outside of the Hawaiian cultural landscape boundary (Group 70 *et al.*:36). The lands of the project area were not particularly suitable for taro cultivation, irrigation networks, settlements, and circulation systems. There were no major natural or cultural landmarks within the project area lands to draw the attention of Hawaiians. The project area, however, did lie within the traditional coltural practices region of the people of Waipi'o. Hawaiians would transit the project area to access the resources of the mountains and adjacent gulches. The matter of the gathering of thatch or medicinal plants within the project area is discussed further in Section V - Native Gathering Practices.

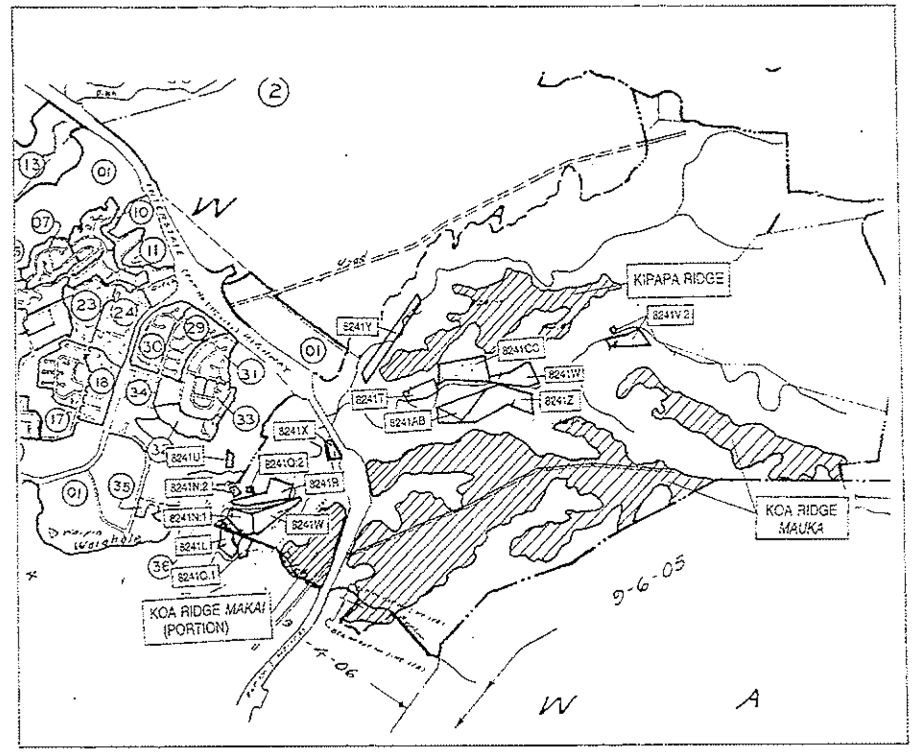

Figure 5 Tax Map Showing Locations of Land Commission Awards and Present Study Parcels in Upper Waipi'o

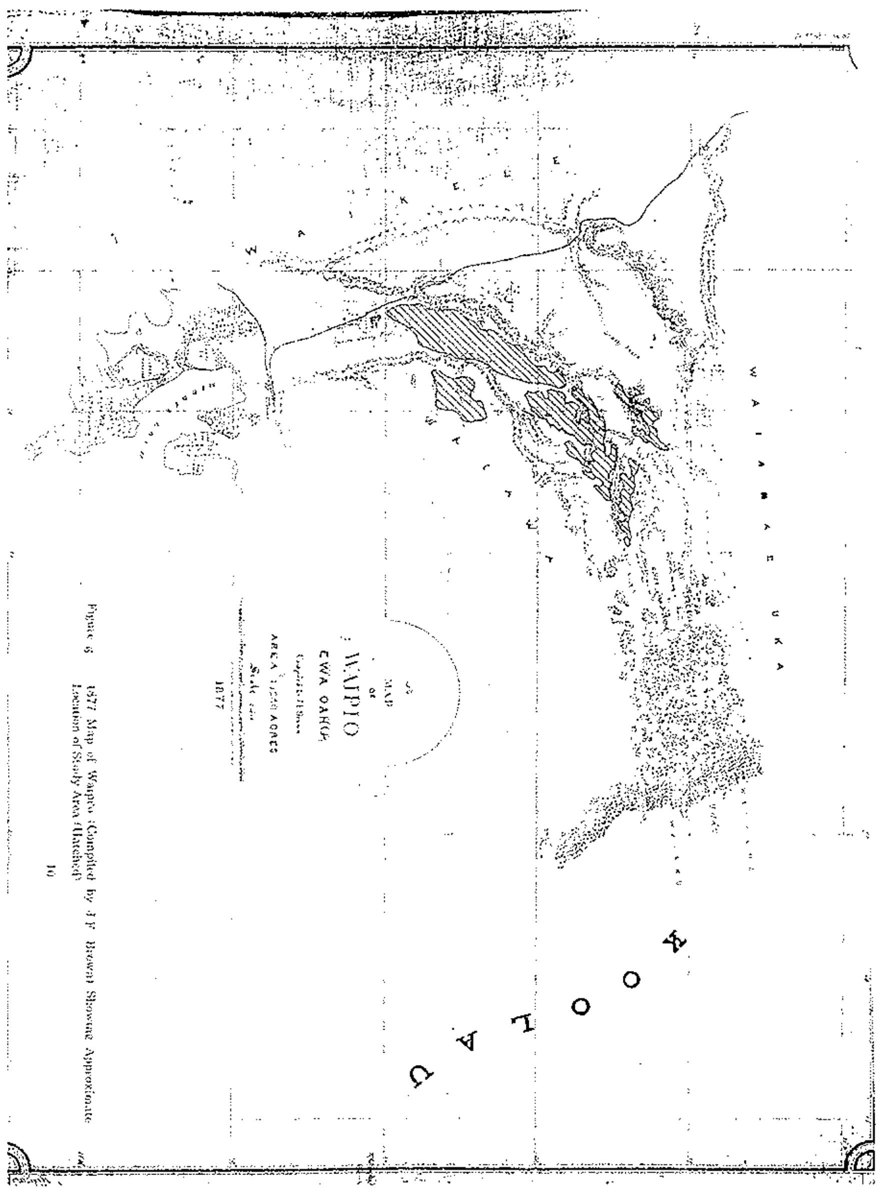

Figure 6 1877 Map of Waipio (Compiled by J.F. Brown) Showing Approximate Location of Study Area (Hatched)

IV. ORIGINAL SOURCE OF TITLE AND HISTORY OF LAND USE

Virtually nothing is known regarding the tenure of the lands of the project area prior to the conquest of O'ahu by Kamehameha I in 1795. The rich lands of Waipi'o were given by Kamehameha to the 'Ī'ī family, who were intimates and junior relatives of the Kamehamehas. In the *Māhele* (Division of Lands) of 1848, the noted Hawaiian jurist and historian, Ioane (John) Papa 'Ī'ī claimed the *ahupua'a* of Waipi'o for himself (LCA 8241) "from the mountain to the sea." In 'Ī'ī's testimony (Native Register 512-517 v.5) he lists the names of 110 "people living on the land of Waipi'o in 'Ewa" including the number of their *mo'o, lo'i*, houselots, houses and children. In the division of lands, 125 *Apana* were awarded at Waipi'o and an additional twenty-three *Apana* claims were not awarded (the fate of one claimed *Apana* is uncertain). The land claims at Waipi'o included 312 *lo'i* (irrigated taro terrace), 43 *mo'o* (narrow strips of land generally in agriculture), 53.5 *kula* (pasture or area for dry land cultivation), 32 houselots, 52 houses, 25 *'okipu'u* (forest clearings), 6 *'auwai* (irrigation ditch), 4 fish ponds, 1 "pond", 4 coconut trees, 2 breadfruit trees, and one sand dune. Most of the land claims were near the shores of Pearl Harbor, but there were seventeen claims and eleven awards in upland portions of Waipi'o (Waipi'o Uka). The upland awards were along Kīpapa stream in Kīpapa Gulch (See Figure 5). There are no known *kuleana* claims in the present project area. While some of the *kuleana* claims have not been postively located by us, they are typically in the well-watered gulches rather than on the flat tops of ridges.

The *ahupua'a* of Waiawa was claimed (LCA 7713) by Victoria Kamamalu, sister of Kamehameha IV and Kamehameha V. Some thirty-eight commoners claimed lands at Waiawa but none of these claims appear to lie within the project area.

V. NATIVE HAWAIIAN CUSTOMS PERTAINING TO THE PROJECT AREA

A. Burials

The draft Archaeological Inventory Survey report (Hammatt *et al.* 1996) identifies no burials within the project area. No burials are believed to exist within the project area.

B. Trails

John Papa ʻĪʻī (1959:97,99) discusses the trail going from the south shore to the north shore through Oʻahu's central valley. He gives some details of the trail alignment from the Wahiawā area (around Kūkaniloko) heading south. The trail "continued on to the stream of Waikakalaua, Piliamoʻo, the plain of Punaluʻu, to a rise, then down to Kīpapa and to Kehualele" and thence on to a place called Pueohulunui where the trail from the North Shore met up with the main trail running from Honolulu to Waiʻanae. While the precise alignment of this trail can not be determined, Paul Rockwood's illustration of "Trails of Leeward Oʻahu as described by ʻĪʻī" (In ʻĪʻī 1959:96) shows the alignment of the major trail passing Kīpapa gulch to the southwest of the project area (outside), near the present highway.

Waipiʻo, as a typical *ahupuaʻa*, had one or more *mauka/makai* trending trails accessing the uplands in prehistoric times. However, documented "trans-Koʻolau traffic" took the easier route across at Kalihi and Nuʻuanu. For example, when ʻĪʻī's own famiy went from Waipiʻo to Kailua (*circa* 1810) they travelled via Nuʻuanu (ʻĪʻī 1959:30-32).

The earliest historic documentation of Hawaiian *mauka/makai* trails in the vicinity of the project area appears to be the 1928 USGS Wahiawā Quadrangle Map. This map shows an un-named trail following the present "Kīpapa Ridge Trail" alignment through a *mauka* portion of the project area up to an elevation of approximately 1780′

where it ends, seemingly at a small structure (perhaps a rain gauge). This 1928 map shows a "Schofield-Waikāne Trail" crossing the crest of the Koʻolaus (to the north of Waipiʻo *ahupuaʻa*) connecting those two locations.

A 1943 series USGS Kaukonahuanui Quadrangle map shows a trail, following the present "Kīpapa Ridge Trail" alignment, labeled the "Waiawa Trail." This trail is depicted as extending on up to the Koʻolau summit and there joining the "Koʻolau Summit Trail" which continues to the northwest linking it to the Schofield-Waikāne Trail.

It seems clear that in the interval between the production of these two maps that the Civilian Conservation Corps (CCC) was active in reforestation and trail improvement along this trail. Most of the observed plantings along the Kīpapa trail are understood to date from the CCC efforts of the 1930s.

The trail is presently listed as "Kīpapa Ridge Trail" by the Division of Forestry, Department of Land and Natural Resources. The trail is not maintained at present.

C. Other Archaeological/Historical Concerns

From an archaeological point of view, there are three major areas in which native rights issues are frequently encountered: religious sites or *heiaus*, burials, and trails. Two important religious sites were located in very close proximity to the project area, in Kīpapa Gulch just west of the southern portion of the project area. McAllister (1933:107) describes them as follows:

> Site 130. Moaula *heiau*, on the Honolulu side of Kīpapa Gulch just above Heiau o Umi, to which it is said to be a companion structure. The site is now covered with cane.
> Site 131. Heiau o Umi, was just northeast of the government road in the bottom of Kīpapa Gulch on the slight elevation at the foot of the pali on the Honolulu side. The level elevation can be seen, though planted in cane.

The Bishop Museum conducted a reconnaissance of the military held lands in

Kīpapa gulch and declared on the "Evaluation of Property Form" for these two sites (Rosendahl 1977) that they were both located in Kīpapa Gulch and both sites are listed as "site destroyed." In the Cultural Surveys fieldwork at Kīpapa Gulch "particular attention was paid to trying to locate Moaula Heiau and Heiau o Umi on the eastern side of the valley *mauka* of the Old Kamehameha Highway. No actual structure was observed, but a fairly level area, with some *ki* plants, was observed" (Hammatt and Borthwick 1988:31), conforming to McAllister's description of the Heiau o Umi site. In summary, three different archaeological studies indicate that the *heiau* sites were not in the present project area and were largely if not completely destroyed by cane cultivation down in Kīpapa gulch.

In the history of Hawai'i, the Kīpapa area is particularly associated with battles, indeed the derivation of the name "Kīpapa" is usually traced to "placed prone (referring to corpses slain in the victory of O'ahu forces over those of Hawai'i in the fourteenth century)" (Pukoi et al. 1976:113). This battle was described by Abraham Fornander as more of a raid than a war between the two islands: "it cannot be considered as a war between the islands, but rather as a raid by some restless and turbulent Hawai'i chiefs, whom the pacific temper of Mailikukahi and the wealthy condition of his island had emboldened to attempt the enterprise (Fornander, 1969 Vol. II, 89). The account continues with the invading force first landing at Waikīkī, then continuing on to the "'Ewa lagoon" (i.e. Pearl Harbor), up the Waikakalaua Gulch and finally into Kīpapa where "the invaders were thoroughly defeated, and the gulch is said to have been literally paved with the corpses of the slain, and received its name 'Kīpapa' from this circumstance (Ibid.)." No burials have been identified within the project area and there is no reason to believe the Kīpapa dead are located there.

The archaeological inventory survey (Hammatt *et al.* 1996) identified only two sites

in the vicinity of the project area. An approximately 3,600' section of the Waiāhole Ditch (Site #2268; built 1913-1916) runs through adjacent portions of Koa Ridge Mauka and Koa Ridge Makai. A portion of the Kīpapa Ditch (Site #9529; built *circa* 1930) lies just to the west (outside) of the Koa Ridge Makai parcel. There is no subsistence or traditional use associated with these 20th-century plantation constructions.

D. Native Hunting Practices

Evidence of pigs has been reported from the Koa Ridge Mauka, Waiawa, and Kīpapa Ridge portions of the project area (Funk, personal communication 1996). Evidence of contemporary pig hunting (dog tracks, hunter camps) has been observed by us at the Kīpapa Ridge portion of the project area. The Koa Ridge Mauka portion of the project area is used for access to pig hunting areas off of Kīpapa Ridge Trail and in adjacent gulches. Hunting of pigs in the immediate vicinity of the project area has been documented as far back as the 1930s (Appendix A: Gallano interview, Hammatt *et al.* 1996:38-39) but the history of hunting within the project area *per se* is unknown. There is no reason to believe that the immediate project area was a particularly good hunting ground in former times.

Goats (in rural O'ahu by the 1820s) and axis deer (introducted to O'ahu in the late 1800s) have been hunted in the southeast portion of the Ko'olau Range, but there is no evidence of deer or goats having been hunted in the vicinity of the project area.

E. Native Gathering Practices

Hawaiians gathered upland resources for quite a variety of purposes. Forest resources were gathered for food, clothing, tools, dying, construction, adornment, fish poison, medicinal purposes and religious purposes. Gathering in the uplands of the *ahupua'a* of Waipi'o is specifically discussed by John Papa 'Ī'ī (1959:77) who was born in Waipi'o in 1800: "here is a wonderful thing about the land of Waipi'o..., while the famine was upon the land, the people had lived on mountain apples (*'ohi'a 'ai*), *tis*, yams, and other upland foods." This account is set in the days prior to the overthrow of *kapu* in 1819 and clearly indicates a practice of native gathering practices in the uplands of Waipi'o.

John Papa 'Ī'ī's list is the only specific account of traditional gathering at Waipi'o as yet discovered. His list is notably open ended and other resources must have been gathered as well. For convenience, the various kinds of items which were gathered are discussed below by categories of animal, vegetable, and mineral with regard to their known distribution in the project area and vicinity.

Animal resources that drew Hawaiians into the uplands included birds for meat and birds which were hunted for their plumage. Species of birds occurring in the uplands of Waipi'o known to have been hunted by Hawaiians include the Pacific Golden Plover or *Kolea* (*Pluvialis dominica fulva*), and the Hawaiian Owl or *Pueo* (*Asio flammeus*). These species have not been reported or observed by us within the project area. Funk (personal communication) has noted the presence of chickens (a polynesian introduction) in the Waiawa portion of the project area as well as three historically introduced species (pheasants, spotted doves and zebra doves) which are widely distributed. Bird species sought for their plumage, which are present in the uplands of Waipi'o include the *'Apapane* (*Himatione sanguinea*) and *O'ahu 'Amakihi* (*Loxops virens*) but these have not been observed by us or recorded for the project area. Tree snails and fish and shellfish from Waipi'o Stream were also available for subsistence gathering in the uplands of Waipi'o. No tree snails, fish, or shellfish have been reported or observed by us within the project area.

Vegetable materials which would have been collected in the uplands of Waipi'o

would have included *lei* or adornment plants such as *'ohia lehua* (*Metrosideros sp.*), *maile* (*Alyxia oliviformis*), *a'ali'i* (*Dodonaea vicosa*), *pukiawe* (*Styphelia tameiameiae*) and various ferns. Plant species used for adornment that have been observed growing within the project area include the ferns *pala'a* (*Sphenomeris chusana*) and *laua'e haole* (*Phlebodium aurieum*) and the *'ohia lehua*. Specific medicinal plants used by Hawaiians that have been identified within the upland portions of the Waipi'o project area are presented in Table 1. No historic documentation of the harvesting or use of medicinal plants within the project area has been identified.

Dye plants present in the uplands of the Waipi'o area include *kolea* (*Myrsine sp.*) but this has not been observed within the project area. Construction materials for houses and canoes in the uplands of Waipi'o would include *hau* (*Hibiscus tiliaceus*), *ki* (*Cordyline terminalis*), *'ohia* (*Metrosideros sp.*), *hala* (*Pandanus sp.*), *koa* (*Acacia koa*), *naio* (*Myoporum sandwicensis*), and *ohe* or bamboo. Only *Koa* and *'ohia* have been observed in the project area. Wood sought for tools in the uplands of Waipi'o would include *'ulei* (*Osteomeles sp.*) which was used for purposes where strength and resilience were needed. No *'ulei* has been reported for the specific project area. Fiber plants to be sought in the uplands of Waipi'o included *mamake* (*Pipturus sp.*) *'ie'ie* (*Freycinetia arborea*) and *olonā* (*Touchardia latifolia*) but these have not been observed in the project area. Clumps of the polynesian narcotic cultigen *'awa* (*Piper methysticum*) grow in the uplands of Waipi'o but have not been observed within the project area. The *akia* (*Wikstroemia sp.*) used for fish poisoning has not been reported for the project area. Wild or semi-cultivated food plants to be sought in the uplands of Waipi'o include varieties of "mountain bananas", *ohelo* (*Vaccinium reticulatum*) and *akala* (*Rubus hawaiiensis*) berries, *'ohia-'ai* or mountain apples (*Eugenia malaccensis*) and early historic introductions such as ginger, guava and

Table 1: Medicinal Plants Identified in the Project Area

Latin Name	Hawaiian Name	Use	Koa Ridge Mauka	Koa Ridge Makai	Waiawa	Kipapa
Centella asiatica	*pohekula*	Tea to treat kidney problems				√
Ageratum conyzoides	*maile hohono*	Tea to treat shingles, itch	√	√		√
Bidens alba	*ko'oko'olau*	Soothing tea	√	√	√	√
Bidens cynapiifolia	*ko'oko'olau*	Soothing tea		√		√
Bidens pilosa	*ko'oko'olalu*	Soothing tea	√	√	√	√
Sonchus oleraceus	*pualele*	Treat diabetic sores			√	√
Momordica charantia	bitter melon	Treat diabetes	√	√	√	√
Ricinus communis	*pa'aila*, castor bean	Many medicinal concoctions		√	√	√
Sida fallax	*'ilima*	Treat indigestion	√	√	√	√
Eucalyptus robusta	*palepiwa*	Treat colds	√	√		√
Psidium guajava	yellow guava	Treat stomach ache & headache	√	√	√	√
Oxalis corniculata	*'ihi*	Treat asthma		√		√
Oxalis corymbosa	*'ihi*	Treat asthma	√		√	√
Plantago lanceolata	*laukahi*	Treat variety of ailments	√	√	√	√
Dodonaea viscosa	*'a'ali'i kūmakani*	Treat headache & insomnia				√
Solanum americanum	*popolo*	Treat digestive tract ailments, & sores	√	√	√	√
Waltheria indica	*'uhaloa*	Pain killer and for sore throat	√	√	√	√
Stachytarpheta spp.	*owi*	Treat a variety of ailments	√	√	√	√
Verbena litoralis	*owi*	Treat fractures		√	√	√
Commelina diffusa	*honohono*	Treat constipation	√	√	√	

coffee. Guava, strawberry guava, mango (one seedling), passion fruit vine, and banana trees have been reported within the project area. Other plant materials such as thatch and firewood undoubtedly were gathered by Hawaiians living in the gulches but for most of the residents of the *ahupua'a* such collection would not have been worth the trip into the project area as these plant materials would have been found in abundance much closer to habitation areas. It is difficult to know what the project area looked like in pre-contact times, and indeed the appearance and resources of the project area may have changed significantly over the centuries of polynesian occupation. One of our earliest detailed maps, the J. F. Brown map of Waipi'o 'Ewa, O'ahu of 1877 indicates that before the beginning of the commercial agriculture of sugar cane and pineapples (1897) the project area was "smooth grassy plain" with the "*ohia* and *koa* forest" designation beginning significantly *mauka* (See Figure 6). The grazing of introduced animals and various human activities however is assumed to have pushed the native forest significantly *mauka* in the previous few generations as "The alteration of natural vegetation in the Hawaiian Islands has progressed steadily upslope since 1778 (Cuddihy and Stone 1990:104).

Native Hawaiians commonly journeyed into upland areas to acquire certain desired geologic substances such as fine grained basalt, volcanic glass, hematite, and scoria, but no particularly unique geological resources are known within the project area.

VI. SUMMARY

This assessment has attempted to give due consideration to the effects which the proposed development activity may have on the specific practices, culture and traditions of native Hawaiians. Specific areas which have been examined have included the issue of burials (there are not believed to be any), the issue of access to Hawaiian trails, other archaeological/historical concerns including *heiaus* and a battle field in the vicinity, Hawaiian hunting practicces and Hawaiian gathering practices. The conclusion of this study is that the impact of the development of this specific parcel *per se* on Hawaiian culture would be minimal.

The lack of impact is a reflection largely of the geographic location of the parcel, set well back from the coast, with no surface water and no unique topographic features. There were no commoner land claims within the project area. While the absence of *kuleana* land claims does not necessarily mean an absence of Hawaiian activity, the patterns of land use in this area are relatively clear, and Hawaiians did not utilize this *kula* land nearly as intensively as they utilized coastal areas, well-watered areas, and forest zones.

The only significant native practices issue would seem to be access to the Kīpapa Ridge Trail for purposes of hunting and native gathering in adjacent gulches and farther upslope areas which lie outside of the project area.

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APPENDIX A:

Interview with Linda Mahoe Gallano

Mrs. Linda Mahoe Gallano, a teacher of the Hawaiian language at Wai'anae High School, and her husband have been caretakers since 1986 of the ranch house and grounds in the *mauka* portion of the Koa Ridge *Mauka* parcel. Mrs. Gallano, an avid hunter and student of Hawaiian culture, has hunted and hiked throughout the *mauka* reaches of Waipi'o and Waiawa *ahupua'a*, and has learned from long-time hunters and farmers of the area. She shared her knowledge of the area during an interview at the ranch on May 8, 1996 and, later, provided approximate locations of some of places mentioned during the interview on a map of upper Waipi'o and Waiawa *ahupua'a* (Figure 7).

Mrs. Gallano described her activities in the uplands and her sources of information:

> I first came up here in 1979. I've been here steady [as caretaker] since 1986. This was a ranch. [Randolph] Crossley had a working ranch here. So this was all levelled and then replanted with all these foreign trees because he had this aviary...But if you walk just a few steps back there, you're in *koa*, thick *koa*, and *'ōhi'a lehua*. [The ranch house and grounds are presently recreation center for Castle and Cooke employees.]
>
> I know the area but I'm always asking questions of other people. My two links to the past are Mr. Claude Ortiz of Pupukea and Sonny Nelson. Sonny Nelson of Wai'anae is an old time hunter of this area and he's hunted here from the 1930s on or the '40s at least.
>
> I started out hiking, but on my own, and then [learned from] listening to hunters. So I found my way up to the [Waiāhole] ditch from the old trail behind the houses...where you come up the hard way and you come out and there you are on top of the ditch trail from here, the Waiāhole ditch trail. And then I found my way across Kīpapa and some of the old trails back there. I've been to the summit a couple of times. We've been all over: Waiawa, Waiāhole, all the way back to the CCC [Civilian Conservation Corps] trail, the Swamp Gulch on the Waiawa side, all of Kīpapa, across from what they call Small Kīpapa, which probably has another name.

Noting that the hunters of the Kīpapa she knows reside elsewhere on O'ahu, Mrs. Gallano mentioned:

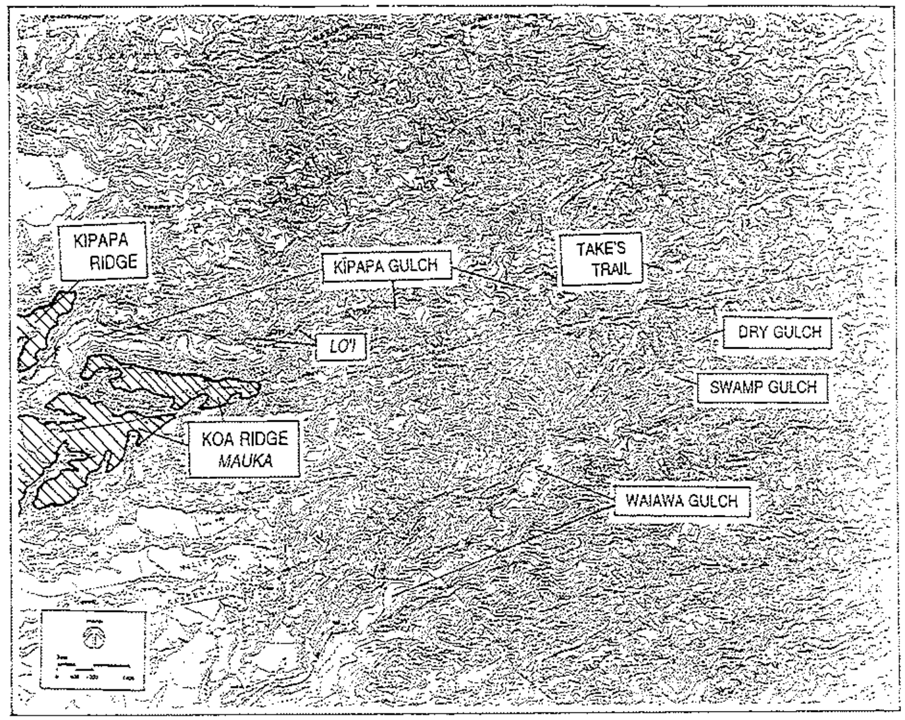

Figure 7 *Mauka* portion of Waipi'o and Waiawa *ahupua'a* showing locations of areas mentioned in interview with Mrs. Linda Mahoe Gallano

You know once you hunt a ground, you feel comfortable hunting that ground because you know where all the *puka* and all the danger places are. I should ask Sonny why does he still come here and hunt. But these are known as his grounds. You talk to young hunters coming up: "Oh, Sonny Nelson, yeah this his grounds." He doesn't live here but they all have this respect: "Oh this is Sonny Nelson's territory."

Mrs. Gallano described some of the trees and plants she's noted in the gulches and on the ridges:

I went with a botanist so I learned the names. There's *'iliahi* and there are tons of them on that Small Kīpapa Ridge over there. Of course there's *koa*, *'ōhi'a*, *lama*, and *'ahakea*, the one they make the gunnels of the canoe with. [The botanist] found an endemic *noni* that's supposed to be rare, because the Hawaiians brought the indigenous *noni* but this is the rare kind that was already here before the Hawaiians got here, so he's pretty excited about that. *Pepeiao*, of course. *'Ōhi'a 'ai*, rose apples. Pretty much everything that you'd find in a rain forest.

There's *'awa* in Waiawa.

[On the flats are] *pili* grass, *alahe'e*, *'a'ali'i*.

There is evidence of earlier 20th-century activity in upper Waiawa and Kīpapa gulches; in Waiawa Gulch:

There were bootleggers on the Waiawa side; you can still see the structures; you can still find bottles. I remember going in the 1970s and finding bottles but the bottle craze came in and a lot af stuff [disappeared]. I found a bottle not too long ago after a big rain.

Mrs. Gallano gave an account of a hermit who lived in the back of Kīpapa Gulch until the 1930s and mentioned the presence of taro *lo'i* in upper Kīpapa:

There was a Japanese man they called Old Man Take who had to have been born in the 1800s. He died around the 1930s. He lived in the back [of Kīpapa Gulch]. They called him a hermit; he was totally self-sufficient. He planted bananas, *'uala*.

They have a trail named after him: Take's Trail. The hunters say "Oh, I'll meet you at Take's." That's a trail about an hour in: you go in along the main CCC [Civilian Conservation Corps] trail - the ridge trail, the Kīpapa summit trail - you go along and all of a sudden there's a sharp left downhill and that's Take's Trail. And if you go down to the bottom it's all lush and you know it had a lot of stuff before. It's getting overgrown with some kind of foreign berry. But you can see where it's levelled off and flat

and there's all kinds of good things to eat down there. So they say that's his trail, he made that trail, and that trail used to not come down this way, it used to straight over to this other big area where there are *lo'i*. So it's like he would go over this hill and there's big wide bowl that later farmers or somebody used as a reservoir because you can see where there are rocks. And then you can see *lo'i* all the way out. The only name I know for that is Swamp Gulch. [From here] it's an hour walking in and then it's a hard hike...Not really, to go into Swamp it's a hard *drop*. It's a hard hike coming back out, especially if you're packing pig.

There's a place way in the back they call "Buddha House" probably because it was his house. I don't know and I've never been there. That is really hard walking in; it's almost to the summit wall. He was a real hermit. They say he used to hunt boar with a club because he didn't have a gun. I don't think he wanted to do too much with society, only when he wanted to come down to the [plantation] camp, maybe to get coffee and sugar, or something like that.

Claude Ortiz used to go up there and bring him presents around the holiday time. Now Mr. Ortiz is in his 80s or late 70s and he remembers him from that time, 1930, but nobody remembers after that so they pretty much think he died [in the 1930s].

The discussion of Take's Trail brought up the question of the age of the Kīpapa trails:

I would think that the CCC trail was built on an old trail. And Take's Trail: if you look at that mountain the fern is horrendous so I wouldn't imagine he just set out and said "I'm going to hack a trail over this mountain"; probably there was something existing.

Mrs. Gallano has observed other taro *lo'i* in Kīpapa besides those mentioned in the account of the hermit:

In Kīpapa is where I found these little pockets...it looks they had to have *lo'i* in there. I asked some *kupuna* from Wai'anae, "Why would the Hawaiians put their *kalo* up there?" It is so hard to get to, especially some of the places way in. They said it was like an insurance policy, that if something killed off all their plants or if they had war they would have *kalo* in the mountains, they could always go and restore. They didn't have to care for it because it grew so well in the mountains. But the last time I went through this big *kalo* patch they had up there, it was all trampled by the pigs. I guess the pigs got hungry. So I guess it wasn't totally safe.

Mrs. Gallano discussed possible former habitation areas in Kīpapa and Waiawa gulches:

[One of the farmers in Kīpapa Gulch] was telling me that all these places up here along this river [in the gulch] where there are big mango trees that there were houses before. And there are not too many, the mango trees don't go far up. But they go far up in Waiawa, they go way in, because it's wider. But over here, Kīpapa, it just gets really narrow and then it splits and it's narrow on both sides. He just said there were houses, I don't know if he meant Hawaiian houses.

Kīpapa is narrow and there are places where it's narrow with these big rock walls so there'd be no escaping [a flood] if you lived in that kind of place but then there are other places where you find these mango trees that are on a bluff, about four or five feet high, and then it's flat for a while, not huge.

Mrs. Gallano described one such possible habitation area nearby in Kīpapa Gulch:

It's right down here, you drop down, you go right down across the river and there's this big mango tree and right next to it is an orange tree and then there's this wide area that only has *'awapuhi* growing there. And there are rocks; you just know somebody lived there before. I had a *kupuna* come up once and he said they probably made *kapa* on this rock right there because it's right by this river so they could easily work on it but it's high enough the river that it's not going to get flooded.

Mrs. Gallano was told about other nearby evidence of Hawaiian activity in Kīpapa Gulch:

[One of the farmers] said they found (and I didn't ask him who is "they") *ulumaika* right down in that little pocket [of the gulch]. He said: "Oh, yeah, had plenty of Hawaiians living there before."

Summarizing the character of the area, Mrs. Gallano concluded:

Kīpapa is a very rough place. We always try to reciprocate so we tell the people we hunt with on the Big Island to come and hunt with us. And they'll hunt with us once and they'll go home and say: "We're never coming back." Because it's just too hard, it's very rugged. A lot of times we spend hanging on trees or just climbing and climbing.

Sometimes we have droughts. I have pictures of Kīpapa dry. Hunting pictures with the dogs standing in the river with big boulders all around them just looking like "Where's the water?"

G | Market Assessment

Economic & Fiscal Impact Assessment

MIKIKO CORPORATION

MARKET ASSESSMENT FOR KOA RIDGE MAKAI AND WAIAWA

ISLAND OF OAHU

Prepared for:
Helber Hastert & Fee, Planners, Inc.

FINAL REPORT

August 2008

Market Assessment for Koa Ridge Makai and Waiawa

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MARKET ASSESSMENT FOR KOA RIDGE MAKAI AND WAIAWA

Report Text

1 – Introduction and Executive Summary

Project Overview

Castle & Cooke Homes Hawaii, Inc. (C&C) is the fee owner of Koa Ridge Makai and Waiawa, covering some 766 acres in the Central Oahu Development Plan Area (DPA) of Oahu. C&C proposes that Koa Ridge Makai and Waiawa be developed as master-planned communities with residential, community and regional-serving facilities with generous landscaping and open spaces. The new community will be one that is safe, modern, and walkable, where residents can live, work and recreate in a master-planned, sustainable community encompassing principles consistent with "smart growth."

Together, Koa Ridge Makai and Waiawa are also referred to herein as "the Project."

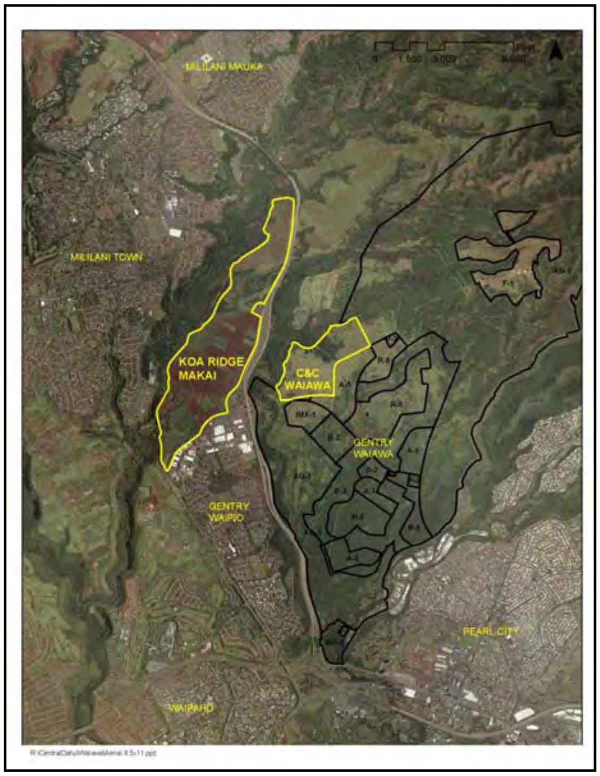
Location (Exhibit 1-1)

Koa Ridge Makai and Waiawa are located mauka of the H-1 freeway and east of Kamehameha Highway. They are adjacent to well-established and developing residential communities in Central Oahu such as Mililani, Gentry Waipio and Waiawa Ridge.

- **Koa Ridge Makai** would extend the existing community of Gentry Waipio northward alongside the H-2 Freeway, on plateaus that mirror Mililani Town across Kipapa Gulch.

- **Waiawa** is adjacent to Increment 1 of Gentry Investment Properties' and A&B Properties, Inc.'s planned Waiawa Ridge development ("Gentry Waiawa" on the map).

Location of Waiawa and Koa Ridge Makai in Central Oahu



Source: Castle & Cooke Homes Hawaii, Inc., 2007.

The large site areas and their varied terrain offer outstanding view orientations, including ocean- and gulch-, mauka- and city-views.

Scope of Development (Exhibit 1-2)

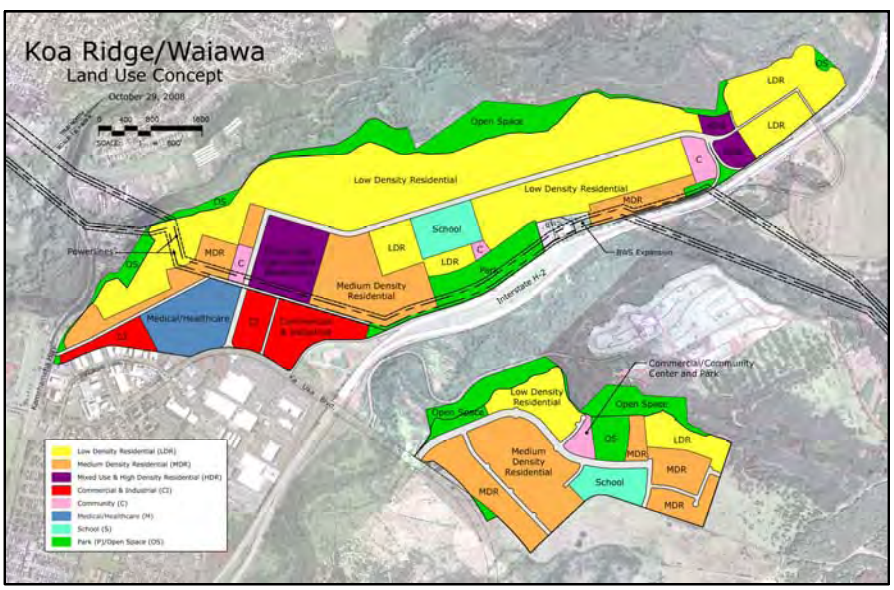
Koa Ridge Makai is planned as a master-planned mixed use community featuring a health care component providing comprehensive health care and wellness services and facilities. The development encompasses approximately 575 acres and would offer up to 3,500 homes balanced by employment-generating health care, commercial, light industrial, hotel and educational facilities.

A key element of the community is the mixed-use "Village Center" area that is planned as the social and community focus. The commercial and health care components will be integrated with the Village Center, which in turn will be linked by pedestrian pathways to the residential areas. A mix of uses and higher densities around the Village Center encourages walking and bicycling rather than use of private automobiles. Senior housing could also be integrated into the Village Center, providing its residents convenient access to retail services and health care. Neighborhoods designed around the planned school, community center and church would also increase the opportunity to walk rather than drive for short trips.

The Village Center also includes a site for a potential 150-room, extended-stay, all-suites hotel.

Koa Ridge Makai features substantial open space and recreation. Open space and pedestrian access will be provided along the edge of Kipapa Gulch, within utility easements, and as links to neighborhood parks. Long distance vistas of Kipapa Gulch will be visible at points along a well-landscaped spine road through the community.

Koa Ridge Makai and Waiawa Master Plans



Source: Castle & Cooke Homes Hawaii, Inc., 2008. See Exhibit 1-2 for a copy at larger scale.

The health care component will encompass approximately 28 acres for medical and health care facilities. These facilities may include a hospital, ambulatory care and skilled nursing, a physicians' office building, and support facilities.

Waiawa encompasses approximately 191 acres adjacent to the proposed Waiawa Ridge development. Primary access to the community is provided along a spine road that has dramatic views at the entry towards the Waianae Mountains. The central portion of the site will feature a community center with neighborhood retail, a neighborhood park, and an elementary school site to provide a concentration of pedestrian-oriented activities.

Waiawa would be a predominantly residential community, with up to 1,500 homes and about 30,000 square feet of neighborhood-serving commercial uses. Some 1,245 multi-family homes are located within convenient walking distance of the community amenities. Lower density homes consisting of approximately 255 single-family residences are located along the spine road extending to the mauka end of the site. The development of Waiawa is dependent on the progress of infrastructure development at the adjacent Waiawa Ridge community that will serve both projects.

Maximum build-out of the Project is summarized as shown below:

Proposed Maximum Development at Koa Ridge Makai and Waiawa

	Koa Ridge Makai	Waiawa	Total
Total acres	575	191	766
Residential units	3,500	1,500	5,000
Commercial retail & office (sq. ft.)	380,000	30,000	410,000
Light industrial (sq. ft.)	90,000	0	90,000
Health community (acres)	28	0	28
Hotel rooms*	150	0	150

* Potential extended-stay, all-suites hotel in Village Center.

Source: Castle & Cooke Homes Hawaii, Inc., August 2008.

C&C estimates that the first real estate products at Koa Ridge Makai could be delivered as early as 2012, while those at Waiawa could be available by about 2015.

Report Overview

C&C has initiated a planning and entitlement process for the Project, including preparation of an Environmental Impact Statement (EIS) that will be used in the State Land Use and County zoning processes. Helber Hastert & Fee, Planners, Inc. (HHF) is assisting C&C in these, and asked Mikiko Corporation (Mikiko) to prepare market, economic and fiscal impact assessments for the Project.

This report covers the Project market assessment. Mikiko's objective in this study was to describe the market support for development of the residential, commercial (retail and office) and light industrial uses proposed at Koa Ridge Makai and Waiawa, in terms of:

a) Evidence of the demand and competitive supply;

b) Anticipated market segments, supportable market shares and market absorption;

c) For residential units, projected supportable unit pricing.

These evaluations are based in part on information and planning parameters provided by HHF and/or C&C. Mikiko's market assessment does not address demand for the proposed health care facility or hotel at Koa Ridge Makai. The health care and hotel facilities have been evaluated by other consultants. The product demand conclusions presented herein are in addition to any that may be associated with the health facilities or hotel.

Highlights of Mikiko's market conclusions are summarized in the sections that follow. The rationale behind these conclusions, as well as documentation of the study methodology and supportive data, may be found in the subsequent chapters.

A statement of report conditions is presented in Appendix 1.

The economic and fiscal impacts of the Project are described in a separate report.

General Community Outlook

Central Oahu is a popular residential location due to:

- Its relative proximity to the many employment centers in and surrounding Pearl Harbor, the Honolulu International Airport, urban Honolulu and Waikiki;
- Its cool, upland climate and commanding views;
- The high quality, master-planned communities established by C&C at Mililani Town and Mililani Mauka;

- Its relative maturity, meaning that a second and third generation of households is now being formed among persons who grew up in Central Oahu; and

- Its affordability relative to East Honolulu.

Regional Changes

The projections developed herein acknowledge that during Koa Ridge Makai and Waiawa's marketing, major public and private investments and other developments in and around the emerging "Second City" of Kapolei will have significant impacts throughout all of Central and West Oahu.

These changes are expected to lead to more "living wage" jobs within the region, and less dependency on out-commuting to Honolulu. This would in turn enhance community values and quality of living, as well as the markets for residential, retail and office uses throughout the area. Within Koa Ridge Makai itself, numerous professional and technical career opportunities would be supported at the proposed health facility and hotel.

Summary of Market Conclusions

The table below summarizes the projected market absorption of the land uses evaluated. These conclusions are further explained in the sections and chapters that follow.

Projected Market Absorption at Koa Ridge Makai and Waiawa

	Total units	Potential absorption period	Years marketing	Average annual absorption
Residential homes	5,000	2012-2025	12-14	360-450
Commercial (square feet)*	410,000	2012-2025	14	30,000
Industrial (sq. ft.)**	90,000	2016-2020	5	N/A

* Commercial areas in addition to any that may be associated with the proposed Koa Ridge Hotel.

** Could be absorbed in a single year by a single or few user(s)/tenant(s); "marketing" period shown reflects potential timing of the site's buildout based on other development sequencing.

Source: Mikiko Corporation, 2008.

Residential Market Assessment

Market Environment

Oahu has an acute shortage of housing suitable for primary residents, with an estimated pent-up demand for some 21,000 units as of mid-2008. Additionally, based on growth projections prepared for or by the State and county agencies, Oahu will need to house some 57,000 more households by 2030.

About 51,000 potential future housing units are currently entitled at the State Land Use Commission (LUC) level.[1] Even assuming substantially accelerated housing development in the short-term, without further Urbanization of lands for residential use, Oahu's housing shortfall could gradually be pared down to some 17,000 units by about 2020, but it could then spiral to about 29,000 units by 2030.[2]

This conclusion is summarized as follows:

Supply and Demand for New Resident Housing Units on Oahu
2008 to 2030

Future Demand	Pent-up demand, 2008	21,000
	Future need, 2008-2030	57,000
	Total need	78,000
Future Supply	Planned and entitled (51,000 less 5% vacancy)	49,000
Shortage	**As of 2030**	**29,000**

Source: Mikiko Corporation, 2008. Future supply estimate assumes full buildout of all lands currently designated Urban by the LUC, and proposed for residential development. See Exhibit 3-6 for further information.

Market Assessment

Koa Ridge Makai and Waiawa's housing units are an important component of the Central Oahu regional plan and could be a solution for up to 17% (5,000/29,000) of the island's currently unentitled housing demand through 2030.

- **Product mix** – Some 70% and 83% of Koa Ridge Makai and Waiawa's residential units, respectively, could be for-sale multifamily homes. Some of these multifamily units could alternatively be developed as senior housing or affordable rental units. The balance of units is preliminarily planned as for-sale single-family units.

[1] In this report, "State-entitled" or "LUC-entitled" means properties carrying LUC "Urban" designation or those that are proposed for development but may be exempt from State regulatory control. Some of these would still require County zoning or other entitlement in order to proceed.

[2] Besides Koa Ridge Makai and Waiawa, the other major development for which a petition for State entitlement is underway is D.R. Horton-Schuler's Ho`opili (up to 11,750 units). Even if this project were entitled and developed to its full potential by 2030, Oahu could still be 17,250 housing units short (29,000 – 11,750).

Overall, the Project's preliminary mix represents 26% single-family and 74% multifamily units, as shown in the following table. The exact mix of units by type will be determined during build-out, as market conditions and preferences materialize.

Conceptual Plan for Residential Products at Koa Ridge Makai and Waiawa

	Koa Ridge Makai	Waiawa	Total	Overall unit mix	Typical units per acre
Single-family	1,054	255	1,309	26%	6
Multifamily	1,162	1,245	2,407	48%	10 to 20
High-density multifamily	1,284	0	1,284	26%	30 to 50
Total homes	**3,500**	**1,500**	**5,000**	**100%**	

Source: Castle & Cooke Homes Hawaii, Inc., August 2008.

- **Development densities** – Koa Ridge Makai and Waiawa's single-family units are proposed at an average 6 units per acre while its multifamily units could range from 10 to 50 units per acre.

- **Target markets** – A substantial share of units throughout the Project will be developed as affordable housing, in accordance with the County's affordable housing policies in effect at the time. These policies are likely to restrict use of these affordable units to primary residents.

  Among the market for-sale units, the majority is expected to be purchased for use by owner-occupants. Some may be purchased as investments and rented out, again resulting in units for primary resident use.

- **Pricing (2008 dollars):**

  - **Market units**: Koa Ridge Makai and Waiawa's market units are expected to support prices ranging from (in 2008 dollars):

    - $350,000 to $600,000 for the high-density multifamily products at Koa Ridge Makai;

    - $350,000 to $550,000 for the low- to medium-density multifamily products;

    - $550,000 to $950,000 for the single-family products.

- **Affordable units**: The pricing of affordable housing at the Project can be expected to be established based on future agreements to be made with County and State agencies. These agreements are likely to consider household income, family size, development types and other factors. Although County affordable housing policies are currently under review, among projects constructed recently, the majority has been required to address the needs of households earning up to 120% of the area median income (AMI.)

- **Absorption –** Based on an analysis of C&C's Oahu new home sales closings and specifically those at Mililani and Mililani Mauka over a 38-year period, the Project is conservatively projected to close 360 to 450 units per year, on average. Year-to-year sales and the location of sales would vary.

This sales pace would lead to complete absorption of the Project's housing by 2022 or 2025. The slower sales scenario (average of 360 home sales per year) is illustrated in the table that follows. The accelerated scenario (average of 450 home sales per year) would alternatively result in the Project selling out by 2022.

Projected Slower Scenario for Residential Sales Absorption at Koa Ridge Makai and Waiawa

	Koa Ridge Makai	Waiawa	Total Project
Potential total inventory	3,500	1,500	5,000
*Average annual sales**	*250*	*140*	*360**
Years on market	*14*	*11*	*14*
Start date	*2012*	*2015*	*2012*
*End date***	*2025*	*2025*	*2025*

* Koa Ridge Makai shown with higher average annual sales than Waiwa because of its several years of marketing prior to commencement of sales at Waiawa. Likewise, total Project sales absorption during an average year would be less than the sum of the two sales rates by community.

** Based on slower scenario projected sales absorption. At accelerated scenario, the Project could be expected to sell out by 2022.

Source: Mikiko Corporation, 2008.

The above assumes all units are built as for-sale housing. However, some housing may be developed as rentals.

Commercial Market Assessment

Overview and Methodology

The commercial market analysis begins with an evaluation of demand and supply for retail- and office-based developments separately, but the final assessment considers the two uses in the aggregate. This is appropriate since the exact mix of commercial uses to be developed at the Project cannot be determined at this time, and the typical shopping center includes office spaces while there are often retail uses in office complexes. Specific types of commercial uses within each area of the Project will be determined in accordance with future market conditions and area-specific needs as each area is planned.

- **Retail –** The retail market analysis is conservative in that it is based on projected demand and supply originating from the Central Oahu Development Plan Area[3] (DPA) only, even though outlying areas are likely to contribute material additional demand.

- **Office –** The office market analysis considers demand originating from future employment in both the Central Oahu and Ewa DPAs, in recognition of the larger area in which employees, as opposed to shoppers, are willing to commute. Competitive office supply is evaluated for this larger trade area also.

The commercial demand projected herein is in addition to any that may arise within or because of the proposed Koa Ridge Hotel and health facilities.

Market Assessment

- **Product overview –** The Project is proposed for up to 410,000 square feet of commercial uses, 30,000 square feet in Waiawa and 380,000 in Koa Ridge Makai. These areas do not consider retail or office-related spaces that may be included in the proposed hotel or health facility.

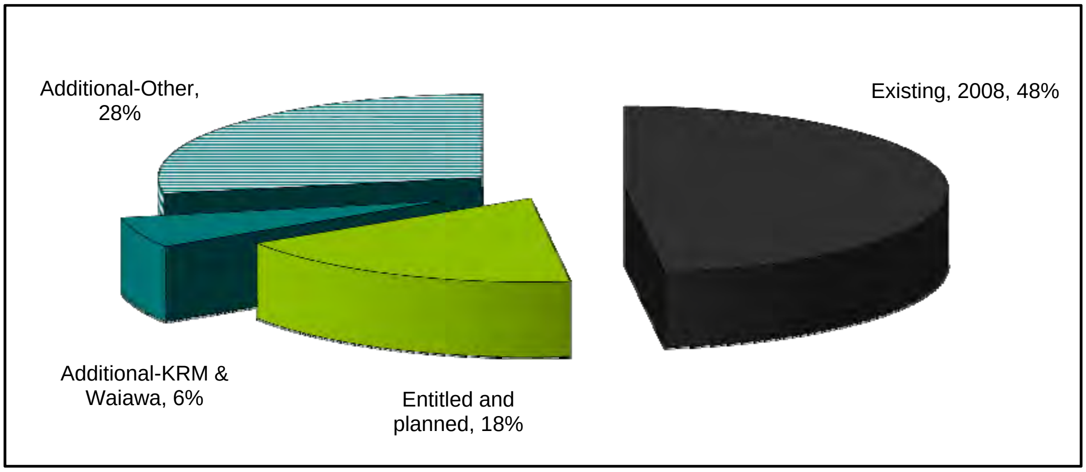
- **Sources of demand –** Koa Ridge Makai and Waiawa's primary retail Trade Area is considered to encompass the Central Oahu DPA. Office facilities at the Project could draw from a larger community, including businesses that attract employees from throughout Oahu. However, in order to be more conservative, the office market was evaluated in terms of demand generated only within Central Oahu and Ewa.

- **Absorption –** Commercial spaces at Koa Ridge Makai and Waiawa are projected to be fully absorbed by about the time of complete residential absorption, which is assumed to be by 2025.

[3] See Chapter 2 for discussion and explanation of Oahu's DPA's.

- **Market share** - If developed to their full proposed capacity, Koa Ridge Makai and Waiawa's commercial spaces could represent some 6% of the Central Oahu DPA's future inventory in 2020 and 2030.

Potential Project Market Share of
Central Oahu DPA Commercial Marketplace,
at Maximum Build-Out, 2030



Source: Exhibit 7-2 for sources and further information.

The Project as a whole could also represent a venue for about 19% of the currently unplanned but future supportable commercial space in Central Oahu through 2020, or 18% through 2030.

These market shares are considered achievable in light of the residential population that will be within the Project itself, as well as projected population and employment increases throughout the region.

Light Industrial Market Assessment

Overview and Methodology

The light industrial space market analysis profiles current industrial land and warehouse space trends in Central Oahu and Ewa, but the assessment for future demand is based on island-wide trends. This is appropriate because as eastern Oahu and the island's urban core are redeveloped with higher-density and higher-value uses, industrial and business park facilities are increasingly being pushed to the central and western areas of the island.

The assessment does not consider government or public/quasi-public use areas such as harbors, airports, universities or utility sites.

The long-term outlook business park or light industrial uses is seen to arise from two types of sources:

- **Employment-driven demand**, which is estimated based on the outlook for civilian job creation.

- **Transition-driven demand**, which is the result of facilities or land uses being displaced from one location to another, and/or the natural turnover of some tenants as their lease terms mature.

Market Assessment

- **Product overview** - The land use plan for Koa Ridge Makai includes a 5-acre site (or about 4 net acres) for business park or light industrial development. At a floor area ratio (FAR) of 0.5, it could be expected to accommodate about 90,000 square feet of building area.

- **Potential markets –** Given the relatively small size of the site, it could be expected to be occupied by a single or just a few tenant(s) or owner(s). Example uses could include an office headquarter campus, a research & development facility, or service-retail uses such as self-storage or auto repair and maintenance.

- **Development timing** - Considering the strong long-term regional market conditions as well as Koa Ridge Makai's central location and the integration of its business park site into a mixed-use community, the site could be expected to find a user or buyer within a single year of its offering, but is likely to be fully absorbed by 2020.

- **Market share –** This site would represent a solution for only about 6% of the net unprovided-for demand in the region, or about 1% of the future DPA marketplace, as of 2020.

2. Economic and Demographic Trends

Time Frame

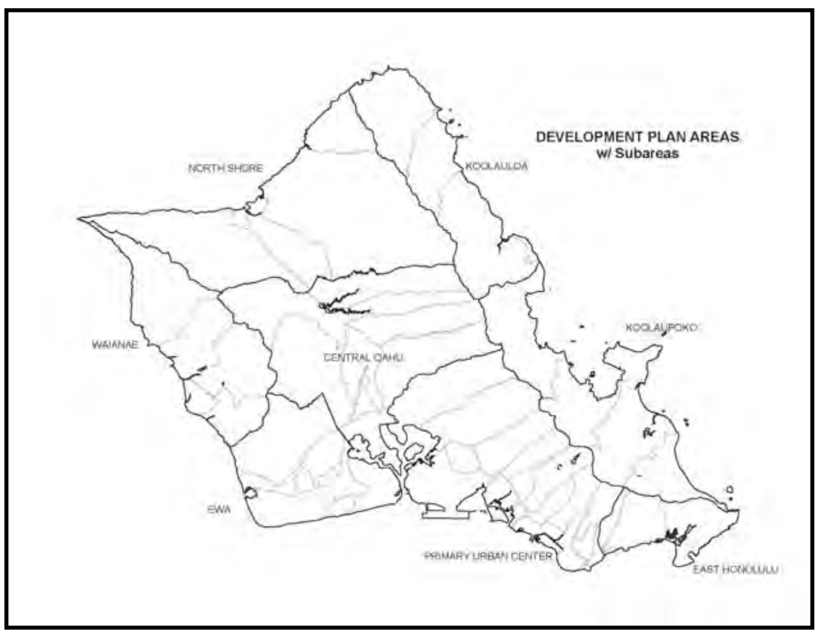
This section presents recent estimates or projections of demographic and economic indicators of relevance to the market assessments. Where data are available, projections are shown to the year 2030, which could be 10 or more years beyond the anticipated date of absorption of the various real estate products evaluated at Koa Ridge Makai and Waiawa.

Geographic Areas of Analysis

City and County DPAs

Much of the economic and demographic data presented herein is organized by the City and County of Honolulu's Development Plan Areas (DPAs). The Project falls within the Central Oahu DPA, which extends inland from the center of Pearl Harbor, in a large swath bordered by the Ko'olau Mountains to the east and the Waianaes to the west. Central Oahu abuts the Ewa DPA along Fort Weaver Road on its western edge, and the Primary Urban Center DPA ("PUC") along its southern and eastern sides.

City and County of Honolulu Development Plan Areas



Source: City and County of Honolulu.

Special attention is also given herein to the Ewa DPA because it represents a supplementary market for the proposed non-residential uses at Koa Ridge Makai and Waiawa, such as in their retail and office market.

- **The Central Oahu DPA** includes the communities of Waipahu, Village Park, Waipio, Wheeler Air Force Base, Schofield Barracks, Wahiawa, Kunia, Mililani Town, Mililani Mauka, Waikele, Waipio Acres and the planned Gentry by Waiawa. It stops short of Pearl City and Waimalu.

- **The Ewa DPA** includes Makakilo, the "Second City" of Kapolei (including the Villages of Kapolei and Kapolei City itself), Ewa Villages, Ewa by Gentry, Ewa Beach, Iroquois Point, and several proposed or developing communities including Mehana, Maka'iwa Hills, Ho`opili and UH West Oahu.

DPAs Approximated by Zip Code (Exhibit 2-1)

DPAs as Approximated by Zip Code

Source: Claritas 2008, see Exhibit 2-1 for copy at larger scale.

The City's DPAs often follow natural features that are not recognized as census divisions, so it is difficult to collect economic and demographic information within the DPAs per se. Thus, this report uses zip code areas as a proxy for the City's DPAs, and data presented as representative of a DPA may be drawn from the corresponding area approximated by zip code. By zip code, these areas differ from the "real" DPAs as follows:

- Central Oahu includes an extension to its northwest, between Routes 803 and 99. This area includes the military housing areas of Whitmore Village and Helemano.

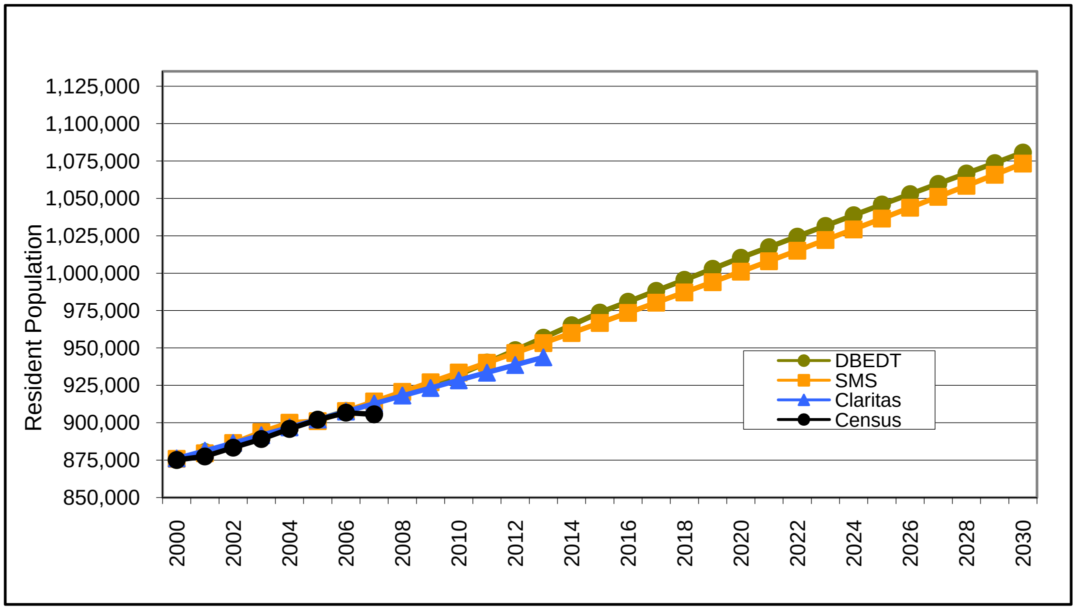
- Ewa includes more land at its northern tip, but this area includes few homes.

Overview of Demographic Trends

Oahu Population (Exhibit 2-2)

Oahu had 876,156 residents at the time of the last U.S. Census on April 1, 2000, or an estimated 875,133 as of July 1, 2000, also according to the U.S. Census Bureau. Four sources are considered in estimating how population has grown since then, and how it is likely to grow over the next two decades.

Resident Population – Island of Oahu



See Exhibit 2-2 for sources and further information.

- In March 2008, the U.S. Census estimated Oahu's 2007 resident population at 905,601, representing a 0.5% annual rate of growth since the Census' 2000 estimate. The Census' 2007 estimate represented a slight decline from its 2006 estimate.

- Claritas[1] provided this study with a 2008 population estimate of 918,194 and a 5-year projection to 943,773 by 2013. Claritas' figures were prepared on the basis of the Census' 2007 estimate.

- The State of Hawaii, Department of Business, Economic Development and Tourism (DBEDT) offers long-term projections; the latest was prepared in January 2008. This series also reflects the Census' most updated estimate. DBEDT shows 919,953 residents on Oahu in 2008 and anticipates 1,080,700 by 2030, at an annual growth rate of 0.7%.

- SMS[2] recently prepared a model that provides a long-term outlook on population and housing statewide. By employing a 0.7% rate of population growth, the model projects 920,638 Oahu residents in 2008 and 1,073,340 by 2030. This growth rate is below the "official parameter" rate of 0.9%, as specified in the 2007 study, but is selected to more

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[1] Claritas is a leading provider of geodemographic market research information to government and industry throughout the U.S. Claritas derives its information from the U.S. Bureau of the Census, State and local governmental planning and forecasting entities, its proprietary Business-Facts ® database and other sources.

[2] SMS, Inc., "Housing Policy Study, 2006: Hawaii Housing Model 2006," February 2007. The study was prepared for a consortium including the Housing Officers and other Administrators of the City and County of Honolulu (as well as the other three Hawaii counties), and the State of Hawaii, Hawaii Housing Finance and Development Corporation, the Office of Hawaiian Affairs, and the Department of Hawaiian Home Lands.

closely conform to the more recent DBEDT and Claritas analyses which had the benefit of the 2007 Census estimate.

Aging of the Population (Exhibit 2-3)

The changing age-composition of the population will have an enormous impact on home-buying and other consumer spending patterns in Hawaii as elsewhere in the nation. While long-term projected age-cohort data are not available by county or sub-areas, the U.S. Census does prepare decennial projections by state.

Viewed in an age pyramid, a most notable feature is the aging of the Baby Boomers, whose members were between the ages of 41 and 60 in 2006, will range from about 45 to 64 years old by 2010, 55 to 74 by 2020, and 65 to 84 by 2030.

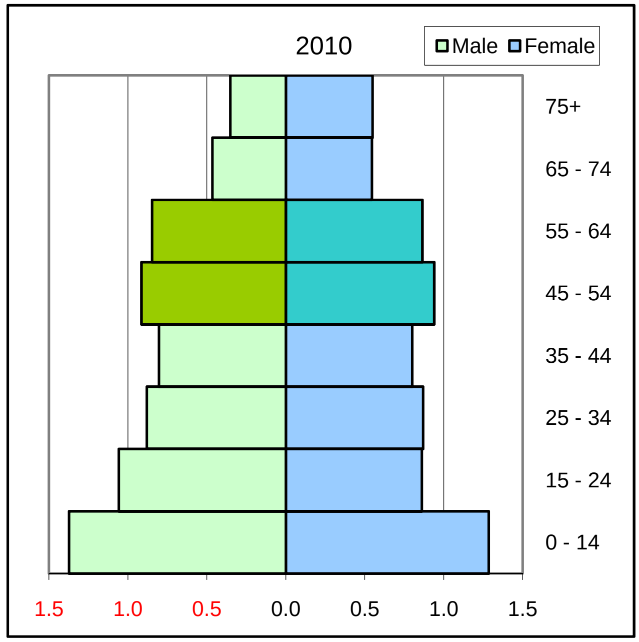
- **2000 to 2010** - As the dominant consumers in the overall marketplace today and for years to come, Baby Boomers are fueling a move-up home-buying market consistent with their middle-aged, peak earnings-power status.

  Age groups showing the most population gains in the 2000 to 2010 period in Hawaii are all over 45:

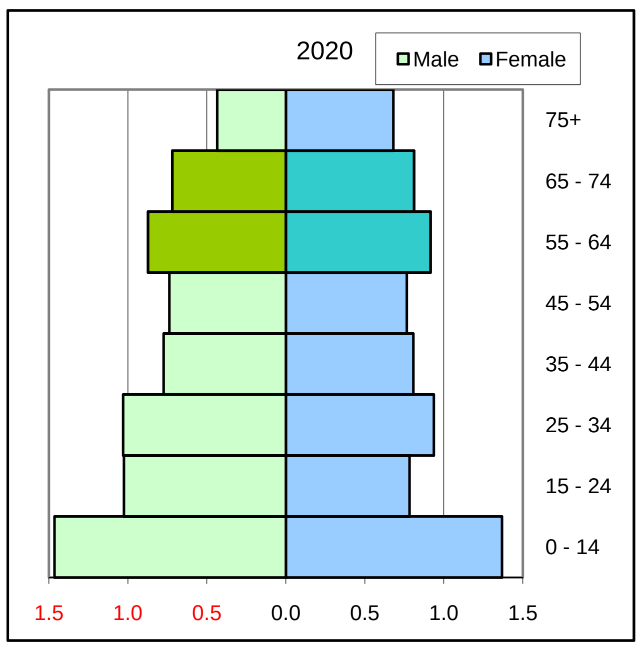
  - 45 to 54: +14,000 persons
  - 55 to 64: +64,000 persons
  - 65 to 74: +16,000 persons
  - 75+: +15,000 persons

- **2010 to 2020** – In the coming decade, Baby Boomers will continue to exert strong influence in the housing market. This is expected to be reflected in rapidly growing demand for downsized, retirement and/or other specialized housing types reflecting their empty nester and retiree stages of

Age Pyramid – State of Hawaii: 2010



Age Pyramid – State of Hawaii: 2020



Note: Each unit on horizontal axis represents 100,000 people.

See Exhibit 2-3 for sources and further information.

life. Also notable in this decade will be strong growth in the entry and early-housing market, represented by persons aged 25 to 34. The latter cohort is a portion of what is sometimes referred to as the "Echo Boom," since many are the children of the Baby Boom cohort.

Thus, age groups projected to show the most gains in this later period include both early and older homebuyers:

- 25 to 34: +22,000 persons
- 55 to 64: +8,000 persons
- 65 to 74: +52,000 persons
- 75+: +21,000 persons

- **2020 to 2030** – The last decade evaluated will be characterized by rapid growth of the elderly population, necessitating specialized and age-catering housing solutions.

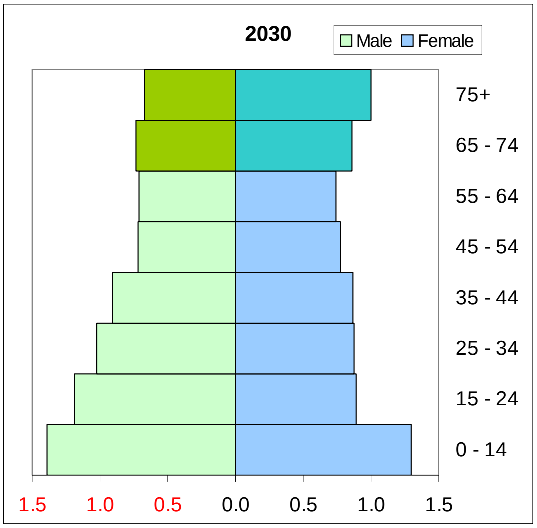
  The second most rapidly growing potential housing market during this period will consist of those aged 15 to 24, an age that usually encompasses household formation, often in rental housing.

  The third rapidly growing group would be those aged 35 to 44, typically a home-buying or early trade-up housing market.

  Cohorts expected to gain population statewide in this decade include:

  - 15 to 24: + 27,000 persons
  - 35 to 44: + 19,000 persons
  - 65 to 74: + 6,000 persons
  - 75+: +56,000 persons

Age Pyramid – State of Hawaii: 2030



Note: Each unit on horizontal axis represents 100,000 people.

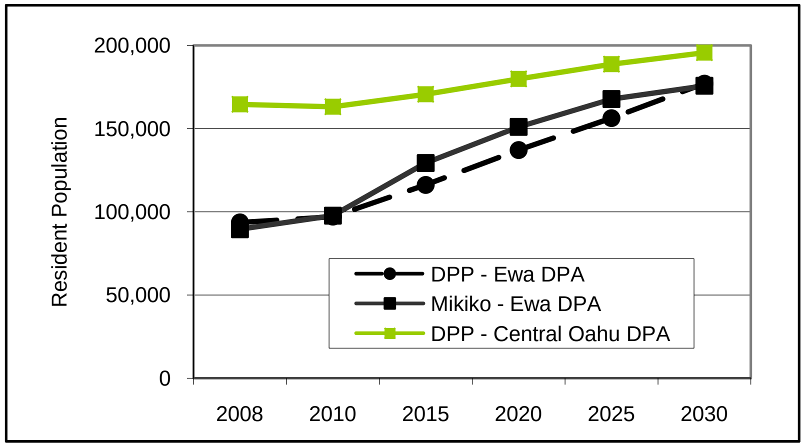
See Exhibit 2-3 for sources and further information.

Demographic Trends by Development Plan Area

Population by Area
(Exhibit 2-4)

DPP uses the State's projections to forecast population within its DPAs. DPP's most recent such forecast was prepared in 2006 and was based on DBEDT's prior projections, prepared in August 2004. However, these allocations of island population to DPAs are valuable in that they consider resident distribution in the context of the City's development policies and plans.

Resident Population – Ewa and Central Oahu



See Exhibit 2-4 for sources and further information.

- **In Central Oahu**, DPP foresees below-average rates of growth over the next 10 years, and above-average rates thereafter. Overall, this would result in an average 0.8% per annum growth from 2008 to 2030, at a slightly faster rate than for the island as a whole. Central Oahu would continue to house approximately 18% of the island's population. This would lead to 195,620 persons living in the DPA in 2030, or 31,040 more than estimated in 2008.

- **In Ewa,** DPP anticipates relatively high rates of growth over the projection period, in concert with its vision for the area as a "Second City." Ewa is eventually seen to house 16% of the island's population, more than doubling from some 93,630 persons in 2008 to 177,030 by 2030. The Ewa DPA is projected to approach Central Oahu in population by the end of the period.

  Mikiko reviewed DPP's Ewa projection in light of the significant inventory of unbuilt but State-entitled housing in that area. Mikiko found that even with dramatically smaller household sizes for new as compared to existing households and phased development of new projects, Ewa area population could grow more rapidly than projected by DPP initially, but could be constrained after 2025 by a lack of further developable housing inventory. In Mikiko's analysis, population in the Ewa DPA is projected to grow 3.1% per annum over the next 24 years, finishing 2030 at about 175,700 persons.[3] Mikiko's projections may still be conservative because:

[3] Note that Mikiko's projections of supportable area population for 2030 are close to Campbell Estate's and its consultant's projections for 2025. See Decision Analysts Hawaii, Inc., which projected Ewa regional population at 175,360 for 2025 ("'Ewa Development, 2006 to 2025: Economic, Population and Fiscal Impacts," September 2005.)

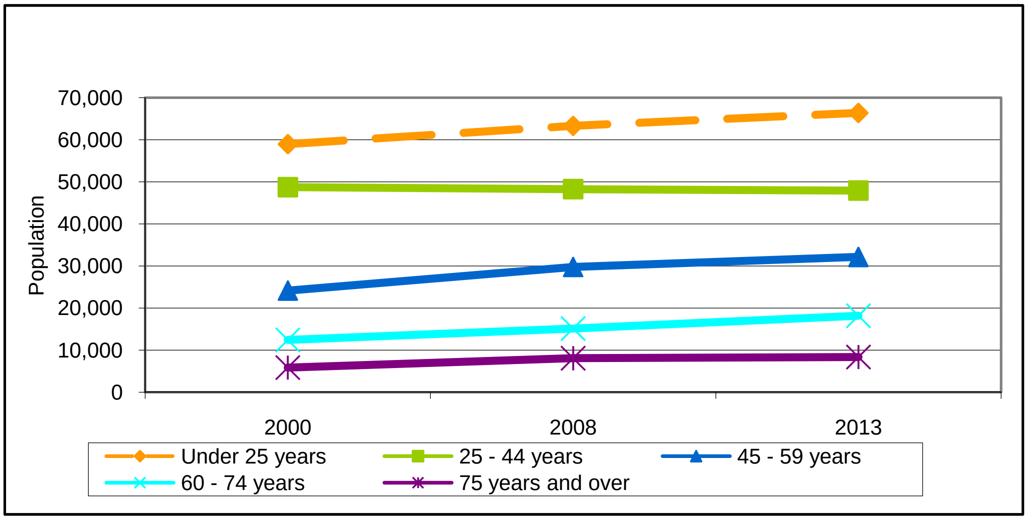
- ❑ We assume the new homes to be added will house fewer persons each than do existing homes, and

- ❑ We do not consider any impact from proposed Ewa area developments that are not yet LUC-entitled, such as the 11,750-unit Ho`opili project.

Population by Age Group (Exhibit 2-5)

The largest age groups in both DPAs were those under 25, followed by the 25 to 44 and 45 to 59 age groups. Over the next five years, the greatest increases are anticipated within the under 25 and the 45 to 59 age groups, followed by the 60 to 74 age group. This reflects the Baby Boom generation moving into its 50s and 60s. In contrast, in this short-term view, Claritas projects that the 25 to 44 age group decline in Central Oahu.

Population by Age Group – Central Oahu



See Exhibit 2-5 for sources and further information.

Central Oahu's population is relatively young, at an estimated 2008 median age of 32.8, compared to the islandwide median of 37.3. Ewa is also a relatively young community, with an estimated a median resident age of 31.8 in 2008. This is attributed to the more numerous entry-level housing options in both Central Oahu and Ewa.

Number and Age of Households (Exhibits 2-6 and 2-7)

In 2008, Claritas estimated Oahu had about 304,600 households. Within this total, some 16% or 48,900 lived in Central Oahu, while 8% or 25,000 lived in Ewa[4]. As average household sizes decline, households are expected to increase more rapidly than population. In Central Oahu, households are projected to increase 1.4% per annum, to

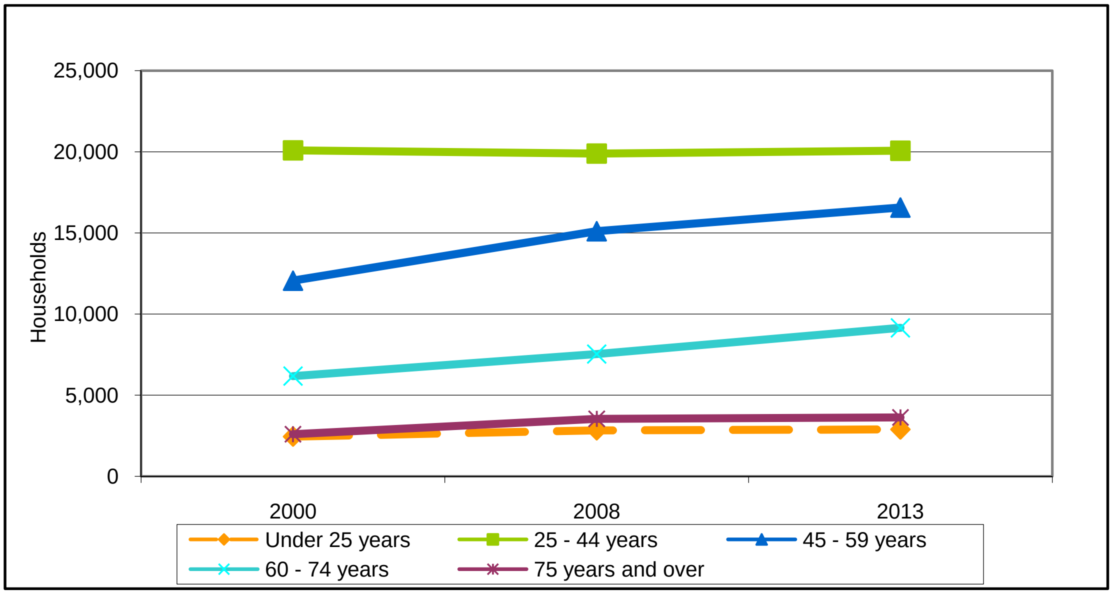
[4] 2008 and 2013 Claritas figures for Ewa adjusted to be consistent with the area population projection presented previously in Exhibit 2-3.

about 52,300 by 2013. This would mean Central Oahu's share of Oahu households would increase slightly, to about 17%.

With its many entitled vacant lands, Ewa's households are expected to gain market share over the next 5 years, to about 11% of County households by 2013. This would represent 33,500 households at an average size of 3.5.

Household heads are older than the population as a whole. The biggest group island-wide is currently householders ranging from 25 to 44.

Households by Age of Head – Central Oahu DPA



See Exhibit 2-7 for sources and further information.

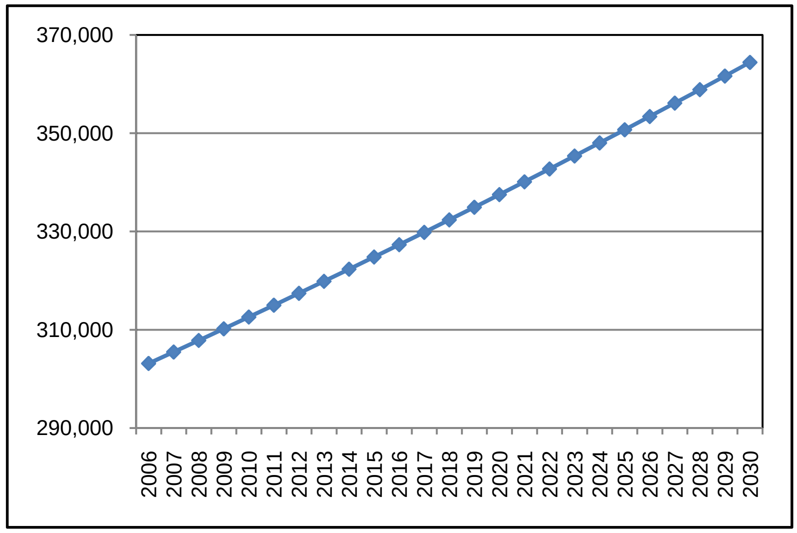
In Central Oahu, the numbers of households headed by those aged 45 to 59 and 60 to 74 are increasing most rapidly. The combination of population growth, aging and a trend towards smaller households could lead to 1,600 more households headed by persons aged 60 to 74, and 1,500 more by those aged 45 to 59 by 2013. In contrast, the number of households headed by those aged 25 to 44 is expected to be static.

Given these changes, the 45 to 59 age group could approach the 25 to 44 age group by 2013 in both the DPAs evaluated. The 45 to 59 age group is considered a prime move-up housing market, while the 25 to 44 age group includes many first-time buyers.

Long-term Projection of Households

The SMS housing study discussed previously also projected Oahu households to 2030, utilizing the assumed 0.7% rate of population growth and the projected population figures shown previously. The household projection also assumes a gradual continuation of the trend towards smaller households. The series shows 307,835 households on Oahu in 2008, (at 2.99 persons per household) and 364,423 in 2030 (at 2.95 per household).

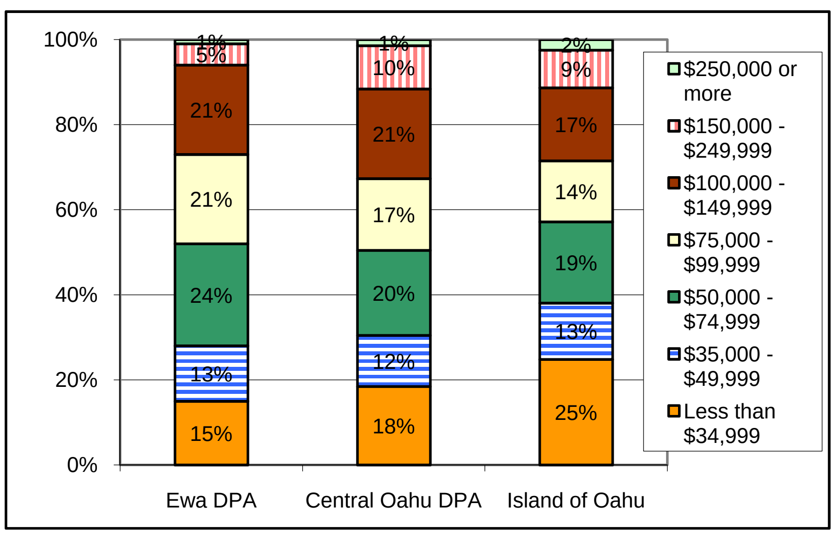
Projected Oahu Households



Source: SMS Research, February 2007.

Households by Income
(Exhibit 2-8)

Households by Household Income, 2008



See Exhibit 2-8 for sources and further information.

Central Oahu and Ewa show a higher household income profile than the island as a whole. Claritas estimates the median 2008 household income is approximately $74,410 in Central Oahu and $81,095 in Ewa, compared to $65,633 for the island of Oahu.

The Central Oahu DPA also shows relatively fewer households with incomes below $74,999 (50%), and a greater share with incomes between $75,000 and $149,999 (38%) than the island as a whole. In comparison, an estimated 57% of Oahu's households earned less than $75,000 and only 31% $75,000 to $149,999 in 2008. Other areas of Oahu may have relatively more households in the highest income brackets; however, these represent a small number of households in absolute terms.

Further evidence of relatively high incomes in the Trade Area is found in an analysis of household income and other wealth indicators by the "wealthiest" 70 zip codes statewide in 2007[5]. According to the study, median household incomes in key area zip codes were well above the Honolulu County median of $65,633:

- **Mililani** (96789) - $82,579, and ranked 7th wealthiest zip code statewide;
- **Kapolei, Makakilo and Kalaeloa** (96707) - $78,450, ranked 10th wealthiest;
- **Waipahu** (96797) - $72,224, ranked 15th wealthiest.
- **Ewa Beach** (96706) - $75,503, ranked 18th wealthiest;

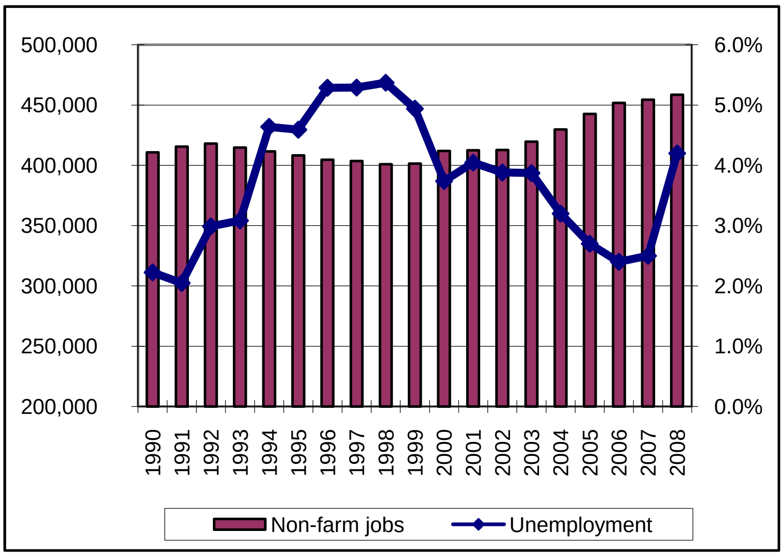
For comparison, 96816 (Kahala, Waialae and Kaimuki) showed an estimated median household income of only $67,003, but was ranked 6th in terms of average net worth.

Employment Trends

(Exhibit 2-9)

The State of Hawaii, Department of Labor and Industrial Relations (DLIR) reports Oahu unemployment averaging 4.2% as of June 2008. This is up sharply from 2007 when it stood at 2.5%[6]. Unemployment is typically cyclical, and, lagging most of the rest of the nation, Oahu has recently suffered job losses. However, Oahu's unemployment rates have been among the lowest in the nation in recent years.

Oahu Labor Force Trends



See Exhibit 2-9 for sources and further information.

Oahu supported annual increases in the number of employed persons between 2002 and 2006, followed by a slight decline in 2007. However, as of June 2008, the count of employed persons was at an all-time high of 442,950 persons, while the total civilian labor force was also up, to 462,250, according to the DLIR.

[5] Pacific Business News, December 21, 2007, 2008 Book of Lists: "Wealthiest Zip Codes." Data provided to Pacific Business News by ESRI, with rankings determined by measures of affluence that include average household income and average net worth.

[6] Not seasonally adjusted, for civilian labor force.

3. Residential Market Environment

Historical Supply Conditions

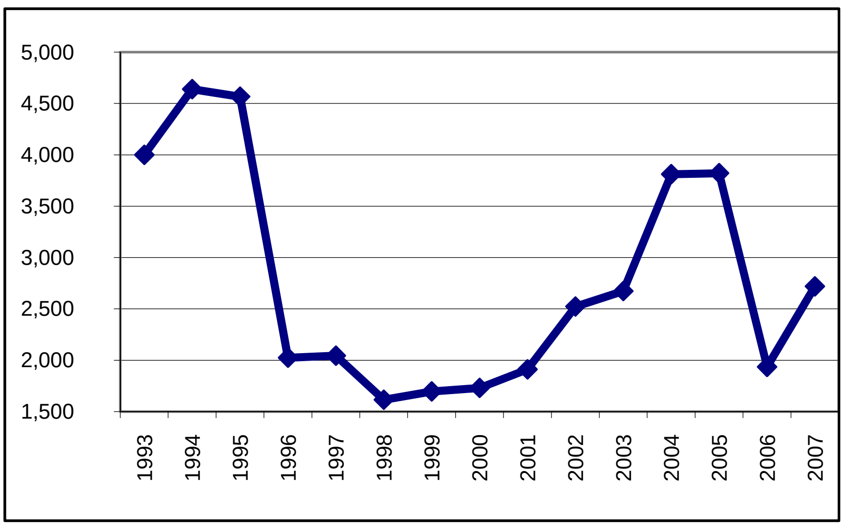
Oahu Inventory, 2006

Oahu had some 332,718 housing units in 2006, of which 299,217 or 90% were estimated to be occupied, according to the U.S. Census, American Community Survey (ACS)[1].

Among occupied units, 58% were owner-occupied and 42% renter-occupied, according to the ACS. Among the 10% of units estimated to be vacant, the majority, over 7% of the total, suggest non-resident housing uses. This is based on the reported homeowner vacancy rate of 0.9% and the rental vacancy rate of 4.7%, which together account for only about 7,500 of the approximately 33,500 vacant units reported.

Residential Building Permits (Exhibit 3- 1)

Oahu Residential Building Permits



See Exhibit 3-1 for sources and further information.

Oahu residential permitting plunged from 1995 to 1996, as the effects of the collapsing real estate "bubble" of the late 1980s and early 1990s were finally realized. Permitting did not rise materially until 2002.

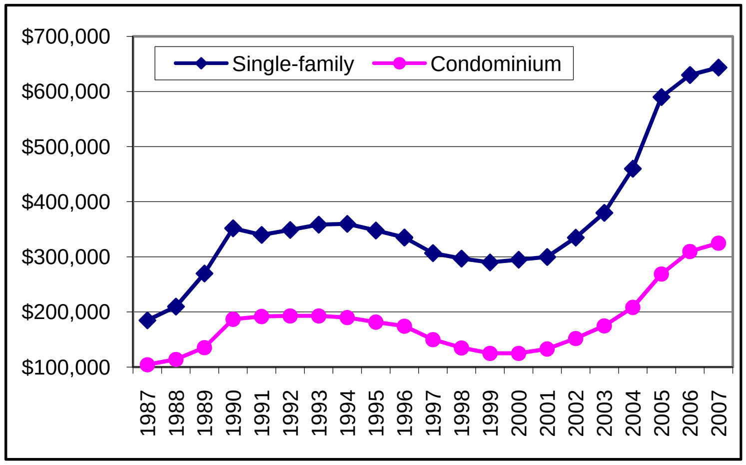
Permitting continued to rise in 2003 and 2004, and held its level in 2005, at some 3,821 new residential building permits on Oahu, according to the City and County. This compares to more than 4,500 per year in 1994 and 1995. Permitting declined rapidly in 2006 but partly rebounded to 2,719 new housing permits in 2007. Residential permitting is reflecting drastic slowing again as of the first quarter of 2008.

[1] Average figure for year, also referred to by State DBEDT as July 1 estimate. U.S. Census, "2006 American Community Survey," released September 12, 2007. The ACS does not survey population living in institutions, college dormitories or other group quarters.

Market Trends

Oahu Home Resales
(Exhibit 3-2)

Oahu Resales – Median Prices



See Exhibit 3-2 for sources and further information.

Rapidly rising home prices in recent years reflect the relatively limited production of new housing, combined with strong labor market conditions and favorable financing conditions.

Sales recordations of existing homes during 2007 showed a median single-family price of $643,500 and a median condominium price of $325,000, according to the Honolulu Board of Realtors (HBOR).[2] These medians are 2% and 5% higher, respectively, than those recorded in 2006.

In the first six months of 2008, prices are flattening, while residential sales velocity has slowed since 2005. Through June 30, 2008, the median single-family home transaction declined to $629,000, while the median price of a condominium rose to $330,000.

Months inventory remaining, while still far below historical levels in the early- to mid-1990s, has been on an upswing since mid-2005, further defining a "landing" to the boom that endured over the prior seven years. As of June 2008, the HBOR estimated there were 8.3 months worth of single-family inventory remaining on the island market, and 7.0 months of condominium inventory, up from 5.1 and 4.2, respectively, in June 2007.

The short-term outlook is for slowing sales and somewhat declining prices as the market corrects for the rapid rises of past years and the beginning of a business cycle slowdown. However, longer-term, ongoing population growth, household formation and the still significant overhang of unhoused persons are expected to continue to fuel demand for new homes.

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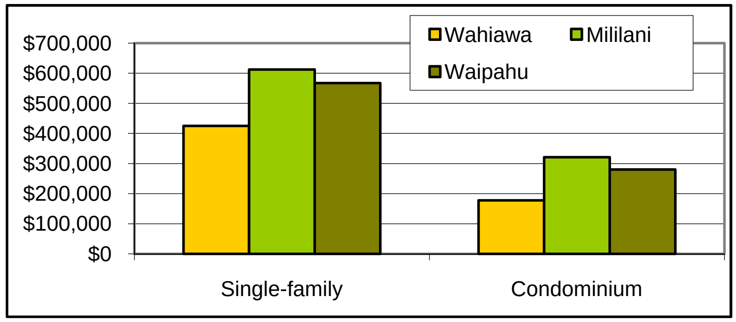
[2] Honolulu Board of Realtors, "June 2008 Monthly Statistical Report," July 1, 2008. The HBOR defines condominiums as duplexes, townhomes and other multifamily units having common areas.

Central Oahu Resales (Exhibit 3-3)

Like the island as a whole, Central Oahu and Ewa neighborhood markets are recording fewer sales, while price appreciation has recently slowed or reversed. In Central Oahu, during the first six months of 2008 (with comparisons to the same period in 2007):

Median Sales Price, June 2008



See Exhibit 3-3 for sources and further information.

- Wahiawa, Mililani and Waipahu showed fewer sales, particularly among condominiums, compared to 2007.

- As of June 2008, the overall median price in Central Oahu was estimated at $578,000 for single-family homes and $299,000 for condominiums. With its relatively newer stock and many community amenities, Mililani tends to support the highest prices.

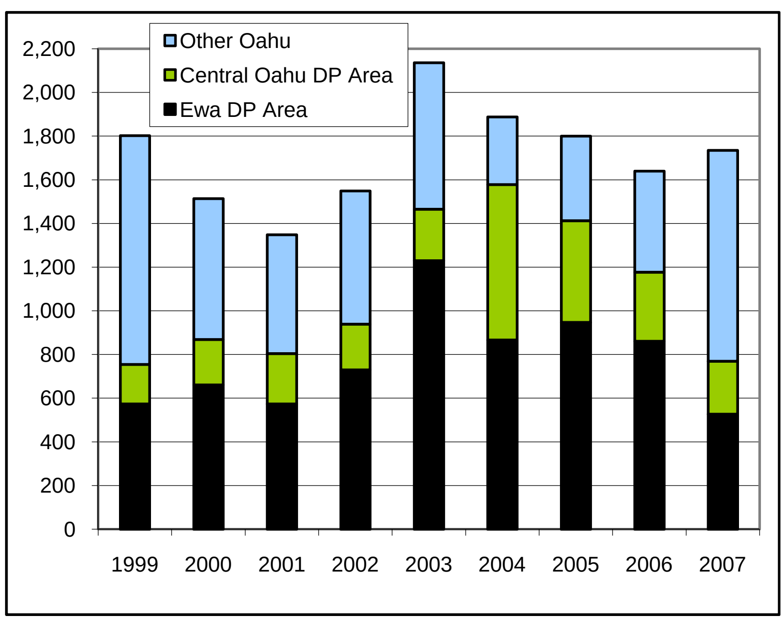
- In terms of price trends, the medians have generally fallen, but vary by area. Mililani continued to show median price increases of 1% and 2% for single-family and condominium homes, respectively, while Waipahu saw declines of 1% and 7%, respectively. The price trends in Wahiawa are considered unreliable due to the small sample of only 38 recorded sales.

Developer Unit Sales by Area (Exhibit 3-4)

Developer-built homes have also shown rising prices but absorption has been limited by production factors such as labor, permitting and the availability of entitled sites.

Oahu recorded an estimated 1,735 new home sales in 2007, compared to 1,640 in 2006, according to The Harris Company. This is down from

Oahu Developer Sales by Location



See Exhibit 3-4 for sources and further information.

the peak production and absorption of 2,136 in 2003.[3] Of the total closings, 14% to 38% of units have been located in the Central Oahu DP area[4] over the past four full years (2004 to 2007).

Notably, there has been no long-term increase in new home production over the past eight years, despite population increases and very strong market activity recently. Production has generally stayed in the 1,500 to 1,900-unit level, subject to business cycles and other factors.

Also in recent years, single-family units have been losing market share to townhouse and high-rise home sales, the latter in the urban core.

Central Oahu Developer Unit Sales by Type (Exhibit 3-4)

Considering only the Central Oahu area, developer sales have ranged from 242 to 711 annually since 2004, with a long-term average of 320 units.

Historically, Central Oahu, like Ewa, provided an opportunity for smaller-unit, single-family living at relatively modest cost, given the trade-off of a longer commute to town. However, as Hawaii home prices have risen across the board, townhomes are assuming an increasing share of even Central Oahu and Ewa area sales. In 2007, townhomes represented some 65% of Central Oahu new sales, compared to an average 25% over the entire period. Additionally, the density of many single-family homes has increased to within the historical range of townhomes and a growing segment includes condominiumized elements such as driveways, courtyards, structural walls and the like. Thus the “single-family” homes being developed are increasingly likely to have characteristics previously associated with multifamily or townhome developments.

Housing Supply Outlook

Planned Communities in Central Oahu and Ewa (Exhibit 3-5)

Mikiko reviewed planned residential development projects within the Central Oahu and Ewa DP areas. This survey targeted projects of 100 units or more for which LUC Urban designation was in place, and/or for which the landowner is exempt from LUC governance.

- **Central Oahu** has only about 7,700 potential future units entitled currently, all of which could be developed and absorbed by 2025, and nearly half by 2015.

[3] Note that developer unit sales are fewer than residential permits granted in any given year (Exhibit 3-1). The difference is due to permitted units not getting built, or being built as rental or other unit types not covered by the residential developer unit surveys.

[4] Includes the Mililani, Waikele and Kunia areas, as defined by the Harris Company.

This count does not include the 3,500 units proposed at Koa Ridge Makai, nor the 1,500 at Waiawa. Nor does it include Gentry and A&B's Waiawa Ridge Increment 2, which is being discussed for up to 7,000 units. All three of these projects require LUC approval.

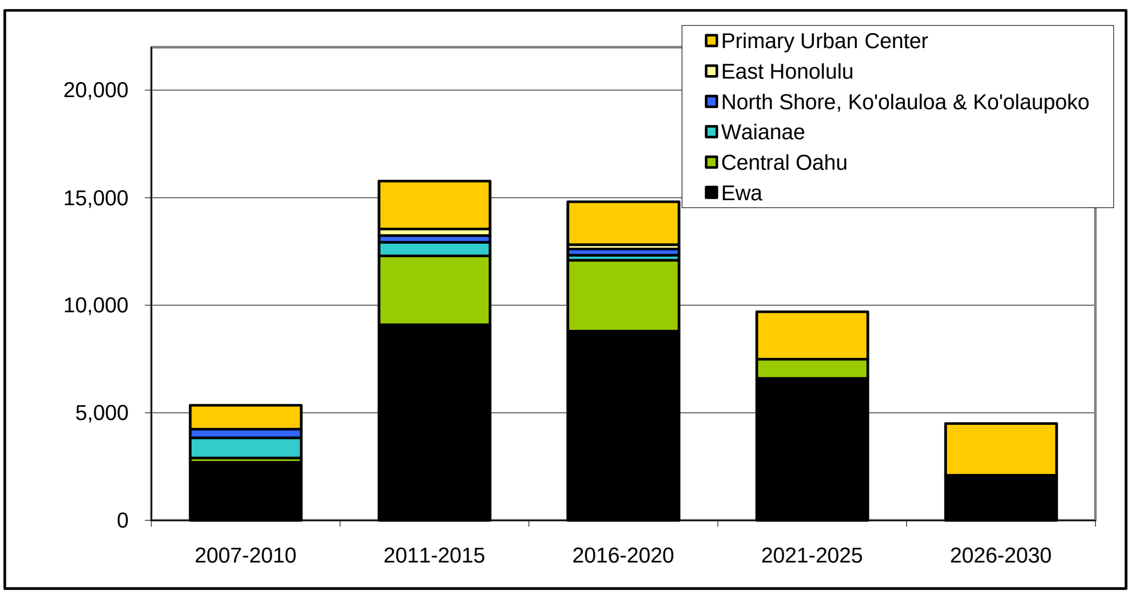
- **Ewa** - Some 29,200 units of State-entitled future development were identified at 24 sites in Ewa. Of this total, about 42% could be absorbed by 2015 and the balance by 2030.

  These figures do not include the proposed 11,750-unit Ho`opili development, where LUC approvals are also being sought.

Combining the data on Central Oahu and Ewa resident housing projects with information gathered on planned developments elsewhere on the island shows some 51,000 potential resident housing units with LUC approval at this time. This number is based on the estimated 7,700 units in Central Oahu, 29,200 in Ewa, 1,800 in Waianae, 1,020 in the North Shore, Ko'olauloa and Ko'olaupoko areas, 500 in East Honolulu and 9,940 in the Primary Urban Center (PUC.) The PUC figure includes an allowance of 2,000 to 2,400 net new units per 5-year period after 2015 for unforeseen redevelopment projects.

These potential inventories are considered generous since they consider current zoning or plan maximums and projected development schedules. Often projects get developed at less than their permitted or planned densities, and/or experience delays that prevent or push inventory further into the future.

Potential New Housing Supply Based on LUC-Entitled and Planned Projects on Oahu



See Exhibit 3-5 for sources and further information.

Considering information provided by developers and landowners and on historical absorption rates of similar products in the area, buildout of these entitled units could occur as shown in the chart above.

Summary of Oahu Demand and Supply (Exhibit 3-6)

- **Current and Future Demand** - The SMS study previously cited projected that the number of Oahu households will increase from about 307,800 in 2008, to 364,400 in 2030. These considerations suggest a need to provide housing for 57,000 new households over the next 22 years, or by 2030. In addition, existing pent-up demand as of mid-2008 is estimated at 21,000 units.

- **Current Supply –** The current supply of housing is estimated using the ACS survey finding of 299,217 occupied housing units on Oahu in 2006, less a 5% allowance for units held for nonresident use such as visitor or part-time resident use. This non-resident discount is considered very conservative based on analyses undertaken by SMS and on the data presented at the beginning of this chapter, both of which suggest a more accurate figure could be over 7%.

  The current assumptions result in an estimated 284,000 occupied resident housing units (RHU) in mid-year 2006. Added to this figure are estimated new unit closings from July 2006 through June 2008. This results in an estimated 287,000 net available RHU by mid-year 2008.

- **Future Supply –** Future supply estimates are based on the schedule of LUC-entitled potential future developments islandwide, representing up to 51,000 units that could be considered deliverable by 2030, as shown previously in Exhibit 3-5. From this figure a 5% vacancy allowance is deducted, resulting in about 336,000 units available for resident housing use by 2030. Note that these estimates are considered generous, as explained previously.

Unmet Needs (reference Exhibit 3-6)

In summary, currently entitled projects are estimated to yield up to 49,000[5] of the 78,000 new housing units expected to be demanded by 2030. This presumes that the new homes are developed within the time frame and at up to their currently planned or entitled use levels.

Despite these substantial developments and a greater than historical rate of new home production initially, the island could still anticipate a 29,000-unit shortage by 2030, the end of the projection period:

[5] This would represent up to 51,000 units delivered, less a 5% vacancy allowance. This figure differs from the 48,000 total shown under "Entitled new developments, 2008-2030," due to the rounding of subtotals.

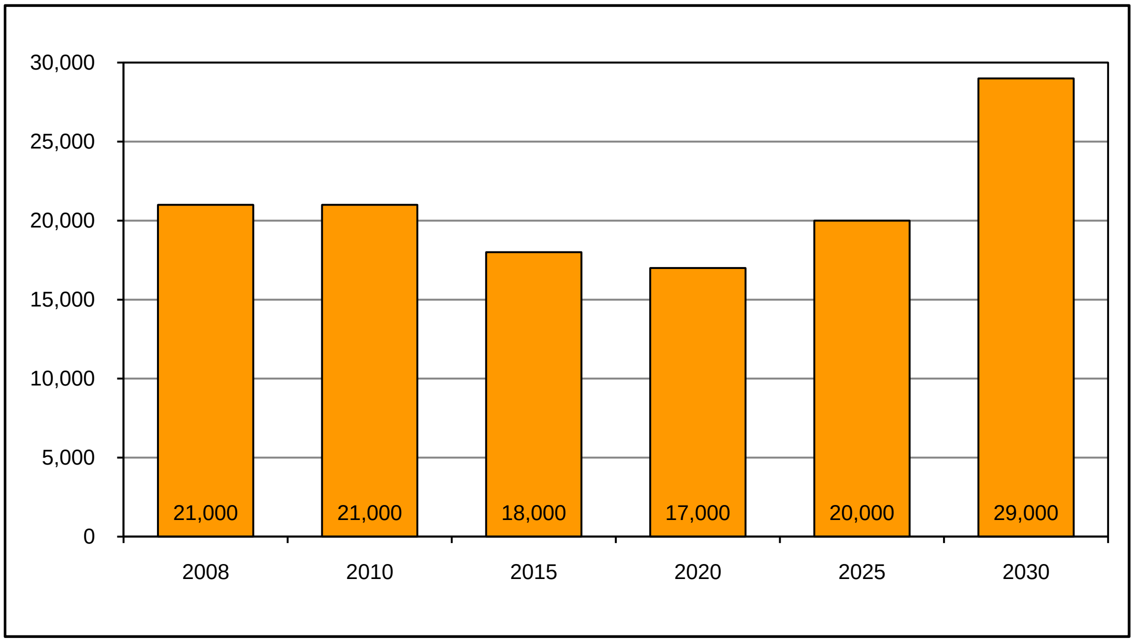
Supply and Demand for New Resident Housing Units on Oahu
2008 to 2030

Future Demand	Pent-up demand, mid-year 2008 Future need, 2008-2030 Total need	21,000 57,000 78,000
Future Supply	Planned and entitled (51,000 less 5% vacancy)	49,000
Shortage	**As of 2030**	**29,000**

Source: Mikiko Corporation, 2008. Future supply estimate assumes full buildout of all lands currently designated Urban by the LUC and proposed for residential development, and those units considered deliverable by 2030. See Exhibit 3-6 for further information.

In conclusion, a stepped-up rate of housing production that appears possible over the next several years could help to pare down the current housing deficit to about 17,000 units by 2020. However, thereafter, currently entitled projects would be unable to keep up with demand. Without further entitlement of significant lands for residential development, a housing crisis of even greater magnitude than today's could be anticipated to emerge after 2020.

Oahu Resident Housing Unit Deficit
After Development of Currently LUC-Urban Lands



See Exhibit 3-6 for sources and further information.

4 – Residential Market Assessment

Proposed Residential Uses

Development Concept

Koa Ridge Makai and Waiawa would address the critical need for new housing on Oahu. The Project would begin after build-out of the highly successful communities of Mililani and Mililani Mauka, building on C&C's good reputation in the region and serving multiple generations of households, many of whom already make Central Oahu home.

- The planned locations offer outstanding views from many areas, as well as privacy and a relatively cool, upland climate.

- The Project will offer a variety of housing types, ranging from traditional single-family homes to medium- and high-density multifamily homes.

- The Koa Ridge master-plan incorporates many primary job opportunities (see subsequent chapters), offering the opportunity to make a career close to one's place of residence.

Number of Units

Together the two projects could offer up to 5,000 new housing units in Central Oahu.

  - **Koa Ridge Makai** is planned for up to 3,500 residential units in a diverse community that will include substantial employment opportunities and a town center. Some of the homes at Koa Ridge Makai might be developed as live-work units and/or situated above commercial establishments within the town center.

  - The smaller **Waiawa** would include about 1,500 units in more traditional housing settings.

Product Mix

Some 74% of Koa Ridge Makai and Waiawa's units are proposed as for-sale multifamily units. These would include a variety of housing environments, with densities ranging from about 10 to 50 units per gross acre. This mix reflects a broad-based U.S. and Hawaii planning interest in sustainable, "smart" communities with higher densities. It also reflects the anticipated trend towards smaller household sizes, and C&C's goal to maintain relatively affordable price points.

The Project would also include single-family units for-sale and may include multifamily rental units. The exact mix of units by type will be determined during the years of build-out, as market conditions and preferences materialize.

Conceptual Plan for Residential Products at Koa Ridge Makai and Waiawa

	Koa Ridge Makai	Waiawa	Total	Overall Project unit mix	Typical units per acre
Single-family	1,054	255	1,309	26%	6
Multifamily	1,162	1,245	2,407	48%	10 to 20
High-density multifamily	1,284	0	1,284	26%	30 to 50
Total homes	**3,500**	**1,500**	**5,000**	**100%**	

Source: Castle & Cooke Homes Hawaii, Inc., August 2008.

Market Evaluation and Project Conclusions

Anticipated Buyer Markets

The proposed products respond to the demographic changes discussed in Chapter 2:

- **Entry-level markets** – Up to 30% of the units, including some of those designated as affordable units, as well as a portion of the other medium- and high-density multifamily units, is conceived to appeal to entry-level markets, typified by the rapidly increasing 25- to 34-year-old Echo Boom cohort in the 2010 to 2020 period.

- **Downsizers** – By 2020, the Baby Boomer cohort will range from 55 to 74-years of age, and will have expanded this age group by 60,000 persons statewide in the prior 10 years. The broad range of multifamily unit types planned at Koa Ridge Makai and Waiawa also respond to this demographic shift by providing opportunities to simplify lifestyles and lessen homeowner maintenance efforts and costs.

- **Retirement/senior markets** – The multifamily areas are also likely to appeal to the growing retirement and senior populations that are the leading edge of the Baby Boom group.

- **Move-up markets** – The move-up market, typically those aged 35 to 54, will show less population gain during the main period of the Project’s marketing. Thus, Koa Ridge Makai and Waiawa allocate about 26% of units to single-family homes.

The great majority of homebuyers are anticipated to be purchasing for use as an owner-occupant.

In terms of market orientation, up to 30% of Koa Ridge Makai and Waiawa's units is expected to be developed as affordable housing, in accordance with the County's affordable housing guidelines. Affordable housing opportunities may be anticipated within the medium and high-density multifamily areas.

Pricing – Market Units (Exhibit 4-1)

C&C's extensive experience in developing a full range of housing types in Central Oahu is considered an ideal basis for projecting the quality and pricing of housing that would be appropriate for Koa Ridge Makai and Waiawa.

C&C's current projects in the region include Nohona and Island Courtyards (multifamily), and Island Classics (single-family condominium). Selected comparison projects by other developers were also surveyed. Recent price indicators at these locations are presented in Exhibit 4-1 and summarized in the table on the next page.

As shown in the following table, Koa Ridge Makai and Waiawa's market units are expected to support prices ranging from (in 2008 dollars):

- $350,000 to $600,000 for the high-density multifamily products at Koa Ridge Makai;
- $350,000 to $550,000 for the low- to medium-density multifamily products;
- $550,000 to $950,000 for the single-family products.

Price adjustments could be expected on individual properties or projects based on view orientations, location with respect to other community amenities characteristics associated with particular units or developments within the Project, or other factors.

Market Unit Price Indicators and Project Assessment*

	High density multifamily units	**Low- and medium density multifamily units**	**Single-family**	**Notes and projects surveyed**
Mililani	None offered	$300,000 - $480,000 (15-21 u/ac)	$575,000 – $877,000 (5-8.5 u/ac)	Ideal community comparison (Nohona, Island Courtyards, Hampton Court; American Classics, Island Classics, Destiny)
Waipahu	None surveyed	None surveyed	$573,000 - $638,000 (5 u/ac)	On edge of Waipahu and close to golf course (Waipio Point)
Hawaii Kai	$450,000 - $750,000	$545,000 - $600,000 (21 u/ac)	None surveyed	Location commands premium over Central Oahu (Colony at Peninsula, Nanea Kai)
Makakilo	None offered	$340,000 - $525,000 (13 u/ac)	None surveyed	Subjects may realize premiums for comparable product (Kai Nani)
Koa Ridge Makai and Waiawa assessment (market units)	**$350,000 - $600,000 (30-50 u/ac)**	**$350,000 - $550,000 (10-20 u/ac)**	**$550,000 - $950,000 (7.5 u/ac)**	May be additional premiums associated with project or unit characteristics

* Excluding units priced at $300,000 or less, which are considered to be affordably-designated housing.

Based on developer's report of current asking prices for projects still in developer sales or prices for units recorded sold between January 1 and August 7, 2008.

Sources: Castle & Cooke Homes Hawaii, Inc., and Mikiko Corporation. See Exhibit 4-1 for further information.

Pricing – Affordable Units

County policies regarding affordable housing are now in flux, but for projects constructed recently, the majority has been required, pursuant to unilateral agreements with the County, to price a share of their units to address the needs of households earning up to 120% of the area median income (AMI.) In some cases, the target benefit group has been extended to 140% of AMI, and there has been at least one County resolution to restrict it to households earning 100% of AMI or less.

The number, type and pricing of affordable housing at the Project can be expected to be established based on future agreements to be made with County and State agencies. These agreements are likely to consider household income, family size, development types and other factors.

Such pricing would address both for-sale and rental housing, as appropriate to the agreement.

Future Market Environment

According to C&C, Koa Ridge Makai's first housing units could be available for occupancy in 2012 and Waiawa's by 2015. At that time, assuming no further State entitlement of major housing developments, the housing market is expected to still be in deficit mode, with about 18,000 to 21,000 fewer units available for resident use than potentially demanded. There could also be a dwindling supply of other residential projects with significant remaining inventory for sale. This contrasts with today's market, where more than 13 State entitled developments of 500 or more remaining units are underway or in planning in Central Oahu and Ewa.

Sales Absorption Evaluation

Since 1970, C&C new home sales closings on Oahu have averaged 500 units per year, or about 540 in the 1970s, 300 in the 1980s, 580 in the 1990s and 510 in the 2000s (through 2007). This long-term trend is considered a solid benchmark for future C&C sales on Oahu, considering:

- This 38-year period spans multiple business cycles, representing a long-term average considering both up- and down-markets.
- About 80% of the company's Oahu sales, an average of about 380 home closings per year, have been at Mililani or Mililani Mauka ("Mililani"), near to Koa Ridge Makai and Waiawa.
- The 550-unit long-term average excludes a number of older projects that C&C developed for which sales data is no longer available. It also excludes homes built by third party developers in Mililani, where about 6% of total homes were built by developers other than C&C.
- During 10 of the years sampled, more than 25% of the time, C&C closed more than 600 home sales on Oahu.
- The population base from which new household formation originates will be bigger in the coming years than it was in the 1970 to 2007 periods from which this data originates.
- In particular, the approximately 16,000 households already living at Mililani themselves provide a prime source of potential home buyers at the Project, and

represent families that are established in the area and have experienced living in a C&C master-planned community. Given that Mililani is now nearly 40 years old, there are now multiple generations of families that call the area home.

Projected Sales Absorption

Based on the above considerations, it is estimated that the Project could realize sales ranging from 360 to 450 units per year, meaning that it could be expected to sell out in 10 to 14 years, or between 2022 and 2025. In the early years of marketing, closings would be all at Koa Ridge Makai, but after 2015, they would represent sales at both Koa Ridge Makai and Waiawa.

The above analysis assumes all units are built as for-sale housing.

Projected Market Share

At a mid-range of about 400 sales per year, the projected pace could mean a Project market share ranging from about 10% to 23%, on average, of total Oahu new housing absorption under two scenarios as discussed below.

- **Scenario 1 -** In recent years, Oahu has absorbed only 1,500 to 2,000 developer units per year, with supply constraints. If this trend were to persist from 2011 to 2025, it would be because only a fraction of the approximately 41,000 entitled additional units that appear deliverable in that period are developed. This would likely result in an increasing housing crisis, and the Project's achieved market share of new unit deliveries could be expected to represent significantly more than the "fair shares" shown above.

- **Scenario 2 -** To begin to address pent-up and future demand over the next decade or so, the island will have to produce around 3,950 units per year[1]. Under this scenario, Koa Ridge Makai and Waiawa could be expected to achieve about a 13% share of the future island market, assuming there is sufficient other Oahu supply to approach the 3,900 units per year goal.

[1] 38,000 future (2011-2025) + 21,000 pent-up demand satisfied over 15 years would require an average production of approximately 3,950 units per year (59,000/15). See demand figures in Exhibit 3-6 for sources.

Hypothetical Project Fair Market Share Under Two Scenarios

	Low Range: At recent historical levels of Oahu production	**High Range: At demand-satisfying levels of Oahu production**	**Notes**
Assumed total Oahu developer sales	1,750	3,950	Ref. Exhibit 3-6
Projected Koa Ridge Makai and Waiawa average annual sales	**400**	**400**	**Approximate mid-point of two projection scenarios**
Estimated Koa Ridge Makai and Waiawa market share	23%	10%	Percent of total Oahu market

Source: Mikiko Corporation, 2008.

The above benchmarks are considered hypothetical since other development plans will inevitably emerge over the next decades. However, they are still relevant indicators since Oahu is running out of large, developable tracts of land for community development.

For comparison, C&C has accounted for 19% to 39% of total Oahu developer sales closings since 1999, the years for which island market data is available (see Exhibit 3-4.) Therefore, a Project market share between 10% and 23% is well supported by C&C's recent experience.

5 - Retail Market Environment

Methodology

This chapter presents the estimated market support for additional commercial space in Central Oahu as derived from retail-based market indicators. While many retail shopping centers include substantial office space, and office buildings often include retail, office market conditions are considered more specifically in the next chapter[1].

The market assessment for retail areas compares retail supply to consumer demand, which consists of resident and daytime populations. Nationally, there was an average of 20.3 square feet of shopping center space per person in the U.S. in 2004, and 63% of all retail space was within shopping centers.[2] This is equivalent to 32 square feet total retail area per person.

This is a useful indicator, but Hawaii's retail market is unique in many respects. Retail supply and population are evaluated for the Central Oahu DPA, which is considered the primary retail Trade Area, as well as for Hawaii Kai, which is considered a benchmark market.

The analyses herein are presented in terms of gross leasable area (GLA), in square feet.

Retail-Based Supply

Island of Oahu (Exhibit 5-1)

Oahu had an estimated 11.2 million square feet of retail GLA in mid-2008, according to surveys and information provided by Colliers Monroe Friedlander, Inc. (CMF). The island's largest property is the 2.1 million square foot Ala Moana Center, which underwent a substantial renovation and expansion with the opening of some 300,000 square feet at the "Nordstrom wing" earlier this year. Additionally, some 107,000 square feet of former JC Penney space at Pearlridge Shopping Center were recently re-established as retail space.

Despite these substantial increases in inventory, Oahu's vacancy was relatively stable at 3.4% as of mid-year 2008, as compared to 3.3% at year-end 2007. While retailers are cognizant of the beginning of a business cycle downturn, asking rents continued to rise in

[1] For purposes of this analysis, these relatively limited office areas within retail shopping centers are considered part of the "retail" market.

[2] National Research Bureau, Inc., "2004 NRB Shopping Center Census," 2005; Niemira, Michael P., "The U.S. Retail Space Market," Research Review, V.12, No. 2, 2005. Mr. Niemira is Vice President, Chief Economist and Director of Research for the International Council of Shopping Centers.

the first two quarters of the year, with increases driven modestly by community, neighborhood and strip centers.

Notwithstanding the current business cycle phase, the island marketplace as a whole may still be considered undersupplied, with much of this undersupply originating from outside of the central business area and in these smaller (not regional-serving) centers, as suggested below.

Central Oahu (Exhibit 5-1)

Central Oahu had some 2.94 million square feet of retail GLA as of mid-2008, according to information obtained from CMF and C&C. The biggest retail complex in Central Oahu is Waikele Center/Waikele Premium Outlets, with a combined 786,000 square feet, followed by the Town Center of Mililani at about 434,000 square feet, excluding its office areas.

Central Oahu's vacancy rate has been substantially lower than that for the island as a whole, suggesting some of the source of the island's unmet demands. As of mid-year 2008, the retail vacancy rate in the region was estimated at 1.2%, up only slightly from 1.1% in December 2007, based on surveys conducted by CMF.

Central Oahu's net asking rents averaged $3.69 in mid-year 2008, trailing only East Oahu, Honolulu and Waikiki.

Benchmark Area (Exhibit 5-1)

As a planned community nearing buildout, with retail centers operating at or near capacity and a growing jobs base, Hawaii Kai is considered an indicator for the relationship of balanced retail supply to population levels in a suburban community. Hawaii Kai had about about 857,000 square feet of GLA in early 2008, of which 247,000 are in the regional Hawaii Kai Towne Center, about 322,000 in Koko Marina Shopping Center, and 133,600 in Hawaii Kai Shopping Center.

According to CMF's mid-year 2008 survey, retail vacancies averaged 0.8% in East Oahu, an area that encompasses Hawaii Kai as well as Aina Haina, Kahala, and Niu Valley. This represents a decline from the 1.9% estimated by CMF in December 2007. Both of these rates are substantially below the corresponding island-wide vacancy rate.

The East Oahu area included the island's highest asking rents outside of Honolulu and Waikiki, at $4.81 per square foot per month as of mid-year 2008.

Planned Development in Central Oahu (Exhibit 5-2)

The Central Oahu DPA has 1.05 million square feet of identified and State-entitled retail projects in planning.[3] About 90% of this is at Waiawa Ridge Increment 1, which has

[3] As for residential developments, this analysis considers only those proposals on lands designated Urban by the LUC, and/or for which the owner may be exempt from LUC compliance.

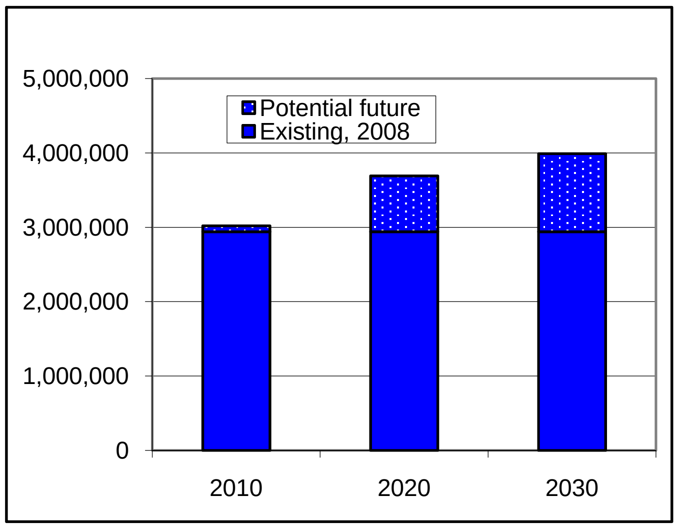
been Urbanized, but some of which still requires zoning. According to management, Waiawa Ridge includes 96 Urban acres that are planned for neighborhood, community and regional shopping centers, and/or office uses. Of these lands, 91 acres are zoned IMX-1 or B-2/1, while 5 acres remain unzoned, as of August 2008. All 96 acres are considered on the potential future retail supply inventory that is reflected in Exhibit 5-2, although some may be developed for office or other commercial purposes consistent with their zoning.

Specific projects and land areas from which these estimates were derived are presented in Appendix 4.

Future Central Oahu Inventory
(Exhibit 5-3)

Considering the planned and entitled projects identified, retail areas in Central Oahu could rise to approximately 3.99 million square feet by 2030.

Potential Future Retail Gross Leasable Area in Central Oahu (square feet)



Source: Exhibit 5-3 for sources and further information.

Retail-Based Demand

Area Resident Profiles
(Exhibit 5-4)

In total, the Central Oahu DPA is home to about 164,600 persons or 18% of the island's population in 2008. It is projected to grow by about 1% per annum over the next five years.

The more mature, benchmark market of Hawaii Kai housed about 29,200 persons in 2008 and is projected to grow 0.7% per annum in the coming five years.

Central Oahu's median household income was estimated at $74,410 in 2008, compared to $65,633 for the island as a whole. On a per capita basis, Central Oahu's income was $26,409 compared $28,115 for the island as a whole.

Hawaii Kai showed a higher median household income than Central Oahu and Oahu as a whole, at an estimated $95,334.

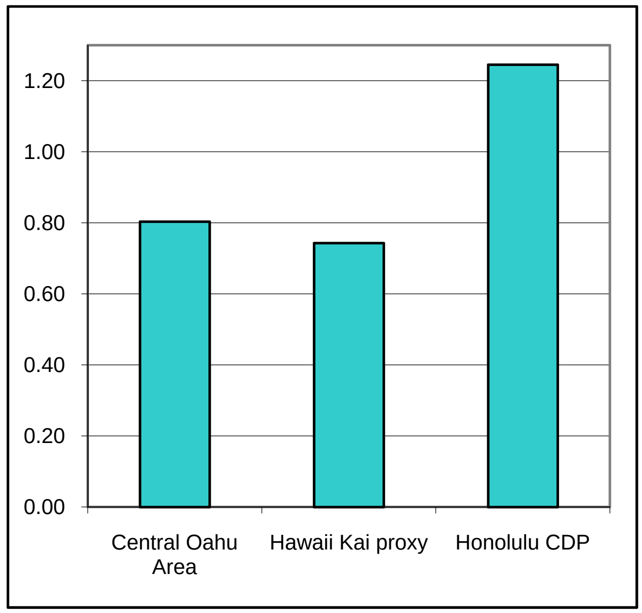
Daytime Population Ratios
(Exhibit 5-5)

Daytime populations within Central Oahu and the benchmark market are estimated based on 2000 ratios prepared by the US Census within Census Designated Places (CDPs)[4]. The Central Oahu DPA includes seven CDPs. The ratios derived from this source are considered baseline figures for the current analysis, as explained below.

Hawaii Kai is not a "Place" designated by the Census. Therefore, Kailua Town's population ratio was used as a proxy for Hawaii Kai's, since both are long-established bedroom communities to Honolulu, located about 30 minutes away, and both have shown recent increases in retail- and service-related employment. As a proxy for Hawaii Kai, Kailua CDP showed a 74% daytime to resident population ratio.

Central Oahu reflects less out-commuting than Hawaii Kai, as evidenced by a daytime ratio averaging 80% among its CDPs.

Ratio of Daytime Population to Residents



See Exhibit 5-5 for sources and further information.

Out-commuting for Central Oahu as a whole should be substantially lower than these figures reflect, because (1) there are persons who live and work in different Census Places but still within the DPA, and (2) the data are based on 2000 employment and residence patterns and significant job creation has occurred since then.

Figures for the Honolulu CDP are also presented as an example of an urban area with net daytime in-commuting, and the ratio achievable within a much larger area.[5] The Honolulu CDP is estimated to provide 54% more jobs than could be filled by its resident workers, and shows a daytime population ratio of 1.25.

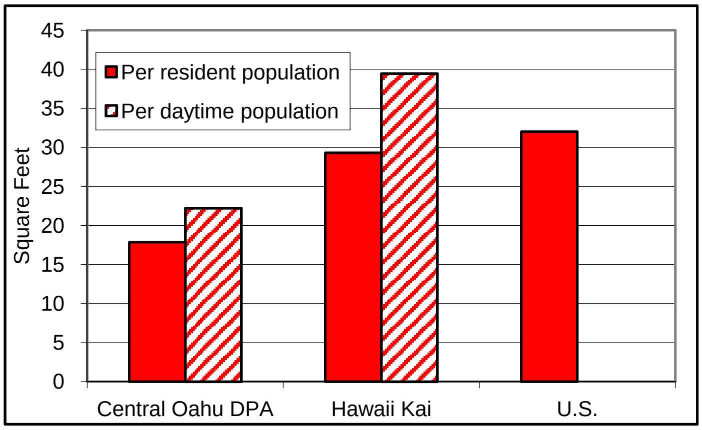
[4] US Census Bureau, Census 2000, PHC-T-40, "Estimated Daytime Population and Employment-Residence Ratios: 2000" Journey to Work and Migration Statistics Branch, 2005.

[5] The Census Bureau defines the Honolulu CDP to include Waikiki, the Primary Urban Center and East Honolulu. Visitors do not skew these data, as they are not inventoried in the Census methodology.

Retail Supply in Relation to Population
(Exhibit 5-6)

Comparing retail GLA to resident population, the Central Oahu DPA appears significantly under-retailed currently, at 18 square feet per resident. Hawaii Kai is considered a relatively balanced suburban market, at 29 square feet per resident. The latter is more consistent with the U.S. average of about 32 square feet per resident, as discussed previously.

Gross Leasable Square Feet per Person



See Exhibit 5-6 for sources and further information.

In comparison to estimated daytime population, Central Oahu again stands out as under-retailed, with a ratio of 22 GLA square feet per resident, just over one-half of the 39 square feet that is offered in Hawaii Kai. Hawaii Kai is able to support these significantly higher space ratios despite virtually no vacancies.

Supportable Retail-Based Area in Central Oahu

Methodology (Exhibits 5-7 and 5-8)

Future support for additional retail areas in Central Oahu will be anchored by its increasing housing stock, compounded by a related increase in job opportunities. The latter will attract more persons to the trade area during working hours, including some who live there and some who commute in for work. Thus, both resident and daytime populations are evaluated as sources of retail markets.

Geographically, the primary market for retail uses in Central Oahu is Central Oahu itself, while population of the adjacent Ewa DPA may be considered a contributing market.

- **Immediate market (Central Oahu DPA) –** Demand is projected by correlating the existing and planned/entitled retail areas in the Central Oahu DPA with its projected resident and daytime populations. These populations are estimated to support 29 square feet GLA per resident (Exhibit 5-7), and 35 square feet per daytime population (Exhibit 5-8). Both of these ratios apply to expenditures within the Central Oahu DPA and are benchmarked to within-community ratios derived from Hawaii Kai.

- **Nearby markets –** While persons living in the Ewa DPA or other nearby areas could also be expected to provide market support for retail facilities in Central Oahu, these secondary markets are not quantified in this analysis in order to provide a more conservative view of the market potential.

Key Assumptions (Exhibits 5-7 and 5-8)

Key assumptions to the projection methodology include the retail to population ratios, daytime to resident population ratios and Ewa's capture rate of retail expenditures made by those who live or work outside the DPA.

- **Retail to population ratios** (as presented above) **-**

  - **Central Oahu** today is a relatively large, diverse area with significant and diverse retail and service industries that provide a job base. However, it is not a major job center and still experiences significant out-commuting. Thus its resident and daytime retail to population ratios of 18 and 22 square feet, respectively, are low indicators for its potential future. Likewise, the area's retail vacancy rate of approximately 1.2% is consistent with potential for further growth relative to its existing population.

  - **Hawaii Kai** is smaller in terms of population, but is a nearly mature bedroom community, with a wide variety of retail, dining and service choices. It also offers facilities that serve a broader regional market. Thus, its ratios of 29 and 39 square feet per resident and daytime population, respectively, are considered more representative of what the Trade Area could achieve in the future. However, given East Honolulu's even lower estimated vacancy (0.8% in mid-year 2008), it could also represent the low end of the range for Central Oahu in the future. Additionally, since these figures are derived from space supported within Hawaii Kai only, they could under-represent the total market support if a larger area within East Honolulu were considered.

  - The estimated **U.S. average** of 32 square feet per resident population helps to further establish the reasonableness of a resident ratio consistent with Hawaii Kai's 29.

- **Daytime population ratios -** This assessment assumes daytime to resident population ratios in 2030 reach 0.85 in Central Oahu. This would compare to the average 0.80 <u>within CDP</u> ratios observed in the area in 2000. These increases in the daytime population ratios over the 30 year period (from observations in 2000 to the end of the projection period in 2030) is considered possibly conservative due to:

  - Some of this change is likely to have occurred already, since the ratios to which these increases are applied were based on 2000 data.

  - The assessment would position the Central Oahu of the future above the Hawaii Kai proxy of 0.74 and the 2000 Central Oahu figure of 0.80. Even as of 2008, both of these areas were still largely bedroom communities and both had very low retail vacancies.

Conclusion for Central Oahu

The two approaches yield a similar conclusion, that some 1.5 million square feet of additional retail-based areas could be supported in Central Oahu by 2020, or 1.7 to 1.8 million (cumulative) by 2030.

Summary of Supportable Additional Retail-Based Areas
In the Central Oahu DPA
Gross leasable square feet, 2020 and 2030

	Basis/reference	2020	2030
Resident population method	Exhibit 5-7	1,500,000	1,700,000
Daytime population method	Exhibit 5-8	1,500,000	1,800,000
Conclusion		**1,500,000**	**1,750,000**

6 - Office Market Environment

Methodology

This chapter presents the estimated market support for additional commercial space in Central Oahu, as derived from office-based market indicators. Although office spaces are often included in retail shopping centers, this chapter focuses on the market for other office-based facilities: those developed as stand-alone office complexes (that may include some retail) as well as those that may be part of mixed-use developments.

Government office buildings are not considered, since their development and placement is often a matter of public policy and budget processes rather than market trends.

Long-term demand for civilian office facilities is related to civilian job creation. In contrast to retail customers, employees are accustomed to commuting. Therefore, demand for office space in Central Oahu is evaluated as a function of civilian employment in a larger reference area than considered for the retail analysis. In this case, employees in the Central Oahu and Ewa DPAs are considered, even though other areas of Oahu may also contribute demand. Urban Honolulu and the island as a whole are also evaluated as benchmarks to portray the types of structural changes that could take place in Central Oahu and Ewa over time.

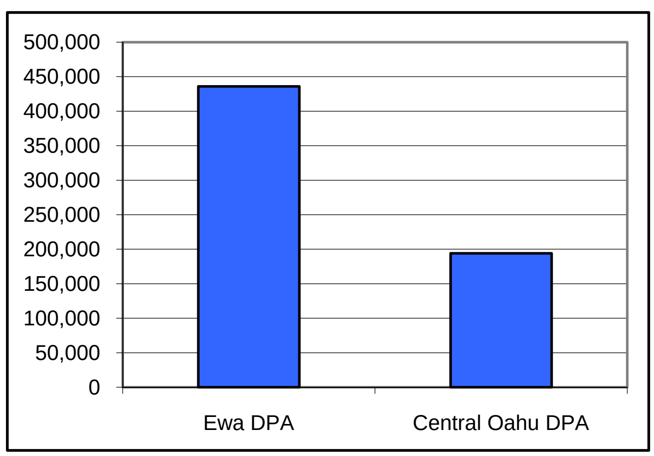
Office supply and demand is evaluated in terms of rentable building area (RBA), expressed in square feet.

Office-Based Supply

Area Inventory (Exhibit 6-1)

Despite its smaller population, Ewa has more RBA in office buildings than does Central Oahu, reflecting the urban intent for Kapolei. As of the first quarter of 2007, the Central Oahu DPA showed some 194,000 square feet of private office space, compared to 436,000 in Ewa.[1]

Existing Office RBA (square feet)



See Exhibit 6-1 for sources and further information.

[1] Not included in the Ewa inventory because they are government facilities are 215,000 square feet at the State Office Building, 96,000 at the City's Kapolei Hale and 50,689 at its Police headquarters. All of these excluded buildings are in Kapolei.

Although occupancy figures are not available for Ewa and Central Oahu separately, "Leeward Oahu," which includes both these areas as well as Waianae, showed a 2.9% office vacancy rate as of mid-year 2008, according to CMF. This compares to a 6.4% office vacancy in the same region as of December 2006.

Benchmark Areas (Exhibit 6-1)

The island of Oahu had a total of some 15.71 million RBA of office space, of which 11.43 million or 73% was in urban Honolulu. For these purposes, urban Honolulu is defined as the Central Business District (CBD), Kapiolani and King Streets, and the Kaka'ako District, with the components as defined by Colliers Monroe Friedlander (CMF). Urban Honolulu would show considerably more office space if its government offices were included. Waikiki is not included in this definition of urban Honolulu.

The island's average office vacancy rate was estimated at 8.1% in mid-2008, compared to 7.2% in the first quarter of 2007, and 7.0% at year-end 2006. According to CMF, the CBD's and Kaka`ako, Kapiolani and King area's office vacancies averaged 9.7% and 6.2%, respectively, in mid-year 2008. These vacancies are up from 6.7% and 6.4%, respectively, in the first quarter 2007.

Planned and Entitled Development (Exhibit 6-2)

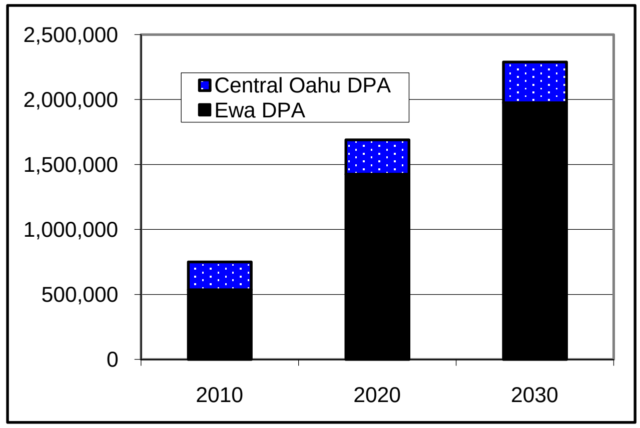
Central Oahu could see dedicated office buildings developed on lands that are already Urban, at Waiawa Ridge Increment 1. In addition, a small professional building in Waikele was just about to come on-line at the time of the fieldwork for this study.

Ewa is poised for a surge in office space, with about 1.87 million square feet of planned and entitled RBA identified as of July 2008. However, 725,000 square feet of this potential future inventory is located in Kalaeloa, where plans are in considerable flux, and where development is likely to include considerable public sector-related office spaces and/or to be realized after 2030. Some 1.54 million square feet of the total proposed areas are anticipated to be realized in Ewa by 2030.

Specific projects and land areas from which these estimates were derived are presented in Appendix 5.

Future Area Inventory (Exhibit 6-3)

Potential Future Office RBA in Ewa and Central Oahu (square feet)



See Exhibit 6-3 for sources and further information.

Considering the planned and entitled projects identified, plus those already operating, Ewa and Central Oahu could have some 2.29 million square feet of RBA by 2030, if all projects are developed as currently planned and on the timetables projected. Most of this new inventory would be added in Ewa, in alignment with the area's projected residential and employment growth.

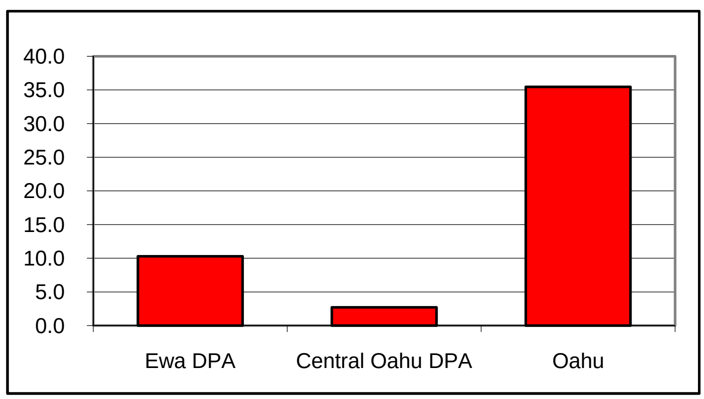
Office-Based Demand

Employment Ratios (Exhibit 6-4)

Civilian employed persons in the Central Oahu DPA currently represent about 43% of its resident population. This compares to 47% in Ewa, 48% for the island as a whole, and 44% in urban Honolulu (defined here as zip code areas 96813 and 96814.) These ratios are down from their benchmarks a few years ago, likely reflecting job losses in recent quarters.

RBA Ratios (Exhibit 6-4)

RBA Ratios Per Civilian Employed Persons



See Exhibit 6-4 for sources and further information.

Central Oahu shows very little dedicated office supply relative to its employment base. This reflects the current composition of employment in the area, with fewer of the professional and technical positions typically housed in multi-tenant office buildings. The Ewa DPA shows more development than Central Oahu, but still significantly less than Oahu as a whole, and far less than urban Honolulu. In 2008, Ewa's private office inventory was estimated at 10 square feet per civilian employed person, compared to 3 in Central Oahu, 35 for the island, and 608 in urban Honolulu.

The very high ratio in urban Honolulu (not depicted in the chart) is evidence of an office worker base that comes from throughout the island. It is anticipated that as it becomes a "Second City," Ewa will also be a magnet for office-based employment on the island, and that it will particularly provide opportunities for those who live in the West Oahu region. Central Oahu opportunities are expected to be positively impacted by this regional economic engine.

Supportable Office-Based Area in Central Oahu

Key Assumptions (Exhibit 6-5)

Unlike for shopping, many people are willing to commute to their job. Thus, while the population of the Central Oahu DPA itself will be a geographically immediate source of demand for future office development, Ewa would be also likely to supply office employees for jobs located in Central Oahu. This assessment is based on the following assumptions:

- **Sources of demand** - Only Ewa and Central Oahu employees are considered as a metric for future demand in Central Oahu. This is conservative since some future enterprises of the DPA could draw employees from throughout the island.

- **Share of population in civilian workforce –** The civilian employee ratios of Central Oahu and Ewa are projected forward at 45% of their resident populations, consistent with the current average for the two DPAs combined, and between the ratios observed for urban Honolulu and Oahu as a whole (44% and 48%, respectively.)

- **Supportable RBA per civilian employee –** Numerous economic initiatives already underway in the region will effect structural changes in regional employment opportunities. Considering these developments, supportable RBA in the Central Oahu and Ewa DPAs combined is projected to increase up to 20 square feet per civilian employed resident. This would be a significant change from the 2008 profiles of the areas, but is still well within the 35-square foot average for the island as a whole or the 608 square feet per resident supported in urban Honolulu in 2008. While the majority of this increase could be realized in Ewa (particularly the Kapolei area), Central Oahu will also realize new opportunities.[2]

- **Central Oahu capture of regional market –** As Ewa emerges as a secondary urban center on Oahu, it is likely to capture the majority of the combined DPA areas' office market. Thus, Central Oahu's capture rate of potential supportable office RBA throughout the office Trade Area is projected at 45%. This is reflective of its declining share of the residents of the two DPAs combined, but also the potential for regional-serving professional centers in Central Oahu, as proposed at Koa Ridge Makai.

[2] According to David Rae, Kapolei Property Development Senior Vice President, while about 22% of Kapolei residents now work in Kapolei, 78% of those who don't would like to. See Honolulu Advertiser, "Zoning panel OKs 3 Kapolei projects," July 31, 2008.

Conclusions for Central Oahu (Exhibit 6-5)

Based on the analyses shown, the Central Oahu DPA is expected to support about 240,000 square feet of additional office-related building area by 2020, or 470,000 by 2030. These anticipated supportable areas are in addition to existing office buildings in the DPA, as well as office-based uses that are entitled and proposed for development in the interim.

7 – Commercial Market Assessment

Overview

Koa Ridge Makai and Waiawa Proposal

C&C proposes to offer up to 410,000 square feet of commercial areas at Koa Ridge Makai and Waiawa, including both retail- and office-based uses. Within Koa Ridge Makai, such uses could be community- as well as regional-serving, and are projected to total up to 380,000 square feet. In contrast, Waiawa is planned for only up to 30,000 square feet in commercial areas, most oriented to its own neighborhoods and the general Waiawa community. As for residential development, the first finished commercial building products are assumed to be available for occupancy in about 2012.

Methodology

The commercial market assessment encompasses both retail- and office-based uses, in recognition of the typical crossover of office spaces within shopping centers and retail uses in office complexes. Thus, although the market support data for retail and office-based uses were developed separately, the assessment does not distinguish between the two. Specific types of retail, service or office uses at the two project areas will likely be determined as each is developed.

This chapter summarizes the projected supportable additional commercial space for the Central Oahu DPA as derived from the retail- and the office-based analyses of the two prior chapters. It also provides the market assessment for commercial uses at Koa Ridge Makai and Waiawa.

The conclusions regarding supportable commercial space at the Project should be considered as separate from and additional to any commercial spaces that may be planned at the proposed Koa Ridge Hotel and health facilities.

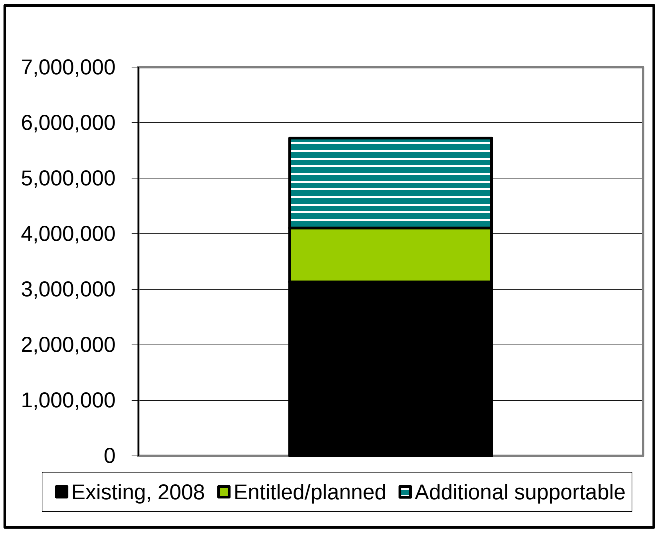
Central Oahu Commercial Market

Projected Supportable Area (Exhibit 7-1)

Considering the analyses of retail- and office-based markets presented previously, by 2020, the Central Oahu DPA is expected to support 1.74 million square feet of commercial space in addition to that already in place and entitled and planned for development. By 2030, Central Oahu could be expected to support a cumulative 2.22 million additional square feet of commercial space.[1]

If added to the existing and proposed/entitled commercial areas identified, the net additional markets represent a potential total Central Oahu DPA commercial marketplace of up to 5.7 million square feet by 2020, or 6.5 million square feet by 2030. This could include neighborhood, community and regional shopping centers, office buildings, and retail spaces mixed into residential and/or office structures.

Projected Supportable Commercial Areas in Central Oahu (square feet): 2020



See Exhibit 7-1 for sources and further information.

Supportive Conditions

The strong commercial outlook for Central Oahu is based on an assumption that economic, workforce, and spending pattern changes take place within the DPA and its neighboring districts prior to or during C&C Waiawa's marketing. Of great significance to commercial markets, these changes are expected to be accompanied by a decrease in out-commuting from the entire region, including Central Oahu, Ewa and Waianae. These changes support the widely held "Second City" vision for Kapolei, which is emerging as the urban center of West Oahu. Many activities already underway in the region support these economic, workforce and spending pattern changes:

- **New centers of "primary jobs,"** meaning jobs with sufficient income to be the primary support for households living in the area;
- **Public policy support for new economic enterprises** relevant to the area, including knowledge- and innovation-based initiatives;
- **More, high quality elementary, middle and high schools,** offering a wide variety of options, including quality public, charter or magnet, private/religious affiliated, and private/non-affiliated schools;

[1] This represents net additional supportable development potential, beyond that for currently existing and proposed, State-entitled developments. See Exhibits 5-9 and 6-5 for further information.

- **More options for entertainment, cultural and civic and spiritual endeavors,** such as performing arts centers, theaters, museums, shopping, social/business clubs, places of worship and libraries;

- **Renewed development** of high quality housing targeting a wide range of income and age groups;

- **Neighborhoods of move-up housing,** to which area households with rising income and home equity would be proud to relocate; and

- **More efficient transportation systems**, both within and into the region.

All of these precursors are in progress in Central Oahu and Ewa. Many are anchored in Kapolei or East Kapolei, while others would be supported within Koa Ridge Makai and Waiawa.

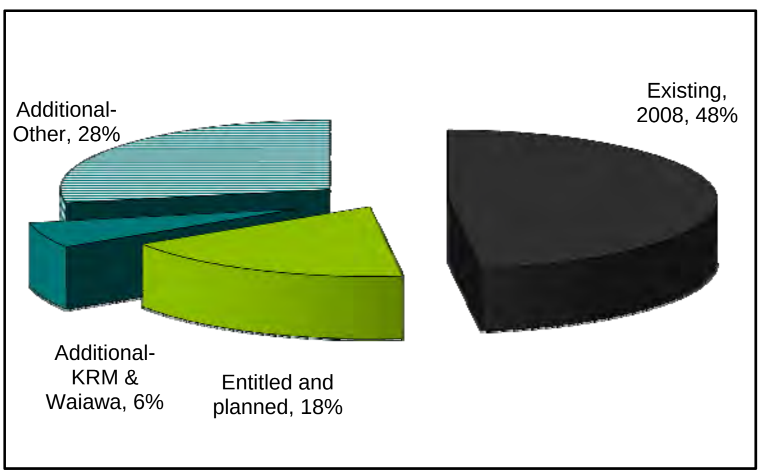
Assessment for C&C Waiawa (Exhibit 7-2)

Market Share

Together, Koa Ridge Makai and Waiawa are proposed for up to 410,000 square feet of commercial uses, including retail and office spaces.

If developed to the full proposed capacity, the Project's commercial spaces could represent some 6% of the Central Oahu DPA's total future inventory in 2020 and in 2030.

Potential Ewa DPA Commercial Space Inventory: 2030



See Exhibit 7-2 for sources and further information.

These developments could also represent venues for about 18% to 19% of the currently unplanned but future supportable commercial space in Central Oahu.

These market shares are considered achievable in light of the medical, hotel and other economic initiatives represented within Koa Ridge, as well as the expected developments in the broader Waiawa community (including Waiawa Ridge.) Given that potential commercial developments on other entitled lands throughout Central Oahu have already been accounted for, Koa Ridge Makai and Waiawa appear to be some of the few significant areas within the DPA on which such development could occur.

Absorption

Koa Ridge Makai and Waiawa's facilities are expected to be supportable by 2025, in concert with the anticipated build-out of its residential units by that date. If the first completions are in 2012, this would mean an approximately 14-year absorption period, averaging some 30,000 net new square feet leased per year:

- Total commercial area proposed - 410,000 square feet
- Projected first occupancy date – 2012
- Projected full absorption date – 2025
- Number of years on market – 14
- Average annual absorption - 30,000 square feet

8 – Business Park Market Environment and Assessment

Overview

Koa Ridge Makai Proposal

The master plan for Koa Ridge Makai allocates some 5 gross (or 4 acres net usable) acres to light industrial uses at the southern tip of the site, adjacent to Gentry Waipio.

Due to its small size and its location within a mixed use residential community, this site is expected to house "clean" industries such as an office headquarter campus, research & development facility, or service-retail uses. As such, the park is expected to have a relatively high floor area ratio (FAR). Koa Ridge Makai's site is preliminarily envisioned to show an FAR of 0.50, which is slightly higher than the average of built-up light industrial lands island-wide, and a good deal higher than the 0.13 observed for built properties in industrial parks in the Ewa-West Oahu region. The relatively low average FAR in the region is attributed to its greater incidence of heavy industrial areas. Based on the 0.50 FAR, if built out with warehouse type facilities, the site could be expected to accommodate about 90,000 square feet of rentable building area.

Methodology

Industrial areas can support business parks, manufacturing, research & development, wholesale, office and retail uses as well as light or heavy industry. They often serve a regional or island-wide market. This analysis profiles current market trends within Central Oahu and Ewa, but the assessment for future demand is based on island-wide trends. As eastern Oahu and the island's urban core are redeveloped with higher density and higher value uses, land-extensive industrial and business park facilities are increasingly being pushed to the western areas of the island.

Like office demand, long-term market demand for business park/industrial land is related to trends in civilian job creation. This analysis does not consider public facilities with industrial-related uses or industrial-designated lands such as at military bases, harbors, universities and airports.

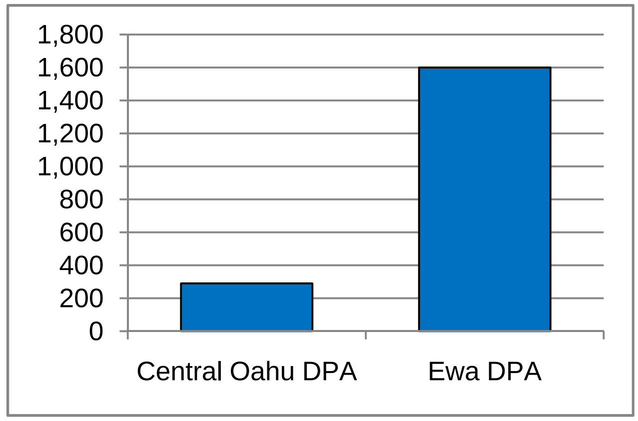
This analysis is prepared in terms of acres of land, although much of the available market data is for square feet within buildings developed on such lands.

Industrial and Business Park Supply

Area Inventory (Exhibit 8-1)

Central Oahu's business park/industrial inventory is dispersed among a long-standing concentration of areas in Waipahu and some in Wahiawa, relatively new facilities in Waipio (Gentry Business Park), and the park setting of C&C's Mililani Technology Park. Most of these lands accommodate light industrial, warehousing and distribution, or business/service uses. Altogether, Central Oahu's developed industrial areas include about 290 gross acres, as of July 2008.

Existing Industrial Lands
(in acres)



See Exhibit 8-1 for sources and further information.

Kapolei includes a far greater concentration of industrial lands, ranging from heavy to light industrial uses, which reflects its proximity to the Kalaeloa/Barber's Point Deep Draft Harbor and former military installations at Kalaeloa. In total, the Ewa DPA's developed or used industrial land inventory is estimated at 1,600 gross acres, all of which are located in Kapolei. The largest properties in Kapolei include the James Campbell Industrial Park and Kapolei Business Park.

Kapolei Property Development Co., a subsidiary of Campbell Estate, is completing zoning on its 345-acre Kapolei Harborside industrial area, while nearby SHM Partners is completing entitlements on the approximately 100-acre West Kalaeloa area. These new developments augment the island's industrial inventory considerably.

These gross land areas should also be evaluated in terms of net acres, since an industrial park or larger area must typically devote some 25% of its lands for circulation, infrastructure, easements, setbacks and the like. Thus in terms of net usable acres, the developed business park/industrial lands as of July 2008 are estimated as follows:

- **Central Oahu DPA –** 220 acres
- **Ewa DPA –** 1,200 acres

Market Trends for Warehouse Space

As of mid-year 2008, Oahu offered an estimated 39.8 million square feet of warehouse/industrial building area, according to CMF.[1] Average base asking rents for warehouse space was $1.26 per square foot per month, down from $1.31 at the end of last year. This is the first decrease in seven years, also according to CMF, and reflects softening in the construction industry as well as rising transportation costs. Warehouse space vacancies are estimated at 4% islandwide in June 2008, up from about 3% at the end of last year and the highest level since 2002.

Within the areas of interest, CMF reports the following survey data:

	Warehouse/ industrial building area (square feet)	Vacancy	Asking rent*
Waipahu/Milltown (Central Oahu)	2.5 million	3.2%	$1.32
Gentry Business Park (Central Oahu)	1.8 million	15.5%	$1.36
Campbell Industrial Park/Kapolei Business Park/Kenai	5.6 million	6.6%	$1.20

* Weighted average net asking rent per square foot per month.
Source: Colliers Monroe Friedlander, 2008.

The high vacancy rate in Gentry Business Park was driven by the 2008 market entry of THM Partners' Waipio Business Center, a new 99-unit commercial condominium project, which is in the early stages of marketing.

The rising vacancy rents and softening rental rates reflect the beginning of a business cycle downturn. They may also reflect some structural changes within the island marketplace as rising transportation costs make outlying locations less attractive to businesses that serve island-wide or super regional markets. However, even at the current 4% average vacancy, the Oahu market would still be considered underserved, with the relative lack of facility choices inhibiting business growth and driving up occupancy costs. A 5%, or even up to 8% vacancy rate is considered to reflect a more balanced market, according to industry advisors.

[1] Colliers Monroe Friedlander, "Industrial Market Report: Honolulu Mid-Year 2008," July 2008. CMF shows 37.0 million square feet within this published report, to which another 2.8 million of unsurveyed spaces in Kaka'ako are added. Kaka'ako figure also provided by CMF, 2007.

Central Oahu Planned Development and Future Inventory (Exhibit 8-2)

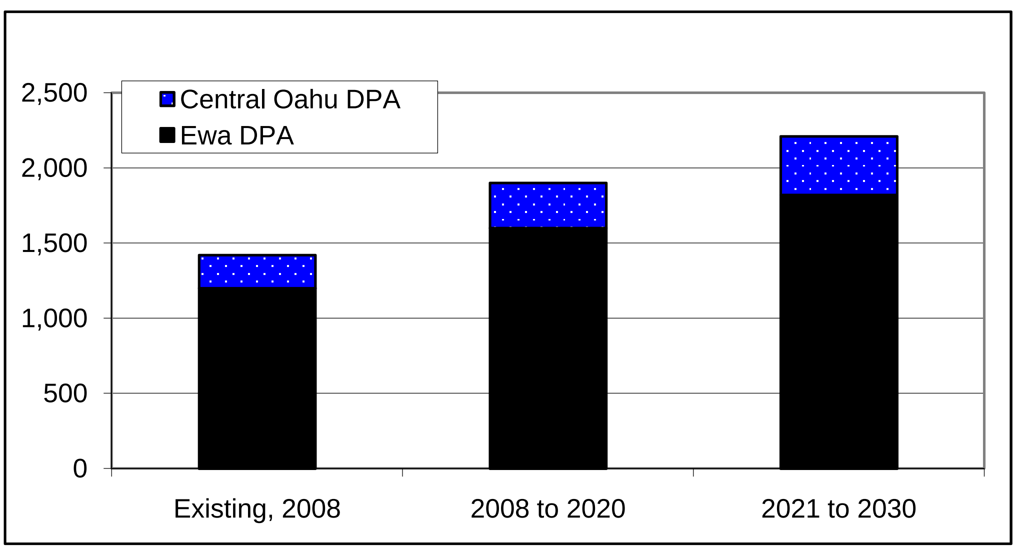
There are some 170 net acres of land entitled and planned for business park/industrial use in the Central Oahu DPA as of July 2008. Most represents remaining inventory at Mililani Technology Park Phase I and the potential for further development at MTP Phase II. The latter is not yet zoned appropriately for marketing. The latest plans for Waiawa Ridge Increment 1 reflect only about 14 net usable acres with State entitlements. The developer has proposed another 85 gross acres for commercial/industrial use, but these lands are not yet designated Urban by the LUC, and so are not counted in this inventory.

With the recent State entitlement of Kapolei Harborside and the acquisition of the West Kalaeloa site by SHM Partners, Ewa shows a net future supply of some 620 entitled acres. However, some 144 acres of this potential future inventory are located in Kalaeloa (Navy plus State of Hawaii-administered lands), and the ultimate use and development timing for these lands are very uncertain.

Specific projects from which these estimates were derived are presented in Appendix 6.

Considering these planned developments, plus areas already in use, Central Oahu and Ewa could have some 2,200 net acres of private business or industrial park lands available by 2030, if all projects are developed as currently planned and on the timetables projected. Central Oahu could account for 390 or about 18% of these net acres, while the regional market center would remain in the Ewa DPA.

Potential Future Industrial Lands
(net acres)



See Exhibit 8-2 for sources and further information.

Industrial and Business Park Demand

Demand for future business park/industrial lands in Central Oahu can be expected to come from two sources:

1. **Employment-driven demand** - This is estimated based on projections of civilian employment and is driven by the future needs of businesses island-wide.

2. **Transition-driven demand -** Within Oahu, some existing industrial tenants and landowners can be expected to move to Central and West Oahu, as they are displaced from areas nearer to the urban core of Honolulu. Transition demand will also be driven by an increasing "pull" from Ewa and Central Oahu with their critical mass of services, facilities and consumers, as well as potentially lower costs and more modern infrastructure.

Employment-Driven Demand (Exhibit 8-3)

Oahu offered some 39.8 million square feet of industrial building area in mid-year 2008, or 90 square feet per civilian employed person, with an average vacancy of 4%. This vacancy is considered less than optimal, reflecting a somewhat supply-constrained marketplace as discussed above. Considering a minimal target vacancy rate of 5%, a more desirable current ratio would be at least 91 square feet per employee, which would support a total of 40.2 million square feet of building area.

The ratio of building area to employees has been increasing, reflecting the strong State economy in recent years. Its rise also reflects as an evolving mix of industries on Oahu, particularly growth outside of tourism in areas such as research, high technology, film and media production and the like. As public policy and private efforts continue to encourage such economic transitions, one can expect to see the ratio of industrial space demand to employment continue to increase.

Compared to eight U.S. market areas reported on by Robert Charles Lesser & Co., LLC (RCL) in 2004,[2] Honolulu's industrial space to employment ratio was the lowest. Comparison locales surveyed in 2004 include:

- Metro Las Vegas – 95 (with 7.6% vacancy);
- Metro Seattle – 111 (with 9.5% vacancy);
- San Diego County – 125 (with 7.6% vacancy);
- San Francisco Bay Area – 131 (with 0.0% vacancy);
- Metro Phoenix, Metro Denver and Los Angeles County – 143 to 236.

[2] Robert Charles Lesser & Co., LLC, "Industrial Market Feasibility: 345-Acre Kapolei Harborside Center," Exhibit II-7, January 31, 2006, (prepared for Aina Nui Corporation). RCL cites Grubb and Ellis and Colliers as its sources.

Based on just a 0.3% per annum increase in Oahu's ratio, to 97 square feet per employee by 2030, the island could be expected to demand up to 50.6 million square feet of industrial building area by 2030. This implies need for another 10.7 million square feet over the next 22 years. The future inventory would represent only about a 1.1% per annum increase over the period, compared to a 0.7% projected annual increase in employed civilians.

Assuming a FAR of 0.20 for the new areas[3], the projected demand for new building space implies need for another 1,232 net acres of land by 2030. This includes some 38 acres of estimated pent-up demand in 2008. The ratio used in this projection would position the Oahu of 2030 between Metro Las Vegas and Metro Seattle of 2004.

Given the 790 net acres identified as planned in Central Oahu and Ewa, plus another 115 documented at three other sites on Oahu, the island could require another 905 net acres of business park/industrial lands by 2030, beyond those already entitled and planned. This is the need component that can be associated with increases in the island's employment base.

Transition-Driven Demand (Exhibit 8-4)

In addition to demand related to a growing employment base, Oahu will need to find new locations for industrial land users moving within the island. Sources of this transition-based demand are two-fold:

- **Displacement –** Two large areas of current business park/industrial use near to Honolulu's urban core are already displacing tenants and can be expected to continue to do so. These include the Kaka'ako District, estimated by CMF to house some 2.8 million square feet of business park/industrial tenants, and the former Kapalama Military Reservation on Sand Island, with an estimated 1.2 million square feet. KMR's transition is expected to take about 4 years, while Kaka'ako's could persist until 2020 or so, as the general area gradually redevelops.

  Together, these two areas represent about 4.0 million square feet of space that will need to relocate within the island. By 2010, some 70 acres worth of tenant space might have already relocated, including most of KMR and a portion of Kaka'ako. Tenants requiring up to another 102 acres might still need to be relocated by 2020.[4]

- **Lease turnover –** Based on a common five-year space lease, in any given year approximately 20% of existing leases would come up for renewal and some 5% of those could be expected to relocate. Considering Oahu's current business park/industrial space inventory (outside of Kaka'ako and KMR), this would represent about 343,000 square feet of industrial building space seeking to relocate in any given

[3] This compares to the 0.13 observed in business park/industrial areas in West Oahu, according to survey data provided by CMF in 2007.

[4] Expiring ground leases, area redevelopment and other factors will also displace tenants at other locations, including the Airport and Mapunapuna areas. These situations are not added to the demand calculations here because of the lack of complete information. The assessment of demand would be higher if more such situations could be documented.

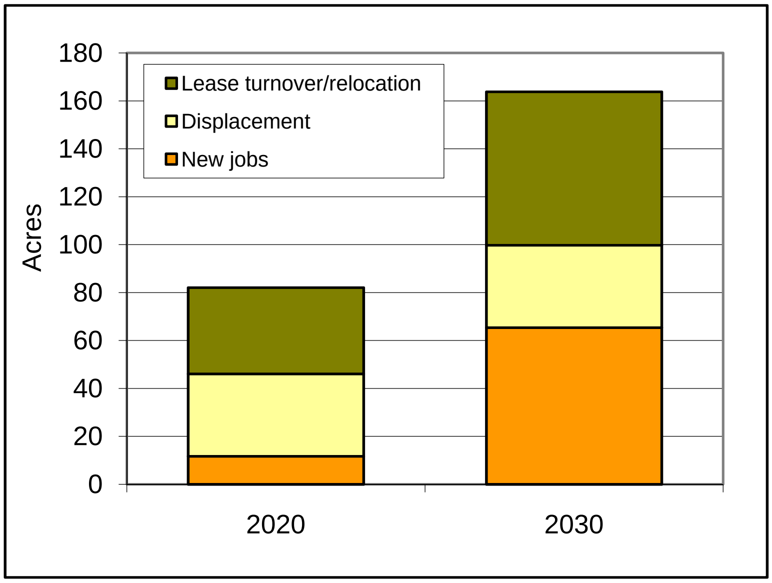
year. While this source of demand will grow as the island inventory of space increases, for these purposes, only the 343,000 square foot figure is used.

Within the study horizon, lease turnover could generate about 7.9 million square feet of relocations (1.02 million + 3.43 million + 3.43 million), which could represent about 320 acres of needed land.

Business Park/Industrial Land Assessment

Central Oahu DPA
(Exhibit 8-5)

Potential Future Business Park/Industrial Land Requirements in the Central Oahu DPA by Demand Source



See Exhibit 8-5 for sources and further information.

The market potential for the Central Oahu DPA will be determined by its capture rates of the employment-driven and the transition-driven sectors of demand.

- **Employment-driven demand** – This demand originates primarily from new or expanding businesses that require new or more space. Because much of this demand could be attributable to new enterprises, it is considered more likely to be able to locate away from Oahu's existing centers of business and tourism near Honolulu and more likely to be attracted to modern infrastructure such as available in the new communities of Central Oahu.

  A 20% capture rate is employed for this source, roughly equivalent to Central Oahu's fair share of anticipated new business park/industrial development on the island. This would result in about 12 more acres supportable in the DPA by 2020, or 65 cumulatively by 2030.

- **Transition-driven demand** – Transition-driven demand is the relocation of existing tenancies rather than a net increase in island-wide demand. Central Oahu could be an attractive area for many transitioning tenants, with its relatively lower occupancy costs, its central island location and its new infrastructure.

On the other hand, the majority of the existing lease turnover tenancies and all of those examined for displacement (Kaka'ako and KMR) are already established near to the urban core, and likely have business and client relations there. Thus only 20% of the identified transitioning sources of demand are assumed to relocate to Central Oahu.

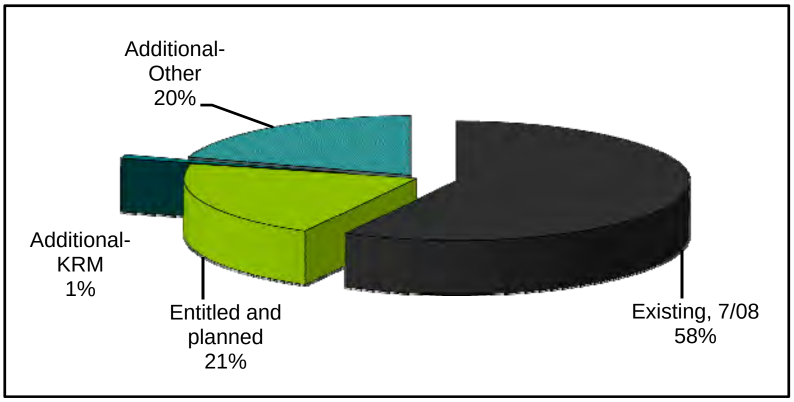
Transition-driven demand could be expected to support some 70 new acres of business park/industrial or business park tenancy in Central Oahu by 2020, or 98 cumulatively by 2030.

- **Total demand** – In total, supportable new industrial/business park land in the Central Oahu DPA, beyond that already entitled and planned, could amount to some 80 acres by 2020, or 160 cumulatively by 2030.

Assessment for Koa Ridge Makai (Exhibit 8-6)

The land use plan for Koa Ridge Makai includes a 5-acre (4 net acres) site for business park or light industrial development. The site is anticipated to support up to 90,000 square feet of business or light industrial building areas when built out.

Potential Supportable Ewa DPA Business Park/Industrial Inventory in 2020



See Exhibit 8-6 for sources and further information.

Given the relatively small size of the site, it could be expected to be occupied by a single or just a few tenant(s) or owner(s). Example uses could include an office headquarter campus, a research & development facility, or service-retail uses such as self-storage or auto repair and maintenance.

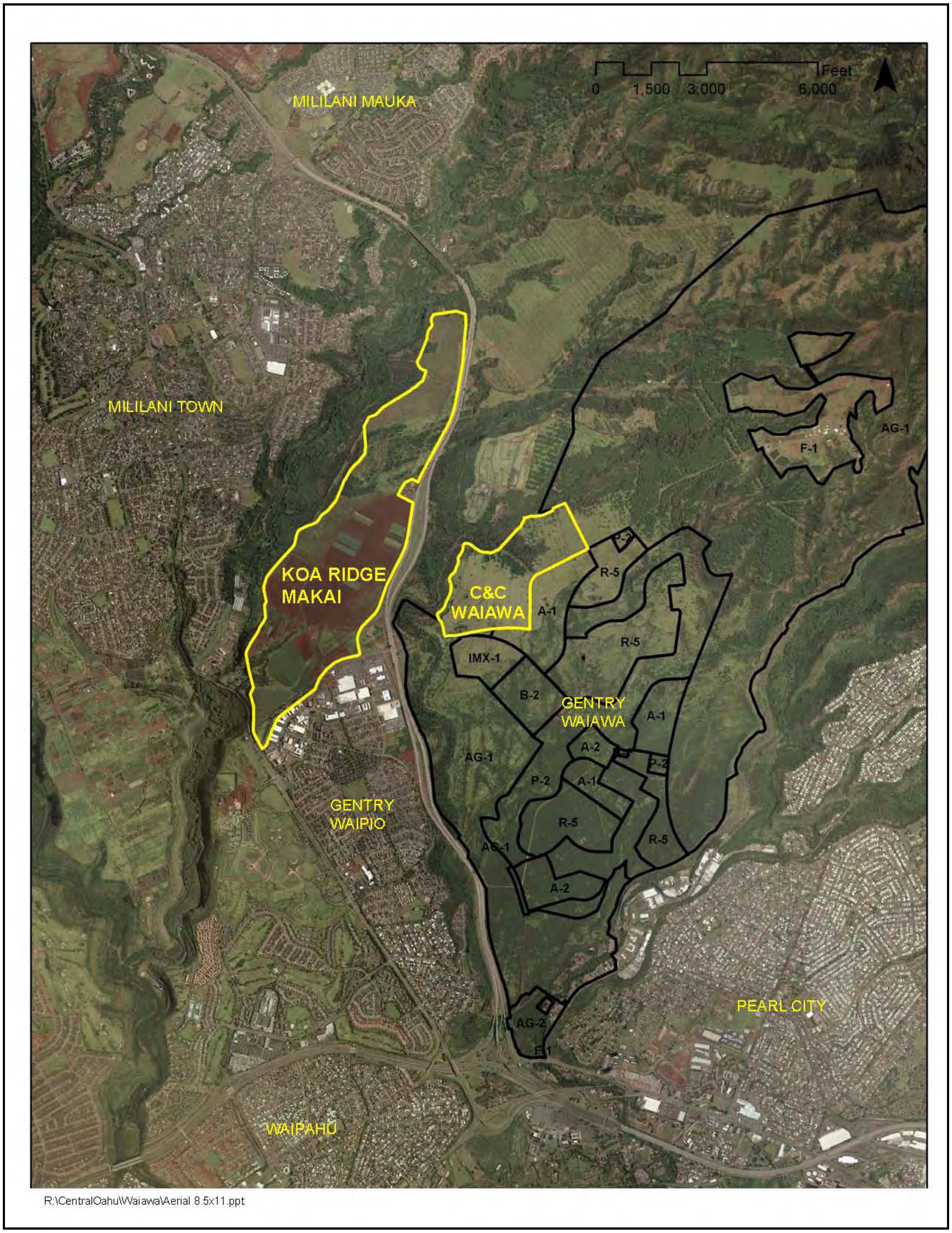
Considering the strong long-term regional market conditions as well as Koa Ridge Makai's central location and the integration of its business park site into a mixed-use community with a range of housing opportunities, the site could find a user or buyer within a single year of its offering, but is likely to be fully absorbed by 2020.

This site would represent a solution for only about 6% of the net unprovided-for demand in the region, or about 1% of the future DPA marketplace, as of 2020.

MARKET ASSESSMENT FOR KOA RIDGE MAKAI AND WAIAWA

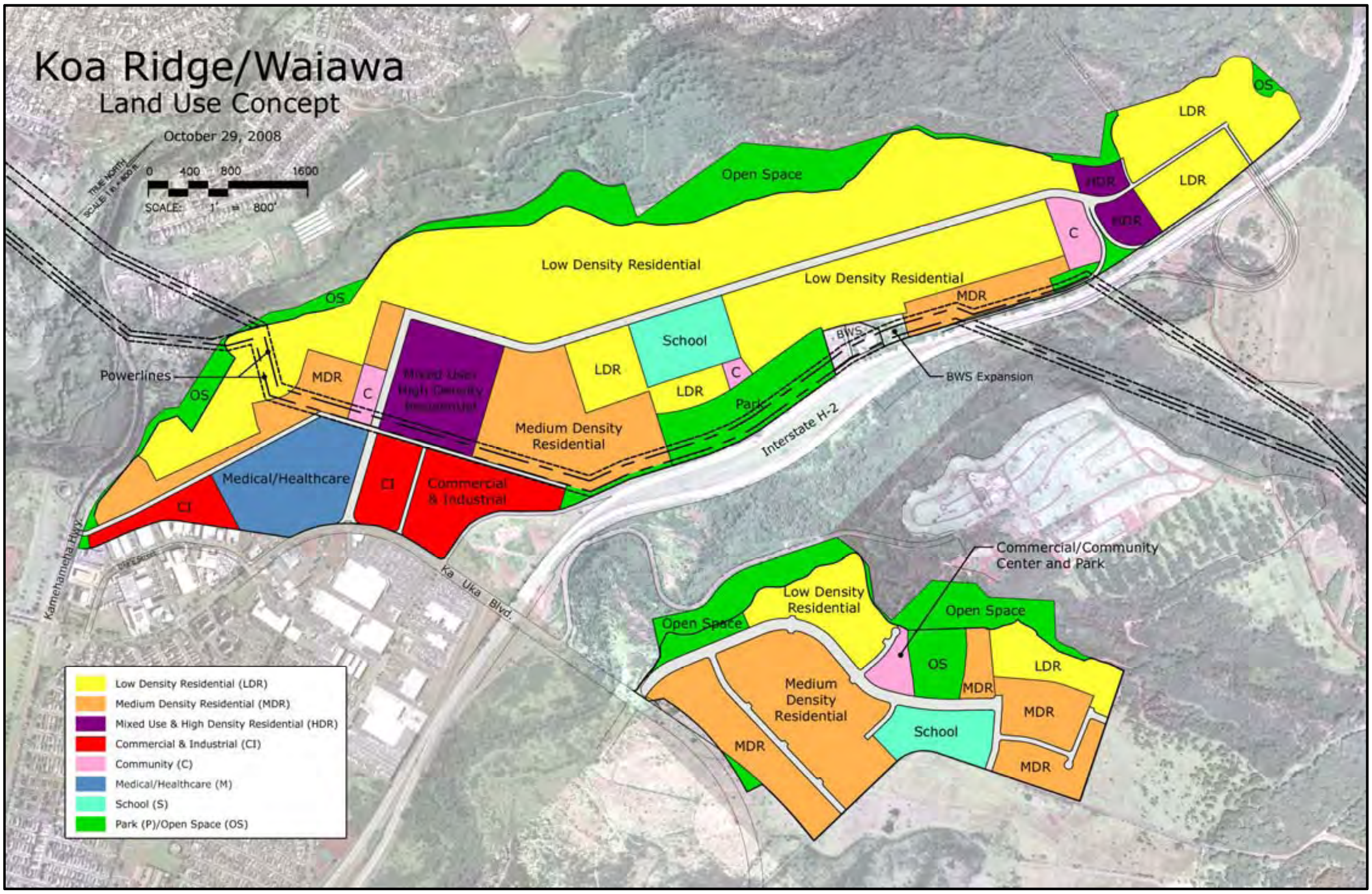
Report Exhibits

Exhibit 1-1
Location of Koa Ridge Makai and Waiawa in Central Oahu



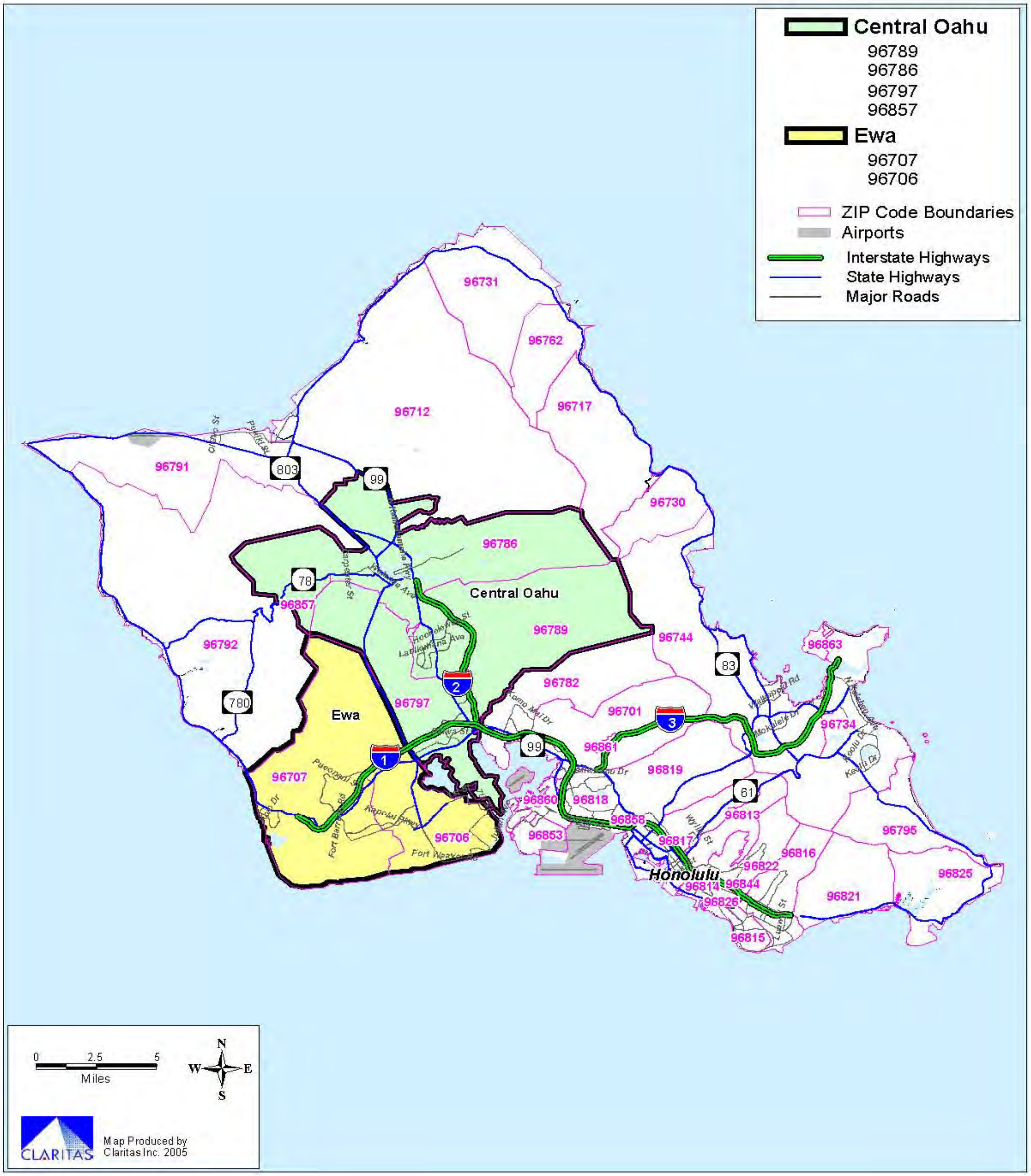
Source: Castle & Cooke Homes Hawaii, Inc., 2008.

Exhibit 1-2
Land Use Plan for Koa Ridge Makai and Waiawa



Source: Castle & Cooke Homes Hawaii, Inc., 2008.

Exhibit 2-1
Development Plan Areas within the Projected Trade Area, as Approximated by Zip Code

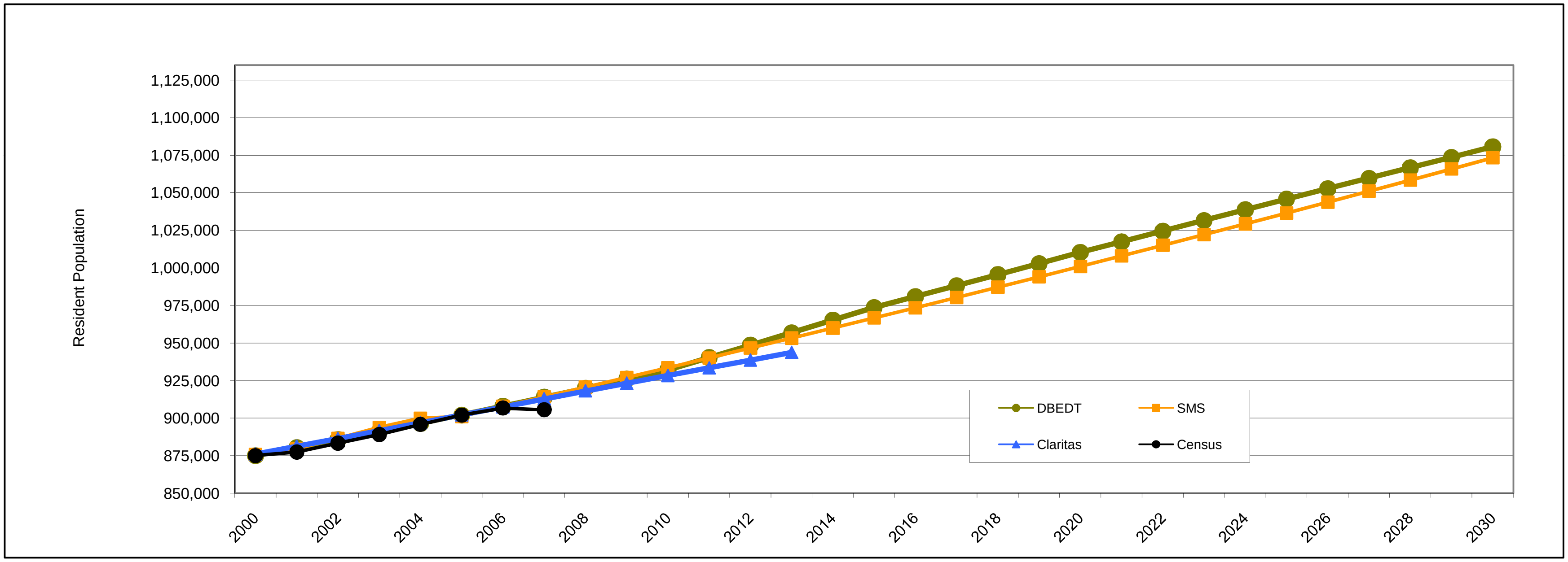


Source: Claritas, Inc., 2006.

Exhibit 2-2
Resident Population - Island of Oahu
Comparison of Estimates and Projections

2000 to 2030

	Date prepared	2000	2007	2008	2010	2013	2015	2020	2025	2030	Av. annual change, 2008 to projection horizon
DBEDT[1]	*2008*	875,100	913,929	919,953	932,120	956,850	973,700	1,010,400	1,046,000	1,080,700	0.7%
SMS[2]	2007	875,881	914,238	920,638	933,572	953,314	966,708	1,001,019	1,036,549	1,073,340	0.7%
Claritas[3]	*2008*	876,156	914,561	918,194	928,341	943,773	-	-	-	-	0.6%
U.S. Census[4]	*Annual*	875,133	905,601	-	-	-	-	-	-	-	N/A



1 State of Hawaii, Department of Business, Economic Development and Tourism, Research and Economic Analysis Division, "Population and Economic Projections for the State of Hawaii to 2035," (DBEDT 2035 Series), January 2008. Projections for 2005 and 5-year increments thereafter to 2030; figures interpolated in-between.

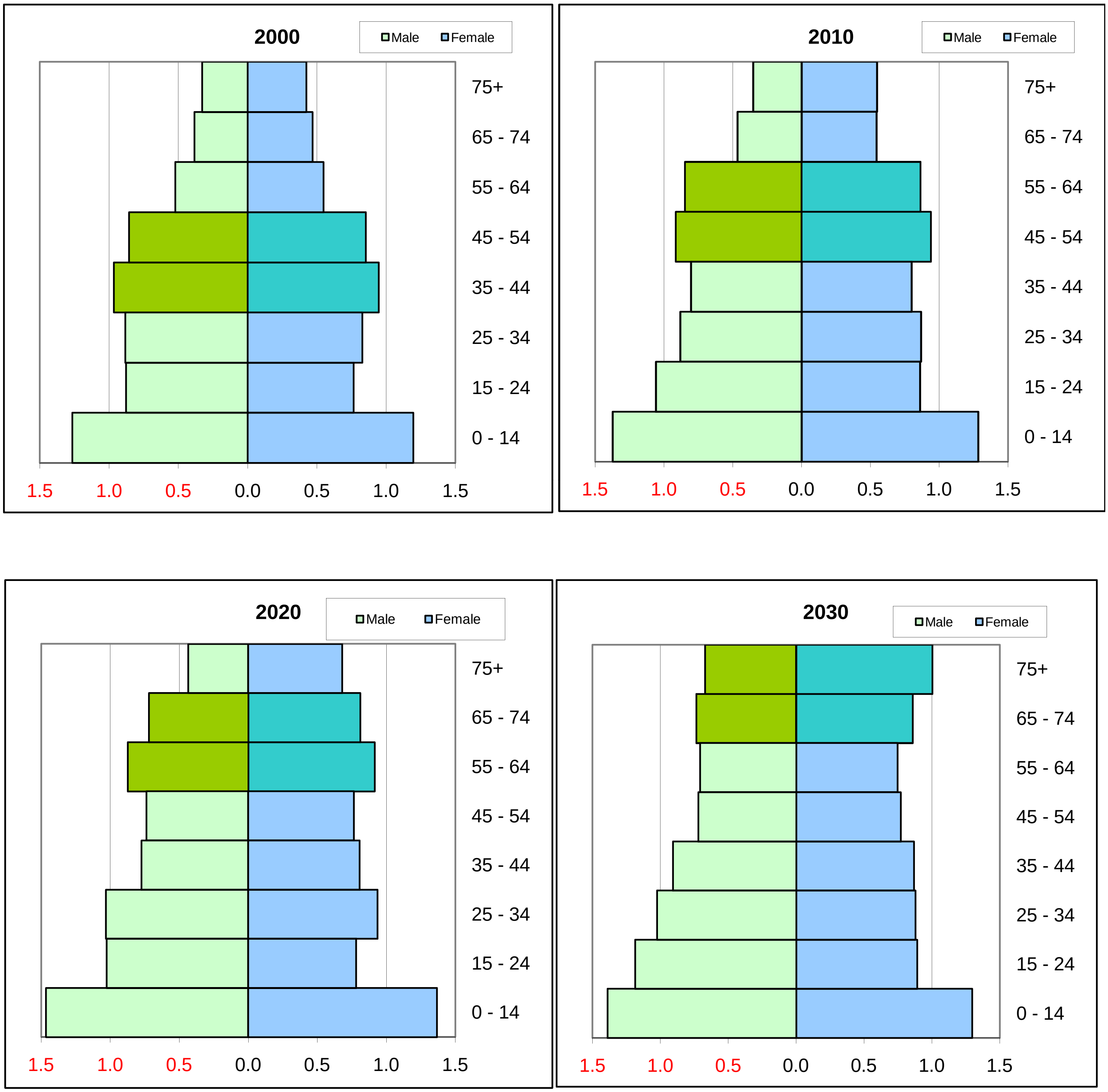
2 SMS, Inc., "Housing Policy Study, 2006: Hawaii Housing Model 2006," February 2007. Population growth set to 0.7% to approximate the updated DBEDT projections; this growth rate is below the "official parameter" for Honolulu County of 0.9%, as stated in the 2007 model.

3 Claritas, Inc., January 29, 2008, July 2 and 7, 2008. Estimates for 2007 and 2008; projection for 2013; figures interpolated in-between.

4 U.S. Census Bureau, Population Estimates Program, annual. As of July 1 for each year (2000 figure differs from April 1, 2000 enumeration.) 2007 county estimates released March 20, 2008.

N/A = Not applicable.

Exhibit 2-3
Projected Population by Age Group - State of Hawaii
2000 to 2030

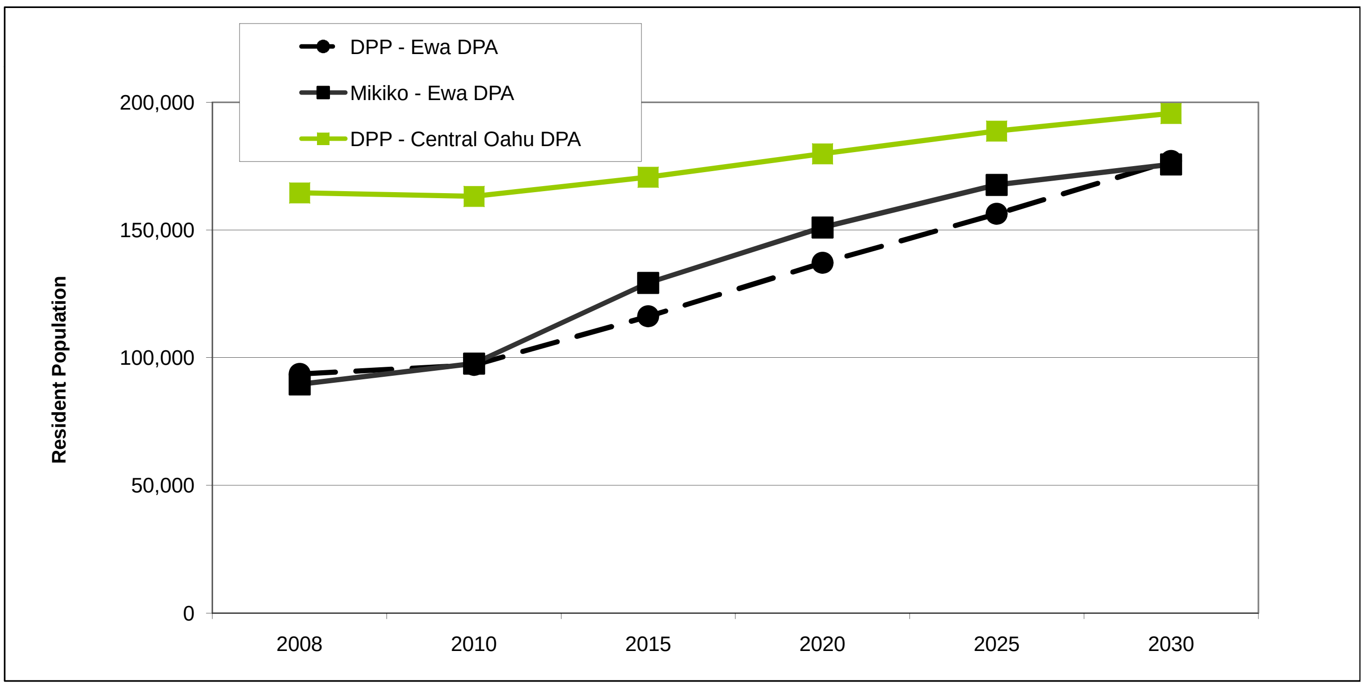


Notes: Each unit on X axis represents 100,000 persons. Highlighted bars include Baby Boom cohort.

Source: U.S. Census Bureau, Population Division, Interim State Population Projections (released 4/21/05), http://www.census.gov/population/www/projections/statepyramid.html.

Exhibit 2-4
Resident Population - Central Oahu and Ewa
2000 to 2030

	Estimated[1]		Projected[2]			Average annual % increase,
	2000	2008	2010	2020	2030	2008-2030
Population by DPA (projections by City, DPP):						
Central Oahu DPA	150,170	164,580	163,150	179,830	195,620	0.8%
Ewa DPA	68,820	93,630	97,110	137,130	177,030	2.9%
Oahu population (projections by State, DBEDT):	876,160	918,190	932,120	1,010,400	1,080,700	0.7%
As a percentage of Oahu:						
Central Oahu DPA	17%	18%	18%	18%	18%	--
Ewa DPA	8%	10%	10%	14%	16%	--
Mikiko/housing entitlement projection for Ewa DPA[3]:						
Population	68,700	89,500	97,700	151,000	175,700	3.1%
Percent of Oahu	8%	10%	10%	15%	16%	--



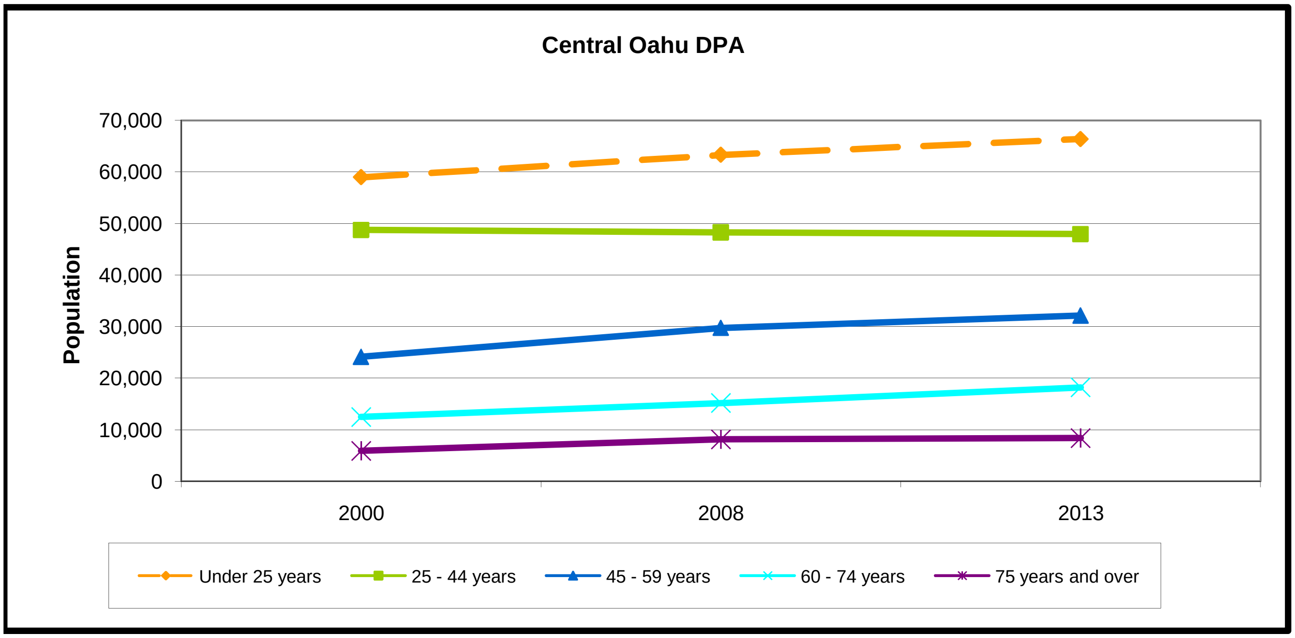
1 2000 Census and 2008 estimates as provided by Claritas, Inc.

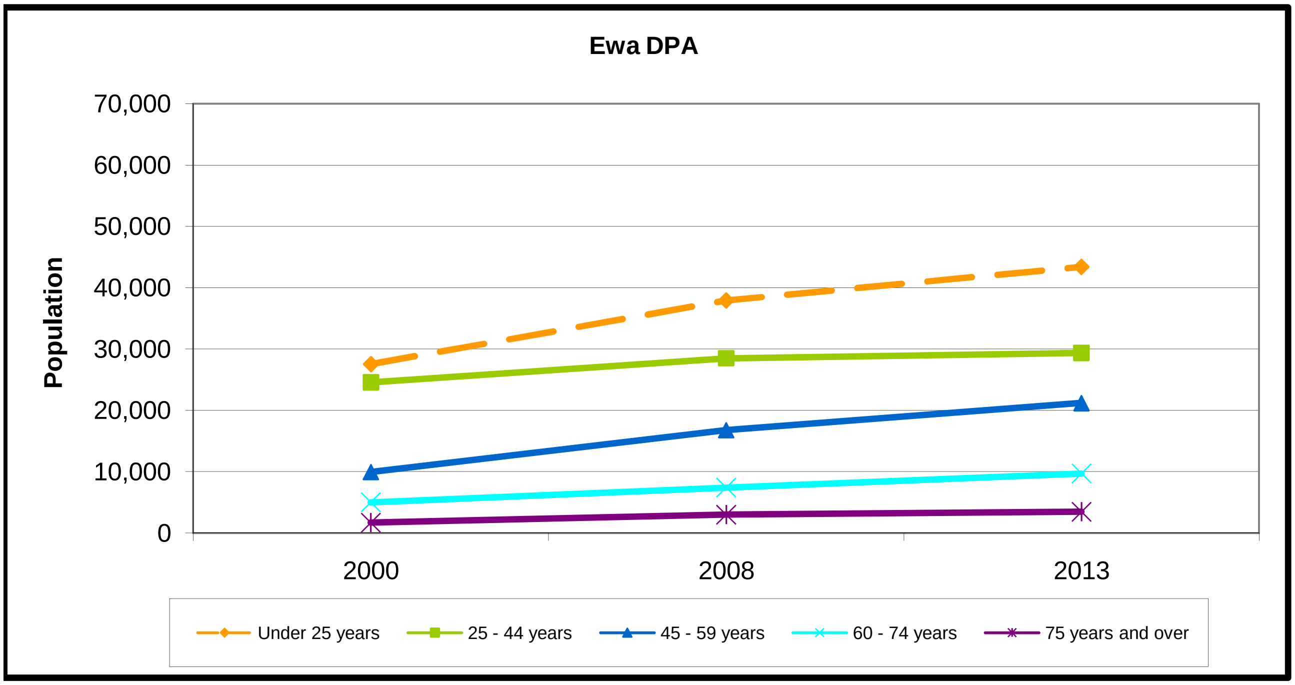
2 Projections for 2010 to 2030 by parties as shown.

3 Projection prepared by Mikiko Corporation considering maximum potential increase in population based on currently State-entitled (or exempt) housing developments (see Appendix 3.) Figures assume DPP's estimates for 2000 and 2005, with population thereafter based on (1) new home closings in Ewa for 2006 and 2007, as provided by The Harris Company, and (2) for 2008 on, potential development of entitled housing in Ewa as shown in Exhibit 3-5. All housing unit projections adjusted 5% for vacancy allowance, with an average household size of 3.1 (vs. historical area estimate of 3.6) in new housing units. Figures do not reflect impact of unentitled, proposed developments. Central Oahu DPA projections not reviewed by Mikiko.

Sources : City and County of Honolulu, Department of Planning and Permitting, Socioeconomic Projects, 2000-2030 by Development Plan Area, November 2007; Mikiko Corporation, 2008; The Harris Company, quarterly.

Exhibit 2-5
Population by Age Group - Central Oahu and Ewa
2000 to 2013





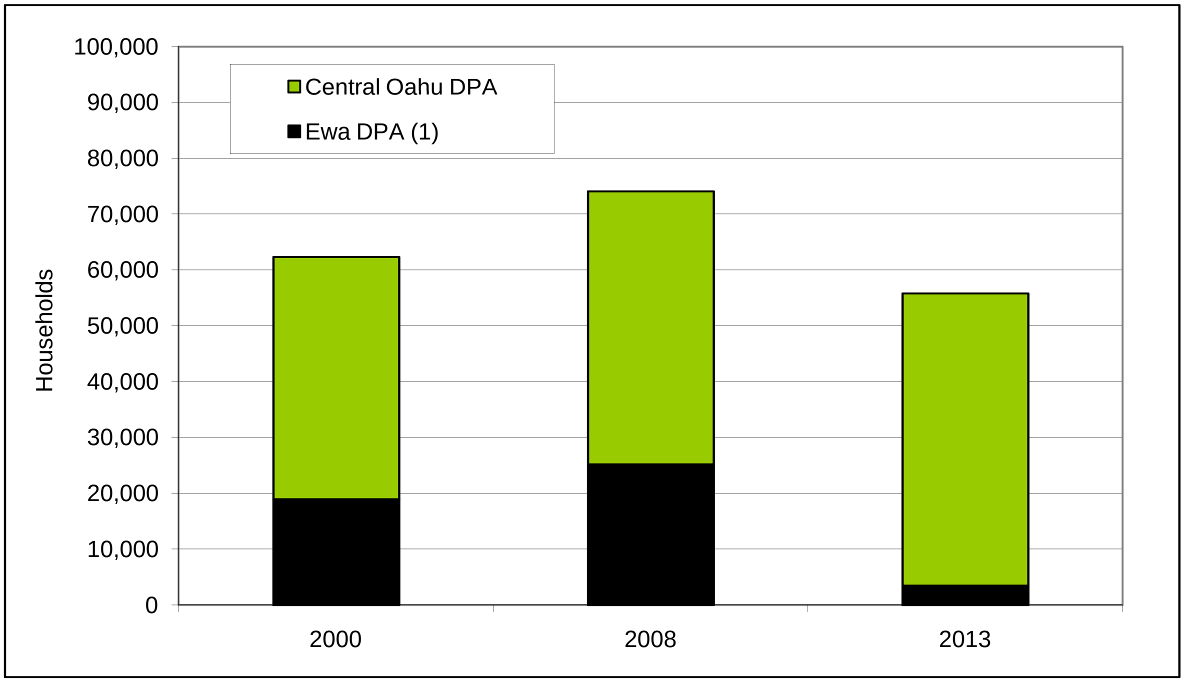
Median ages 2008: Ewa DPA - 31.8 Central Oahu - 32.8 Oahu - 37.3

Note: DPAs (Development Plan Areas) are those defined by the City and County of Honolulu, but approximated for data generation purposes by zip code area. See Chapter 2 for further information.

Sourced: Claritas, Inc., July 2 and 7, 2008.

Exhibit 2-6
Households - Central Oahu and Ewa
2000 to 2013

	2000	2008	2013	Average annual % increase 2000 - 2008	Average annual % increase 2008 - 2013
Number of households:					
Central Oahu DPA	43,376	48,900	52,300	1.5%	1.4%
Ewa DPA[1]	18,949	25,200	3,500	3.6%	-32.6%
Island of Oahu	286,731	304,585	316,003	0.8%	0.7%
Average household size:					
Central Oahu DPA	3.3	3.2	3.2	-0.3%	-0.3%
Ewa DPA[1]	3.7	3.6	33.4	-0.5%	56.6%
Island of Oahu	3.0	2.9	2.9	-0.2%	-0.2%

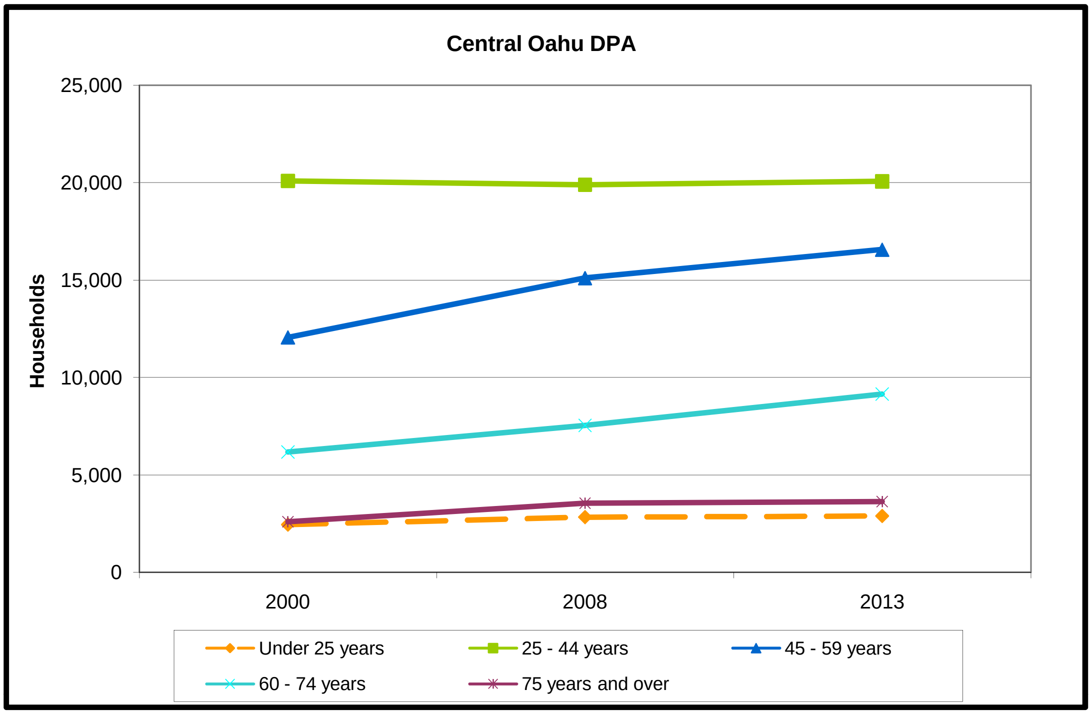


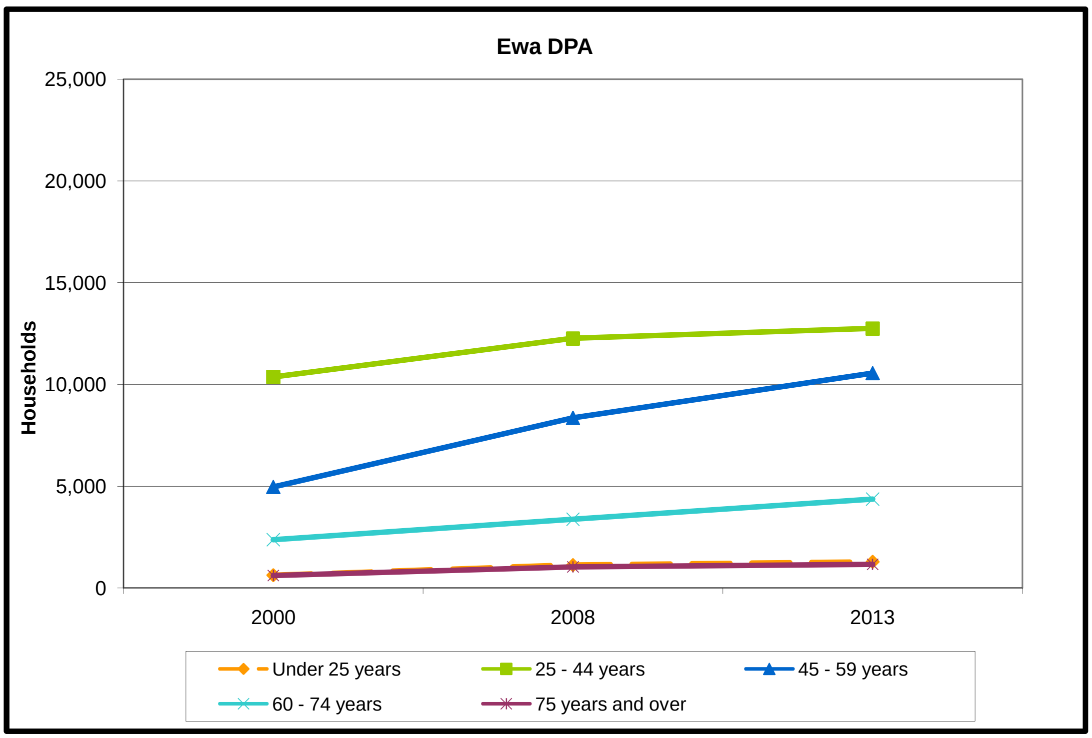
1 Claritas figures for 2008 and 2013 adjusted by Mikiko Corporation to reflect anticipated population levels based on State LUC-entitled expected housing development, as shown in Exhibit 2-4. New households assumed to average 3.1 persons, while households existing as of 2008 assumed to average 3.6.

Note: DPAs (Development Plan Areas) are those defined by the City and County of Honolulu, but approximated for data generation purposes by zip code area. See Chapter 2 for further information.

Sources: Claritas, Inc., July 2 and 7, 2008; Mikiko Corporation.

Exhibit 2-7
Households by Age of Head - Central Oahu and Ewa
2000 to 2013



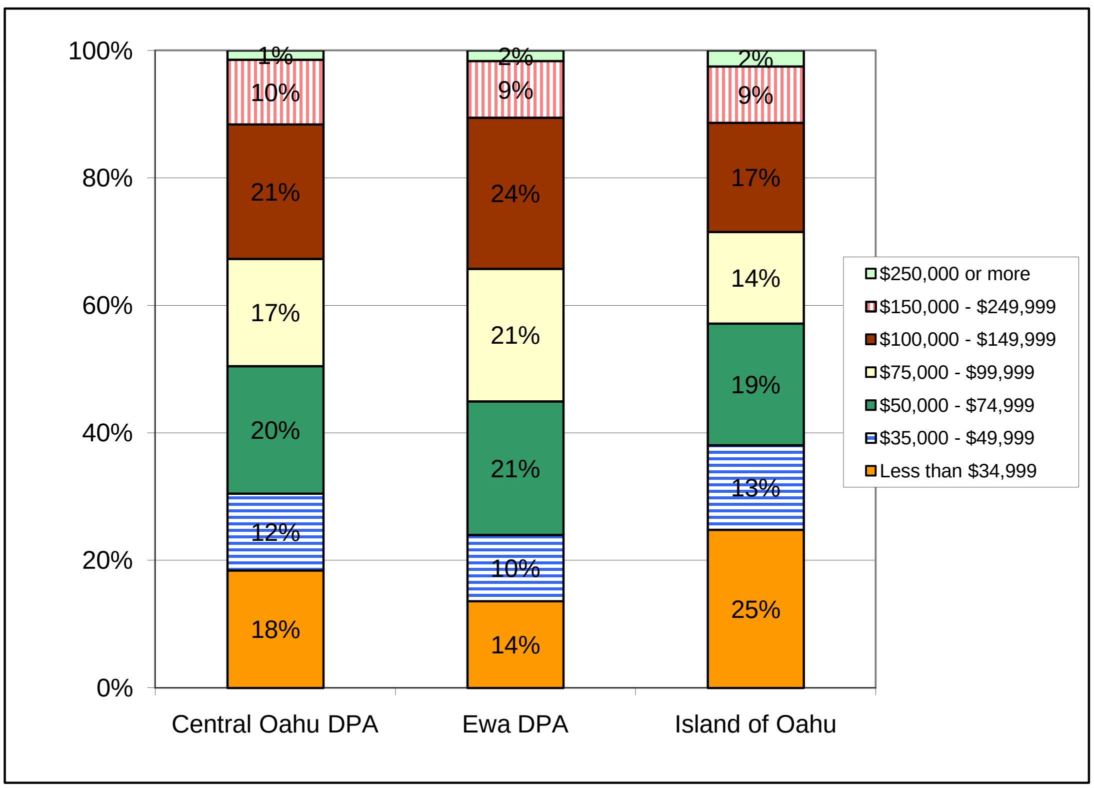


Note: DPAs (Development Plan Areas) are those defined by the City and County of Honolulu, but approximated for data generation purposes by zip code area. See Chapter 2 for further information.

Sources: Claritas, Inc., July 2 and 7, 2008.

Exhibit 2-8
Households by Household Income - Central Oahu and Ewa
2008 Estimate

	Central Oahu DPA	Ewa DPA[1]	Island of Oahu
Median household income	**$74,410**	**$81,095**	**$65,633**
Per capita income	**$26,409**	**$25,457**	**$28,115**
Number of households, by income -			
Less than $34,999	9,025	3,396	75,560
$35,000 - $49,999	5,877	2,603	40,356
$50,000 - $74,999	9,789	5,233	58,171
$75,000 - $99,999	8,240	5,202	43,689
$100,000 - $149,999	10,320	5,932	52,263
$150,000 - $249,999	4,967	2,217	26,951
$250,000 or more	703	417	7,595
Total, rounded	**49,000**	**25,000**	**305,000**



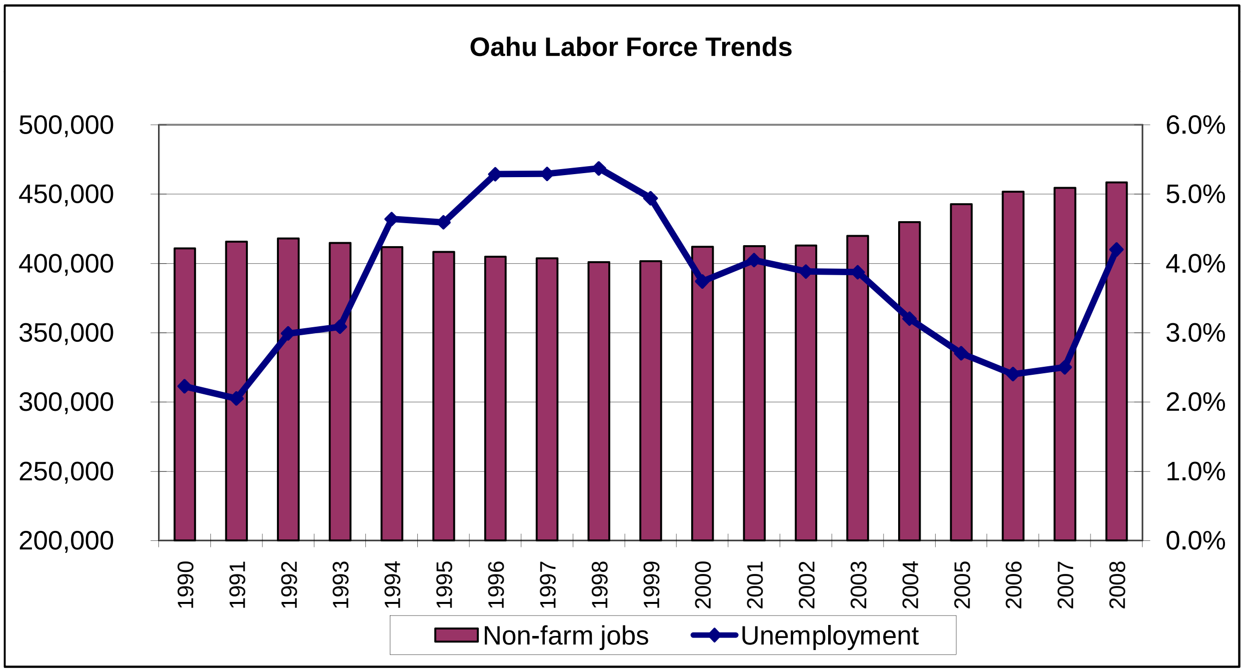
Note: DPAs (Development Plan Areas) are those defined by the City and County of Honolulu, but approximated for data generation purposes by zip code area. See Chapter 2 for further information.

[1] Total number of households in Ewa reflect Mikiko Corporation estimate as shown in Exhibit 2-6, with distribution according to Claritas' projections.

Sources: Claritas, Inc., July 2 and 7, 2008; Mikiko Corporation.

Exhibit 2-9
Labor Force Trends - Honolulu County
1990 to 2008[1]

	Civilian labor force	Employed persons	Non-farm wage & salary jobs	Percent unemployment
1990	409,250	401,250	410,700	2.0%
2000	433,100	416,450	412,000	3.9%
2001	435,300	417,500	412,450	4.1%
2002	429,800	412,900	412,800	3.9%
2003	433,750	417,500	419,700	3.7%
2004	436,150	422,500	429,700	3.1%
2005	445,200	433,350	442,650	2.7%
2006	451,300	440,500	451,800	2.4%
2007	449,850	438,600	454,500	2.5%
2008[1]	462,250	442,950	458,500	4.2%



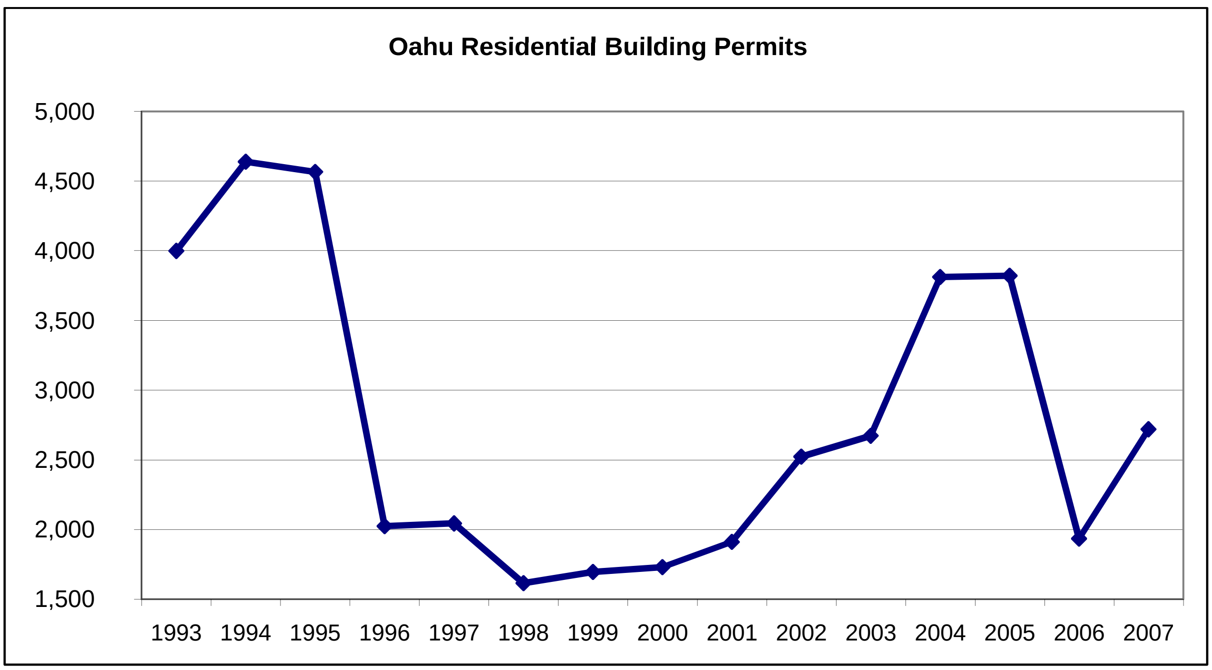
Note: 1990-1999 data reflect 2000 Census-based geography and new model-based controls at the state level. 2000-2007 data reflect 2000-based geography, new model controls, 2000 Census inputs and methodological changes. 2003-22007 have been benchmarked. Reflects revised inputs, re-estimation, and new statewide controls.

[1] As of June 2008.

Source: Hawaii State Department of Labor & Industrial Relations, 2008. As referenced in: http://www.hiwi.org/admin/uploadedPublications/466_LFHN.PDF. Non-farm wage and salary job estimates provided by DLIR as referenced in: http://www.hiwi.org/article.asp?ARTICLEID=515&PAGEID=94&SUBID=.

Exhibit 3-1
Private Residential Building Permits - Island of Oahu
1993 to 2008[1]

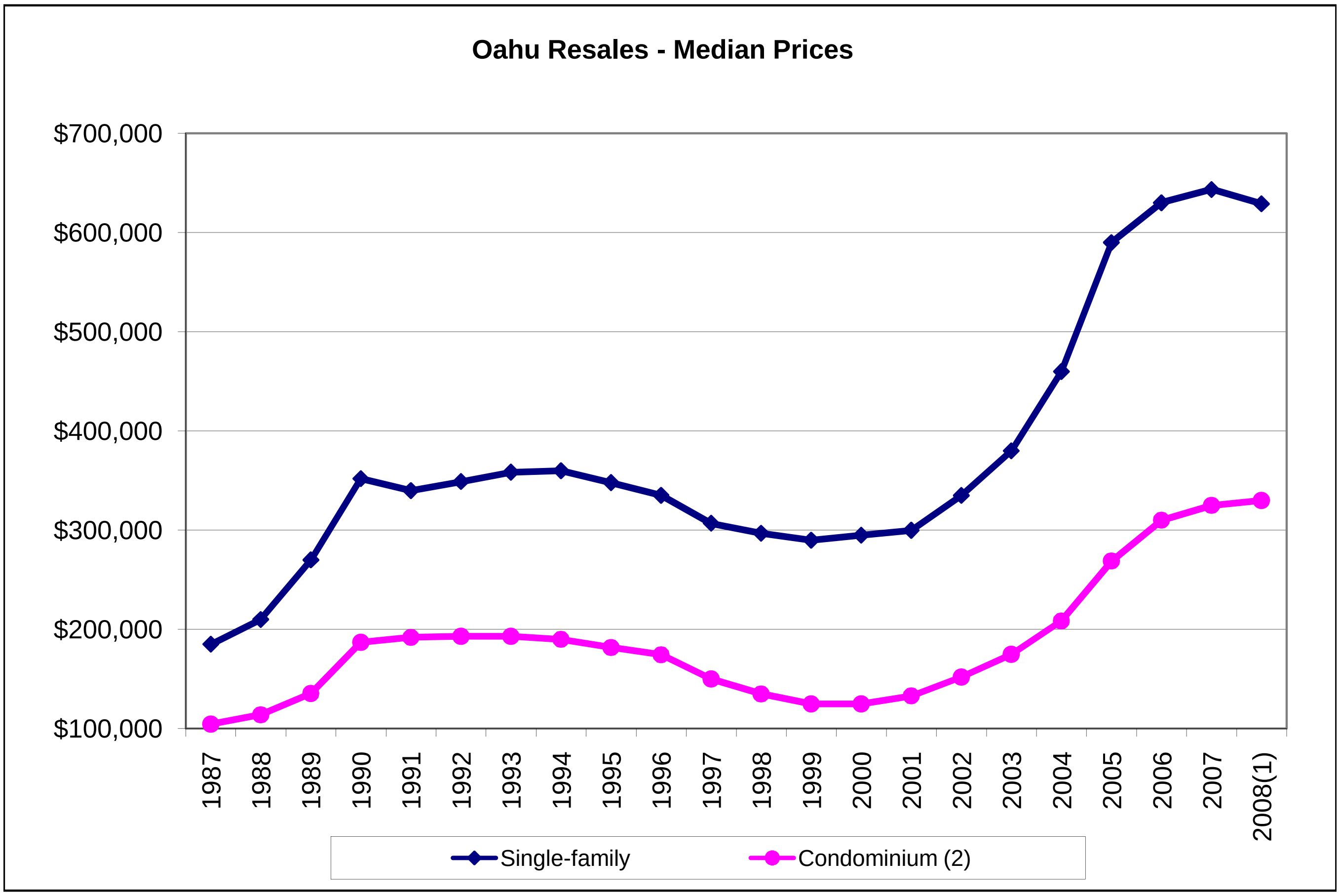
	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Annual
1993	554	992	1,545	908	3,999
2000	352	469	382	527	1,730
2001	466	595	497	353	1,911
2002	296	553	807	867	2,523
2003	682	785	576	630	2,673
2004	1,509	940	620	742	3,811
2005	520	954	965	1,382	3,821
2006	453	473	440	569	1,935
2007	556	1,260	586	317	2,719
2008[1]	194	--	--	--	--



Source: City & County of Honolulu Building Department, as referenced in QSER Archives, 2nd Q 2008, at: http://hawaii.gov/dbedt/info/economic/data_reports/qser/archive-qser/qser-2008q2.pdf.

Exhibit 3-2
Median Home Sales Prices - Honolulu County
1987 to 2008[1]

	Single-family	Condominium[2]
1987	$185,000	$104,500
1990	$352,000	$187,000
2000	$295,000	$125,000
2001	$299,900	$133,000
2002	$335,000	$152,000
2003	$380,000	$175,000
2004	$460,000	$208,500
2005	$590,000	$269,000
2006	$630,000	$310,000
2007	$643,500	$325,000
2008[1]	$629,000	$330,000



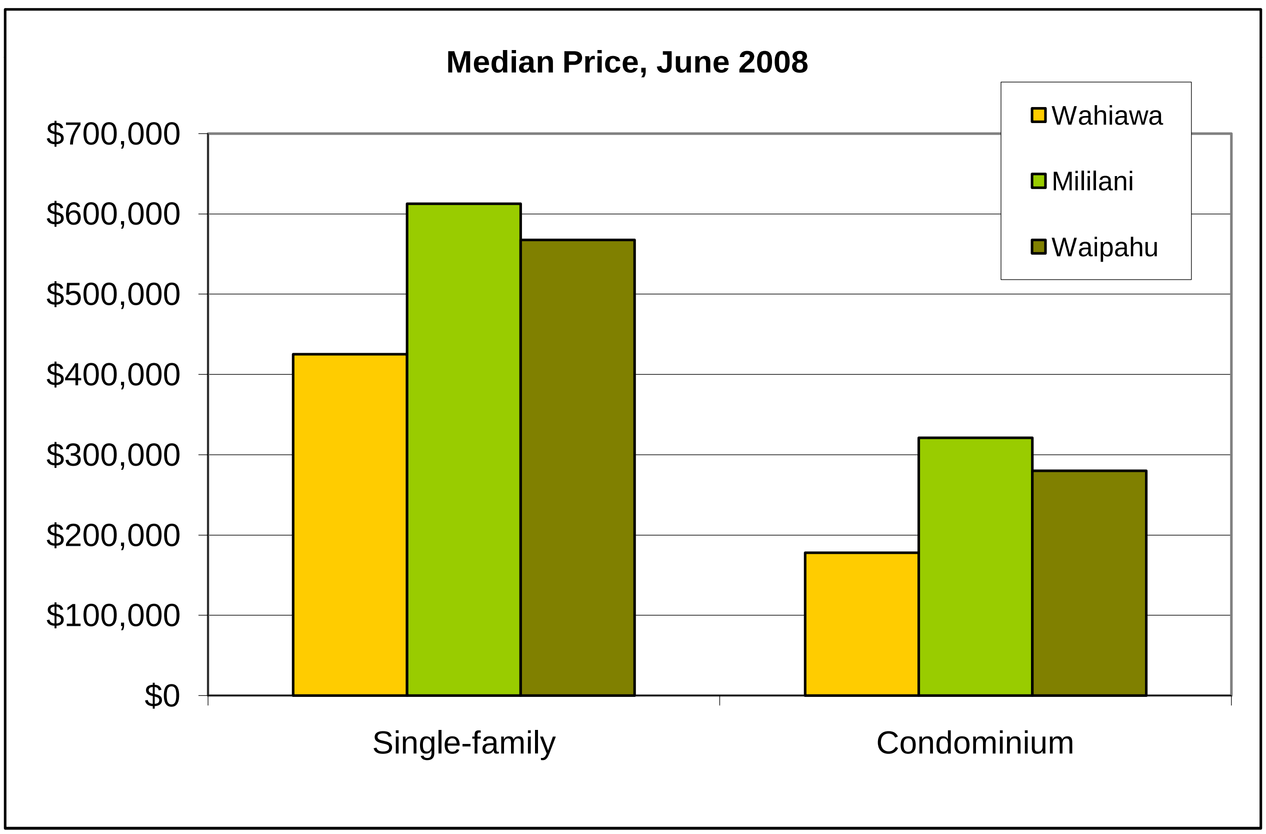
Note: Resales only; shows residential units that are entered in the Multiple Listing Service.

[1] Year to date, June 2008.
[2] Includes duplexes, townhomes and other multifamily units with common areas.

Source: Honolulu Board of Realtors, "Residential Resale Activity on Oahu," monthly.

Exhibit 3-3
Residential Resales Indicators - Central Oahu
As of June 2008

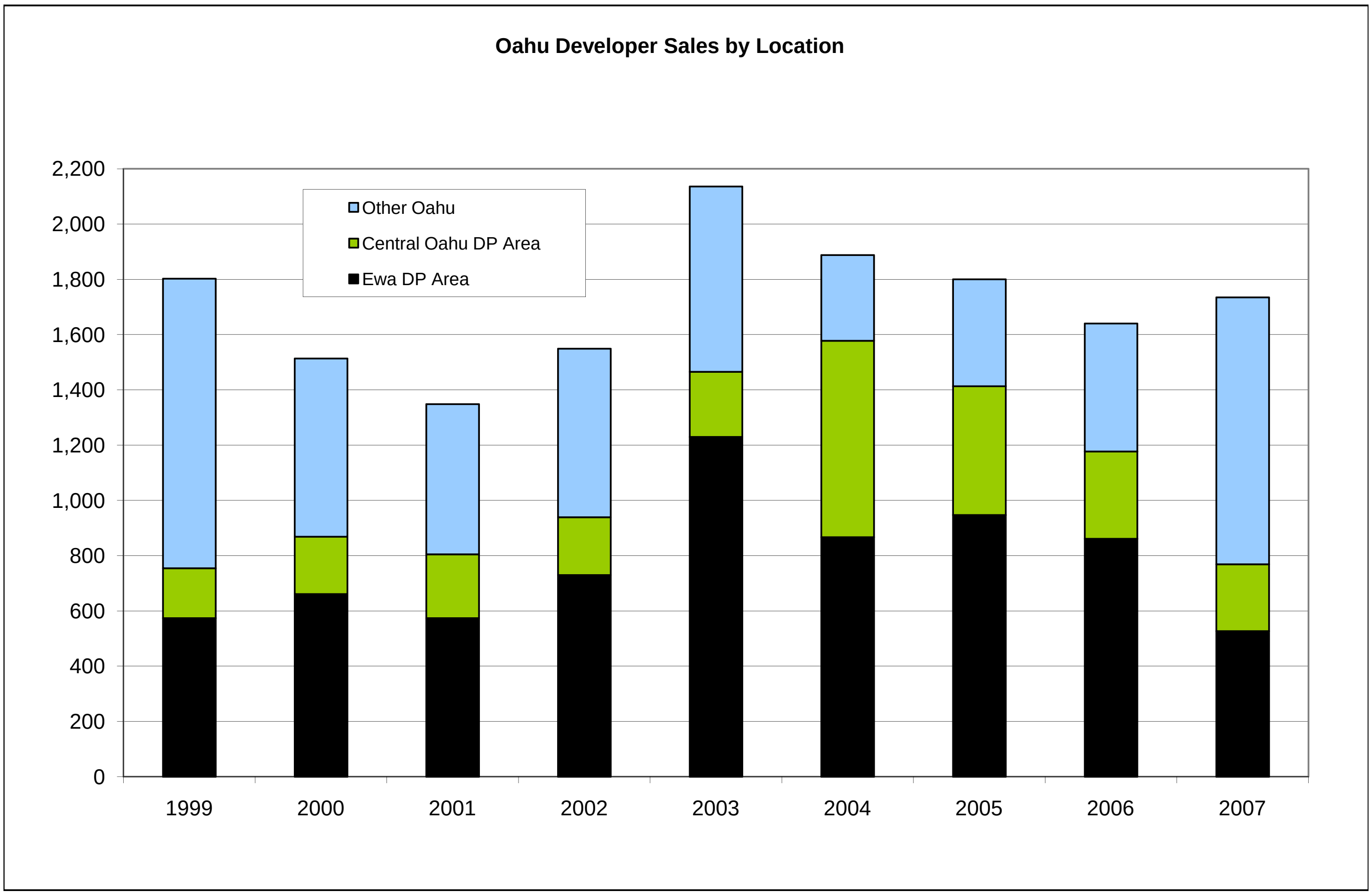
	Number of sales, January - June 2008			**Median price, June 2008**	
	Single-family	**Condominium**	**Total**	**Single-family**	**Condominium**
Wahiawa	25	13	38	$425,000	$178,000
Mililani	143	165	308	$612,500	$321,000
Waipahu	112	114	226	$567,500	$280,000
Total	280	292	572	$578,000	$299,000
	Percent change since Jan. - June 2007:			*Percent change since 06/07:*	
Wahiawa	*-40%*	*-52%*	*-45%*	*-46%*	*0%*
Mililani	*-9%*	*-37%*	*-26%*	*1%*	*2%*
Waipahu	*-31%*	*-29%*	*-30%*	*-1%*	*-7%*
Total	*-23%*	*-35%*	*-29%*	*-6%*	*-1%*



Source: Honolulu Board of Realtors, "Residential Resale Activity on Oahu," monthly.

Exhibit 3-4
Developer Unit Sales - Island of Oahu and Central Oahu DPA
1999 to 2008

	1999	2000	2001	2002	2003	2004	2005	2006	2007	1Q 2008	Average annual[1]
Island of Oahu:											
Single-family units	912	1,115	1,025	1,155	1,744	1,315	1,086	955	523	77	1,092
Townhouse units	290	195	268	381	371	547	531	358	269	61	357
High-rise condominium units	601	204	55	13	21	26	183	327	943	265	264
Total	**1,803**	**1,514**	**1,348**	**1,549**	**2,136**	**1,888**	**1,800**	**1,640**	**1,735**	**403**	**1,713**
Central Oahu DP Area:											
Single-family units	145	169	163	168	207	558	331	345	84	5	241
Townhouse units	36	39	67	41	29	153	135	53	158	43	79
Total	**181**	**208**	**231**	**209**	**236**	**711**	**466**	**316**	**242**	**48**	**320**
As % of island	***10%***	***14%***	***17%***	***13%***	***11%***	***38%***	***26%***	***19%***	***14%***	***12%***	***19%***



[1] 1999 to 2007.

Source: The HARRIS Company, figures represent units reported by developers to have closed escrow and recorded.

Exhibit 3-5
Entitled, Potential New Housing Supply - Island of Oahu

Projects with State Land Use Entitlement or Exemption, as of July 2008

Development Plan Area	**July 2008 - 2010**	**2011 - 2015**	**2016 - 2020**	**2021 - 2025**	**2026 - 2030**	**Total, 2008-2030**	**Comment**
Central Oahu	200	3,200	3,300	900	0	7,700	Excludes the Subject, Koa Ridge Makai and Waiawa, which requires SLUC approvals. See Appendix 2.
Ewa	2,700	9,100	8,800	6,600	2,100	29,200	Includes off-ocean sites at Ko Olina, with resident use valued at 20% of development potential, other projects as shown in Appendix 3.
Waianae	940	630	230	0	0	1,800	Includes units by DHHL; Village Pokai Bay; Sea Country; self-help; maximum affordable condition at Makaha Valley; others.
North Shore, Ko'olauloa & Ko'olaupoko	400	320	290	0	0	1,020	Includes DHHL units in Waimanalo. Excludes resort units but includes maximum affordable condition at Turtle Bay Resort under existing Unilateral Agreement.
East Honolulu	0	300	200	0	0	500	Represents two controversial projects: Hale Alii plus potential for some 200 units at Kamilonui (Urban but currently under lease.)
Primary Urban Center	1,110	2,230	2,000	2,200	2,400	9,940	Majority high rise; inventories discounted for estimated share nonresident units (generally 20% in Kaka'ako and 60%-80% at Waikiki projects); also includes military family homes on Ford Island and on-going allowance of 2,000+ units per 5-year period after 2015 for unforeseen future redevelopment projects.
Total (rounded)	**5,000**	**16,000**	**15,000**	**10,000**	**5,000**	**51,000**	**Subtotal and total columns rounded to thousands.**
Percent of period	**10%**	**31%**	**29%**	**20%**	**10%**	**100%**	

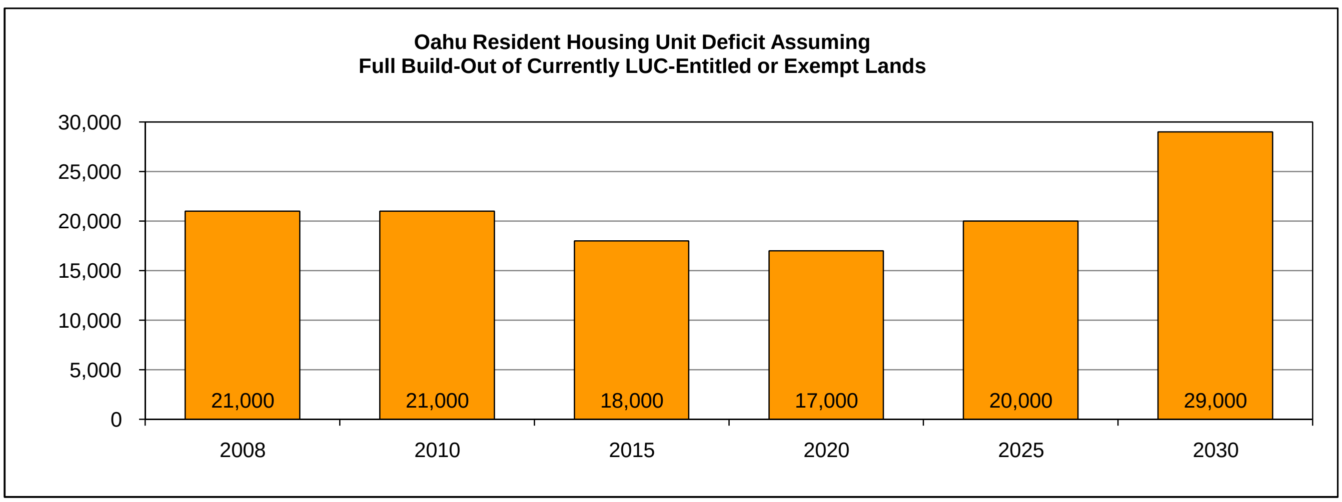
SLUC - State Land Use Commission; DHHL - State of Hawaii, Department of Hawaiian Home Lands.

Note: Targeting projects of 100 units or more. Excludes emergency shelters, dormitory beds and other group living quarters.

Sources: Appendices 2 & 3; interviews with developers, landowners and project principals; City and County of Honolulu, Department of Planning and Permitting, "Annual Report on the Status of Land Use on Oahu: Fiscal Year 2004," July 2005; interviews with developers and landowners; Neighborhood Board Meeting Minutes; Honolulu Advertiser, "Special Report on Homeless on the Wai`anae Coast," October 20, 2006; Ibid, other; Star Bulletin; Pacific Business News.

Exhibit 3-6
Projected Supply and Demand for Housing - Island of Oahu
Projects with State Land Use Entitlement or Exemption, as of July 2008

	Reference	2008	2010	2015	2020	2025	2030	Total/ average, 2008-2030 rounded
Demand (households):								
Number	SMS[1]	307,800	312,600	324,800	337,500	350,700	364,400	--
Change since prior date -								
Total (rounded)		--	5,000	12,000	13,000	13,000	14,000	57,000
Average annual		--	2,500	2,400	2,600	2,600	2,800	2,600
Supply (resident housing units):								
Estimated occupied RHUs in 2006[2]	U.S. Census	284,000						
New homes delivered, 2006-08[3]	Harris	3,000						
Entitled new developments, 2008-2030:								
Development since prior date	Exhibit 3-5	--	5,000	16,000	15,000	10,000	5,000	51,000
Less vacancy allowance (applied to new units)	5%	--	-250	-800	-750	-500	-250	(2,550)
Net available RHUs (rounded)		287,000	292,000	307,000	321,000	331,000	336,000	48,000
Change since prior date -								
Average annual		--	146,000	61,400	64,200	66,200	67,200	2,200
Resident housing unit surplus (deficit):								
At prior date shown		INA	(21,000)	(21,000)	(18,000)	(17,000)	(20,000)	
Net surplus (deficit) in RHU production since prior date		INA	0	3,000	1,000	(3,000)	(9,000)	
By end of year, column date		(21,000)	(21,000)	(18,000)	(17,000)	(20,000)	(29,000)	



INA = Information not available.

1 Projections derived from SMS, Inc., "Housing Policy Study, 2006: Hawaii Housing Model 2006," February 2007. Population growth rate set to 0.7% rather than "official parameter" for Honolulu County of 0.9% per annum, in order to more closely approach State DBEDT 2008 population projection (see Exhibit 2-2.)

2 RHU = resident housing unit. Occupied housing units estimated by U.S. Census Bureau, 2006 American Community Survey (ACS, released September 2007) at 299,217. From this total, 5% are conservatively estimated to be used as second homes, vacation homes or for other nonresident uses. Note that a 2003 SMS study prepared for the State and Counties projected nonresident housing units on Oahu at 7.5% for 2006, while the ACS estimates that 40% of the 10.1% of units found to be vacant were held for seasonal, recreational or occasional use.

3 Developer ("new") unit sales from mid-2006 to mid-2008, since the Census survey of supply refers to an "average" figure for 2006. Based on quarterly surveys of developer sales closings as provided by The Harris Company, with 2Q 2008 closings estimated at same level as 1Q 2008. Also considers 326-unit Kau'e'a development in Kapolei by DHHL, which was occupied in early 2008.

Exhibit 4-1
Comparison Project Price Indicators
Selected Comparison Projects on Oahu

	Developer	Location	Units per acre	Recent sales prices, rounded	Comments
High-density MF:					***Subject is planned at 30-50 units/acre***
The Colony at the Peninsula	Stanford Carr Development	Hawaii Kai	34	$450,000 to $750,000[1]	4 stories over parking
Kapolei Village 6	Castle & Cooke Homes Hawaii	Kapolei	37	$291,000 to $323,000[2]	Restricted to 120% AMI and below; stacked flats
Low- and medium-density MF:					***Subject is planned at 10-20 units/acre***
Kai Nani	D.R. Horton, Inc. - Schuler Division	Makakilo	13	$340,000 to $525,000[1]	
Nohona	Castle & Cooke Homes Hawaii	Mililani	15	$344,000 to $425,000[2]	Entry market TH
Island Courtyards	Castle & Cooke Homes Hawaii	Mililani	20	$183,000 to $356,000[2]	Some designated affordable; stacked flats
Hampton Court	Castle & Cooke Homes Hawaii	Mililani	21	$454,000 - $480,000[1]	
Nanea Kai	D.R. Horton, Inc. - Schuler Division	Hawaii Kai	21	$545,000 to $600,000[1]	
Single-family:					***Subject is planned at 6 units/acre***
American Classics	Castle & Cooke Homes Hawaii	Mililani	5	$784,000 to $877,000[2]	Upper market SF; average lot 6,500 s.f.
Waipio Point	Castle & Cooke Homes Hawaii	Waipahu	5	$573,000 to $638,000[2]	Average lot 6,400 s.f.
Island Classics	Castle & Cooke Homes Hawaii	Mililani	6 to 8	$635,000 to $700,000[2]	MF-118; average lot 5,000 s.f.
Destiny	Castle & Cooke Homes Hawaii	Mililani	9	$575,000 to $640,000[1]	Average lot 4,000 s.f.

INA - information not available; TH - townhome; SF - Single-family; AMI - area median income; s.f. - square feet

[1] Based on unit sales recorded between January 1 and August 7, 2008, as provided by MLS Hawaii, Inc.
[2] Base sales price, as provided by Castle & Cooke Homes Hawaii, Inc., May 2008.

Sources: MLS Hawaii, Inc. database, August 2008; Castle & Cooke Homes Hawaii, Inc., May 2008; D.R. Horton, Inc. - Schuler Division, January 2007.

Exhibit 5-1
Existing Retail Inventory and Market Indicators in Central Oahu and Benchmark Market

Gross leasable area, in square feet, mid-year 2008

	Central Oahu DPA	Benchmark - Hawaii Kai	Oahu
Existing inventory:			
Waipahu	1,986,000		1,986,000
Mililani[1]	954,000		954,000
Hawaii Kai		857,000	857,000
Other Oahu			7,363,000
Total, rounded	**2,940,000**	**857,000**	**11,160,000**
Vacancy indicators:[2]	1.2% "Central Oahu" (mostly Mililani) and "Leeward"	0.8% "East Oahu"	3.4% 2Q 2008
Prominent properties (gross leasable square feet):	Waikele Center/Waikele Premium Outlets (786,300)	Koko Marina Shopping Center (322,300)	Ala Moana Center (2,100,000)
	Town Center of Mililani (434,000 excluding offices)	Hawaii Kai Towne Center (247,000)	Pearlridge Center (1,260,200)

[1] Excludes 109,000 square feet of office spaces, which are shown on the office schedule (Exhibit 6-1.)

[2] Area vacancies based on CMF surveys of representative centers within areas as defined by CMF. These vary somewhat from the DPA, and are described above.

Sources: Castle & Cooke Homes Hawaii, Inc., 2008; Colliers Monroe Friedlander, Inc. 2008, "Retail Market Report: Oahu Mid-Year 2008," released July 24, 2008; Ibid, 2008, "Retail Market Report: Oahu Year-End 2007," released January 2008; Pacific Business News, "Book of Lists: 2008," 2007; internet searches.

Exhibit 5-2
Planned and Entitled Retail Areas
in Central Oahu

Square feet of gross leasable area

Location	Estimated total[1]	Potential timing of deliveries			
		2008-2010	2011-2020	2021-2030	Total, 2008-2030
Mililani Mauka	118,000	48,000	70,000	0	**118,000**
Waiawa Ridge Increment 1	900,000	0	600,000	300,000	**900,000**
Waipahu	34,000	34,000	0	0	**34,000**
Total, rounded	**1,050,000**	**80,000**	**670,000**	**300,000**	**1,050,000**

[1] See Appendix 3 for detailed listings. Based on State-entitled lands with development proposals in place; plans available as of July 2008.

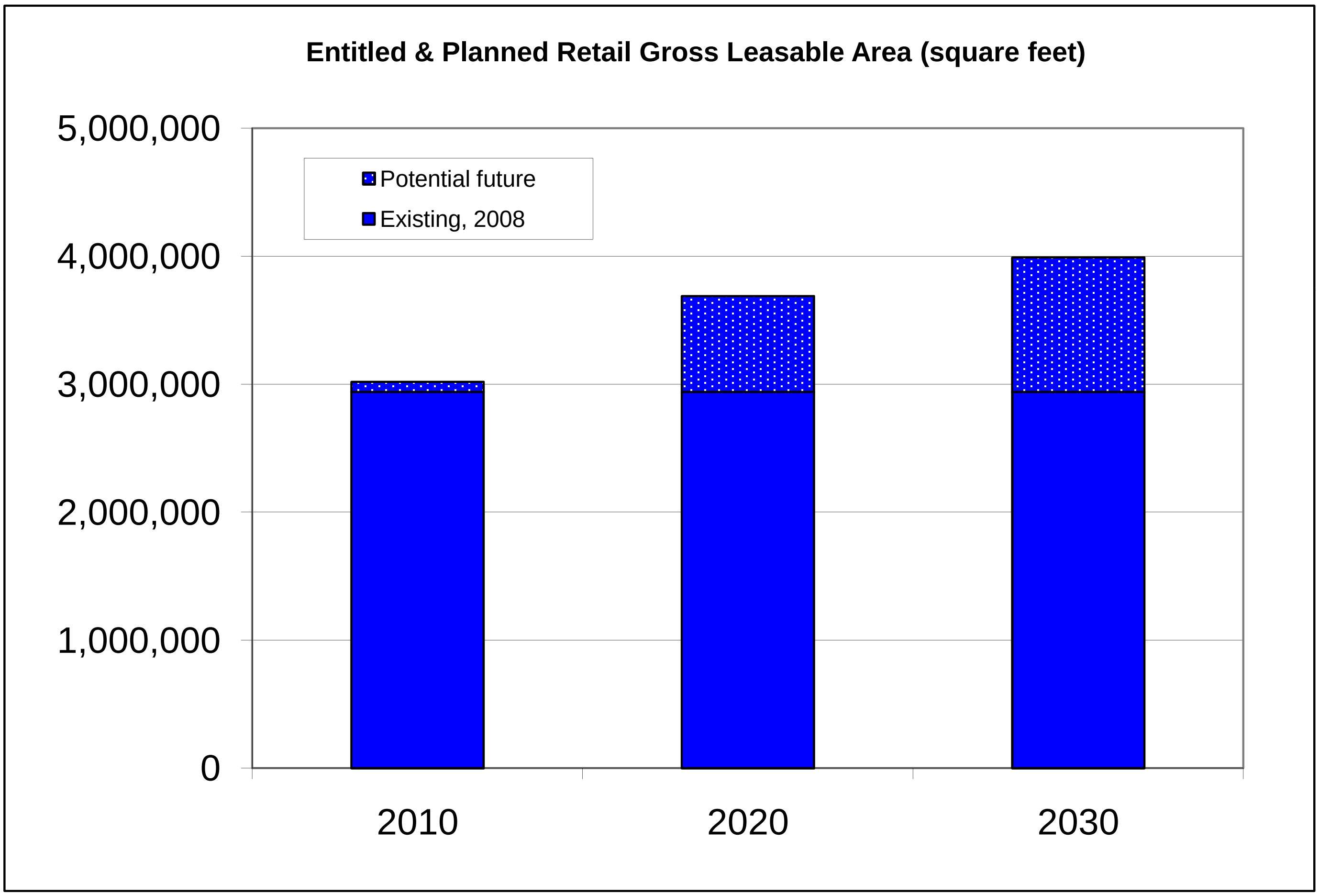
Note: Areas are net of those expected to primarily serve visitors, and of planned exclusive office or business park uses (may include some office uses mixed with retail in shopping-center type settings.) A typical 10% of large areas that are still in conceptual planning phase are presumed to be office development, and those areas are reflected on schedules in Chapter 6.

Sources: Interviews with developers, landowners and brokers; area site visits; Pacific Business News, "Book of Lists 2008," 2007; Pacific Business News (weekly); Colliers Monroe Friedlander; developer websites; Honolulu Advertiser; Hawaii Community Development Authority; Internet searches.

Exhibit 5-3
Potential Future Retail Areas in Central Oahu

Existing and Planned/Entitled Developments as of July 2008

	Existing, 2008	Potential future		
		2010	2020	2030
Cumulative square feet	2,940,000	3,020,000	3,690,000	3,990,000



Source: Mikiko Corporation, based on Exhibits 5-1 and 5-2.

Exhibit 5-4
Area Resident Profiles
2008 estimates and 2013 projections

	Central Oahu DPA	Benchmark - Hawaii Kai
Resident population:		
2008 estimated	164,580	29,238
2013 projected	173,022	30,255
Compound annual % increase	1.0%	0.7%
Income (2008):		
Median per household	$74,410	$95,334
Est. per capita	$26,409	$40,570

Note: DPAs (Development Plan Areas) are those defined by the City and County of Honolulu, but approximated for data generation purposes by zip code area. See Chapter 2 for further information. INA = Information not available.

Sources: Exhibits 2-4 and 2-8; Claritas Inc., July 2, 2008.

Exhibit 5-5
Daytime Population and Employment Residence Ratios by Census Designated Places
2000

	Residents, 2000	Employment residence ratio[1]	Daytime population[2]	Daytime pop/ residents
Central Oahu area CDPs -				
Mililani Town CDP	28,608	0.27	17,394	0.61
Schofield Barracks CDP	14,228	1.68	19,703	1.38
Wahiawa CDP	16,151	0.80	14,872	0.92
Village Park CDP	9,625	0.16	5,484	0.57
Waipahu CDP	33,108	0.55	27,397	0.83
Waipio CDP	11,672	0.37	7,547	0.65
Waipio Acres CDP	5,298	0.08	2,981	0.56
Total/weighted av.	118,690	0.58	95,378	0.80
Benchmark markets:				
Hawaii Kai proxy[3]	INA	0.49	INA	0.74
Honolulu CDP[4]	371,657	1.54	462,962	1.25

INA = Information not available.

Note: All ratios shown are within the respective CDP. Ratios would be higher if reported on a regional basis.

1 Number of workers working in the CDP divided by number of workers living in the CDP.

2 Residents plus in-commuters less out-commuters.

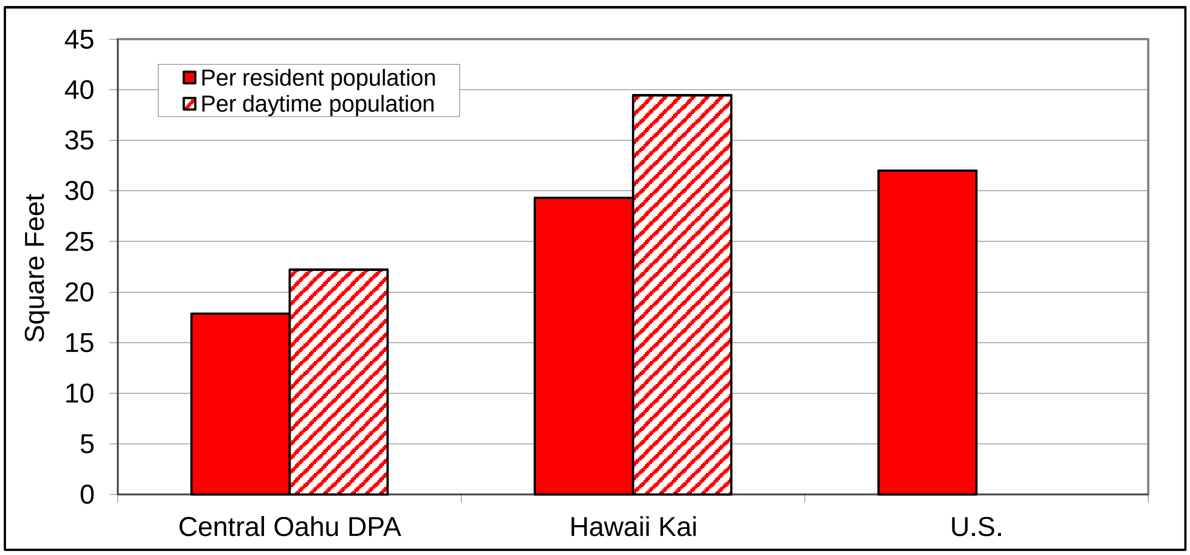
3 The 2000 Census included Hawaii Kai within the Honolulu CDP, so Kailua CDP used as a proxy for Hawaii Kai ratios; actual population figures not relevant.

4 Includes PUC and East Honolulu, encompassing Waikiki, Aina Haina, Hawaii Kai. The Census' daytime population calculations in this case do not consider visitors.

Source: US Census Bureau, Census 2000, PHC-T-40, "Estimated Daytime Population and Employment-Residence Ratios: 2000" Journey to Work and Migration Statistics Branch, 2005.

Exhibit 5-6
Existing Retail Areas in Relation to Consumer Population
As of 2008, except where noted

	Central Oahu DPA	Benchmark markets: Hawaii Kai	Benchmark markets: 2004 US average[1]
Estimated consumers:			
Resident population[2]	164,580	29,238	INA
Daytime ratio[3]	*0.80*	*0.74*	INA
Daytime population	132,300	21,728	INA
Existing retail GLA[4]	2,940,000	857,000	INA
Existing GLA ratios:			
Per resident population	18	29	32
Per daytime population	22	39	INA



Note: DPAs (Development Plan Areas) are those defined by the City and County of Honolulu, but approximated for data generation purposes by zip code area. See Chapter 2 for further information.

INA - Information not available.

1 Based on shopping center per resident ratio of 20.3, as reported by National Research Bureau; figure adjusted by the estimated 37% U.S. retail space not located in shopping centers, as reported by the same source.

2 Trade Area populations as shown in Exhibit 2-4.

3 2000 ratios, as shown in Exhibit 5-4

4 As shown in Exhibit 5-1.

Sources: Claritas Inc., 2008; Colliers Monroe Friedlander, Inc., "Retail Market Report: Oahu Mid-Yer 2008," released July 24, 2008; State of Hawaii, Department of Business Economic Development and Tourism; National Research Bureau, Inc., "2004 NRB Shopping Center Census," 2005; Niemira, Michael P., "The U.S. Retail Space Market," Research Review, V.12, No. 2, 2005.

Exhibit 5-7
Projected Supportable Additional Retail-Based Commercial Areas in the Central Oahu DPA, Based on Resident Population Ratios
Gross leasable square feet, 2008 to 2030

	Basis/reference	Estimated 2008	Projected 2020	Projected 2030	Av. annual change, 2008-2030
Immediate market (Central Oahu DPA)					
Resident population	Exhibit 2-4	164,580	179,830	195,620	0.8%
Supportable GLA in Central Oahu	29 sf/person[1]	4,800,000	5,200,000	5,700,000	0.8%
Less existing & planned GLA	Exhibit 5-3	2,940,000	3,700,000	4,000,000	1.4%
Subtotal, additional GLA in Central Oahu		1,860,000	1,500,000	1,700,000	-0.4%
Nearby markets (Ewa DPA)	Not considered	N/A	N/A	N/A	0.0%
Total additional market potential in Central Oahu DPA		**1,860,000**	**1,500,000**	**1,700,000**	

Notes: GLA - gross leasable area (in square feet). DPAs (Development Plan Areas) as defined by the City and County of Honolulu. The City's DPAs differ slightly from those approximated by zip code area, as shown elsewhere in this report. See Chapter 2 for further information. N/A = not applicable.

[1] Figures are net of assumed spending leakage to other districts. Reference within Hawaii Kai and average U.S. ratios as shown in Exhibit 5-6.

Exhibit 5-8
Projected Supportable Additional Retail-Based Commercial Areas in the Central Oahu DPA, Based on Daytime Population Ratios
Gross leasable square feet, 2008 to 2030

	Basis/reference	Estimated 2008	Projected 2020	Projected 2030	Av. annual change, 2008-2030
Immediate market (Central Oahu DPA):					
Resident population	Exhibit 2-4	164,580	179,830	195,620	0.8%
Daytime population -					
Ratio to resident pop	0.80 in 2000[1]	0.81	0.82	0.85	0.2%
Projected persons		133,310	147,461	166,277	1.0%
Supportable GLA in Central Oahu	35 sf/person[2]	4,700,000	5,200,000	5,800,000	1.0%
Less existing & planned	Exhibit 5-3	3,000,000	3,700,000	4,000,000	1.3%
Subtotal, additional GLA in Central Oahu		1,700,000	1,500,000	1,800,000	-1.0%
Nearby markets (Ewa DPA)	Not considered	N/A	N/A	N/A	0.0%
Total additional market potential in Central Oahu DPA		**1,700,000**	**1,500,000**	**1,800,000**	

Notes: GLA - gross leasable area (in square feet). DPAs (Development Plan Areas) as defined by the City and County of Honolulu. The City's DPAs differ slightly from those approximated by zip code area, as shown elsewhere in this report. See Chapter 2 for further information. N/A = not applicable.

[1] Based on figures for Census Defined Places, not regions, in 2000, as shown in Exhibit 5-6. Hence these benchmarks are considered below daytime ratios that would be effective for the larger regions considered here.

[2] Reference within Hawaii Kai ratio, shown in Exhibit 5-6.

Exhibit 6-1
Existing Office Space in Central Oahu, Ewa and Benchmarks
Rentable building area, in square feet, mid-year, 2008

	Central Oahu DPA	Ewa DPA	Total	Benchmark markets: Island of Oahu	Benchmark markets: Urban Honolulu[1]
Existing inventory:					
Kapolei		422,000	422,000	422,000	
Ewa Beach		14,000	14,000	14,000	
Waipahu	85,000		85,000	85,000	
Mililani	109,000		109,000	109,000	
Central Business District				8,064,000	8,064,000
Kaka'ako/Kapiolani/ King				3,367,000	3,367,000
Other Oahu				3,645,000	
Total, rounded	**194,000**	**436,000**	**630,000**	**15,706,000**	**11,431,000**
Vacancy indicators	INA	INA	2.9% "Leeward Oahu"	8.1%	9.7% and 6.2% CBD and Kaka'ako/ Kapiolani/King
Prominent properties/areas (Rentable building area)	Lee Towne Center (52,557)	Bank of Hawaii Building (208,406)	Bank of Hawaii Building (208,406)	Central Business District (8.1 million)	101 buildings, including Chinatown & Capitol district
	Castle & Cooke Building (34,241)	Campbell Square (136,868)	Campbell Square (136,868)	Kaka'ako/ Kapiolani/King (3.4 million)	

Notes: Excludes government-owned buildings and exclusively owner-occupied buildings. INA - information not available.

[1] Includes the Central Business District, Kapiolani and King Streets and Kaka'ako District, as defined by CMF. Excludes the Waikiki and the Airport/Mapunapuna districts, which are captured in "Other Oahu."

Sources: Colliers Monroe Friedlander, Inc., "Office Market Report: Honolulu Mid-Year 2008," 2008; Ibid, personal communicationss, 2008; Castle & Cooke Homes Hawaii, Inc., 2008; internet searches.

Exhibit 6-2
Planned and Entitled Office Developments in Central Oahu and Ewa
Square feet of rentable building area, 2008 to 2030

	Potential new development[1]				
Location	**Total**	**July 2008-2010**	**2011-2020**	**2021-2030**	**Comments**
Central Oahu DPA:					
Waikele	17,500	17,500	0	0	Tenant improvements under way as of August 2008.
Waiawa Ridge Increment 1	100,000	0	50,000	50,000	Based on estimated 10% of total proposed commercial areas; see Exhibit 5-2.
Subtotal, rounded	**120,000**	**20,000**	**50,000**	**50,000**	
Ewa DPA:					
Kapolei and East Kapolei	1,110,000	100,000	760,000	250,000	Stand-alone and MUD buildings.
Makaiwa	30,000	0	30,000	0	Much in mixed-use development.
Kalaeloa	725,000	0	100,000	300,000	Long-term development, assumed to extend beyond 2030 and to include government offices.
Subtotal, rounded	**1,870,000**	**100,000**	**890,000**	**550,000**	
Total, rounded	**1,990,000**	**120,000**	**940,000**	**600,000**	

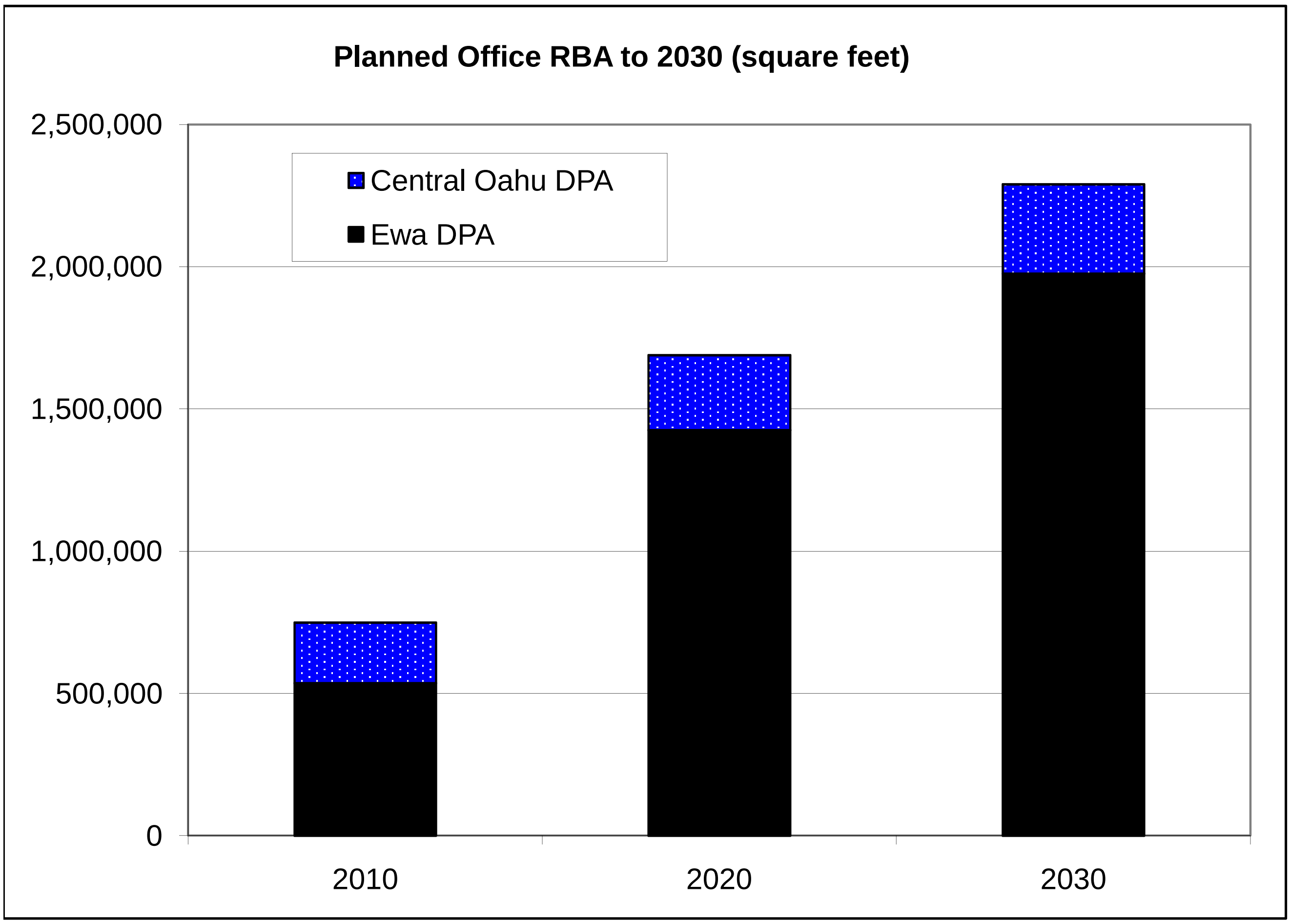
1 Excludes buildings intended exclusively or primarily for government agencies. See Appendix 5 for detailed listings. Based on State LUC-entitled lands and plans known as of July 2008 Some proposed projects assumed to occur beyond the projection period, if at all.

Sources: Interviews with developers, landowners and brokers; area site visits; Pacific Business News, 2007, "Book of Lists 2008"; Pacific Business News (weekly); Colliers Monroe Friedlander Inc., 2006; developer websites; Honolulu Advertiser; internet searches.

Exhibit 6-3
Potential Future Office Areas in Central Oahu and Ewa

Existing and Planned/Entitled Developments as of 2008

	Existing,	Potential future		
	2008	**2010**	**2020**	**2030**
Central Oahu DPA	194,000	214,000	264,000	314,000
Ewa DPA	436,000	536,000	1,426,000	1,976,000
Total	630,000	750,000	1,690,000	2,290,000

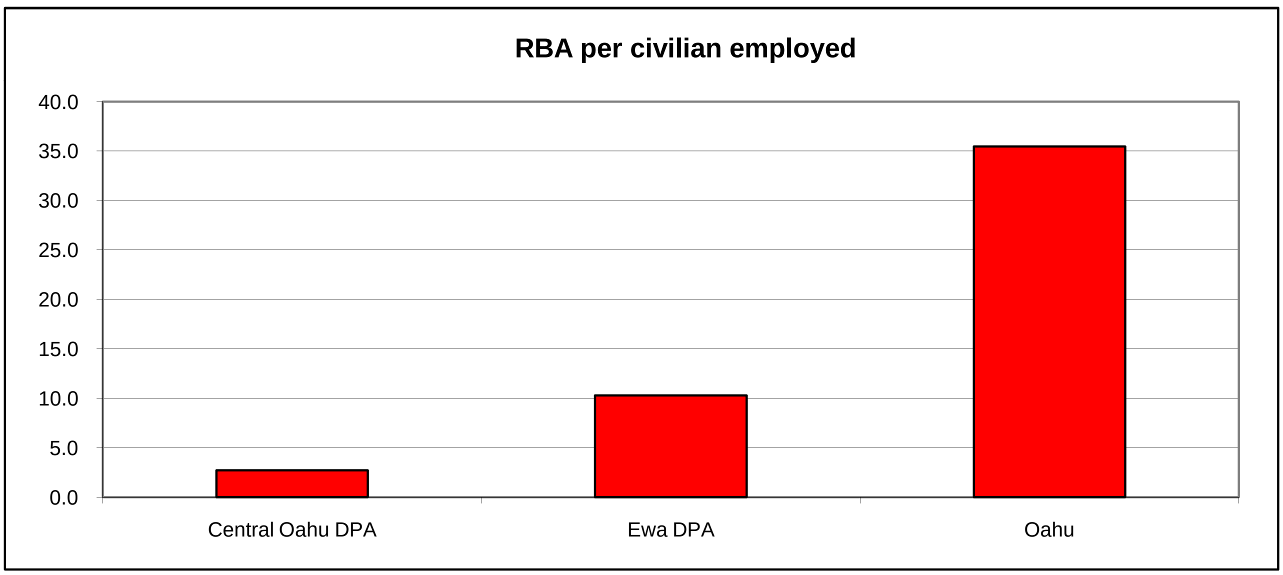


Note: Excludes government-owned buildings. RBA - rentable building area, in square feet.

Source: Mikiko Corporation, based on Exhibits 6-1 and 6-2.

Exhibit 6-4
Existing Office RBA in Relation to Employment
As of 2008, except where noted

				Benchmark markets	
	Central Oahu DPA	**Ewa DPA**	**Total**	**Island of Oahu**	**Urban Honolulu[1]**
Estimated consumers:					
Resident population[2]	164,580	89,500	254,080	918,200	43,000
% civilian employed	43%	47%	45%	48%	44%
Civilian employed persons[3]	71,500	42,400	113,900	442,900	18,800
Existing office RBA[4]	194,000	436,000	630,000	15,706,000	11,431,000
Existing RBA ratio:					
Per civilian resident employee	3	10	6	35	608



Note: INA - Information not available; RBA - Rentable building area, in square feet.

[1] RBA based on the Central Business District, Kapiolani and King Streets and Kaka'ako District, as defined by CMF. Associated population and employment data are for zip codes 96813 and 96814, as provided by Claritas, August 2008.

[2] As shown in Exhibit 2-4, using Mikiko estimate for Ewa, as shown. See footnote 1 re Honolulu.

[3] Indicates civilians resident in the area who are employed, but not necessarily in the area. 2008 estimates for Ewa and Central Oahu provided by Claritas, Inc., 2008; Island figure derived from DLIR estimate of civilian employed persons, as of June 2008, as shown in Exhibit 2-9. See footnote 1 re Honolulu.

[4] As shown in Exhibit 6-1.

Sources: Claritas Inc., 2008; prior exhibits as cited.

Exhibit 6-5
Projected Supportable Additional Office-Based Commercial Areas in the Central Oahu DPA

Private sector rentable building area, in square feet, 2010 to 2030

	Basis/reference	2010	2020	2030	Av. annual change, 2010-2030
Ewa and Central Oahu region:					
Resident population (Ewa and Central Oahu DPAs)	Exhibit 2-4[1]	260,850	330,830	371,320	1.8%
Number of civilian employees	45% of population	117,400	148,900	167,100	1.8%
Supportable RBA/employee[2]	In Ewa and Central Oahu	10	15	20	3.5%
Supportable RBA	In Ewa and Central Oahu	1,174,000	2,233,500	3,342,000	5.4%
Less existing & planned in Ewa and Central Oahu	Exhibit 6-3	750,000	1,690,000	2,290,000	5.7%
Supportable additional RBA in region, rounded[3]		420,000	540,000	1,050,000	4.7%
Central Oahu DPA conclusion:					
Share captured in Central Oahu DPA	Share of region	45%	45%	45%	0.0%
Total additional market potential in Central Oahu (cumulative)		**190,000**	**240,000**	**470,000**	**4.6%**

Notes: Does not consider needs of government agencies, nor demand that could originate from employment provided to residents beyond the two DPAs evaluated.

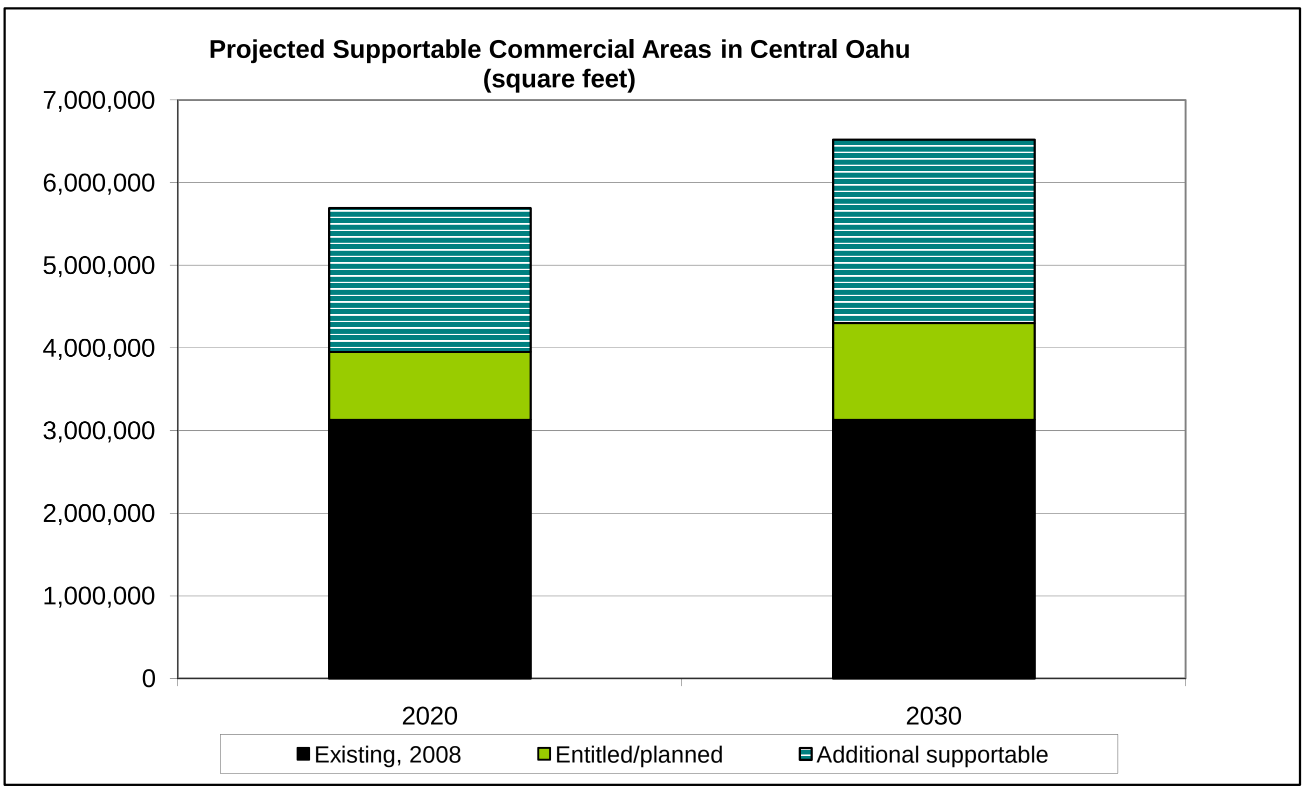
[1] Ewa DPA as assessed by Mikiko Corporation; others as projected by City & County of Honolulu, Department of Planning & Permitting, 2006.

[2] Expected to approach Oahu ratio shown in Exhibit 6-4.

[3] As supported by Ewa and Central Oahu populations; other areas could also contribute to demand.

Exhibit 7-1
Central Oahu DPA Commercial Market Summary
Retail and office uses, cumulative square feet, 2020 and 2030

	Basis/reference	2020	2030
Completed as of July 2008:			
Retail	*Exhibit 5-1*	2,940,000	2,940,000
Office	*Exhibit 6-1*	194,000	194,000
Subtotal		3,134,000	3,134,000
Entitled and planned:			
Retail	*Exhibit 5-2; includes some office*	750,000	1,050,000
Office	*Exhibit 6-2; other areas included above in retail*	70,000	120,000
Subtotal		820,000	1,170,000
Net additional supportable	*Exhibits 5-9 & 6-5*	**1,740,000**	**2,220,000**
Projected future supportable, rounded		**5,700,000**	**6,500,000**



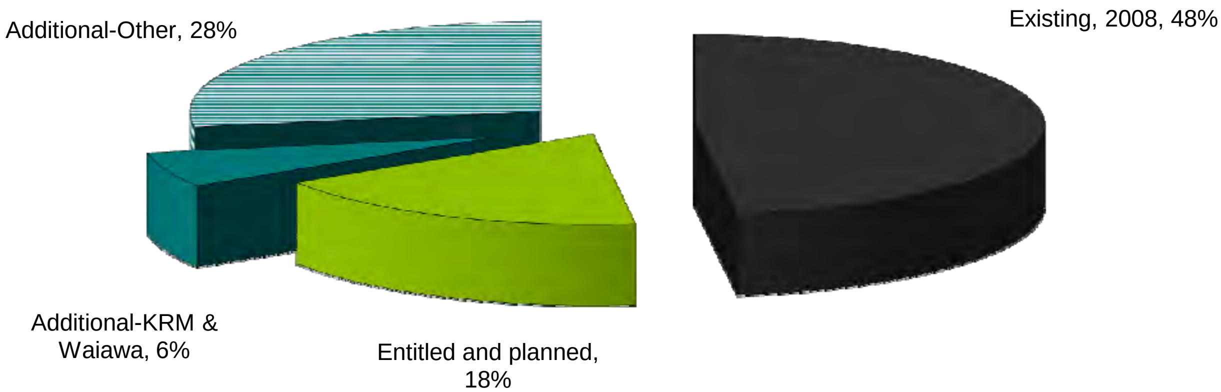
Source: Mikiko Corporation, 2008.

Exhibit 7-2
Commercial Market Assessment for Koa Ridge Makai and Waiawa

Retail and office uses, in square feet, 2020

	Basis/reference		2020	2030
Potential development phasing:	*Proposal*			
Waiawa	*30,000*	*maximum*	30,000	30,000
Koa Ridge Makai	*380,000*	*maximum*	300,000	380,000
Total	*410,000*	*maximum*	**330,000**	**410,000**
Market share of total supportable in Central Oahu DPA:				
Waiawa			1%	0%
Koa Ridge Makai			5%	6%
Total			**6%**	**6%**
Market share of net additional supportable in Central Oahu DPA:				
Waiawa			2%	1%
Koa Ridge Makai			17%	17%
Total			**19%**	**18%**
Summary of projections for Central Oahu DPA:	*Exhibit 7-1*			
Existing, 2008			3,134,000	3,134,000
Entitled and planned			820,000	1,170,000
Net additional supportable			1,740,000	2,220,000
Total, rounded			**5,700,000**	**6,500,000**

Potential Central Oahu DPA Commercial Space Inventory: 2030



Source: Mikiko Corporation, 2008

Exhibit 8-1
Developed Business Park/Industrial Lands in Central Oahu, Ewa and Island-wide
In acres, as of July 2008

	Central Oahu DPA	Ewa DPA	Island of Oahu[1]
Existing inventory, gross acres:			
Kapolei		1,600	
Waipahu	121		
Mililani	43		
Waipio	122		
Wahiawa	4		
Total, rounded	**290**	**1,600**	**INA**
Existing inventory, net acres[2]	**220**	**1,200**	**INA**
Vacancy indicators[3]	3.2% Waipahu, Mill Town Business Center	6.6% Campbell Industrial Park, Kapolei Business Park, Kapolei Harborside	4.0% Island of Oahu average
	15.5% Gentry Business Park		Up from 3% at year-end 2007
Weighted average net asking rent psf (developed space, per month)[2]	\$1.32-Waipahu/ Milltown \$1.36 - Gentry	\$1.20 - Campbell Industrial/Kapolei Business Park	\$1.26

Notes: Based on lands in use or sold as shown in Appendix 6. Net of government-owned and operated facilities such as military bases, harbors, airports and universities.

INA - Information not available.

1 Data not available in land acres. CMF survey covers 36.97 million square feet in 1,713 buildings but exclude approximately 2.88 million square feet in Kaka'ako.

2 Estimated as 75% of gross acres, after allowance for roads, easements, infrastructure, etc. Oahu figure not available in acres, but supply estimated at 39.8 million square feet of warehouse/industrial building floor area.

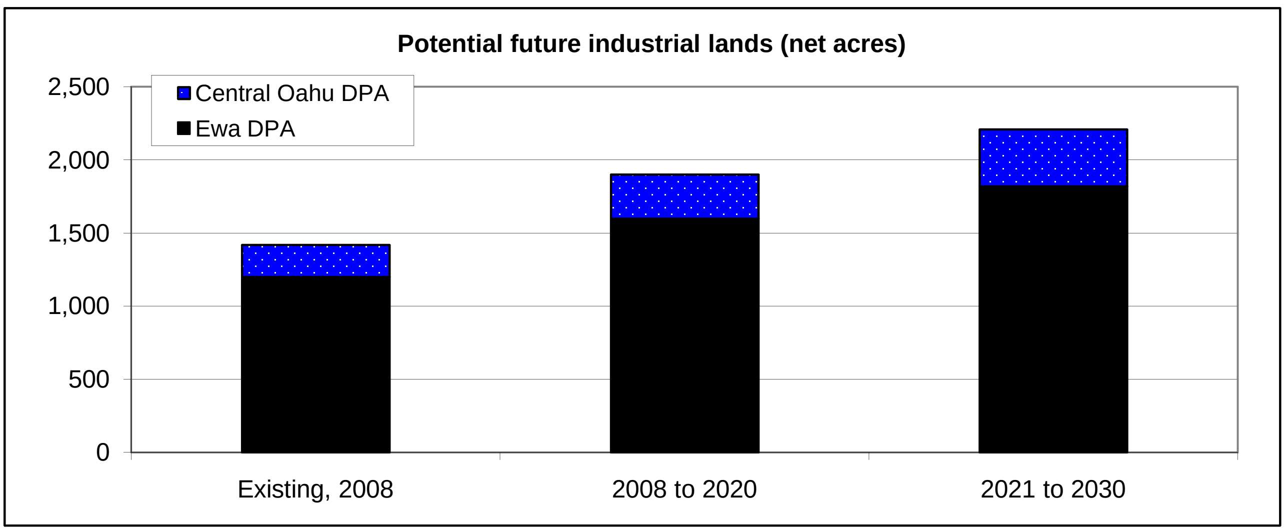
3 Based on spaces in I-1 and I-2 zoned lands. Excludes IMX-zoned lands, which can also permit retail development, as well as Kaka`ako, where vacancies could be higher than this average.

Sources: Appendix 6; Colliers Monroe Friedlander, Inc. 2008, "Industrial Market Report: Honolulu Mid-Year 2008," 2008.

Exhibit 8-2
Planned and Entitled Business Park/Industrial Lands in Central Oahu and Ewa DPAs

Net acres; plans known as of July 2008

Location	Existing, 2008	Potential new development[1] 2008 to 2020	2021 to 2030	Total	Areas
Entitled potential supply (net acres since prior date):					
Central Oahu DPA		80	90	170	Mililani, Waiawa, Waipahu
Ewa DPA		400	220	620	Kapolei, Kalaeloa, Ewa Beach
Total, rounded		**480**	**310**	**790**	
Potential future supply (existing and planned, cumulative):					
Central Oahu DPA	220	300	390		
Ewa DPA	1,200	1,600	1,820		
Total, rounded	**1,420**	**1,900**	**2,210**		



Note: Net acres represent salable or leasable areas, after allowance for major roads and other infrastructure. Planned inventory excludes government-owned and operated facilities such as military bases, harbors, airports and universities.

[1] See Appendix 6 for detailed listings. Based on plans known as of July 2008. Some proposed projects assumed to occur beyond the projection period, if at all. Future use of the Kalaeloa lands, representing some 144 net acres of the proposed Ewa DPA inventory, is considered very preliminary but are included within the projection period to be conservative.

Sources: Interviews with project landowners, their consultants, planners, land managers, and brokers; Pacific Business News; company web sites; Enterprise Honolulu; Hawaii Community Development Authority, "Draft Kalaeloa Master Plan," 2005; Colliers Monroe Friedlander Inc., 2008.

Exhibit 8-3
Projected Business Park/Industrial Land Requirements -
Employment-Based Demand
Cumulative, Island of Oahu: 2020 and 2030

	Basis/notes	Benchmark - 2008	Projected 2020	Projected 2030	Average annual change, 2008-2030
Sources of demand:					
Resident population[1]	Exhibit 2-4	918,200	1,010,400	1,080,700	0.7%
Civilian employed persons[2]	48% of residents	442,900	487,400	521,300	0.7%
2008 market characteristics:[3]					
Building area (sq. ft.), 2008	Mid-year, 2008	**39,837,000**			
Occupied building area, 2008	4.0% vacancy	38,255,000			
Net additional demand:					
Required building area for balanced market	5.0% vacancy	40,170,000	45,530,000	**50,570,000**	1.1%
Ratio for balanced market[4]	Bldg. sq. ft. per employee	91	93	97	0.3%
Additional sq. ft. required to achieve balance	Cumulative, vs. 2008 existing	333,000	5,693,000	10,733,000	17.1%
Associated land area (cumulative net acres)	0.20 Floor Area Ratio (FAR)[5]	**38** [6]	653	**1,232**	
Planned and entitled supply (cumulative net acres):					Percent mix, 2030
Central Oahu & Ewa	Exhibit 8-2		480	790	87%
Other - Hawaiian Cement	CMF, RCL		29	29	3%
Other - Manana Lands	CMF, RCL		15	15	2%
Other - Tesoro	CMF, RCL		71	71	8%
Total, cumulative			595	905	100%
Net additional requirements (cumulative acres)			**58**	**327**	

Notes: Net of government-owned and operated facilities such as military bases, harbors, airports and universities. FAR - Floor area ratio.

1 State DBEDT long-term projections as cited in Exhibit 2-2.

2 2008 ratio is based on DLIR's civilian labor force estimate, as shown in Exhibit 2-9. Projections assume ratio remains stable.

3 Based on island-wide CMF data as shown on Exhibit 8-1. However, according to CMF, these figures exclude approximately 2.88 million square feet in Kaka`ako. Kaka'ako areas estimated at vacancies similar to average for island.

4 RCL reports 2004 ratios (not adjusted for vacancy) at 80 in Honolulu, 95 Metro Las Vegas, 111 Seattle, and 125 San Diego County. Oahu's industrial building area required ratio is expected to increase as the economy transitions.

5 According to data provided by CMF, 2006 industrial inventory in West Oahu, including Pearl City, Ewa, and Central Oahu, averaged 0.13 FAR over 1,980 acres (11.4 million sf). Industrial uses in more urban areas would show higher FARs.

6 Estimate of pent-up demand.

Sources: Colliers Monroe Friedlander, Inc. 2008, "Industrial Market Report: Honolulu Mid-Year 2008"; Robert Charles Lesser & Co., LLC, "Industrial Market Feasibility: 345-Acre Kapolei Harborside Center," January 31, 2006; State of Hawaii, Department of Labor & Industrial Relations, and Department of Business, Economic Development and Tourism, 2008.

Exhibit 8-4
Projected Business Park/Industrial Land Requirements - Transitioning Demand
Within Oahu: 2020 and 2030

	Occupied sq. ft.	Impacted area (sq. ft.)[1]	Loss over # years	Average annual replacement need (sq. ft.)	Duration Start	Duration End
Areas of displacement:						
Kapalama Military Reservation	1,230,000	1,230,000	4	308,000	2008	2011
Kaka'ako	2,770,000	2,770,000	13	213,000	2008	2020
Subtotal, in square feet	4,000,000	4,000,000		521,000		
Lease turnover:						
Oahu inventory (net of above), in square feet	34,290,000	343,000	On-going	343,000	On-going	

Total, replacement requirements (rounded):	Estimated total area impacted: Square feet	Estimated total area impacted: Acres[2]	Annual: Square feet	Annual: Acres[2]
Due to displacement -				
2008-2010	1,563,000	**70**	521,000	22
2011-2020	2,438,000	**102**	213,000	9
Due to turnover -				
2008-2010	1,029,000	**40**	343,000	14
2011-2020	3,430,000	**140**	343,000	14
2021-2030	3,430,000	**140**	343,000	14

Notes: Net of government-owned and operated facilities such as at military bases, harbors, airports and universities.

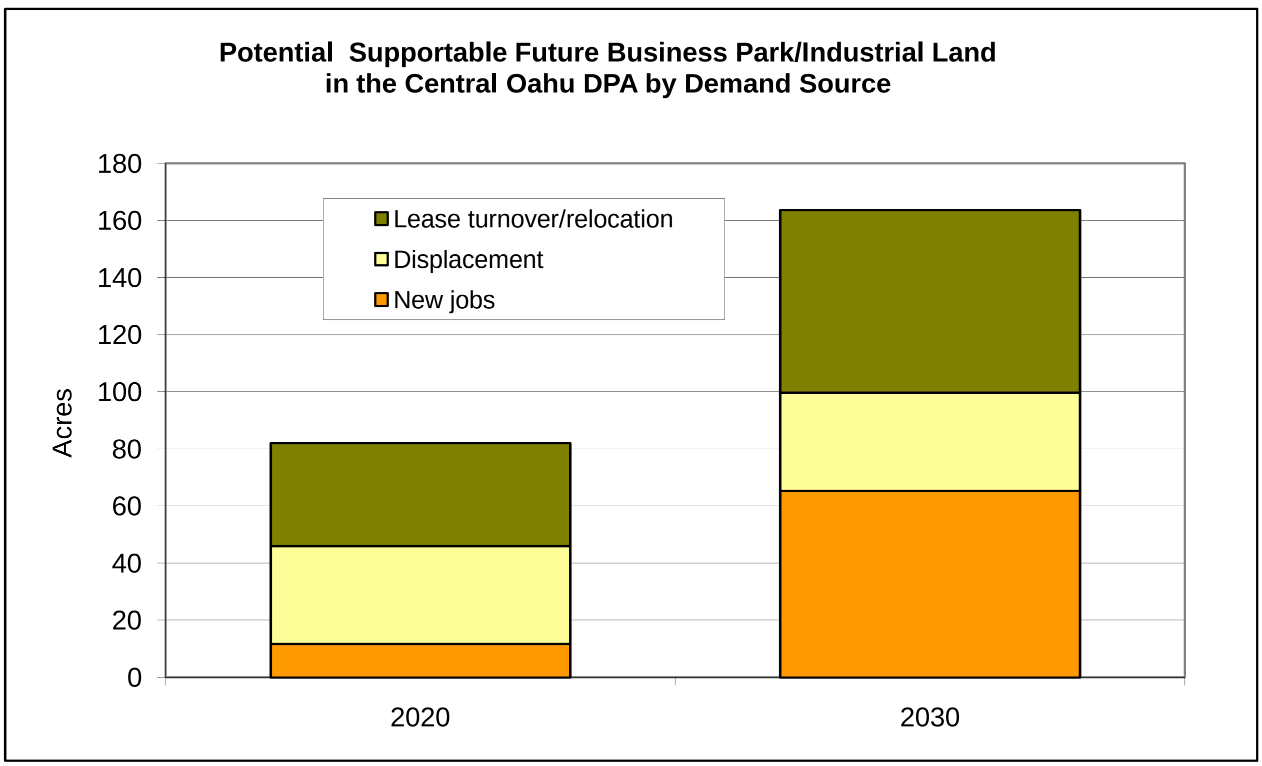
[1] Kapalama and Kaka'ako impacted areas based on occupied square feet. Oahu lease turnover assumes 5-year terms and 5% of those expiring seeking to move. Turnover estimate is conservative in that it does not account for an increasing Oahu inventory.

[2] Based on an average FAR of 0.55 which considers the higher than average existing densities of the areas to be relocated.

Sources: Colliers Monroe Friedlander, Inc., 2006, custom reports and subsequent discussions; Ibid, 2008, "Industrial Market Report: Honolulu Mid-Year 2008"; Robert Charles Lesser & Co., LLC, "Industrial Market Feasibility: 345-Acre Kapolei Harborside Center," January 31, 2006; internet research.

Exhibit 8-5
Business Park/Industrial Market Assessment for the Central Oahu DPA
Required additional land, cumulative acres, 2020 and 2030

	Basis/ reference	Potential Island-wide 2020	Potential Island-wide 2030	Central Oahu DPA Capture rate	Central Oahu DPA 2020	Central Oahu DPA 2030
Employment-driven demand	Exhibit 8-3	58	327	20%	12	65
Transition-driven demand:	Exhibit 8-4					
Due to displacement[1]	2008-2020	172	172	20%	34	34
Due to lease turnover[2]	2008-2030	180	320	20%	36	64
Subtotal		352	492		70	98
Total demand, rounded[3]		**410**	**820**		**80**	**160**



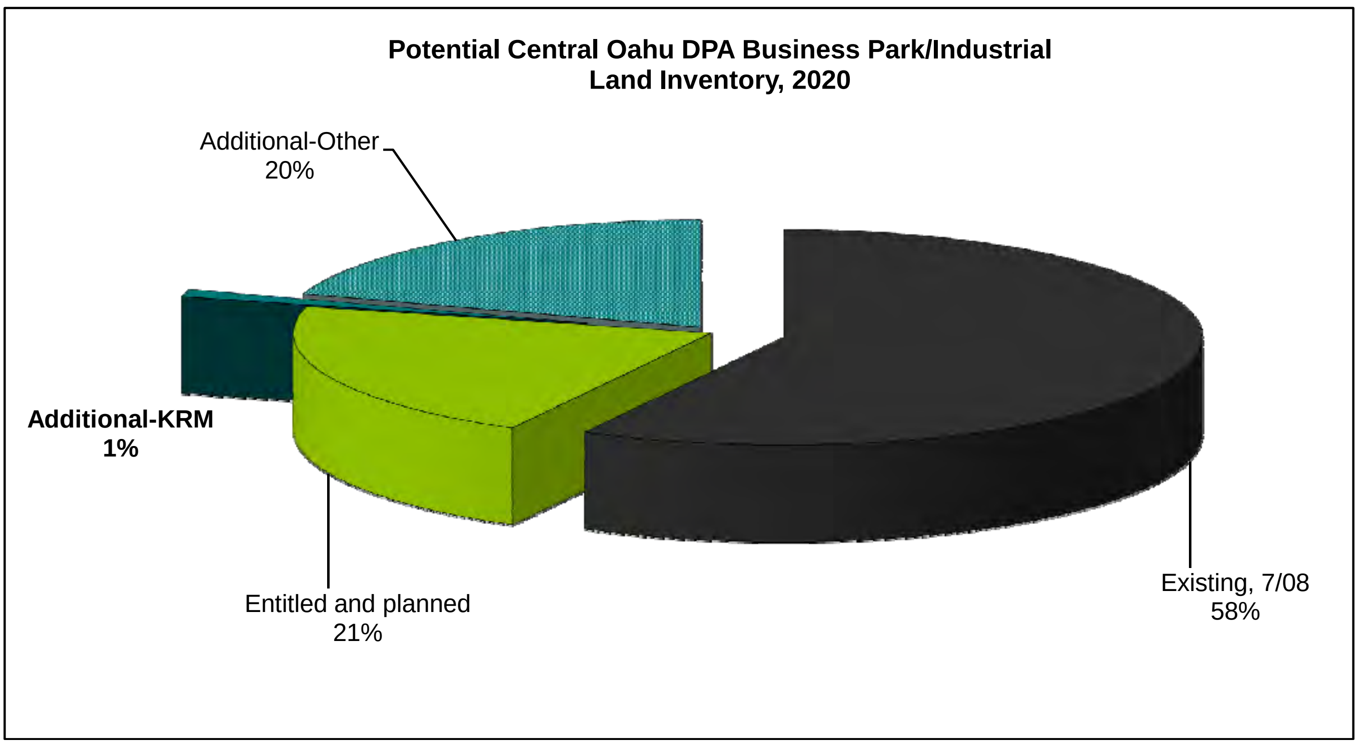
[1] Cumulative demand by 2020 based on 2008 to 2010 and 2011 to 2020 impacted areas, as shown in Exhibit 8-4.

[2] Cumulative demand by 2020 based on 2008 to 2010 and 2011 to 2020 impacted areas; demand by 2030 based on 2020 total plus 2021 to 2030 impacted areas, as shown in Exhibit 8-4. Turnover estimate considered conservative in that it does not account for an increasing Oahu inventory.

[3] Beyond those lands already State LUC entitled.

Exhibit 8-6
Business Park/Industrial Market Assessment for Koa Ridge Makai
Cumulative net acres

	Basis/reference	2020	2030
Projected supportable in Central Oahu DPA:			
Existing, mid-year 2008	Exhibit 8-1	220	220
Entitled and planned	Exhibit 8-2	80	170
Net additional supportable in Central Oahu	Exhibit 8-5	80	160
Total, rounded		380	550
Koa Ridge Makai market:			
Proposed net acres		4	4
Potential RBA	0.50 FAR	90,000	90,000
Share of total future Central Oahu DPA		1%	1%
Share of net additional Central Oahu RBA		5%	3%



Note: RBA - required building area; FAR - floor area ratio

Source: Mikiko Corporation, 2008.

MARKET ASSESSMENT FOR KOA RIDGE MAKAI AND WAIAWA

Appendices

Appendix 1: Report Conditions

This assessment is based on information provided by HHF, C&C, government agencies, developers, brokers, landowners, and other third party sources. While every attempt has been made to verify information via multiple sources, it is not always possible to do so. Mikiko has noted any data that appears inconsistent, but cannot guarantee the accuracy of all information upon which its assessments may be based.

Mikiko has no responsibility to update this report or any of the underlying data for events and circumstances occurring after July 30, 2008, the date of substantial completion of primary data collection.

This report is for the planning purposes of C&C, HHF and their consultants, as well as for public disclosure of the nature of the Project pursuant to seeking State and County land entitlements. It is not to be used for solicitation of investment or other third party purposes without prior written consent of the author.

This report does not offer an appraisal of the Subject, nor should it be construed as an opinion of value for the Project.

Appendix 2: Planned Residential Development Projects in the Central Oahu Development Plan Area

Projects with State Land Use Entitlement or Exemption, as of July 2008

		Number of units				
Project	Developer or Owner	Total	Delivered as of 7/08	Potential remaining	Estimated project timing/buildout	Residential product mix
Mililani Mauka	Castle & Cooke Homes Hawaii, Inc.	6,300	6,288	12	Projected sell-out by 2008	70% SF historically; c. 55% future
Waiawa Ridge Increment I (Phases 1 & 2)	Gentry Investment Properties	5,046	0	5,046	Unit sales estimated 2012-2022	Estimated 67% MF, 33% SF
Kau'olu Properties	GSF, Inc.	370	0	370	>2010	For-sale condos
Mokuola Vista	GSF, Inc.	70	0	70	Under construction, est. occupancy 2009	Family rentals, <60% MFY
Royal Kunia II	Horita (161 acres); Robinson Trusts (50 acres)	2,000	0	2,000	Indefinite	SF and MF 600 affordable
Plantation Town Apartments	Plantation Town Apartments LLC	330	170	160	Completed 2008; c. 170 contracts in place as of 7-08	Two 12-story towers
	Total, rounded	**14,100**	**6,500**	**7,700**		

Note - Excludes the Subject, Koa Ridge Makai and Waiawa (up to 5,000 units), which requires SLUC approval. Exhibit shows net remaining units to be developed at each master planned project, targeting those of 100+ units each. Figures shown based on stated owner or developer plans within entitlement restrictions, wherever information is available.

INA - Information not available; DP - on City Development Plan Map; SF - Single-family; MF - Multifamily; TH - Townhouse (multifamily); SLUC - State Land Use Commission; HCDCH - Housing & Community Development Corporation of Hawaii; DHHL - Department of Hawaiian Home Lands; DLNR - Department of Land & Natural Resources; MFY - median family income for City and County of Honolulu; DEIS - Draft Environmental Impact Statement.

Sources: Interviews with project principals, developers, planners and brokers, and City and State officials; Honolulu Advertiser; Honolulu Star Bulletin; Pacific Business News; Catholic Charities; project websites.

Appendix 3: Planned Residential Development Projects in the Ewa Development Plan Area

Projects with State Land Use Entitlement or Exemption, as of July 2008

Project	Developer or Owner	Number of units: Total	Number of units: Delivered as of 7/08	Number of units: Potential remaining	Estimated project timing/buildout	Residential product mix
Kapolei West	Aina Nui Corporation (Campbell Estate)	1,450	0	1,450	2010 - 2025	SF & TH
Makaiwa Hills I and II	Makaiwa Hills LLC (Campbell & Monarch Group)	4,100	0	4,100	2010 - 2025	Affordable to luxury
Palailai Mauka (also "Kapolei Mauka")	Aina Nui Corporation (Campbell Estate)	750	0	750	2012+	Undetermined
Kealakai & Nohona, Villages of Kapolei	Castle & Cooke Homes Hawaii, Inc.	404	13	391	2008 - 2012	Affordable for sale and rental units
Other, Villages of Kapolei	Castle & Cooke Homes Hawaii, Inc.	273	0	273	2008 - 2012	Affordable for sale and rental units
Wai Kalo'i, Makakilo	Castle & Cooke Homes Hawaii, Inc.	275	174	101	By 2009	SF detached, min. 5,000 s.f. lots
Ewa Villages	City and County of Honolulu	57	0	57	Indefinite	Vacant lots
Kahiwelo	D.R. Horton/Schuler Homes	472	40	432	2008 - 2015	SF homes
Mehana (prev. "Kapolei Makai")	D.R. Horton/Schuler Homes	1,150	0	1,150	2008 - 2020	TH, condo, live-work units, 250 SF or duplex
Ewa by Gentry and Gentry Ewa Makai	Gentry Homes	8,489	6,760	1,729	By 2015	SF condo, SF detached, MF
Ocean Pointe (prev. "Ewa Marina")	Haseko Hawaii, Inc.	2,500	2,420	80	1997 - 2010	SF detached & TH
Hoakalei Resort	Haseko Hawaii, Inc.	1,175	20	1,155	2008-2020+	Ka Makana, 900-unit first subdivision, mostly SF
Leihano Senior Village	Hawaii Village Associates, Inc. (Brookfield/ Kisco)	850	0	850	2011 - 2020+	Active adult and seniors
E A H "Ewa Villages"	Hui Kauhale, Inc. (E A H) & Avalon	242	0	242	2010 - 2011	192 apartment rentals (EAH) 50 SF lots for-sale (Avalon)

Appendix 3: Planned Residential Development Projects in the Ewa Development Plan Area, Con't.

Projects with State Land Use Entitlement or Exemption, as of July 2008

Project	Developer or Owner	Number of units: Total	Number of units: Delivered as of 7/08	Number of units: Potential remaining	Estimated project timing/buildout	Residential product mix
Ko Olina Resort & Marina	Ko Olina Development LLC (various entities) and Sekiguchi	500	232	54	2010 +	Condo: tower & low-rise; see comment
Franciscan Vistas Ewa	St. Francis Development Corp.	298	0	298	For sale/rent 4Q2008	149 senior rentals 149 for-sale SF & TH
East Kapolei I	State of Hawaii (DHHL)	350	0	350	Occupancy 2009+	All SF
East Kapolei II & III	State of Hawaii (DHHL, DLNR)	5,300	0	5,300	Occupancy 2009+	1,000 SF 1,200 MF
East Kapolei II, Parcels 1 & 2	State of Hawaii (HHFDC)	600	0	600	Development agreement under negotiation for Parcel 1 (308 units)	MF affordable rentals
Villas at A'eloa	Pacific Housing Assistance Corp.	72	0	72	2009	Family rental housing
Senior Residences at Kapolei	Pacific Housing Assistance Corp.	80	0	80	60 units by 2008; balance 2010	Senior rentals
Malu'ohai, Kapolei	Pacific Housing Assistance Corp.	80	0	80	2010-2011	Rentals
UH West Oahu project	UH/West Oahu Campus Development LLP (Hunt ELP Ltd.)	4,041	0	4,041	2011 to 2025+	761 - student & faculty 355 - workforce /affordable
Kalaeloa	Various (State HCDA is master planner)	6,350	60	6,290	60-units in 2006; 80 studios 2/09; most rest 2015-2030+	Med-high density TH and apartments
	Total, rounded	**39,900**	**9,700**	**29,900**		

Note - Excludes Subject. Shows remaining units to be developed at each masterplanned project, targeting those of 100+ units each. Figures shown based on stated owner or developer plans within entitlement restrictions, wherever information is available.

INA - Information not available; DP - on City Development Plan Map; SF - Single-family; MF - Multifamily; TH - Townhouse (multifamily); SLUC - State Land Use Commission; HHFDC - Hawaii Housing Finance & Development Corporation; HCDA - Hawaii Community Development Authority; DHHL - Department of Hawaiian Home Lands; DLNR - Department of Land & Natural Resources; AMI - median family income for City and County of Honolulu; DEIS - Draft Environmental Impact Statement.

Sources: Interviews with project principals, developers, planners and brokers, and City and State officials; Honolulu Advertiser; Honolulu Star Bulletin; Pacific Business News; Catholic Charities; project websites.

Appendix 4: Planned Retail Developments in the Central Oahu and Ewa Development Plan Areas

Projects with State LUC Entitlement, as of July 2008

Project	Location	Developer	Site area (ac)	Estimated retail GLA (SF)	Potential new project delivery (square feet) 2008-2010	2011-2020	2021-2030
Ewa:							
Kapolei Village Center (commercial condos)	Kapolei	Castle & Cooke Homes Hawaii, Inc.	INA	4,000	4,000	0	0
Costco	Kapolei	Costco Wholesale	17.8	165,000	165,000	0	0
Crossroads at Kapolei	Kapolei	Crocodile Partners & Lettuce Expand LLC (City Mill subsidiary)	2.8	40,000	40,000	0	0
East Kapolei Village	East Kapolei	DeBartolo Development LLC (DHHL)	67.0	950,000	450,000	500,000	0
Kapolei Village Center	Kapolei	Foodland Supermarket Ltd.	4.0	56,320	56,320	0	0
Ocean Pointe/ Hoakalei Resort	Ocean Pointe	Haseko	INA	100,000	0	50,000	50,000
Leihano Senior Village	Kapolei	Hawaii Villlage Associates, Inc. (KISCO Senior Living/Brookfield)	13.4	40,000	0	40,000	0
Ko Olina Station & Ko Olina Center	Ko Olina	Honu Group	INA	56,000	56,000	0	0
Kapolei West	Kapolei	Kapolei Property Development LLC (James Campbell Co.)	21.0	125,000	0	125,000	0
City of Kapolei - other	Kapolei	Kapolei Property Development LLC (James Campbell Co.)	INA	315,000	0	150,000	165,000
Makaiwa Hills	Makakilo	Kapolei Property Development LLC (James Campbell Co.)	INA	220,000	0	100,000	120,000
Kapolei Promenade (formerly "Boat Parcel")	Kapolei	LA-Kapolei III, LLC (Low-Archibald of CA)	14.0	88,000	88,000	0	0
Laulani Village	Ewa by Gentry	Laulani Village LLC (Bristol Group/Hamico)	20.0	250,000	250,000	0	0

Appendix 4: Planned Retail Developments in the Central Oahu and Ewa Development Plan Areas, Con't.

Projects with State LUC Entitlement, as of July 2008

Project	Location	Developer	Site area (ac)	Estimated retail GLA (SF)	Potential new project delivery (square feet) 2008-2010	2011-2020	2021-2030
Ewa, con't.:							
Kapolei Commons	Kapolei	MKC Management (MacNaughton /Kobayashi Groups)	50.0	605,000	605,000	0	0
Former Kapolei Town Square site	Kapolei	MW Group (property being marketed, summer 2008)	10.0	112,000	0	112,000	0
Hawaii Self-Storage	Kapolei	MW Group	2.0	113,400	113,400	0	0
2 lots Haumea & Uluohia Streets	Kapolei	None	1.4	15,000	0	15,000	0
Kalaeloa	Kalaeloa	State/private partner(s)	INA	116,000	0	31,000	85,000
UH West Oahu Campus Village	East Kapolei	UH/West Oahu Campus Development LLP (Hunt ELP Ltd.)	46.0	160,000	0	100,000	60,000
Wal-Mart	Kapolei	Wal-Mart Stores (Beach Development)	25.0	140,000	140,000	0	0
Central Oahu:							
Plaza at Mill Town	Waipahu	Avalon Development Co. LLC	2.0	34,000	34,000	0	0
Mililani Mauka Commercial A	Mililani Mauka	Castle & Cooke	INA	18,000	18,000	0	0
Mililani Mauka Commercial B & C	Mililani Mauka	Castle & Cooke	INA	100,000	30,000	70,000	0
Waiawa Ridge Increment 1	Waiawa	Waiawa Ridge Development, LLC (Gentry and A&B)	96.0	900,000	0	600,000	300,000
Totals/average of available information, rounded:							
	Ewa			**3,670,000**	**1,970,000**	**1,220,000**	**480,000**
	Central Oahu			**1,050,000**	**80,000**	**670,000**	**300,000**
	Total			**4,720,000**	**2,050,000**	**1,890,000**	**780,000**

INA = Information not available U/C = Under construction MUD = Mixed-use development, including residential and retail SC = Shoppi

Sources: Interviews with project developers, landowners, planners and brokers; area site visits; Pacific Business News, 2007, "Book of Lists: 2008"; Pacific Business News (weekly); Colliers Monroe Friedlander, Inc.; developer websites; Honolulu Advertiser; Hawaii Community Development Authority; Hawaii State Department of Business Economic Development & Tourism, Research and Economic Analysis Division, "Economic Impacts of the Proposed Kalaeloa Project," January 2007.

Appendix 5: Planned Office Developments in the Central Oahu and Ewa Development Plan Areas

Projects with State LUC Entitlements, as of July 2008

Project	Location	Developer/ Owner	RBA or building size (sq. ft.)	Potential new delivery (sq. ft.) July 2008-2010	2011-2020	2021-2030
Central Oahu:						
Waikele Professional Center	Waikele	American Assets, Inc.	17,500	17,500	0	0
Waiawa Ridge Increment 1	Waiawa	Waiawa Ridge Development, LLC (Gentry/A&B)	100,000	0	50,000	50,000
Ewa:						
Kapolei Pacific Center	Kapolei	Avalon Development Co. LLC	260,000	100,000	160,000	0
BMX-3 site	Kapolei	Avalon Development Co. LLC	230,000	0	230,000	0
East Kapolei Village	Kapolei	DeBartolo Development LLC (DHHL)	150,000	0	100,000	50,000
City of Kapolei - other	Kapolei	Kapolei Property Development LLC (Campbell)	35,000	0	35,000	0
Makaiwa Hills	Makaiwa	Makaiwa Hills LLC (Campbell)	30,000	0	30,000	0
Unnamed	Kapolei	Maryl Group	420,000	0	220,000	200,000
Kalaeloa	Kalaeloa	State/private partner(s)	725,000	0	100,000	300,000
UH West Oahu Campus Village	East Kapolei	UH/West Oahu Campus Development LLP (Hunt ELP Ltd.)	15,000	0	15,000	0
	Totals of available information, rounded:					
	Ewa		**1,870,000**	**100,000**	**890,000**	**550,000**
	Central Oahu		**120,000**	**20,000**	**50,000**	**50,000**
	Total Trade Area		**1,990,000**	**120,000**	**940,000**	**600,000**

Notes: RBA - rentable building area. Excludes buildings intended exclusively or primarily for public sector use.

Sources: Interviews with project developers, landowners, planners and brokers; area site visits; Pacific Business News, 2007, "Book of Lists 2008"; Pacific Business News (weekly); Colliers Monroe Friedlander; www.kapolei.com and other internet sites; Honolulu Advertiser; Hawaii Community Development Authority; Hawaii State Department of Business Economic Development & Tourism, Research and Economic Analysis Division, "Economic Impacts of the Proposed Kalaeloa Project," January 2007.

Appendix 6: Existing and Planned Business and Industrial Parks in Central Oahu and Ewa DPAs

As of July 2008

Project	Location	Developer/ owner	Year opened/ projected	Land area (gross acres) Total	In use or built	Future supply[1]	Future net acres[2]	Potential new delivery (net acres) 2008-2010	2011-2020	2021-2030	Zoning
Central Oahu:											
Mililani Technology Park Phase I[3]	Mililani	Castle & Cooke Properties	1989	101	43	58	44	5	39	0	IMX-1
Mililani Technology Park Phase II	Mililani	Castle & Cooke Properties	Indefinite	135	0	135	101	0	10	91	LUC Urban but zoned AG-1
Wahiawa Industrial Center	Wahiawa	INA	1990	4	4	0	0	0	0	0	I-2
Waiawa Ridge Increment 1	Waiawa	Waiawa Ridge Development, LLC (Gentry/A&B)	2010+	19	0	19	14	0	14	0	Urban but unzoned
Mill Town Business Center	Waipahu	A&B Properties, Inc.	1998	48	35	13	11	11	0	0	I-1
Waipahu	Waipahu	Various	INA	86	86	0	0	0	0	0	Most I-2; some B-2
Gentry Business Park	Waipio	Gentry Properties	1980	122	122	0	0	0	0	0	IMX-1, I-2, B-1
Subtotal, rounded				**520**	**290**	**230**	**170**	**20**	**60**	**90**	
Ewa:											
Coral Creek Business Park	Ewa by Gentry	Gentry Properties	2010+	42	0	42	32	15	17	0	IMX-1
Kenai Industrial Park	Kapolei	INA	1990	60	60	0	0	0	0	0	I-3
Former Hawaii Raceway Park	Kapolei	Irongate	2010	66	0	66	49	0	20	29	I-2

Appendix 6: Existing and Planned Business and Industrial Parks in Central Oahu and Ewa DPAs, Con't.

As of July 2008

Project	Location	Developer /owner	Year opened/ projected	Land area (gross acres) Total	In use or sold	Future supply[1]	Future net acres[2]	Potential new delivery (net acres) 2008-2010	2011-2020	2021-2030	Zoning
Ewa (continued):											
James Campbell Industrial Park	Kapolei	James Campbell Estate	1959	1,367	1,367	0	0	0	0	0	I-2
Kapolei Harborside	Kapolei	Kapolei Property Development Co. (Campbell)	2010	345	0	345	259	50	125	84	I-3
Kapolei Business Park	Kapolei	LV Kapolei 54 LLC	1993	189	135	54	41	10	31	0	I-2, restricted
West Kalaeloa	Kapolei	SHM Partners	2008+	100	0	100	75	15	60	0	I-2
Kapolei Studios	Kapolei	SHM Partners	2008+	23	0	23	17	15	2	0	I-2
Kalaeloa - Navy brokered & State administered properties	Kalaeloa	State of Hawaii and Federal	2010+	192	0	192	144	0	35	109	INA
Subtotal, rounded				**2,380**	**1,560**	**820**	**620**	**110**	**290**	**220**	
Total, rounded				**2,900**	**1,850**	**1,050**	**790**	**130**	**350**	**310**	

[1] Estimated lands with State entitlement or exemption, and planned but not yet committed.

[2] Net acres estimated at 75% of gross acres, to allow for roads, infrastructure, etc.

[3] About 29 acres of sold lands held by Kaiser remain undeveloped and are counted as potential future deliveries.

INA - Information not available   s.f. - square feet.   FAR - Floor Area Ratio

Sources: Interviews with project landowners, their consultants, planners, land managers, and brokers; Pacific Business News; company web sites; Honolulu Advertiser; Honolulu Star Bulletin; Enterprise Honolulu; Hawaii Community Development Authority, "Draft Kalaeloa Master Plan," 2005; Colliers Monroe Friedlander Inc., 2006.

MIKIKO
CORPORATION

ECONOMIC AND FISCAL IMPACT ASSESSMENT FOR KOA RIDGE MAKAI AND WAIAWA

ISLAND OF OAHU

Prepared for:
Helber Hastert & Fee Planners, Inc.

FINAL REPORT

November 2008

Economic and Fiscal Impact Assessment for Koa Ridge Makai and Waiawa

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ECONOMIC AND FISCAL IMPACT ASSESSMENT FOR KOA RIDGE MAKAI AND WAIAWA

Report Text

1 – Introduction and Executive Summary

This chapter relates the study background, objectives, approach and principal conclusions of an economic and fiscal impact assessment prepared for the proposed Koa Ridge Makai and Waiawa communities in Central Oahu. The following chapters offer a more detailed explanation of the findings and analyses on which these conclusions are based.

Project and Study Background

Castle & Cooke Homes Hawaii, Inc. (C&C) is the fee owner of Koa Ridge Makai and Waiawa, covering some 766 acres in the Central Oahu Development Plan Area (DPA) of Oahu. C&C proposes that Koa Ridge Makai and Waiawa be developed as master-planned communities with residential, community and regional-serving facilities with generous landscaping and open spaces.

Together, Koa Ridge Makai and Waiawa are also referred to herein as "the Project." Maximum build-out of the Project is summarized as shown below:

Proposed Maximum Development at Koa Ridge Makai and Waiawa

	Koa Ridge Makai	Waiawa	Total
Land area (acres)	575	191	766
Residential units	3,500	1,500	5,000
Commercial retail & office (sq. ft.)	380,000	30,000	410,000
Light industrial (sq. ft.)	90,000	0	90,000
Health community (acres)	28	0	28
Hotel rooms	150	0	150

Source: Castle & Cooke Homes Hawaii, Inc., August 2008.

C&C estimates that the first real estate products at Koa Ridge Makai could be delivered as early as 2012, while those at Waiawa could be available by about 2015.

Mikiko Corporation Engagement and Study Objectives

Helber Hastert & Fee Planners, Inc. (HHF) is preparing materials to support C&C's entitlement efforts for these lands. HHF engaged Mikiko to prepare two reports:

1) **Market assessment** – An assessment of the market support for the residential, commercial and industrial uses proposed at Koa Ridge Makai and Waiawa, including:

   - ❑ Evidence of demand and competitive supply
   - ❑ Assessment of appropriate markets, pricing, and supportable absorption

   Market studies for the proposed hotel at Koa Ridge and the Koa Ridge Medical Center were prepared by Hospitality Advisors LLC and Cattaneo & Stroud, Inc., respectively.

2) **Economic and fiscal impact assessment** – An assessment of the economic and fiscal impacts of the entire Project, including its hotel and medical-related uses. This assessment is presented in terms of population, employment, personal income and State and County government operating expenditures.

Mikiko's market report is contained in a separate document. The economic and fiscal impact assessment reported in this document uses the findings of the Mikiko, Hospitality Advisors and Cattaneo & Stroud market studies as input assumptions.

Economic and Fiscal Impact Approach

This economic and fiscal assessment is intended to assess the Project's impacts within the State of Hawaii (State) and the City and County of Honolulu (County). Impacts that were evaluated include:

- Economic impacts:

   - ❑ Expenditures by persons attracted to reside on Oahu;
   - ❑ Development-related employment;
   - ❑ Operations-related employment; and
   - ❑ Personal income deriving from development and operations.

- Population impacts:

   - ❑ Residential utilization patterns;
   - ❑ Average daily visitor population; and
   - ❑ In-migrant resident population.

- Fiscal impacts:
  - Property tax and other County government revenues;
  - General excise tax, income tax, transient accommodations tax and other State government revenues;
  - County and State government operating expenditures; and
  - County and State net fiscal operating impacts.

State and County revenues and expenses estimated herein are based on the structure of tax collections and services reported as of the fiscal year ending June 30, 2007 (FY 2007). The impacts estimated would differ if governmental taxing and spending policies were to be materially altered.

All dollar amounts in this report are stated in 2008 dollars, and year references are to calendar years, unless otherwise stated.

Executive Summary

Development Proposal

C&C is the fee owner of Koa Ridge Makai and Waiawa, covering some 575 and 191 acres in the Central Oahu DPA, respectively. The site locations and more detailed description of the proposed development programs are presented above and in the Mikiko market study.

Based on the entitlements required to commence development, the Project's first properties could be expected to be available for sale or lease in 2012. The entire Project could be expected to be built out and fully absorbed by 2025.

In accordance with County policies, about 30% of Koa Ridge Makai and Waiawa's residential units would be priced to County standards for affordable housing (see note to table that follows.) This analysis assumes that all affordable housing would be developed for sale at prices to be determined in agreements with governing agencies. Alternatively, some of C&C's affordable housing commitment at the Project could be met with rental housing.

Overview of Proposed Developments at Koa Ridge Makai and Waiawa
2008 dollars

	Comment	2009-15	2016-25	Total
Homes:	***Overall mix:***			
Market units	*70%*	840	2,660	3,500
Affordable units*	*30%*	360	1,140	1,500
Total		1,200	3,800	5,000
Average home sales price:				
Market units		$560,000	$560,000	$560,000
Affordable units**		$300,000	$300,000	$300,000
Weighted average		$482,000	$482,000	$482,000
Commercial uses:				
Light industrial	*Net acres*	0	4	4
Light industrial	*Same area, but in building sq. ft.*	0	90,000	90,000
Retail & office centers	*Estimated GLA sq. ft.*	210,000	200,000	410,000
Hotel	*Rooms*	0	150	150
Koa Ridge Medical Center	*Acres*	10	18	28
Community support:				
Elementary schools	*700-student schools*	1	1	2
Community parks & community centers	*Acres*	0	20	20
Church(es)	*Acres*	0	4	4
Total development costs* **	*Hard and soft costs (mils)*	**$962.0**	**$1,275.9**	**$2,237.9**

* Assumes 30% of total units and a 1:1 credit per County guidelines currently in effect. Actual credits could vary depending on affordable housing market segments and other factors to be agreed upon with the County, and such variation could change the affordable unit count.

** Estimated average price considers County's recent guidelines for pricing of for-sale units for a family of four earning 80% to 120% of the County median family income. Target markets and specific pricing will be determined in agreements to be established with the County.

*** Includes hard costs for vertical and infrastructure construction, site preparation, off-site water system, professional services and home office overhead for development management. Excludes construction costs for schools and church(es), as well as budgets for furniture, fixtures, equipment and contingencies.

Build out of Koa Ridge Makai and Waiawa is estimated to result in the expenditure of some $2.24 billion in development-related expenditures within the state between 2009 and 2025. This would represent an average development budget of about $132 million per year. This figure includes on- and off-site infrastructure, vertical construction, commercial tenant improvements, landscaping and soft costs such as professional services, administration of operating subsidiaries, pre-opening marketing and the like. The figure does not cover construction of the church(es) and schools, nor does it include budgets for furniture, fixtures and equipment within the various facilities or at parks, or financing, insurance, real property tax or contingency allowances.

Projected Impacts[1]

The Project would generate significant, on-going economic and fiscal benefits for residents of the islands, as well as for the County and State governments. Development of facilities would generate employment and consequent income and taxes. In addition, by attracting new residents to Oahu and generating additional real estate sales activity, the Project is expected to support long-term impacts, including additional consumer expenditures, employment opportunities, personal income and government revenue enhancement.

Highlights of the Project impacts are summarized in the table on the next page.

[1] See following chapter for study methodology and definitions of key terminology, such as “direct,” “indirect” and “induced” impacts.

Summary of Projected Economic and Fiscal Impacts
2008 dollars, in millions except where noted

	Comment	*2009-15*	*2016-25*
FTE employment:*	***Direct, indirect and induced, except as noted***		
Development-related	*Average annual in preceding period*	1,990	1,730
	Annual, on-going		
Operations-related -			
On-site	*Generated at Project facilities (direct effects only)*	1,440	2,460
Net new jobs Statewide	*New to County or State*	980	1,490
Total personal earnings:**	***Direct, indirect and induced***		
Development-related	*Average annual in preceding period*	$119.3	$100.3
Operations-related	*Annual, on-going on net new jobs only*	$62.5	$90.3
Average earnings per FTE job:**	***Direct, indirect and induced (not in millions)***		
Development-related	*Average annual in preceding period*	$60,000	$58,000
Operations-related	*On net new jobs only*	$64,000	$61,000
In-migrant resident population:	***Average daily employees, dependents, and new island residents of the Project***		
To the County		190	430
To the State	*Subset of County in-migrants*	120	280
Net additional government operating revenues:***	***Operating revenues less operating expenditures, at end of period***		
For the County		$3.8	$10.1
For the State		$12.2	$12.3
Revenue/expenditure ratio:***	***For government operations, at end of period***		
For the County		12.6	13.0
For the State		20.6	9.4

Note: Other than on-site employment, the estimates do not consider impacts of the two planned elementary schools, since equivalent facilities would be assumed to be developed elsewhere on Oahu even if the Project was not developed.

* FTE = Full-time equivalent, defined as 40 hours per week or 2,080 hours per year.

** Earnings defined to include wage, salary and proprietary incomes, plus directors' fees and employer contributions to health insurance, less employee contributions to social insurance.

*** Net revenues after 2025, and hence also the revenue/expenditure ratios, would be less than those shown for 2025 due to the completion of initial development activity by 2025. See report text for further discussion. The analyses do not consider applicable impact, connection and permit fees to be paid to the County, including building permit, sewer, water system, water meter and other fees and permits; nor do the figures consider impact or permit fees to be paid to the State, if any.

- **Development employment –** During its early years of infrastructure development, Koa Ridge Makai and Waiawa could generate employment for some 1,990 full-time equivalent (FTE) persons per year, through its direct, indirect and induced impacts. During the subsequent years of the Project's build out, it could support some 1,730 FTE development-related jobs per year, also considering direct, indirect and induced impacts. These jobs are expected to be associated with annual personal earnings[2] of some $119 million (2009 to 2015) and $100 million (2016 to 2025) per year, at about $58,000 to $60,000 per FTE job.

- **Operational employment –**

  - On-site jobs - By the time of its expected completion in 2025, the Project could be expected to have generated some 2,460 direct FTE jobs on-site at its retail, office, industrial, hotel, medical and school facilities. Because these on-site jobs would all be supported at Project components, they are all direct impacts; there are assumed to be no indirect or induced employment impacts on-site.

    This estimate does not include Realtors and brokers that may locate on-site, nor does it include private household workers or employees of public or community facilities such as the parks and community centers.

  - Net new jobs - Considering the Project's direct, indirect and induced impacts statewide, Koa Ridge Makai and Waiawa could alternatively be seen to have generated 1,490 permanent, on-going FTE jobs that would not have existed had the Project not been developed. These "net new" jobs could include professional, technical, managerial and other staff positions at Koa Ridge Medical Center, the hotel and the proposed office and retail areas; sales and marketing positions supported by the on-going resales and releasing of property at the Project; and myriad other positions generated throughout the economy. The net new job estimate is lower than the on-site job estimate because some of the jobs shown at Project facilities could be expected to be created elsewhere in the state even if the Project were not developed.

    Altogether, these net new operations-related positions could be expected to generate personal earnings for Hawaii residents of about $90 million per year by 2025, or an average of about $61,000 per FTE job.

- **Population movements -** It can be assumed that the jobs supported by Koa Ridge Makai and Waiawa, particularly the professional, technical and managerial career opportunities, will create incentives for some neighbor islanders or former Hawaii residents to move to Oahu. Koa Ridge Makai and Waiawa's housing opportunities themselves could be expected to attract some households that previously lived off-island. These could include retirees as well as younger households.

[2] Earnings are defined as wage, salary and proprietary income, plus director's fees and employer contributions to health insurance, less employee contributions to social insurance.

These and other indirect factors can be expected to result in perhaps 430 persons living on Oahu who might not otherwise have lived on the island (in-migration to the County) by the time of Project completion in 2025. Within this total, some 280 might be persons who had previously lived out-of-State.

- **Net County fiscal impacts** - The Project could be expected to contribute some $10.1 million per year in net additional County revenues at its completion. By 2025, new County government revenues are estimated to represent about 13 times the new County government operating expenditures required to support the additional population that could be attracted to Oahu by the Project. The major contributor to these fiscal benefits would be the Project's new real property taxes.

- **Net State fiscal impacts** - For the State, net additional operating revenues generated by the Project are estimated at about $12.3 million per year by 2025. This represents a revenue/expenditure ratio of about 9. These benefits would be expected to be less than these amounts after 2025 due to the cessation of the initial development activity thereafter. Review of the analyses without the impacts of initial development suggests net additional revenue of $4 million annually after 2025, and a 4.0 revenue/expenditure ratio.

These public sector contributions do not consider the value of the school sites, public parks or various off-site infrastructural improvements to be contributed by C&C. Neither do they consider the various impacts and permit fees expected to be paid to the County and State governments during the development of the Project. These additional contributions could increase the net public benefits of Koa Ridge Makai and Waiawa.

Report Organization

The rest of the report is organized in three parts, as follows:

1) **Remainder of Report Text** - Explanation of the study analyses and conclusions, including:

    - Study Approach
    - Economic Impacts
    - In-Migrant Population
    - Fiscal Impacts

2) **Exhibits**- Detailed bases and findings on which the conclusions are based.

3) **Appendices** – Report conditions and further documentation of input assumptions.

2. Study Approach

Special Considerations

Special considerations for some of Koa Ridge Makai and Waiawa's facilities guide the analyses presented herein. These and other aspects of this study's analytical framework are set forth below:

- **Time frame –** This analysis extends from 2009 to 2025, a 17-year period that would span from preconstruction planning through Project build-out. The first product sales, homes and a commercial site are anticipated at Koa Ridge Makai in 2012. All residential units at both Koa Ridge Makai and Waiawa, as well as commercial and industrial spaces, the hotel and the Koa Ridge Medical Center, are projected to be sold and/or in stabilized operations by 2025.

- **Use and classification of residential units –** Although not considered a major market segment, the Project could attract some buyers that previously lived on a neighbor island or out-of-state. These new island residents may be expected to include households at many stages of life, including retirees. This group is distinguished from buyers who are already established island residents in terms of their economic and fiscal impacts.

  - New island residents who buy homes at the Project bring new investments, earnings and expenditures to the State and County. Conversely, they also require additional government resources and services. In short, they generate new economic and fiscal impacts within the County and State.

  - Previously established island residents who buy homes at the Project are assumed to have lived elsewhere on Oahu even if the Project were not developed. Thus, while they may increase population at the Koa Ridge Makai and Waiawa sites themselves, from the County or State's standpoint, their presence is not a new impact.

- **Commercial facilities** - The proposed commercial facilities are expected to attract spending from unit buyers at Koa Ridge Makai and Waiawa, Oahu residents not living at the Project, as well as Oahu visitors.

  It is likely that Oahu residents and visitors would have spent an equivalent amount on dining out and/or personal services whether or not the Project's commercial facilities were developed. Thus, given the competitive retail market on Oahu, the planned complexes could lead to a geographic reallocation of spending within the region, but would not in themselves be expected to increase expenditures made in the County or State.

On the other hand, commercial facilities would contribute to the Project's ability to attract residential buyers to Koa Ridge Makai and Waiawa.

In other words, Koa Ridge Makai and Waiawa's on-site commercial facilities will employ workers, pay taxes and generate other economic and fiscal benefits. These are considered directly generated impacts and most of these jobs would be located on-site. However, the net benefits of the Project's commercial facilities are best measured in terms of the new island residents Koa Ridge Makai and Waiawa attracts, and the spending, taxes and other benefits these persons will generate throughout the County and State. Many of these impacts are likely to be felt off-site.

- **Other uses/considerations not modeled –** Other than development and landscaping of the public and private parks and a recreation center, this assessment does not consider the economic and fiscal impacts of development that would be of a public or civic nature. Thus, building or other facilities at the schools, churches, or any other public/civic facilities, are not modeled. Neither is the value of the lands to be contributed to governmental agencies considered.

- **Entitlement spending not considered** – C&C's currently on-going entitlement process for Koa Ridge Makai and Waiawa is already generating economic and fiscal benefits by employing professionals and supporting various vendors around the State. However, since such benefits are not dependent on the outcome of the entitlement process, they are not enumerated in this analysis.

- **Other –**This study does not compare the proposed developments to prior master plan(s) for the property nor to other developments that could be hypothesized given the lands' existing entitlements.

Definition of Terminology

Within this report, the following definitions apply:

- **Direct impacts** - Those economic, population or other impacts attributable to persons or activities that are a direct result of the proposed development. For instance, direct employment impacts might include those involved in building the proposed facilities, such as construction workers, and those who would later work at them in their operations.

  Many, but not all of direct impacts can be expected to occur on-site. For instance, a portion of the construction budget is for architects and engineers. While such persons' employment might be temporarily dependent on contracts regarding Koa Ridge Makai and Waiawa, they may do the majority of their work from offices in Kapolei, Honolulu or elsewhere. Likewise, administrative and managerial staff located off-site would support construction professionals working on-site.

- **Indirect impacts** - Indirect impacts occur when the businesses or persons who are directly affected make expenditures for additional supplies or services. For instance, some of the additional retail spending by those newly attracted to Hawaii by the Project could be spent on eating out. These elevated dining out expenditures could indirectly increase demand for produce, seafood and meats from Hawaii farms, fishermen and/or ranching enterprises. Koa Ridge Makai and Waiawa would thus have <u>indirectly</u> supported new business opportunities for area providers of such goods and services.

- **Induced impacts** - Induced impacts occur throughout the community when those persons or companies that have benefited from the direct or indirect impacts of the Project spend their associated earnings on consumer goods and services. For instance, a construction worker may spend her earned wages to buy a new pair of shoes, or to pay for her child's day care. The farmer who sells produce to a restaurant at Koa Ridge Makai and Waiawa may use some of his profit to take his family out to the movies. The businesses and individuals impacted by such re-spending are said to enjoy <u>induced</u> economic impacts from the Project.

- **Total impacts** - Total impacts are defined as the sum of direct, indirect and induced impacts for any given variable.

- **Resident population -** Resident population refers to all those persons who habitually reside in a given area, whether or not they may have temporarily traveled away.

- **Full-time equivalent** - This study measures employment opportunities in full-time equivalent (FTE) units. One full-time equivalent position is defined herein as 2,080 hours of employment (including paid vacation and sick leave) per year. This is equivalent to 40 hours per week, and may also be referred to as a "person-year" of employment. Two half-time jobs would be considered to together represent one FTE job.

Project Parameters

Assumptions regarding the scale, nature and timing of the Project are made in order to assess its impacts. This assessment is based on findings of the market study prepared by Mikiko, as well as the analyses prepared by Hospitality Advisors and Cattaneo & Stroud. It also relies on timelines and development programs provided by C&C, HHF and others as noted.

Development Program (Exhibit 2-1)

The Project is proposed to be developed with up to 5,000 residential units, up to 410,000 square feet of commercial (retail and office) space, some 90,000 square feet of industrial space (based on the 4 net acre or 5 gross acre site), a 150-unit, limited service, all-suites hotel, and a hospital and other medical-related uses. The Project is also planned to include two elementary schools, however, other than for on-site employment, their impacts are not assessed in this analysis because they would be expected to be developed elsewhere on Oahu even if the Project were not developed.

Among the residential units, about 30% or some 1,500 are assumed to be developed as affordable housing, in accordance with County guidelines. If these units were developed for sale (as opposed to rentals), they could expect to be marketed for about $300,000 on average, based on recent County guidelines for a family of four earning 80% to 120% of the County median family income. Affordable units might be produced at a rate of about 107 per year, on average.

The average market-priced unit could be expected to be sold at $560,000, with an average of 250 units selling each year.

Assuming entitlements are obtained on a timely basis, the landowner believes construction of infrastructure could begin in 2009, and the first units could be available for occupancy in 2012. The Project as a whole is anticipated to be fully sold out and/or leased by 2025. This analysis begins in 2009, in order to capture the impacts of pre-construction but post-discretionary permit planning, design and related professional services.

Residential Buyer and Utilization Patterns (Exhibit 2-2)

County guidelines restrict the use of affordable housing units to primary residents.

Based on C&C buyer origins patterns at representative other developments in Central Oahu after 2005, 97% of market units are expected to be purchased by persons who were already established as Oahu residents. The remaining 3% could be purchased by households that previously lived off-island, on a neighbor island or out-of-State. These would include those who intend to move to Oahu for employment or family reasons, and for whom the homes or other developments at Koa Ridge Makai and Waiawa enabled or attracted such relocation.

Established island resident market units at Koa Ridge Makai and Waiawa are assumed to be occupied 95% of the time, at 3.2 persons per household for market units, and 3.5 per household for the affordable units. These are based on the average household sizes of recent new home purchasers in Central Oahu, as well as the estimated 3.23 persons per household now resident in the DPA, and the projected 3.18 per household by 2013[3]

[3] Claritas, Inc., 2008.

New island residents are assumed to reside in their Koa Ridge Makai and Waiawa home an average of 90% of the year, with an average household size of 3.0 persons per unit.

These assumptions support an average daily Project population of some 15,590 persons, assuming its full build-out and sales absorption by 2025.

Hotel Operations and Utilization Patterns (Exhibit 2-3)

According to a study by Hospitality Advisors,[4] the 150-room hotel at Koa Ridge can be expected to experience average annual occupancy of 72% to 75% upon its stabilization. For purposes of this study, a mid-range figure of 74% is used.

The typical party size is anticipated to be 2.5 persons per room. This would result in an average daily guest population of 280 persons. Among these guests, 55% are projected to be Oahu residents (mostly military personnel and their families in the process of relocation), 20% are projected to come from the neighbor islands, and 25% from out-of-state.

The average daily room rate is projected by Hospitality Advisors to range from $125 to $150 at stabilization; the economic and fiscal model uses a mid-range figure of $140. While the hotel is not recommended to include restaurants or other significant support facilities or amenities, buffet style breakfast service could be provided via vendors.

Other hotel revenues are projected at $2.35 per occupied room. Together with the room revenues, this would yield total annual revenues of $5.7 million per year at stabilization, excluding revenues to third party vendors such as food service providers.

[4] Hospitality Advisors LLC, "Phase II Refinement of Development Plan for the Koa Ridge Master Plan," September 15, 2008.

3. Economic Impacts

Koa Ridge Makai and Waiawa may be expected to impact the State and County economies by (a) attracting new Oahu residents who would make new expenditures, (b) attracting new visitors to the hotel, (c) generating development activity, which supports expenditures for goods and services, and (d) creating and supporting jobs and business enterprises in its ongoing operations. The new jobs would in turn generate additional personal earnings in the County and throughout the State.

Visitor and New Island Resident Expenditures (Exhibit 3-1)

Expenditures by transient visitors and new island residents attracted to Oahu by the Project will contribute to Koa Ridge Makai and Waiawa's economic benefits.

- **Visitors –** By 2025, the hotel at Koa Ridge is projected to house some 56 visitors from neighbor islands and about 70 from out-of-state on an average day. Direct expenditures by these visitors are expected to amount to $1.2 million and $1.4 million per year, respectively. Considering also their indirect and induced impacts, these visitors could be expected to contribute some $2.3 million and $2.9 million, respectively, to the local economy, annually.

- **New residents** - Direct expenditures made in Hawaii by the new island residents themselves are projected to amount to about $3.7 million per year by the Project's stabilization in 2025. Including the indirect and induced impacts of these direct expenditures, the total contribution to the State economy by Koa Ridge Makai and Waiawa's new island residents is expected to amount to about $7.3 million per year by 2025 and thereafter.

Project Costs

Coefficients and Multipliers (Exhibit 3-2)

The State of Hawaii, Department of Business Economic Development and Tourism (DBEDT) periodically evaluates the economic interdependencies of the various industries within the State, and their rates of job and personal earnings creation. The latest such study is dated June 2006 and entitled, "The 2002 State Input-Output Study for Hawaii." Appendix 2 shows the information extracted from this report for use in the analysis of the Project's development activity.

- **Final demand industry coefficients** show the relationship between input, or spending within any given industry category, and its resulting creation of jobs and earnings in other sectors of the State economy[5]. Such coefficients are used to estimate the direct effects of the construction and development activities planned for Koa Ridge Makai and Waiawa.

- **Industry multipliers** show the relationship between direct jobs or earnings and the indirect and induced jobs or earnings that they can be expected to subsequently support.

Development Costs (Exhibits 3-3 and 3-4)

Based on estimates provided by C&C and other sources as cited in the exhibits, Koa Ridge Makai and Waiawa's development is expected to lead to some $2.24 billion expended over the 17 years between 2009 and 2025. This budget is in 2008 dollars and includes:

- **Professional services –** planning, architectural, engineering, landscape design, development management, legal, and similar services. Note that those services related to the effort to entitle Koa Ridge Makai and Waiawa's lands are not included in this estimate, since they are not contingent on the entitlement.

- **Construction –** including on- and off-site infrastructure[6], land subdivision and site preparation, commercial, industrial, hotel, residential and medical-related facility development, and retail and office tenant improvements. Construction costs for the schools and church(es) are not considered here.

- **Other –** including administrative overhead, subsidiary operations, pre-opening marketing, public relations, and other "soft" costs incurred during the Project's development.

Because the latest DBEDT coefficients are calibrated to 2002 dollars, the development budgets are also re-estimated in 2002 dollars.

Exhibit 3-4 restates the 2008 figures on an average annual basis within each period, rather than as a total budget. Over the projection period, the Project could be expected to average some $132 million per year in development expenditures in the state. The rate of expenditures would be higher than this average between 2009 and 2015, when a great deal of both the planned infrastructure and vertical construction is expected to take place.

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[5] Personal earnings are defined in the DBEDT study as wage and salary income plus proprietors' income, plus director's fees, plus employer contributions to health insurance, less personal contributions to social insurance (i.e., social security taxes). See pp. 23 to 24.

[6] The only off-site infrastructure item estimated herein is the Project's water system.

Employment and Earnings

Development Employment (Exhibit 3-5)

During their build out, Koa Ridge Makai and Waiawa could directly generate some 13,000 person-years of development-related work. The majority of this work would occur on-site. However, some of this employment, such as the professional services and administrative positions, could be located off-site, generally elsewhere in the region. This estimate includes wage, salaried and proprietary employment opportunities supported by the Project's development.

Considering also the indirect and induced employment opportunities that these direct impacts are likely to support, the total impacts of the Project's development could represent 31,200 total FTE jobs in the state by 2025.

The impacts are also considered on an average annual basis. Over the 2009 to 2025 study period, the Project is anticipated to support an average 760 direct FTE development-related jobs within the state. Total employment impacts, including direct, indirect and induced FTE jobs, could represent about 1,830 FTE positions in an average year.

Personal Earnings from Development (Exhibits 3-6 and 3-7)

Direct personal earnings associated with Hawaii-based positions could amount to some $968 million over the Project's development. Considering also the indirect and induced earnings, Hawaii workers could expect to enjoy a total of some $1.84 billion in additional earnings over the Project's development.

On an annual basis, the direct earnings represent an average of $57 million per year from 2009 to 2025, while total earnings could amount to $108 million per year. The indirect and induced benefits could be expected to be supported throughout the State, with concentration on Oahu.

Comparing projected earnings to the employment figures shown previously, the FTE-wages, salaries, proprietary income and other earnings generated by the Project's overall development are estimated to average about $74,000 per direct FTE position, or $59,000 considering its total, more dispersed impacts.

Since most families in Hawaii include more than one job-holder, and many employees themselves hold more than one job, these position-specific salaries can be expected to be associated with higher average family incomes.[7] On average, those employed in positions directly supported by Koa Ridge Makai and Waiawa's development could be expected to have family incomes averaging $139,000 at the Project's stabilization, while those associated with all jobs created through the Project's direct, indirect or induced

[7] Ratio derived from the 2007 average annual wage in the Honolulu Metropolitan Statistical Area, as reported by the State Department of Labor & Industrial Relations and the FY 2008 median family income as reported for the Honolulu MSA by the U.S. Department of Housing & Urban Development. See Exhibit 3-7 for further information.

effects could be expected to have family incomes averaging $111,000. These would represent 180% and 144% of the median family income for Honolulu County, respectively, based on the estimated median of $77,300 in FY 2008.[8]

Operational Employment (Exhibits 3-8 and 3-9)

In addition to its development-related positions, Koa Ridge Makai and Waiawa would create numerous long-term permanent jobs in its operations. Operational employment may be considered in two ways:

- **On-site employment** (Exhibit 3-8) – Koa Ridge Makai and Waiawa's facilities are expected to directly generate some 2,460 permanent positions in its operations. These would include employees of the Koa Ridge Medical Center, the hotel, light industrial area, the various retail and office facilities, and the two schools. This estimate does not include any allowance for Realtor and brokerage-related positions in the initial marketing of Koa Ridge Makai and Waiawa, some of which will likely also locate on-site. These estimates also do not include employees of public or community facilities that may be developed on-site, such as at its parks, community centers or church(es).

  Because these on-site jobs would all be supported by the Project's facilities, they are all direct impacts; there are assumed to be no indirect or induced employment impacts on-site.

- **Net additional employment** (Exhibit 3-9) - It is likely that existing Oahu residents would spend an equivalent amount on consumer goods and services whether or not the Project's commercial facilities were developed. One impact of the Project's development may be a geographic reallocation of spending and hence jobs within the region, as explained previously in Chapter 2. Thus, from a broader geographic viewpoint, many of the commercial facility-related jobs located at Koa Ridge Makai and Waiawa would not be net new jobs for the island or state.

  On the other hand, about 50% of positions forecast at the Koa Ridge Medical Center, all those to be created at the hotel and 25% of those to be created at the light industrial area are expected to represent new employment opportunities for Oahu. In addition, to the extent that Koa Ridge Makai and Waiawa attract new residents to the island, those persons' spending can be considered new monies in the State's and sometimes also the County's economy. Such new spending will generate new employment opportunities that may be dispersed statewide.

  In conclusion, Koa Ridge Makai and Waiawa's impacts on employment opportunities statewide are estimated:

[8] U.S. Department of Housing & Urban Development, HUD USER, as accessed October 9, 2008.

- As a share of the total employment forecast at the Koa Ridge Medical Center, the hotel and the light industrial area;
- Via employment multipliers applied to estimated spending by new island residents attracted by the Project (this generates commercial and other employment estimates); and
- Via employment multipliers applied to the projected volume of sales and leasing costs and commissions.

Altogether, some 740 direct operational jobs to be generated by Koa Ridge Makai and Waiawa are considered likely to be net new jobs for the state. Indirect and induced effects could add another 750 permanent positions in Hawaii, for a total of some 1,490 net new permanent positions by the Project's stabilization in 2025.

Personal Earnings from Net New Operational Activity (Exhibits 3-10 and 3-11)

Personal earnings are estimated only for the net new operational jobs supported by Koa Ridge Makai and Waiawa. Direct wages and salaries paid to those employed in the Project's operations, plus proprietary earnings, director's fees and the like earned as a direct result of the Project's resident spending are expected to reach $46 million per year by Project stabilization in 2025. Including personal earnings associated with the indirect and induced positions, the Project could generate some $90 million per year in ongoing payroll within the State.

These figures do not include gratuities, bonuses or some of the employee benefits that would also be realized by many of the employees and proprietors benefiting from this economic growth.

Based on the multipliers derived from DBEDT's Input-Output Study, the direct employment and proprietary opportunities generated by Koa Ridge Makai and Waiawa could be expected to support average FTE earnings of about $62,000 at stabilization. Considering the Project's total impacts, operational positions could be expected to support FTE earnings of about $61,000.

As for development employment, these earnings per job would be associated with higher average family incomes. Using the same methodology explained previously, the families that include a person employed through direct, indirect or induced employment impacts of Koa Ridge Makai and Waiawa can be expected to have average incomes of about $116,000. This would mean these Koa Ridge Makai and Waiawa-associated families earn about 150% of the FY 2008 Oahu median family income.

4. In-Migrant Population

Koa Ridge Makai and Waiawa are expected to lead to some in-migration to the state and County as discussed below.

Koa Ridge Makai and Waiawa Residents (Exhibit 4-1)

Home buyers coming from off-island represent population increase for Oahu. The majority of such in-migrants are anticipated to come from out-of State, but some could be newcomers to Oahu only, having moved from a neighbor island. Those moving could be attracted by a variety of factors, including the homes or community styles at the Project, or its job opportunities.

By 2025, new island residents living at Koa Ridge Makai and Waiawa are estimated at about 280 FTE persons. Some 180 of these persons are estimated to also be in-migrants to the state, having moved from the US mainland or abroad. These persons, together with perhaps 100 others that could have moved to Oahu from another island comprise the estimated total of 280 in-migrants to the County.

Employees and Dependents (Exhibit 4-1)

Some of those taking advantage of the construction and net new operational employment generated by the Project might move from other counties or states because of a job opportunity at Koa Ridge Makai or Waiawa. These might include young householders who grew up in Hawaii but who had been living and working on the US mainland due to the lack of attractive career and living environments in Hawaii, or neighbor islanders who seek employment and lifestyle opportunities such as envisioned at Koa Ridge Makai and Waiawa. Other household members might also accompany such in-migrating workers.

- **Development employees** - Hawaii's labor market is considered to have sufficient supply and the required skills to satisfy most of the Project's development labor needs. A nominal 3% of FTE specialty staffing needs is assumed to come from the US mainland. Such persons might be temporarily resident in the islands during periods of the Project's development.

  Those moving or commuting between islands during the Project's development could fill another 2%. Together with those from out-of-State, this would represent 5% of development employees being temporary in-migrants to the County. However, this would still be a nominal number of development positions in any given year (estimated at 36 FTE persons per year in this model.)

- **Operational employees –** Some 95% of the Project's operational employee needs are anticipated to be satisfied from within the State's and 93% from within Oahu's labor pool. Conversely, this could mean that perhaps 40 operational employees are attracted to Hawaii because of Koa Ridge Makai and Waiawa's net new operational employment opportunities, and an additional approximately 10 could have been attracted from the neighbor islands.

- **Dependents -** In-migrant dependents are estimated at an average of 0.2 per FTE in-migrant construction worker, since the position on which the "move" is based would be temporary. For operational employees, the dependent ratio is estimated at 1.0 per FTE in-migrant operational employee.

Total In-Migrant Impacts (Exhibit 4-1)

In total, by 2025, Koa Ridge Makai and Waiawa's new residential and employment opportunities are projected to have been associated with about 430 in-migrants to the County, of whom about 280 could also have been new to the State.

Projected In-Migrant Impacts, 2025

	Attracted by residential opportunities	Attracted by employment opportunities	Total
To County	280	150	430
To State	180	100	280

Source: Mikiko Corporation, November 2008.

5. Fiscal Impacts

Koa Ridge Makai and Waiawa's fiscal impacts are estimated by comparing its anticipated impacts on government revenues to the government service costs associated with the additional population the Project could attract to the State and County.

Operating Revenues

Real Property Taxes (Exhibit 5-1)

For the County, the Project's most significant fiscal impact would be the higher real property taxes it would generate compared to those currently paid. Net new real property taxes are based on the County's FY 2008 rates for land and building uses of the relevant land use classifications.

Future assessed values will be based on the County assessors' estimates at a future time, and County standards of practice for establishing such values. For projection purposes, the following proxies are used:

- **Assessed values of the residential areas as improved** are based on the estimated average home sales price of $482,000, considering both affordable and market homes.
- **Assessed values of the unimproved residential areas** are based on comparison to FY 2008 tax assessed values per acre at other Urban-designated and Unimproved Residential use lands held by C&C at in Mililani Mauka, and a pro-rata share of the Project's residential lands assumed to remain undeveloped at any given time.
- **Assessed values of the commercial, light industrial, hotel and medical-related improvements** are estimated based on the estimated "hard" construction costs for the buildings, plus their tenant improvement costs, as presented previously in Exhibit 3-3.
- **Assessed values of the lands associated with the above** are based on assessed values for other commercial sites held by C&C in Mililani and/or Mililani Mauka, and on lands in Mililani Technology Park.

Based on these proxies, the Project is estimated to have a tax assessed value of about $758 million in 2015, and $2.62 billion by 2025, when it is assumed to be fully built-out.

County Real Property Tax Revenues (Exhibit 5-1)

Considering the estimated assessments and the current County real property taxation structure, Koa Ridge Makai and Waiawa could support potential new real property taxes of some $3.7 million by 2015 or $11.5 million per year by 2025 and thereafter.

Deductions from these figures include real property taxes currently paid for the subject lands, and an allowance for homeowners' exemptions.

On balance, Koa Ridge Makai and Waiawa is projected to supply the County with about $3.3 million in net additional real property tax revenues in 2015, or $10.1 million on an on-going annual basis after its completion in 2025.

Total County Government Operating Revenues (Exhibit 5-2)

In addition to real property taxes, the County obtains liquid fuel, utility franchise, motor vehicle weight, and other license and permit fees from residents and businesses. Based on Honolulu County revenues reported by City and County of Honolulu for FY 2007, these minor County taxes and fees amount to about $216 per resident, in 2008 dollars.

The County also receives a share of transient accommodations tax (TAT) revenues collected by the State. Currently, this share represents 19.8% of total collections.

Honolulu County also receives a 0.5% "surcharge" on all Gross Excise Tax (GET) collected by the State. This is applied to the development and operational activities of the Project that would be subject to GET.

Added to the real property taxes discussed above, net new taxes earned by the County as a result of the Project's development and operations are estimated at some $4.1 million in 2015 or $11.0 million per year by 2025.

These figures do not include impact and permit fees anticipated to be paid to the County during the development of the Project, nor the value of lands to be dedicated to County agencies such as for parks and roads.

State Government Operating Revenues (Exhibits 5-3 and 5-4)

Operating revenues accruing to the State government are expected to derive principally from:

- GET applied to Koa Ridge Makai and Waiawa's development expenditures, brokers' commissions, and the in-state spending by its residents and employees who came from out of state;
- The TAT on room revenues at the hotel at Koa Ridge;

- Individual income taxes paid by the Project's employees, including both its development- and operations-related employees; and

- Specific excise, licenses, fees, fines and other payments to the State made by those who move to Hawaii because of the Project.

Assumptions on which the above sources are estimated are shown in Exhibit 5-3.

Exhibit 5-4 applies these assumptions and shows net new operating revenues for the State at some $12.8 million in 2015, or $13.7 million by 2025.

These projected State tax revenues may be conservative in that they do not include:

- Potential income taxes from certain business operating incomes, including those that may be paid by the operating entity for Koa Ridge Makai and Waiawa,

- Personal income tax on gratuities, bonuses or other earnings by Project employees not accounted for herein,

- GET on any portion of Homeowners' Association fees that may be non-exempt,

- Conveyance taxes on commercial space leasing,

- Conveyance taxes on the ongoing resales of residential (if no longer a primary residence) and commercial properties within the Project, and

- State surcharges on motor and tour vehicles that could be rented by the hotel guests and the Project's residents.

The figures cited above also exclude fees that are expected to be paid to the State on behalf of Koa Ridge Makai and Waiawa over the years of its development. Neither do they include the value of lands to be dedicated to the State such as to the Department of Education.

After 2025, the on-going State revenues would be expected to be less than that shown above, however, due to the completion of the Project's initial development activity and the loss of GET and income taxes on the associated earnings and expenditures.

Operating Expenses

Per Capita Government Operating Expenditures (Exhibits 5-5 and 5-6)

Both State and County governments can be expected to incur additional operating expenses in supporting the in-migrants that are attracted by the Project. An analysis of the County's FY 2007 operating expenditures, net of Federal and State grants, suggests that the County spends some $1,709 per FTE resident and $838 per FTE visitor, in 2008 dollars. These expenditures support functions ranging from public safety and highways to recreation, as well as County debt service and benefits for its employees.

A similar analysis of State government operating expenditures for FY 2007 suggests that the State spends about $5,208 per year to support government operations on behalf of each FTE resident and $871 per FTE visitor, in 2008 dollars.

Additional County Government Operating Expenditures (Exhibit 5-7)

The per capita budgets derived above are applied to the counts of anticipated in-migrants to the County because of employment or housing opportunities. This results in an estimated $0.8 million in additional County government operating expenditures in 2025.

Additional State Government Operating Expenditures (Exhibit 5-8)

Employing an analogous methodology, the State could be expected to require up to $1.5 million more per year to support the net additional residents the Project could eventually attract, by 2025.

Net Fiscal Benefits (Exhibit 5-9)

Comparing the net new government operating revenues and expenditures discussed above yields the projected net fiscal benefits for the County and State governments.

- **County government** operating revenues attributable to Koa Ridge Makai and Waiawa are anticipated to exceed the additional operating expenses in both of the benchmark years evaluated. By 2025, net additional operating revenues could represent some $10.1 million per year, for a revenue/expenditure ratio of about 13.

  County net revenues would be expected to decline slightly after 2025 as the revenues originating from the Project's initial development cease. However, since the majority of the Project's County tax revenue contributions come from real property taxes, the revenue/expenditure ratio is not anticipated to change significantly.

- **The State government's** projected operating revenues also exceed its additional operating expenses throughout the study period. Net additional revenues are projected to amount to $12.3 million per year by 2025. These new revenues could then represent about 9 times the associated new State government operating expenditures.

  For the State, the net additional revenues and the revenue/expenditure ratio are expected to be lower after 2025, particularly as GET and income tax revenues that originated from the initial build-out of the Project stop. A separate analysis of these contributions after 2025 suggests on-going net additional revenues of $4.0 million per year, with a revenue/expenditure ratio of about 4.

ECONOMIC AND FISCAL IMPACT ASSESSMENT FOR KOA RIDGE MAKAI AND WAIAWA

Exhibits

Exhibit 2-1
Project Concept and Potential Development Timing
2009 to 2025

	Unit	Notes		2009-15	2016-25	Total
Highlights of period: ("KRM" = Koa Ridge Makai; "W" = Waiawa)		*2009+: infrastructure planning and development* *Full Project build out by 2025* *Schools, parks, community centers, church(es) planned for 2015-2020*		■ *First home deliveries: KRM 2012, W 2015* ■ *First retail & office, KRM* ■ *Ph 1 health facilities*	■ *Hotel opens at KRM, 2017* ■ *First retail & office, W* ■ *Ph 2-3 health facilities* ■ *Light industrial at KRM*	
Development in period:						
Residential unit completions/sales -		*Av. price:*	*Av. sales/year*			
Market units (single & multifamily)	*Sold homes*	*$560,000*	*250*	840	2,660	3,500
Affordable units (multifamily)[1]	*Sold homes*	*$300,000*	*107*	360	1,140	1,500
Total, residential units/weighted average price		*$482,000*	*357*	1,200	3,800	5,000
Light industrial land	*Net acres*			0	4	4
Light industrial buildings	*Built square feet*	*0.5*	*floor area ratio*	0	90,000	90,000
Commercial centers	*Gross leasable square feet*			210,000	200,000	410,000
Hotel	*Rooms*			0	150	150
Koa Ridge Medical Center	*Acres*			10	18	28
Elementary schools	*Schools*	*Estimated at 700 students each*		1	1	2
Cumulative development by end of period:						
Residential unit completions/sales -						
Market units (single & multifamily)	*Sold homes*			840	3,500	
Affordable units (multifamily)	*Sold homes*			360	1,500	
Total				1,200	5,000	
Light industrial land	*Net acres*			0	4	
Light industrial buildings	*Built square feet*			0	90,000	
Commercial Centers	*Gross leasable square feet*			210,000	410,000	
Hotel	*Rooms*			0	150	
Koa Ridge Medical Center	*Acres*			10	28	
Elementary schools	*Schools*			1	2	

1 Assumes 30% of total units and a 1:1 credit per County guidelines currently in effect. Actual credits could vary depending on affordable housing market segments and other factors to be agreed upon with the County, and such variation could change the affordable unit count. Estimated average price considers County's recent guidelines for pricing of for-sale units for a family of four earning 80% to 120% of the County median family income. Target markets and specific pricing to be determined in agreements to be established with the County.

Sources: Castle & Cooke Homes Hawaii, Inc., 2008; Mikiko Corporation.

Exhibit 2-2
Buyer Origins and Residential Utilization Patterns
2015 and 2025

	Basis/reference	2015	2025
Usage assumptions:			
Market units-established island residents [1]	*97% of sold market units*	815	3,395
Market units-new island residents [1]	*3% of sold market units*	25	105
Affordable units [2]	*100% of sold affordable units*	360	1,500
Total		1,200	5,000
Unit occupancy assumptions:			
Market units-established island residents [1]	*Allowance for vacancy/transitions*	*95%*	*95%*
Market units-new island residents [1]	*Share of time spent on-island*	*90%*	*90%*
Affordable units	*Allowance for vacancy/transitions*	*95%*	*95%*
Utilization pattern:			
Average daily occupied units -	*Exhibit 2-1 + usage assumption*		
Market units-established island residents[1]		774	3,225
Market units-new island residents[1]		23	95
Affordable units (all primary homes)		342	1,425
Total, rounded		**1,140**	**4,740**
Average daily persons in residence[3] -			
Market units-established island residents[1]	*3.2 persons per occupied unit*	2,477	10,321
Market units-new island residents[1]	*3.0 persons per occupied unit*	68	284
Affordable units	*3.5 persons per occupied unit*	1,197	4,988
Total, rounded		**3,740**	**15,590**

1 C&C sales contracts typically require that buyers use the unit as a primary residence for at least the first 12 months. Based on previous C&C buyer patterns in Central Oahu, 97% of units are expected to be sold to persons who previously resided elsewhere on Oahu, while a few are anticipated to be sold to persons relocating from off-island. The latter buyer classification is expected to have different household and utilization characteristics than the former.

2 Assumes 30% of total units and a 1:1 credit per County guidelines currently in effect. Actual credits could vary depending on affordable housing market segments and other factors to be agreed upon with the County, and such variation could change the affordable unit count.

3 Established island resident occupancy based C&C surveys of 2005 to 2007 buyers at representative projects on Oahu, and on Claritas, Inc., 2008 estimate of average 3.23 persons per household in the Central Oahu area and projected 3.18 by 2013. Households of relocating families assumed to be slightly smaller on average, while those residing in affordable housing assumed to be larger.

Exhibit 2-3
Hotel Operations and Utilization Patterns
2015 and 2025

	Basis/reference	2015	2025
Number of rooms	*Exhibit 2-1*	0	150
Unit occupancy assumptions:			
Average occupancy	*Mid-point of projected low and high ranges*	0%	74%
Average party size	*Number of persons per occupied room*	0.0	2.5
Average daily guests	*Rounded*	**0**	**280**
Projected guest mix:	*Fit between projected low and high ranges*		
Oahu residents -			
Military/government	*Including TLA & relocations from off-Island*	0%	51%
Other	*Including outbound military*	0%	4%
Subtotal		0%	55%
Neighbor island residents -			
Business		0%	8%
Visiting friends & family		0%	6%
Attending sporting events		0%	6%
Subtotal		0%	20%
Out-of-state residents -			
Business		0%	8%
Visiting friends & family		0%	10%
Attending sporting events		0%	7%
Subtotal		0%	25%
Total		0%	100%
Average daily room rate	*Mid-point of projected low and high ranges*	$0	$140
Projected revenues	*In millions*		
Rooms		$0.0	$5.6
Other	*$2.35 per occupied room*	$0.0	$0.1
		$0.0	$5.7

TLA - Transient Living Allowance

Sources: Castle & Cooke Homes Hawaii, Inc., 2008 (for development timing); Hospitality Advisors LLC, "Phase III Refinement of Development Plan for the Koa Ridge Master Plan," September 15, 2008 (all other assumptions.)

Exhibit 3-1
Visitor and New Island Resident Expenditures in Hawaii, Average Annual
2015 and 2025 (2008 dollars, in millions, except as noted)

	Basis/reference (not in millions)		2015	2025
New residents of Oahu:				
Bases for projection:				
Average household income [1]	*Honolulu median family income*	*$77,300*		
Percent of income spent on island [2]	*(See Exhibit 2-2):*	*50%*		
Persons per household	*(See Exhibit 2-2):*	*3.0*		
Projections:				
Direct expenditures	*Expenditure per FTE person:*	*$12,900*	$0.9	$3.7
Indirect & induced	*1.00 multiplier* [3]		$0.9	$3.6
Total			**$1.8**	**$7.3**
Visitors to Oahu:				
From neighbor islands:				
Number of visitors	*Based on share of visitors shown in Exhibit 2-3*		-	*56*
Direct expenditures	*Based on share of revenues shown in Exhibit 2-3*		$0.0	$1.2
Indirect & induced	*1.00 multiplier* [3]		$0.0	$1.2
Total			**$0.0**	**$2.3**
From out-of-State:				
Number of visitors	*Based on share of visitors shown in Exhibit 2-3*		-	*70*
Direct expenditures	*Based on share of revenues shown in Exhibit 2-3*		$0.0	$1.4
Indirect & induced	*1.00 multiplier* [3]		$0.0	$1.4
Total			**$0.0**	**$2.9**

1 For FY2008, Honolulu Metropolitan Statistical Area, as provided by U.S. Department of Housing & Urban Development, HUD USER, as accessed 10/9/08.

2 Based on average spending on local consumption items of 53% of pre-tax income, considering that recent in-migrants may have more on-going obligations or interests outside of the state than do previously established residents. Estimates derived from figures shown in Department of Business, Economic Development and Tourism, State of Hawaii Data Book 2006, "Table 13.25, Average Annual Expenditures and Other Characteristics of Consumer Units, for Honolulu: 2000-2001 to 2004-2005," 2004-2005 figures, excluding shelter and personal insurance and pensions expenditures. DBEDT source references U.S. Bureau of Labor Statistics, Selected Western Metropolitan Statistical Areas: Average annual Expenditures and Characteristics, Consumer Expenditure Survey (annual.)

3 Based on Type II Direct-Effect Multipliers for earnings (less 1.0 each) as shown by industry groups in Appendix 2. New island residents based on all industries shown.

Exhibit 3-2
Industry Coefficients and Multipliers for Development Activities

FINAL DEMAND INDUSTRY COEFFICIENTS[1]

	DBEDT industrial categories applied	Final demand coefficient per $1 million (2002$) project cost: Jobs[2]	FTE factor[3]	$ Earnings[4]
Professional services	*#45-Architectural and engineering services*	10.31	0.80	0.63
Construction:				
Residential units	*#13-SF housing construction, #14-Construction of other buildings*	7.99	0.89	0.40
Light industrial	*#14-Construction of other buildings*	8.41	0.89	0.44
Commercial facilities	*#14-Construction of other buildings*	8.41	0.89	0.44
Tenant improvements	*#14-Construction of other buildings*	8.41	0.89	0.44
Hotel	*#14-Construction of other buildings*	8.41	0.89	0.44
Koa Ridge Medical Center	*#14-Construction of other buildings*	8.41	0.89	0.44
Infrastructure	*#15-Heavy & civil engineering construction*	11.61	0.89	0.86
Other costs	*#42-Real estate, #44-Legal services, #40-Other finance and insurance*	8.55	0.80	0.52

DIRECT-EFFECT INDUSTRY MULTIPLIERS[5]

	DBEDT industrial categories applied	Indirect & induced multiplier per direct: FTE job	$ Earnings[4]
Professional services	*Same as above*	1.03	0.63
Construction:			
Residential units	*Same as above*	1.46	1.12
Light industrial	*Same as above*	1.42	1.05
Commercial facilities	*Same as above*	1.42	1.05
Tenant improvements	*Same as above*	1.42	1.05
Hotel	*Same as above*	1.42	1.05
Koa Ridge Medical Center	*Same as above*	1.42	1.05
Infrastructure	*Same as above*	1.40	0.67
Other	*Same as above*	0.97	1.17

1 For direct impacts of development expenditures. Type I total jobs and earnings direct impact coefficients, from Hawaii State Department of Business, Economic Development & Tourism, "The 2002 State Input-Output Study for Hawaii," June 2006 (revised from May 2006), Detailed Tables. Jobs coefficients are for 2012; earnings coefficients not provided for future years.

2 Input-Output Study estimates total wage, salaried and proprietary jobs, both full- and part-time (not full-time equivalent).

3 Adjustment factor applied in addition to the jobs coefficient to estimate full-time equivalent jobs at 40 hours per week. Factor derived from the 35.6 average weekly hours reported worked in the natural resources, mining and construction industries and 31.8 in professional and business services industries for the State of Hawaii for January 2007 through August 2008, as reported by Hawaii Department of Labor and Industrial Relations, at www.hawaii.gov/labor/rs, "Experimental Series for All Employee Hours and earnings on Private Non-Farm Payrolls," as accessed October 9, 2008.

4 Earnings defined to include wage, salary and proprietary incomes, plus directors' fees and employer contributions to health insurance, less employee contributions to social insurance.

5 For indirect and induced impacts of respective direct impacts. Indirect and induced factors derived from Type II Direct-Effect total job/total job and earnings/earnings multipliers as shown in DBEDT, Ibid, "Job multipliers for 2012-2012" and "2002 Detailed Output, Earnings and Tax Multipliers for Hawaii."

Exhibit 3-3
Estimated Current Development Costs: Total for Each Period
2009 to 2025 (2008 and 2002 dollars, in millions unless stated)

	Basis/reference (not in mils unless stated)	**2009 2015**	**2016 2025**	**Total**
In 2008 dollars:[1]				
Professional services[2]	*C&C, Rider Levett Bucknall; Hospitality Advisors LLC; Architects Hawaii*	$52.2	$44.2	$96.4
Construction -	*Net of contingencies*			
Residential units	*C&C - includes options*	$259	$797	$1,056.3
Light industrial	*$200 per square foot in place as of date*	$0.0	$18.0	$18.0
Commercial facilities[3]	*$224 per square foot in place as of date*	$47.0	$44.8	$91.9
Tenant improvements[4]	*$100 Per square foot industrial & commercial space*	$21.0	$29.0	$50.0
Hotel	*$14.5 million, Hospitality Advisors LLC*	$5.8	$8.7	$14.5
Koa Ridge Medical Center	*Hospital, ambulatory care, skilled nursing, medical offices & central plant*	$226.3	$62.7	$288.9
Infrastructure[5]	*C&C; Rider Levett Bucknall; Architects Hawaii*	$335.2	$247.8	$583.1
Subtotal		$894.7	$1,207.9	$2,102.6
Other	*Home office overhead - C&C; Rider Levett Bucknall*	$15.1	$23.8	$39.0
Total, rounded		**$962.0**	**$1,275.9**	**$2,237.9**
In 2002 dollars:[6]	*72% of 2008 values*			
Professional services		$37.5	$31.7	$69.2
Construction -				
Residential units		$186.4	$572.6	$758.9
Light industrial		$0.0	$12.9	$12.9
Commercial facilities		$33.8	$32.2	$66.0
Tenant improvements		$15.1	$20.8	$35.9
Hotel		$4.2	$6.2	$10.4
Koa Ridge Medical Center		$162.6	$45.0	$207.6
Infrastructure		$240.9	$178.1	$418.9
Other		$10.9	$17.1	$28.0
Total, rounded		**$691.2**	**$916.7**	**$1,607.9**

1 Provided by Castle & Cooke Homes Hawaii, Inc., 2008.

2 Planning, engineering and related for Project infrastructure and commercial and residential pad development; architectural, engineering and related for vertical developments.

3 Based on 2/3 of total commercial development costs estimated at $300 per square foot, with remaining 1/3 allocated to "Infrastructure" to cover commercial areas site infrastructure and pad preparation.

4 Includes developer- and tenant-provided construction budgets. Kapolei area examples for first generation buildouts include office space at $150-170 per square foot, and retail at $150-$250 per square foot, as provided by Colliers Monroe Friedlander, 2007; restaurants minimum $300 per square foot per SL Sofos & Co., Ltd.

5 Covers Project water system (off-site); on-site residential pads, commercial, industrial, hotel and health facility pads with utility installation; private and public parks, and a community center. Excludes park equipment to be donated, school impact fees, sewer and water connection fees and contingencies.

6 Based on Honolulu single-family home construction cost indices as reported by UHERO, "Construction Indicators," 2008 (for 2002-2007); Ibid, "Annual Hawaii Construction Forecast," September 5, 2008 (projected 4.9% construction cost inflation for 2008).

Exhibit 3-4
Estimated Current Development Costs: Average Annual
2009 to 2025 (2008 dollars, in millions)

	Basis/reference	2009 2015	2016 2025	Overall average
Costs by type:	*Exhibit 3-3, annualized*			
Professional services		$7.5	$4.4	$5.7
Construction -				
Residential units		$37.1	$79.7	$62.1
Light industrial		$0.0	$1.8	$1.1
Commercial facilities		$6.7	$4.5	$5.4
Tenant improvements[1]		$3.0	$2.9	$2.9
Hotel		$0.8	$0.9	$0.9
Koa Ridge Medical Center		$32.3	$6.3	$17.0
Infrastructure[2]		$47.9	$24.8	$34.3
Other		$2.2	$2.4	$2.3
Total, rounded		**$137.4**	**$127.6**	**$131.6**

1 Includes developer- and tenant-provided construction budgets.

2 Covers Project water system (off-site); on-site residential pads, commercial, industrial, hotel and health facility pads with utility installation; private and public parks, and a community center. Excludes park equipment to be donated, school impact fees, sewer and water connection fees and contingencies.

Exhibit 3-5
Development Employment, FTE Jobs[1]
2009 to 2025 (Total in each period)

	Basis/reference	2009 2015	2016 2025	Total/ average
Total:				
Direct jobs -	*Exhibits 3-2 and 3-3*			
Professional services		307	260	568
Construction -				
Residential units		1,325	4,072	5,397
Light industrial		0	97	97
Commercial facilities		253	241	494
Tenant improvements[2]		113	156	269
Hotel		31	47	78
Koa Ridge Medical Center		1,217	337	1,554
Infrastructure[3]		2,489	1,840	4,329
Other		74	116	190
Subtotal direct jobs (rounded)		5,800	7,200	13,000
Indirect and induced jobs[4]	*Exhibit 3-2*	8,099	10,148	18,247
Total jobs (rounded)		**13,900**	**17,300**	**31,200**
Average annual:				
Direct jobs -				
Professional services		44	26	33
Construction[2,3]		775	679	719
Other		11	12	11
Subtotal direct jobs (rounded)		**830**	**720**	**760**
Indirect and induced jobs[4]		1,157	1,015	1,073
Total jobs (rounded)		**1,990**	**1,730**	**1,830**

1 FTE = Full time equivalent, defined as 40 hours per week or 2,080 hours per year.

2 Includes employees supported by developer- and tenant-provided construction activities.

3 Covers Project water system (off-site); on-site residential pads, commercial, industrial, hotel and health facility pads with utility installation; private and public parks, and a community center. Excludes park equipment to be donated, school impact fees, sewer and water connection fees and contingencies.

4 Based on weighted average of Direct-Effect jobs multipliers for each job category, as shown on Exhibit 3-2.

Exhibit 3-6
Personal Earnings from Development - Total in Period
2009 to 2025 (2008 dollars, in millions)

	Basis/reference	2009 2015	2016 2025	Total
Direct earnings[1]:	*Exhibits 3-2 & 3-3*			
Professional services		$23.7	$20.1	$43.8
Construction -				
Residential units		$83.7	$257.2	$341.0
Light industrial		$0.0	$6.4	$6.4
Commercial facilities		$16.7	$15.9	$32.6
Tenant improvements[2]		$7.5	$10.3	$17.8
Hotel		$2.1	$3.1	$5.1
Koa Ridge Medical Center		$80.3	$22.3	$102.6
Infrastructure[3]		$232.7	$172.0	$404.7
Other		$5.7	$8.9	$14.6
Subtotal, direct		**$452.3**	**$516.2**	**$968.5**
Indirect and induced earnings[4]		$383.1	$487.3	$870.4
Total earnings		**$835.4**	**$1,003.5**	**$1,838.9**

Note: Earnings defined to include wage, salary and proprietary incomes, plus directors' fees and employer contributions to health insurance, less employee contributions to social insurance.

1 Based on industry coefficients and FTE factors as shown in Exhibit 3-2 and estimated construction costs in 2002 dollars, as shown in Exhibit 3-3. Figures inflated forward to estimated 2008 dollars based on Honolulu CPI-U index from 2002 (first half) to 2008 (first half) dollars, at: 26.2% based on U.S. Department of Labor, Bureau of Labor Statistics, at http://data.bls.gov/PDQ/servlet, as accessed October 9, 2008.

2 Includes earnings supported by developer- and tenant-provided construction activities.

3 Covers Project water system (off-site); on-site residential pads, commercial, industrial, hotel and health facility pads with utility installation; private and public parks, and a community center. Excludes park equipment to be donated, school impact fees, sewer and water connection fees and contingencies.

4 Weighted average of estimated direct earnings by industry as shown above, and Direct-Effect industry multipliers shown in Exhibit 3-2.

Exhibit 3-7
Personal Earnings from Development - Average Annual
2009 to 2025 (2008 dollars, in millions except average earnings)

	Basis/reference	2009 2015	2016 2025	Average
Average annual in period:	*Exhibit 3-6, refers to all jobs*			
Direct earnings		$64.6	$51.6	$57.0
Indirect & induced earnings		$54.7	$48.7	$51.2
Total earnings		**$119.3**	**$100.3**	**$108.2**
Average per new FTE job:	*Exhibits 3-5 and 3-6, rounded*			
Direct jobs		$78,000	$72,000	$74,000
Indirect and induced jobs		$47,000	$48,000	$48,000
Average per job		**$60,000**	**$58,000**	**$59,000**
Estimated average family income[1]:	*1.9 times average wage*			
For direct job-holders		$146,000	$135,000	$139,000
For indirect and induced job-holders		$88,000	$90,000	$90,000
All Project-related job-holders		**$112,000**	**$109,000**	**$111,000**
Percent of median income[2]:	*$77,300 median family income, FY2008*			
For direct job-holders		189%	175%	180%
For indirect and induced job-holders		114%	116%	116%
All Project-related job-holders		**145%**	**141%**	**144%**

Note: Earnings defined to include wage, salary and proprietary incomes, plus directors' fees and employer contributions to health insurance, less employee contributions to social insurance.

1 Ratio estimated from 2007 average annual wage in Honolulu Metropolitan Statistical Area, all occupations ($41,250), as provided by State of Hawaii, Department of Labor & Industrial Relations, and FY 2008 median family income in Honolulu MSA ($77,300), as provided by U.S. Department of Housing & Urban Development, HUD USER. Reflects multiple job-holders within each family as well as multiple job-holding by individuals.

2 U.S. Department of Housing & Urban Development, HUD USER, as accessed October 9, 2008.

Exhibit 3-8
Direct On-Site Operational Employment, FTE Jobs
2015 and 2025

		Basis/reference	2015	2025
Commercial facilities -				
Light industrial	*600*	*square feet RBA per FTE job*	0	150
Commercial retail/office	*425*	*square feet GLA per FTE job*	494	965
Other facilities -				
Hotel		*Hospitality Advisors LLC* [1]	0	30
Koa Ridge Medical Center		*Cattaneo & Stroud, Inc., 2008* [2]		
Hospital & Ambulatory Care Center			490	590
Skilled Nursing & Medical Offices			360	530
Elementary schools[3]	*100*	*FTE positions per school*	100	200
Total on-site jobs, rounded			**1,440**	**2,460**

Note: Excludes Realtors and brokers that may locate on-site, as well as private household maintenance and other assistance, and employees at public or community facilities, such as the parks and community centers.

1 Hospitality Advisors LLC, "Phase III Report for the Koa Ridge Hotel," September 2008. FTE employment estimated at 30 to 35 if hotel is independent, or at 3 to 4 fewer positions if it is affiliated with a management company that provides centralized sales and accounting services.

2 Cattaneo & Stroud, Inc., "Koa Ridge Health Campus: Facilities Planning Forecast 2015-2025," First Draft, 2008.

3 According to Castle & Cooke Homes Hawaii, Inc., the State of Hawaii, Department of Education (DOE) estimates that a 700-student elementary school supports 100 FTE positions, of which 60% would be instructional staff and 40% support staff. These positions are not counted on the "net" impacts shown on the next exhibit because it is assumed that the DOE would develop these schools elsewhere on Oahu even if the Project were not developed.

Exhibit 3-9
Net Additional Operational Employment, FTE Jobs[1]
2015 and 2025 (2008 dollars, in millions)

	Basis/reference		2015	2025
Bases for projection:				
Av. annual spending by new island residents	*Direct, indirect & induced, in state: Exhibit 3-1*		*$1.8*	*$7.3*
Av. annual residential selling costs	*See Exhibit 3-1*			
Sell-out of developer inventory	*2.0%*	*of gross sales, preceding years[2]*	*$2.9*	*$3.7*
Resales	*3.0%*	*Turnover per year[3]*	*$0.3*	*$0.4*
	6.0%	*of gross sales, same av. price*		
Av. annual commercial leasing expenses -	*Listor & outside brokers' commissions plus sales & marketing expenses*			
Initial lease-up	*$2.1*	*mil total, listing & outside agents*	*$0.2*	*$0.1*
Releasing after 2015	*5.0%*	*Turnover per year*	*$0.0*	*$0.0*
Projected net additional jobs:				
Direct -				
Attributable to new island residents[4]	*22.8*	*/$mil, net margin: 35%*	14	58
Real estate leasing & sales	*14.0*	*/$mil selling costs, new and resales*	47	59
Light industrial	*25%*	*assumed new jobs to island, see Ex. 3-8*	0	38
Hotel	*100%*	*assumed new jobs to island, see Ex. 3-8*	0	30
Koa Ridge Medical Center	*50%*	*assumed new jobs to island, see Ex. 3-8*	425	560
Subtotal, direct jobs, rounded			**490**	**740**
Indirect and induced -	*Multiplier and industry category applied[5]:*			
Attributable to new island residents[4]	*1.08*	*Average of select industries*	15	63
Real estate leasing & sales	*1.91*	*Real estate & rentals industries*	90	113
Light industrial	*0.91*	*Average of select industries*	0	34
Hotel	*1.06*	*Accommodations industry*	0	32
Koa Ridge Medical Center	*0.91*	*Health services industry*	387	510
Subtotal, indirect & induced jobs, rounded			490	750
Total net additional jobs			**980**	**1,490**

1 FTE = Full time equivalent, defined as 40 hours per week or 2,080 hours per year.

2 Represents 2% inside commissions; no outside commissions.

3 Resales activity assumed at 3.0% of completed and sold residential inventory shown in Exhibit 2-1. Resales factor considers 2004 Oahu recorded sales of 12,590 resales vs. estimated 300,000 housing units (4.2%); 2006 ratio of 10,421 resales among approximately 332,700 housing units (3.1%); and 2007 ratio of 9,126 resales among approximately 334,800 housing units (2.7%) : Honolulu Board of Realtors and American Community Survey. Commissions and other selling costs estimated at rate shown and average prices shown in Exhibit 2-1.

4 Category addresses commercial impact, including shopping center and office operational employment, since net additional employment is largely considered a function of induced new spending on-island, not leasable area to be developed at the Project. Also spending by existing island residents, such as at the commercial centers to be developed, is assumed to have occurred elsewhere on-island even if the Project were not developed.
Retail spending subject to reduction by 35% assumed retail trade margin prior to application of weighted average Type II jobs multiplier shown in Appendix 2.
This results in conservative estimates since DBEDT multipliers for many applicable industry categories such as services, agriculture, food processing & etc. are calculated assuming they will be applied to total expenditures rather than trade margin expenditures.

5 Based on Type II Direct-Effect Multipliers for employment (less 1.0 each) as shown by industry groups in Appendix 2. New island residents based on all industries shown.

Exhibit 3-10
Personal Earnings from Net New Operational Activity - Total Annual
2015 and 2025 (2008 dollars, in millions except where noted)

	Basis/reference (not in millions)		2015	2025
Direct earnings -	*Estimated average FTE salary or other basis[1]:*			
Attributable to new island residents[2]	*$42,800*	*Average Honolulu wage*	$0.6	$2.5
Av. annual commercial leasing -	*Residential & commercial properties, Ex. 3-9*			
Initial lease-up			$0.2	$0.1
Releasing after 2015			$0.0	$0.0
Real estate sales & marketing -	*Residential & commercial properties, Ex. 3-9*			
Sell out of developed inventory			$3.1	$3.8
On-going resales after 2012			$0.3	$0.4 `
Light industrial	*$57,800*	*average wage, select industries*	$0.0	$2.2
Hotel	*$39,900*	*average wage, hotels & motels*	$0.0	$1.2
Koa Ridge Medical Center	*$64,200*	*Cattaneo & Stroud[3]*	$27.3	$36.0
Subtotal, direct earnings			**$31.5**	**$46.2**
Indirect and induced earnings -	*Multiplier and industry category[4]:*			
Attributable to new island residents[2]	*1.00*	*Average of select industries*	$0.6	$2.5
Real estate leasing and sales	*3.07*	*Real estate & rentals industries*	$11.1	$13.4
Light industrial	*0.75*	*Average of select industries*	$0.0	$1.6
Hotel	*0.90*	*Accommodations industry*	$0.0	$1.1
Koa Ridge Medical Center	*0.71*	*Health services industry*	$19.4	$25.5
Subtotal, indirect & induced			$31.0	$44.1
Total earnings			**$62.5**	**$90.3**

Notes: Earnings defined to include wage, salary and proprietary incomes, plus directors' fees and employer contributions to health insurance, less employee contributions to social insurance. They would not include tips. The figures shown are considered conservative in that only wage data is available for the "new island resident," light industrial and hotel employment categories.

Exhibit portrays on those earnings on positions that would be new to the community; not on all employment associated with Project.

1 Average Honolulu salary based on $40,784 reported for 2007 by Department of Labor and Industrial Relations, "Employment and Wages of Workers covered by Hawai`i Employment Security Law and Unemployment compensation for Federal Employees Classified by Industry for Calendar Year 2007" as accessed October 20, 2008; inflation to 2008 dollars based on Honolulu CPI-U for first half 2008 vs. first half 2007. Considered conservative because it incorporates no adjustment to FTE work.

2 Includes employment at all commercial facilities statewide, as supported by new resident spending.

3 Cattaneo & Stroud, Inc., "Koa Ridge Health Campus: Facilities Planning Forecast 2015-2025," First Draft, 2008.

4 Based on Type II Direct-Effect Multipliers for earnings (less 1.0 each) as shown by industry groups in Appendix 2. New island residents based on all industries shown.

Exhibit 3-11
Personal Earnings from Net New Operational Activity - Average Per Job and Family
2015 and 2025 (2007 dollars)

	Basis/reference	2015	2025
Average earnings per new FTE job:	*Not in millions*		
Direct jobs		$64,000	$62,000
Indirect and induced jobs		$63,000	$59,000
Average per job		**$64,000**	**$61,000**
Estimated average family income[1]:	*1.9 times average wage; not in millions*		
For direct job-holders		$121,000	$118,000
For indirect and induced job-holders		$119,000	$112,000
All Project-related job-holders		**$121,000**	**$116,000**
Percent of median income[2]:	*$77,300 median family income, 2008*		
For direct job-holders		157%	153%
For indirect and induced job-holders		154%	145%
All Project-related job-holders		**157%**	**150%**

Note: Exhibit portrays on those earnings on positions that would be new to the community; not on all employment associated with the Project.

Earnings defined to include wage, salary and proprietary incomes, plus directors' fees and employer contributions to health insurance, less employee contributions to social insurance.

1 Ratio estimated from CY 2007 average annual wage in Honolulu County ($40,784), as provided by State of Hawaii, Department of Labor & Industrial Relations, and FY 2008 median family income in Honolulu MSA ($77,300), as provided by U.S. Department of Housing & Urban Development, HUD USER. Reflects multiple job-holders within each family as well as multiple job-holding by individuals.

2 U.S. Department of Housing & Urban Development, HUD USER.

Exhibit 4-1
Average Daily In-Migrant Population
2015 and 2025

	Basis/reference	2015	2025
New island residents at Project:			
Average FTE persons in residence	*At new island resident units: Exhibit 2-2*	68	284
In-migrants to State (rounded)	*65% of FTE persons in residence*	40	180
In-migrants to Co. (rounded)[1]	*100% of FTE persons in residence*	70	280
Employees:			
In-migrants to the State[1] -	*(Subset of in-migrants to County)*		
Development employees	*3% of direct av. annual jobs (Ex. 3-5)*	25	22
Direct operational employees	*5% of net jobs generated (Exhibit 3-9)*	25	37
Dependents[2]	*Ratio of in-migrant employees*	30	40
In-migrants to State (rounded)[3]		80	100
In-migrants to County[3] -	*(Includes in-migrants to State)*		
Development employees	*5% of direct av. annual jobs (Ex. 3-5)*	42	36
Operational employees	*7% of net jobs generated (Exhibit 3-9)*	34	52
Dependents[2]	*Ratio of in-migrant employees*	40	60
In-migrants to County (rounded)[3]		120	150
Total in-migrants:	*Those attracted by residences plus those attracted by employment*		
To State		**120**	**280**
To County		**190**	**430**

1 Subset of County in-migrants. See footnote 3, below.

2 In-migrant dependents estimated to average 0.2 per in-migrant development employee, and 1.0 per in-migrant operational employee.

3 In-migrants to the County include all those moving to the State plus any that may move between islands due to job opportunities at the Project.

Exhibit 5-1
Real Property Taxes Generated by Development
2015 and 2025 (2008 dollars, in millions except as noted)

	Basis/reference (not in millions)		2015	2025
Total assessed values[1]:				
Improved residential	*Based on number sold by average price (Ex. 2-1)*		$578.4	$2,410.0
Unimproved residential	*Estimated assessed value per acre:*	*$212,000*	$48.3	$0.0
Light industrial - land	*5 acres, @ per acre:*	*$1,000,000*	$5.0	$5.0
Light industrial - improvements	*Vert. cost + 2015 share of TI @*	*18%*	$0.0	$23.2
Commercial - land	*46 acres, @ per acre:*	*$1,150,000*	$52.9	$52.9
Commercial - improvements	*Vert. cost + 2015 share of TI @*	*82%*	$68.0	$115.6
Hotel - land	*2 acres, @ per acre:*	*$1,150,000*		
Hotel - improvements	*Vertical cost (Ex. 3-3)*		$5.8	$14.5
Koa Ridge Medical Center	*Assumed exempt*		$0.0	$0.0
Parks, recreation center & other[2]	*Not estimated*		$0.0	$0.0
Total assessed values			**$758.5**	**$2,621.2**
Real property tax revenues:				
Potential new revenues -	*FY 2008 rates per $1,000 net taxable value*			
Improved residential	*$3.29*	*Improved Residential*	$1.9	$7.9
Unimproved residential	*$3.29*	*Unimproved Residential*	$0.2	$0.0
Light industrial - land	*$12.40*	*Industrial*	$0.1	$0.3
Light industrial - improvements	*$12.40*	*Industrial*	$0.0	$0.9
Commercial - land	*$12.40*	*Commercial*	$0.7	$0.7
Commercial - improvements	*$12.40*	*Commercial*	$0.8	$1.4
Hotel - land	*$12.40*	*Hotel*	$0.0	$0.0
Hotel - improvements	*$12.40*	*Hotel*	$0.1	$0.2
Koa Ridge Medical Center	*$0.00*	*Assumed exempt*	$0.0	$0.0
Parks & open spaces	*$0.00*	*Not estimated*	$0.0	$0.0
Subtotal, potential tax revenues			$3.7	$11.5
Less deductions -				
RPT payments prior to Project	*$7,408*	*FY 2008, per C&C*	$0.0	$0.0
Homeowners' exemption[3]	*$88,000*	*/unit, primary residences (Ex. 2-2)*	$0.3	$1.4
Subtotal deductions			$0.3	$1.4
Estimated net additional RPT			**$3.3**	**$10.1**

TI - Tenant improvements; RPT - real property tax

Note: Figures exclude real property tax impacts of public facility lands such as schools, parks and roads presumed to be dedicated but not taxed.

1 Tax assessed values for unimproved lands based on other lands of same classification held by C&C in Mililani Mauka. Undeveloped residential areas estimated pro rata based on the number of units sold and total of: 300 acres, for a total land value of: $63.60 million. Estimate is considered conservative because these lands include areas expected to be designated mixed-use, which could result in higher applicable tax rates.

2 Taxes on parks, recreation center, schools and open spaces not estimated as they are assumed to be exempt (if publicly owned) and/or taxed at a minimal level.

3 Assumes 20% of households at $120,000 exemption, and 80% at $80,000 exemption. Note methodology may overstate exemptions/understate tax revenues, since by 2013, some 17% of Central Oahu area households could be headed by persons 65 or older (Claritas, Inc., 2008.) Exemption levels as stated in City and County of Honolulu, "Real Property Assessment Exemption Information," as accessed October 23, 2008

Exhibit 5-2
Total Annual Revenues to County Government
Attributable to Development & In-Migrant Population
2015 and 2025 (2008 dollars, in millions, except as noted)

	Basis/reference (not in millions)		2015	2025
Bases for projection:				
FTE in-migrants to County -		*Exhibit 4-1*		
Project new island residents			*70*	*280*
Employees and their dependents			*120*	*150*
GET County surcharges		*Spending as shown in Exhibit 5-3*		
Estimated tax and other revenues:				
Net new property tax revenues		*Exhibit 5-1*	$3.3	$10.1
Taxes and other revenue sources		*Other than real property taxes*		
from in-migrant residents[1]	*$216*	*per person (residents + employees)*	$0.0	$0.1
Transient accommodations tax[2]	*19.8%*	*of total TAT collections (see 5-2 and 5-3)*	$0.0	$0.1
General excise taxes, on -		*County GET surcharges only*		
Development	*0.5%*	*of professional service and construction costs*	$0.7	$0.6
Real estate sales and marketing	*0.5%*	*of costs*	$0.0	$0.0
Hotel revenues	*0.5%*	*of all revenues (Ex. 2-3)*	$0.0	$0.0
Spending by Project's new island residents	*0.5%*	*of spending*	$0.0	$0.0
Spending by in-migrants to State	*0.5%*	*of employee & dependent spending*	$0.0	$0.0
Total new County revenues			**$4.1**	**$11.0**

Note: Does not consider impact, connection and permit fees paid to County, including building permits, sewer, water system, water meter and other fees and permits, as well as any applicable impact fees. After 2025, revenues would be less than shown for 2025 due to the decline of development activity thereafter.

1 Includes fuel and motor vehicle weight taxes, licenses and permits and charges for services. Excludes forfeitures, fines and penalties, public utility franchise tax, transient accommodation taxes, public service company tax, sewer charges, bus transportation revenues, solid waste & other revenues. As stated in City and County of Honolulu, "The Executive Program and Budget: Fiscal Year 2008 - Volume 1 - Operating Program and Budget," 2007 (summary of resources by source.)

2 Based on Honolulu County share of 44.1% of the 44.8% of the TAT revenues that are distributed among the four counties, per State tax policies as accessed October 24, 2008 at http://www.capitol.hawaii.gov/hrscurrent/Vol04_Ch0201-0257/HRS0237D/HRS_0237D-0006_0005.htm

Exhibit 5-3
Bases for Projecting State Government Revenues
2015 and 2025 (2008 dollars, in millions, except as noted)

	Basis/reference		2015	2025
For GET calculations:				
Project development costs -	*Exhibit 3-4, average annual for preceding period*			
Professional services			$7.5	$4.4
Construction and other			$130.0	$123.2
Subtotal development cost			$137.4	$127.6
Real estate sales & marketing costs -	*Based on average activity in prior 5 years*			
Residential	*New and resold units, Exhibit 3-9*		$3.2	$4.1
Commercial	*Leasing revenue, Exhibit 3-9*		$0.2	$0.1
Total			$3.4	$4.2
Spending by new island residents	*In-State spending: Exhibit 3-9*		$1.8	$7.3
Spending by in-migrant employees & dependents to State -				
Number persons	*Exhibit 4-1, employment impact only*		80	100
Estimated number households	*2.5 persons per household*		32	40
In-State spending by hhds[1]	*58% of average of earnings per development and operational job (below)*		$1.2	$1.4
Hotel, all revenues	*Exhibit 2-3*		$0.0	$5.7
For transient accommodation tax:				
Hotel room revenues	*Exhibit 2-3*		$0.0	$5.6
Total TAT collected	*7.25% of room revenues*		$0.0	$0.4
For individual income taxes:				
Net new personal income earned -	*Average annual in preceding period*			
Development employment	*Exhibit 3-7 (total personal earnings)*		$119.3	$100.3
Operational employment	*Exhibit 3-10 (total personal earnings)*		$62.5	$90.3
Av. personal earnings/FTE job -				
Development employment	*Exhibit 3-7 (total personal earnings)*	*Not in millions >>*	$60,000	$58,000
Operational employment	*Exhibit 3-10 (total personal earnings)*	*Not in millions >>*	$64,000	$61,000
For other State taxes:				
FTE in-migrants to State	*FTE new island residents & established island residents: Exhibit 4-1*		120	280

Note: Does not consider impact or permit fees paid to State, if any.

1 U.S. Department of labor, Bureau of Labor Statistics, "Consumer Spending Patterns in Honolulu: 2001-02", released April 30, 2004 at www.bls.gov/ro9/cexhono.htm. Estimate uses study findings showing 77.6% of pre-tax income of household units was spent, of which 75.1% were on items likely subject to Hawaii Gross Excise Tax. Excludes spending on shelter (owned dwellings), cash contributions, personal insurance and pensions. Applied to estimated in-migrant households and average of personal earnings for 2015 and 2025 for operational employees, as shown. Excludes potential household income from other household members.

Exhibit 5-4
Projected State Government Revenues
2015 and 2025 (2008 dollars, in millions, except as noted)

	Basis/reference (not in millions)			2015	2025
General excise taxes, on:	*County GET surcharges accounted for on Ex. 5-2*				
Development[1]				$3.7	$3.4
Real estate sales and marketing	*4.0%*	*of costs*		$0.1	$0.2
Hotel revenues	*4.0%*	*of revenues*		$0.0	$0.2
Spending by Project's new island residents	*4.0%*	*of spending*		$0.1	$0.3
Spending by in-migrants to State	*4.0%*	*of employee & dependent spending*		$0.0	$0.1
Transient accommodations tax, on:					
Hotel revenues	*55.2%*	*State share of total collections*[2]		$0.0	$0.2
Individual income taxes[3]:					
Development employees	*4.9%*	*effective tax rate on av. family AGI*		$5.8	$4.9
	estimated at	*$83,000*	*based on Ex.3-7*		
Operational employees	*4.9%*	*effective tax rate on av. family AGI*		$3.1	$4.5
	estimated at	*$87,000*	*based on Ex.3-11*		
Other taxes and revenues from in-migrants[4]	*$228*	*per person*		$0.0	$0.1
Total, additional revenues				**$12.8**	**$13.7**

Note: Does not consider impact or permit fees paid to State, if any. After 2025, revenues would be less than those shown for 2025 due to the decline of development activity thereafter.

1 Based on 4% on 100% of professional services and 60% of construction costs, plus a wholesale construction materials tax of 0.5% against 40% of construction costs.

2 Based on State tax policies as accessed October 24, 2008 at http://www.capitol.hawaii.gov/hrscurrent/Vol04_Ch0201-0257/HRS0237D/HRS_0237D-0006_0005.htm

3 Based on average family incomes for all Project-related job holders as shown previously, and on 2007 Tax Table, Schedule II for married taxpayers filing joint returns. Adjusted Gross Incomes (AGI) assumed to be 25% less than total average family earnings, considering potential deductions.

4 Based on total FY 2007 State tax revenue receipts as reported by State of Hawaii, "Comprehensive Annual Financial Report for the Fiscal Year Ended June 30, 2007," statement of activities-general revenue taxes. Includes tobacco and liquor taxes, liquid fuel tax, and motor vehicle weight & registration tax. Excludes fines & forfeitures, licenses, franchise tax, rental motor vehicle surcharge tax, public service companies tax, tax on premiums of insurance companies and other fees.

Exhibit 5-5
City and County of Honolulu Governmental Expenditures
Net of Intergovernmental Revenues (State and Federal)
Per Capita in Fiscal Year July 1, 2006 to June 30, 2007

	Expenditures ($thousands)	Service population[1]	Expenditures (not in thousands) per: Resident	Visitor
Executive:				
General Government	$141,459	994,800	$142	$142
Public Safety	$306,161	994,800	$308	$308
Highways and Streets	$21,000	994,800	$21	$21
Sanitation	$2,674	994,800	$3	$3
Human Services	$60,883	906,200	$67	$0
Culture-Recreation	$71,084	994,800	$71	$71
Utilities or Other Enterprises	$22,917	994,800	$23	$23
Debt Service (principal and interest)	$206,663	994,800	$208	$208
Retirement and health benefits	$137,615	906,200	$152	$0
Miscellaneous	$22,832	994,800	$23	$23
Capital Outlays	$187,001	906,200	$206	$0
Subtotal	$1,180,289		$1,224	$799
Proprietary funds:				
Housing	$5,363	906,200	$6	$0
Sewer	$76,742	906,200	$85	$0
Solid Waste	$118,208	906,200	$130	$0
Public Transportation System	$166,094	906,200	$183	$0
Subtotal	$366,407		$404	$0
Total, in 2007 dollars	**$1,546,696**		**$1,629**	**$799**
Total, in 2008 dollars, based on increase of[2]		4.9%	**$1,709**	**$838**

1 Resident population for January 1, 2007 estimated based on data from the U.S. Census Bureau, Population Division, as reported by State of Hawai`i, Department of Business, Economic Development and Tourism (January 1 population estimated based on average of July 1, 2006 to July 1, 2007 estimates); average daily visitor population based on Hawaii State Department of Business, Economic Development and Tourism, Research & Economic Analysis Division, "Annual Visitor Research Report," data for 2006 and 2007.

2 Based on 1st half 2008 vs. 1st half 2007 Honolulu CPI-U, as reported by U.S. Department of Labor, Bureau of Labor Statistics at http://data.bls.gov, accessed October 2008.

Source: City and County of Honolulu, "Comprehensive Annual Financial Report Fiscal Year Ended June 30, 2007," January 17, 2008.

Exhibit 5-6
State of Hawai`i Government Expenditures
Net of Intergovernmental Revenues (Federal)
Per Capita in Fiscal Year July 1, 2006 to June 30, 2007

	Operating expenditures ($thousands)	Service population[1]	Expenditures (not in thousands) per: Resident	Visitor
Governmental activities:				
General government	$458,236	1,470,400	$312	$312
Public safety	$376,032	1,470,400	$256	$256
Highways	$337,862	1,470,400	$230	$230
Conservation of natural resources	$107,578	1,470,400	$73	$73
Health	$832,333	1,470,400	$566	$566
Welfare	$1,770,707	1,281,000	$1,382	$0
Lower education	$2,305,280	1,281,000	$1,800	$0
Higher education	$759,777	1,281,000	$593	$0
Other education	$20,122	1,281,000	$16	$0
Culture and recreation	$92,574	1,470,400	$63	$63
Urban redevelopment and housing	$170,614	1,281,000	$133	$0
Economic development and assistance	$147,146	1,281,000	$115	$0
Other	$7,248	1,281,000	$6	$0
Debt service	$502,733	1,470,400	$342	$342
Less: Intergovernmental revenues	($1,727,895)	1,470,400	($1,175)	($1,175)
Subtotal	$6,160,347		$4,711	$666
Business-type activities:				
Airports	$210,215	1,470,400	$143	$143
Harbors	$46,180	1,470,400	$31	$31
Unemployment compensation	$112,411	1,281,000	$88	$0
Nonmajor proprietary fund	$5,017	1,470,400	$3	$3
Less: Federal grants to Airports Division	($19,983)	$1,470,400	($14)	($14)
Subtotal	$353,840		$252	$164
Total, in 2007 dollars	**$6,514,187**		**$4,962**	**$830**
Total, in 2008 dollars, based on increase of[2]		4.9%	**$5,208**	**$871**

Note: General government includes legislative expenses; line items may also have debt service and employee benefit expenses within each. Excludes expenses of "Component Units" including the University of Hawaii, Housing and Community Development Corporation of Hawaii, Hawaii Health Systems Corporation and Hawaii Hurricane Relief Fund. The first three charge for services, and receive capital and operating grants and contributions.

1 Resident population for January 1, 2007 estimated based on data from the U.S. Census Bureau, Population Division, as reported by State of Hawai`i, Department of Business, Economic Development and Tourism (January 1 population estimated based on average of July 1, 2006 to July 1, 2007 estimates); average daily visitor population based on Hawaii State Department of Business, Economic Development and Tourism, Research & Economic Analysis Division, "Annual Visitor Research Report," data for 2006 and 2007.

2 Based on 1st half 2008 vs. 1st half 2007 Honolulu CPI-U, as reported by U.S. Department of Labor, Bureau of Labor Statistics at http://data.bls.gov, accessed October 2008.

Source: State of Hawaii, Department of Accounting and General Services, "State of Hawaii: Comprehensive Annual Financial Report For the Fiscal Year Ended June 30, 2007," May 7, 2008.

Exhibit 5-7
Annual County Government Expenditures
Attributable to Visitors and Population In-Migrating
2015 and 2025 (2008 dollars, in millions, except where noted)

	Basis/reference (not in millions)			2015	2025
Bases for County projection -					
FTE in-migrants to County	*New island residents, employees and dependents (Ex. 4-1)*			*190*	*430*
Visitors from off-island	*Exhibit 2-3*			*-*	*127*
Annual expenditures -					
FTE in-migrants to County	*$1,709*	*per person, ref:*	*Exhibit 5-5*	$0.3	$0.7
Visitors from off-island	*$838*	*per person, ref:*	*Exhibit 5-5*	$0.0	$0.1
Subtotal new County expenditures				**$0.3**	**$0.8**

Note: Does not consider applicable impact, connection and permit fees to be paid to County, including building permit, sewer, water system, water meter and other fees and permits.

Exhibit 5-8
Annual State Government Expenditures
Attributable to Population In-migrating
2015 and 2025 (2008 dollars, in millions, except where noted)

	Basis/reference (not in millions)	2015	2025
Bases for State projection -			
FTE in-migrants to State	*New island residents, employees and dependents (Ex. 4-1)*	*120*	*280*
Visitors from out-of-State	*Exhibit 2-3*	*-*	*70*
Annual expenditures -			
FTE in-migrants to State	*$5,208 per FTE person, ref: Exhibit 5-6*	$0.6	$1.5
Visitors from out-of-State	*$871 per FTE person, ref: Exhibit 5-6*	$0.0	$0.1
Subtotal new State expenditures		**$0.6**	**$1.5**

Note: Does not consider impact or permit fees paid to State, if any.

Exhibit 5-9
County & State Government Revenue and Expenditure Comparison
2015 and 2025 (2008 dollars, in millions)

	Basis/reference	2015	2025
City and County of Honolulu:			
New revenues	*Exhibit 5-2*	$4.1	$11.0
New expenditures	*Exhibit 5-7*	$0.3	$0.8
Net additional revenues		$3.8	$10.1
Revenue ÷ expenditure ratio[1]		**12.6**	**13.0**
State of Hawaii:			
New revenues[2]	*Exhibit 5-4*	$12.8	$13.7
New expenditures	*Exhibit 5-8*	$0.6	$1.5
Net additional revenues		$12.2	$12.3
Revenue ÷ expenditure ratio[1]		**20.6**	**9.4**

N/A - Not applicable.

Note: After 2025, government operating revenues would be lower than those shown for 2025, and this would lead to lower revenue/expenditure ratios. See report text for further discussion. Analyses do not consider applicable impact, connection and permit fees to be paid to County and State governments. These could include building permit, sewer, water, transportation and other fees and permits.

1 New revenues divided by new expenditures. Calculated where denominator (additional expenses) exceeds zero.

2 Excludes potential income taxes from any operating entities and GET on ground lease rents.

ECONOMIC AND FISCAL IMPACT ASSESSMENT FOR KOA RIDGE MAKAI AND WAIAWA

Appendices

Appendix 1: Report Conditions

This assessment incorporates information provided by government agencies, developers, brokers, landowners, C&C, HHF, and other sources as cited in the exhibits. While attempts have been made to verify information via multiple sources, it is not always possible to do so. Mikiko cannot guarantee the accuracy of all information upon which its assessments may be based.

Mikiko has no responsibility to update this report or any of the underlying data for events and circumstances occurring after October 10, 2008, the date of substantial completion of primary data collection.

This report is for the planning purposes of C&C, HHF and their consultants, as well as for public disclosure of the nature of the Project pursuant to seeking State and County land entitlements. It is not intended to be used for solicitation of investment.

This report does not offer an appraisal of the Subject, nor should it be construed as an opinion of value for the Project.

Appendix 2: Multipliers for Select Industries

	Type II final demand multipliers		Type II direct effect multipliers (for indirect & induced impacts)	
	Earnings	Job	Earnings	Job
Agriculture	0.66	36.6	1.77	1.44
Mining & Construction	0.65	19.70	1.79	2.23
Food processing	0.51	21.6	3.05	3.05
Other manufacturing	0.34	10.2	1.97	2.36
Transportation	0.57	17.7	2.26	2.55
Information	0.52	13.6	1.71	2.15
Utilities	0.33	8.2	2.38	4.17
Wholesale trade	0.55	17.1	1.76	1.96
Retail trade	0.57	24.4	1.69	1.51
Real estate & rentals	0.22	9.1	4.07	2.91
Professional services	0.81	23.3	1.69	1.97
Business services	0.83	30.9	1.69	1.62
Educational services	0.83	33.2	1.70	1.57
Health services	0.77	24.1	1.71	1.91
Arts & entertainment	0.77	37.4	1.59	1.38
Accommodations	0.63	20.0	1.90	2.06
Eating & drinking	0.60	30.5	1.99	1.54
Other services	0.69	30.7	1.80	1.54
Government	0.85	24.7	1.40	1.54
Average	**0.62**	**22.8**	**2.00**	**2.08**

Source: State of Hawaii, Department of Business, Economic Development and Tourism, "The 2002 State Input-Output Study for Hawaii," June 2006 (as revised from May 2006), Table 2.4.

H | Agricultural Impact Assessment

KOA RIDGE MAKAI:
IMPACT ON AGRICULTURE

Decision Analysts Hawai'i, Inc.

KOA RIDGE MAKAI:
IMPACT ON AGRICULTURE

PREPARED FOR:

Castle & Cooke Homes Hawai'i, Inc.

PREPARED BY:

Decision Analysts Hawai'i, Inc.

April 2008

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Executive Summary

1. Proposed Development

Castle & Cooke Homes Hawai'i, Inc. proposes to develop Koa Ridge Makai, a master planned community in Central O'ahu referred to in this report as "the Project." The Project will cover 575 acres and, at full development, will include: about 3,500 residential units, medical and healthcare facilities, commercial and industrial space, community facilities, a school, parks, and open space.

2. Agricultural Conditions

About 430 acres of the Project area has arable land suitable for growing low-elevation crops. The fields have favorable soil conditions and soil ratings, the terrain is gently sloping, the climate is mild and sunny, and access is good. A water allocation of 1.1 million gallons per day from Waiahole Ditch is sufficient to irrigate about 314 acres of land in diversified crops.

3. Impact on Aloun Farms

a. Operations

Since 2002, Aloun Farms has leased 446 acres at Koa Ridge Makai, of which about 430 acres are arable and about 325 acres are farmed. The land is used to grow leafy vegetables for the Honolulu market and, in Spring, seed corn for export. In total the company farms a total of about 2,440 acres on leased land, most of which is on the 'Ewa Plain. They are the second largest diversified crop farm in Hawai'i, have their own cooling plant, and supply both Hawai'i and overseas markets.

The Koa Ridge Makai lands are farmed more intensively than other lands leased by Aloun Farms: on average, about half the lands at Koa Ridge Makai are in crop versus about one-third in crop for most of the remaining lands. As a result, the estimated 34 field, packing and other jobs provided by the farm operations on the Koa Ridge Makai lands are about 24% of the total jobs at Aloun Farms, even though the leased acreage amounts to about 18% of the total.

b. Replacement Lands for Koa Ridge Makai

In order to replace the land lost to the Project and to allow an orderly transition to new fields, Castle & Cooke Homes Hawai'i has arranged for Dole Food Company Hawai'i to issue a license to Aloun Farms for about 335 acres of former pineapple land located north of the Dole Plantation. The license will be issued in late 2008, and the transition from Koa Ridge to the replacement fields should occur by early 2010.

The replacement land will allow Aloun Farms to grow the same crops and maintain about the same production, revenues, operating costs, delivery costs, employment and payroll as would occur at Koa Ridge Makai. However, some adjustments in varieties and cultivation practices might be required due to slightly different agronomic conditions (e.g., soils, temperature, solar radiation, and rainfall). Also, Aloun Farms could incur additional expenditures to prepare the soils and irrigation systems for their particular crops.

Because of the replacement lands that are being made available, development of Koa Ridge Makai will not have a significant impact on the operations of Aloun Farms.

c. Mitigating Measures

Inasmuch as farm land will be made available to replace those lost to the Project, no additional mitigating measures are recommended.

4. GROWTH OF DIVERSIFIED CROPS

a. Recent Crop-acreage Trends

For all diversified crops—i.e., all crops other than sugarcane and pineapple, including crops to replace imports and crops for export—Statewide land requirements grew as shown in Figure ES-1. As illustrated, growth in acreage has slowed over time, with an average growth of about 160 acres per year from 2000 to 2005. During this same period, the major growth in acreage for diversified crops came from just two crop categories: seed crops (264 acres per year) and flowers/nursery products (235 acres per year). For crops grown for the Hawai'i market, acreage declined by an average of 190 acres per year.

b. Potential Acreage Required to Relocate Farm

In addition to farm land that will be required to accommodate the growth of diversified farming, about 3,600 acres could be required to relocate all or portions of four existing farms that will or could be displaced from Koa Ridge Makai, 'Ewa, and lower Kunia due to urban development and to changes in agricultural uses (e.g., seed corn replacing diversified crop farming).

c. Land Available for Diversified Crops

Statewide

Statewide, a vast amount of land has been released from plantation agriculture: about 251,800 acres between 1968 and 2005, resulting in an average release of over 6,800 acres per year over a 37-year period (see Figure ES-1). The 2006 Del Monte closure in Kunia increased this figure by another 4,400 acres, resulting in a total release of at least 256,200 acres from plantation agriculture between 1968 and 2007. Over the 1968-to-2005 period, the demand for land for diversified crops increased by about 26,300 acres (about 10% of the land released from plantation agriculture).

The acreage released from plantation agriculture has far outpaced the demand for land for diversified crops. The net decrease of land in crop amounts to about 229,900 acres. While some of the released land has been converted or is scheduled to be converted to urban uses and tree plantations, an estimated 160,000+ acres remain available for diversified crops.

O'ahu

On O'ahu, a similar release of plantation land occurred. In total, about 10,900 acres of former high-quality plantation land remain available for other crops, including about 3,150 acres of former pineapple land in Kunia plus about 7,750 acres of former sugarcane and pineapple lands on the North Shore.

However, portions of the available 10,900 acres have limitations for growing certain crops. Some limitations reflect permanent agronomic conditions. For example, higher elevation fields in Kunia and on the North Shore have less solar radiation compared to 'Ewa. But some of the limitations can be overcome with investment in improvements. On the North Shore, parts of the water delivery systems need major repairs and upgrades, and the types of crops on fields irrigated with water from Wahiawa Reservoir (Lake Wilson) will be restricted as long as partially-treated wastewater continues to be discharged into the lake.

d. Impact on the Growth of Diversified Crops

The Project will commit about 430 acres of arable land to a non-agricultural use. In view of the available supply of farm land (160,000+ acres Statewide and about 10,900 acres of high-quality land on O'ahu), the development of this agricultural land—combined with the other planned developments in Hawai'i—involves the loss of too little agricultural land to significantly affect either (1) the growth of diversified crop farming (averaging about 160 acres per year), or (2) the relocation of farms that are being displaced or could be displaced from Central O'ahu, 'Ewa and lower Kunia (about 3,600 acres).

e. Mitigating Measures

In view of the negligible impact of the Project on the growth of diversified agriculture in Hawai'i, mitigating measures for the loss of this agricultural land are not recommended.

However, recommendations are directed to the City and to the Army to upgrade their wastewater treatment plants in Central O'ahu so that the water they discharge into the Wahiawa Irrigation System meets the State's R-1 water-quality standard. Until the quality of the discharge water is improved, most of the available agricultural land on the North Shore cannot be used to grow the types of vegetable crops the farmers grow in Central O'ahu and 'Ewa. Thus, agricultural operations that will be displaced by various development projects may not be able to fully relocate to the North Shore until the improvements are made.

5. OFFSETTING BENEFITS

The Project will result in the loss of 430 acres of arable land which currently provides about 34 agricultural jobs. In practice, however, the Project will result in little or no loss of existing or potential agricultural activity since other lands are available for farming, and suitable replacement lands have been secured for the Aloun Farms operations at Koa Ridge.

This potential loss to agriculture will be offset by the following benefits:

— about 3,500 new homes

— regional medical facilities and services

— over 1,800 jobs at full development of the project

6. CONSISTENCY WITH STATE AND CITY POLICIES

a. Availability of Lands for Agriculture

The *Hawaii State Constitution*, the *Hawaii State Plan*, the *State Agriculture Functional Plan*, and the *General Plan of the City and County of Honolulu* call directly or implicitly for preserving the economic viability of plantation agriculture and promoting the growth of diversified crops. To accomplish this, an adequate supply of agriculturally suitable lands and water must be assured.

With regard to plantation agriculture, development of the Project will have no impact on pineapple operations since Dole no longer grows pineapple in Central O'ahu.

With regard to diversified crops, development of the Project Area will result in a loss of about 430 acres of arable land, but this loss will not limit the growth of diversified crops since ample agricultural land is available on O'ahu and on other islands. This is due to the enormous supply of agricultural land that is now available following the contraction of plantation agriculture (see Figure ES-1).

b. Conservation of Agricultural Lands

In addition to the above, State policies call for conserving and protecting prime agricultural lands, including protecting agricultural lands from urban development.

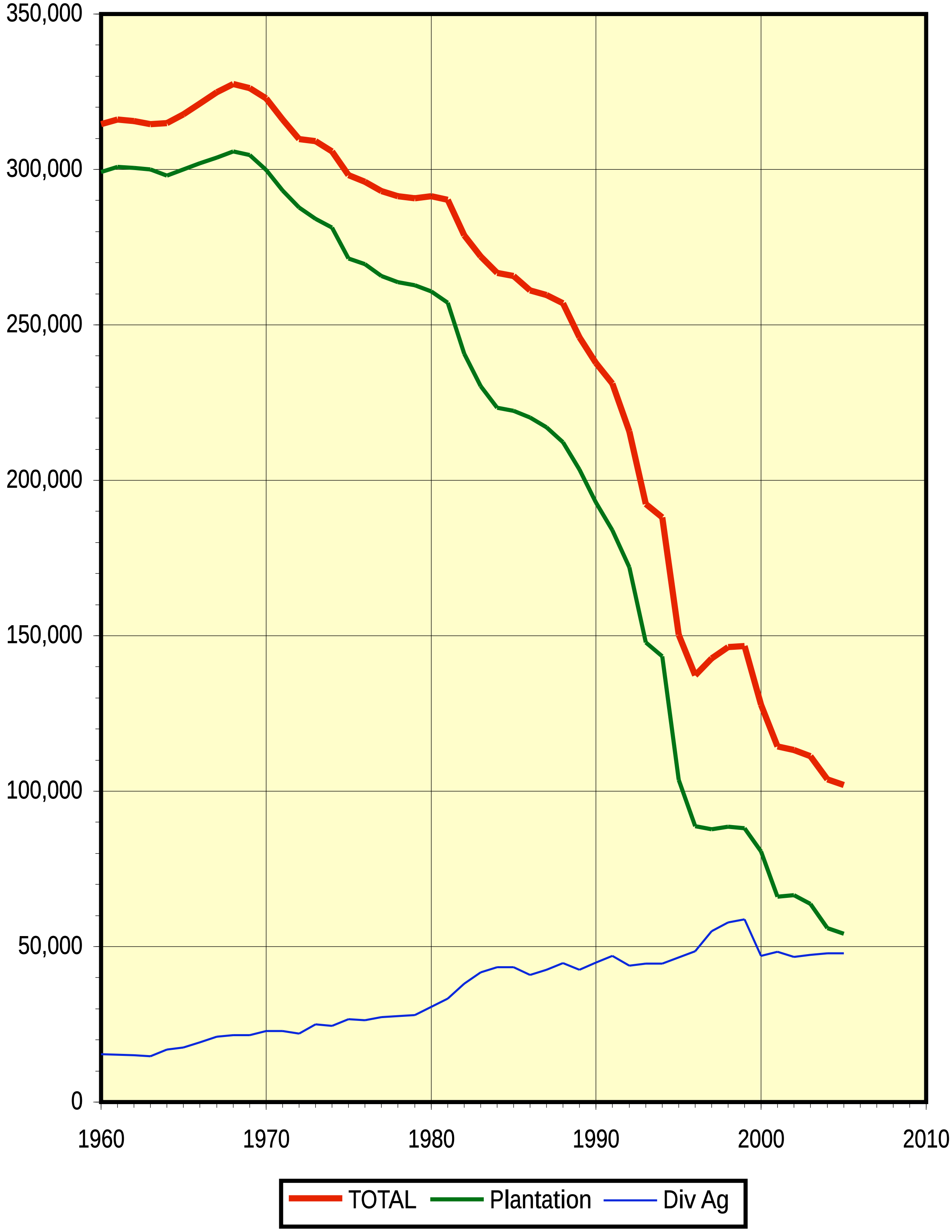
However, these policies—which were written before the major contraction of plantation agriculture in the 1990s—assume implicitly that profitable agricultural activities eventually will be available to utilize all available agricultural lands. This has proven to be a questionable assumption in view of the enormity of the contraction of plantation agriculture, the abundant supply of land that came available for diversified agriculture, and the slow growth in the amount of land being utilized for diversified agriculture.

Furthermore, discussions in the Agriculture portion of the *State Functional Plan* recognize that redesignation of lands from Agricultural to Urban should be allowed "… upon a demonstrated change in economic or social conditions, and where the requested redesignation will provide greater benefits to the general public than its retention in …agriculture;" that is, when an "overriding public interest exists." The enormous contraction of plantation agriculture, resulting in the supply of agricultural land far exceeding demand, constitutes a major change in economic conditions. Moreover, the proposed Project will provide community benefits (about 3,500 homes, medical facilities and services, and over 1,800 jobs) that far exceed those which are now provided by diversified agriculture (about 34 jobs). In practice, however, development of the Project Area is expected to have no impact on agricultural employment.

c. Central O'ahu Sustainable Communities Plan

The Petition Area is within the City's designated Urban Expansion Area of the Central O'ahu Sustainable Communities Plan in an area designated for residential development. Thus, in terms of future land use, the Project is consistent with the Central O'ahu Sustainable Communities Plan.

Figure ES-1 - Statewide Acreage in Crop: 1960 to 2005



KOA RIDGE MAKAI:
IMPACT ON AGRICULTURE

1. INTRODUCTION[1]

Castle & Cooke Homes Hawai'i, Inc. proposes to develop Koa Ridge Makai, a master planned community in Central O'ahu referred to in this report as “the Project.”

This report addresses the impacts on agriculture of developing the Project. The material below gives the following information on the Project: its location; its description; the agricultural conditions of the Project Area; potential crops; locational advantages and disadvantages for crop production; surrounding land uses; past and current agricultural land uses; the impact of the Project on existing agricultural operations, the growth of diversified crops, food security, and open space; benefits of the Project that will offset adverse agricultural impacts; and consistency of the Project with State and City agricultural policies.

The report is followed by four figures that provide maps on the location of the Project, the site plan, soil types, and soil ratings. In addition, a figure at the end of the Executive Summary plots the changes in crop acreage in Hawai'i since 1960. The Appendix provides a summary of State and City goals, objectives, policies and guidelines related to agricultural lands.

2. LOCATION OF THE PROJECT[1]

As shown in Figures 1 to 4, the Project is located in Central O'ahu between Mililani to the north, and Waipio to the south.

3. PROJECT DESCRIPTION

The Project will cover 575 acres and, at full development, will include: about 3,500 residential units, medical and healthcare facilities, commercial and industrial space, community facilities, a school, parks, and open space.

4. AGRICULTURAL CONDITIONS

a. Soil Types[2]

The land area contains eight soil types that are categorized below by their quality as rated by the Soil Conservation Service, now known as the Natural Resources Conservation Service (NRCS):

		NRCS Ratings
Higher-Quality Soils		
WaA	Wahiawa silty clay, 0 to 3% slopes	I
LaB	Lahaina silty clay, 3 to 7% slopes	IIe
MpB	Manana silty clay, 3 to 8% slopes	IIe
WaB	Wahiawa silty clay, 3 to 8% slopes	IIe
Moderate-Quality Soils		
MoC	Manana silty clay loam, 6 to 12% slopes	IIIe
WaC	Wahiawa silty clay, 8 to 15% slopes	IIIe
Lower-Quality Soils		
LaC3	Lahaina silty clay, 7 to 15% slopes	IVe
HLMG	Helemano silty clay, 30 to 90% slopes	VIIe

As shown in Figure 2, most of the soils are WaA and WaB.

b. Soil Ratings

Three classification systems are commonly used to rate soils in Hawai'i: (1) Land Capability Grouping, (2) Agricultural Lands of Importance to the State of Hawai'i, and (3) Overall Productivity Rating.

Land Capability Grouping (NRCS Rating)[2]

The 1972 Land Capability Grouping by the U.S. Department of Agriculture, NRCS rates soils according to eight levels, ranging from the highest classification level "I" to the lowest "VIII."

Most of the soils in the Project area are rated as I or IIe. Class I soils have few limitations that restrict their use. Class II soils have moderate limitations that reduce the choice of plants or require moderate conservation practices. The subclassification "e" indicates that the soils are subject to moderate erosion.

Agricultural Lands of Importance in the State of Hawai'i (ALISH)[3]

ALISH ratings were developed in 1977 by the NRCS, the University of Hawai'i (UH) College of Tropical Agriculture and Human Resources, and the State of Hawai'i, Department of Agriculture. This system classifies land into three categories: (a) “Prime” agricultural land which is land that is best suited for the production of crops because of its ability to sustain high yields with relatively little input and with the least damage to the environment; (b) “Unique” agricultural land which is non-Prime agricultural land used for the production of specific high-value crops; and (c) “Other” agricultural land which is non-Prime and non-Unique agricultural land that is important to the production of crops.

As indicated in Figure 3, most of the soils are rated Prime.

Overall Productivity Rating (LSB Rating)[4]

In 1972, the UH Land Study Bureau (LSB) developed the Overall Productivity Rating, which classifies soils according to five levels, with “A” representing the class of highest productivity and “E” the lowest.

Most of the soils are rated B (see Figure 4).

Summary Evaluation of Soil Quality

The above three soil-rating systems indicate that most of the Project area has soils that are good for cultivating crops (II or better under the NRCS rating, Prime under the ALISH rating, and B or better under the LSB rating).

c. Arable Land[5]

The lessee estimates that about 430 acres of the Project site has arable land.

d. Elevation

The elevation of the Project area ranges from 420 feet to over 740 feet. Thus, the land is suitable for crops that are generally referred to as “low-elevation crops,” as opposed to “high-elevation crops” such as those being grown in Kula, Maui or Waimea on the Big Island.

e. Slopes

Most of the Project area has slopes that are less than 5%.

f. Climatic Conditions

Like other areas in Hawai'i, Central O'ahu has a mild *semi*tropical climate that is due primarily to three factors: (1) Hawai'i's mid-Pacific location near the Tropic of Cancer, (2) the influence of surrounding warm ocean waters that vary little in temperature between the winter and summer seasons, and (3) the prevailing northeasterly tradewinds that bring air having temperatures that are close to those of the surrounding waters.

Solar Radiation[6]

Most of the Project area receives a moderately high amount of sunshine, with an average daily insolation of 450 calories per square centimeter.

Temperatures[7]

Average daily temperatures in the area are generally moderate, ranging from about 65°F to 85°F.

Rainfall[7]

Average annual rainfall ranges from about 35 inches to about 50 inches, depending on the elevation.

Winds and Storms[7]

During normal tradewind conditions, winds are typically less than 15 miles per hour. Storms are infrequent, occurring mostly from the south in the winter months during Kona weather.

g. Irrigation Water[8]

The landowner has a water allocation of 1.1 million gallons per day from Waiahole Ditch to irrigate crops on lands owned by Castle & Cooke at Koa Ridge and Waiawa Ridge (1,248 acres). This water allocation is sufficient to irrigate about 314 acres in diversified crops (based on 3,500 gallons per acre per day), and is now used to irrigate crops grown at Koa Ridge Makai.

h. Road Access

Fields in the Project area are reached via a plantation road that connects to Ka Uka Boulevard. In turn, this road connects to the H-2 Freeway.

i. Summary

About 430 acres of the Project area has arable land suitable for growing low-elevation crops. The fields have favorable soil conditions and soil ratings, the terrain is gently sloping, the climate is mild and sunny, and access is good. The water allocation of 1.1 million gallons per day from Waiahole Ditch is sufficient to irrigate about 314 acres of land in diversified crops.

5. POTENTIAL CROPS AND CROP PRODUCTION[9]

a. Potential Crops

Based on the above agronomic conditions, the Project area is suitable for low-elevation crops commercially grown in Hawai'i, including but not limited to: asparagus, beans (green, bush and snap), bell peppers, bittermelon, cantaloupe, Chinese peas, cucumbers, daikon, dry onions, eggplant, flowers / nursery products, ginger root, green onions, green peppers, head and semi-head lettuces, herbs, honeydew melons, limes, lotus root, lychee, Manoa lettuce, mango, mustard cabbage, Oriental squash, parsley, pumpkins, seed crops, sweet corn, sweet potatoes, tangerines, and watermelons.

As mentioned in Section 9, Koa Ridge Makai is well-suited for growing leafy vegetables and summer seed corn due to the relative cool temperatures and low rainfall.

b. Potential Crop Production

Potential crop production at Koa Ridge Makai is estimated at about 6.5 million pounds per year. This is based on the following assumptions: (1) about 430 acres of good farm land; (2) a mix of vegetable crops grown on the land; (3) the land is farmed intensely, with an average of about 50% of it kept in crop; and (4) yields average about 30,000 pounds of vegetables per acre per year.

6. LOCATIONAL ADVANTAGES AND DISADVANTAGES FOR CROP PRODUCTION

The Project area is well-located for serving the Honolulu consumer market and export markets. This is due to the short trucking distance to the Honolulu markets, the Honolulu International Airport, and Honolulu Harbor.

In the U.S. mainland market, however, farmers in Hawai'i must compete against farmers on the mainland and in Mexico, Central and South America, the Caribbean, Australia, New Zealand, Southeast Asia, etc. Most of the competing farm areas have lower production and delivery costs than Hawai'i does. Competing against Mexico is particularly difficult given the North America Free Trade Agreement (NAFTA) and Mexico’s proximity to major U.S. markets.

7. SURROUNDING LAND USES

Land uses surrounding the Project Area are shown in Figures 1, and include:

— To the north, Kipapa Gulch then Mililani town

— To the east, the H-2 Freeway

— To the south, the Waipi'o community which includes light industry, commercial areas, then homes

— To the west, Kipapa Gulch then Kamehameha Highway

As indicated, the Project components are surrounded by existing urban areas, gulches, and major highways. In effect, the Koa Ridge land is an agricultural remnant.

8. PAST AND CURRENT AGRICULTURAL LAND USES

a. Historic Pineapple Use

For the greater part of a century, Dole Food Company Hawai'i (Dole) grew pineapple on the land. This was a feasible crop for the area because pineapple requires little water compared to most other crops. However, by 2002 Dole had shifted all of its pineapple operations to O'ahu’s North Shore in order to consolidate their operations near the Dole packing plant, base yard, and offices. The North Shore land became available due to the closure of Waialua Sugar Company, Inc. in 1996.

b. Current Agricultural Uses[10]

Currently, Aloun Farms leases about 446 acres at Koa Ridge Makai.

9. IMPACT ON ALOUN FARMS

a. Farm Operations[10,5]

Since 2002, Aloun Farms has leased 446 acres at Koa Ridge Makai, of which about 430 acres are arable, about 325 acres are farmed and, on average, about 215 acres are in crop. The lease expires in 2012, but is subject to withdrawal rights by the landowner. Current lease rents are about $180 per acre per year. On this land, Aloun Farms grows leafy vegetables for the Honolulu market and, in Spring, seed corn for export.

In addition to the Koa Ridge Makai lands, Aloun Farms and a company affiliated with it (A.M. Enterprises, LLC) lease over 2,090 acres in 'Ewa and

Kunia. Thus, Aloun Farms leases a total of about 2,540 acres. However, about 100 acres of its 'Ewa lands are subleased, resulting in a net of about 2,440 acres available to Aloun Farms. Nearly all of this land is arable, and most of the fields are of high quality. Having fields in 'Ewa, Kunia and Central O'ahu allows Aloun Farms to maintain year-round production of certain crops by taking advantage of the climatic and seasonal differences between the planting areas.

Aloun Farms is the second largest diversified crop farm in Hawai'i, has its own cooling plant, and supplies both Hawai'i and overseas markets. The farm is managed by skilled entrepreneurs who have special expertise in Asian vegetables and melons, and in Asian markets.

Table 1 summarizes the Aloun Farms operations on the Koa Ridge Makai lands, their total operations, and the direct and indirect economic impacts of their operations at Koa Ridge Makai. Many of the estimates are by the consultant based on similar farm operations in Hawai'i and on economic multipliers provided by the State.[11,12]

The Koa Ridge Makai and Kunia lands are farmed more intensively than other lands leased by Aloun Farms: on average, about half the lands at Koa Ridge Makai and Kunia are in crop versus about one-third in crop for the remainder of the farm. As a result, the jobs provided by the farm operations on the Koa Ridge Makai lands are estimated at about 24% of the total jobs at Aloun Farms, even though the leased acreage amounts to about 18% of the total. As indicated, the Aloun Farms Koa Ridge Makai operation generates an estimated $2.15 million per year in revenues, and provides about 34 jobs (field, packing and other) having a total annual payroll of about $750,000. Based on State economic multipliers, the purchases of goods and services by Aloun Farms and by the families of their employees generate indirect revenues of about $1.03 million per year, and provide indirect employment of about 16 jobs with a total annual payroll of about $660,000.

b. Replacement Lands for Koa Ridge Makai[13]

In order to replace the land lost to the Project and to allow an orderly transition to new fields, Castle & Cooke Homes Hawai'i has arranged for Dole Food Company Hawai'i to issue a license to Aloun Farms for about 335 acres of former pineapple land located north of the Dole Plantation. The license will be issued in late 2008, and the transition from Koa Ridge to the replacement fields should occur by early 2010.

The replacement land will allow Aloun Farms to grow the same crops and maintain about the same production, revenues, operating costs, delivery costs, employment and payroll as would occur at Koa Ridge Makai. However, some

TABLE 1. ALOUN FARMS

	Koa Ridge Makai Operations		Total Operations
Land			
Leased Acreage (excluding sublease)	430	(18%)	2,440*
Acreage in Crop (average)	about 215	(24%)	about 910
Annual Revenues			
Direct	about $2.15 million (based on $10,000 per acre in crop*)		n.e.
Indirect	about $1.03 million (based on 48% of direct revenues)		n.e.
Total	about $3.18 million		n.e.
Employment (full-time equivalents)			
Direct Jobs (field, packing and other)	about 34 jobs (based on acres in crop)	(24%)	about 140*
Indirect Jobs	about 16 jobs (based on 48% of direct jobs)		n.e.
Total Jobs	about 50 jobs		n.e.
Annual Payroll			
Direct	about $750,000 (based on $22,000 per job for agriculture*)		n.e.
Indirect	about $660,000 (based on O'ahu average of $41,000 per job)		n.e.
Total	about $1.41 million		n.e.

* Provided by Aloun Farms. All other figures are estimated by Decision Analysts Hawai'i.

n.e.: not estimated.

adjustments in varieties and cultivation practices might be required due to slightly different agronomic conditions (e.g., soils, temperature, solar radiation, and rainfall). Also, Aloun Farms could incur additional expenditures to prepare the soils and irrigation systems for their particular crops.

Because of the replacement lands that are being made available, development of Koa Ridge Makai will not have a significant impact on the operations of Aloun Farms.

c. Other Changes to Aloun Farms[14,15]

Over a period of about 20 years or more, Aloun Farms could gradually lose about 1,950 acres of the land they now lease on the 'Ewa Plain, including 100 acres they sublease. This acreage is located in areas that the City has designated for Urban Expansion. If the farm loses all this acreage, it could be left with the above-mentioned 335 acres of replacement land plus another 160 acres it leases in Kunia, for a total of about 495 acres. This remaining acreage is designated for agriculture by the City and State, and is outside the City's Urban Expansion Area.

Aloun Farms could adjust to the gradual loss of their leased acreage on the 'Ewa Plain by leasing available land in Kunia and on the North Shore. As discussed in Section 10.b, about 10,900 acres of former sugarcane and pineapple land remain available for diversified farming on O'ahu, including about 3,150 acres in Kunia and about 7,750 acres on the North Shore (including the 335 acres to be licensed to Aloun Farms). However, compared to 'Ewa, some of the higher-elevation lands have low solar radiation, and some lands on the North Shore have temporary limitations as to the types of crops due to low-quality water (see Section 10.d).

Assuming that Aloun Farms secures lands to replace those lost to urbanization on the 'Ewa Plain, then the farm could maintain about the same level of production, sales revenues, employment and payroll. However, major adjustments to the farm would be required since the replacement lands would not have the same agronomic conditions). Adjustments could include a change in the types of crops grown. If Aloun Farms leases replacement lands in Kunia, their trucking costs would remain about the same. If they lease on the North Shore, they would incur higher costs for hauling produce into Honolulu—costs that would be similar to what North Shore farmers currently pay, but the costs would be lower than what Kahuku farmers pay. At the same time, the higher trucking costs could be partially offset by lower land rents on the North Shore as compared to land rents in Kunia.

If sufficient replacement land is not available on O'ahu due to its being leased to grow an energy crop—which is regarded as unlikely as explained in

Section 10.a—then one alternative to Aloun Farms would be to scale back their operations. This would be possible because diversified crop farms such as Aloun Farms generally are flexible as to their size: profitability can be achieved with a farm that becomes smaller. In response to reduced production by Aloun Farms, other farmers on O'ahu and the Neighbor Islands would likely increase their production to partially or fully offset the reduction. A second alternative for Aloun Farms would be to turn to a Neighbor Island for replacement lands. However, this might require relocating all of the farm to the Neighbor Island in order to avoid splitting the operations between two locations. Also, the company would incur higher transportation costs to import supplies from, and transport produce to, Honolulu. The costs would be similar to those that Neighbor Island farmers now pay to supply the Honolulu market. If the Superferry proves successful, then cultivating crops on the Neighbor Islands for the Honolulu market may become more feasible than is currently the case. In any case, the higher transportation costs could be partially offset by lower rents on a Neighbor Island.

d. Farm Reconfigurations

Reconfigurations of farms is common and appropriate when farmers lease land in the path of planned urban expansion of a growing city. This is the case with Aloun Farms. Much of their leased land is located in areas that have been designated for eventual urban expansion by the landowners, the City, and—for much of the Ewa Plain—the State. For diversified crop farmers who supply nearby markets, locations on the edge of town may be ideal because of the low trucking costs. And until these lands are urbanized, the best “temporary” use of them may be farming—a use which may last for decades. But when urbanization does occur, the farmers must incur the expense and disruption of relocating all their farm lands, or portions of them, to other areas. Since lessees only have temporary rights to the land, the cost of relocating normally falls on the lessees and is not an obligation of the landowners.

e. Mitigating Measures

Inasmuch as farm land will be made available to replace those lost to the Project, no additional mitigating measures are recommended.

10. GROWTH OF DIVERSIFIED CROPS

The Project will commit about 430 acres of arable land to a non-agricultural use. The impact of this commitment on the growth of diversified crops is addressed below. The material covers: (1) the potential acreage required for the future growth of diversified farming, (2) potential acreage required to relocate farms from 'Ewa and Kunia, (3) availability of land for diversified crops, (4) impact of the Project on the growth of diversified crops, and (5) mitigating measures.

a. Potential Acreage Required for the Future Growth of Diversified Farming

Crops to Replace Imports of Fruits and Vegetables[16]

For low-elevation fruits and vegetables that have a history of profitable production in Hawai'i, potential land requirements in 2010 for 100% import substitution for the Hawai'i and O'ahu markets are estimated at 12,700 acres and 8,600 acres, respectively, plus additional acreage for fallowing land between crop plantings. When allowing for competition from imports, these estimates drop to about half. These estimates take into account estimated consumption, production trends, seasonal and annual market shares, yields, and the number of crops per year. Also, these figures are for acreage in crop—not harvested acreage as is typically reported in government publications.

For the many crops grown in Hawai'i, market shares for Hawai'i growers are limited by the following factors: (1) local varieties are not perfect substitutes for all imports (e.g., premium-priced sweet Maui onions versus inexpensive storage onions); (2) some crops cannot be produced profitably in the summer due to competition from low-cost imports of fruits and vegetables from California, other states, and Mexico; and (3) over-production must be avoided in order to maintain profitable price levels.

Since Hawai'i farmers already supply a portion of the Hawai'i market, land requirements for increased import substitution are a fraction of the above estimates.

Export Crops[9,17,18]

The potential market for export crops is far larger than the Hawai'i market. In 2005, the U.S. population was 296.41 million, compared to a Hawai'i's resident-plus-visitor population of 1.45 million. To take advantage of this large potential, Hawai'i farmers are exploring various export crops on lands released from plantation agriculture. Over the next 20+ years, one or more of these crops may prove to be successful and may grow into a major export crop.

However, the history of agricultural efforts in Hawai'i reveals that the successful development of major new export crops requiring large amounts of land is difficult and infrequent. For example, over the past 50 years in Hawai'i, farmers have explored numerous possibilities for export crops, but they have developed overseas markets for just one diversified crop that requires more than 10,000 acres (macadamia nuts at 18,300 acres in 2005); one additional crop that requires more than 5,000 acres (coffee at 8,000 acres); and only five additional crops or crop categories that require more than 1,000 acres each (papaya at 2,395 acres, bananas at 1,145 acres, tropical specialty fruits at 1,230 acres, flowers / nursery products at 3,895 acres, and seed crops at 4,220 acres). Tropical specialty fruits include longan, lychee, mango, rambutan, star-fruit, etc.

Feed Crops[19]

If feed crops could be grown in Hawai'i and priced competitively against mainland imports, they could replace a portion of the grains and hay that is now being imported to the State. Unfortunately, a number of commercial attempts in Hawai'i to grow grains and alfalfa have been unsuccessful. The major problems have been (1) pests, particularly birds that eat the grains before they are harvested; (2) humidity that is too high for drying alfalfa properly; and (3) high production costs compared to those of mainland farms.

Biofuel Crops[11,20-25]

Crops can be grown to produce biomass to fuel a boiler, or as feedstock to produce fuels. Examples of the latter include sugarcane, corn, or sorghum used to produce ethanol. In turn, the ethanol is used to produce E-10 gasohol (90% gasoline and 10% ethanol). Also, palm oil, soybean, sunflower, kukui nut, avocado, coconut, neem and other crops can be grown to produce biodiesel.[26]

In Hawai'i, the common practice has been to produce biomass as a by-product of some principal crop. For example, at HC&S on Maui and at Gay & Robinson on Kaua'i, the sugarcane by-product bagasse is burned to help fuel their respective power plants. In addition, the biofuel company Maui Ethanol plans to use the sugarcane by-product, molasses, from the two sugarcane plantations as feedstock to produce ethanol.[20,21] Using conventional technology, the sugar in the molasses will be fermented to produce ethanol, followed by distillation to extract the alcohol.

O'ahu Ethanol Corporation plans to build an ethanol plant at Campbell Industrial Park using conventional technology but, at least initially, plans to use imported molasses as the feedstock.[21,22] The rated capacity will be 15 million gallons of ethanol per year. For the longer term, this company is exploring the economics of growing sweet sorghum to supply feedstock to its ethanol plant. The sorghum would have to be grown on O'ahu because it would be too expensive to ship the sorghum juice from a Neighbor Island to O'ahu. Sorghum juice is mostly water having a low concentration of sugar compared to molasses.

Acreage requirements for a new sorghum biofuel plantation on O'ahu would range from about 6,000 acres for viability to 15,000 acres if juice from sorghum were to replace all imported molasses.[22] This acreage comprises a substantial share, if not all, of the estimated 10,900 acres of crop land that is available on O'ahu as of mid-2007. But it is a small share of the 160,000+ acres of crop land available statewide (see Section 11.c).

Imperium Renewables Hawai'i LLC is proposing to build by 2009 a biodiesel refinery on State land at Kalaeloa Harbor; it would produce about 100 million gallons of biodiesel annually.[27,28] Similarly, BlueEarth Maui Biodiesel LLC plans to build a similar refinery on Maui that would produce about 120 million gallons annually by 2011. Both will use imported palm oil from Malaysia and other countries as their feed stock, but would refine locally produced vegetable oil if available.

A number of substantial difficulties must be overcome in order to develop one or more biofuel plantations to supply feedstock for ethanol or biodiesel production, including:

— Long-term Leases

In many areas of the State, it will be difficult to lease the large amount of land required for a biofuel plantation at low lease rents for the 30 or so years required to capitalize the investment in a new plantation. Over time, other farmers and other users of land are likely to make higher offers to landowners of lease rents or land purchases. In view of this potential for landowners, the current market value of available farm lands is likely to be higher if landowners do <u>not</u> commit long-term to rents that are low enough to be affordable to a biofuel plantation.

— Capital

Substantial investment capital will be required to cover the cost of improvements and equipment such as: a mill to extract the juice from a biofuel crop; a generating plant to provide power; improvements and upgrades to irrigation systems that are in disrepair; trucks and equipment to harvest and haul harvested plants to the mill, and haul the extracted juice to an ethanol plant or the vegetable oil to a refinery, etc.

— Short-term Profitability

Annual revenues from selling the ethanol plus direct subsidies are estimated by the consultant at about $2,700 per acre (based on an estimated 900 gallons per acre per year of ethanol at about $3 per gallon). Even with subsidies, this is low compared to revenues from other crops in Hawai'i. Per-acre returns from biodiesel crops are even less.

Furthermore, the cost of importing molasses or palm oil for feedstock, or importing ethanol may prove to be less expensive than growing a biofuel crop in Hawai'i. For similar crops (such as feed crops), importing has proven to be less expensive than growing and processing crops locally. Also, the U.S. Department of Agriculture has found sorghum to be an expensive feedstock for producing ethanol—about 3.7 times more expensive than corn and 63% more expensive than molasses.[24]

As ethanol production increases on the mainland and in Hawai'i, there is a risk that the combined Federal and State subsidies for ethanol (over $2 per gallon) could be reduced, thereby compromising the profitability of a biofuel crop.

— Long-term Profitability

Over the long-term, emerging technology holds promise for a cheaper source of feedstock for ethanol than does growing a biofuel crop on a plantation.[23] Instead of producing ethanol using sugars from conventional sources (e.g., molasses, sugarcane, grains, fruits, etc.), the sugar would come from “cellulosic” sources. Using new technology that is in the early stages of commercialization, sugar that is locked in complex carbohydrates of plants is separated into fermentable sugars. Feedstock would include agricultural wastes, yard clippings, discarded paper, wood waste, etc.—i.e., the green waste that is now used for composting. This new technology promises (1) much higher ethanol yields per ton of biomass because the entire plant can be used as feedstock, and (2) lower costs—particularly if there are no growing costs when waste product is used, and if the operator is paid a fee to dispose of municipal and agricultural waste. Eventually, this less expensive source of feedstock could result in unprofitable biofuel plantations. In Hawai'i, this new technology is being explored by ClearFuels Technology Inc.

O'ahu’s municipal waste could produce an estimated 160 million gallons of ethanol compared to the current annual consumption of about 400 million gallons of gasoline.

The above difficulties and risks suggest that the probability of successfully developing and sustaining a biofuel plantation in Hawai'i is low. The more likely scenario is that ethanol will be produced as a by-product of sugar and, over the long-term, it will be produced from green waste.

Commercial Forest[20,29,30]

Although not categorized as a crop, commercial timber can be grown on crop land as well as on grazing land. On the Big Island, Prudential Timber has more than 20,000 acres planted in eucalyptus trees on former sugarcane and ranch lands. The timber is to be used for veneer, paper pulp, and as a biofuel. On Kaua'i, Hawaiian Mahogany grows eucalyptus and albizia trees for high-end furniture and landscape timber.

A commercial forest requires a major investment and a long commitment (30 years or more) before significant returns are realized. It is also a risky investment given the uncertainty over future lumber prices and potential losses to fire. Over time, projected returns from forests are greater than returns from grazing, but less than returns from crop farming. A recent study indicated that, with Federal and State subsidies, a small koa operation on the Big Island would provide higher returns than would grazing.

A commercial forest is best suited as an alternative to grazing when there is a high probability that the land will not be needed for a higher-value use (such as crop farming) for a period of 30 years or more. While some land on O'ahu might be suitable for small stands of high-value timber species such as koa, far more land is available on the Big Island where a commitment has already been made to develop a timber industry.

Recent Crop-acreage Trends[9]

For all diversified crops—i.e., all crops other than sugarcane and pineapple, including crops to replace imports and crops for export—statewide land requirements grew as shown in Figure ES-1, with the annual growth by selected periods summarized as follows:[1,2]

1. In Figure ES-1, the rapid growth in diversified-crop acreage that occurred during the 1979-to-1983 period largely reflects (1) growth in macadamia-nut acreage which continued until about 1986 when tax-shelter advantages were terminated, and (2) a temporary increase in feed-crop acreage that declined after 1983 and offset the acreage gains in macadamia nuts. The growth in feed-crop acreage may reflect the situation addressed in Footnote 2.
2. In Figure ES-1, the temporary bump in diversified-crop acreage that occurred in the late 1990s reflects the fact that some former sugarcane fields were newly planted with grasses for future cattle grazing. After cattle grazing began in 2000, much of this acreage was recategorized by NASDA from crop land to grazing land.

— 1963 to 1979: about 839 acres per year.

— 1979 to 1983: about 3,450 acres per year.[1]

— 1983 to 2000: about 310 acres per year.[2]

— 2000 to 2005: about 160 acres per year.

For the 2000-to-2005 period, the major growth in acreage for diversified crops came from just two crop categories: seed crops (264 acres per year) and flowers / nursery products (235 acres per year). For crops grown for the Hawai'i market, acreage declined by an average of 190 acres per year during this same period.

As the above trends illustrate, growth in acreage of diversified crops has slowed over time even though there was a massive increase in the available supply of land for diversified agriculture following the contraction of plantation agriculture. The slower growth is explained by the following:

— The most promising opportunities for diversified farming were exploited first.

— Along with the decline in plantation agriculture, Hawai'i lost much of its agricultural expertise.

— A 1986 change in the Federal tax code eliminated tax advantages of investing in macadamia nut farms.

— Tourism bid up wages, thereby increasing the cost of farm labor.

— Trade agreements and transportation improvements resulted in more specialization and trade which, in turn, contributed to a higher standard of living but this came at the expense of reduced self-sufficiency.

<u>Factors Limiting the Growth of Diversified Crops</u>[16]

A great many crops can be grown in Hawai'i's year-round subtropical climate, and a number of them can be grown profitably in volumes that require a few hundred acres. However, the modest growth in land requirements for diversified crops reflects the fact that few crops can be grown profitably on a large scale. The primary factors that have limited the growth of diversified agriculture in Hawai'i are given below.

— Hawai'i's subtropical climate is not well-suited to the commercial production of major crops that grow better in the temperate mainland climates.

— For certain crops, special hybrids adapted to Hawai'i's subtropical climate are yet to be developed.

— Crop pests are more prevalent and more expensive to control in Hawai'i than they are on the mainland where the cold winters kill many pests.

— Fruit-fly infestations prevent exports of many crops, or require expensive treatment.

— Most soils in Hawai'i have low nutrient levels and therefore require high expenditures for fertilizer.

— Hawai'i suffers from high farm-labor costs, largely because the agriculture industry must compete against the visitor, construction, and other industries for workers.

— Compared to many other farm areas that supply U.S. markets, the cost of shipping agricultural supplies and equipment to Hawai'i is high, as is the cost of exporting produce from Hawai'i to mainland markets. High shipping costs are a result of Hawai'i's remote location and of Federal regulations that require use of American-built ships and U.S. crews between U.S. ports.

— For a number of crops, consumption volumes in Hawai'i are too small to support large, efficient farms (that is, the volumes are too small to realize economies of scale).

— On-going trends towards food suppliers purchasing produce that is certified as safe and towards buying from a single supplier of many food items favor large farms.

— Hawai'i farmers must compete against highly efficient mainland and foreign farms which, in a number of cases, can deliver produce to Hawai'i more cheaply than it can be produced locally. This is due to economies of scale and, in comparison to Hawai'i, low costs for land, labor, supplies, fertilizer, pest control, equipment, etc.

b. Potential Acreage Required to Relocate Farms[11]

In addition to farm land that will be required to accommodate the growth of diversified farming, about 3,600 acres could be required to relocate all or portions of four existing farms that will or could be displaced from Koa Ridge Makai, 'Ewa, and lower Kunia due to urban development and to changes in agricultural uses. The affected farms and acreages are shown in Table 2. This accounting does not include the 135 acres for the proposed Castle & Cooke Waiawa project since this acreage is no longer farmed.

Table 2. Approximate Acreage Required to Relocate Farms Displaced from Central O'ahu, 'Ewa and Lower Kunia

Cause of Displacement	Aloun Farms	Fat Law's Farm	Jefts Farms	Syngenta	TOTAL
Urban Projects					
Koa Ridge Makai,[1] Central O'ahu	430	-	-	-	430
Ho'opili,[1] 'Ewa	1,000	100	197	200	1,497
State Projects, 'Ewa	850	-	95	-	945
Other Farm Uses					
State Ag Park, Kunia	-	-	150	-	150
Monsanto Co., Kunia	-	-	220	360	580
TOTAL	2,280	100	662	560	3,602

1. Proposed and within the City's Urban Expansion Area.

Source: Decision Analysts Hawai'i, Inc. 2007.

Aloun Farms, Fat Law's Farm, and Jefts Farms grow a variety of diversified crops. Monsanto and Syngenta are competing seed companies. As indicated in Table 2, Monsanto's expansion into lower Kunia will displace portions of Syngenta's and Jefts Farms' operations. As a result of the displacement, Syngenta might relocate its O'ahu operations to Kaua'i where most of its operations are currently located.

Regarding potential urban development, Koa Ridge and Ho'opili are proposed projects that are within the City's Urban Expansion Area.

c. Land Available for Diversified Crops

Statewide

Statewide, a vast amount of land has been released from plantation agriculture: about 251,800 acres between 1968 and 2005, resulting in an average release of over 6,800 acres per year over a 37-year period (see Figure ES-1).[9,31] The 2006 Del Monte closure in Kunia increased this figure by another 4,400 acres, resulting in a total release of at least 256,200 acres from plantation agriculture between 1968 and 2007.[11,32] Over the 1968-to-2005 period, the demand for land for diversified crops increased by about 26,300 acres (about 10% of the land released from plantation agriculture).[9]

As the above figures indicate, the acreage released from plantation agriculture has far outpaced the demand for land for diversified crops. The net decrease of land in crop amounts to about 229,900 acres. While some of the released land has been converted or is scheduled to be converted to urban uses and tree plantations, an estimated 160,000+ acres remain available for diversified crops.[11] Because of the increased availability of agricultural land, a number of landowners report lower per-acre agricultural land rents on O'ahu and the Neighbor Islands compared to rents charged before the major contraction in plantation agriculture.[25]

If the Superferry proves successful, cultivating crops on the Neighbor Islands for the Honolulu market, and vice versa, may become more economically feasible. For a full load carried in a large pick-up truck, the one-way fare is about 4.5¢ per pound.[33] However, the ferry service may not be sufficiently frequent for certain crops, and / or delivery times may not be sufficiently rapid.

The above information indicates that considerable land is available in Hawai'i to accommodate the relocation of farms as well as the growth of diversified crop farming.

O'ahu

On O'ahu, a similar release of plantation land occurred. Between 1968 and 2007, about 51,900 acres were released due to the contraction of five plantations and the closures of all but one of them.[9,11] About 32,700 acres were released after 1990. Much of this land remains available for agriculture, and most of it lies outside the City's Urban Expansion Area.

The Kunia fields are considered to be among the best farm land in the State, based on the high solar radiation; high-quality soils; and the short trucking distance to the large Honolulu market, the airport, and Honolulu Harbor.[19] Except for lands recently released by Del Monte, all of the better Kunia fields have already been leased for diversified crop farming. However, on average, only about one-third of this land is in crop.[34] The large amount of fallowing reflects best farm practices when land is abundant and land rents are relatively low. Fallowing increases soil fertility and helps control unwanted volunteer plants, weeds, insects and disease. When demand for farm land is strong and rents are high in response to a strong demand for agricultural products, then more intensive farming of the land may be warranted even if this increases farmers' costs for pest control and soil additives.

Of the estimated 4,400 acres of Kunia land recently farmed by Del Monte, about 3,150 acres remain available. The decrease was due to (1) Monsanto's land purchase in lower Kunia for seed crops, and (2) the U.S. Army's land purchase in upper Kunia to expand Schofield Barracks. These two purchases involve considerable land, including about 1,220 acres of former pineapple fields.[35,36] About 640 acres of the Monsanto purchase will remain in agriculture.

Another possible land purchase could impact the future supply of farm land in Kunia. The Army Hawai'i Family Housing LLC (AHFH), a public/private partnership between the U.S. Army and Actus Lend Lease, plans to acquire about 2,520 acres in northern Kunia from Campbell, including about 1,570 acres of former pineapple land.[35,37] AHFH intends to "bank" the land for future needs, which will allow a portion it to be used for military housing if needed in the distant future. If and when AHFH proposes the land for development, the project will be subject to all State and City development approvals and permits, which could prove difficult since the development would be outside the City's existing Urban Expansion Area. AHFH has indicated that if they acquire the land, it will remain in agriculture for the foreseeable future.

On the North Shore, various crops are being grown, but about 7,750 acres of higher-quality fields formerly in sugarcane and pineapple remain fallow or are in a low-value use, all of which have current or potential access to irrigation water.[25,38]

In total, about 10,900 acres of former high-quality plantation land remain available on O'ahu for other crops. This includes the 3,150 acres of former pineapple land in Kunia plus the 7,750 acres on the North Shore. However, it excludes any adjustment for the farm land that is already leased for diversified crops but is not farmed intensively, some arable lands in the foothills that are currently used for grazing, and a portion of the 2,290 acres (about 1,600 acres arable) purchased by Monsanto that may be made available for crops other than seed crops. Also, this accounting excludes the 135 acres for the proposed Castle & Cooke Waiawa project since this acreage is within the City's existing Urban Expansion Area.

Given the large release of land from plantation agriculture on O'ahu, the amount of available farm land that remains on the island is less than what one might expect. This is explained by the following: (1) diversified crop farmers relocated to and / or expanded their operations on these high-quality and favorably located lands, but much of this was at the expense of production elsewhere on O'ahu and the Neighbor Islands; (2) seed companies increased their operations on O'ahu because of these same advantages; (3) many farmers keep only a portion of their land in crop, leaving most of it fallow (see Section 11.c, ¶6); (4) many fields in the foothills were reallocated to grazing because better lands are available elsewhere for farming; (5) considerable land in 'Ewa and Central O'ahu was or will be urbanized; and (6) the military acquired some land in upper Kunia.

Some of the 10,900 acres of former high-quality plantation land remaining available on O'ahu has limitations for growing certain diversified crops, some of which are short-term limitations but some are permanent. In particular, fields at the higher elevations in Kunia and on the North Shore have lower solar radiation compared to 'Ewa: the average daily insolation is about 400 calories per square centimeter at the higher elevations compared to as much as 500 calories in 'Ewa.[6] Also, some fields at the higher elevations incur higher pumping costs.

On the North Shore, portions of the water delivery systems need major repairs or upgrades, and the types of crops on fields irrigated with water from Wahiawa Reservoir (Lake Wilson) will be restricted as long as partially-treated wastewater continues to be discharged into the lake.[25,39] Water from the lake can be used to irrigate tree crops (e.g., papaya and coffee) and crops such as sugarcane that are processed sufficiently to kill pathogens. However, the water cannot be used to irrigate unprocessed leafy vegetable crops.

Also, North Shore farmers encounter longer trucking distances to Honolulu markets, the airport, and the harbor.

d. Cumulative Impact on the Growth of Diversified Crops

The Project will commit about 430 acres of arable land to a non-agricultural use. In view of the available supply of farm land (160,000+ acres Statewide and about 10,900 acres on O'ahu), the development of this agricultural land—combined with the other planned developments in Hawai'i including the proposed Castle & Cooke Waiawa project—involves the loss of too little agricultural land to significantly affect either (1) the growth of diversified crop farming (averaging about 160 acres per year), or (2) the relocation of farms that are being displaced or could be displaced from Central O'ahu, 'Ewa and lower Kunia (about 3,600 acres, including the 430 acres of Koa Ridge Makai).

e. Mitigating Measures

In view of the negligible impact of the Project on the growth of diversified agriculture in Hawai'i, mitigating measures directed to the developer are not recommended.

However, recommendations are directed to the City and to the Army to upgrade their wastewater treatment plants in Central O'ahu so that the water they discharge into the Wahiawa Irrigation System meets the State's R-1 water-quality standard. Until the quality of the discharge water is improved, most of the available agricultural land on the North Shore cannot be used to grow the types of vegetable crops the farmers grow in Central O'ahu and 'Ewa. Thus, one or more agricultural operations that will be displaced by various development projects may not be able to fully relocate to the North Shore until the improvements are made (assuming that relocating to the North Shore is their best option).

11. IMPACT ON AGRICULTURAL LAND VALUES AND RENTS[11]

A concern that is sometimes raised is whether the development of agricultural land will cause a general increase in agricultural land values and / or rents which, in turn, could cause some farmers to be displaced because they are unable to afford the higher land costs. This issue is addressed below for Koa Ridge Makai.

a. Agricultural Land Values

On O'ahu, the value of agricultural land largely reflects its development potential. If farm land is within the City's Urban Expansion Area and development is likely to start within a few years, then the land value can exceed $100,000 per acre. But if the land is unlikely to be developed in the foreseeable future, then the value may be less than $20,000 per acre.

Development approvals for Koa Ridge Makai are likely to reduce the development pressure on other farm lands on O'ahu and delay their development, particularly those farm lands that are in the path of urbanization but are outside the City's Urban Expansion Area (e.g., Kunia and much of the North Shore). Thus, the Project would <u>reduce</u> the development potential of these other lands, resulting in slightly lower agricultural land values than would otherwise be the case.

b. Agricultural Land Rents

Agricultural land rents are based on the supply and demand of land for farming, and on what farmers can afford to pay while still remaining profitable. Agricultural rents are not based on the value of the land. If they were, high rents would preclude farming in such areas as the 'Ewa Plain and Kunia. Yet, these areas are leased at rents that are affordable for farming.

The Project will decrease the supply of agricultural land on Oahu. However, given the large supply of available farm land on O'ahu due to the recent closure of two sugarcane plantations and the Del Monte pineapple plantation, this loss is too small to significantly affect agricultural land rents.

12. FOOD SECURITY[9,11]

Another concern that is sometimes raised is that an abundant supply of farm land might be needed to grow food crops in the event that some unforeseen catastrophe cuts off food imports to Hawai'i. However, such a catastrophe would also cut off crop exports. In this situation, the supply of farm land that would be available to grow food crops for local consumption would include much of the 86,000+ acres that are now used for export crops (sugar, pineapple, macadamia nuts, coffee, seed crops, flowers, etc.), plus the 160,000+ acres of farm land that are fallow or in a low-value use. For perspective, about 12,500 acres were used to grow food for the Hawai'i market in 2006.

The loss of 430 acres of arable land in the Project Area constitutes too small an amount of land to threaten food security in the event of a catastrophe that could cut off food imports to Hawai'i.

13. VALUE OF OPEN SPACE[17,40,41]

Leaving the land in agriculture would provide open space to the O'ahu residents. A community survey performed in 1995 by University of Hawai'i researchers revealed that O'ahu households would pay about 0.23 cent annually to preserve one additional acre of agricultural land in open space, with the value being subject to change based on the supply of agricultural land, household incomes, and general price inflation. Based on the island population and economic conditions in 2005, this translates to about $900 per year that all O'ahu residents combined would pay to preserve one acre of open space. Assuming a 3% discount rate, 1 acre of open space would be valued at about $30,000 ($900 ÷ 0.03). For Koa Ridge Makai, the total value of open space amounts to about $17 million (575 acres x $30,000 / acre).

This 1995 value of open space by O'ahu households could be high in that it was 6 to 45 times higher than the corresponding figures for U.S. mainland and Canadian communities (lower values on open space were given by residents in rural areas, and higher values were given by those living in more developed areas). Also, surveys that reveal intentions can result in estimates that are higher than actual behavior. Finally, neither the City nor the State has shown a willingness to purchase a significant amount of agricultural land in order to prevent development and thereby preserve the land in open space, even though agricultural land has been available at prices well below $30,000 per acre.

More realistically, most of the agricultural land at Koa Ridge is not easily seen, so has limited value as open space. In fact, only glimpses of a small portion of the Koa Ridge land can be seen while traveling on the H-2 Freeway or from other areas. Furthermore, in cases where agriculture fields can be seen easily, the common practice among many diversified-crop farmers is to build berms (some as high as 15 feet) and plant vegetation to block the view of their fields. This helps reduce theft and nuisance problems.

14. OFFSETTING BENEFITS[1,11,13]

The Project will result in the loss of 430 acres of arable land which currently provides about 34 agricultural jobs. In practice, however, the Project will result in little or no loss of existing or potential agricultural activity since other lands are available for farming, and suitable replacement lands have been secured for the Aloun Farms operations at Koa Ridge.

This potential loss to agriculture will be offset by the following benefits:

- about 3,500 new homes
- regional medical facilities and services
- over 1,800 jobs at full development of the project

15. CONSISTENCY WITH STATE AND CITY POLICIES[42]

a. Availability of Lands for Agriculture

The *Hawaii State Constitution*, the *Hawaii State Plan*, the *State Agriculture Functional Plan*, and the *General Plan of the City and County of Honolulu* call directly or implicitly for preserving the economic viability of plantation agriculture and promoting the growth of diversified crops. To accomplish this, an adequate supply of agriculturally suitable lands and water must be assured.

With regard to plantation agriculture, development of the Project will have no impact on pineapple operations since Dole no longer grows pineapple in Central O'ahu.

With regard to diversified crops, development of the Project Area will result in a loss of about 430 acres of arable land, but this loss will not limit the growth of diversified crops since ample agricultural land is available on O'ahu and on other islands. This is due to the enormous supply of agricultural land that is now available following the contraction of plantation agriculture (see Section 11.c and Figure ES-1). However, if a biofuel crop is developed on O'ahu—which is regarded by the consultant as unlikely—then some crop production could be diverted to the Neighbor Islands where more land is available.

b. Conservation of Agricultural Lands

In addition to the above, State policies call for conserving and protecting prime agricultural lands, including protecting agricultural lands from urban development.

However, these policies—which were written before the major contraction of plantation agriculture in the 1990s—assume implicitly that profitable agricultural activities eventually will be available to utilize all available agricultural lands. This has proven to be a questionable assumption in view of the enormity of the contraction of plantation agriculture, the abundant supply of land that came available for diversified agriculture, and the slow growth in the amount of land being utilized for diversified agriculture (see Section 11 and Figure ES-1).

Furthermore, discussions in the Agriculture portion of the *State Functional Plan* recognize that redesignation of lands from Agricultural to Urban should be allowed "… upon a demonstrated change in economic or social conditions, and where the requested redesignation will provide greater benefits to the general public than its retention in …agriculture;" that is, when an "overriding public interest exists." The enormous contraction of plantation agriculture, resulting in the supply of agricultural land far exceeding demand, constitutes a major change in economic conditions. Moreover, the proposed Project will provide community benefits (about 3,500 homes, medical facilities and services, and over 1,800 jobs) that far exceed those which are now provided by diversified agriculture (about 34 jobs). In practice, however, development of the Project Area is expected to have no impact on agricultural employment since replacement land has been made available.

c. Central O'ahu Sustainable Communities Plan

The Petition Area is within the City's designated Urban Expansion Area of the Central O'ahu Sustainable Communities Plan in an area designated for residential development. Thus, in terms of future land use, the Project is consistent with the Central O'ahu Sustainable Communities Plan.

16. REFERENCES

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[42] Appendix.

FIGURES

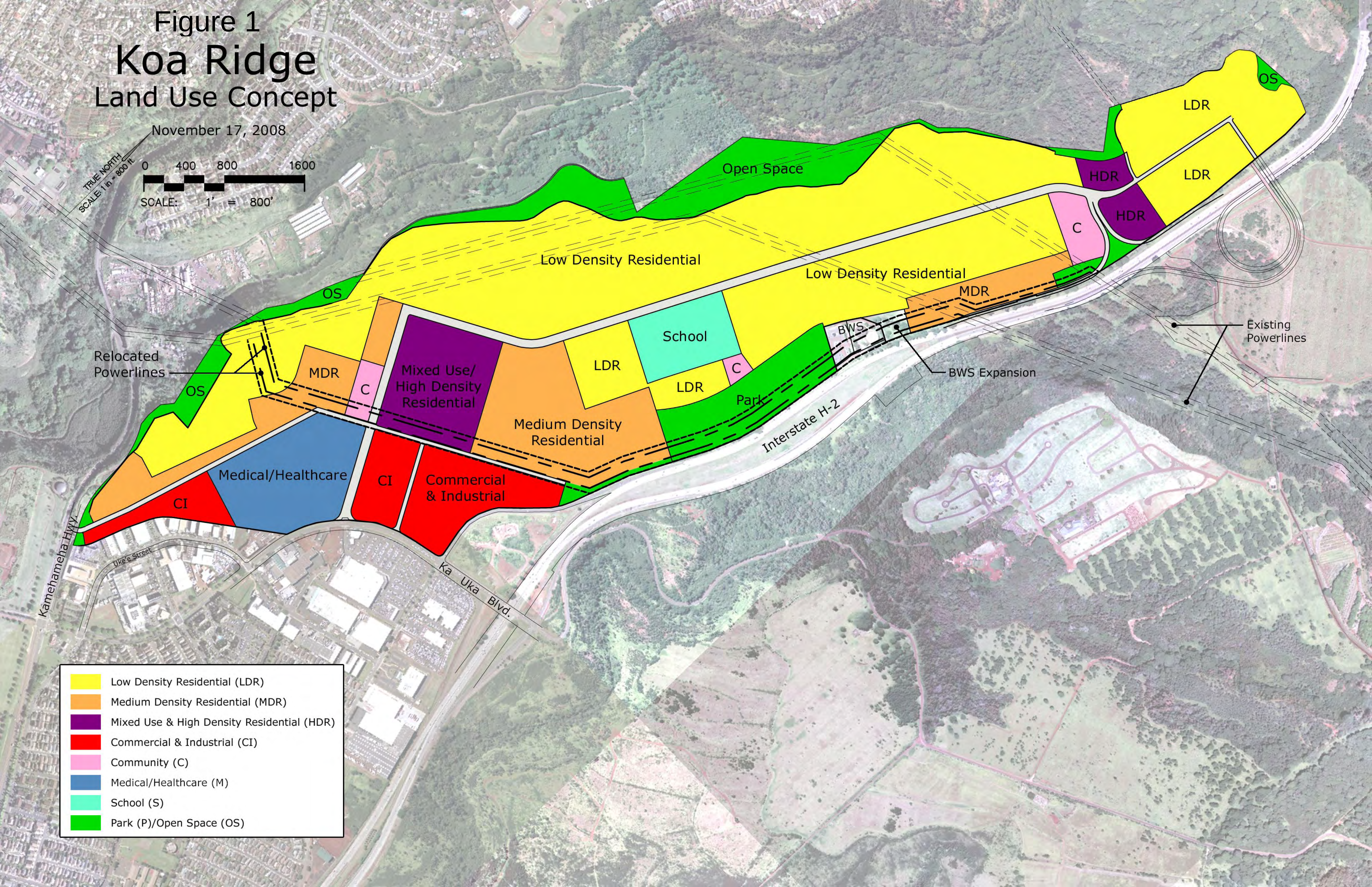
Figure 1
Koa Ridge
Land Use Concept
November 17, 2008
TRUE NORTH
SCALE: 1 in = 800 ft.
0 400 800 1600
SCALE: 1' = 800'
Open Space
LDR
OS
HDR
LDR
HDR
C
Low Density Residential
Low Density Residential
MDR
OS
Relocated Powerlines
MDR
C
Mixed Use/ High Density Residential
LDR
School
C
LDR
BWS
Existing Powerlines
BWS Expansion
OS
Medium Density Residential
Park
Interstate H-2
Medical/Healthcare
CI
Commercial & Industrial
CI
Kamehameha Hwy
Uke'e Street
Ka Uka Blvd.
Low Density Residential (LDR)
Medium Density Residential (MDR)
Mixed Use & High Density Residential (HDR)
Commercial & Industrial (CI)
Community (C)
Medical/Healthcare (M)
School (S)
Park (P)/Open Space (OS)

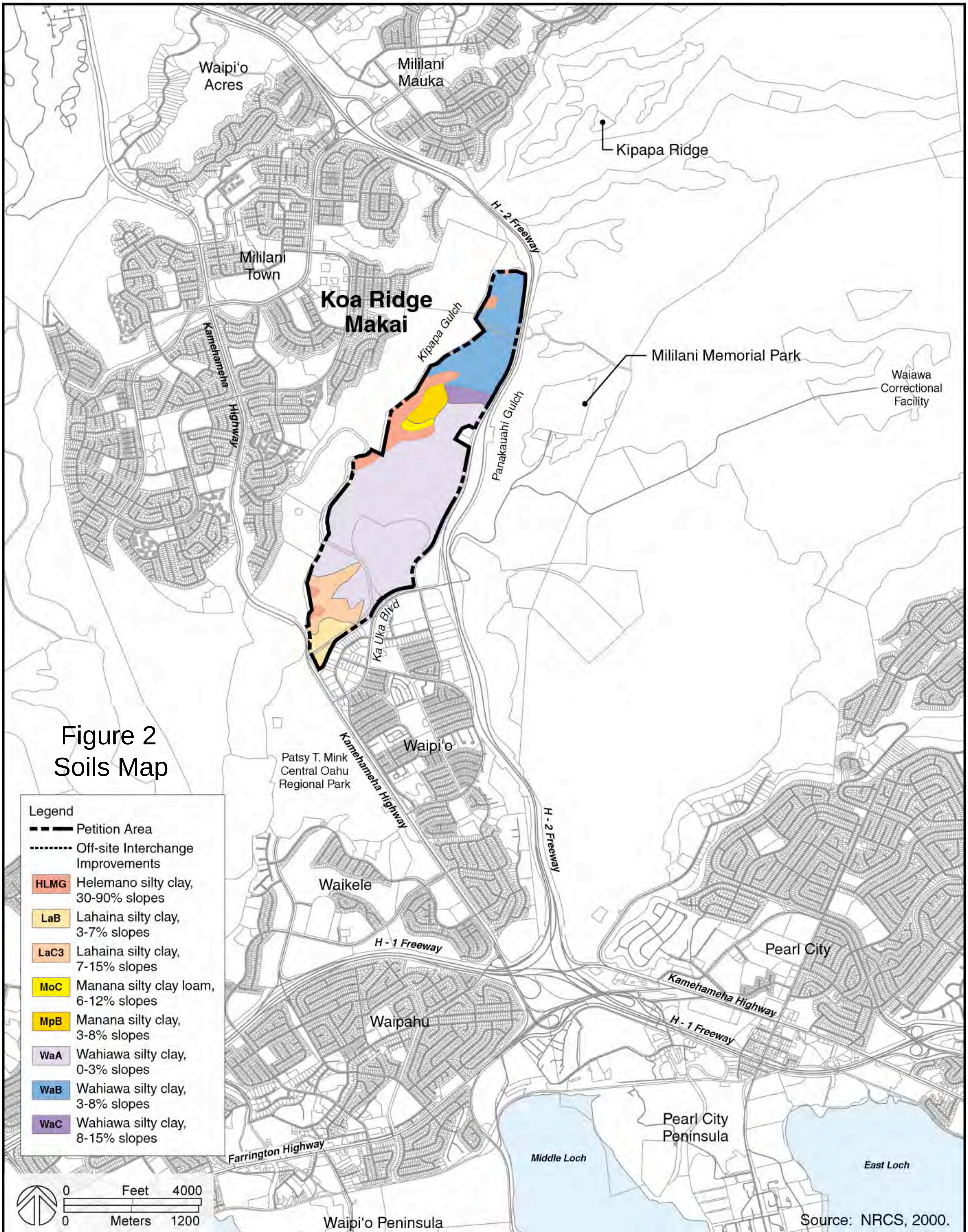

Figure 2
Soils Map

Source: NRCS, 2000.

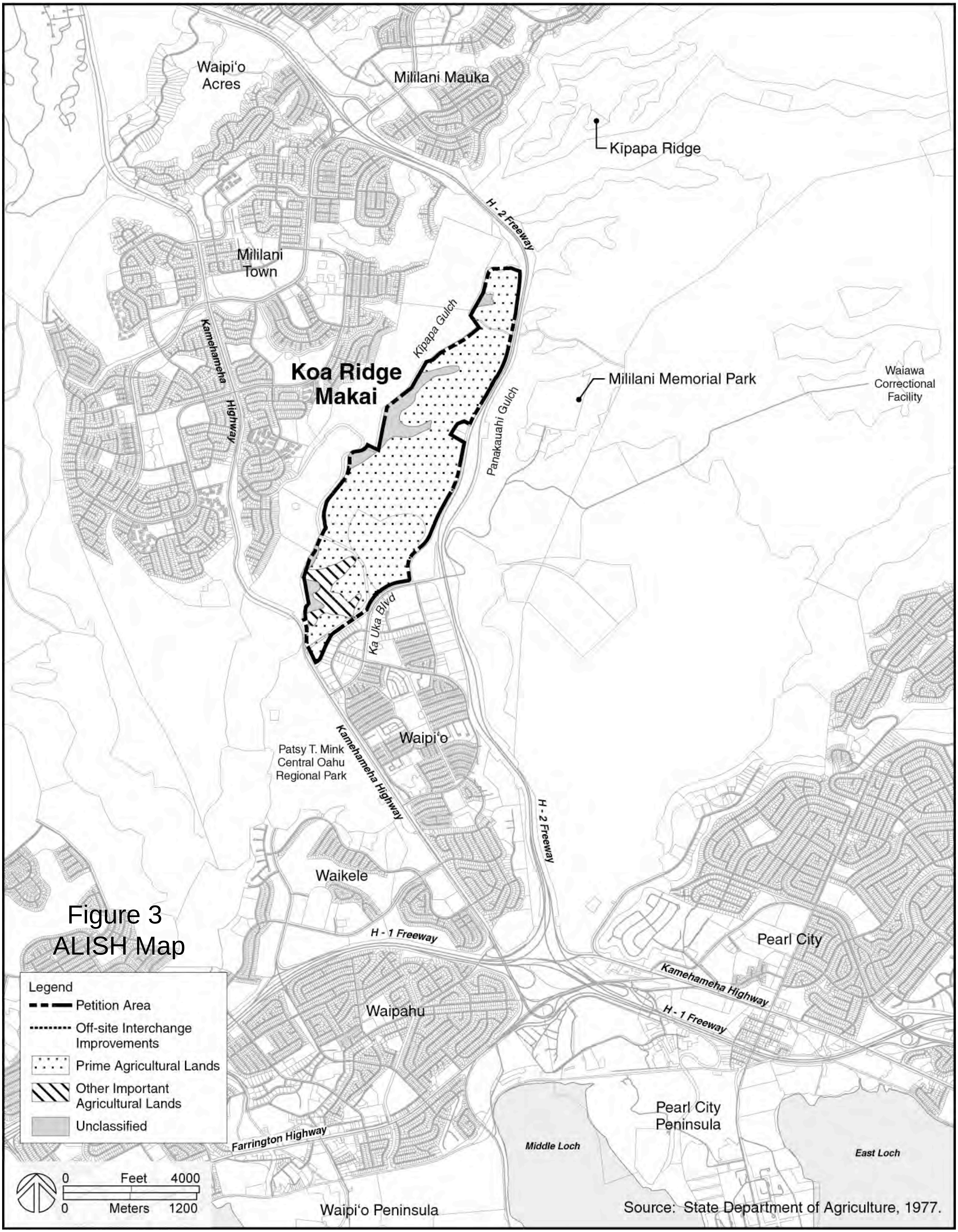

Figure 3
ALISH Map

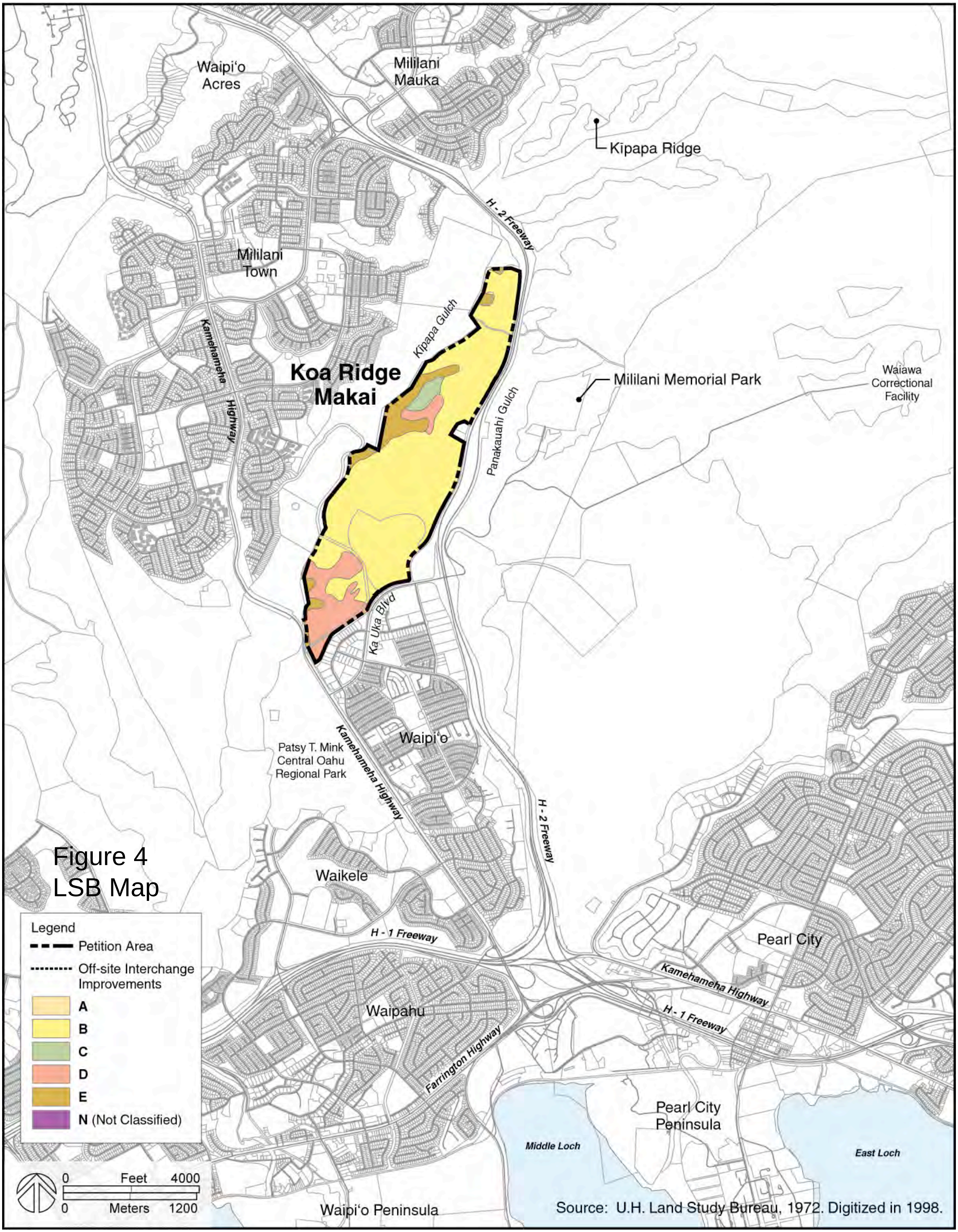

Figure 4
LSB Map

APPENDIX

APPENDIX A:
SELECTED STATE AND CITY GOALS, OBJECTIVES, POLICIES, AND GUIDELINES RELATED TO AGRICULTURAL LANDS

1. HAWAI'I STATE CONSTITUTION (Article XI, Section 3):

…to conserve and protect agricultural lands, promote diversified agriculture, increase agricultural self-sufficiency and assure the availability of agriculturally suitable lands…

2. HAWAI'I STATE PLAN (Chapter 226, Hawaii Revised Statutes, as amended):[1,2]

Section 226-7 Objectives and policies for the economy--agriculture.

(a) Planning for the State's economy with regard to agriculture shall be directed towards achievement of the following objectives:

(1) Viability in Hawaii's sugar and pineapple industries.

(2) Growth and development of diversified agriculture throughout the State.

(3) An agriculture industry that continues to constitute a dynamic and essential component of Hawaii's strategic, economic, and social well-being.

(b) To achieve the agricultural objectives, it shall be the policy of the State to:

(2) Encourage agriculture by making best use of natural resources.

(10) Assure the availability of agriculturally suitable lands with adequate water to accommodate present and future needs.

(16) Facilitate the transition of agricultural lands in economically nonfeasible agricultural production to economically viable agricultural uses.

Section 226-103 Economic priority guidelines.

(c) Priority guidelines to promote the continued viability of the sugar and pineapple industries:

(1) Provide adequate agricultural lands to support the economic viability of the sugar and pineapple industries.

(d) Priority guidelines to promote the growth and development of diversified agriculture and aquaculture:

(1) Identify, conserve, and protect agricultural and aquacultural lands of importance and initiate affirmative and comprehensive programs to promote economically productive agricultural and aquacultural uses of such lands.

(10) Support the continuation of land currently in use for diversified agriculture.

Section 226-104 Population growth and land resources priority guidelines.

(b) Priority guidelines for regional growth distribution and land resource utilization:

(2) Make available marginal or non-essential agricultural lands for appropriate urban uses while maintaining agricultural lands of importance in the agricultural district.

Section 226-106 Affordable Housing

Priority guidelines for the provision of affordable housing:

(1) Seek to use marginal or nonessential agricultural land and public land to meet housing needs of low- and moderate-income and gap-group households.

3. AGRICULTURAL STATE FUNCTIONAL PLAN (1991)[3]

(Functional plans are guidelines for implementing the State Plan. They are approved by the Governor, but not adopted by the State Legislature.)

Objective H: Achievement of Productive Agricultural Use of Lands Most Suitable and Needed for Agriculture.

Policy H(2): Conserve and protect important agricultural lands in accordance with the Hawaii State Constitution.

Action H(2)(a): Propose enactment of standards and criteria to identify, conserve, and protect important agricultural lands and lands in agricultural use.

Action H(2)(c): Administer land use district boundary amendments, permitted land uses, infrastructure standards, and other planning and regulatory functions on important agricultural lands and lands in agricultural use, so as to ensure the availability of agriculturally suitable lands and promote diversified agriculture.

4. CITY AND COUNTY OF HONOLULU GENERAL PLAN, Objectives and Policies (Resolution No. 87-211)[4]

Economic Activity

Objective C. To maintain the viability of agriculture on Oahu.

Policy 1. Assist the agricultural industry to ensure the continuation of agriculture as an important source of income and employment.

Policy 2. Support agricultural diversification in all agricultural areas on Oahu.

Policy 3. Support the development of markets for local products, particularly those with the potential for economic growth.

Policy 4. Provide sufficient agricultural land in Ewa, Central Oahu, and the North Shore to encourage the continuation of sugar and pineapple as viable industries.

Policy 5. Maintain agricultural land along the Windward, North Shore, and Waianae coasts for truck farming, flower growing, aquaculture, livestock production, and other types of diversified agriculture.

Policy 6. Encourage the more intensive use of productive agricultural land.

Policy 7. Encourage the use of more efficient production practices by agriculture, including the efficient use of water.

Policy 8. Encourage the more efficient use of nonpotable water for agricultural use.

5. CITY AND COUNTY OF HONOLULU CENTRAL O'AHU SUSTAINABLE COMMUNITIES PLAN[5]

Executive Summary

Central O'ahu's Role in O'ahu's Development Pattern

- Promote diversified agriculture and pineapple on 10,350 acres of prime and unique agricultural lands

Elements of the Vision

- **Urban Community Boundary** sets limits to urban development for the foreseeable future; protects 10,350 acres of diversified agriculture and pineapple lands along Kunia Road, above Wahiawa, around Mililani and on the Waipio Peninsula.

1. Central O'ahu's Role in O'ahu's Development Pattern

- Promotes diversified agriculture and pineapple on 10,350 acres of prime and unique agricultural lands along Kunia Road, north of Wahiawa, surrounding Mililani, and on the Waipio Peninsula in accordance with the General Plan policies to support agricultural diversification in all agricultural areas and to encourage continuation of a viable pineapple industry.

2. The Vision for Central O'ahu's Future

2.1 Vision Statement

Creation of an Open Space Network

- Urban growth will be contained within a boundary which will protect prime agricultural lands along Kunia Road, north of Wahiawa, surrounding Mililani, and on the Waipio Peninsula for diversified agriculture and pineapple. Preservation of these prime and unique agricultural lands for use in diversified agriculture and pineapple will help retain open space and views, in addition to supporting economic diversification.

2.2 Key Elements of the Vision

- Retention of Prime and Unique Agricultural Lands.

2.2.1 Urban Community Boundary

Criteria

- The boundary generally circumscribes the existing communities and planned developments of Royal Kunia, Wahiawa, Mililani, Mililani Mauka, Koa Ridge Makai, Waiawa, Waiawa Castle & Cooke, Gentry Waipio, Waikele and Mililani Technology Park, …

Objectives

- Support diversification of agriculture and preservation of the viability of the pineapple industry in Central O'ahu.

Protection for Prime Agricultural Land.

- The Urban Community Boundary protects prime agricultural lands along Kunia Road, north of Wahiawa, surrounding Mililani, and on the Waipio Peninsula from urban development for the foreseeable future, providing an incentive for landowners to give long term leases to farmers. No proposals for urban uses will be considered for these areas.

2.2.2 Retention of Agricultural Lands

- The Central Oahu Sustainable Communities Plan protects the highest value prime and unique agricultural lands in Central Oahu from urban development.

  These high value lands are located in four areas: lands along both sides of Kunia Road, lands north of Wahiawa, lands surrounding Mililani, and lands on the Waipio Peninsula which are in the Blast Zone of the West Loch Naval Magazine. State agencies indicated that these prime and unique agricultural lands in Central Oahu should be retained in agriculture because they are among the best in the State, are supported by an extensive, well-developed agricultural infrastructure, and are near the major transportation hub for export markets.

3. Land Use Policies, Principles, and Guidelines

3.1 Open Space Preservation and Development

3.1.1 General Policies

- Provide long range protection for diversified agriculture and pineapple on lands outside the Urban Community Boundary and for two agricultural areas located inside the Urban Community Boundary (Pine Spur and Honbushin).

3.7 Central O'ahu Plantation Villages

3.7.3.5 Adjacent Land Uses

- Agricultural use should be maintained on adjacent lands.

3.12 Military Areas

3.12..2 Pearl Harbor Naval Base (Waipio Peninsula)

- The City supports continued use of these lands for diversified agriculture or aquaculture activities.

3.12.2 Panning Principles

- Agricultural uses should be continued on the Waipio Peninsula in the West Loch Naval Magazine Blast Zone.

Appendix A: Conceptual Maps

Agriculture Boundary

- The agricultural boundary is to protect important agricultural lands for their economic and open space values, and for their value in helping give a region its identifiable character.

  Lands within this boundary include agriculturally valuable lands outside the Urban Community Boundary. They include agriculturally important lands designated by ALISH as “prime,” “unique,” or “other.”

Agricultural Areas

- Lands with agricultural value by virtue of current agricultural use or high value for future agricultural use, including those areas identified as Prime, Unique, or Other Important lands on the Agricultural Lands Important to the State of Hawai'i (ALISH) maps. “Agriculture” includes lands suitable for crop growing, grazing and livestock raising, flower cultivation, nurseries, orchards, aquaculture, or similar activities.

Maps A1, A2, A3 and A4

- These maps show that Koa Ridge Makai is within the Urban Expansion Areas.

6. REFERENCES

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CASTLE & COOKE WAIAWA: IMPACT ON AGRICULTURE

Decision Analysts Hawai'i, Inc.

Castle & Cooke Waiawa:
Impact on Agriculture

PREPARED FOR:

Castle & Cooke Homes Hawai'i, Inc.

PREPARED BY:

Decision Analysts Hawai'i, Inc.

October 2007

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EXECUTIVE SUMMARY

1. PROPOSED DEVELOPMENT

Castle & Cooke Homes Hawai'i, Inc. proposes to develop Castle & Cooke Waiawa, a master planned community in Central O'ahu referred to in this report as “the Project.” At full development, the Project will cover 191 acres, and will provide: approximately 1,500 single-family and multi-family homes, an elementary school, a recreation center, community parks, a neighborhood retail center, and trails and open space.

2. AGRICULTURAL CONDITIONS

About 135 acres (71%) of the Project area is suitable for growing low-elevation crops. This evaluation is based on favorable soil conditions and soil ratings over much of the site, gently-sloping terrain, mild sunny climate, and good access.

3. CURRENT GRAZING OPERATION

a. Flying R Livestock Co., Ltd.

Since 2000, about 186 acres of the Project Area plus another 218 acres of adjoining gulch land have been leased to Flying R Livestock Co. for grazing cattle. About 40 cow-and-calf units and 3 bulls graze on the 404 acres, and calf sales generate about $12,200 per year. The operation involves the part-time effort of a single rancher with no employees.

Flying R Livestock leases a total of about 5,130 acres for cattle grazing, including the 404 acres at Waiawa, plus an additional 4,725 acres split between Waiawa Ridge (about 800 acres), Koa Ridge Mauka (about 625 acres) and the North Shore (about 3,300 acres). The Waiawa Ridge land is also subject to eventual urban development.

b. Impact on Grazing Operations

Development of the Project would eliminate cattle grazing in the Project Area and adjoining gulch lands. However, the proposed development is expected to have no significant impact on cattle production or employment since the herd at Caste & Cooke Waiawa, as well as the herd at Waiawa Ridge, can be moved onto the rancher's leased land at Koa Ridge Mauka (about 625 acres) and the North Shore (about 3,300 acres).

c. Availability of Grazing Land

The total supply of grazing land in Hawaii is very large—an estimated 1.15 million acres statewide and over 50,000 acres on O'ahu. Furthermore, the supply of grazing land has increased statewide and on O'ahu due to the contraction of plantation agriculture (see Figure ES-1).

Thus, the Project will have negligible impacts on the supply of grazing land statewide or on O'ahu—the decreases will amount to about 0.016% and 0.37%, respectively.

d. Mitigating Measures

Mitigating measures for the loss of grazing lands are not recommended because the Project will have a negligible impact on the cattle industry.

4. GROWTH OF DIVERSIFIED CROPS

a. Recent Crop-acreage Trends

For all diversified crops—i.e., all crops other than sugarcane and pineapple, including crops to replace imports and crops for export—Statewide land requirements grew as shown in Figure ES-1. As illustrated, growth in acreage has slowed over time, with an average growth of about 160 acres per year from 2000 to 2005. During this period, major export crops grew by an average of about 350 acres per year, while crops grown for the Hawai'i market declined by an average of about 190 acres per year.

b. Potential Acreage Required to Relocate Farm

In addition to farm land that will be required to accommodate the growth of diversified farming, about 3,600 acres could be required to relocate all or portions of four existing farms that will or could be displaced from Central O'ahu, 'Ewa, and lower Kunia due to urban development and to changes in agricultural uses (e.g., seed corn replacing diversified crop farming).

c. Land Available for Diversified Crops

Statewide

Statewide, a vast amount of land has been released from plantation agriculture: about 251,800 acres between 1968 and 2005, resulting in an average release of over 6,800 acres per year over a 37-year period (see Figure ES-1). The 2006 Del Monte closure in Kunia increased this figure by another 4,400 acres, resulting in a total release of at least 256,200 acres from plantation agriculture between 1968 and 2007. Over the 1968-to-2005 period, the demand for land for diversified crops increased by about 26,300 acres (about 10% of the land released from plantation agriculture).

The acreage released from plantation agriculture has far outpaced the demand for land for diversified crops. The net decrease of land in crop amounts to about 229,900 acres. While some of the released land has been converted or is scheduled to be converted to urban uses and tree plantations, an estimated 160,000+ acres remain available for diversified crops.

O'ahu

On O'ahu, a similar release of plantation land occurred. In total, about 10,900 acres of former high-quality plantation land remain available for other crops, including about 3,150 acres of former pineapple land in Kunia plus about 7,750 acres of former sugarcane and pineapple lands on the North Shore.

However, portions of the available 10,900 acres have limitations for growing certain crops. Some limitations reflect permanent agronomic conditions. For example, higher elevation fields in Kunia and on the North Shore have less solar radiation compared to 'Ewa. But some of the limitations can be overcome with investment in improvements. On the North Shore, parts of the water delivery systems need major repairs and upgrades, and the types of crops on fields irrigated with water from Wahiawa Reservoir (Lake Wilson) will be restricted as long as partially-treated wastewater continues to be discharged into the lake.

d. Impact on the Growth of Diversified Crops

The Project will commit about 135 acres of good agricultural land to a non-agricultural use, most of which is suitable for farming but has not been farmed since 1993. In view of the available supply of farm land (160,000+ acres Statewide and about 10,900 acres of high-quality land on O'ahu), the development of this agricultural land—combined with the other planned developments in Hawai'i—involves the loss of too little agricultural land to significantly affect either (1) the growth of diversified crop farming (averaging about 160 acres per year), or (2) the relocation of farms that are being displaced or could be displaced from Central O'ahu, 'Ewa and lower Kunia (about 3,600 acres).

e. Mitigating Measures

In view of the negligible impact of the Project on the growth of diversified agriculture in Hawai'i, mitigating measures for the loss of this agricultural land are not recommended.

5. OFFSETTING BENEFITS

The Project will result in the loss of about 135 acres of good agricultural land which currently provides a fraction of one ranch job. This potential loss to agriculture will be offset by the following benefits:

— approximately 1,500 single-family and multi-family homes

— an elementary school

— a recreation center

— community parks

— trails and open space

— construction and related jobs provided by Project development

— a variety of jobs provided by the neighborhood retail center

6. CONSISTENCY WITH STATE AND CITY POLICIES

a. Availability of Lands for Agriculture

The *Hawaii State Constitution*, the *Hawaii State Plan*, the *State Agriculture Functional Plan*, and the *General Plan of the City and County of Honolulu* call directly or implicitly for preserving the economic viability of plantation agriculture and promoting the growth of diversified crops. To accomplish this, an adequate supply of agriculturally suitable lands and water must be assured.

With regard to plantation agriculture, development of the Project will have no impact on pineapple operations since Dole no longer grows pineapple in Central O'ahu.

With regard to diversified crops, development of the Project Area will result in a loss of about 135 acres of good farm land, but this loss will not limit the growth of diversified crops since ample agricultural land is available on O'ahu and on other islands. This is due to the enormous supply of agricultural land that is now available following the contraction of plantation agriculture (see Figure ES-1).

b. Conservation of Agricultural Lands

In addition to the above, State policies call for conserving and protecting prime agricultural lands, including protecting agricultural lands from urban development.

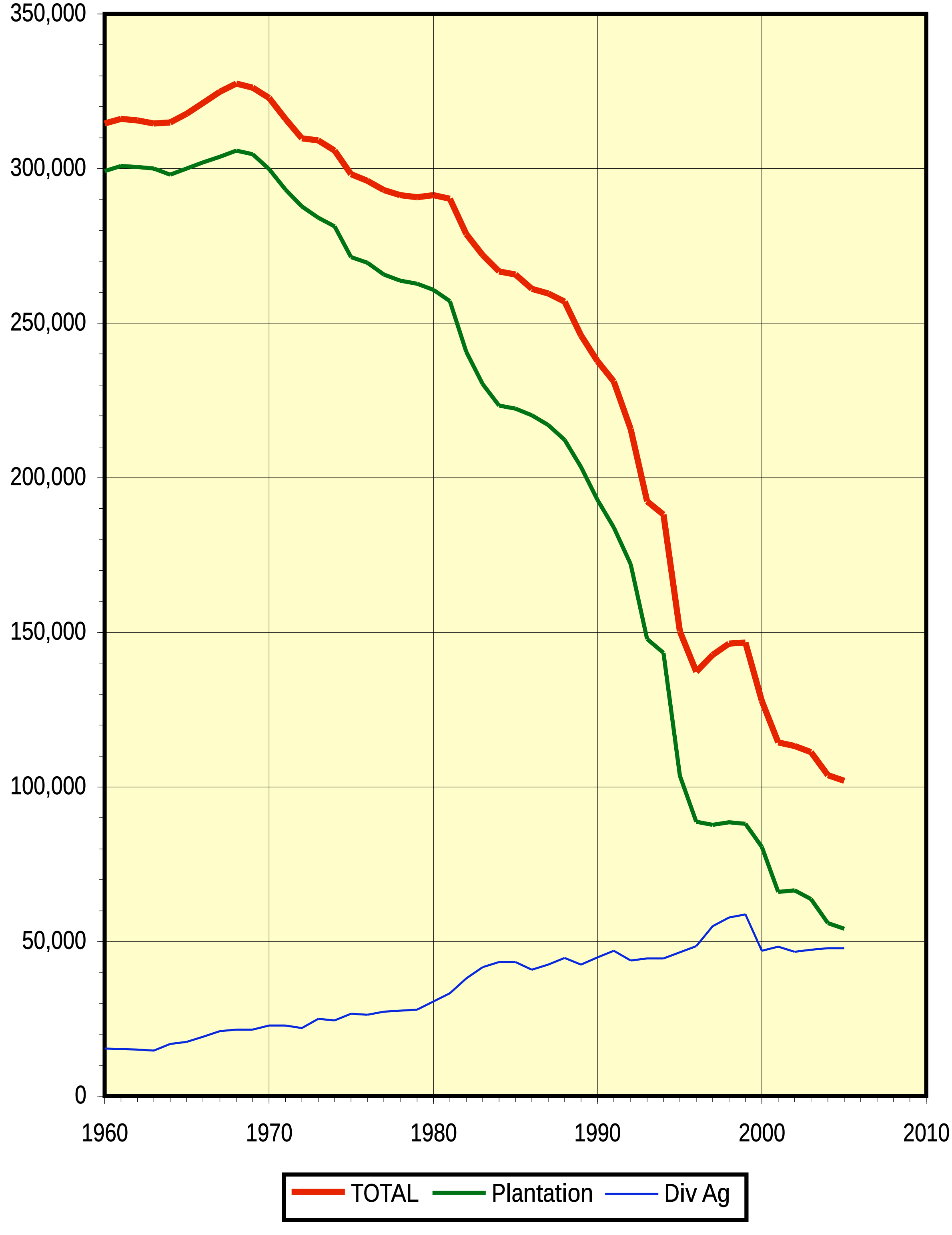
However, these policies—which were written before the major contraction of plantation agriculture in the 1990s—assume implicitly that profitable agricultural activities eventually will be available to utilize all available agricultural lands. This has proven to be a questionable assumption in view of the enormity of the contraction of plantation agriculture, the abundant supply of land that came available for diversified agriculture, and the slow growth in the amount of land being utilized for diversified agriculture (see Figure ES-1).

Furthermore, discussions in the Agriculture portion of the *State Functional Plan* recognize that redesignation of lands from Agricultural to Urban should be allowed "… upon a demonstrated change in economic or social conditions, and where the requested redesignation will provide greater benefits to the general public than its retention in …agriculture;" that is, when an "overriding public interest exists." The enormous contraction of plantation agriculture, resulting in the supply of agricultural land far exceeding demand, constitutes a major change in economic conditions. Moreover, the proposed Project will provide community benefits (approximately 1,500 homes, an elementary school, a recreation center, community parks, trails and open space, construction employment, and retail employment) that far exceed those which are now provided by the Flying R Livestock Co. (a fraction of a single job). In practice, however, development of the Project Area is expected to have no impact on agricultural employment.

c. Central O'ahu Sustainable Communities Plan

The Petition Area is within the City's designated Urban Expansion Area of the Central O'ahu Sustainable Communities Plan in an area designated for residential development. Thus, in terms of future land use, the Project is consistent with the Central O'ahu Sustainable Communities Plan.

Figure ES-1 - Statewide Acreage in Crop: 1960 to 2005



CASTLE & COOKE WAIAWA:
IMPACT ON AGRICULTURE

1. INTRODUCTION[1]

Castle & Cooke Homes Hawai'i, Inc. proposes to develop Castle & Cooke Waiawa, a master planned community in Central O'ahu referred to in this report as “the Project.”

This report addresses the impacts on agriculture of developing the Project. The material below gives the following information on the Project: its location; a description of planned development; existing State and City land-use designations; the agricultural conditions of the Project Area; potential crops; locational advantages and disadvantages for crop farming; surrounding land uses; the agricultural history of the land; the impact of the Project on current grazing operations; the impact of the Project on the growth of diversified crops; the impact of the Project on agricultural land values and rents; the impact of the Project on food security; the impact of the Project on open space provided by agriculture; benefits of the Project offsetting adverse agricultural impacts; and consistency of the Project with State and City agricultural policies.

The report is followed by nine figures that provide maps of the location of the Project, a conceptual master plan of the Project, existing State and City land-use designations, soil types, soil ratings, and slopes. In the Executive Summary, Figure ES-1 plots changes in crop acreage since 1960. Finally, the Appendix provides a summary of State and City goals, objectives, policies and guidelines related to agricultural lands.

2. LOCATION OF THE PROJECT[1]

As shown in Figure 1, the Project is located in Central O'ahu east-north-east of the interchange that provides access to Waipi'o from the H-2 Freeway. The Petition Area is also defined by three TMKs:

— 9-6-04:21

— 9-4-06:Por. 29

— 9-4-06:Por. 31

3. PROJECT DESCRIPTION[1]

At full development, the Project will cover 191 acres, and will include: approximately 1,500 single-family and multi-family homes, a neighborhood retail center, an elementary school, a recreation center, community parks, trails and open space (Figure 2).

4. EXISTING STATE AND CITY LAND-USE DESIGNATIONS[1]

As shown in Figure 3, the Project is within the State Agricultural District. However, the Project Area is designated for residential and related development in the City's Central O'ahu Sustainable Communities Plan (Figure 4), but is currently zoned "Agricultural" (Figure 5).

Thus, development of the Project will require (1) a State Land Use Boundary Amendment to change the districting from Agricultural to Urban, and (2) changes in zoning from Agriculture to appropriate residential and other urban categories.

5. AGRICULTURAL CONDITIONS

a. Soil Types[2]

The land area contains six soil types which are categorized below by their quality as rated by the Soil Conservation Service, now known as the Natural Resources Conservation Service (NRCS):

Few or Moderate Limitations		Acres	NRCS Ratings
WaA	Wahiawa silty clay, 0 to 3% slopes	52	I
MpB	Manana silty clay, 3 to 8% slopes	3	IIe
WaB	Wahiawa silty clay, 3 to 8% slopes	71	IIe
Severe Limitations			
MpC	Manana silty clay, 8 to 15% slopes	10	IIIe
Very Severe Limitations			
MpD	Manana silty clay, 15 to 25% slopes	14	IVe
HLMG	Helemano silty clay, 30 to 90% slopes	41	VIIe

As shown above and in Figure 6, most of the better soils are WaA and WaB. These are deep, well-drained soils, and the erosion hazard is slight for WaB.

b. Soil Ratings

Three classification systems are commonly used to rate soils in Hawai'i: (1) Land Capability Grouping, (2) Agricultural Lands of Importance to the State of Hawai'i, and (3) Overall Productivity Rating.

Land Capability Grouping (NRCS Rating)[2]

The 1972 Land Capability Grouping by the U.S. Department of Agriculture, NRCS rates soils according to eight levels, ranging from the highest classification level "I" to the lowest "VIII."

As indicated above, about 126 acres (66%) in the Project Area have soils that are rated I or IIe. Class I soils have few limitations that restrict their use. Class II soils have moderate limitations that reduce the choice of plants or require moderate conservation practices. The subclassification "e" indicates that the soils are subject to moderate erosion. The remaining soils have severe or very severe limitations for farming.

Agricultural Lands of Importance in the State of Hawai'i (ALISH)[3]

ALISH ratings were developed in 1977 by the NRCS, the University of Hawai'i (UH) College of Tropical Agriculture and Human Resources, and the State of Hawai'i, Department of Agriculture. This system classifies land into three categories: (a) "Prime" agricultural land which is land that is best suited for the production of crops because of its ability to sustain high yields with relatively little input and with the least damage to the environment; (b) "Unique" agricultural land which is non-Prime agricultural land used for the production of specific high-value crops; and (c) "Other" agricultural land which is non-Prime and non-Unique agricultural land that is important to the production of crops.

About 137 acres (72%) in the Project Area have soils that are rated Prime (see Figure 7).

Overall Productivity Rating (LSB Rating)[4]

In 1972, the UH Land Study Bureau (LSB) developed the Overall Productivity Rating, which classifies soils according to five levels, with "A" representing the class of highest productivity and "E" the lowest.

About 143 acres (75%) in the Project Area have soils that are rated A or B (see Figure 8).

Summary Evaluation of Soil Quality

An average of the above three soil-rating systems indicates that about 135 acres (71%) of the Project Area has soils that are good for cultivating crops (II or better under the NRCS rating, Prime under the ALISH rating, and B or better under the LSB rating).

c. Elevation[1]

The elevation of the Project Area ranges from about 440 feet to 620 feet. Thus, the land is suitable for crops that are generally referred to as "low-elevation crops," as opposed to "high-elevation crops" such as those being grown in Kula, Maui or Waimea on the Big Island.

d. Slopes[1]

As indicated in Figure 9, slopes over most of the Project Area are less than 5%.

e. Climatic Conditions

Like other areas in Hawai'i, Central O'ahu has a mild semitropical climate that is due primarily to three factors: (1) Hawai'i's mid-Pacific location near the Tropic of Cancer, (2) the influence of surrounding warm ocean waters that vary little in temperature between the winter and summer seasons, and (3) the prevailing northeasterly tradewinds that bring air having temperatures that are close to those of the surrounding waters.

Solar Radiation[5]

Most of the Project Area receives a moderately high amount of sunshine, with an average daily insolation of about 450 calories per square centimeter.

Temperatures[1]

Average daily temperatures in the area are generally moderate, ranging from about 65°F to 85°F.

Rainfall[6]

Rainfall averages slightly less than 40 inches per year.

Winds and Storms[6]

During normal tradewind conditions, winds are typically less than 15 miles per hour. Storms are infrequent, occurring mostly from the south in the winter months during Kona weather.

f. Irrigation Water[7]

The landowner has a water allocation of 1.1 million gallons per day from Waiahole Ditch to irrigate crops on lands owned by Castle & Cooke in Waiawa and Koa Ridge (1,248 acres). This water allocation is sufficient to irrigate about 314 acres in diversified crops (based on 3,500 gallons per acre per day), and is now used to irrigate crops grown at Koa Ridge Makai.

g. Road Access

Fields in the Project Area are reached via plantation roads that connect to Ka Uka Boulevard and Cemetery Road. In turn, these roads connect to the H-2 Freeway.

h. Summary

About 135 acres in the Project Area is suitable for growing low-elevation crops. This evaluation is based on favorable soil conditions and soil ratings over much of the site, the gently-sloping terrain, mild sunny climate, and good access.

However, the limited water allocation of 1.1 million gallons per day from Waiahole Ditch is sufficient to irrigate only about 314 acres planted in diversified crops, or about 25% of the 1,248 acres of agricultural land at Waiawa and Koa Ridge.

6. POTENTIAL CROPS AND CROP PRODUCTION[8]

a. Potential Crops

Based on the above agronomic conditions, the Project Area is suitable for low-elevation crops commercially grown in Hawai'i, including but not limited to: asparagus, beans (green, bush and snap), bell peppers, bittermelon, cantaloupe, Chinese peas, cucumbers, daikon, dry onions, eggplant, flowers / nursery products, ginger root, green onions, green peppers, head and semi-head lettuces, herbs, honeydew melons, limes, lotus root, lychee, Manoa lettuce, mango, mustard cabbage, Oriental squash, parsley, pumpkins, seed crops, sweet corn, sweet potatoes, tangerines, and watermelons.

b. Potential Crop Production

Potential crop production at Waiawa is estimated at about 2 million pounds per year. This is based on the following assumptions: (1) about 135 acres of good farm land; (2) a mix of vegetable crops grown on the land; (3) the land is farmed intensely, with an average of about 50% of it kept in crop; and (4) yields average about 30,000 pounds of vegetables per acre per year.

7. LOCATIONAL ADVANTAGES AND DISADVANTAGES FOR CROP FARMING[9]

The Project Area is well-located for serving the Honolulu consumer market and export markets. This is due to the short trucking distance to the Honolulu markets, the Honolulu International Airport, and Honolulu Harbor.

In the U.S. mainland market, however, farmers in Hawai'i must compete against farmers on the mainland and in Mexico, Central and South America, the Caribbean, Australia, New Zealand, Southeast Asia, etc. Most of the competing farm areas incur lower production and delivery costs than does Hawai'i. Competing against Mexico is particularly difficult given the North America Free Trade Agreement (NAFTA) and Mexico’s proximity to major U.S. markets

8. SURROUNDING LAND USES[1]

Existing and planned land uses surrounding the Project Area are shown in Figures 1, 4 and 5, and include:

- — To the west, Panakauahi Gulch then the H-2 Freeway.
- — To the north, Panakauahi Gulch and Mililani Memorial Park.
- — To the east and south, Gentry / A&B’s planned Waiawa community project.

In view of the surrounding land uses, the Project Area has become an agricultural remnant cut off from other agricultural lands.

9. AGRICULTURAL HISTORY[7,10]

a. Pineapple

For the greater part of a century, Dole Food Company Hawai'i (Dole) grew pineapple on about 144 acres in the Project Area. This was a feasible crop for the area because pineapple requires little water compared to most other crops. However, in 1993 Dole ceased growing pineapple on this land. By 2002 Dole had shifted its remaining Central O'ahu pineapple operations to the North Shore in order to consolidate its operations near the Dole packing plant, base yard, and offices. The North Shore land came available after Waialua Sugar Company, Inc. closed in 1996.

b. Grazing

In recent years, most of the Petition area has been used for grazing cattle.

10. CURRENT GRAZING OPERATION

a. Flying R Livestock Co., Ltd.[10,11]

Since 2000, about 186 acres of the Project Area plus another 218 acres of adjoining gulch land have been leased to Flying R Livestock Co. for grazing cattle. For the entire 404 acres, 2007 lease rents were less than $13 per acre.

About 40 cow-and-calf units and 3 bulls graze on the 404 acres, although the capacity is about 75 units and 5 bulls. Revenues are estimated by the consultant at about $12,200 per year (about $30 per acre per year), based on annual calf production of about 80% of the cows and a selling price of about $380 per calf. At the carrying capacity of the land, potential revenues could be as high as $22,800 per year, which amounts to about $56 per acre per year. The operation involves the part-time effort of a single rancher with no employees.

Flying R Livestock leases a total of about 5,130 acres for cattle grazing, including the 404 acres at Waiawa, plus an additional 4,725 acres split between Waiawa Ridge (about 800 acres), Koa Ridge Mauka (about 625 acres) and the North Shore (about 3,300 acres). The Waiawa Ridge land is also subject to eventual urban development. The entire operation provides employment for two people.

b. Impact on Grazing Operations[9,11]

Development of the Project would eliminate cattle grazing in the Project Area and adjoining gulch lands. However, the proposed development is expected to have no significant impact on cattle production or employment since the herd at Caste & Cooke Waiawa, as well as the herd at Waiawa Ridge, can be moved onto the rancher's leased land at Koa Ridge Mauka (about 625 acres) and the North Shore (about 3,300 acres).

c. Availability of Grazing Land[8,12]

The total supply of grazing land in Hawaii is very large—an estimated 1.15 million acres statewide and over 50,000 acres on O'ahu. Furthermore, the supply of grazing land has increased statewide and on O'ahu due to the contraction of plantation agriculture (see Section 11.c and Figure ES-1). For comparison, the statewide figure for acreage available for grazing is about three times the entire land area of O'ahu (381,632 acres).

Thus, the Project will have negligible impacts on the supply of grazing land statewide or on O'ahu—the decreases will amount to about 0.016% and 0.37%, respectively.

d. Mitigating Measures

Mitigating measures for the loss of grazing lands are not recommended because the Project will have a negligible impact on the cattle industry.

11. GROWTH OF DIVERSIFIED CROPS

The Project will commit about 135 acres of good agricultural land to a non-agricultural use. The impact of this commitment on the growth of diversified crops is addressed below. The material covers: (1) the potential acreage required for the future growth of diversified farming, (2) potential acreage required to relocate farms from 'Ewa and Kunia, (3) availability of land for diversified crops, (4) impact of the Project on the growth of diversified crops, and (5) mitigating measures.

a. Potential Acreage Required for the Future Growth of Diversified Farming

Crops to Replace Imports of Fruits and Vegetables[13]

For low-elevation fruits and vegetables that have a history of profitable production in Hawai'i, potential land requirements in 2010 for 100% import substitution for the Hawai'i and O'ahu markets are estimated at 12,700 acres and 8,600 acres, respectively, plus additional acreage for fallowing land between crop plantings. When allowing for competition from imports, these estimates drop to about half. These estimates take into account estimated consumption, production trends, seasonal and annual market shares, yields, and the number of crops per year. Also, these figures are for acreage in crop—not harvested acreage as is typically reported in government publications.

For the many crops grown in Hawai'i, market shares for Hawai'i growers are limited by the following factors: (1) local varieties are not perfect substitutes for all imports (e.g., premium-priced sweet Maui onions versus inexpensive storage onions); (2) some crops cannot be produced profitably in the summer due to competition from low-cost imports of fruits and vegetables from California, other states, and Mexico; and (3) over-production must be avoided in order to maintain profitable price levels.

Since Hawai'i farmers already supply a portion of the Hawai'i market, land requirements for increased import substitution are a fraction of the above estimates.

Export Crops[8,12,14]

The potential market for export crops is far larger than the Hawai'i market. In 2005, the U.S. population was 296.41 million, compared to a Hawai'i's resident-plus-visitor population of 1.45 million. To take advantage of this large potential, Hawai'i farmers are exploring various export crops on lands released from plantation agriculture. Over the next 20+ years, one or more of these crops may prove to be successful and may grow into a major export crop.

However, the history of agricultural efforts in Hawai'i reveals that the successful development of major new export crops requiring large amounts of land is difficult and infrequent. For example, over the past 50 years in Hawai'i, farmers have explored numerous possibilities for export crops, but they have developed overseas markets for just one diversified crop that requires more than 10,000 acres (macadamia nuts at 18,300 acres in 2005); one additional crop that requires more than 5,000 acres (coffee at 8,000 acres); and only five additional crops or crop categories that require more than 1,000 acres each (papaya at 2,395 acres, bananas at 1,145 acres, tropical specialty fruits at 1,230 acres, flowers / nursery products at 3,895 acres, and seed crops at 4,220 acres). Tropical specialty fruits include longan, lychee, mango, rambutan, star-fruit, etc.

<u>Feed Crops</u>[15]

If feed crops could be grown in Hawai'i and priced competitively against mainland imports, they could replace a portion of the grains and hay that is now being imported to the State. Unfortunately, a number of commercial attempts in Hawai'i to grow grains and alfalfa have been unsuccessful. The major problems have been (1) pests, particularly birds that eat the grains before they are harvested; (2) humidity that is too high for drying alfalfa properly; and (3) high production costs compared to those of mainland farms.

<u>Biofuel Crops</u>[9,16-21]

Crops can be grown to produce biomass to fuel a boiler, or as feedstock to produce fuels. Examples of the latter include sugarcane, corn, or sorghum used to produce ethanol. In turn, the ethanol is used to produce E-10 gasohol (90% gasoline and 10% ethanol). Also, palm oil, soybean, sunflower, kukui nut, avocado, coconut, neem and other crops can be grown to produce biodiesel.[22]

In Hawai'i, the common practice has been to produce biomass as a by-product of some principal crop. For example, at HC&S on Maui and at Gay & Robinson on Kaua'i, the sugarcane by-product bagasse is burned to help fuel their respective power plants. In addition, the biofuel company Maui Ethanol plans to use the sugarcane by-product, molasses, from the two sugarcane plantations as feedstock to produce ethanol.[16,17] Using conventional technology, the sugar in the molasses will be fermented to produce ethanol, followed by distillation to extract the alcohol.

However, O'ahu Ethanol Corporation plans to build an ethanol plant at Campbell Industrial Park using conventional technology but, at least initially, plans to use imported molasses as the feedstock.[17,18] The rated capacity will be 15 million gallons of ethanol per year. For the longer term, this company is exploring the economics of growing sweet sorghum to supply feedstock to its ethanol plant. The sorghum would have to be grown on O'ahu because it would be too expensive to ship the sorghum juice from a Neighbor Island to O'ahu. Sorghum juice is mostly water having a low concentration of sugar compared to molasses.

Acreage requirements for a new sorghum biofuel plantation on O'ahu would range from about 6,000 acres for viability to 15,000 acres if juice from sorghum were to replace all imported molasses.[18] This acreage comprises a substantial share, if not all, of the estimated 10,900 acres of crop land that is available on O'ahu as of mid-2007. But it is a small share of the 160,000+ acres of crop land available statewide (see Section 11.c).

Also, Imperium Renewables Hawai'i LLC is proposing to build by 2009 a biodiesel refinery on State land at Kalaeloa Harbor; it would produce about 100 million gallons of biodiesel annually.[23,24] Similarly, BlueEarth Maui Biodiesel LLC plans to build a similar refinery on Maui that would produce about 120 million gallons annually by 2011. Both will use imported palm oil from Malaysia and other countries as their feed stock, but would refine locally produced vegetable oil if available.

A number of substantial difficulties must be overcome in order to develop one or more biofuel plantations to supply feedstock for ethanol or biodiesel production, including:

— Long-term Leases

In many areas of the State, it will be difficult to lease the large amount of land required for a biofuel plantation at low lease rents for the 30 or so years required to capitalize the investment in a new plantation. Over time, other farmers and other users of land are likely to make higher offers to landowners of lease rents or land purchases. In view of this potential for landowners, the current market value of available farm lands is likely to be higher if landowners do <u>not</u> commit long-term to rents that are low enough to be affordable to a biofuel plantation.

— Capital

Substantial investment capital will be required to cover the cost of improvements and equipment such as: a mill to extract the juice from a biofuel crop; a generating plant to provide power;

improvements and upgrades to irrigation systems that are in disrepair; trucks and equipment to harvest and haul harvested plants to the mill, and haul the extracted juice to an ethanol plant or the vegetable oil to a refinery, etc.

— Short-term Profitability

Annual revenues from selling the ethanol plus direct subsidies are estimated by the consultant at about $2,700 per acre (based on an estimated 900 gallons per acre per year of ethanol at about $3 per gallon). Even with subsidies, this is low compared to revenues from other crops in Hawai'i. Per-acre returns from biodiesel crops are even less.

Furthermore, the cost of importing molasses or palm oil for feedstock, or importing ethanol may prove to be less expensive than growing a biofuel crop in Hawai'i. For similar crops (such as feed crops), importing has proven to be less expensive than growing and processing crops locally. Also, the U.S. Department of Agriculture has found sorghum to be an expensive feedstock for producing ethanol—about 3.7 times more expensive than corn and 63% more expensive than molasses.[20]

As ethanol production increases on the mainland and in Hawai'i, there is a risk that the combined Federal and State subsidies for ethanol (over $2 per gallon) could be reduced, thereby compromising the profitability of a biofuel crop.

— Long-term Profitability

Over the long-term, emerging technology holds promise for a cheaper source of feedstock for ethanol than does growing a biofuel crop on a plantation.[19] Instead of producing ethanol using sugars from conventional sources (e.g., molasses, sugarcane, grains, fruits, etc.), the sugar would come from "cellulosic" sources. Using new technology that is in the early stages of commercialization, sugar that is locked in complex carbohydrates of plants is separated into fermentable sugars. Feedstock would include agricultural wastes, yard clippings, discarded paper, wood waste, etc.—i.e., the green waste that is now used for composting. This new technology promises (1) much higher ethanol yields per ton of biomass because the entire plant can be used as feedstock, and (2) lower costs—particularly if there are no growing costs when waste product is used, and if the operator is paid a fee to dispose of municipal and agricultural waste. Eventually, this less expensive source of feedstock could result in unprofitable biofuel plantations. In Hawai'i, this new technology is being explored by ClearFuels Technology Inc.

O'ahu's municipal waste could produce an estimated 160 million gallons of ethanol compared to the current annual consumption of about 400 million gallons of gasoline.

The above difficulties and risks suggest that the probability of successfully developing and sustaining a biofuel plantation in Hawai'i is low. The more likely scenario is that ethanol will be produced as a by-product of sugar and, over the long-term, it will be produced from green waste.

Commercial Forest[16,25,26]

Although not categorized as a crop, commercial timber can be grown on crop land as well as on grazing land. On the Big Island, Prudential Timber has more than 20,000 acres planted in eucalyptus trees on former sugarcane and ranch lands. The timber is to be used for veneer, paper pulp, and as a biofuel. On Kaua'i, Hawaiian Mahogany grows eucalyptus and albizia trees for high-end furniture and landscape timber.

A commercial forest requires a major investment and a long commitment (30 years or more) before significant returns are realized. It is also a risky investment given the uncertainty over future lumber prices and potential losses to fire. Over time, projected returns from forests are greater than returns from grazing, but less than returns from crop farming. A recent study indicated that, with Federal and State subsidies, a small koa operation on the Big Island would provide higher returns than would grazing.

A commercial forest is best suited as an alternative to grazing when there is a high probability that the land will not be needed for a higher-value use (such as crop farming) for a period of 30 years or more. While some land on O'ahu might be suitable for small stands of high-value timber species such as koa, far more land is available on the Big Island where a commitment has already been made to develop a timber industry.

Recent Crop-acreage Trends[8]

For all diversified crops—i.e., all crops other than sugarcane and pineapple, including crops to replace imports and crops for export—statewide land requirements grew as shown in Figure ES-1, with the annual growth by selected periods summarized as follows:[1,2]

1. In Figure ES-1, the rapid growth in diversified-crop acreage that occurred during the 1979-to-1983 period largely reflects (1) growth in macadamia-nut acreage which continued until about 1986 when tax-shelter advantages were terminated, and (2) a temporary increase in feed-crop acreage that declined after 1983 and offset the acreage gains in

— 1963 to 1979: about 839 acres per year.

— 1979 to 1983: about 3,450 acres per year.[1]

— 1983 to 2000: about 310 acres per year.[2]

— 2000 to 2005: about 160 acres per year.

As the above illustrates, growth in acreage of diversified crops has slowed over time.

Regarding major export crops and crop categories, acreage increased for four of them from 2000 to 2005: coffee up an average of 20 acres per year; tropical specialty fruits up 54 acres per year, flowers / nursery products up 235 acres per year, and seed crops up 264 acres per year. During this same period, acreage declined for three of the major export crops: macadamia nuts down an average of 20 acres year, papaya down 90 acres per year, and bananas down 113 acres per year. The net change was an average increase of 350 acres per year.

Regarding crops grown for the Hawai'i market, acreage declined by an average of 190 acres per year from 2000 to 2005.

In summary, the major growth in acreage for diversified crops from 2000 to 2005 came from just two crop categories: seed crops and flowers / nursery products.

These trends are consistent with U.S. and worldwide advances in economic development, transportation and trade. In essence, communities increase their standard of living by increasing their economic specialization and their trade with other communities.

Factors Limiting the Growth of Diversified Crops[13]

A great many crops can be grown in Hawai'i's year-round subtropical climate, and a number of them can be grown profitably in volumes that require a few hundred acres. However, the modest growth in land requirements for diversified crops reflects the fact that few crops can be grown profitably on a large scale. The primary factors that have limited the growth of diversified agriculture in Hawai'i are given below.

— Hawai'i's subtropical climate is not well-suited to the commercial production of major crops that grow better in the temperate mainland climates.

macadamia nuts. The growth in feed-crop acreage may reflect the situation addressed in Footnote 2.

2. In Figure ES-1, the temporary bump in diversified-crop acreage that occurred in the late 1990s reflects the fact that some former sugarcane fields were newly planted with grasses for future cattle grazing. After cattle grazing began in 2000, much of this acreage was recategorized by NASDA from crop land to grazing land.

— For certain crops, special hybrids adapted to Hawai'i's subtropical climate are yet to be developed.

— Crop pests are more prevalent and more expensive to control in Hawai'i than they are on the mainland where the cold winters kill many pests.

— Fruit-fly infestations prevent exports of many crops, or require expensive treatment.

— Most soils in Hawai'i have low nutrient levels and therefore require high expenditures for fertilizer.

— Hawai'i suffers from high farm-labor costs, largely because the agriculture industry must compete against the visitor, construction, and other industries for workers.

— Compared to many other farm areas that supply U.S. markets, the cost of shipping agricultural supplies and equipment to Hawai'i is high, as is the cost of exporting produce from Hawai'i to mainland markets. High shipping costs are a result of Hawai'i's remote location and of Federal regulations that require use of American-built ships and U.S. crews between U.S. ports.

— For a number of crops, consumption volumes in Hawai'i are too small to support large, efficient farms (that is, the volumes are too small to realize economies of scale).

— On-going trends towards food suppliers purchasing produce that is certified as safe and towards buying from a single supplier of many food items favor large farms.

— Hawai'i farmers must compete against highly efficient mainland and foreign farms which, in a number of cases, can deliver produce to Hawai'i more cheaply than it can be produced locally. This is due to economies of scale and, in comparison to Hawai'i, low costs for land, labor, supplies, fertilizer, pest control, equipment, etc.

b. Potential Acreage Required to Relocate Farms[9]

In addition to farm land that will be required to accommodate the growth of diversified farming, about 3,600 acres could be required to relocate all or portions of four existing farms that will or could be displaced from Central O'ahu, 'Ewa, and lower Kunia due to urban development and to changes in agricultural uses. The affected farms and acreages are shown in Table 1.

Aloun Farms, Fat Law's Farm, and Jefts Farms grow a variety of diversified crops. Monsanto and Syngenta are competing seed companies. As indicated in

Table 1. Approximate Acreage Required to Relocate Farms Displaced from Central O'ahu, 'Ewa and Lower Kunia

Cause of Displacement	Aloun Farms	Fat Law's Farm	Jefts Farms	Syngenta	TOTAL
Urban Projects					
Koa Ridge,[1] Central O'ahu	430	-	-	-	430
Ho'opili,[1] 'Ewa	1,000	100	197	200	1,497
State Projects, 'Ewa	850	-	95	-	945
Other Farm Uses					
State Ag Park, Kunia	-	-	150	-	150
Monsanto Co., Kunia	-	-	220	360	580
TOTAL	2,280	100	662	560	3,602

1. Proposed and within the City's Urban Expansion Area.

Source: Decision Analysts Hawai'i, Inc. 2007.

Table 1, Monsanto's expansion into lower Kunia will displace portions of Syngenta's and Jefts Farms' operations. As a result of the displacement, Syngenta might relocate its O'ahu operations to Kaua'i where most of its operations are currently located.

Regarding potential urban development, Koa Ridge and Ho'opili are proposed projects that are within the City's Urban Expansion Area.

c. Land Available for Diversified Crops

Statewide

Statewide, a vast amount of land has been released from plantation agriculture: about 251,800 acres between 1968 and 2005, resulting in an average release of over 6,800 acres per year over a 37-year period (see Figure ES-1).[8,27] The 2006 Del Monte closure in Kunia increased this figure by another 4,400 acres, resulting in a total release of at least 256,200 acres from plantation agriculture between 1968 and 2007.[9,28] Over the 1968-to-2005 period, the demand for land for diversified crops increased by about 26,300 acres (about 10% of the land released from plantation agriculture).[8]

As the above figures indicate, the acreage released from plantation agriculture has far outpaced the demand for land for diversified crops. The net decrease of land in crop amounts to about 229,900 acres. While some of the released land has been converted or is scheduled to be converted to urban uses and tree plantations, an estimated 160,000+ acres remain available for diversified crops.[9] Because of the increased availability of agricultural land, a number of landowners report lower per-acre agricultural land rents on O'ahu and the Neighbor Islands compared to rents charged before the major contraction in plantation agriculture.[21]

If the Superferry begins operations, cultivating crops on the Neighbor Islands for the Honolulu market, and vice versa, may become more economically feasible. For a full load carried in a large pick-up truck, the one-way fare will be about 2¢ per pound.[29] However, the ferry service may not be sufficiently frequent for certain crops, and / or delivery times may not be sufficiently rapid.

The above information indicates that considerable land is available in Hawai'i to accommodate the relocation of farms as well as the growth of diversified crop farming.

<u>O'ahu</u>

On O'ahu, a similar release of plantation land occurred. Between 1968 and 2007, about 51,900 acres were released due to the contraction of five plantations and the closures of all but one of them.[8,9] About 32,700 acres were released after 1990. Much of this land remains available for agriculture, and most of it lies outside the City’s Urban Expansion Area.

The Kunia fields are considered to be among the best farm land in the State, based on the high solar radiation; high-quality soils; and the short trucking distance to the large Honolulu market, the airport, and Honolulu Harbor.[15] Except for lands recently released by Del Monte, all of the better Kunia fields have already been leased for diversified crop farming. However, on average, only about one-third of this land is in crop.[30] The large amount of fallowing reflects best farm practices when land is abundant and land rents are relatively low. Fallowing increases soil fertility and helps control unwanted volunteer plants, weeds, insects and disease. When demand for farm land is strong and rents are high in response to a strong demand for agricultural products, then more intensive farming of the land may be warranted even if this increases farmers’ costs for pest control and soil additives.

Of the estimated 4,400 acres of Kunia land recently farmed by Del Monte, about 3,150 acres remain available. The decrease was due to (1) Monsanto's land purchase in lower Kunia for seed crops, and (2) the U.S. Army's land purchase in upper Kunia to expand Schofield Barracks. These two purchases involve considerable land, including about 1,220 acres of former pineapple fields.[31,32] About 640 acres of the Monsanto purchase will remain in agriculture.

Another possible land purchase could impact the future supply of farm land in Kunia. The Army Hawai'i Family Housing LLC (AHFH), a public / private partnership between the U.S. Army and Actus Lend Lease, plans to acquire about 2,520 acres in northern Kunia from Campbell, including about 1,570 acres of former pineapple land.[31,33] AHFH intends to "bank" the land for future needs, which will allow a portion it to be used for military housing if needed in the distant future. If and when AHFH proposes the land for development, the project will be subject to all State and City development approvals and permits, which could prove difficult since the development would be outside the City's existing Urban Expansion Area. AHFH has indicated that if they acquire the land, it will remain in agriculture for the foreseeable future.

On the North Shore, various crops are being grown, but about 7,750 acres of higher-quality fields formerly in sugarcane and pineapple remain fallow or are in a low-value use, all of which have current or potential access to irrigation water.[21,34]

In total, about 10,900 acres of former high-quality plantation land remain available on O'ahu for other crops. This includes the 3,150 acres of former pineapple land in Kunia plus the 7,750 acres on the North Shore. However, it excludes any adjustment for the farm land that is already leased for diversified crops but is not farmed intensively, some arable lands in the foothills that are currently used for grazing, and a portion of the 2,290 acres (about 1,600 acres arable) purchased by Monsanto that may be made available for crops other than seed crops.

Given the large release of land from plantation agriculture on O'ahu, the amount of available farm land that remains on the island is less than what one might expect. This is explained by the following: (1) diversified crop farmers relocated to and / or expanded their operations on these high-quality and favorably located lands, but much of this was at the expense of production elsewhere on O'ahu and the Neighbor Islands; (2) seed companies increased their operations on O'ahu because of these same advantages; (3) many farmers keep only a portion of their land in crop, leaving most of it fallow (see Section 11.c, ¶6); (4) many fields in the foothills were reallocated to grazing because better lands are available elsewhere for farming; (5) considerable land in 'Ewa and Central O'ahu was or will be urbanized; and (6) the military acquired some land in upper Kunia.

Some of the 10,900 acres of former high-quality plantation land remaining available on O'ahu has limitations for growing certain diversified crops, some of which are short-term limitations but some are permanent. In particular, fields at the higher elevations in Kunia and on the North Shore have lower solar radiation compared to 'Ewa: the average daily insolation is about 400 calories per square centimeter at the higher elevations compared to as much as 500 calories in 'Ewa.[5] Also, some fields at the higher elevations incur higher pumping costs.

On the North Shore, portions of the water delivery systems need major repairs or upgrades, and the types of crops on fields irrigated with water from Wahiawa Reservoir (Lake Wilson) will be restricted as long as partially-treated wastewater continues to be discharged into the lake.[21,35] Water from the lake can be used to irrigate tree crops (e.g., papaya and coffee) and crops such as sugarcane that are processed sufficiently to kill pathogens. However, the water cannot be used to irrigate unprocessed leafy vegetable crops.

Also, North Shore farmers encounter longer trucking distances to Honolulu markets, the airport, and the harbor.

d. Cumulative Impact on the Growth of Diversified Crops

The Project will commit 135 acres of good agricultural land to a non-agricultural use, most of which is suitable for farming but has not been farmed since 1993. In view of the available supply of farm land (160,000+ acres Statewide and about 10,900 acres on O'ahu), the development of this agricultural land—combined with the other planned developments in Hawai'i—involves the loss of too little agricultural land to significantly affect either (1) the growth of diversified crop farming (averaging about 160 acres per year), or (2) the relocation of farms that are being displaced or could be displaced from Central O'ahu, 'Ewa and lower Kunia (about 3,600 acres).

e. Mitigating Measures

In view of the negligible impact of the Project on the growth of diversified agriculture in Hawai'i, mitigating measures for the loss of this agricultural land are not recommended.

12. IMPACT ON AGRICULTURAL LAND VALUES AND RENTS[9]

A question that is sometimes raised is whether the development of agricultural land will cause a general increase in agricultural land values and/or rents which, in turn, could cause some farmers to be displaced because they are unable to afford the higher land costs. This issue is addressed below for Castle & Cooke Waiawa.

a. Agricultural Land Values

On O'ahu, the value of agricultural land largely reflects its development potential. If farm land is within the City's Urban Expansion Area and development is likely to start within a few years, then the land value can exceed $100,000 per acre. But if the land is unlikely to be developed in the foreseeable future, then the value may be less than $20,000 per acre.

Development approvals for Castle & Cooke Waiawa are likely to <u>delay</u> the development of other farm lands on O'ahu, particularly those which are in the path of urbanization but are outside the City's Urban Expansion Area (e.g., Kunia and much of the North Shore). Thus, the Project would <u>reduce</u> the development potential of these other lands, resulting in slightly lower agricultural land values than would otherwise be the case.

b. Agricultural Land Rents

Agricultural land rents are based on the supply and demand of land for farming, and on what farmers can afford to pay while still remaining profitable. Agricultural rents are <u>not</u> based on the value of the land. If they were, high rents would preclude farming in such areas as the 'Ewa Plain and Kunia. Yet, these areas are leased at rents that are affordable for farming.

The Project will decrease the supply of agricultural land on Oahu. However, given the large supply of available farm land on O'ahu due to the recent closure of two sugarcane plantations and the Del Monte pineapple plantation, this loss is too small to significantly affect agricultural land rents.

13. FOOD SECURITY[8,9]

Another concern that is sometimes raised is that an abundant supply of farm land might be needed to grow food crops in the event that some unforeseen catastrophe cuts off food imports to Hawai'i. However, such a catastrophe would also cut off crop exports. In this situation, the supply of farm land that would be available to grow food crops for local consumption would include much of the 90,000+ acres that are now used for export crops (sugar, pineapple, macadamia nuts, coffee, papaya, seed crops, etc.), plus the 160,000+ acres of farm land that are fallow or in a low-value use.

Thus, a loss of 135 acres of good agricultural land in the Project Area constitutes too small an amount of land to threaten food security in the event of a catastrophe that could cut off food imports to Hawai'i.

14. VALUE OF OPEN SPACE[12,36,37]

Leaving the land in agriculture would provide open space to the O'ahu residents. A community survey performed in 1995 by University of Hawai'i researchers revealed that O'ahu households would pay about 0.23 cent annually to preserve one additional acre of agricultural land in open space, with the value being subject to change based on the supply of agricultural land, household incomes, and general price inflation. Based on the island population and economic conditions in 2005, this translates to about $800 per year that all O'ahu residents combined would pay to preserve one acre of open space. Assuming a 3% discount rate, 1 acre of open space would be valued at about $26,700 ($800 ÷ 0.03). For Castle & Cooke Waiawa, the total value of open space amounts to about $5.1 million (191 acres x $26,700 / acre).

This 1995 value of open space by O'ahu households could be high in that it was 6 to 45 times higher than the corresponding figures for U.S. mainland and Canadian communities (lower values on open space were given by residents in rural areas, and higher values were given by those living in more developed areas). Also, surveys that reveal intentions can result in estimates that are higher than actual behavior. Finally, neither the City nor the State has shown a willingness to purchase a significant amount of agricultural land in order to prevent development and thereby preserve the land in open space, even though agricultural land has been available at prices below $26,700 (e.g., Kunia).

More realistically, only small portions of the Project are visible from roads frequently traveled by the public. About 20 acres of the steeper sloping land on the western edge of the Project Area can be seen from the northbound H-2 / Ka Uka Boulevard interchange (see Figure 9). This 20 acres of visible open space has a value of about $500,000, assuming that the $26,700-per-acre value mentioned above is reasonably accurate. When traveling north on the H-2 Freeway, an even smaller portion of the Project Area can be briefly glimpsed after driving under the Ka Uka Boulevard overpass. When traveling south on the H-2 Freeway, a berm between the north and south lanes blocks a view of the Project Area. None of the Project Area can be seen from Cemetery Road once it drops into the bottom of Panakauahi Gulch. The only prominent view of the Project Area is from the access road to Waiawa Correctional Facility, but the volume of traffic there is low.

If the area were to be farmed, the common practice among many diversified-crop farmers is to build berms (some as high as 15 feet) and plant screens to block views of their fields. While this helps reduce farmers' theft and nuisance problems, it also reduces the value of their fields as open space.

15. OFFSETTING BENEFITS[1,9]

The Project will result in the loss of about 135 acres of good agricultural land which currently provides a fraction of one ranch job. If all of this good land were used to grow typical vegetable and fruit crops, it could support about 7 farm jobs (based on an average of 40% of the land in crop and about 12.5 jobs per 100 acres). In practice, however, the Project will result in little or no loss of existing or potential agricultural employment since other lands are available for farming.

This potential loss to agriculture will be offset by the following benefits:

— approximately 1,500 single-family and multi-family homes

— an elementary school

— a recreation center

— community parks

— trails and open space

— construction and related jobs provided by Project development

— a variety of jobs provided by the neighborhood retail center

16. CONSISTENCY WITH STATE AND CITY POLICIES[38]

a. Availability of Lands for Agriculture

The *Hawaii State Constitution*, the *Hawaii State Plan*, the *State Agriculture Functional Plan*, and the *General Plan of the City and County of Honolulu* call directly or implicitly for preserving the economic viability of plantation agriculture and promoting the growth of diversified crops. To accomplish this, an adequate supply of agriculturally suitable lands and water must be assured.

With regard to plantation agriculture, development of the Project will have no impact on pineapple operations since Dole no longer grows pineapple in Central O'ahu.

With regard to diversified crops, development of the Project Area will result in a loss of about 135 acres good farm land, but this loss will not limit the growth of diversified crops since ample agricultural land is available on O'ahu and on other islands. This is due to the enormous supply of agricultural land that is now available following the contraction of plantation agriculture (see Section 11.c and Figure ES-1).

b. Conservation of Agricultural Lands

In addition to the above, State policies call for conserving and protecting prime agricultural lands, including protecting agricultural lands from urban development.

However, these policies—which were written before the major contraction of plantation agriculture in the 1990s—assume implicitly that profitable agricultural activities eventually will be available to utilize all available agricultural lands. This has proven to be a questionable assumption in view of the enormity of the contraction of plantation agriculture, the abundant supply of land that came available for diversified agriculture, and the slow growth in the amount of land being utilized for diversified agriculture (see Section 11 and Figure ES-1).

Furthermore, discussions in the Agriculture portion of the *State Functional Plan* recognize that redesignation of lands from Agricultural to Urban should be allowed "… upon a demonstrated change in economic or social conditions, and where the requested redesignation will provide greater benefits to the general public than its retention in …agriculture;" that is, when an "overriding public interest exists." The enormous contraction of plantation agriculture, resulting in the supply of agricultural land far exceeding demand, constitutes a major change in economic conditions. Moreover, the proposed Project will provide community benefits (approximately 1,500 homes, an elementary school, a recreation center, community parks, trails and open space, construction employment, and retail employment) that far exceed those which are now provided by the Flying R Livestock Co. (a fraction of a single job). In practice, however, development of the Project Area is expected to have no impact on agricultural employment.

c. Central O'ahu Sustainable Communities Plan

As shown in Figure 4, the Petition Area is within the City's designated Urban Expansion Area of the Central O'ahu Sustainable Communities Plan in an area designated for residential development. Thus, in terms of future land use, the Project is consistent with the Central O'ahu Sustainable Communities Plan.

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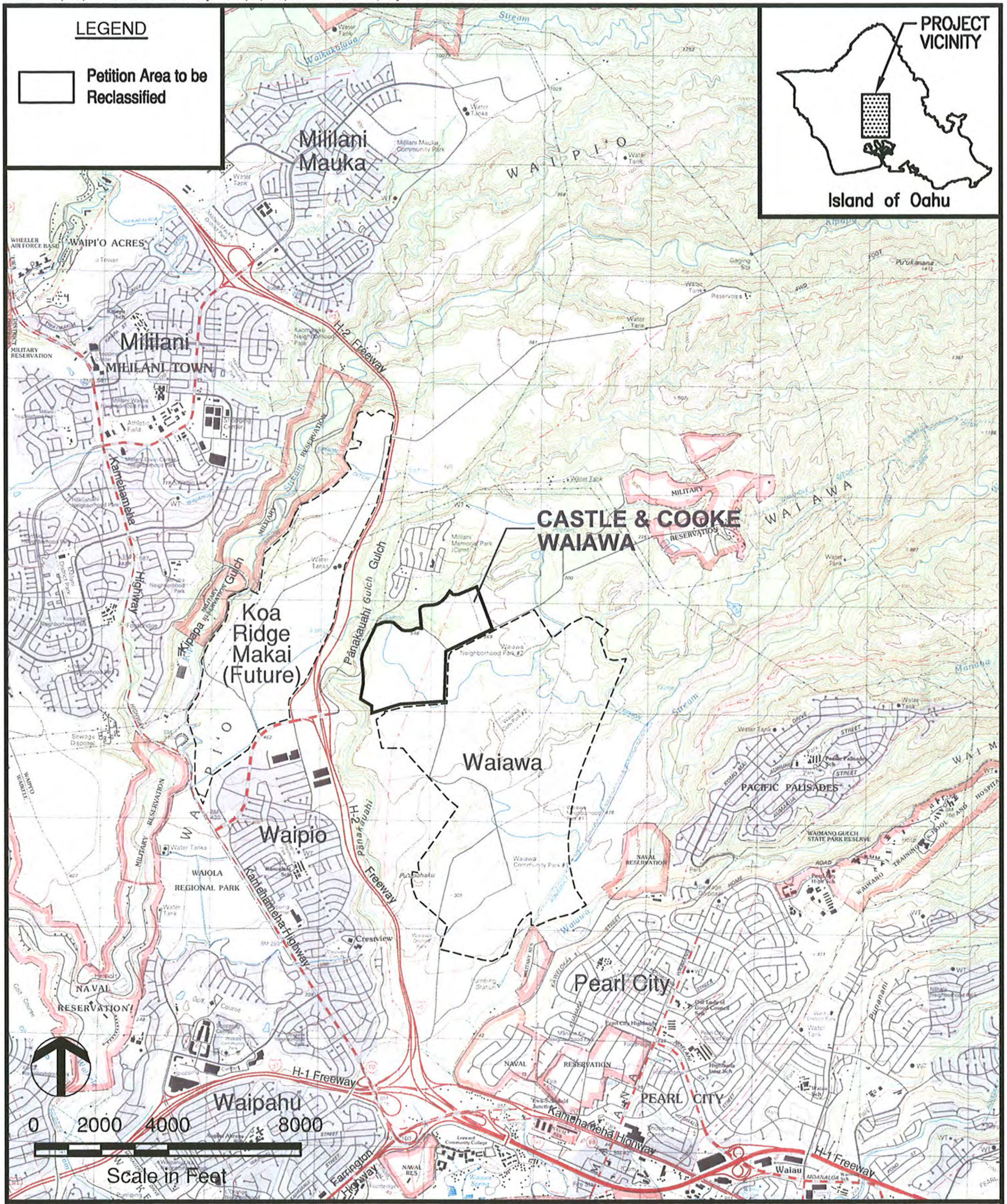
FIGURES

FILE PATH: M:\WOA\7101-02 Waiawa & Koa Ridge Makai\Graphics\7101-02 Location Map.dwg PLOT DATE: Jun 29, 2007



CASTLE & COOKE WAIAWA	**Location Map**	**Figure 1-1**
	Prepared for: Castle & Cooke Homes Hawaii, Inc.	**Prepared by:** Wilson Okamoto Corporation

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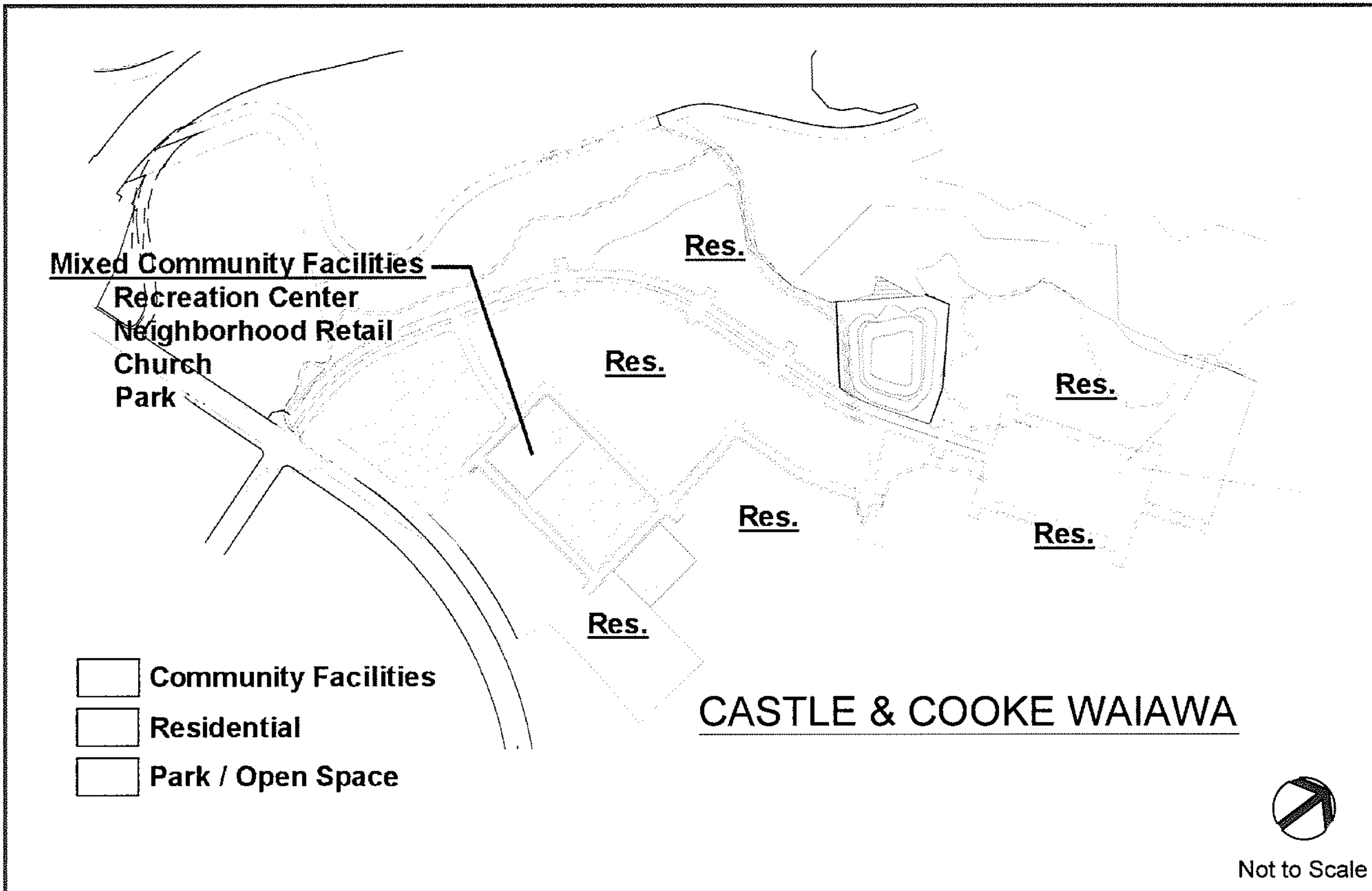

CASTLE & COOKE WAIAWA

Conceptual Master Plan

Figure 2-1

Prepared for:
Castle & Cooke Homes Hawaii, Inc.

Prepared by:
Wilson Okamoto Corporation

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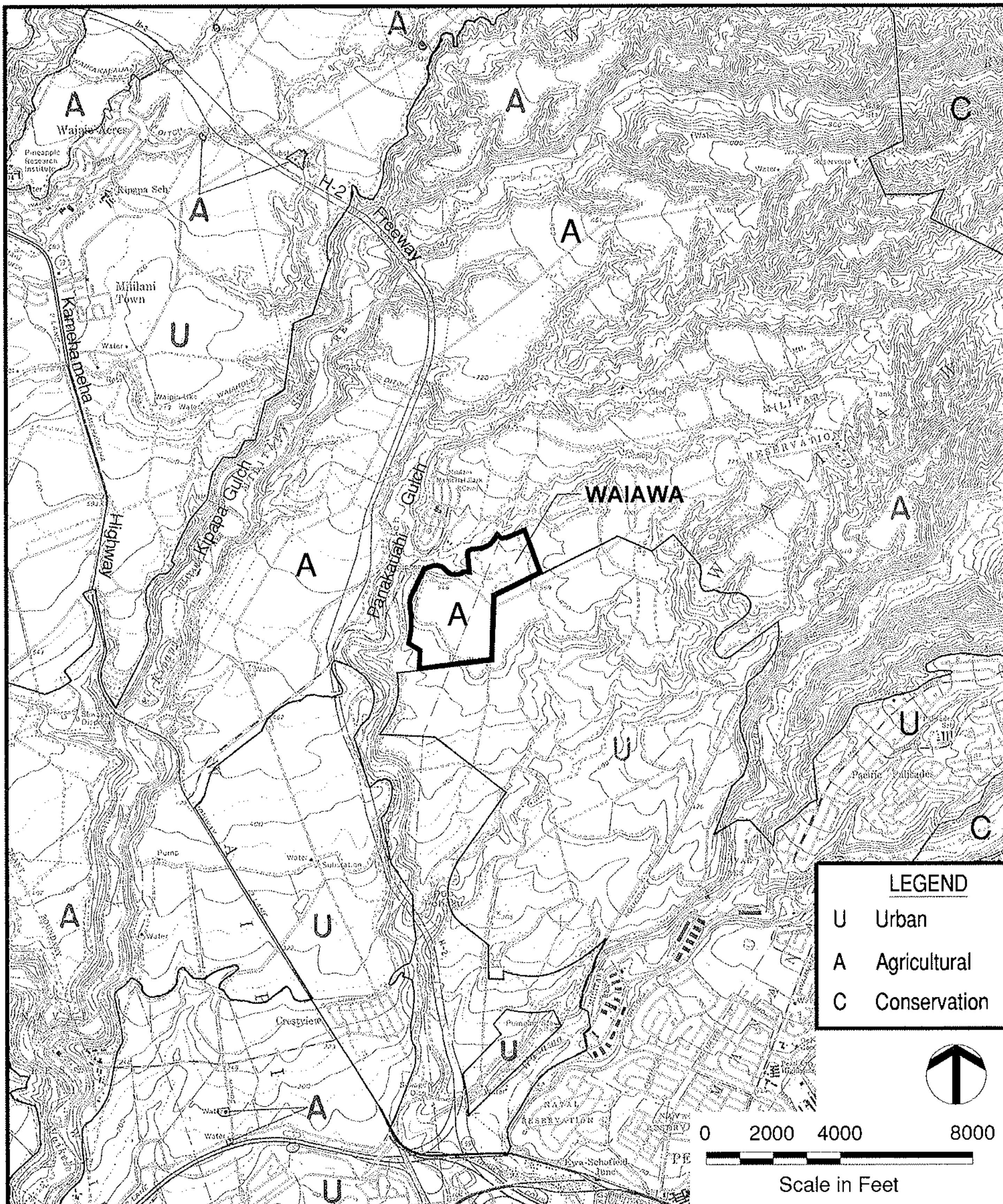

CASTLE & COOKE WAIAWA

Existing State Land Use Districts **Figure 4-1**

Prepared for: Castle & Cooke Homes Hawaii, Inc.

Prepared by: Wilson Okamoto Corporation

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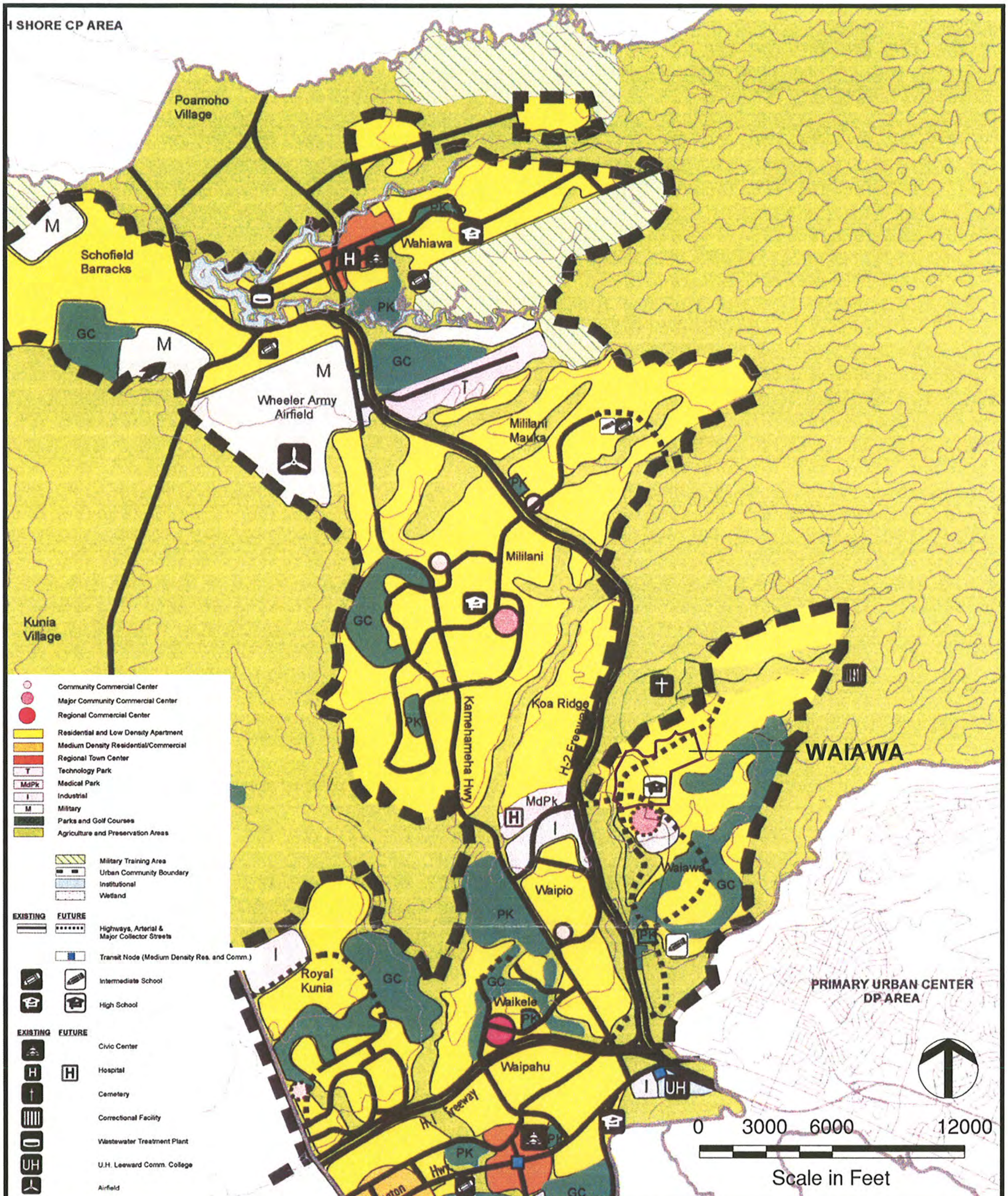


CASTLE & COOKE WAIAWA

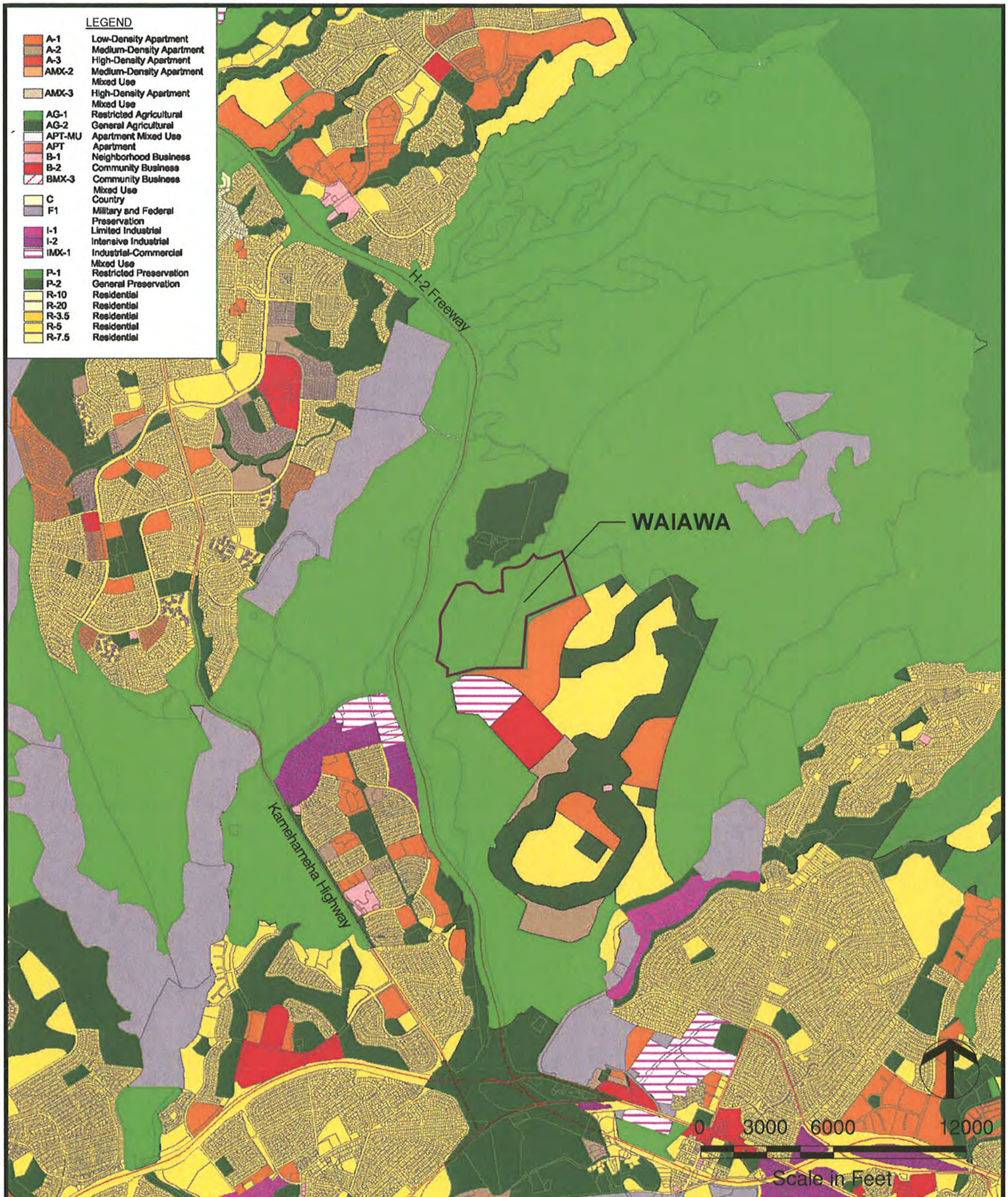
Central Oahu Sustainable Communities Plan Urban Land Use

Figure 4-2

Prepared for: Castle & Cooke Homes Hawaii, Inc.

Prepared by: Wilson Okamoto Corporation

FILE PATH: M:\WOA\7101-02 Waiawa & Koa Ridge Makai\Graphics\7101-02 Zoning Map.dwg PLOT DATE: Jun 16, 2007



CASTLE & COOKE
WAIAWA

Existing Zoning Map | **Figure 4-3**

Prepared for:
Castle & Cooke Homes Hawaii, Inc.

Prepared by:
Wilson Okamoto Corporation

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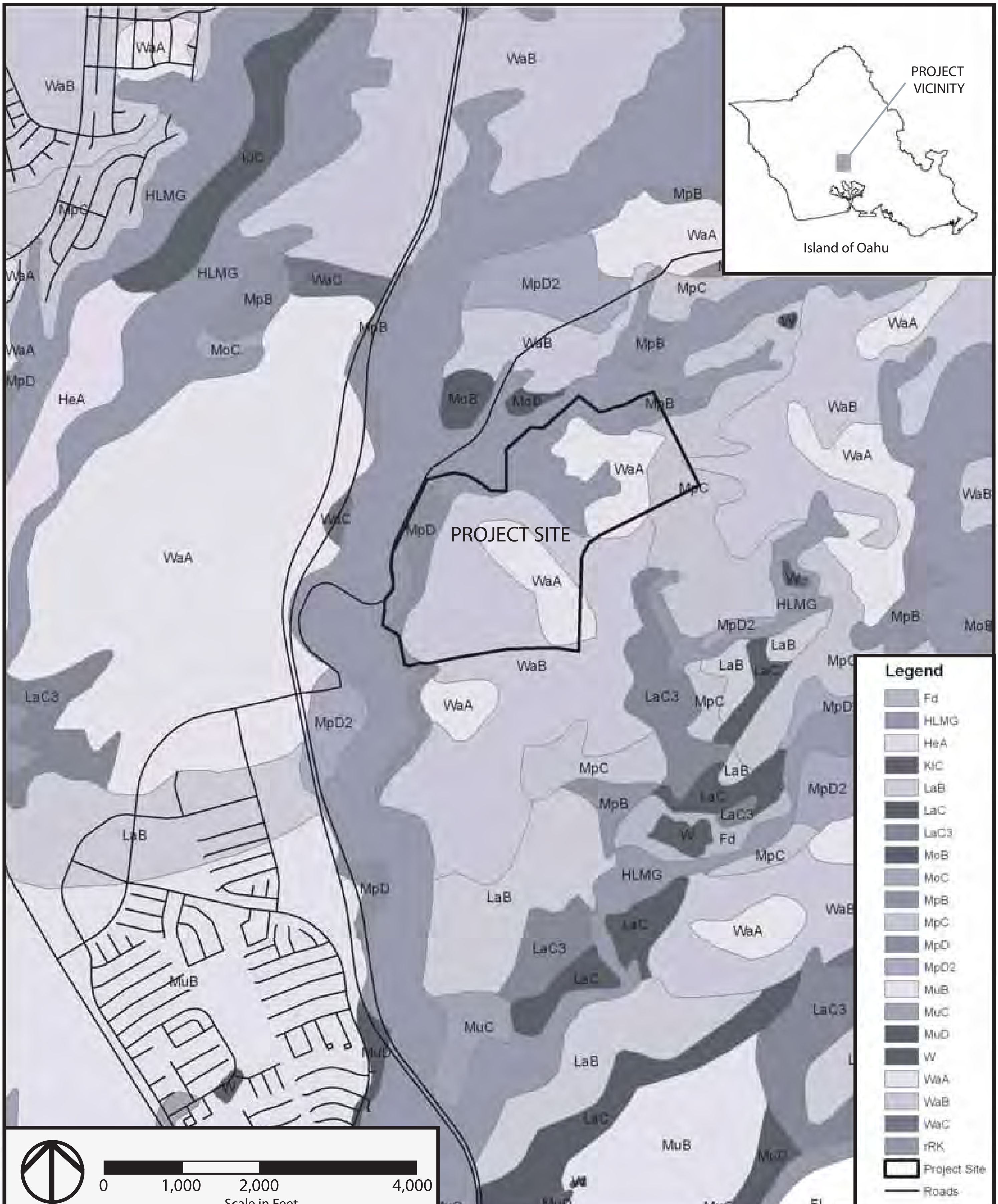

CASTLE & COOKE WAIAWA

Soils Map

Figure 6

Prepared for:
Castle & Cook Homes Hawaii, Inc.

Prepared by:
Wilson Okamoto Corporation

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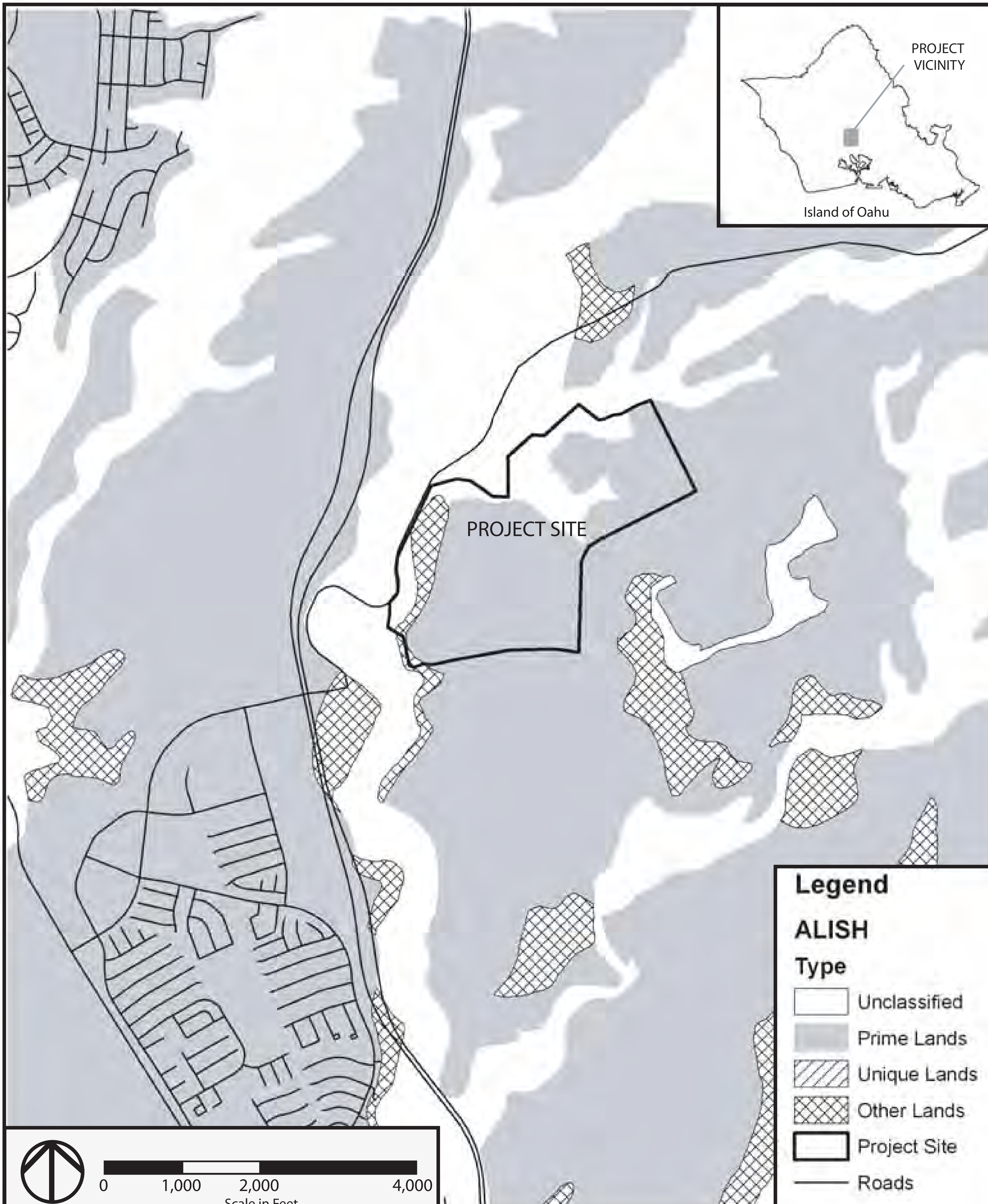

CASTLE & COOKE
WAIAWA

ALISH Map

Figure 7

Prepared for:
Castle & Cook Homes Hawaii, Inc.

Prepared by:
Wilson Okamoto Corporation

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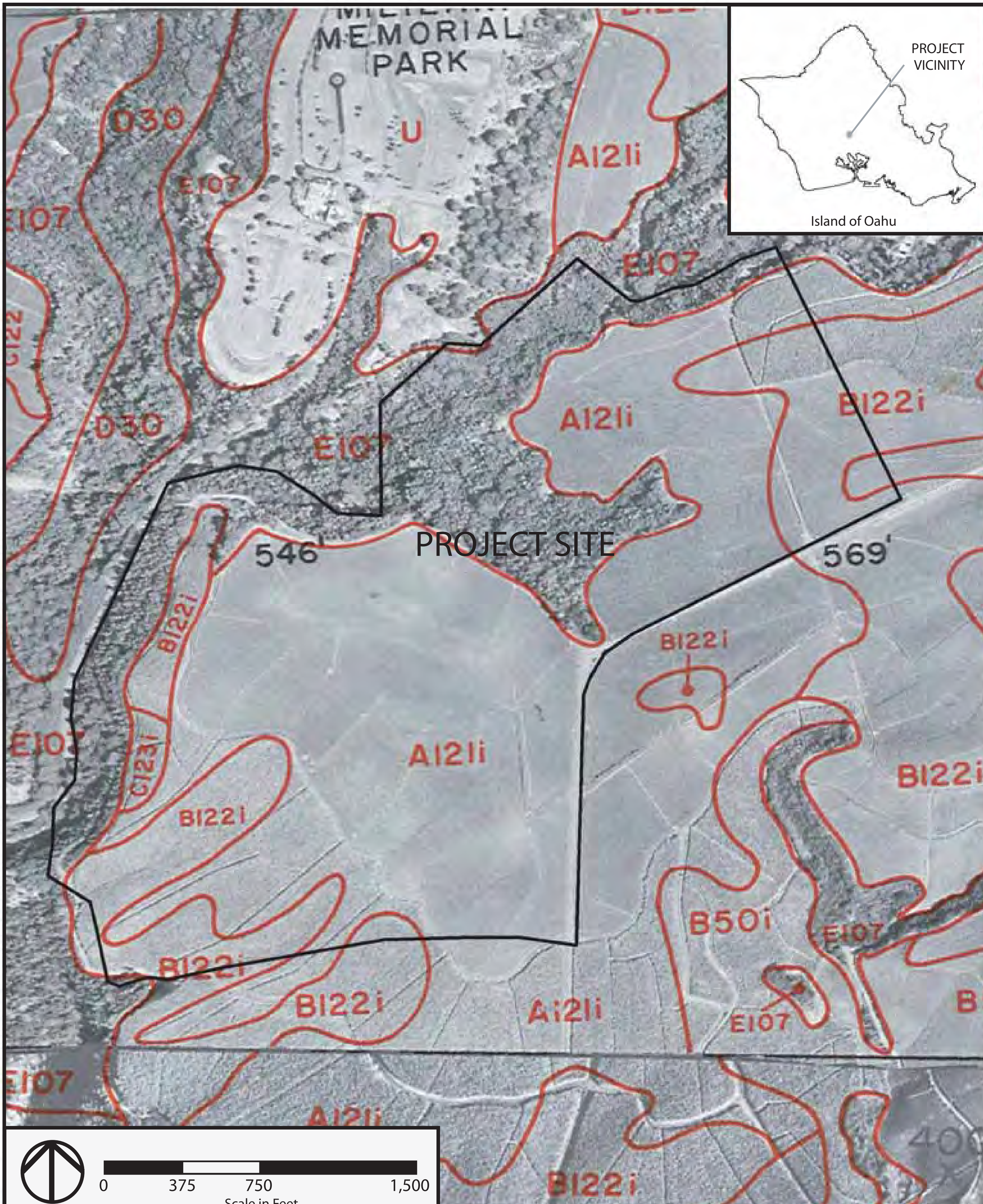


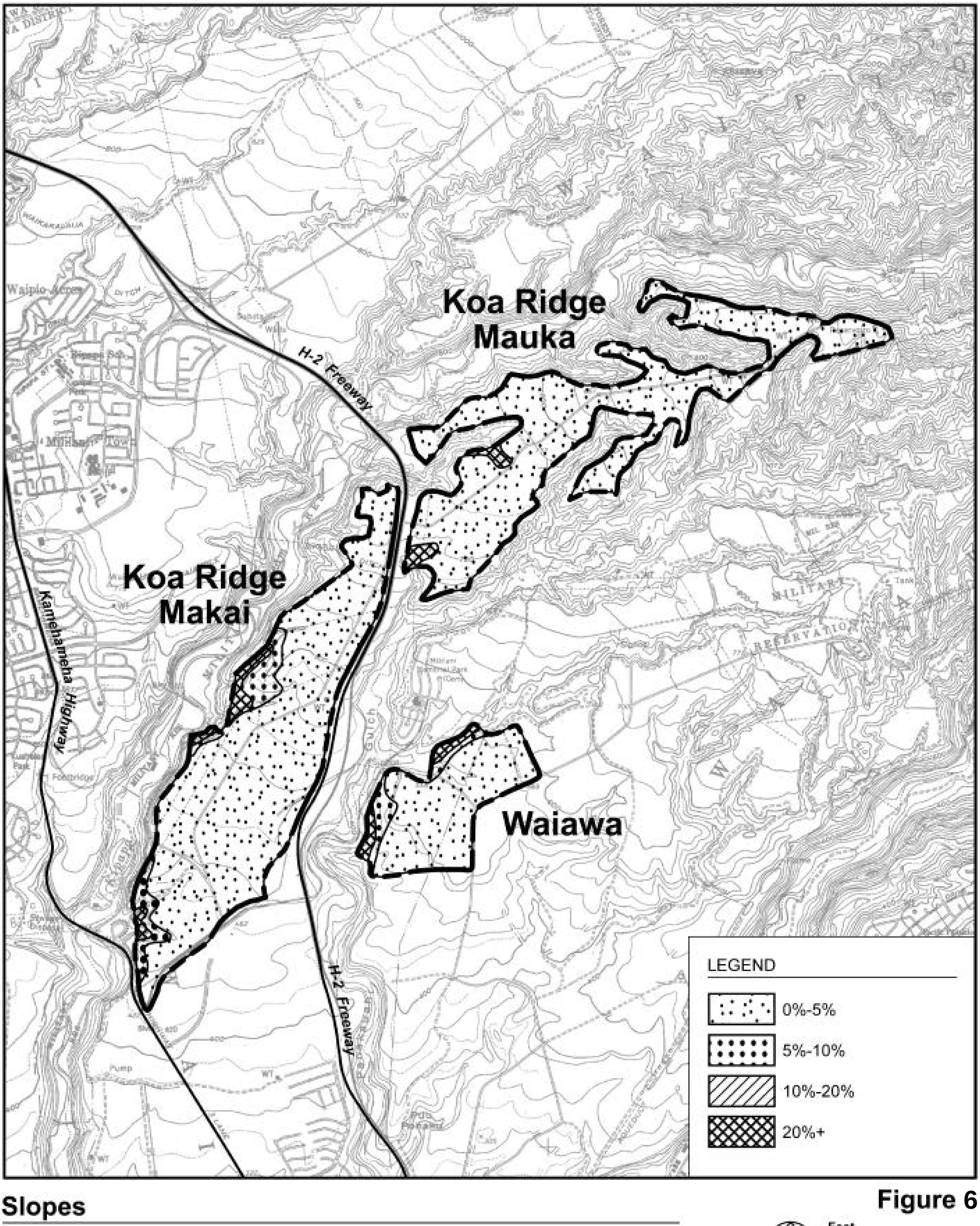
CASTLE & COOKE
WAIAWA

Land Study Bureau Map

Figure 8

Prepared for:
Castle & Cook Homes Hawaii, Inc.

Prepared by:
Wilson Okamoto Corporation



Slopes

Figure 6

Koa Ridge Development

Castle & Cooke Homes Hawaii, Inc./Pacific Health Community, Inc.

Feet 0 1500 3000

Helber Hastert & Fee, Planners November 2000

APPENDIX

APPENDIX
SELECTED STATE AND CITY GOALS, OBJECTIVES, POLICIES, AND GUIDELINES RELATED TO AGRICULTURAL LANDS

1. HAWAI'I STATE CONSTITUTION (Article XI, Section 3):

…to conserve and protect agricultural lands, promote diversified agriculture, increase agricultural self-sufficiency and assure the availability of agriculturally suitable lands…

2. HAWAI'I STATE PLAN (Chapter 226, Hawaii Revised Statutes, as amended):[1,2]

Section 226-7 Objectives and policies for the economy--agriculture.

(a) Planning for the State's economy with regard to agriculture shall be directed towards achievement of the following objectives:

(1) Viability in Hawaii's sugar and pineapple industries.

(2) Growth and development of diversified agriculture throughout the State.

(3) An agriculture industry that continues to constitute a dynamic and essential component of Hawaii's strategic, economic, and social well-being.

(b) To achieve the agricultural objectives, it shall be the policy of the State to:

(2) Encourage agriculture by making best use of natural resources.

(10) Assure the availability of agriculturally suitable lands with adequate water to accommodate present and future needs.

(16) Facilitate the transition of agricultural lands in economically nonfeasible agricultural production to economically viable agricultural uses.

Section 226-103 Economic priority guidelines.

(c) Priority guidelines to promote the continued viability of the sugar and pineapple industries:

(1) Provide adequate agricultural lands to support the economic viability of the sugar and pineapple industries.

(d) Priority guidelines to promote the growth and development of diversified agriculture and aquaculture:

(1) Identify, conserve, and protect agricultural and aquacultural lands of importance and initiate affirmative and comprehensive programs to promote economically productive agricultural and aquacultural uses of such lands.

(10) Support the continuation of land currently in use for diversified agriculture.

Section 226-104 Population growth and land resources priority guidelines.

(b) Priority guidelines for regional growth distribution and land resource utilization:

(2) Make available marginal or non-essential agricultural lands for appropriate urban uses while maintaining agricultural lands of importance in the agricultural district.

Section 226-106 Affordable Housing

Priority guidelines for the provision of affordable housing:

(1) Seek to use marginal or nonessential agricultural land and public land to meet housing needs of low- and moderate-income and gap-group households.

3. AGRICULTURAL STATE FUNCTIONAL PLAN (1991)[3]

(Functional plans are guidelines for implementing the State Plan. They are approved by the Governor, but not adopted by the State Legislature.)

Objective H: Achievement of Productive Agricultural Use of Lands Most Suitable and Needed for Agriculture.

Policy H(2): Conserve and protect important agricultural lands in accordance with the Hawaii State Constitution.

Action H(2)(a): Propose enactment of standards and criteria to identify, conserve, and protect important agricultural lands and lands in agricultural use.

Action H(2)(c): Administer land use district boundary amendments, permitted land uses, infrastructure standards, and other planning and regulatory functions on important agricultural lands and lands in agricultural use, so as to ensure the availability of agriculturally suitable lands and promote diversified agriculture.

4. CITY AND COUNTY OF HONOLULU GENERAL PLAN, Objectives and Policies (Resolution No. 87-211)[4]

Economic Activity

Objective C. To maintain the viability of agriculture on Oahu.

Policy 1. Assist the agricultural industry to ensure the continuation of agriculture as an important source of income and employment.

Policy 2. Support agricultural diversification in all agricultural areas on Oahu.

Policy 3. Support the development of markets for local products, particularly those with the potential for economic growth.

Policy 4. Provide sufficient agricultural land in Ewa, Central Oahu, and the North Shore to encourage the continuation of sugar and pineapple as viable industries.

Policy 5. Maintain agricultural land along the Windward, North Shore, and Waianae coasts for truck farming, flower growing, aquaculture, livestock production, and other types of diversified agriculture.

Policy 6. Encourage the more intensive use of productive agricultural land.

Policy 7. Encourage the use of more efficient production practices by agriculture, including the efficient use of water.

Policy 8. Encourage the more efficient use of nonpotable water for agricultural use.

5. CITY AND COUNTY OF HONOLULU CENTRAL O'AHU SUSTAINABLE COMMUNITIES PLAN[5]

Executive Summary

Central O'ahu's Role in O'ahu's Development Pattern

- Promote diversified agriculture and pineapple on 10,350 acres of prime and unique agricultural lands

Elements of the Vision

- **Urban Community Boundary** sets limits to urban development for the foreseeable future; protects 10,350 acres of diversified agriculture and pineapple lands along Kunia Road, above Wahiawa, around Mililani and on the Waipio Peninsula.

1. Central O'ahu's Role in O'ahu's Development Pattern

- Promotes diversified agriculture and pineapple on 10,350 acres of prime and unique agricultural lands along Kunia Road, north of Wahiawa, surrounding Mililani, and on the Waipio Peninsula in accordance with the General Plan policies to support agricultural diversification in all agricultural areas and to encourage continuation of a viable pineapple industry.

2. The Vision for Central O'ahu's Future

2.1 Vision Statement

Creation of an Open Space Network

- Urban growth will be contained within a boundary which will protect prime agricultural lands along Kunia Road, north of Wahiawa, surrounding Mililani, and on the Waipio Peninsula for diversified agriculture and pineapple. Preservation of these prime and unique agricultural lands for use in diversified agriculture and pineapple will help retain open space and views, in addition to supporting economic diversification.

2.2 Key Elements of the Vision

- Retention of Prime and Unique Agricultural Lands.

2.2.1 Urban Community Boundary

Criteria

- The boundary generally circumscribes the existing communities and planned developments of Royal Kunia, Wahiawa, Mililani, Mililani Mauka, Koa Ridge Makai, Waiawa, Waiawa Castle & Cooke, Gentry Waipio, Waikele and Mililani Technology Park, …

Objectives

- Support diversification of agriculture and preservation of the viability of the pineapple industry in Central O'ahu.

Protection for Prime Agricultural Land.

- The Urban Community Boundary protects prime agricultural lands along Kunia Road, north of Wahiawa, surrounding Mililani, and on the Waipio Peninsula from urban development for the foreseeable future, providing an incentive for landowners to give long term leases to farmers. No proposals for urban uses will be considered for these areas.

2.2.2 Retention of Agricultural Lands

- The Central Oahu Sustainable Communities Plan protects the highest value prime and unique agricultural lands in Central Oahu from urban development.

  These high value lands are located in four areas: lands along both sides of Kunia Road, lands north of Wahiawa, lands surrounding Mililani, and lands on the Waipio Peninsula which are in the Blast Zone of the West Loch Naval Magazine. State agencies indicated that these prime and unique agricultural lands in Central Oahu should be retained in agriculture because they are among the best in the State, are supported by an extensive, well-developed agricultural infrastructure, and are near the major transportation hub for export markets.

3. Land Use Policies, Principles, and Guidelines

3.1 Open Space Preservation and Development

3.1.1 General Policies

- Provide long range protection for diversified agriculture and pineapple on lands outside the Urban Community Boundary and for two agricultural areas located inside the Urban Community Boundary (Pine Spur and Honbushin).

3.7 Central O'ahu Plantation Villages

3.7.3.5 Adjacent Land Uses

- Agricultural use should be maintained on adjacent lands.

3.12 Military Areas

3.12..2 Pearl Harbor Naval Base (Waipio Peninsula)

- The City supports continued use of these lands for diversified agriculture or aquaculture activities.

3.12.2 Panning Principles

- Agricultural uses should be continued on the Waipio Peninsula in the West Loch Naval Magazine Blast Zone.

Appendix A: Conceptual Maps

Agriculture Boundary

- The agricultural boundary is to protect important agricultural lands for their economic and open space values, and for their value in helping give a region its identifiable character.

  Lands within this boundary include agriculturally valuable lands outside the Urban Community Boundary. They include agriculturally important lands designated by ALISH as “prime,” “unique,” or “other.”

Agricultural Areas

- Lands with agricultural value by virtue of current agricultural use or high value for future agricultural use, including those areas identified as Prime, Unique, or Other Important lands on the Agricultural Lands Important to the State of Hawai'i (ALISH) maps. “Agriculture” includes lands suitable for crop growing, grazing and livestock raising, flower cultivation, nurseries, orchards, aquaculture, or similar activities.

Maps A1, A2, A3 and A4

- These maps show that <u>Koa Ridge Makai</u> and <u>Waiawa Castle & Cooke</u> are within the Urban Expansion Areas.
- These maps show that Koa Ridge Mauka is within the Agricultural Area.

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[5] City and County of Honolulu, Planning Department. *Central O'ahu Sustainable Communities Plan.* Honolulu, Hawaii. December 2002.

I | Traffic Impact Analysis Report
Alternative Transportation Components

Traffic Impact Analysis Report

Koa Ridge Makai and Waiawa Developments

Prepared For

Castle & Cooke Homes Hawaii

Prepared By

Wilson Okamoto Corporation

November 2008
Revised February 2009

TRAFFIC IMPACT ANALYSIS REPORT

FOR

KOA RIDGE MAKAI AND WAIAWA DEVELOPMENTS

Prepared for:

Castle & Cooke Homes Hawaii
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November 2008
Revised February 2009

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I. INTRODUCTION

A. Purpose of Study

The purpose of this study is to identify and assess the traffic impacts resulting from the proposed Castle & Cooke Koa Ridge and Waiawa Developments located in Central Oahu. The project will entail the development of mixed uses to include residential single-family and multi-family units, commercial areas, community land uses, and a variety of parks and other open spaces. Proposed access to the Koa Ridge development would be through new roadway connections at Ka Uka Boulevard west of the Waipio Interchange, at Kamehameha Highway just north of the intersection with Ka Uka Boulevard, and a proposed new interchange along the Interstate H-2 Freeway at the existing Pineapple Road Overpass. Proposed primary access to the Waiawa development would be through a new eastward extension of Ka Uka Boulevard east of the Waipio Interchange along the Interstate H-2 Freeway.

B. Scope of Study

This report presents the findings and conclusions of the traffic study, the scope of which includes:

1. Description of the proposed project and proposed development plan.
2. Evaluation of existing roadway and traffic operations in the vicinity.
3. Analysis and development of trip generation characteristics for the proposed project.
4. Development of traffic projections and future traffic conditions.
5. Superimposition of site-generated traffic over future traffic conditions.
6. The identification and analysis of traffic impacts resulting from the proposed project.
7. Development of recommended roadway or intersection improvements, as appropriate, to alleviate anticipated adverse future roadway and traffic conditions with the proposed project.

The report also incorporates additional discussion and analyses undertaken to respond to comments provided by the Mililani/Waipio/Melemanu Neighborhood Board No. 25 in a resolution adopted at its regular meeting on November 28, 2007 (see Appendix A). These additional assessments addressed the following:

- More definitive discussion of the potential indirect and cumulative impacts of development in the region relative to traffic;
- Analysis of commuter travel time;
- Discussion of the impacts of the rapid transit system; and
- Impacts of the proposed improvements from the Oahu Metropolitan Planning Organization's 2030 Oahu Regional Transportation Plan.

II. PROJECT DESCRIPTION

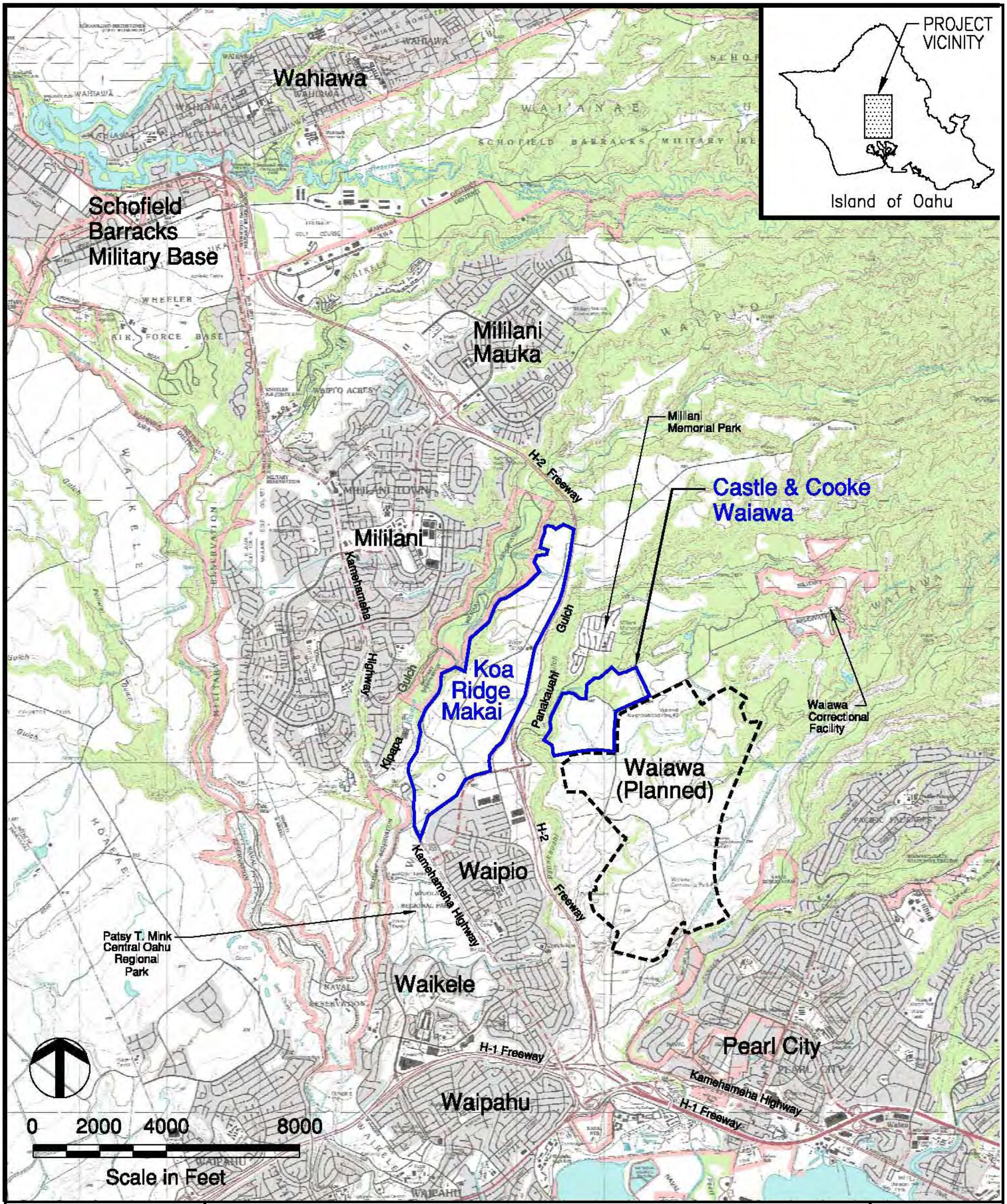
A. Location

The proposed Koa Ridge Makai development will be located in Central Oahu, west of the Interstate H-2 Freeway, immediately north of Ka Uka Boulevard, and east of Kamehameha Highway. The Koa Ridge development site is further identified as Tax Map Keys: 9-4-06: 38, 9-4-06: por 2, 9-4-06: 14, 9-4-06: 15, and 9-5-03: 4, and encompasses about 575 acres of land. Primary access points to the proposed Koa Ridge Makai development will be provided via a road connection to Ka Uka Boulevard and Kamehameha Highway, and a proposed new freeway interchange along the Interstate H-2 Freeway at the existing Pineapple Road Overpass.

The proposed Waiawa Development will also be included in Central Oahu east of the Interstate H-2 Freeway, immediately north of the Waipio Interchange, and adjacent to the proposed Waiawa Ridge Development, also in Central Oahu. The project site is further identified as Tax Map Keys: 9-6-04: 21, 9-4-06: por. 29, and 9-4-06: por 31, and encompasses about 191 acres of land. Primary access to the project site will be provided via an eastward extension of Ka Uka Boulevard from the Waipio Interchange along the Interstate H-2 Freeway. Figure 1 shows the location and vicinity maps of both the proposed Koa Ridge Makai and Waiawa developments.

B. Project Characteristics

The proposed Koa Ridge Makai and Waiawa developments will be mixed-use master planned communities providing a variety of housing types, retail and commercial uses, schools, employment opportunities, health care, and community amenities and other services that emphasize walking, bicycling, and transit as alternate travel modes. The Koa Ridge Makai development will include a Village



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KOA RIDGE MAKAI AND WAIAWA

LOCATION MAP AND VICINITY MAP

FIGURE 1

Center that supports higher density residential housing and mixed-use buildings. The Village Center is the central core of the Koa Ridge Makai community providing opportunities for a multitude of daily activities within the localized region. Surrounding the central core are less dense residential uses, medical facilities, specialized retail areas, industrial uses, and open spaces. This development will include multiple connections to regional roadway systems surrounding the project site that include Ka Uka Boulevard, Kamehameha Highway, and the Interstate H-2 Freeway.

The proposed Waiawa Development will be located adjacent to the future extension of Ka Uka Boulevard immediately adjacent to the proposed Waiawa Ridge Development and will include residential single- and multi-family units, commercial areas, an elementary school, parks, and open spaces. Both the Koa Ridge Makai and Waiawa developments are expected to proceed concurrently in two major development phases, the first of which is expected to be completed and occupied by the Year 2016, with build-out in the second phase at Year 2025.

Phase 1 of the proposed Koa Ridge Makai development entails the approximate development of the following within each project site:

- 275,000 square feet floor area of commercial/retail uses
- Approximately 912 multi-family residential homes
- Approximately 479 single-family residential homes
- Elementary School to service the area residential developments
- Approximately 10 acres for healthcare uses
- 43,000 square feet floor area of light industrial uses
- 10,000 square feet floor area of office uses
- Approximately 1 acres for community center
- Approximately 2 acres for church use

The first phase of the proposed Waiawa development shall include 200 multi-family residential units by the Year 2016. Beyond Year 2016 to the ultimate build-out of the proposed Koa Ridge Makai and Waiawa developments in Year 2025, Phase 2 of the project would entail the approximate additional development of the following within each project site:

Koa Ridge Makai

- 75,000 square feet floor area of commercial/retail uses
- Approximately 1,534 multi-family residential homes
- Approximately 575 single-family residential homes
- 150 room extended-stay hotel
- Approximately 18 acres for healthcare uses
- Approximately 17 acres for park use
- 40,000 square feet of light industrial uses
- 20,000 square feet of office uses
- Approximately 2 acres for community center
- Approximately 2 acres for church use

Waiawa

- 30,000 square feet floor area of commercial/retail uses
- Approximately 1,045 multi-family residential homes
- Approximately 255 single-family residential homes
- Elementary School to service the area residential developments

For the purpose of the traffic analyses contained in this report, the proposed development absorption schedules for both Koa Ridge Makai and Castle & Cooke Waiawa Developments are shown in Figure 1.1. It should be noted, however, as with all market driven commercial and residential developments, the anticipated development schedule may change due to market conditions throughout the development planning as well as at the time of construction. Nevertheless, the incremental development assumptions contained in this report represent a realistic and practical development schedule for planning and traffic analysis purposes. Figures 2 and 3 show the Koa Ridge Makai and Waiawa development site plans, respectively.

III. EXISTING CONDITIONS

A. General

The proposed Koa Ridge Makai development will be located west of the Waipio Interchange between the Interstate H-2 Freeway and Kamehameha Highway,

KOA RIDGE MAKAI/WAIAWA TRAFFIC ABSORPTION

KOA RIDGE MAKAI		2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Residential	**Total Units**														
Single Family	1,054	88	135	86	83	87	71	80	72	71	71	63	53	42	52
Multi-Family	1,162	114	166	131	81	81	84	80	89	84	84	77	70	21	0
High Density Multi-Family	1,284	0	0	135	103	101	115	115	109	103	104	107	103	103	86
Total	3,500	202	301	352	267	269	270	275	270	258	259	247	226	166	138
Commercial	**Total Floor Area**														
Big Box Retail	150,000		150,000												
Retail	200,000			30,000	20,000	75,000	25,000			50,000					
Office	30,000	10,000						20,000							
Light Industrial	83,000					43,000				40,000					
Hotel							150 rooms								
Other	**Acres**														
Healthcare	28				10					8					10
Elementary School	12				12										
District Park	17						17								
Community Center	3					1				2					
Church	4					2				2					
WAIAWA															
Residential	**Total Units**														
Single Family	255	0	0	0	0	0	13	13	18	20	20	23	46	51	51
Multi-Family	1,245	0	0	0	100	100	87	87	87	100	100	113	117	180	174
Total	1,500	0	0	0	100	100	100	100	105	121	121	136	163	231	225
Other	**Area**														
Commercial	30,000 sq.ft.								30,000						
Elementary School	12 acres									12					

Source: Castle & Cooke Homes Hawaii

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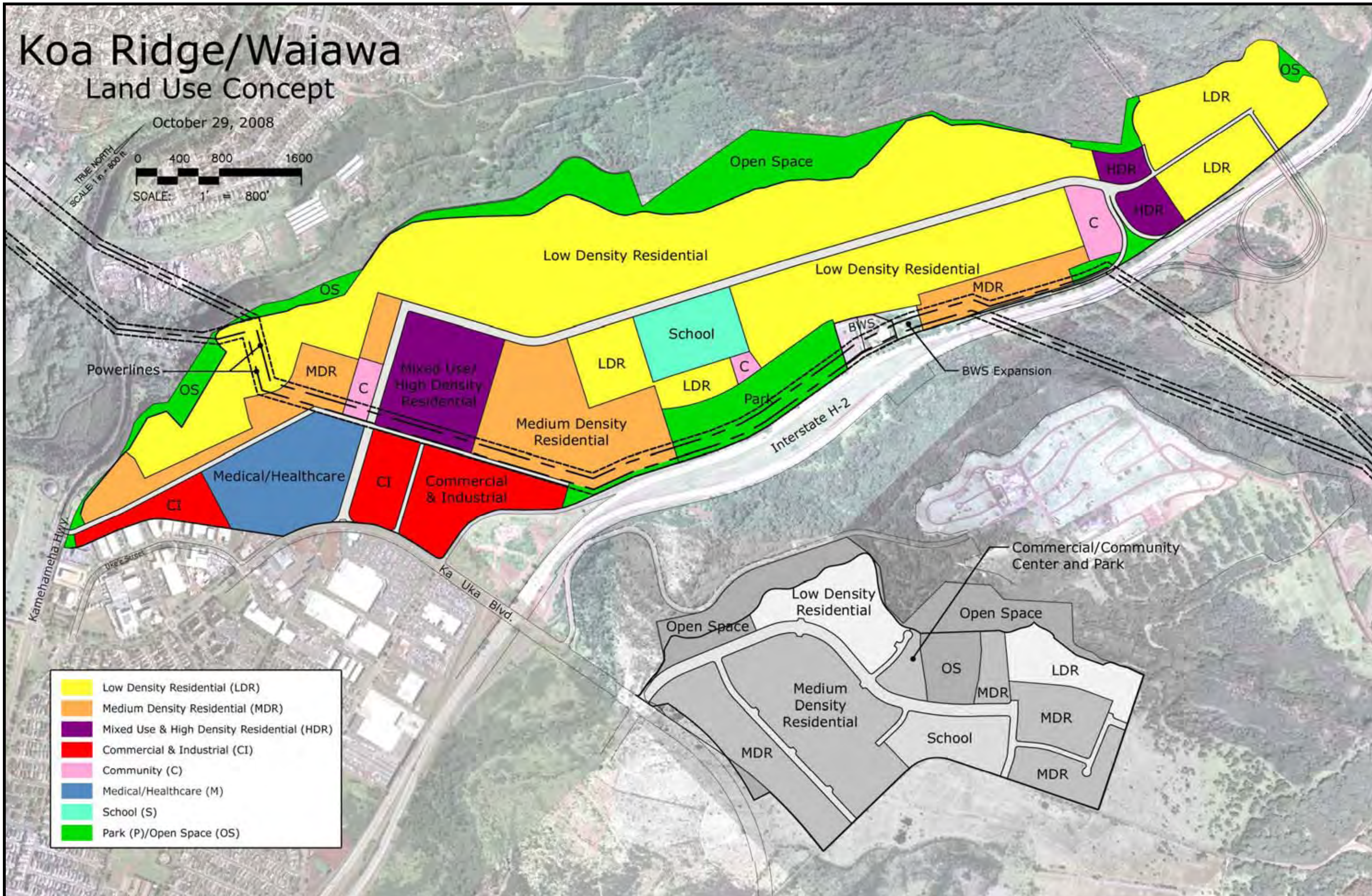
KOA RIDGE MAKAI AND WAIAWA

KOA RIDGE MAKAI AND WAIAWA
DEVELOPMENT SCHEDULE

FIGURE 1.1



WILSON OKAMOTO CORPORATION ENGINEERS - PLANNERS	KOA RIDGE MAKAI AND WAIAWA	FIGURE
	PROJECT SITE PLAN – KOA RIDGE MAKAI	2

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KOA RIDGE MAKAI AND WAIAWA

PROJECT SITE PLAN - WAIAWA

FIGURE 3

Figure 3

immediately north of Ka Uka Boulevard. The primary access to the proposed Koa Ridge Makai development will be via Ka Uka Boulevard between Moaniani Street and Ukee Street (east). Other access points to the Koa Ridge Makai development include roadway connections at Kamehameha Highway and future connections at a new interstate freeway interchange on the northern portion of the site at the existing Pineapple Road overpass.

The proposed Waiawa development will be located east of the Waipio Interchange near the northbound on- and off-ramps to the Interstate H-2 Freeway. The Waipio Interchange serves as a junction between the Interstate H-2 Freeway and Ka Uka Boulevard and is configured as a traditional "diamond interchange". The area is well serviced by regional transportation facilities that include the interstate freeway systems, Kamehameha Highway, and other major collector roadways. Traffic volumes along the freeway, Kamehameha Highway, and Ka Uka Boulevard in the project vicinity have been increasing slightly over the years due to on-going development within Central Oahu.

B. Area Roadway System

In the vicinity of the Koa Ridge Makai and Waiawa projects, Ka Uka Boulevard is predominantly a two-way, four-lane, divided City and County of Honolulu collector roadway providing east-west mobility between the Interstate H-2 Freeway and Kamehameha Highway. Exclusive turning lanes are provided at selected major intersections along its alignment. The posted speed limit of Ka Uka Boulevard is 25 miles per hour.

Immediately west of the access roadway to both the Waiawa Ridge Development and Waiawa Development, Ka Uka Boulevard intersects with the northbound on- and off-ramp junction of the Waipio Interchange providing east-west mobility and access to areas west of the Interstate H-2 Freeway, and Mililani Memorial Park and the Waiawa Correctional Facility to the east. At this signalized intersection, the northbound off-ramp approach services an exclusive left-turn lane and a shared left-turn, through, and right-turn lane. The westbound Ka Uka Boulevard intersection approach provides a through lane, and an exclusive right-turn lane. The eastbound Ka Uka Boulevard approach provides an exclusive left-turn lane and an exclusive through movement lane. The intersection services traffic demands utilizing a two-phase traffic signal system operation.

West of the northbound on- and off-ramps intersection, Ka Uka Boulevard intersects the southbound off-ramp of the Waipio Interchange and Moaniani Street. Moaniani Street provides access to residential and commercial uses such as Costco, Tony Auto Dealership and other uses to the south of Ka Uka Boulevard. At this signalized intersection, the westbound intersection approach of Ka Uka Boulevard provides an exclusive left-turn lane and two through movement lanes, while the eastbound approach provides an exclusive through movement lane and a shared through and right-turn lane. The northbound approach of Moaniani Street provides exclusive left-turn and right-turn lanes, while the H-2 southbound off-ramp provides one shared left-turn, through, and right-turn lane. The State Department of Transportation is currently implementing improvements on the southbound off-ramp approach to Ka Uka Boulevard to provide and additional lane to service right-turn movements onto Ka Uka Boulevard. The intersection services traffic demands utilizing a four-phase traffic signal system operation providing split phasing between the off-ramp and Moaniani Street, with an exclusive left-turn signal phase for westbound left-turn movements from Ka Uka Boulevard to southbound Moaniani Street.

Further west along Ka Uka Boulevard, the roadway intersects with a driveway servicing commercial uses on the south side of the roadway forming an unsignalized T-intersection providing access to commercial entities such as Starbuck's and Seattle's Best Coffee, as well as serve as a secondary access to the Costco commercial establishment. The Ka Uka Boulevard westbound approach of the intersection provides an exclusive left-turn lane and two through movement lanes while the eastbound approach provides an exclusive through lane and a shared through and right-turn lane. The permitted movement on the northbound approach of the driveway services right-turn movements only.

Continuing west, Ka Uka Boulevard intersects with Ukee Street (east) providing access to residential and commercial uses such as Aloha Petroleum, The Lock-up Self Storage establishment, West Oahu Federal Credit Union, as well as other uses in the residential and industrial areas in the vicinity. At this unsignalized intersection, the eastbound and westbound approaches provide an exclusive left-turn lane, an exclusive through movement lane, and a shared through movement and right-turn lane. The northbound and southbound approaches of Ukee Street (east) each provide one shared lane serving left-turn, through, and right-turn movements. It should be noted that although the intersection of Ka Uka Boulevard with Ukee Street (east) was unsignalized at the time of this report, traffic signal hardware and appurtenances are already visibly installed at the intersection.

West of Ukee Street (east), Ka Uka Boulevard intersects with Waipio Uka Street providing access to residential and commercial uses such as Zippy's Restaurant, Tesoro Gas Station, and other uses in the residential and industrial areas. At this signalized intersection, the eastbound and westbound approaches provide an exclusive left-turn lane, an exclusive through movement lane, and a shared through movement and right-turn lane. The northbound and southbound approaches of Waipio Uka Street each provide one shared lane serving left-turn, through, and right-turn movements. The intersection services traffic demands utilizing a two-phase traffic signal system operation.

Continuing further west, Ka Uka Boulevard intersects with Ukee Street (west) providing access to residential and commercial uses such as Shell Gas Station, McDonalds Restaurant, the Hawaii Okinawa Center, as well as other uses in the Gentry Business Park area. At this signalized intersection, the eastbound and westbound approaches provide an exclusive left-turn lane, an exclusive through movement lane, and a shared through movement and right-turn lane. The northbound and southbound approaches of Ukee Street each provide one shared lane serving left-turn, through, and right-turn movements. The intersection services traffic demands utilizing a three-phase traffic signal system operation.

At the western terminus of Ka Uka Boulevard, the roadway intersects with Kamehameha Highway providing access to the Central Oahu Regional Park and other uses located north and south of the intersection. At this signalized intersection, the westbound approach provides an exclusive left-turn lane, a through movement lane, and an exclusive right-turn lane, while the eastbound approach provides an exclusive left-turn lane, two through movement lanes, and an exclusive right-turn lane. The northbound approach of Kamehameha Highway provides an exclusive left-turn lane, two through movement lanes, and an exclusive right-turn lane, while the southbound approach of the highway provides two exclusive left-turn lanes, two through movement lanes, and an exclusive right-turn lane. The traffic signal system at the intersection services traffic demands utilizing a four-phase traffic signal operation.

South of Ka Uka Boulevard, Kamehameha Highway intersects Waipio Uka Street, also providing access to the Oahu Central Regional Park as well as other commercial uses in the immediate vicinity such as Jack-In-The-Box Restaurant and the Waipio Shopping Center. At this signalized intersection, the westbound approach provides two exclusive left-turn lanes, a through movement lane, and an exclusive right-turn lane, while the eastbound approach provides an exclusive left-turn lane, a through movement lane, and an exclusive right-turn lane. The northbound and southbound approaches of Kamehameha Highway each provide an exclusive left-turn lane, two through movement lanes, and an exclusive right-turn lane. The traffic signal system at the intersection services traffic demands utilizing a four-phase traffic signal operation.

Further south, Kamehameha Highway intersects with Lumiaina Street providing access to Waikele Shopping Center and Waikele residential communities to the west, and communities of Crestview and Sea View to the east. At this signalized intersection, the northbound and southbound approaches of Kamehameha Highway provide exclusive left-turn lanes, two through movement lanes, and exclusive right-turn lanes. The eastbound approach of Lumiaina Street provide a shared left-turn/through movement lane and an exclusive right-turn lane while the westbound approach provides an exclusive left-turn lane and a shared through movement/right-turn lane. The traffic signal system at the intersection services traffic demands utilizing a three-phase traffic signal operation.

South of the intersection with Lumiaina Street, Kamehameha Highway intersects with Lumiauau Street also providing access to the communities of Waikele, Crestview and Sea View. At this signalized intersection, the northbound and southbound approaches of Kamehameha Highway provide exclusive left-turn lanes, two through movement lanes, and exclusive right-turn lanes. The eastbound approach of Lumiauau Street provide a shared left-turn/through movement lane and an exclusive right-turn lane while the westbound approach provides an exclusive left-turn lane and a shared through movement lane with a channelized right-turn lane. The traffic signal system at the intersection services traffic demands utilizing a three-phase traffic signal operation.

South of the intersection with Lumiauau Street, Kamehameha Highway intersects with Waipahu Street providing access to the residential and other uses in Waipahu Town. At this signalized T-intersection, the northbound approach of Kamehameha Highway provides an exclusive left-turn lane and two through movement lanes while the southbound approach provides two through movement lanes and an exclusive right-turn lane. The eastbound approach of Waipahu Street provides one lane serving left-turn movements and channelized right-turn movements. The traffic signal system at the intersection services traffic demands utilizing a three-phase traffic signal operation.

C. Traffic Volumes and Conditions

1. General

a. Field Investigation

To ensure adequate sampling of traffic data reflecting current traffic conditions, traffic count surveys were conducted during several periods throughout the years spanning from 2007 to 2008. The most current traffic data available were collected in September 2008 that consisted of manual turning movement count surveys and traffic flow assessments in the vicinity of the project. In consultation with the

State Department of Transportation, the manual turning movement counts were conducted between the morning peak hours of 6:00 AM and 9:00 AM, and between the afternoon peak hours of 3:00 PM and 6:00 PM at the following intersections:

- Ka Uka Boulevard and the Interstate H-2 Freeway northbound on- and off-ramps at the Waipio Interchange
- Ka Uka Boulevard and the Interstate H-2 Freeway southbound on-ramp at the Waipio Interchange
- Ka Uka Boulevard and the Interstate H-2 southbound off-ramp/Moaniani Street
- Ka Uka Boulevard and the commercial driveway just west of Moaniani Street
- Ka Uka Boulevard and Ukee Street (east)
- Ka Uka Boulevard and Waipio Uka Street
- Ka Uka Boulevard and Ukee Street (west)
- Kamehameha Highway and Ka Uka Boulevard
- Kamehameha Highway and Waipio Uka Street
- Kamehameha Highway and Lumiaina Street
- Kamehameha Highway and Lumiauau Street
- Kamehameha Highway and Waipahu Street

In addition, a 24-hour traffic volume surveys were collected or reviewed along the Interstate H-2 Freeway, Waipio Interchange freeway ramps, and Kamehameha Highway in the project vicinity. Appendix B includes the existing traffic count data.

b. Capacity Analysis Methodology

The highway capacity analysis performed in this study is based upon procedures presented in the "Highway Capacity Manual", Transportation Research Board, 2000, and the "Highway Capacity Software", developed by the Federal Highway Administration. The analysis is based on the concept of Level of Service (LOS).

LOS is a quantitative and qualitative assessment of traffic operations. Levels of Service are defined by LOS "A" through "F". LOS "A" represents ideal or free-flow traffic operating conditions and LOS "F" represents unacceptable or potentially congested traffic operating conditions. LOS "B", "C", "D", and "E" represent the intermediate traffic operational characteristics between the two extremes of LOS "A" and LOS "F". The LOS definitions are included in Appendix C.

"Volume-to-Capacity" (v/c) ratio is another measure indicating the relative traffic demand to the roadway carrying capacity. A v/c ratio of one (1.00) indicates that the roadway is operating at or near capacity. A v/c ratio of greater than 1.00 generally indicates that the traffic demand exceeds the road's carrying capacity.

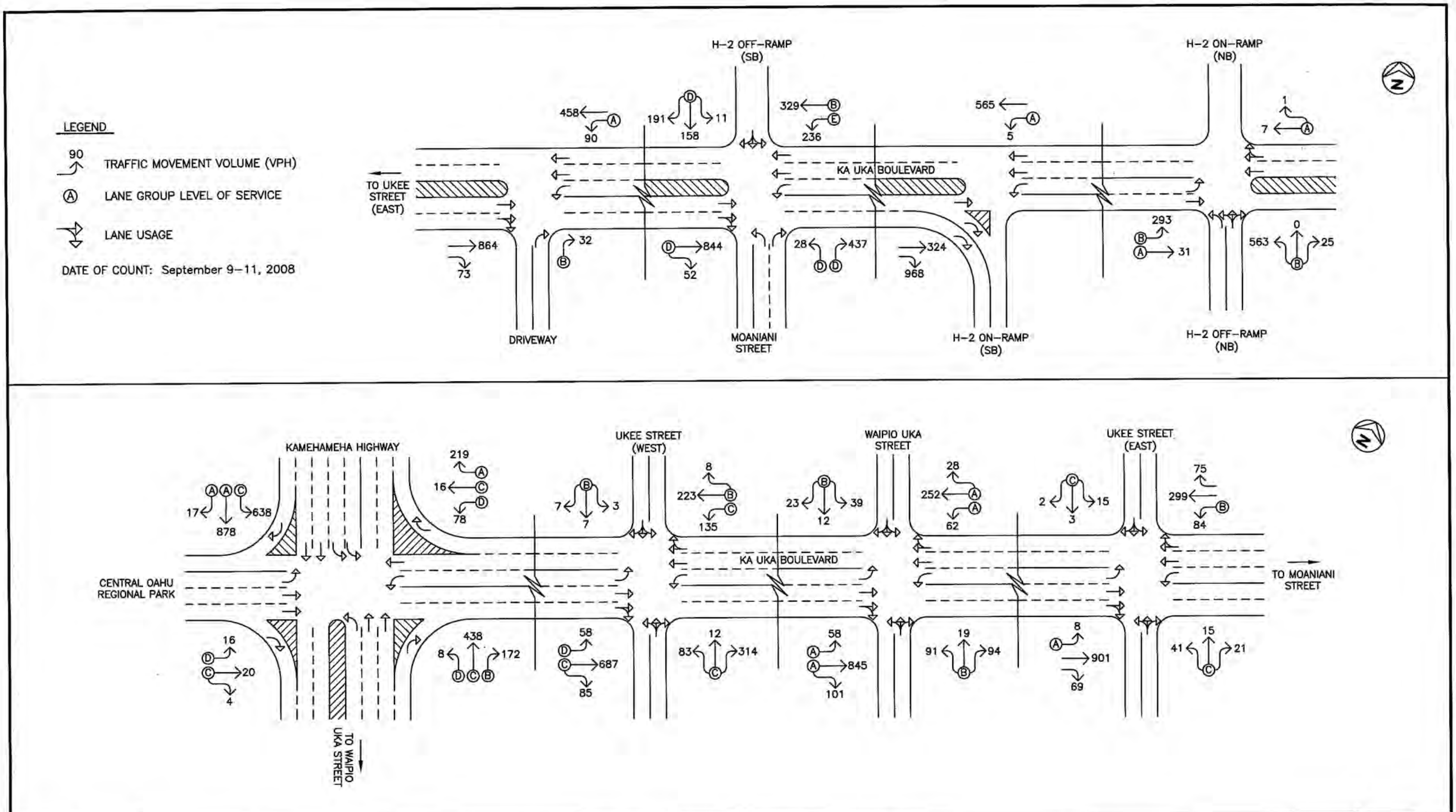
2. Existing Peak Hour Traffic

a. General

Figures 4 through 7 show the existing AM and PM peak hour traffic volumes and traffic operating conditions within the vicinity of the proposed project. The morning peak hour of traffic generally occurs between 7:00 AM and 8:00 AM in the project vicinity. In the afternoon, the peak hour of traffic generally occurs between the hours of 4:00 PM and 5:00 PM. Although the peak hours of traffic generally occur around the same time periods at each of the study intersections, the absolute commuter peak hour time periods for each intersection may differ slightly as shown in Table 1.

Table 1: Peak Hours of Traffic

Intersection	AM Peak	PM Peak
Ka Uka Blvd/Waipio IC NB ramps	7:15 AM – 8:15 AM	4:45 PM – 5:45 PM
Ka Uka Blvd/Waipio IC SB on-ramp	6:45 AM – 7:45 AM	4:00 PM – 5:00 PM
Ka Uka Blvd/Moaniani St/SB off-ramp	7:00 AM – 8:00 AM	3:00 PM – 4:00 PM
Ka Uka Blvd/ Commercial Dwy	7:15 AM – 8:15 AM	4:45 PM – 5:45 PM
Ka Uka Blvd/ Ukee St (east)	7:00 AM – 8:00 AM	3:00 PM – 4:00 PM



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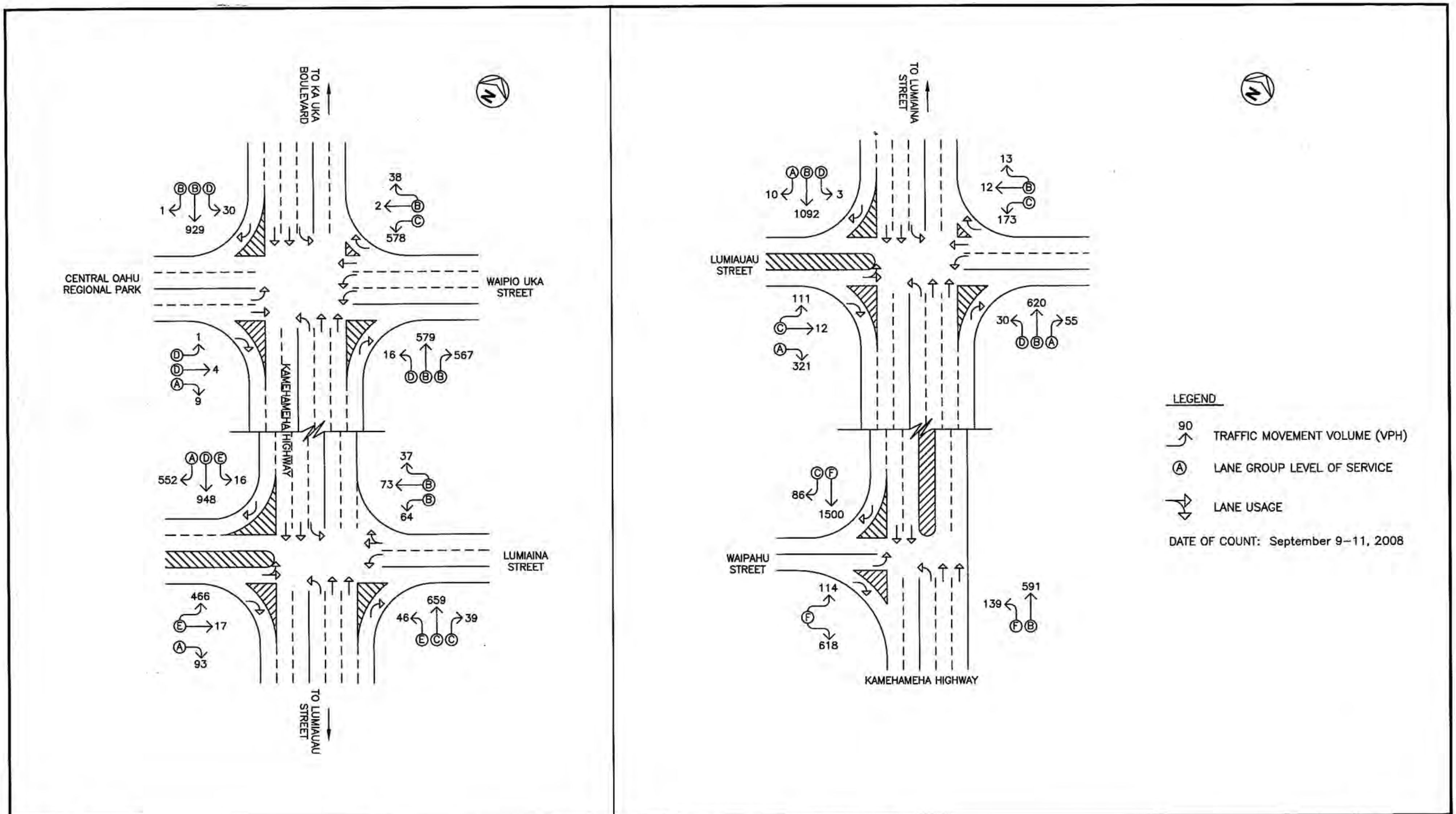
KOA RIDGE MAKAI AND WAIAWA DEVELOPMENT

EXISTING AM PEAK HOUR OF TRAFFIC - KA UKA BOULEVARD

FIGURE 4



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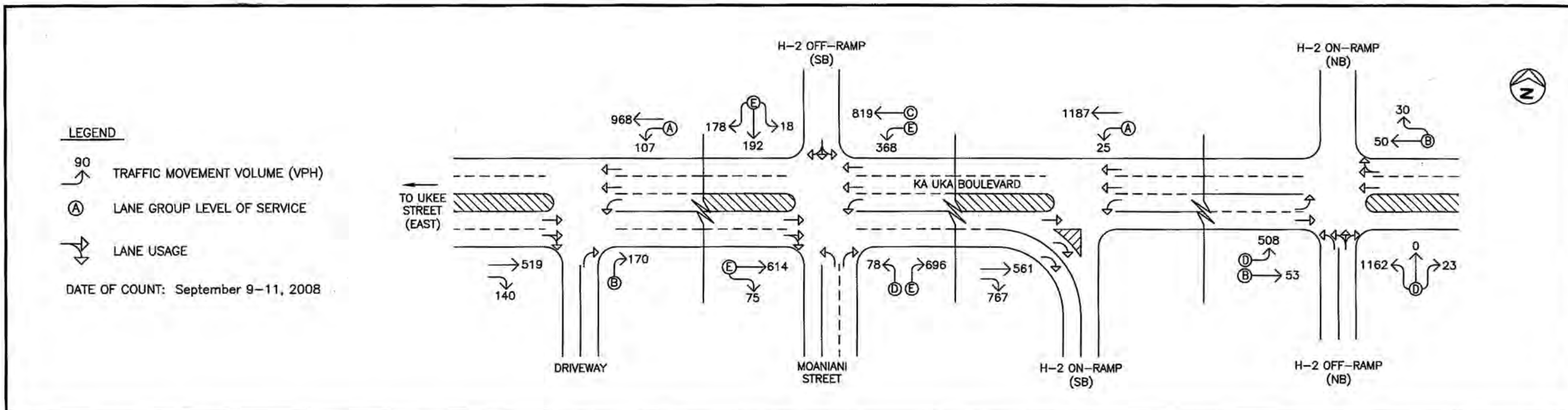
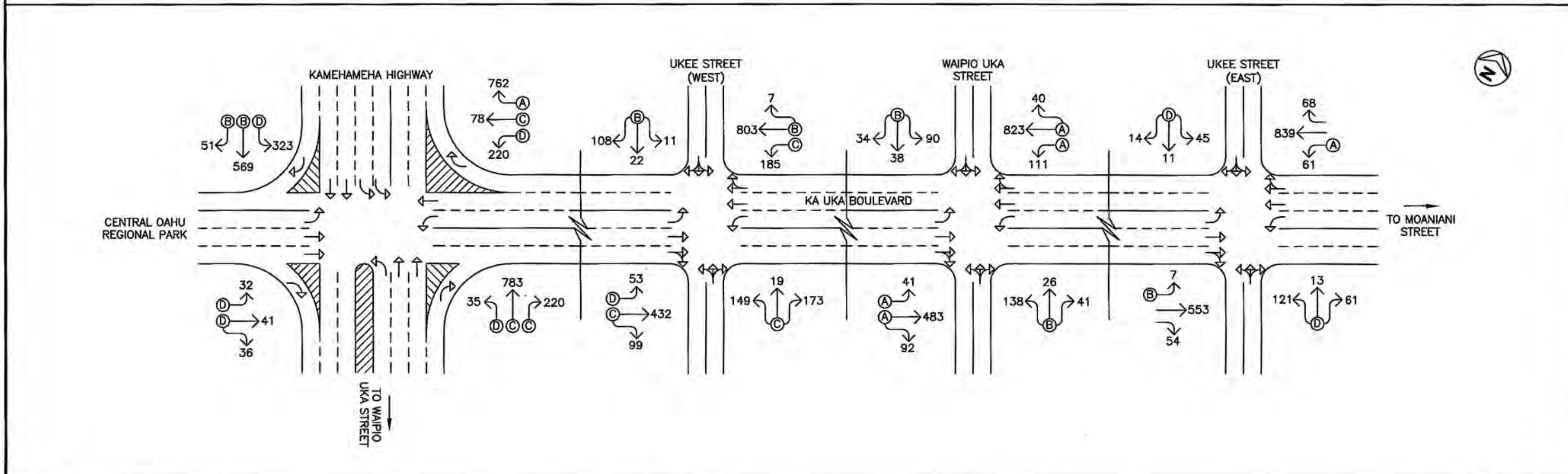
EXISTING AM PEAK HOUR OF TRAFFIC - KAMEHAMEHA HIGHWAY

FIGURE 5





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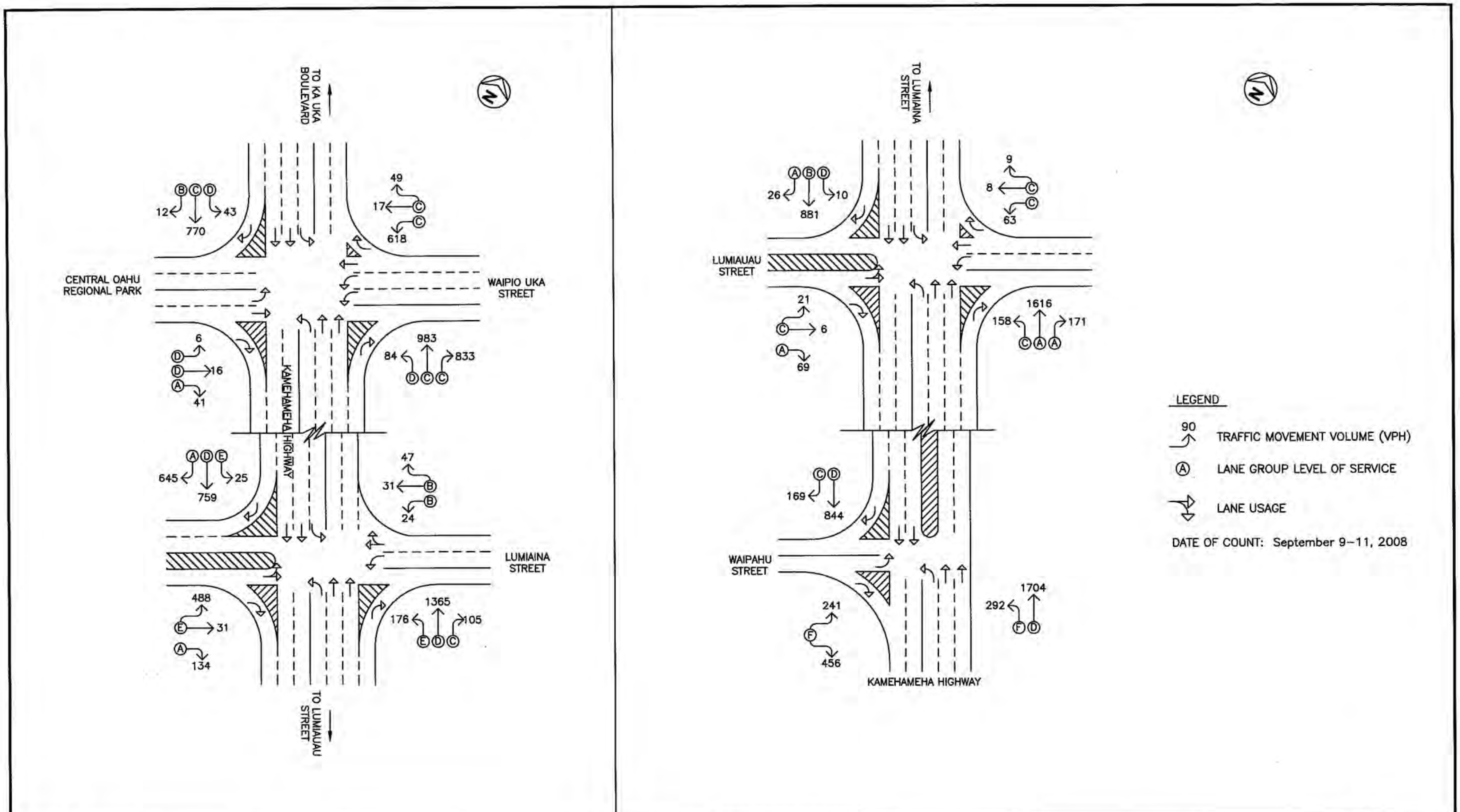
EXISTING PM PEAK HOUR OF TRAFFIC - KA UKA BOULEVARD

FIGURE 6



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KOA RIDGE MAKAI AND WAIAWA DEVELOPMENT

EXISTING PM PEAK HOUR OF TRAFFIC - KAMEHAMEHA HIGHWAY

FIGURE 7

Table 1: Peak Hours of Traffic (Cont'd)

Intersection	AM Peak	PM Peak
Ka Uka Blvd/ Waipio Uka St	7:15 AM – 8:15 AM	4:00 PM – 5:00 PM
Ka Uka Blvd/ Ukee St (west)	7:00 AM – 8:00 AM	4:15 PM – 5:15 PM
Ka Uka Blvd/ Kamehameha Hwy	7:00 AM – 8:00 AM	4:00 PM – 5:00 PM
Kamehameha Hwy/ Waipio Uka St	7:15 AM – 8:15 AM	4:00 PM – 5:00 PM
Kamehameha Hwy/ Lumiaina St	7:00 AM – 8:00 AM	4:00 PM – 5:00 PM
Kamehameha Hwy/ Lumiauau St	7:00 AM – 8:00 AM	4:15 PM – 5:15 PM
Kamehameha Hwy/ Waipahu St	7:15 AM – 8:15 AM	4:00 PM – 5:00 PM

The analysis is based on the above absolute commuter peak hour time periods for each intersection to identify the traffic impacts resulting from the proposed project. LOS calculations are included in Appendix D.

b. Ka Uka Boulevard at Waipio Interchange Northbound Ramps Intersection

At the intersection with the Waipio Interchange northbound on- and off-ramps, the eastbound approach of Ka Uka Boulevard carries 324 with the eastbound left-turn and through movements operating at LOS "B" and LOS "A", respectively, during the AM peak period. During the PM peak period, the traffic volume is greater with 561 vehicles traveling eastbound with the left-turn movement operating at LOS "D" and the through movement operating at LOS "B". Vehicular queues periodically formed on the northbound off-ramp approach of this intersection with the most significant queuing occurring during the PM peak period. During this period, queues in the eastbound left-turn lane of the intersection would oftentimes extend beyond the capacity of the turning lane and encroach into the eastbound through traffic movement lane.

The westbound approach of the intersection carries relatively very little traffic with 8 vehicles and 80 vehicles during the AM and PM peak periods, respectively. The westbound approach operates at LOS "B" or better during both the AM and PM peak hours of traffic. No significant vehicular queuing was observed on this approach to the intersection.

The northbound off-ramp intersection approach carries 588 vehicles during the AM peak hour of traffic and operates at LOS "B" with a significant portion of the approach volume executing left-turn maneuvers. During the PM peak hour, the northbound intersection approach carries significantly more traffic with 1,188 vehicles, and operates at LOS "D". Average maximum queue lengths range from 15 to 20 vehicles during the PM peak hour of traffic with minimal queue lengths of approximately seven vehicles occurring during the AM peak hours.

c. Ka Uka Boulevard at Waipio Interchange Southbound On-Ramp Intersection

At the intersection with the Waipio Interchange southbound on-ramp, the westbound approach of Ka Uka Boulevard carries a total of 570 vehicles during the AM peak hour of traffic with the westbound left-turn movement operating at LOS "A". During the PM peak hour of traffic, the westbound approach of Ka Uka Boulevard at the southbound on-ramp carries a total of 1,212 vehicles with the westbound left-turn movement also operating at LOS "A" conditions.

The eastbound Ka Uka Boulevard right-turn movement onto the southbound on-ramp of the Waipio Interchange flow unimpeded with 968 vehicles and 767 vehicles during the AM and PM peak hours of traffic, respectively. The eastbound through movement on Ka Uka

Boulevard through the intersection also flow unimpeded with 324 vehicles and 561 vehicles during the AM and PM peak hours of traffic, respectively. No significant vehicular queuing was observed at this intersection.

d. Ka Uka Boulevard at Moaniani Street/Waipio Interchange Southbound Off-Ramp Intersection

At the intersection with Moaniani Street and the Waipio Interchange southbound off-ramp, the westbound approach of Ka Uka Boulevard carries 565 vehicles during the AM peak hour of traffic with the left-turn movement operating at LOS "E" and the through movement operating at LOS "B". During the PM peak hour of traffic, the westbound Ka Uka Boulevard approach carries a total of 1,187 vehicles with the left-turn movement operating at LOS "E" and the through movement operating at LOS "C" conditions. Oftentimes, vehicles queues associated with the westbound left-turn movement would extend beyond the capacity of the left-turn lane and spillback to adjacent intersections impeding both the westbound through traffic movement as well as the adjacent intersection operations.

The eastbound approach of Ka Uka Boulevard at the intersection with Moaniani Street and the southbound off-ramp carries a total of 896 vehicles during the AM peak hour of traffic and operates at LOS "D". During the PM peak hour of traffic, the eastbound approach carries 689 vehicles and operates at LOS "E" conditions. The LOS "D" and LOS "E" conditions during both the AM and PM peak periods, respectively, are primarily due to the high conflicting traffic volumes at the intersection resulting in extensive delays associated with the traffic signal phasing that are necessary to accommodate the relatively high traffic volumes.

The northbound approach of Moaniani Street at the Ka Uka Boulevard intersection carries a total 465 vehicles during the AM peak hour of traffic with both the left-turn and right-turn movements operating at LOS "D" conditions. Similarly, during the PM peak hour of traffic, the northbound approach of Moaniani Street at the Ka Uka Boulevard intersection carries 774 vehicles with the left-turn and right-turn movements operating at LOS "E" and LOS "D" conditions, respectively.

The southbound off-ramp at the Ka Uka Boulevard and Moaniani Street intersection carries 360 vehicles during the AM peak hour of traffic with observed average maximum queue lengths in the range of 12 to 15 vehicles. During the PM peak hour of traffic, the southbound off-ramp at the Ka Uka Boulevard and Moaniani Street intersection carries 388 vehicles with maximum queue lengths of 15 to 20 vehicles, and operates at LOS "E" conditions. The queuing during both peak periods is generally due in part to construction activities along the west side of the on-ramp approach to the intersection. The State Department of Transportation is currently constructing roadway improvements that include an exclusive right-turn lane on the southbound off-ramp approach to the intersection. Construction barricades are place along the right edge of the approach that prohibits southbound right turn on red movements. As such, right-turn movements only proceed on the traffic signal green indications for the southbound approach. As a result, queues form on the southbound approach to the intersection with Ka Uka Boulevard. With the completion of the exclusive right-turn lane, queues are expected to significantly reduce improving the operating levels of service for the intersection approach. The relatively high conflicting traffic volumes at the intersection affect the resulting operating levels of service for the southbound approach, for both periods.

e. Ka Uka Boulevard at Commercial Driveway

The westbound and eastbound approaches of Ka Uka Boulevard at the intersection with the commercial driveway carries a total of 548 vehicles and 937 vehicles during the AM peak hour of traffic, respectively. The westbound left-turn movement operates at LOS "A". During the PM peak hour of traffic, the westbound approach carries 1,075 vehicles while the eastbound approach carries 659 vehicles. The westbound left-turn movement operates at LOS "A".

The northbound approach of the driveway at the Ka Uka Boulevard intersection carries 32 vehicles and 170 vehicles during the AM and PM peak hours of traffic, respectively, and operates at LOS "B" conditions during both peak hours.

f. Ka Uka Boulevard at Ukee Street (east)

At the intersection with Ukee Street (east), the westbound approach of Ka Uka Boulevard carries 458 vehicles during the AM peak hour of traffic with the left-turn movement operating at LOS "C". During the PM peak hour of traffic, the westbound Ka Uka Boulevard approach carries a total of 968 vehicles with the left-turn movement operating at LOS "A" conditions.

The eastbound approach of Ka Uka Boulevard at the intersection with Ukee Street (east) carries a total of 978 vehicles during the AM peak hour of traffic with the left-turn movement operating at LOS "C". During the PM peak hour of traffic, the eastbound approach carries a total of 614 vehicles with the left-turn movement operating at LOS "B" conditions.

The northbound approach of Ukee Street (east) at the Ka Uka Boulevard intersection carries a total 77 vehicles during the AM peak hour of traffic and operates at LOS "A". During the PM peak hour of traffic, the northbound approach of Ukee Street (east) at Ka Uka Boulevard carries 195 vehicles and operates at LOS "D". The southbound approach of Ukee Street (east) at the Ka Uka Boulevard intersection carries 20 vehicles during the AM peak hour and operates at LOS "B", while the southbound approach carries 70 vehicles during the PM peak hour of traffic and operates at LOS "D".

g. Ka Uka Boulevard at Waipio Uka Street

At the intersection with Waipio Uka Street, the westbound approach of Ka Uka Boulevard carries 342 vehicles during the AM peak hour of traffic with the left-turn, through, and right-turn movements all operating at LOS "A". During the PM peak hour of traffic, the westbound Ka Uka Boulevard approach carries a total of 974 vehicles with the left-turn, through, and right-turn movements also operating at LOS "A" conditions.

The eastbound approach of Ka Uka Boulevard at the intersection with Waipio Uka Street carries a total of 1,004 vehicles and 616 vehicles during the AM and PM peak hour of traffic, respectively. During both peak periods, all traffic movement on the eastbound approach of Ka Uka Boulevard at the Waipio Uka Street intersection operates at LOS "A" conditions.

The northbound approach of Waipio Uka Street at the Ka Uka Boulevard intersection carries a total 202 vehicles during the AM peak hour of traffic and operates at LOS "B". During the PM peak hour of traffic, the northbound approach of Waipio Uka Street at Ka Uka Boulevard carries 205 vehicles and also operates at LOS "B" conditions. The southbound approach of Waipio Uka Street at the Ka Uka Boulevard intersection carries 74 vehicles during the AM peak hour and operates at LOS "B", while the southbound approach carries 162 vehicles during the PM peak hour of traffic and also operates at LOS "B" conditions.

h. Ka Uka Boulevard at Ukee Street (west)

At the intersection with Ukee Street (west), the westbound approach of Ka Uka Boulevard carries 366 vehicles during the AM peak hour of traffic with the left-turn movement operating at LOS "C" and the shared through/right-turn movements operating at LOS B". During the PM peak hour of traffic, the westbound Ka Uka Boulevard approach carries a total of 995 vehicles with the left-turn movement operating at LOS "C" and the shared through and right-turn movements operate at LOS "B" conditions.

The eastbound approach of Ka Uka Boulevard at the intersection with Ukee Street (west) carries a total of 830 vehicles during the AM peak hour of traffic with the left-turn movement operating at LOS "D" and the shared through/right-turn movement operating at LOS "C" conditions. During the PM peak hour of traffic, the eastbound approach carries a total of 584 vehicles with the left-turn movement operating at LOS "D" conditions while the shared through/right-turn movements operate at LOS "C".

The northbound approach of Ukee Street (west) at the Ka Uka Boulevard intersection carries a total 409 vehicles during the AM peak hour of traffic and operates at LOS "C". During the PM peak hour of traffic, the northbound approach of Ukee Street (west) at Ka Uka Boulevard carries 341 vehicles and operates at LOS "C". The southbound approach of Ukee Street (west) at the Ka Uka Boulevard intersection carries 17 vehicles during the AM peak hour and operates at LOS "B", while the southbound approach carries 141 vehicles during the PM peak hour of traffic and also operates at LOS "B".

i. Ka Uka Boulevard at Kamehameha Highway

At the intersection with Ka Uka Boulevard and the Kamehameha Highway, the westbound approach of Ka Uka Boulevard carries 313 vehicles during the AM peak hour of traffic with the left-turn movement operating at LOS "D" and the through movement operating at LOS "C". During the PM peak hour of traffic, the westbound Ka Uka Boulevard approach carries a total of 1,060 vehicles with the left-turn movement operating at LOS "D" and the through movement operating at LOS "C" conditions. Vehicles queues associated with the westbound left-turn movement would extend beyond the capacity of the left-turn lane and impede the westbound through traffic movement.

The eastbound approach of Ka Uka Boulevard at the intersection with Kamehameha Highway carries relatively low traffic volumes with a total of 40 vehicles during the AM peak hour of traffic resulting in LOS "D" and "C" conditions for the individual eastbound left-turn and shared through/right-turn traffic movements, respectively. During the PM peak hour of traffic, the eastbound approach carries 109 vehicles with all of the individual movements generally operating at LOS "D" conditions. The LOS "D" conditions during both peak periods are primarily due to the high conflicting traffic volumes at the intersection resulting in delays associated with the traffic signal phasing necessary to accommodate the high traffic volumes of the conflicting traffic movements.

The northbound approach of Kamehameha Highway at the Ka Uka Boulevard intersection carries a total 618 vehicles during the AM peak hour of traffic with the left-turn movement operating at LOS "D", and the through and right-turn movements operating at LOS "C" and LOS "B" conditions, respectively. During the PM peak hour of traffic, the northbound approach of Kamehameha Highway at the Ka Uka Boulevard intersection carries a total of 1,038 vehicles with the left-turn movement operating at LOS "D", and the through movement and right-turn movement operating at LOS "C" conditions.

The southbound approach of Kamehameha Highway at the Ka Uka Boulevard intersection carries 1,533 vehicles during the AM peak hour of traffic with the left-turn movement operating at LOS "C" conditions while the through and right-turn movements both operate at LOS "A". During the PM peak hour of traffic, the southbound approach of Kamehameha Highway at the Ka Uka Boulevard intersection carries 943 vehicles with the left-turn movement operating at LOS "D", and the through and right-turn movements operating at LOS "B" conditions.

j. Kamehameha Highway at Waipio Uka Street

At the intersection with Kamehameha Highway, the westbound approach of Waipio Uka Street carries 618 vehicles during the AM peak hour of traffic with the left-turn movement operating at LOS "C" while the shared through/right-turn traffic movements operate at LOS "B" conditions. During the PM peak hour of traffic, the westbound Waipio Uka Street approach carries a total of 684 vehicles with the left-turn movement operating at LOS "C" and the through and right-turn movements also operate at LOS "C" conditions. Vehicles queues associated with the westbound left-turn movement would oftentimes extend beyond the capacity of the leftmost left-turn lane and affect intersection movements at the adjacent intersection of Waipio Uka Street and Ukee Street located immediately east.

The eastbound approach of Waipio Uka Street at the intersection with Kamehameha Highway carries relatively low traffic volumes with a total of 14 vehicles during the AM peak hour of traffic resulting in LOS "D" conditions for the left-turn and through movements. During the PM peak hour of traffic, the eastbound approach carries 63 vehicles with the left-turn and through movements also operating at LOS "D" conditions. Although relatively low traffic demands on the eastbound approach to the intersection, the low levels of service during both peak periods are primarily due to the high conflicting traffic volumes at the intersection resulting in delays associated with the traffic signal phasing necessary to accommodate the high traffic volumes of the conflicting traffic movements.

The northbound approach of Kamehameha Highway at the Waipio Uka Street intersection carries a total 1,162 vehicles during the AM peak hour of traffic with the left-turn movement operating at LOS "D", and both the through and right-turn movements operating at LOS "B" conditions. During the PM peak hour of traffic, the northbound approach of Kamehameha Highway at the Waipio Uka Boulevard intersection carries a relatively high traffic volume of 1,900 vehicles with the left-turn movement operating at LOS "D", and the through and right-turn movements operating at LOS "C".

The southbound approach of Kamehameha Highway at the Waipio Uka Boulevard intersection carries 960 vehicles during the AM peak hour of traffic with the left-turn movement operating at LOS "D", and the through and right-turn movement operating at LOS "B" conditions. During the PM peak hour of traffic, southbound Kamehameha Highway at the Waipio Uka Street intersection carries 825 vehicles with the left-turn movement operating at LOS "D", and the through and right-turn movements operating at LOS "C" or better conditions.

k. Kamehameha Highway at Lumiaina Street

At the intersection with Kamehameha Highway, the westbound approach of Lumiaina Street carries 174 vehicles during the AM peak hour of traffic with the left-turn and shared through/right-turn movements operate at LOS "B". During the PM peak hour of traffic, the westbound Lumiaina Street approach carries a total of 102 vehicles with the left-turn, through, and right-turn movements also operating at LOS "B" conditions.

The eastbound approach of Lumiaina Street at the intersection with Kamehameha Highway carries 576 vehicles during the AM peak hour of traffic resulting in LOS "E" conditions for the left-turn movements, and LOS "A" conditions for the shared through/right-turn movements. During the PM peak hour of traffic, the eastbound approach carries 653 vehicles with the left-turn movement continuing to operate at LOS "E" while the through movement operates at LOS "A". Vehicles queue lengths associated with the eastbound left-turn movement would oftentimes extend westward beyond the capacity of the left-turn lane and affect intersection movements at the adjacent intersection located immediately west.

The northbound approach of Kamehameha Highway at the Lumiaina Street intersection carries a total 744 vehicles during the AM peak hour of traffic with the left-turn movement operating at LOS "E", and both the through and right-turn movements operating at LOS "C" conditions. During the PM peak hour of traffic, the northbound approach of Kamehameha Highway at the Lumiaina Street intersection carries a relatively high traffic volume of 1,646 vehicles with the left-turn movement operating at LOS "E", the through movement operating at LOS "D", and the right-turn movement operating at LOS "C".

The southbound approach of Kamehameha Highway at the Lumiaina Street intersection carries 1,516 vehicles during the AM peak hour of traffic with the left-turn movement operating at LOS "E", the through movement operating at LOS "D", and the right-turn movement operating at LOS "A" conditions. During the PM peak hour of traffic, southbound Kamehameha Highway at the Lumiaina Street intersection carries 1,429 vehicles with the left-turn movement operating at LOS "E", the through movement operating at LOS "D", and the right-turn movement operating at LOS "A" conditions.

I. Kamehameha Highway at Lumiauau Street

At the intersection with Kamehameha Highway, the westbound approach of Lumiauau Street carries 198 vehicles during the AM peak hour of traffic with the left-turn and shared through/right-turn movements operate at LOS "C" and LOS "B", respectively. During the PM peak hour of traffic, the westbound Lumiaina Street approach carries a total of 80 vehicles with the left-turn, through, and right-turn movements also operating at LOS "C" conditions.

The eastbound approach of Lumiauau Street at the intersection with Kamehameha Highway carries 444 vehicles during the AM peak hour of traffic resulting in LOS "C" conditions for the shared left-turn/through movements, and LOS "A" conditions for the right-turn movement. During the PM peak hour of traffic, the eastbound approach carries 96 vehicles with the shared left-turn/through movements operating at LOS "C" while the right-turn movement operates at LOS "A". The northbound approach of Kamehameha Highway at the Lumiauau Street intersection carries a total 705 vehicles during the AM peak hour of traffic with the left-turn movement operating at LOS "B", and both the through and right-turn movements operating at LOS "B" or better conditions. During the PM peak hour of traffic, the northbound approach of Kamehameha Highway at the Lumiauau Street intersection carries 1,945 vehicles with the left-turn movement operating at LOS "C", and the through and right-turn movements operating at LOS "A".

The southbound approach of Kamehameha Highway at the Lumiauau Street intersection carries 1,105 vehicles during the AM peak hour of traffic with the left-turn movement operating at LOS "E", the through movement operating at LOS "B", and the right-turn movement operating at LOS "A" conditions. During the PM peak hour of traffic, southbound Kamehameha Highway at the Lumiauau

Street intersection carries 917 vehicles with the left-turn movement operating at LOS "D", the through movement operating at LOS "B", and the right-turn movement operating at LOS "A" conditions.

m. Kamehameha Highway at Waipahu Street

At the intersection with Kamehameha Highway, the eastbound approach of Waipahu Street carries 732 vehicles during the AM peak hour of traffic with both the left-turn and right-turn movements operating at LOS "F" conditions. During the PM peak hour of traffic, the eastbound Waipahu Street approach carries a total of 697 vehicles with the left-turn and right-turn movements also operating at LOS "F" conditions.

The northbound approach of Kamehameha Highway at the Waipahu Street intersection carries a total 730 vehicles during the AM peak hour of traffic with the left-turn movement operating at LOS "F", and both the through movement operating at LOS "B" conditions. During the PM peak hour of traffic, the northbound approach of Kamehameha Highway at the Waipahu Street intersection carries 1,996 vehicles with the left-turn movement also operating at LOS "F" and the through movement operating at LOS "D".

The southbound approach of Kamehameha Highway at the Waipahu Street intersection carries 1,586 vehicles during the AM peak hour of traffic with the through movement operating at LOS "F" and the right-turn movement operating at LOS "C" conditions. During the PM peak hour of traffic, southbound Kamehameha Highway at the Waipahu Street intersection carries 1,013 vehicles with the through movement operating at LOS "D" and the right-turn movement operating at LOS "C" conditions.

n. Interstate H-2 Freeway Segments

During the AM peak hour of traffic, the Interstate H-2 Freeway just south of the Waipio Interchange carries 2,768 vehicles northbound and 4,373 vehicles southbound. The northbound and southbound freeway segments along H-2 just south of the Waipio Interchange operate at LOS "B" and LOS "C" during the existing AM peak hour of traffic. Vehicle queues as a result of spillback conditions from the Waiawa Interchange located further south extend to about one-third the distance to the Waipio Interchange, or approximately 4,300 feet. No vehicular queues would occur in the northbound direction during the AM peak hours of traffic.

North of the Waipio Interchange, the Interstate H-2 Freeway carries approximately 2,474 vehicles northbound and 3,760 vehicles southbound during the morning peak hours of traffic and operates at LOS "A" and LOS "B", respectively. No visible queuing was observed along the freeway segment during the morning peak periods.

During the PM peak hours of traffic, the Interstate H-2 Freeway just south of the Waipio Interchange carries 4,412 vehicles northbound and 3,099 vehicles southbound. The northbound and southbound Interstate H-2 Freeway segments just south of the Waipio Interchange both operate at LOS "B" conditions during the PM peak hours of traffic. No visible queuing was observed along this freeway segment during the PM peak hours of traffic.

North of the Waipio Interchange, the Interstate H-2 Freeway carries approximately 3,765 vehicles northbound and 2,695 vehicles during the PM peak hours of traffic. This freeway segment operates at LOS "B" for both the northbound and southbound directions during the PM peak hours of traffic. No visible vehicular queuing was observed along this freeway segment durng the PM peak hours of traffic.

Further discussions on freeway segment operations and travel times during the morning and afternoon commute periods are presented in Section V of this report.

o. Waipio Interchange Ramp Merge/Diverge Operations

During existing AM peak hour traffic operations, the Interstate H-2 Freeway northbound off-ramp on northbound on-ramp at the Waipio Interchange operate at LOS "B". The southbound on- and off-ramps both operate at LOS "C" conditions during the AM pea hours of traffic. Merge and diverge conditions at all of the ramps operate well with no visible queuing at the ramp and freeway interfaces.

During the existing PM peak hour of traffic, the northbound off-ramp at the Waipio Interchange operates at LOS "C" with occasional queuing at the ramp junction. However, diverge conditions operate well with no queuing as a result of diverge maneuvers. The northbound on-ramp also operates well at LOS "B" during the PM peak hour of traffic. The traffic demand on the northbound on-ramp is controlled primarily by the upstream traffic signal system at the ramp junction. As a result, with traffic signal operations to accommodate the heavier left-turn movements from the northbound off-ramp, vehicle queues associated with the eastbound left-turn movement entering the northbound on-ramp generally extend beyond the existing left-turn lane capacity resulting in spillback conditions on the bridge overpass of the interchange.

The southbound on- and off-ramps both operate at LOS "B" during the PM peak hours of traffic with visible queuing as a result of diverge and merge operations at the ramp and freeway interfaces.

Table 1.1 summarizes the freeway segments and ramp operations along the Interstate H-2 Freeway and at the Waipio Interchange.

Table 1.1: Summary of Existing Interstate H-2 Freeway Segment and Ramp LOS Operations

Freeway Segment/ Interchange Ramp	AM Peak	PM Peak
NB segment south of Waipio Interchange	B	C
NB segment north of Waipio Interchange	A	B
SB segment south of Waipio Interchange	C	B
SB segment north of Waipio Interchange	B	B
NB Off-ramp	B	C
NB On-ramp	B	B
SB On-ramp	C	B
SB Off-ramp	C	B

IV. PROJECTED TRAFFIC CONDITIONS

A. Through Traffic Forecasting Methodology

The travel forecast is based upon the average annual traffic growth rate as described in the Oahu Regional Transportation Plan (ORTP). The ORTP, prepared for the Oahu Metropolitan Planning Organization (OMPO), serves as a guide for the development of the major surface transportation facilities and programs to be implemented on Oahu. The ORTP identifies strategies and actions that will lead to the development of an integrated intermodal transportation system that facilitates the efficient movement of people and goods. Use of the ORTP for traffic forecasting more accurately reflects the anticipated impacts of traffic growth in the region than the use of historical traffic count data that can sometimes result in extremely unrealistic projections for long-range forecasts. Based upon statewide population, employment, and visitor forecasts to the Year 2020, interpolation of the ORTP estimates result in annual average daily traffic projections in the project vicinity of approximately 1.4% per year. However, this average rate incorporates the Koa Ridge and Waiawa developments in the forecast traffic demands. Adjustments to segregate trips associated with Koa Ridge, Castle & Cooke Waiawa, Waiawa Ridge/Gentry

Developments yield average annual growth rate factors of 1.04 and 1.085 for projected Year 2016 and Year 2025 analysis scenarios, using Year 2008 as the base year. The rates are supported by the anticipated minimal future growth in areas further north of the project site. These rates were subsequently applied to the existing baseline through traffic demands along the Interstate H-2 Freeway, Ka Uka Boulevard, and Kamehameha Highway to achieve the projected Year 2016 and Year 2025 traffic demands. The trips as a result of the Koa Ridge Makai and Waiawa developments were incorporated in analyses of project-related impacts covered in later sections of this report that discuss future traffic conditions with the proposed projects.

B. Adjacent Waiawa Ridge Development

The proposed Waiawa Ridge development will be located in Central Oahu east of the Interstate H-2 Freeway and immediately south of the proposed Castle & Cooke Waiawa development in Waipio. Access to the Waiawa Ridge development will be provided via an extension of Ka Uka Boulevard east of the Interstate H-2 northbound on- and off-ramps intersection. The proposed project is expected to be completed and occupied by the Year 2020 and is assumed to include a mix of single-family and multi-family residential units (total of approximately 5,000 units), as well as, ~770,000 square feet of commercial uses representing the primary trip generating components of the project. In conjunction with this development, the roadway and intersection improvements in the project vicinity that are identified in the "Waiawa Gentry Phase 2 Traffic Study" dated December 2001, and its supplemental report dated February 2002 are assumed to be implemented as traffic mitigating measures for the region. Discussions between Castle & Cooke Homes Hawaii and Waiawa Ridge Development to formulate an Agreement to fund and implement improvements are proceeding. These improvements are therefore considered committed projects and are listed in the following section of this document as such.

Based on the trip generation rates and procedures identified in the Institute of Transportation Engineers publication on trip generation for specific land use types, and based on the assumed development components identified above, the Waiawa

Ridge development is anticipated to generate an external total of approximately 3,489 trips and 5,661 trips during the AM and PM peak hours of traffic, respectively. Accommodations were made for internal capture of site-generated trips during the PM peak period in accordance with guidelines identified in the Institute of Transportation Engineers publication on trip generation. These resulting external trips were assigned to the street network in the project vicinity to account for trips generated by the proposed Waiawa Ridge development.

C. Projected Year 2016 Traffic Conditions

1. Roadway Improvements Without Project

The *Without Project* scenario analysis incorporates the development of other projects based on assumed development schedules and ambient growth to the Year 2016, as well as, the implementation of improvements at the study intersections identified as needs for the aforementioned Waiawa Ridge (aka Gentry) traffic studies. In particular, the Without Project improvements assumed to be made to the Interchange are based on the *Waipio Interchange Modifications, Interstate Access Modification Request Update, December 2008*. The document was prepared by Waiawa Ridge Development for the DOT, included phasing and costs of improvements, and is thus assumed to contain committed improvements. These improvements include the following:

<u>*Ka Uka Boulevard/Interstate H-2 Northbound On- and Off-Ramps*</u>

- Two exclusive right-turn lanes on the Interstate H-2 northbound off-ramp approach.
- Four eastbound lanes located east of the Waipio Interchange northbound on- and off-ramps to accept two free-flow right-turn lanes from the off-ramp and two eastbound through lanes on Ka Uka Boulevard.
- Two through movement lanes and an exclusive right-turn lane on the westbound approach of Ka Uka Boulevard.
- Two through lanes on the eastbound approach of Ka Uka Boulevard.
- Widen the Interstate H-2 northbound off-ramp to two ramp diverge lanes to accommodate two northbound left-turn lanes and two exclusive right-turn lanes at the ramp junction of Ka Uka Boulevard.

Ka Uka Boulevard/Interstate H-2 Southbound On-Ramp

- Southbound loop on-ramp to the Interstate H-2 freeway in the northwest quadrant of the Waipio Interchange.
- One through lane, a shared through and right-turn lane, and an exclusive right-turn lane on the eastbound approach of Ka Uka Boulevard.
- One through lane and a shared through and right-turn lane on the westbound approach of Ka Uka Boulevard.

Ka Uka Boulevard/Interstate H-2 Southbound Off-Ramp/Moaniani Street

- Two exclusive left-turn lanes and two through lanes on the westbound approach of Ka Uka Boulevard.
- Two southbound departure lanes along Moaniani Street to accept the double left-turn lanes from westbound Ka Uka Boulevard.
- Three lanes on the Interstate H-2 southbound off-ramp approach to accommodate an exclusive left-turn lane, a shared left-turn/through lane, and an exclusive right-turn lane.
- Widen Ka Uka Boulevard between Moaniani Street and the Interstate H-2 southbound on-ramp (from west) to accommodate an additional eastbound lane providing free-flow movement from northbound right-turn Moaniani Street.

Ka Uka Boulevard/Kamehameha Highway

- Modify the traffic signal phasing at the intersection to allow for simultaneous left-turn movements on the eastbound and westbound approaches.
- Provide an exclusive left-turn lane, a through lane, and two exclusive right-turn lanes on the westbound approach of Ka Uka Boulevard. Intersection geometry may need to be adjusted to accommodate the necessary approach laneage.

Kamehameha Highway/Lumiaina Street

- Provide an additional eastbound left-turn lane that results in an exclusive left-turn lane, a shared left-turn/through lane, and an exclusive right-turn lane on Lumiaina Street.
- Modify traffic signal system to permit split phases for the eastbound and westbound approaches of Lumiaina Street.

Kamehameha Highway/Waipahu Street

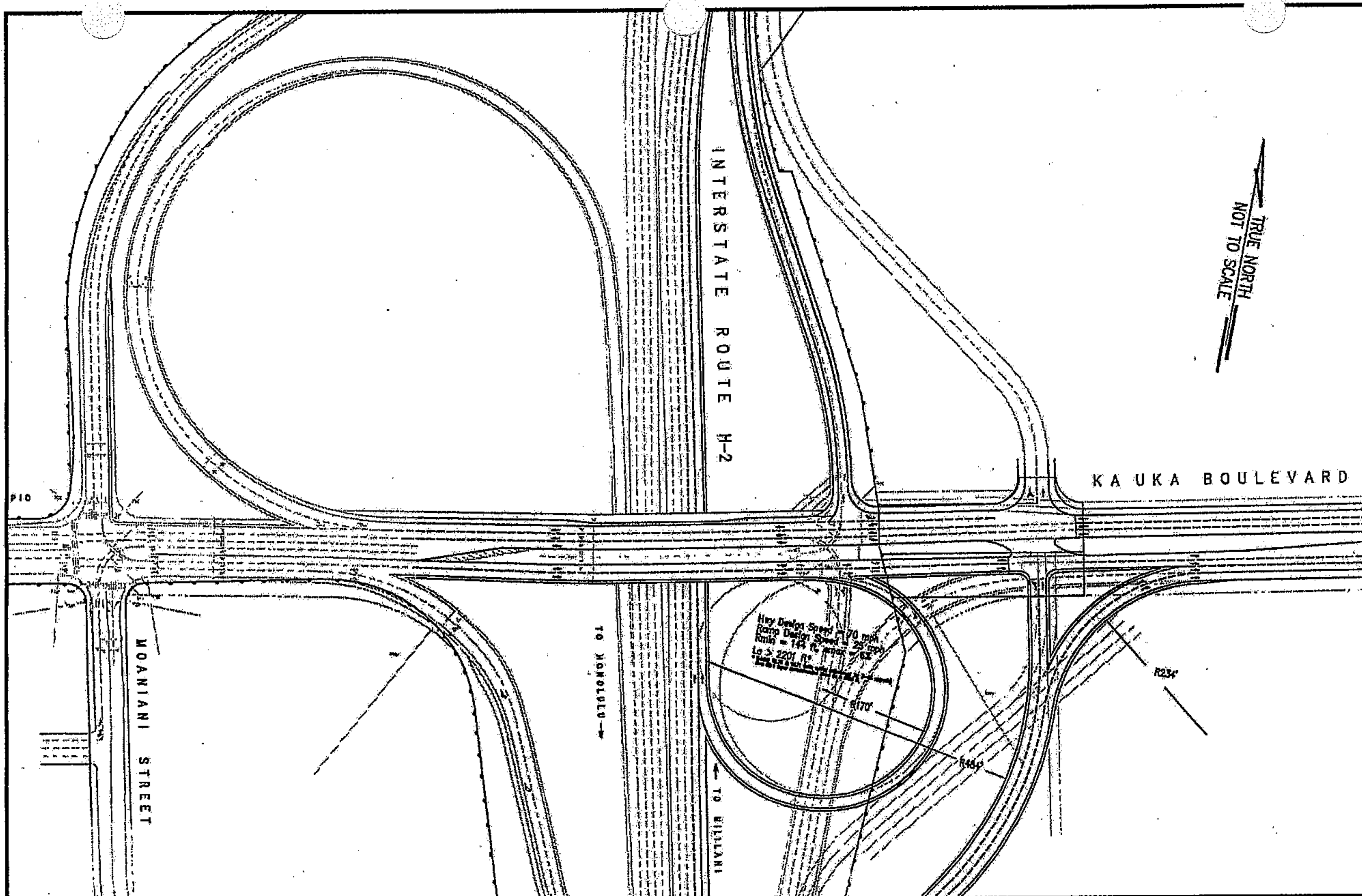
- Provide an additional lane on the eastbound approach of Waipahu Street that results in separate left-turn and right-turn lanes with a southbound intersection departure lane on Kamehameha Highway to accommodate the new eastbound right-turn lane.
- Modify traffic signal system to permit overlap phasing for eastbound right-turn movements.

In addition, to accommodate increased traffic demands associated with development areas east of the Interstate H-2 Freeway, and to eliminate conflicting movements at the existing ramp terminal at the intersection with the northbound ramps and Ka Uka Boulevard, a freeway northbound loop on-ramp is incorporated in the street network used for the traffic analysis. This proposed loop ramp would be located at the southeast quadrant of the existing Waipio Interchange. Figure 8 shows a conceptual layout of the proposed northbound loop on-ramp. Castle & Cooke Homes Hawaii and Waiawa Ridge Development are formulating a cost-sharing agreement to fund and construct the interchange improvements to mitigate the combined impacts of the developments which is expected to include this northbound loop on-ramp.

2. Projected Year 2016 Traffic Volumes Without Koa Ridge Makai and Waiawa Developments

a. General

The Year 2016 AM and PM peak hour traffic volumes and operating conditions at the study intersections without the proposed Koa Ridge Makai and Waiawa developments are shown in Figures 9 to 12, and summarized in Table 2. As previously discussed, at the time of this report, traffic signal hardware and appurtenances are visibly installed at the intersection of Ka Uka Boulevard and Ukee Street (east). As such, and based on discussions with the City and County of Honolulu, this intersection is assumed to be signalized by the Year 2016. The existing levels of service are included in the table for comparison purposes. LOS calculations are included in Appendix E.



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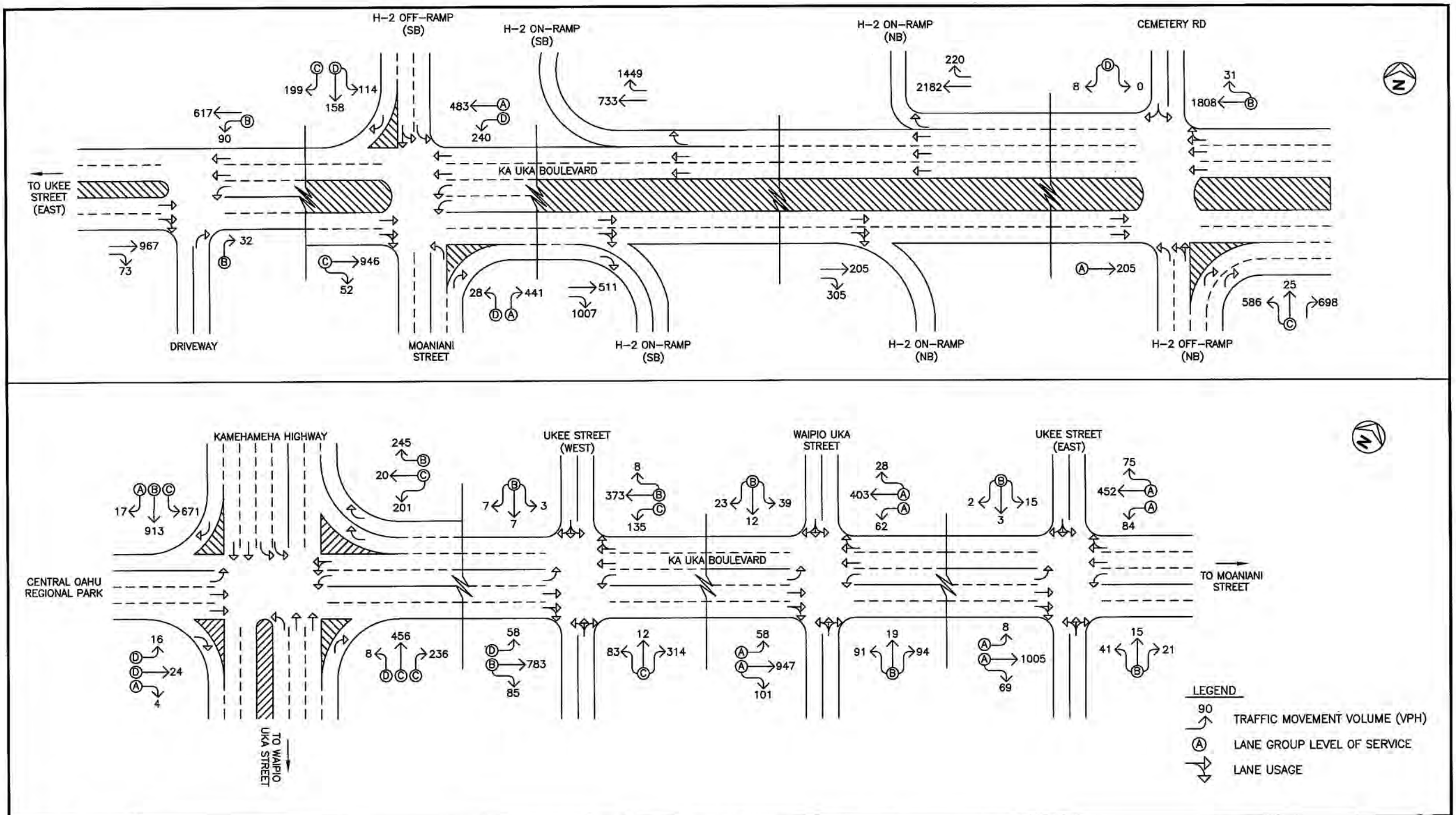
KOA RIDGE MAKAI AND WAIAWA

KA UKA INTERCHANGE CONFIGURATION

FIGURE 8



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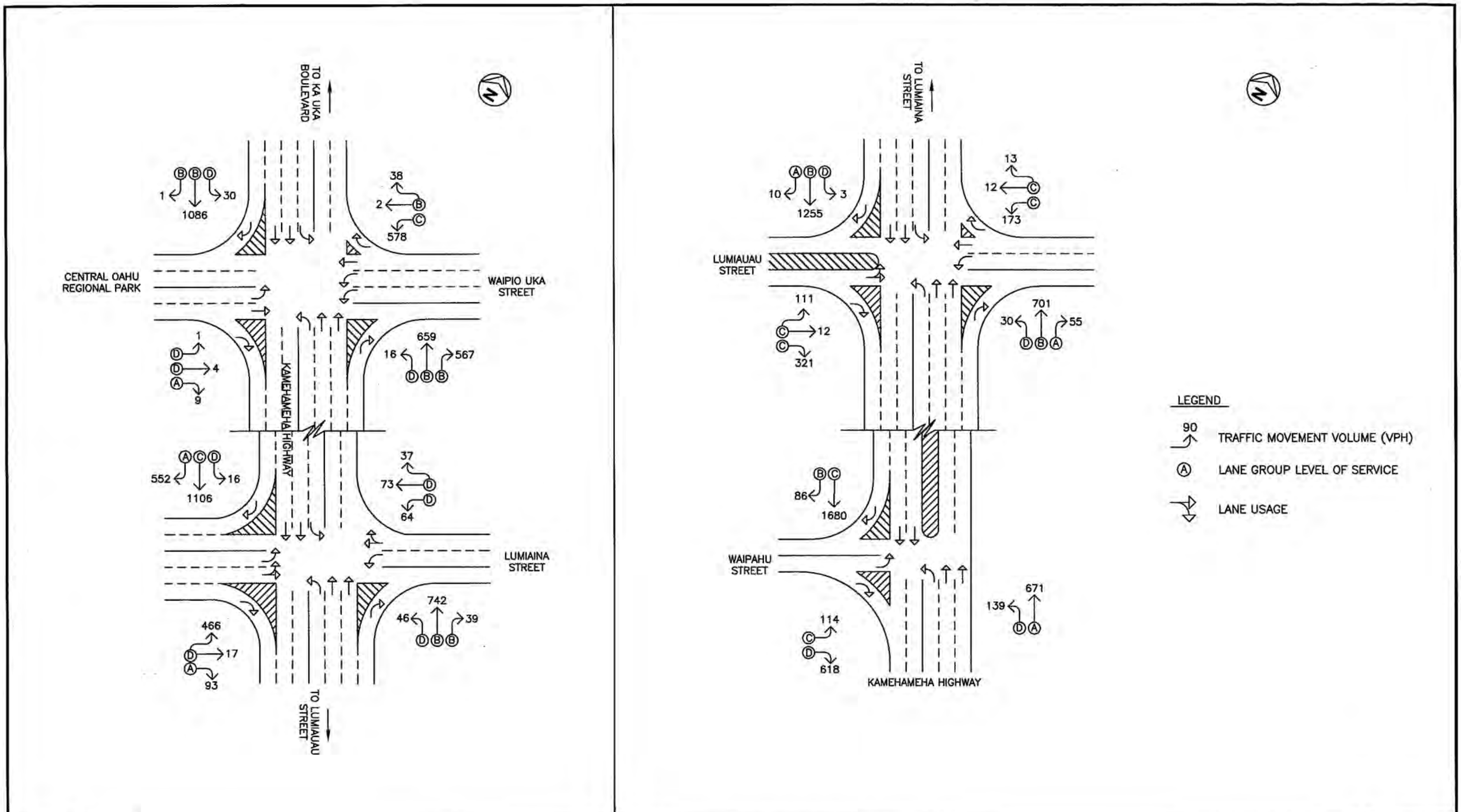
KOA RIDGE MAKAI AND WAIAWA DEVELOPMENT

YEAR 2016 AM PEAK HOUR OF TRAFFIC WITHOUT PROJECT
KA UKA BOULEVARD

FIGURE 9



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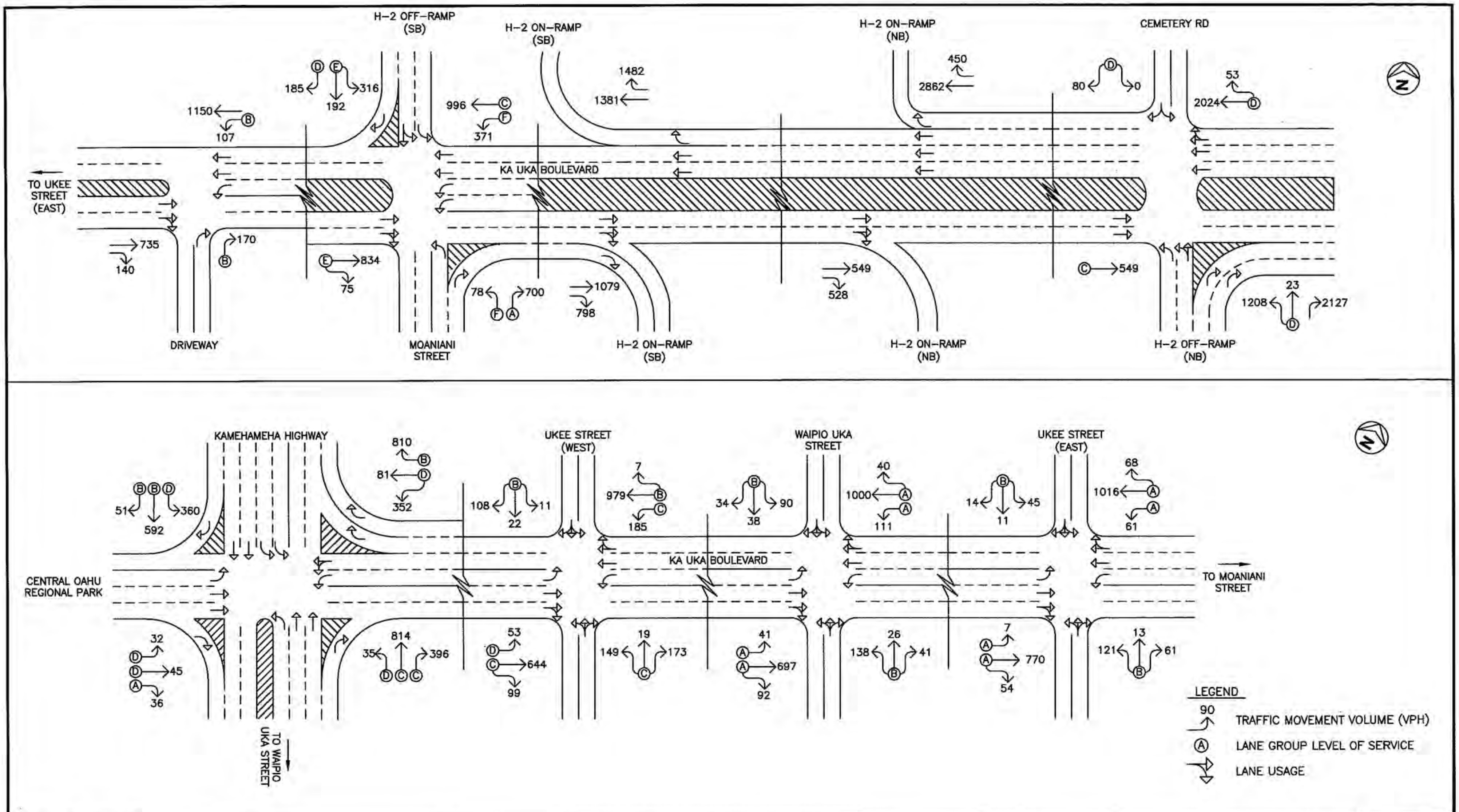
KOA RIDGE MAKAI AND WAIAWA DEVELOPMENT

YEAR 2016 AM PEAK HOUR OF TRAFFIC WITHOUT PROJECT
KAMEHAMEHA HIGHWAY

FIGURE
10



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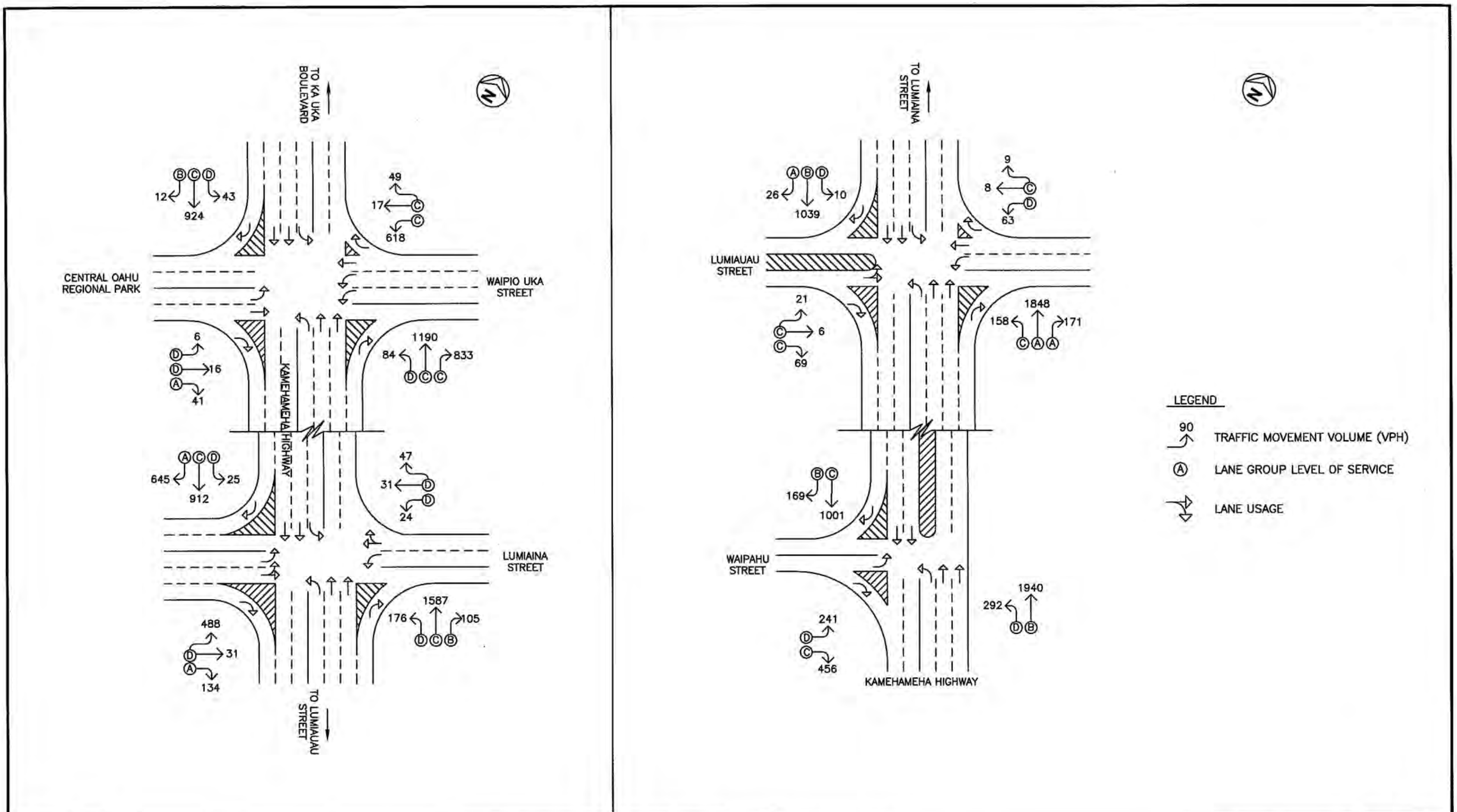
KOA RIDGE MAKAI AND WAIAWA DEVELOPMENT

YEAR 2016 PM PEAK HOUR OF TRAFFIC WITHOUT PROJECT
KA UKA BOULEVARD

FIGURE
11



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KOA RIDGE MAKAI AND WAIAWA DEVELOPMENT

YEAR 2016 PM PEAK HOUR OF TRAFFIC WITHOUT PROJECT
KAMEHAMEHA HIGHWAY

FIGURE 12

Table 2: Existing and Projected (Year 2016 Without Project) Levels of Service

Intersection	Traffic Movement		AM		PM	
			Exist	Year 2016 w/out Proj	Exist	Year 2016 w/out Proj
Ka Uka Blvd/ Waipio IC NB Ramps*	EB	LT	B	-	D	-
		TH	A	A	B	C
	WB	TH-RT	A	B	B	D
	NB	LT-TH	B	C	D	D
		RT		-		-
	SB	LT-RT	-	D	-	D
Ka Uka Blvd/ Waipio IC SB On-Ramp*	WB	LT	A	-	A	-
Ka Uka Blvd/ Moaniani St/ Waipio IC SB Off-Ramp*	EB	TH-RT	D	C	E	E
	WB	LT	E	D	E	F
		TH	B	A	C	C
	NB	LT	D	D	D	F
		RT	D	A	E	A
	SB	LT-TH	D	D	E	D
		RT		C		D
Ka Uka Blvd/ Driveway	WB	LT	A	B	A	B
	NB	RT	B	B	B	B
Ka Uka Blvd/ Ukee St (East)*	EB	LT	A	A	B	A
		TH-RT	-	A	-	A
	WB	LT	B	A	A	A
		TH-RT	-	A	-	A
	NB	LT-TH-RT	C	B	D	B
	SB	LT-TH-RT	C	B	D	B

*Traffic signal system installed.

**Intersection modifications implemented.

Table 2: Existing and Projected (Year 2016 Without Project) Levels of Service (Cont'd)

Intersection	Traffic Movement		AM Exist	AM Year 2016 w/out Proj	PM Exist	PM Year 2016 w/out Proj
Ka Uka Blvd/ Waipio Uka St	EB	LT	A	A	A	A
		TH-RT	A	A	A	A
	WB	LT	A	A	A	A
		TH-RT	A	A	A	A
	NB	LT-TH-RT	B	B	B	B
	SB	LT-TH-RT	B	B	B	B
Ka Uka Blvd/ Ukee St (West)	EB	LT	D	D	D	D
		TH-RT	C	B	C	C
	WB	LT	C	C	C	C
		TH-RT	B	B	B	B
	NB	LT-TH-RT	C	C	C	C
	SB	LT-TH-RT	B	B	B	B
Ka Uka Blvd/ Kamehameha Hwy**	EB	LT	D	D	D	D
		TH	C	D	D	D
		RT		A		A
	WB	LT	D	C	D	D
		TH	C		C	
		RT	A	B	A	B
	NB	LT	D	D	D	D
		TH	C	C	C	C
		RT	B	C	C	C
	SB	LT	C	C	D	D
		TH	A	B	B	B
		RT	A	A	B	B

*Traffic signal system installed.
**Intersection modifications implemented.

Table 2: Existing and Projected (Year 2016 Without Project) Levels of Service (Cont'd)

Intersection	Traffic Movement		AM Exist	AM Year 2016 w/out Proj	PM Exist	PM Year 2016 w/out Proj
Kamehameha Hwy/ Waipio Uka St	EB	LT	D	D	D	D
		TH	D	D	D	D
		RT	A	A	A	A
	WB	LT	C	C	C	C
		TH-RT	B	B	C	C
	NB	LT	D	D	D	D
		TH	B	B	C	C
		RT	B	B	C	C
	SB	LT	D	D	D	D
		TH	B	B	C	C
		RT	B	B	B	B
Kamehameha Hwy/ Lumiaina St*	EB	LT-TH	E	D	E	D
		RT	A	A	A	A
	WB	LT	B	D	B	D
		TH-RT	B	D	B	D
	NB	LT	E	D	E	D
		TH	C	B	D	C
		RT	C	B	C	B
	SB	LT	E	D	E	D
		TH	D	C	D	C
		RT	A	A	A	A
Kamehameha Hwy/ Lumiauau St	EB	LT-TH	C	C	C	C
		RT	A	C	A	C
	WB	LT	C	C	C	D
		TH-RT	B	C	C	D
	NB	LT	D	D	C	C
		TH	B	B	A	A
		RT	A	A	A	A
	SB	LT	D	D	D	D
		TH	B	B	B	B
		RT	A	A	A	A

*Intersection modifications implemented.

Table 2: Existing and Projected (Year 2016 Without Project) Levels of Service (Cont'd)

Intersection	Traffic Movement		AM		PM	
			Exist	Year 2016 w/out Proj	Exist	Year 2016 w/out Proj
Kamehameha Hwy/ Waipahu St*	EB	LT	F	C	F	D
		RT		D		C
	NB	LT	F	D	F	D
		TH	B	A	D	B
	SB	TH	F	C	D	C
		RT	C	B	C	B

*Intersection modifications implemented.

Under the *Year 2016 Without Koa Ridge Makai and Waiawa Project* conditions, traffic operations in the project vicinity are expected to deteriorate from existing conditions during both peak periods of traffic due to ambient traffic growth and the assumed development of other projects in the vicinity. At the intersection of Ka Uka Boulevard and the northbound ramps of the Waipio Interchange, the eastbound left-turn movement, the westbound through movement, and the northbound through/right-turn movements are all expected to operate at LOS "F" under the existing roadway configuration without any improvements. However, the other critical traffic movements at the remaining study intersections are anticipated to operate at acceptable levels of service with the implementation of a variety of intersection and roadway improvements identified above. All of the existing operational deficiencies for both existing peak hour periods were mitigated with the aforementioned committed intersection and roadway improvements, also resulting in additional levels of service improvements for other individual movements at the study intersections.

b. Ka Uka Boulevard at Waipio Interchange Northbound Off-Ramp Intersection

At the intersection with the Waipio Interchange northbound on- and off-ramps, the eastbound approach of Ka Uka Boulevard is expected to service 205 vehicles with the eastbound through movement operating at LOS "A" during the projected AM peak period. During the PM peak period, the traffic volume would be greater with 549 vehicles traveling eastbound with the through movement operating at LOS "C".

The westbound approach of the intersection is expected to service 1,839 vehicles and 2,077 vehicles during the AM and PM peak periods, respectively. The westbound approach would operate at LOS "B" during the projected AM peak hours of traffic and LOS "D" during PM peak hours of traffic.

The northbound off-ramp intersection approach is expected to service 1,309 vehicles during the AM peak hour of traffic and would operate at LOS "C". During the PM peak hour, the northbound intersection approach is expected to service 3,358 vehicles, and is expected to operate at LOS "D".

c. Ka Uka Boulevard at Waipio Interchange Southbound Loop On-Ramp Intersection

At the intersection with the Waipio Interchange southbound loop on-ramp, the westbound approach of Ka Uka Boulevard is expected to service a total of 2,402 vehicles while the southbound loop on-ramp services 220 vehicles during the AM peak hour of traffic. The eastbound traffic flow on Ka Uka Boulevard is expected to service 2,182 vehicles during the AM peak hour. During the PM peak hour of traffic, the westbound approach of Ka Uka Boulevard at the southbound loop on-ramp is expected to service a total of 3,312 vehicles with the southbound loop on-ramp servicing 450 vehicles.

The eastbound traffic flow on Ka Uka Boulevard is expected to service 2,862 vehicles during the projected PM peak hour of traffic.

d. Ka Uka Boulevard at Moaniani Street/Waipio Interchange Southbound Off-Ramp Intersection

At the intersection with Moaniani Street and the Waipio Interchange southbound off-ramp, the westbound approach of Ka Uka Boulevard is expected to service 723 vehicles during the AM peak hour of traffic with the left-turn movement operating at LOS "D" and the through movement operating at LOS "A". During the PM peak hour of traffic, the westbound Ka Uka Boulevard approach is expected to carry a total of 1,367 vehicles with the left-turn movement operating at LOS "F" and the through movement operating at LOS "C" conditions.

The eastbound approach of Ka Uka Boulevard at the intersection with Moaniani Street and the southbound off-ramp is expected to service a total of 998 vehicles during the AM peak hour of traffic and operate at LOS "C". During the PM peak hour of traffic, the eastbound approach is expected to service 909 vehicles and operate at LOS "E" conditions.

The northbound approach of Moaniani Street at the Ka Uka Boulevard intersection is expected to service a total 469 vehicles during the AM peak hour of traffic with the left-turn and right-turn movements operating at LOS "D" and LOS "A", respectively. Similarly, during the PM peak hour of traffic, the northbound approach of Moaniani Street at the Ka Uka Boulevard intersection is expected to service 778 vehicles with the left-turn and right-turn movements operating at LOS "F" and LOS "A" conditions, respectively.

The southbound off-ramp at the Ka Uka Boulevard and Moaniani Street intersection is expected to service 471 vehicles during the AM peak hour of traffic with the approach operating at LOS "C".

During the PM peak hour of traffic, the southbound off-ramp at the Ka Uka Boulevard and Moaniani Street intersection is expected to service 693 vehicles with the approach operating at LOS "E".

e. Ka Uka Boulevard at Commercial Driveway

The westbound and eastbound approaches of Ka Uka Boulevard at the intersection with the commercial driveway is expected to service a total of 707 vehicles and 1,040 vehicles during the AM peak hour of traffic, respectively. The westbound left-turn movement is expected to operate at LOS "B". During the PM peak hour of traffic, the westbound approach is expected to service 1,262 vehicles while the eastbound approach services 875 vehicles. The westbound left-turn movement would operate at LOS "B".

The northbound approach of the driveway at the Ka Uka Boulevard intersection is expected to service 32 vehicles and 170 vehicles during the AM and PM peak hours of traffic, respectively, and operate at LOS "B" conditions during both projected peak hours.

f. Ka Uka Boulevard at Ukee Street (east)

At the intersection with Ukee Street (east), the westbound approach of Ka Uka Boulevard is expected to service 611 vehicles during the AM peak hour of traffic with the left-turn movement operating at LOS "A". During the PM peak hour of traffic, the westbound Ka Uka Boulevard approach is expected to service a total of 1,145 vehicles with the left-turn movement operating at LOS "A" conditions.

The eastbound approach of Ka Uka Boulevard at the intersection with Ukee Street (east) is expected to service a total of 1,082 vehicles during the AM peak hour of traffic with the left-turn movement operating at LOS "A". During the PM peak hour of traffic, the eastbound approach would service a total of 831 vehicles with the left-turn movement operating at LOS "A" conditions.

The northbound approach of Ukee Street (east) at the Ka Uka Boulevard intersection is expected to service a total 77 vehicles during the AM peak hour of traffic and operate at LOS "B". During the PM peak hour of traffic, the northbound approach of Ukee Street (east) at Ka Uka Boulevard is expected to service 195 vehicles and operate at LOS "B". The southbound approach of Ukee Street (east) at the Ka Uka Boulevard intersection would service 20 vehicles during the AM peak hour and operate at LOS "B", while the southbound approach services 70 vehicles during the PM peak hour of traffic and operate at LOS "B".

g. Ka Uka Boulevard at Waipio Uka Street

At the intersection with Waipio Uka Street, the westbound approach of Ka Uka Boulevard is expected to service 493 vehicles during the AM peak hour of traffic with the left-turn, through, and right-turn movements all operating at LOS "A". During the PM peak hour of traffic, the westbound Ka Uka Boulevard approach would service a total of 1,151 vehicles with the left-turn, through, and right-turn movements also operating at LOS "A" conditions.

The eastbound approach of Ka Uka Boulevard at the intersection with Waipio Uka Street is expected to service a total of 1,106 vehicles and 830 vehicles during the projected AM and PM peak hour of traffic, respectively. During both peak periods, all traffic movement on the eastbound approach of Ka Uka Boulevard at the Waipio Uka Street intersection would operate at LOS "A" conditions.

The northbound approach of Waipio Uka Street at the Ka Uka Boulevard intersection is expected to service a total of 204 vehicles during the AM peak hour of traffic and would operate at LOS "B". During the PM peak hour of traffic, the northbound approach of Waipio Uka Street at Ka Uka Boulevard is expected to service 205 vehicles and also would operate at LOS "B" conditions. The southbound approach of Waipio Uka Street at the Ka Uka Boulevard intersection is expected to service 74 vehicles during the AM peak hour and operate at LOS "B", while the southbound approach is expected to service 162 vehicles during the PM peak hour of traffic and would also operate at LOS "B" conditions.

h. Ka Uka Boulevard at Ukee Street (west)

At the intersection with Ukee Street (west), the westbound approach of Ka Uka Boulevard is expected to service 516 vehicles during the AM peak hour of traffic with the left-turn movement operating at LOS "C" and the shared through/right-turn movements operating at LOS B". During the PM peak hour of traffic, the westbound Ka Uka Boulevard approach is expected to service a total of 1,171 vehicles with the left-turn movement operating at LOS "C" and the shared through and right-turn movements operating at LOS "B" conditions.

The eastbound approach of Ka Uka Boulevard at the intersection with Ukee Street (west) is expected to service a total of 926 vehicles during the AM peak hour of traffic with the left-turn movement operating at LOS "D" and the shared through/right-turn movement operating at LOS "B" conditions. During the PM peak hour of traffic, the eastbound approach is expected to service a total of 796 vehicles with the left-turn movement operating at LOS "D" conditions while the shared through/right-turn movements would operate at LOS "C".

The northbound approach of Ukee Street (west) at the Ka Uka Boulevard intersection is expected to service a total 409 vehicles during the AM peak hour of traffic and would operate at LOS "C". During the PM peak hour of traffic, the northbound approach of Ukee Street (west) at Ka Uka Boulevard is expected to service 341 vehicles and would operate at LOS "C". The southbound approach of Ukee

Street (west) at the Ka Uka Boulevard intersection is expected to service 17 vehicles during the AM peak hour and operates at LOS “B”, while the southbound approach is expected to service 141 vehicles during the PM peak hour of traffic and also would operate at LOS “B”.

i. Ka Uka Boulevard at Kamehameha Highway

At the intersection with Ka Uka Boulevard and the Kamehameha Highway, the westbound approach of Ka Uka Boulevard is expected to service 466 vehicles during the AM peak hour of traffic with the shared left-turn/through movements operating at LOS “C” and the right-turn movement operating at LOS “B”. During the PM peak hour of traffic, the westbound Ka Uka Boulevard approach is expected to service a total of 1,243 vehicles with the shared left-turn/through movements operating at LOS “D” and the right-turn movement operating at LOS “B” conditions. The eastbound approach of Ka Uka Boulevard at the intersection with Kamehameha Highway is expected to service a total of 44 vehicles during the AM peak hour of traffic resulting in LOS “D” conditions for both the individual eastbound left-turn and shared through/right-turn traffic movements, respectively. During the PM peak hour of traffic, the eastbound approach is expected to service 114 vehicles with all of the individual movements generally operating at LOS “D” conditions.

The northbound approach of Kamehameha Highway at the Ka Uka Boulevard intersection is expected to service a total 700 vehicles during the AM peak hour of traffic with the left-turn movement operating at LOS “D”, and the through and right-turn movements both operating at LOS “C” conditions. During the PM peak hour of traffic, the northbound approach of Kamehameha Highway at the Ka Uka Boulevard intersection is expected to service a total of 1,245 vehicles with the left-turn movement operating at LOS “D”, and the through movement and right-turn movement operating at LOS “C” conditions.

The southbound approach of Kamehameha Highway at the Ka Uka Boulevard intersection is expected to service 1,601 vehicles during the AM peak hour of traffic with the left-turn movement operating at LOS "C" conditions while the through and right-turn movements both would operate at LOS "B" or better. During the PM peak hour of traffic, the southbound approach of Kamehameha Highway at the Ka Uka Boulevard intersection is expected to service 1.003 vehicles with the left-turn movement operating at LOS "D", and the through and right-turn movements operating at LOS "B" conditions.

j. Kamehameha Highway at Waipio Uka Street

At the intersection with Kamehameha Highway, the westbound approach of Waipio Uka Street is expected to service 618 vehicles during the AM peak hour of traffic with the left-turn movement operating at LOS "C" while the shared through/right-turn traffic movements would operate at LOS "B" conditions. During the PM peak hour of traffic, the westbound Waipio Uka Street approach is expected to service a total of 684 vehicles with the left-turn movement operating at LOS "C" and the through and right-turn movements also operate at LOS "C" conditions.

The eastbound approach of Waipio Uka Street at the intersection with Kamehameha Highway is expected to service a total of 14 vehicles during the AM peak hour of traffic resulting in LOS "D" conditions for the left-turn and through movements. During the PM peak hour of traffic, the eastbound approach is expected to service 63 vehicles with the left-turn and through movements also operating at LOS "D" conditions.

The northbound approach of Kamehameha Highway at the Waipio Uka Street intersection is expected to service a total 1,242 vehicles during the AM peak hour of traffic with the left-turn movement operating at LOS "D", and both the through and right-turn movements operating at LOS "B" conditions. During the PM peak hour of traffic, the northbound approach of Kamehameha Highway at the Waipio Uka Boulevard intersection is expected to service 2,107 vehicles with the left-turn movement operating at LOS "D", and the through and right-turn movements operating at LOS "C".

The southbound approach of Kamehameha Highway at the Waipio Uka Boulevard intersection is expected to service 1,117 vehicles during the AM peak hour of traffic with the left-turn movement operating at LOS "D", and the through and right-turn movement operating at LOS "B" conditions. During the PM peak hour of traffic, southbound Kamehameha Highway at the Waipio Uka Street intersection is expected to service 979 vehicles with the left-turn movement operating at LOS "D", and the through and right-turn movements operating at LOS "C" or better conditions.

k. Kamehameha Highway at Lumiaina Street

At the intersection with Kamehameha Highway, the westbound approach of Lumiaina Street is expected to service 174 vehicles during the AM peak hour of traffic with the left-turn and shared through/right-turn movements operating at LOS "D". During the PM peak hour of traffic, the westbound Lumiaina Street approach is expected to service a total of 102 vehicles with the left-turn, through, and right-turn movements also operating at LOS "D" conditions.

The eastbound approach of Lumiaina Street at the intersection with Kamehameha Highway is expected to service 576 vehicles during the AM peak hour of traffic resulting in LOS "D" conditions for the left-turn movements, and LOS "A" conditions for the right-turn movements. During the PM peak hour of traffic, the eastbound approach is expected to service 653 vehicles with the left-turn movement operating at LOS "D" while the right-turn movement operate at LOS "A".

The northbound approach of Kamehameha Highway at the Lumiaina Street intersection is expected to service a total 827 vehicles during the AM peak hour of traffic with the left-turn movement operating at LOS "D", and both the through and right-turn movements operating at LOS "B" conditions. During the PM peak hour of traffic, the northbound approach of Kamehameha Highway at the Lumiaina Street intersection is expected to service 1,868 vehicles with the left-turn movement operating at LOS "D", the through movement operating at LOS "C", and the right-turn movement operating at LOS "B".

The southbound approach of Kamehameha Highway at the Lumiaina Street intersection is expected to service 1,674 vehicles during the AM peak hour of traffic with the left-turn movement operating at LOS "D", the through movement operating at LOS "C", and the right-turn movement operating at LOS "A" conditions. During the PM peak hour of traffic, southbound Kamehameha Highway at the Lumiaina Street intersection is expected to service 1,582 vehicles with the left-turn movement operating at LOS "D", the through movement operating at LOS "C", and the right-turn movement operating at LOS "A" conditions.

l. Kamehameha Highway at Lumiauau Street

At the intersection with Kamehameha Highway, the westbound approach of Lumiauau Street is expected to service 198 vehicles during the AM peak hour of traffic with both the left-turn and shared through/right-turn movements operating at LOS "C" conditions. During the PM peak hour of traffic, the westbound Lumiaina Street approach is expected to service a total of 80 vehicles with the left-turn operating at LOD "D", and the shared through/right-turn movements operating at LOS "C", conditions.

The eastbound approach of Lumiauau Street at the intersection with Kamehameha Highway is expected to service 444 vehicles during the AM peak hour of traffic resulting in LOS "C" conditions for the shared left-turn/through movements, and also LOS "C" conditions for the right-turn movement. During the PM peak hour of traffic, the eastbound approach is expected to service 96 vehicles with the shared left-turn/through movements operating at LOS "C" while the right-turn movement also operating at LOS "C". The northbound approach of Kamehameha Highway at the Lumiauau Street intersection is expected to service a total 786 vehicles during the AM peak hour of traffic with the left-turn movement operating at LOS "D", and both the through and right-turn movements operating at LOS "B" or better conditions. During the PM peak hour of traffic, the northbound approach of Kamehameha Highway at the Lumiauau Street intersection is expected to service 2,177 vehicles with the left-turn movement operating at LOS "C", and the through and right-turn movements operating at LOS "A".

The southbound approach of Kamehameha Highway at the Lumiauau Street intersection is expected to service 1,268 vehicles during the AM peak hour of traffic with the left-turn movement operating at LOS "D", the through movement operating at LOS "B", and the right-turn movement operating at LOS "A" conditions. During the PM peak hour of traffic, southbound Kamehameha Highway at the Lumiauau Street intersection is expected to service 1075 vehicles with the left-turn movement operating at LOS "D", the through movement operating at LOS "B", and the right-turn movement operating at LOS "A" conditions.

m. Kamehameha Highway at Waipahu Street

At the intersection with Kamehameha Highway, the eastbound approach of Waipahu Street is expected to service 732 vehicles during the AM peak hour of traffic with both the left-turn and right-turn movements operating at LOS "C and LOS "D", respectively. During the PM peak hour of traffic, the eastbound Waipahu Street approach is expected to service a total of 697 vehicles with the left-turn and right-turn movements operating at LOS "D" and LOS "C", respectively.

The northbound approach of Kamehameha Highway at the Waipahu Street intersection is expected to service a total 810 vehicles during the AM peak hour of traffic with the left-turn movement operating at LOS "D", and the through movement operating at LOS "A" conditions. During the PM peak hour of traffic, the northbound approach of Kamehameha Highway at the Waipahu Street intersection is expected to service 2,232 vehicles with the left-turn movement also operating at LOS "D" and the through movement operating at LOS "B".

The southbound approach of Kamehameha Highway at the Waipahu Street intersection is expected to service 1,766 vehicles during the AM peak hour of traffic with the through movement operating at LOS "C" and the right-turn movement operating at LOS "B" conditions. During the PM peak hour of traffic, southbound Kamehameha Highway at the Waipahu Street intersection is expected to service 1,170 vehicles with the through movement operating at LOS "C" and the right-turn movement operating at LOS "B" conditions.

n. Interstate H-2 Freeway Segments

During the projected Year 2016 AM peak hour of traffic without the proposed project, the Interstate H-2 Freeway south of the Waipio Interchange would carry 3,574 vehicles northbound and 5,989 vehicles southbound. The northbound and southbound freeway segments along H-2 south of the Waipio Interchange would operate at LOS "B" and LOS "C" during the projected Year 2016 AM peak hour of traffic without the proposed project. Simulation modeling of traffic operations for this freeway segment resulted in no significant queuing. However, queuing further south as a result of spillback conditions from the Waiawa Interchange is expected to continue and is further discussed in later section of this report. No vehicular queuing is expected in the northbound direction during the projected Year 2016 AM peak hour of traffic.

North of the Waipio Interchange, the Interstate H-2 Freeway would carry approximately 2,790 vehicles northbound and 4,004 vehicles southbound during the projected morning peak hours of traffic and would both operate at LOS "B". Simulation modeling of traffic operations for this freeway segment resulted in no significant queuing during the projected morning peak periods.

During the PM peak hours of traffic, the Interstate H-2 Freeway south of the Waipio Interchange would carry 6,712 vehicles northbound and 4,678 vehicles southbound. The northbound and southbound Interstate H-2 Freeway segments south of the Waipio Interchange would operate at LOS "D" and LOS "C" during the projected Year 2016 PM peak hours of traffic without the project. No significant queuing is expected along this freeway segment during the projected Year 2016 PM peak hours of traffic without the proposed project.

North of the Waipio Interchange, the Interstate H-2 Freeway is expected to carry approximately 4,332 vehicles northbound and 3,091 vehicles during the PM peak hours of traffic. This freeway segment is expected to operate at LOS "C" and LOS "B" for the northbound and southbound directions, respectively, during the PM peak hours of traffic. No significant queuing is expected along this freeway segment during the projected Year 2016 PM peak hours of traffic.

Further discussion on freeway segment operations and travel times during the morning and afternoon commute periods are presented in Section V of this report.

o. Waipio Interchange Ramp Merge/Diverge Operations

During projected Year 2016 AM peak hour traffic operations, the Interstate H-2 Freeway northbound off-ramp at the Waipio Interchange would operate at LOS "A", an improvement from existing conditions with the implementation of the committed loop on-ramp identified in earlier sections of this document. The existing configuration of the northbound on-ramp to service westbound Ka Uka Boulevard traffic east of the interchange destined to areas north via the northbound Interstate H-2 Freeway would continue to operate at LOS "B" conditions. The southbound loop on-ramp would operate at LOS "C" during the projected Year 2016 without the project while the existing southbound on-ramp accommodating eastbound Ka Uka Boulevard destined to areas south via the Interstate H-2 Freeway would continue to operate at LOS "C" during the project Year 2016 AM peak hours of traffic without the project. The southbound off-ramp would continue to operate at LOS "C" conditions during the same period. With the committed improvement to extend the northbound off-ramp capacity, merge and diverge conditions at all of the ramps would operate well with no anticipated queuing at the ramp and freeway interfaces.

During the existing PM peak hour of traffic, the northbound off-ramp at the Waipio Interchange would operate at LOS "D" with occasional queuing anticipated at the ramp junction. However, diverge conditions would operate well with no anticipated queuing effects on the freeway due to the proposed committed improvement to extend the deceleration lane of the northbound off-ramp as well as the provision for two exclusive right-turn lanes downstream from the ramp and freeway interface. The northbound loop on-ramp would also operate well at LOS "B" during the projected Year 2016 PM peak hour of traffic, while the existing configuration of the northbound on-ramp serving westbound traffic from areas east of the freeway also operate at LOS B" conditions.

The southbound loop on-ramp and existing southbound on-ramp configuration would both operate at LOS "C", while the southbound off-ramp operate at LOS "B" during the projected Year 2016 PM peak hour of traffic. Based on modeling and traffic simulations, the merge and diverge operations are not expected to result in queuing on to the freeway.

Table 2.1 summarizes the freeway segments and ramp operations along the Interstate H-2 Freeway and at the Waipio Interchange for Year 2016 without project conditions.

Table 2.1: Summary of Year 2016 (without project) Interstate H-2 Freeway Segment and Ramp LOS Operations

Freeway Segment/ Interchange Ramp	AM Peak		PM Peak	
	Exist	2016 w/o proj	Exist	2016 w/o proj
NB segment south of Waipio Interchange	B	B	C	D
NB segment north of Waipio Interchange	A	B	B	C
SB segment south of Waipio Interchange	C	C	B	C
SB segment north of Waipio Interchange	B	B	B	B
NB Off-ramp	B	A*	C	D
NB On-ramp	B	B	B	B

* LOS Improvement as a result of secondary effects from other committed improvements

Table 2.1: Summary of Year 2016 (without project) Interstate H-2 Freeway Segment and Ramp LOS Operations (Cont'd)

Freeway Segment/ Interchange Ramp	AM Peak		PM Peak	
	Exist	2016 w/o proj	Exist	2016 w/o proj
NB Loop On-ramp	-	A	-	B
SB On-ramp	C	C	B	C
SB Loop On-Ramp	-	C	-	C
SB Off-ramp	C	C	B	B

* LOS Improvement as a result of secondary effects from other committed improvements

D. Koa Ridge Makai and Waiawa Year 2016 Site-Generated Traffic

1. Trip Generation Methodology

The trip generation methodology used in this study is based upon generally accepted techniques developed by the Institute of Transportation Engineers (ITE) and published in "Trip Generation, 7th Edition," 2003. The ITE trip generation rates are developed empirically by correlating the vehicle trip generation data with various land use characteristics such as the number of vehicle trips generated per dwelling unit or 1,000 square feet of development.

In consideration of the Koa Ridge project's plans which advocate mixed use, compact development, and a pedestrian/transit emphasis, a separate assessment was undertaken to evaluate potential reductions in vehicle trip generation (*Castle & Cooke Koa Ridge Makai and Waiawa Project, Alternative Transportation Components,* prepared by Weslin Consulting Services, Inc., November 2008). The study notes that the ITE trip generation rates, based on vehicle-oriented, single land use projects, can be reduced for multi-land use projects and those projects with good pedestrian-bicycle facilities and access to public transportation. Accordingly, based on the Koa Ridge project's more progressive land use plan and characteristics, adjustments were made to the ITE rates. Internal capture refers to trips that have both their origin and destination within the project. The Weslin study notes that the Koa Ridge and Waiawa projects have a very balanced mix of land uses, resulting in a calculated 24% to 28% reduction during peak periods. Pass-by trips (1% to 4% during the peak hour) are for those trips that are assumed to pass-by or be diverted into and out of a commercial use such as a restaurant or retail store. Bus transit trip reductions are estimated at 8%. Pedestrian and bicycle trips are 3%. Transportation Demand Management (TDM) techniques which include subsidized transit passes, flexible work schedules, car sharing and carpooling programs are estimated to yield a 16% reduction in trips. The total trip reductions amount to 56% during peak periods.

Although the Weslin study provides a good rationale for the reductions, some of the specific components, such as bus transit routes and TDM strategies, have yet to be specifically determined for the project. The methodology, analysis, and supporting justification are included in the Weslin report and provided in Appendix F. For the purpose of this report, however, a more conservative assumption of 30% total reduction of site-generated trips was assumed for the traffic analysis. Tables 3 and 4 summarize the net project site trip generation characteristics applied to the Year 2016 AM and PM peak hours of traffic.

Table 3: Koa Ridge Makai Peak Hour Trip Generation (External Trips Only)

YEAR 2016		
SINGLE-FAMILY DETACHED HOUSING INDEPENDENT VARIABLE: # of Dwelling Units = 479		
		PROJECTED TRIP ENDS
AM PEAK	ENTER	63
	EXIT	188
	TOTAL	251
PM PEAK	ENTER	214
	EXIT	125
	TOTAL	339

Table 3: Koa Ridge Makai Peak Hour Trip Generation (Cont'd)
(External Trips Only)

YEAR 2016 (Cont'd)		
MULTI-FAMILY HOUSING (CONDOMINIUM/TOWNHOUSE)		
INDEPENDENT VARIABLE:		# of Dwelling Units = 573
		PROJECTED TRIP ENDS
AM PEAK	ENTER	30
	EXIT	146
	TOTAL	176
PM PEAK	ENTER	140
	EXIT	69
	TOTAL	209
MULTI-FAMILY HOUSING (APARTMENT)		
INDEPENDENT VARIABLE:		# of Dwelling Units = 339
		PROJECTED TRIP ENDS
AM PEAK	ENTER	24
	EXIT	97
	TOTAL	121
PM PEAK	ENTER	96
	EXIT	51
	TOTAL	147
FREE STANDING DISCOUNT STORE		
INDEPENDENT VARIABLE:		1,000 sf of development = 150
		PROJECTED TRIP ENDS
AM PEAK	ENTER	60
	EXIT	28
	TOTAL	88
PM PEAK	ENTER	199
	EXIT	207
	TOTAL	406

Table 3: Koa Ridge Makai Peak Hour Trip Generation (Cont'd)
(External Trips Only)

YEAR 2016 (Cont'd)		
RETAIL (SHOPPING CENTER)		
INDEPENDENT VARIABLE:		1,000 sf of development = 125
		PROJECTED TRIP ENDS
AM PEAK	ENTER	55
	EXIT	35
	TOTAL	90
PM PEAK	ENTER	157
	EXIT	171
	TOTAL	328
ELEMENTARY SCHOOL		
INDEPENDENT VARIABLE:		Students = 875
		PROJECTED TRIP ENDS
AM PEAK	ENTER	40
	EXIT	34
	TOTAL	74
PM PEAK	ENTER	15
	EXIT	19
	TOTAL	34
HOSPITAL		
INDEPENDENT VARIABLE:		1,000 sf of development = 109
		PROJECTED TRIP ENDS
AM PEAK	ENTER	62
	EXIT	30
	TOTAL	92
PM PEAK	ENTER	30
	EXIT	60
	TOTAL	90
GENERAL OFFICE BUILDING		
INDEPENDENT VARIABLE:		1,000 sf of development = 10
		PROJECTED TRIP ENDS
AM PEAK	ENTER	10
	EXIT	1
	TOTAL	11
PM PEAK	ENTER	2
	EXIT	9
	TOTAL	11

Table 3: Koa Ridge Makai Peak Hour Trip Generation (Cont'd) (External Trips Only)

YEAR 2016 (Cont'd)		
GENERAL LIGHT INDUSTRIAL INDEPENDENT VARIABLE: 1,000 sf of development = 43		
		PROJECTED TRIP ENDS
AM PEAK	ENTER EXIT TOTAL	24 4 28
PM PEAK	ENTER EXIT TOTAL	3 26 29
YEAR 2016 TOTALS		
		PROJECTED TRIP ENDS
AM PEAK	ENTER EXIT TOTAL	368 563 931
PM PEAK	ENTER EXIT TOTAL	856 737 1593

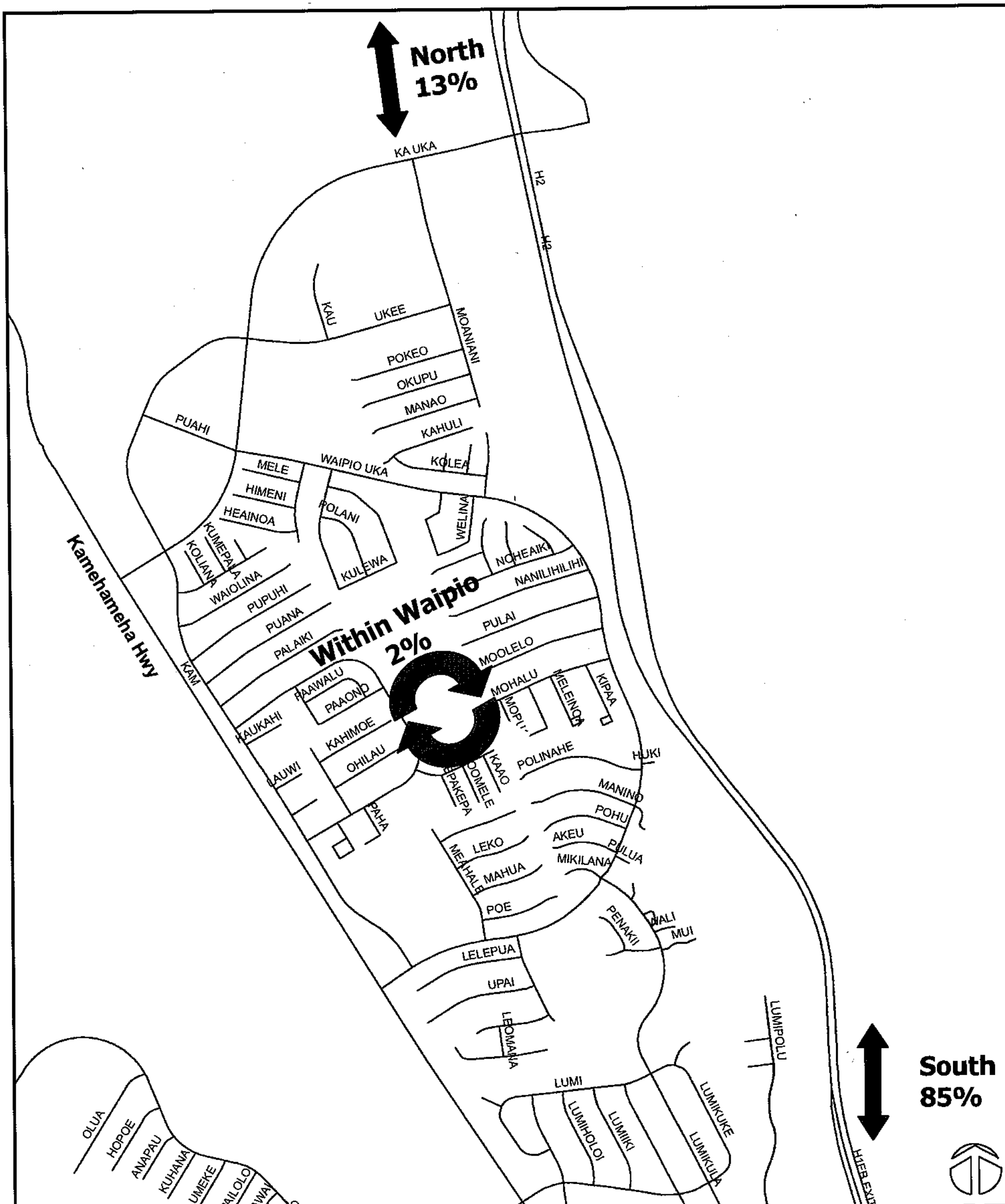
Table 4: Waiawa Peak Hour Trip Generation (External Trips Only)

YEAR 2016		
MULTI-FAMILY HOUSING (CONDOMINIUM/TOWNHOUSE) INDEPENDENT VARIABLE: # of Dwelling Units = 200		
		PROJECTED TRIP ENDS
AM PEAK	ENTER EXIT TOTAL	10 51 61
PM PEAK	ENTER EXIT TOTAL	49 24 73

2. Trip Distribution

a. General

Figure 12.1 shows the percent distribution of population and activity centers based on state census information used for the trip distribution in this report. Figures 12.2 and 12.3 show the north-south



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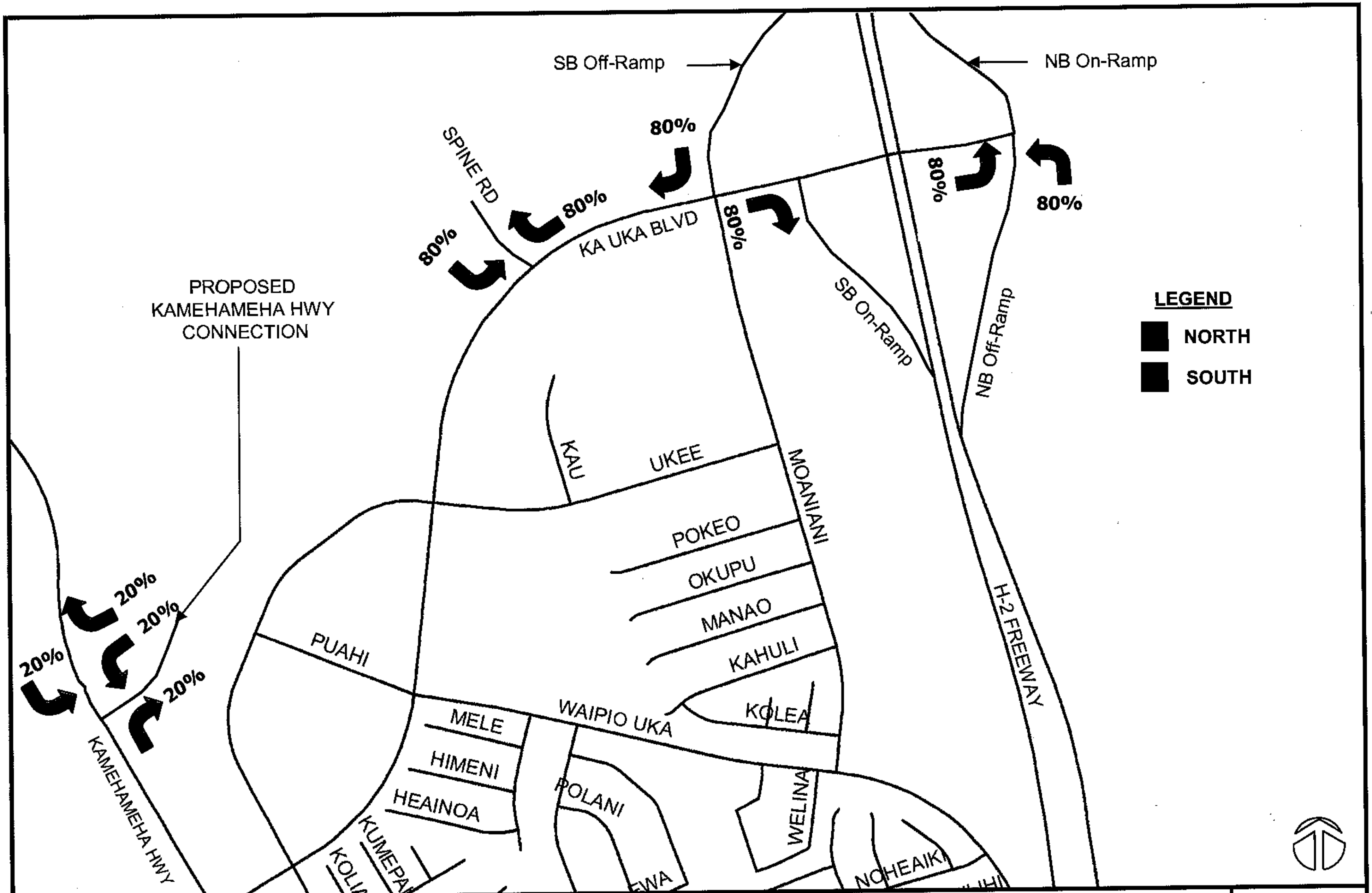
KOA RIDGE MAKAI AND WAIAWA

DISTRIBUTION OF POPULATION AND ACTIVITY CENTERS

FIGURE 12.1



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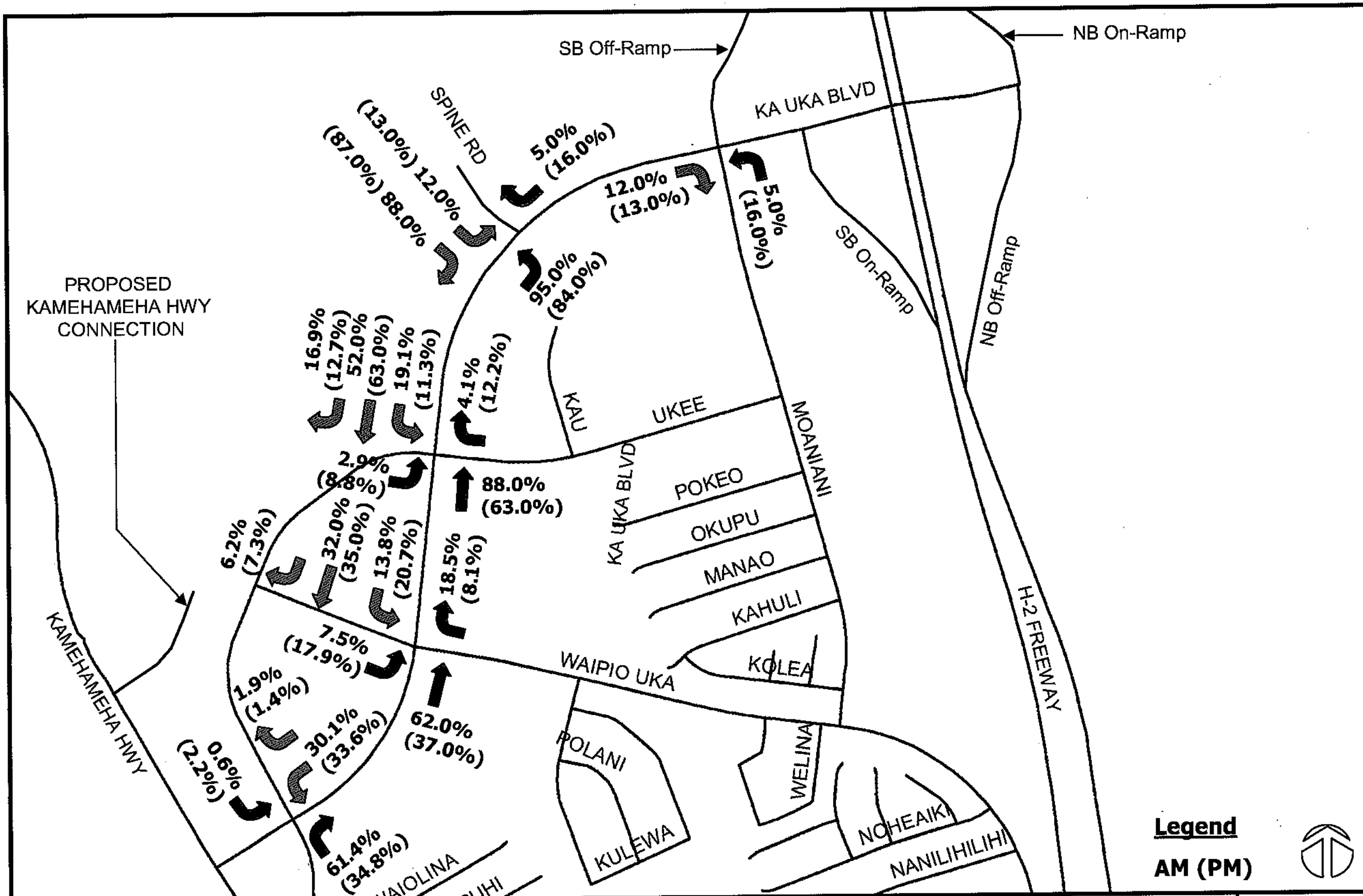
KOA RIDGE MAKAI AND WAIAWA

TRIP DISTRIBUTION – NORTH & SOUTH
KOA RIDGE MAKAI

FIGURE 12.2



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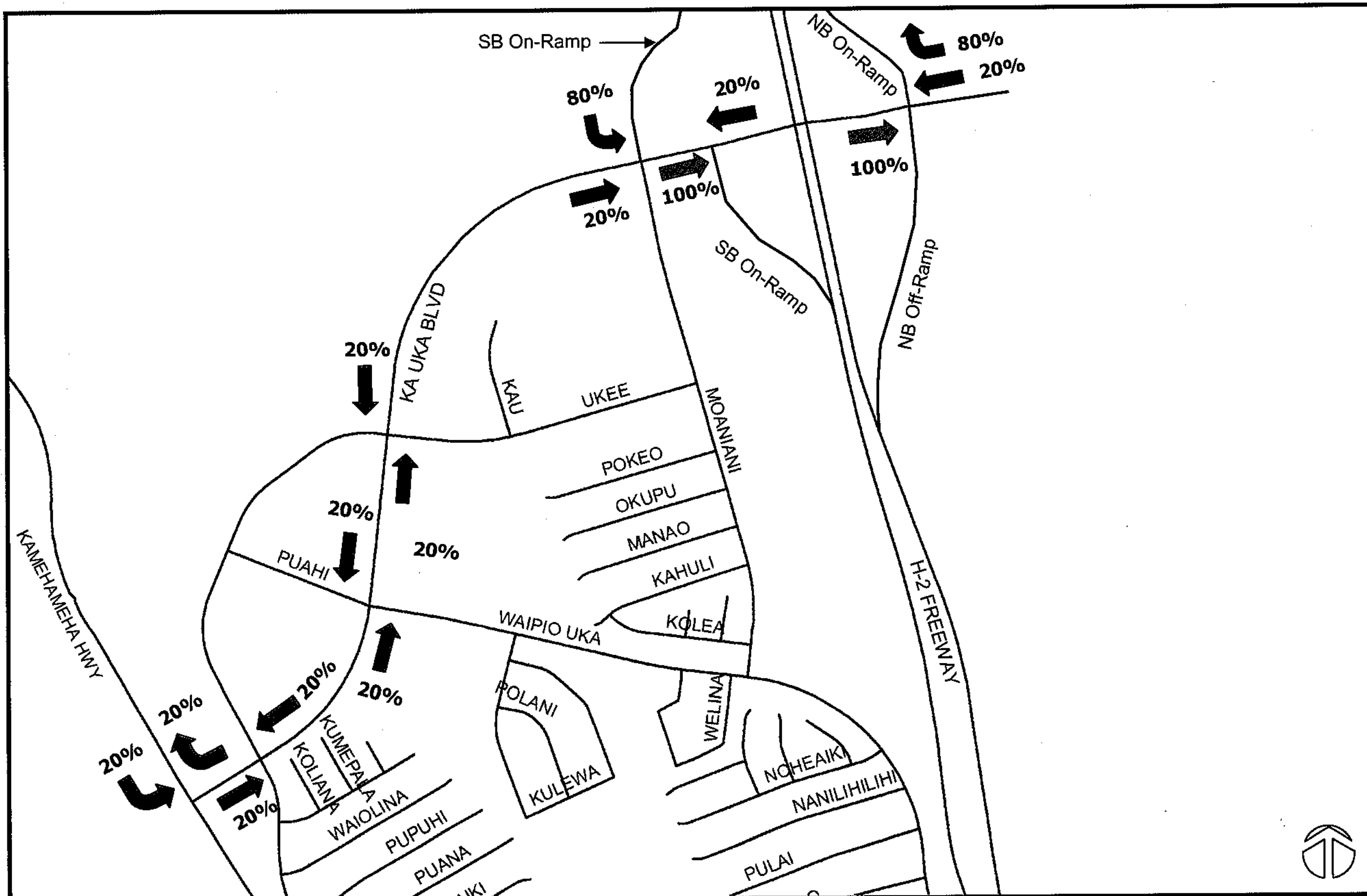
KOA RIDGE MAKAI AND WAIAWA

TRIP DISTRIBUTION – WITHIN WAIPIO
KOA RIDGE MAKAI

FIGURE
12.3

distribution and localized distribution of site-generated traffic for Koa Ridge Makai, respectively. The north-south distribution is based on the relative distribution of traffic between the two major arterials of Kamehameha Highway and the Interstate H-2 Freeway located within the north-south corridor of the region, and the localized distribution is based of traffic distribution along the collector road Ka Uka Boulevard linking the two primary roadway facilities. Similarly, the north-south and localized distributions for Castle & Cooke's Waiawa development are shown on Figures 12.4, 12.5, and 12.6. These distributions are also based on the relative distribution of traffic between the two primary north-south arterials of Kamehameha Highway and the Interstate H-2 Freeway, and localized distribution along the collector road of Ka Uka Boulevard.

Figures 13 to 16 show the resulting traffic assignments on the surrounding roadways based on AM and PM peak hour distributions of project site-generated traffic at each of the study intersections for the first development phase Year 2016. To accommodate direct access to Kamehameha Highway and reduce point-access concentrated traffic demands, a proposed new project access road connecting to Kamehameha Highway immediately north of the Ka Uka Boulevard intersection is shown on the Figures. Costle & Cooke Homes Hawaii has committed to provide the design and construction of the access road and proposed new intersection along Kamehameha Highway.



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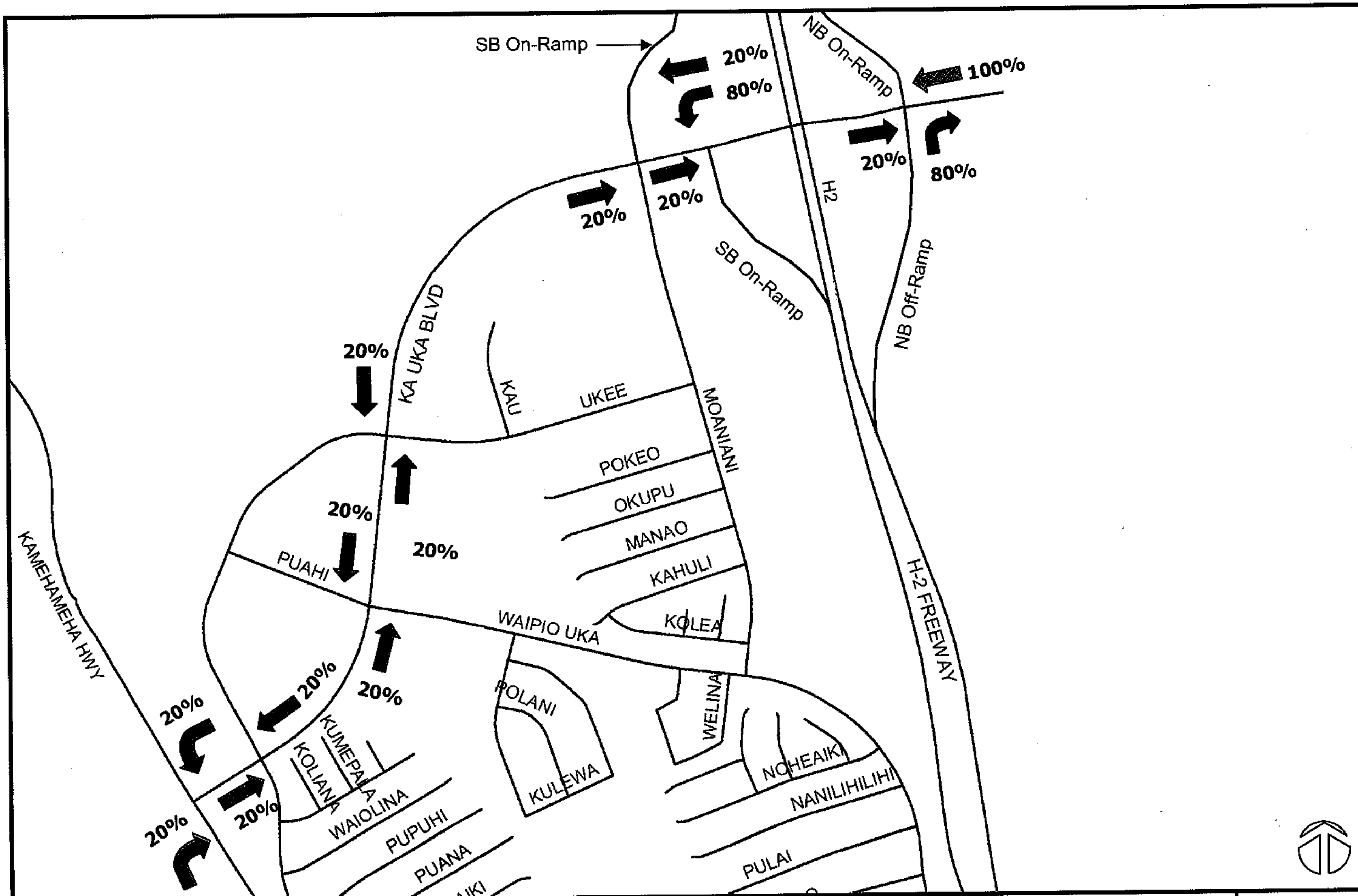
KOA RIDGE MAKAI AND WAIAWA

TRIP DISTRIBUTION – NORTH
WAIAWA

FIGURE
12.4



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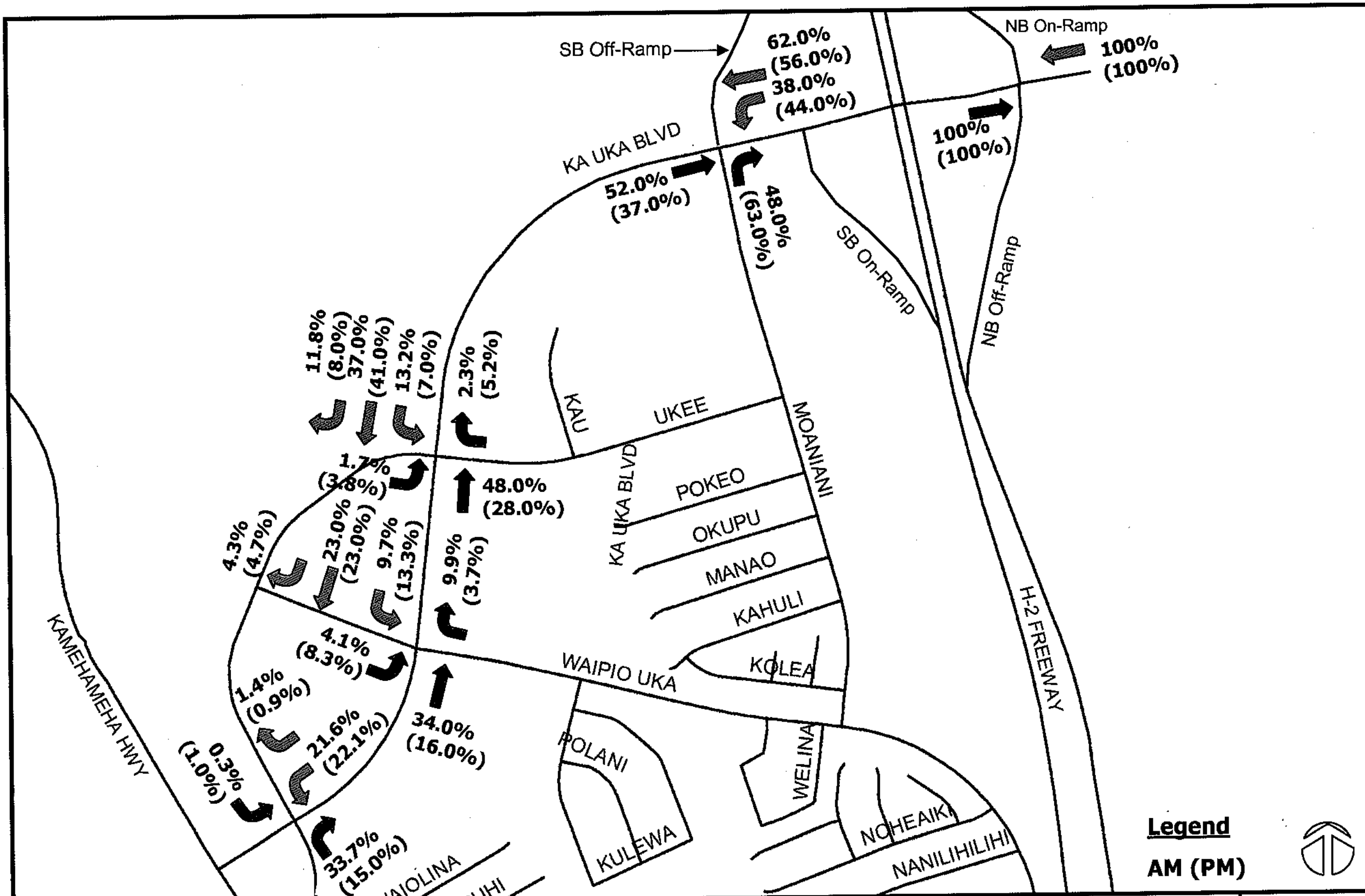
KOA RIDGE MAKAI AND WAIAWA

TRIP DISTRIBUTION – SOUTH
WAIAWA

FIGURE
12.5



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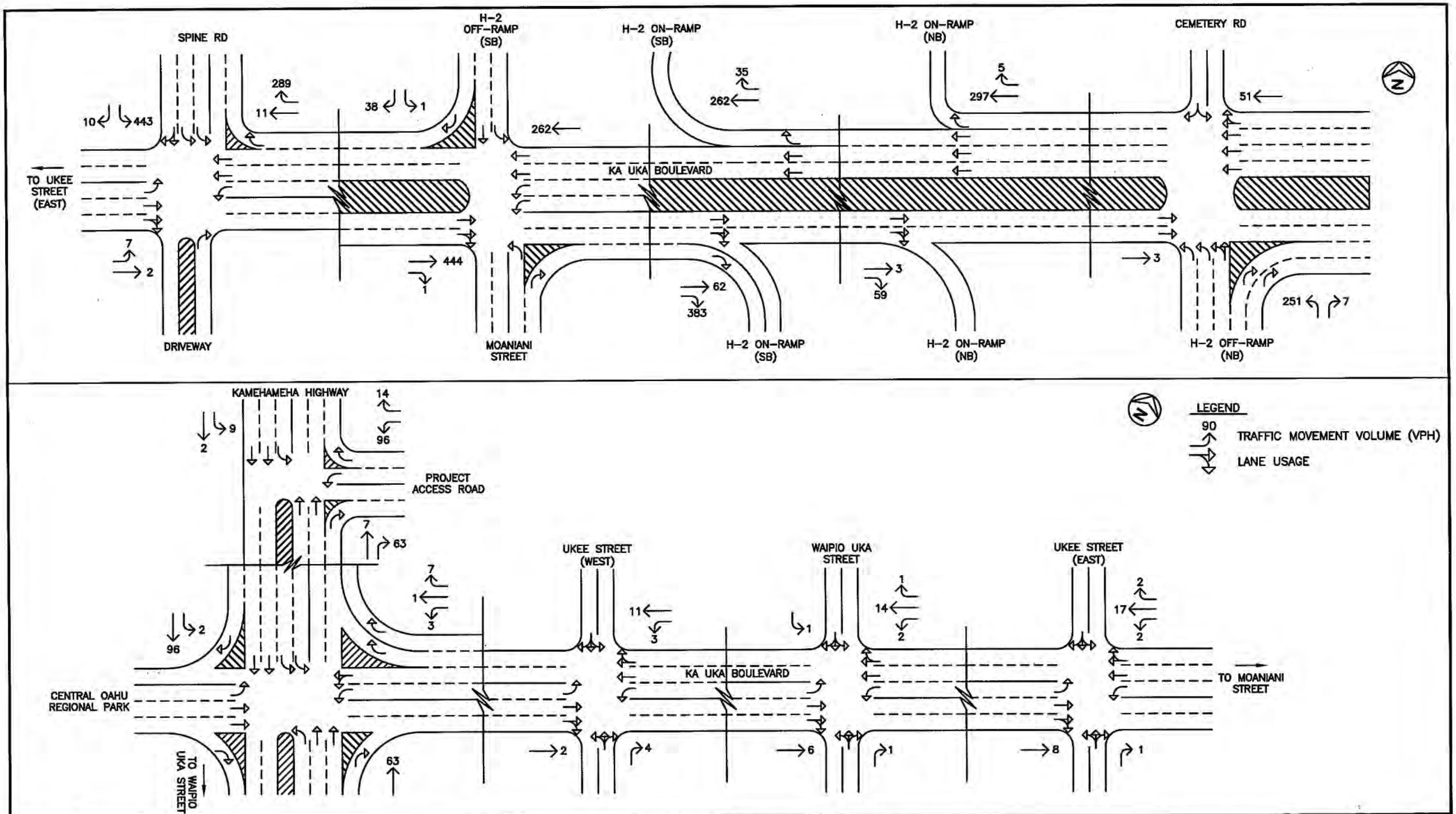
KOA RIDGE MAKAI AND WAIAWA

TRIP DISTRIBUTION – WITHIN WAIPIO
WAIAWA

FIGURE
12.6



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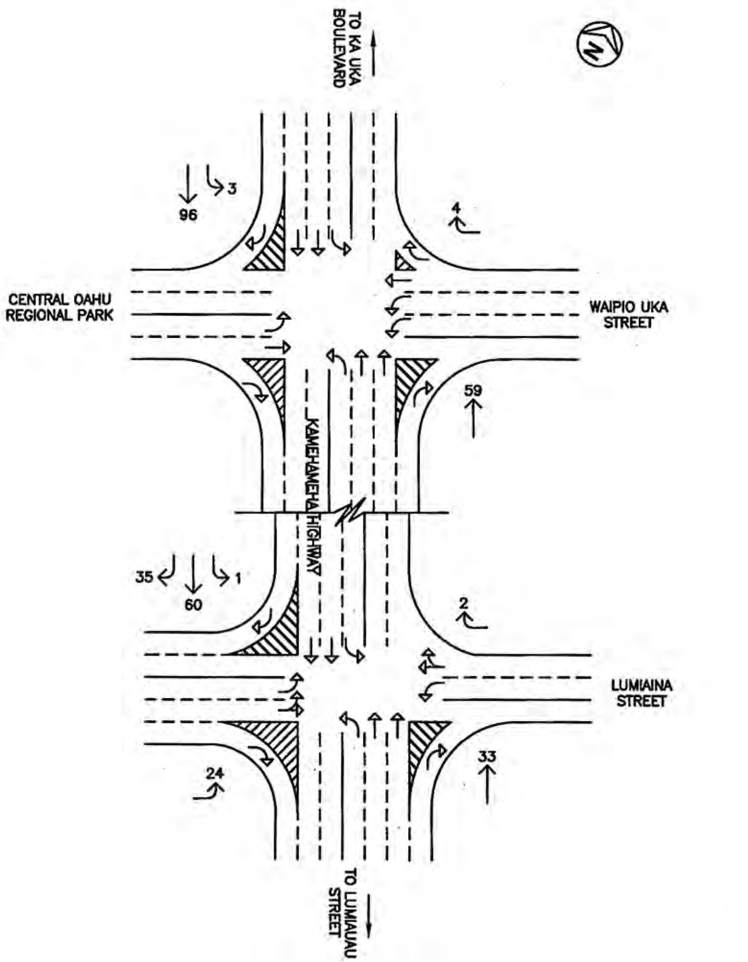
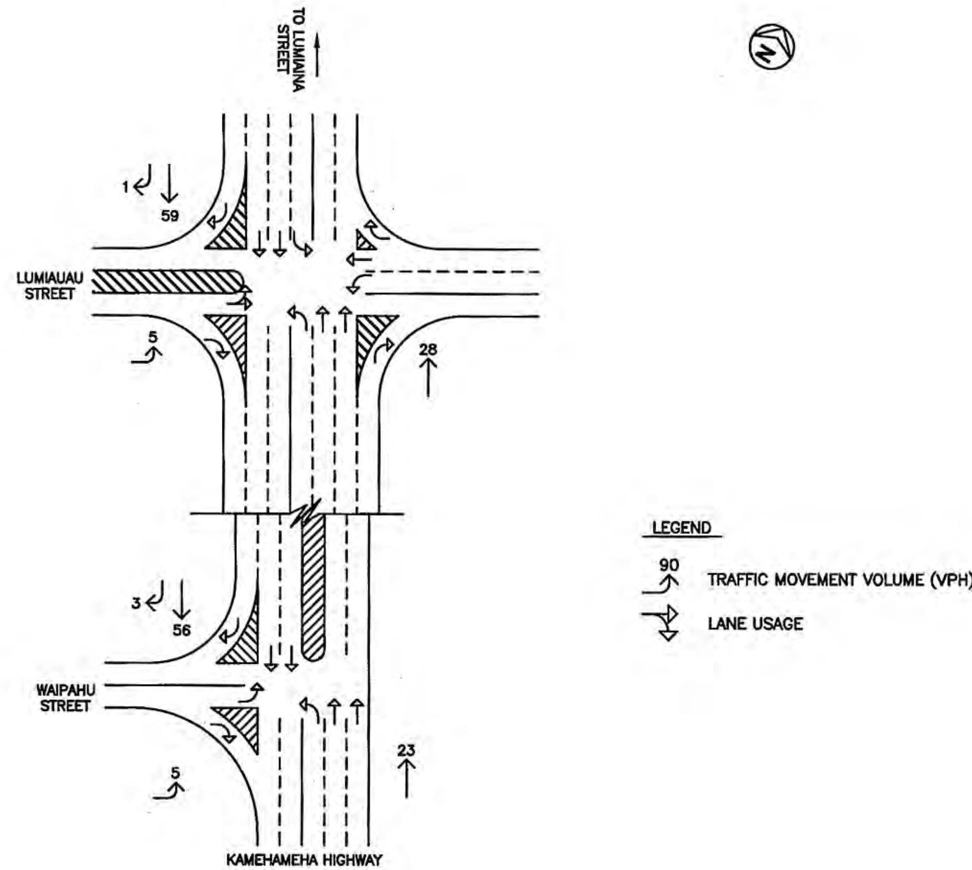
KOA RIDGE MAKAI AND WAIAWA DEVELOPMENT

YEAR 2016 DISTRIBUTION OF SITE - GENERATED VEHICLES
AM PEAK HOUR OF TRAFFIC - KA UKA BOULEVARD

FIGURE 13





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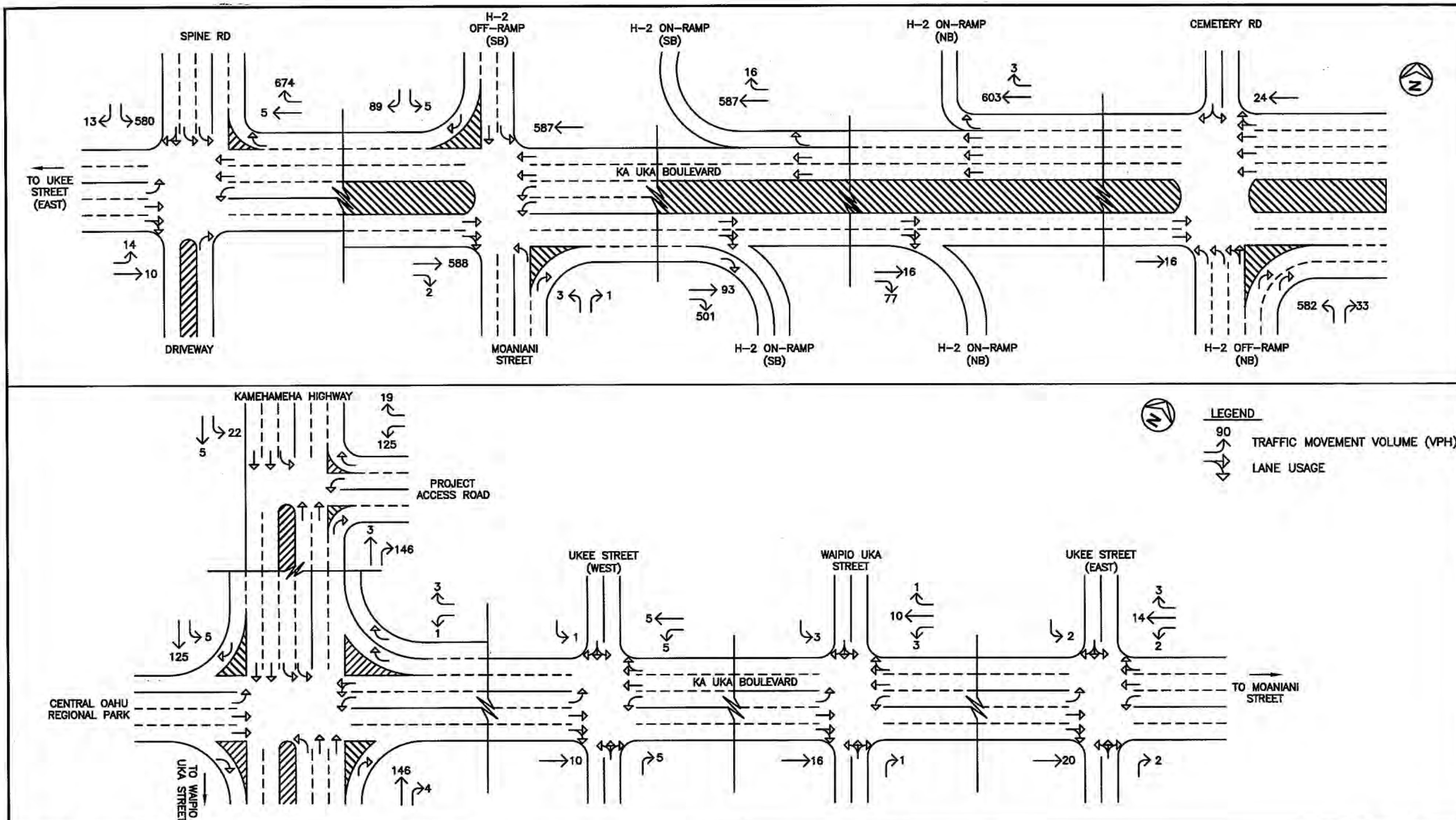
KOA RIDGE MAKAI AND WAIAWA DEVELOPMENT

YEAR 2016 DISTRIBUTION OF SITE - GENERATED VEHICLES
AM PEAK HOUR OF TRAFFIC - KAMEHAMEHA HIGHWAY

FIGURE 14



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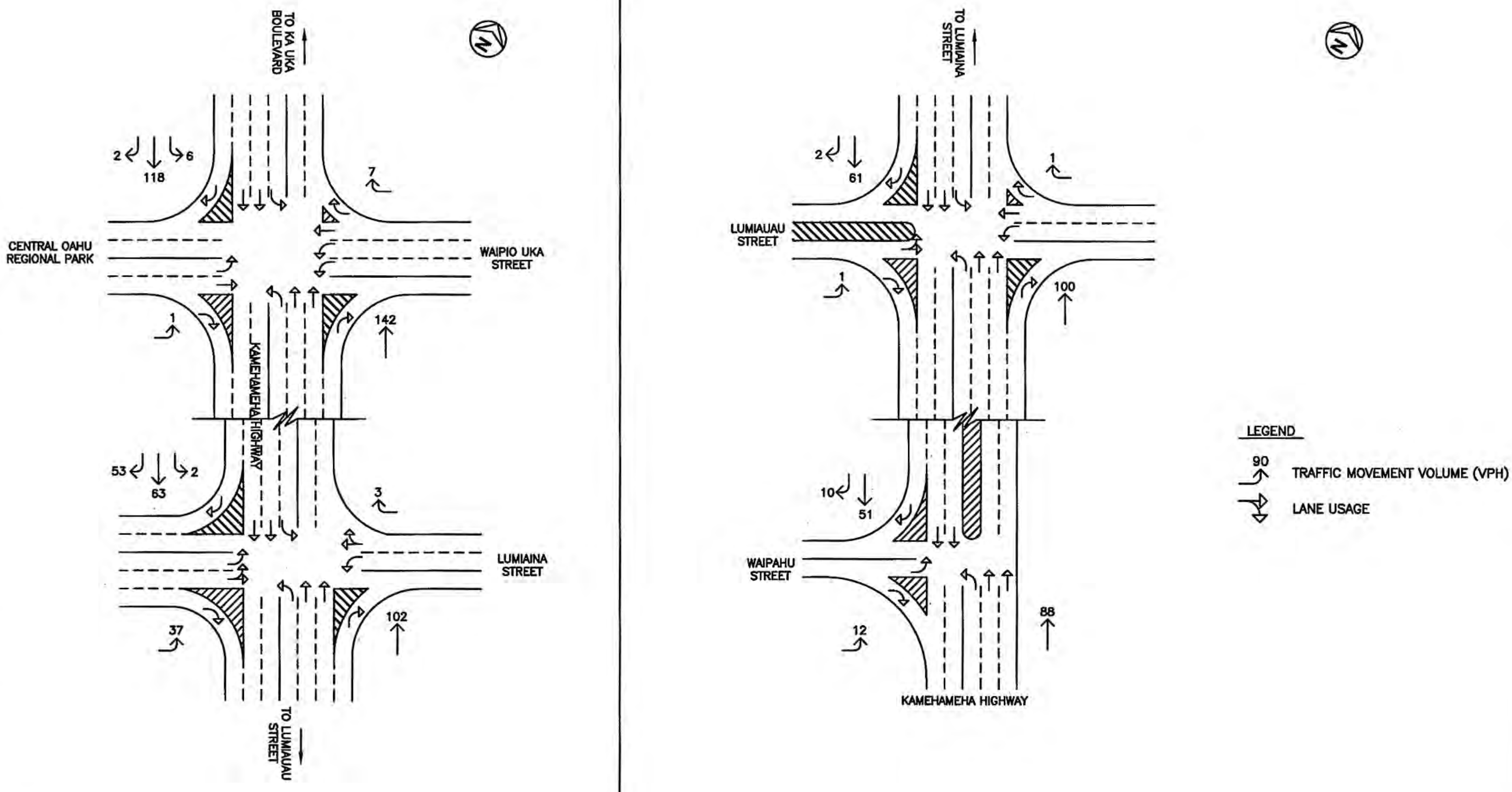
KOA RIDGE MAKAI AND WAIAWA DEVELOPMENT

YEAR 2016 DISTRIBUTION OF SITE - GENERATED VEHICLES
PM PEAK HOUR OF TRAFFIC - KA UKA BOULEVARD

FIGURE
15



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KOA RIDGE MAKAI AND WAIAWA DEVELOPMENT

YEAR 2016 DISTRIBUTION OF SITE - GENERATED VEHICLES
PM PEAK HOUR OF TRAFFIC - KAMEHAMEHA HIGHWAY

FIGURE 16

b. Koa Ridge Makai

During the first phase of development, primary vehicular access to the proposed Koa Ridge Makai development will be provided via a new access road off Kamehameha Highway and an existing access road (referred to as the Spine Road) off Ka Uka Boulevard. The directional distribution of all site-generated vehicles is based upon the distribution of population and activity centers on the island of Oahu. As such, approximately 13% of the vehicles are assumed to be traveling to/from areas to the north, approximately 85% are assumed to be traveling to/from areas to the south, and approximately 2% are assumed to be internal trips traveling to/from areas within Waipio. For those vehicles traveling to/from areas outside of Waipio, the distribution of these vehicles between the two primary accesses is based on the relative distribution between the two north-south roadways in the vicinity, the Interstate H-2 Freeway and Kamehameha Highway. As such, approximately 80% of the vehicles were assumed to utilize the Spine Road to access Ka Uka Boulevard and the Interstate H-2 Freeway while approximately 20% of the vehicles were assumed to utilize the access road along Kamehameha Highway. For internal trips within Waipio, all vehicle trips were assumed to utilize the Spine Road and Ka Uka Boulevard to access Moaniani Street, Ukee Street (East), Waipio Uka Street, or Ukee Street (West). The distribution of traffic between these local roadways was based upon the relative distribution of prevailing turning traffic at each of these roadways.

c. Waiawa

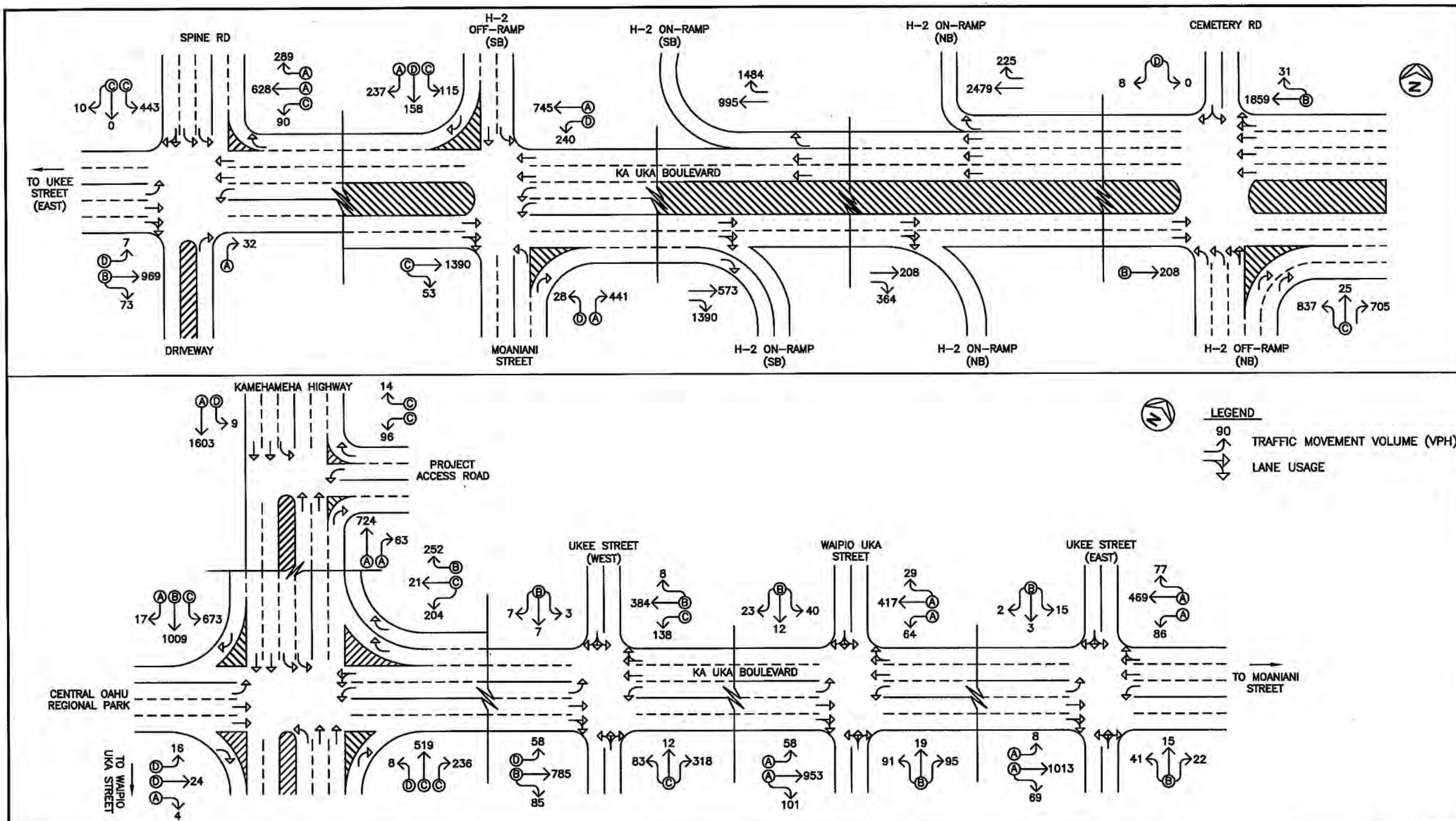
Vehicular access to the proposed Waiawa development will be provided off a Ka Uka Boulevard eastward extension. The directional distribution of all site-generated vehicles is based upon the distribution of population and activity centers on the island of Oahu. As such, approximately 13% of the vehicles are assumed to be traveling to/from areas to the north, approximately 85% are assumed to be traveling to/from areas to the south, and approximately 2% are assumed to be internal trips traveling to/from areas within Waipio. All vehicles traveling to/from areas outside of Waipio were distributed between the two north-south roadways in the vicinity, the Interstate H-2 Freeway and Kamehameha Highway, based upon the relative distribution of traffic between those two roadways. As such, approximately 80% of the vehicles were assumed to utilize the Interstate H-2 Freeway while approximately 20% of the vehicles were assumed to access Kamehameha Highway via Ka Uka Boulevard. For internal trips within Waipio, all vehicles were assumed to utilize Ka Uka Boulevard to access Moaniani Street, Ukee Street (East), Waipio Uka Street, or Ukee Street (West). The distribution of traffic between these local roadways was based upon the relative distribution of turning traffic at each of these roadways.

E. Year 2016 Traffic Projections With Koa Ridge Makai and Waiawa Developments

1. General

The cumulative Year 2016 AM and PM peak hour traffic conditions resulting from the projected external traffic, ambient growth, other developments in the region, and the Koa Ridge Makai and Waiawa developments are shown in Figures 18 to 21, and summarized in Table 5. The projected Year 2016 operating conditions without the proposed developments are provided for comparison purposes. The LOS calculations are included in Appendix G.

Figure 17 - Intentionally Left Blank



KOA RIDGE MAKAI AND WAIAWA DEVELOPMENT

YEAR 2016 AM PEAK HOUR OF TRAFFIC WITH PROJECT
KA UKA BOULEVARD

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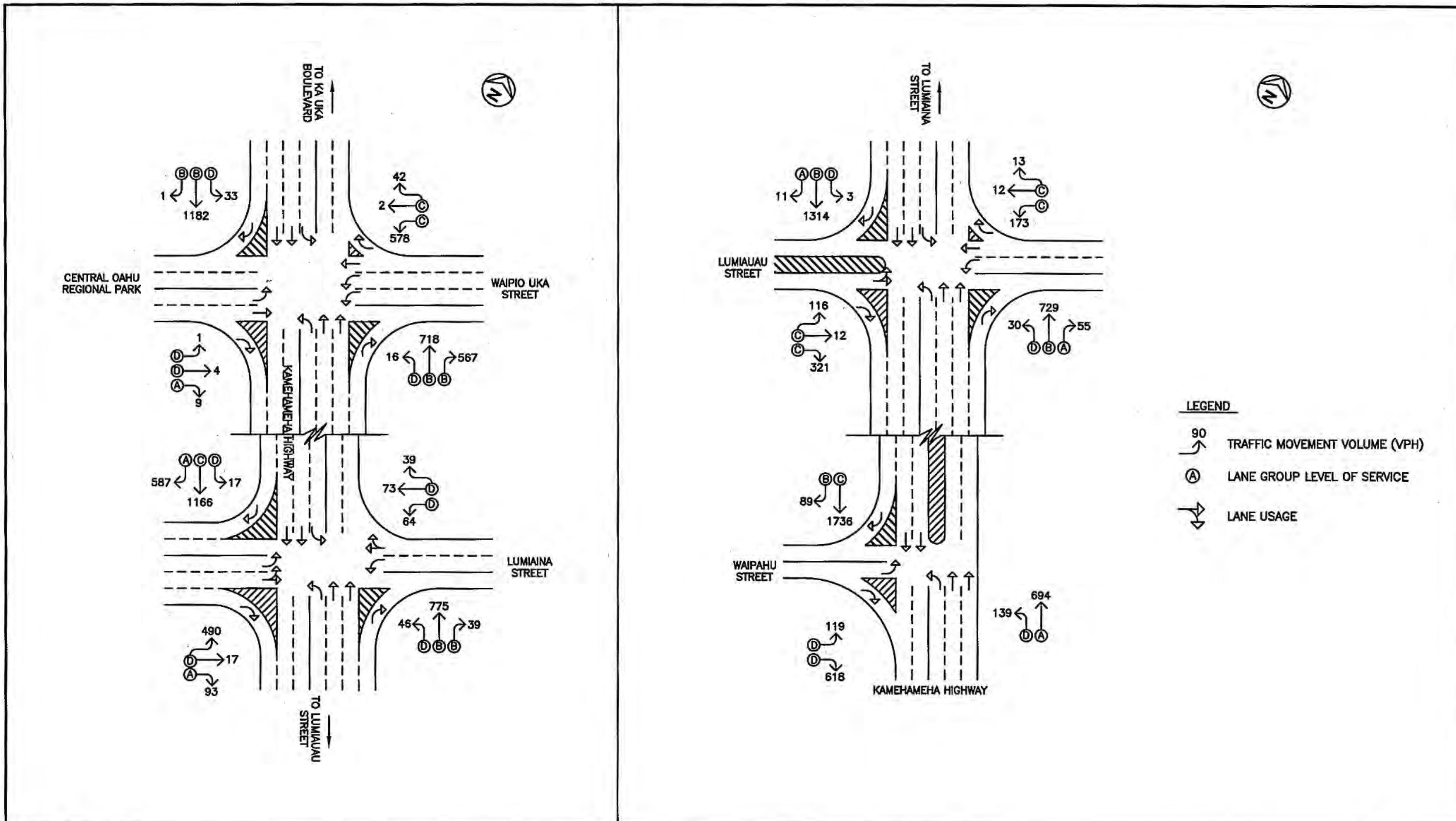
FIGURE
18



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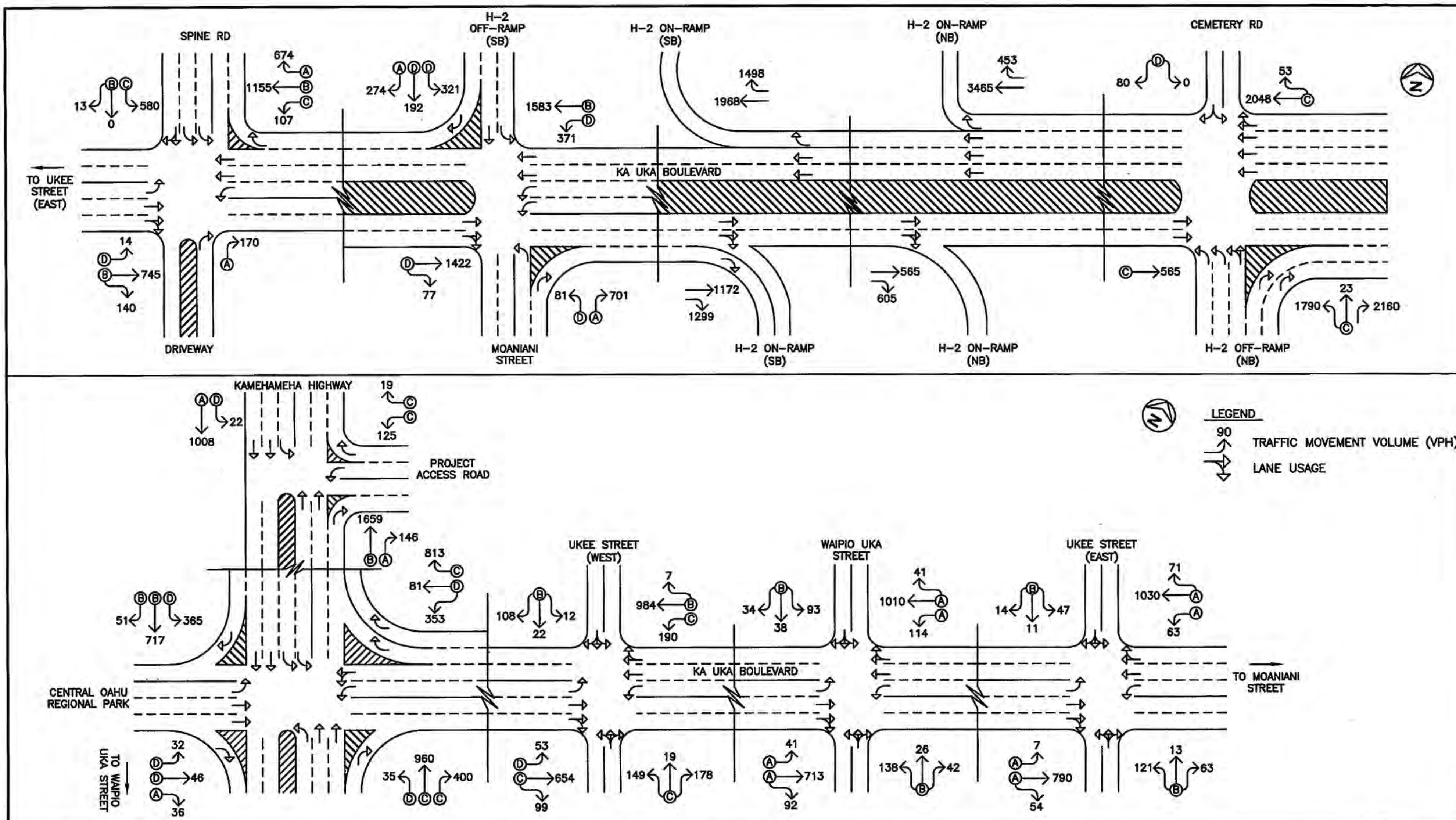
KOA RIDGE MAKAI AND WAIAWA DEVELOPMENT

YEAR 2016 AM PEAK HOUR OF TRAFFIC WITH PROJECT
KAMEHAMEHA HIGHWAY

FIGURE
19



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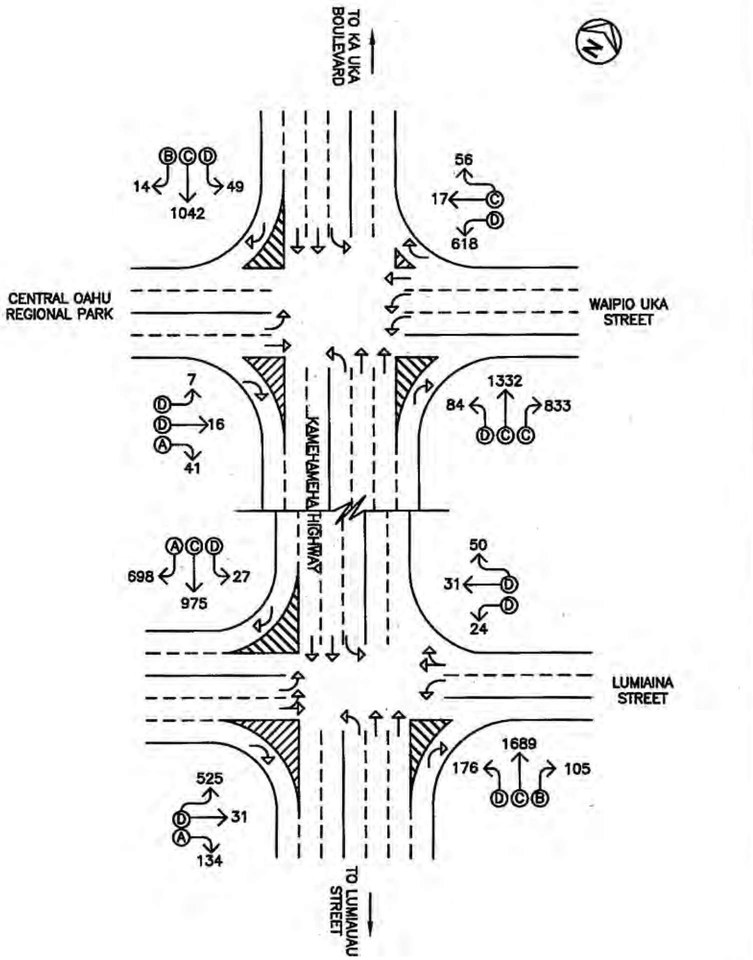
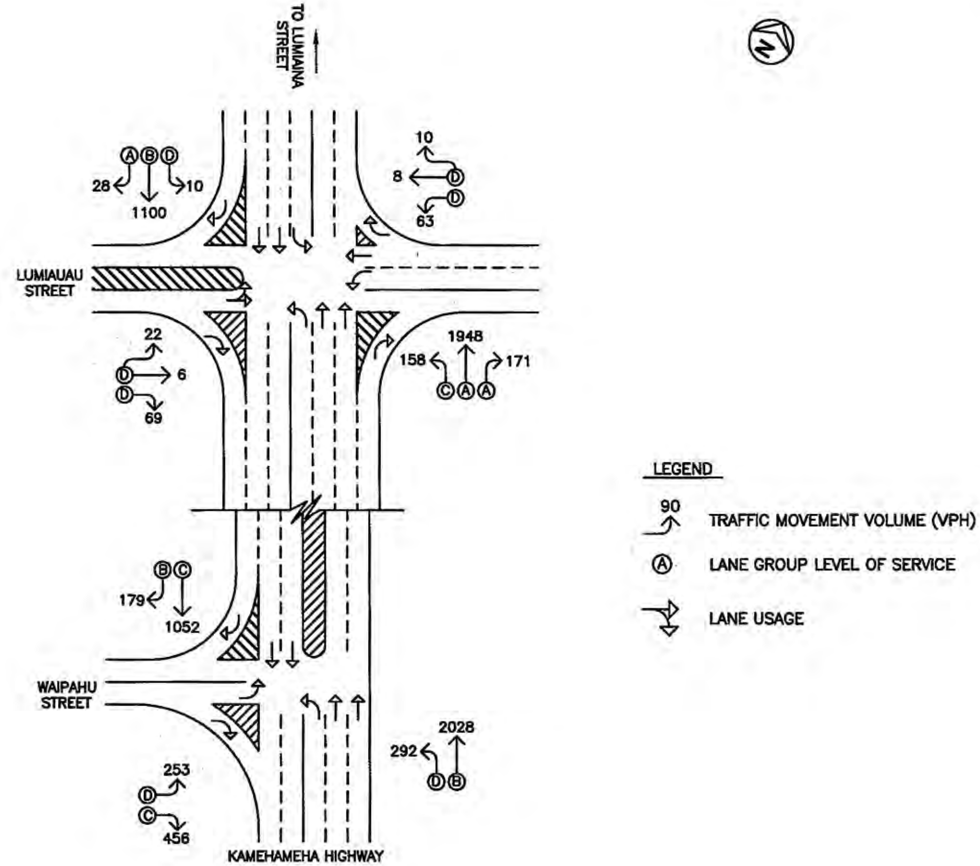
KOA RIDGE MAKAI AND WAIAWA DEVELOPMENT

YEAR 2016 PM PEAK HOUR OF TRAFFIC WITH PROJECT
KA UKA BOULEVARD

FIGURE 20





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KOA RIDGE MAKAI AND WAIAWA DEVELOPMENT

YEAR 2016 PM PEAK HOUR OF TRAFFIC WITH PROJECT
KAMEHAMEHA HIGHWAY

FIGURE
21

Table 5: Projected Year 2016 (Without and With Project)
Levels of Service

Intersection	Traffic Movement		AM		PM	
			Year 2016 w/out Proj	Year 2016 w/ Proj	Year 2016 w/out Proj	Year 2016 w/ Proj
Ka Uka Blvd/ Waipio IC NB Ramps/ Cemetery Road*	Eastbound	TH	A	B	C	C
	Westbound	TH-RT	B	B	D	C
	Northbound	LT-TH	C	C	D	C
	Southbound	LT-RT	D	D	D	D
Ka Uka Blvd/ Moaniani St/ Waipio IC SB Off-Ramp*	Eastbound	TH-RT	C	C	E	D
	Westbound	LT	D	D	F	D
		TH	A	A	C	B
	Northbound	LT	D	D	F	D
		RT	A	A	A	A
	Southbound	LT	D	C	D	D
		TH		D		D
Ka Uka Blvd/ Driveway**	Eastbound	LT	-	D	-	D
		TH-RT	-	B	-	B
	Westbound	LT	B	C	B	C
		TH	-	A	-	B
		RT	-	A	-	A
	Northbound	RT	B	A	B	A
	Southbound	LT	-	C	-	C
		TH-RT	-	C	-	B
Ka Uka Blvd/ Ukee St (East)	Eastbound	LT	A	A	A	A
		TH-RT	A	A	A	A
	Westbound	LT	A	A	A	A
		TH-RT	A	A	A	A
	Northbound	LT-TH-RT	B	B	B	B
	Southbound	LT-TH-RT	B	B	B	B
Ka Uka Blvd/ Waipio Uka St	Eastbound	LT	A	A	A	A
		TH-RT	A	A	A	A
	Westbound	LT	A	A	A	A
		TH-RT	A	A	A	A
	Northbound	LT-TH-RT	B	B	B	B
	Southbound	LT-TH-RT	B	B	B	B

* Intersection modifications implemented.
** Intersection modifications implemented and traffic signal system installed.

Table 5: Projected Year 2016 (Without and With Project) Levels of Service

Intersection	Traffic Movement		AM		PM	
			Year 2016 w/out Proj	Year 2016 w/ Proj	Year 2016 w/out Proj	Year 2016 w/ Proj
Ka Uka Blvd/ Ukee St (West)	Eastbound	LT	D	D	D	D
		TH-RT	B	B	C	C
	Westbound	LT	C	C	C	C
		TH-RT	B	B	B	B
	Northbound	LT-TH-RT	C	C	C	C
	Southbound	LT-TH-RT	B	B	B	B
Ka Uka Blvd/ Kamehameha Hwy	Eastbound	LT	D	D	D	D
		TH	D	D	D	D
		RT	A	A	A	A
	Westbound	LT-TH	C	C	D	D
		RT	B	B	B	C
	Northbound	LT	D	D	D	D
		TH	C	C	C	C
		RT	C	C	C	C
	Southbound	LT	C	C	D	D
		TH	B	B	B	B
		RT	A	A	B	B
Kamehameha Hwy/ Waipio Uka St	Eastbound	LT	D	D	D	D
		TH	D	D	D	D
		RT	A	A	A	A
	Westbound	LT	C	C	C	D
		TH-RT	B	C	C	C
	Northbound	LT	D	D	D	D
		TH	B	B	C	C
		RT	B	B	C	C
	Southbound	LT	D	D	D	D
		TH	B	B	C	C
		RT	B	B	B	B
Kamehameha Hwy/ Lumiaina St	Eastbound	LT-TH	D	D	D	D
		RT	A	A	A	A
	Westbound	LT	D	D	D	D
		TH-RT	D	D	D	D

Table 5: Projected Year 2016 (Without and With Project) Levels of Service (Cont'd)

Intersection	Traffic Movement		AM		PM	
			Year 2016 w/out Proj	Year 2016 w/ Proj	Year 2016 w/out Proj	Year 2016 w/ Proj
Kamehameha Hwy/ Lumiaina St	Northbound	LT	D	D	D	D
		TH	B	B	C	C
		RT	B	B	B	B
	Southbound	LT	D	D	D	D
		TH	C	C	C	C
		RT	A	A	A	A
Kamehameha Hwy/ Lumiauau St	Eastbound	LT-TH	C	C	C	D
		RT	C	C	C	D
	Westbound	LT	C	C	D	D
		TH-RT	C	C	C	D
	Northbound	LT	D	D	C	C
		TH	B	B	A	A
		RT	A	A	A	A
	Southbound	LT	D	D	D	D
		TH	B	B	B	B
		RT	A	A	A	A
Kamehameha Hwy/ Waipahu St	Eastbound	LT	C	D	D	D
		RT	D	D	C	C
	Northbound	LT	D	D	D	D
		TH	A	A	B	B
	Southbound	TH	C	C	C	C
		RT	B	B	B	B
Kamehameha Hwy/ Project Access Road	Westbound	LT	C	D	D	D
		RT	D	D	C	C
	Northbound	TH	D	D	D	D
		RT	A	A	B	B
	Southbound	LT	C	C	C	C
		TH	B	B	B	B

The cumulative volumes consist of site-generated traffic superimposed over Year 2016 projected traffic demands. The implementation of intersection and roadway improvements identified above for the *Year 2016 Without Castle & Cooke Project* analysis scenario is also assumed. Castle & Cooke Homes Hawaii has indicated they will fund and construct the recommended improvements which abut the project site on Ka Uka Boulevard and Kamehameha Highway. Waipio Interchange improvements will be part of a cost-sharing agreement between Castle & Cooke Homes Hawaii and Waiawa Ridge Development. The following are the additional With Project improvements needed by Year 2016:

Ka Uka Boulevard/Interstate H-2 Northbound Off-Ramp

- Provide additional northbound left-turn lane resulting in two exclusive left-turn lanes and a shared left-turn/through lane.

Ka Uka Boulevard/Interstate H-2 Southbound Off-Ramp/Moaniani Street

- Modify southbound approach to include and exclusive left-turn lane, a through lane, and an exclusive right-turn lane.
- Modify the traffic signal phasing at the intersection to allow for simultaneous left-turn movements on the northbound and southbound approaches. Intersection geometry may need to be adjusted to provide adequate vehicle spacing to accommodate turning maneuvers.

Ka Uka Boulevard/Commercial Use Driveway/New Spine Road

- Three lanes on the southbound approach of the Spine Road (Koa Ridge Makai Access) to accommodate two exclusive left-turn lanes and a shared through and right-turn lane.
- Provide an exclusive right-turn lane on the westbound approach of Ka Uka Boulevard between the H-2 southbound off-ramp and Spine Road.
- Install a traffic signal system with protected left-turn movements along Ka Uka Boulevard.

Kamehameha Highway/New Project Access Road

- Provide project access connection to Kamehameha Highway north of Ka Uka Boulevard as a full-service signalized intersection. The intersection shall include turn pockets, channelized right-turn lanes, and appropriate acceleration lane.
- Coordinate the traffic signal system with other traffic signal systems in the vicinity.

<u>*Miscellaneous Improvements*</u>

- Coordinate the traffic signal systems along the entire length of Ka Uka Boulevard to improve traffic flow progression along the roadway.

2. Ka Uka Boulevard at Waipio Interchange Northbound Off-Ramp Intersection

At the intersection with the Waipio Interchange northbound on- and off-ramps, the eastbound approach of Ka Uka Boulevard is expected to service 208 vehicles with the eastbound through movement operating at LOS "B" during the projected AM peak period. During the PM peak period, the traffic volume would be greater with 565 vehicles traveling eastbound with the through movement operating at LOS "C".

The westbound approach of the intersection is expected to service 1,890 vehicles and 2,101 vehicles during the AM and PM peak periods, respectively. The westbound approach would operate at LOS "B" during the projected AM peak hours of traffic and LOS "C" during PM peak hours of traffic.

The northbound off-ramp intersection approach is expected to service 1,567 vehicles during the AM peak hour of traffic and would operate at LOS "C". During the PM peak hour, the northbound intersection approach is expected to service 3,973 vehicles, and is expected to operate at LOS "C".

3. Ka Uka Boulevard at Waipio Interchange Southbound Loop On-Ramp

At the intersection with the Waipio Interchange southbound loop on-ramp, the westbound approach of Ka Uka Boulevard is expected to service a total of 2,479 vehicles while the southbound loop on-ramp services 1,484 vehicles during the AM peak hour of traffic. The eastbound traffic flow on Ka Uka Boulevard is expected to service 1,963 vehicles during the AM peak hour. During the PM peak hour of traffic, the westbound approach of Ka Uka Boulevard at the southbound loop on-ramp is expected to service a total of 3,466 vehicles with the southbound loop on-ramp servicing 1,490 vehicles.

The eastbound traffic flow on Ka Uka Boulevard is expected to service 2,471 vehicles during the projected PM peak hour of traffic.

4. Ka Uka Boulevard at Moaniani Street/Waipio Interchange Southbound Off-Ramp

At the intersection with Moaniani Street and the Waipio Interchange southbound off-ramp, the westbound approach of Ka Uka Boulevard is expected to service 985 vehicles during the AM peak hour of traffic with the left-turn movement operating at LOS "D" and the through movement operating at LOS "A". During the PM peak hour of traffic, the westbound Ka Uka Boulevard approach is expected to carry a total of 1,954 vehicles with the left-turn movement operating at LOS "D" and the through movement operating at LOS "B" conditions.

The eastbound approach of Ka Uka Boulevard at the intersection with Moaniani Street and the southbound off-ramp is expected to service a total of 1,443 vehicles during the AM peak hour of traffic and operate at LOS "C". During the PM peak hour of traffic, the eastbound approach is expected to service 1,499 vehicles and operate at LOS "D" conditions.

The northbound approach of Moaniani Street at the Ka Uka Boulevard intersection is expected to service a total 469 vehicles during the AM peak hour of traffic with the left-turn and right-turn movements operating at LOS "D" and LOS "A", respectively. Similarly, during the PM peak hour of traffic, the northbound approach of Moaniani Street at the Ka Uka Boulevard intersection is expected to service 782 vehicles with the left-turn and right-turn movements operating at LOS "D" and LOS "A" conditions, respectively.

The southbound off-ramp at the Ka Uka Boulevard and Moaniani Street intersection is expected to service 510 vehicles during the AM peak hour of traffic with the approach operating at LOS "C". During the PM peak hour of traffic, the southbound off-ramp at the Ka Uka Boulevard and Moaniani Street intersection is expected to service 787 vehicles with the approach operating at LOS "D".

5. Ka Uka Boulevard at Commercial Driveway

The westbound and eastbound approaches of Ka Uka Boulevard at the intersection with the commercial driveway is expected to service a total of 1,007 vehicles and 1,049 vehicles during the AM peak hour of traffic, respectively. The westbound left-turn movement is expected to operate at LOS "B". During the PM peak hour of traffic, the westbound approach is expected to service 1,936 vehicles while the eastbound approach services 899 vehicles. The westbound left-turn movement would operate at LOS "C".

The northbound approach of the driveway at the Ka Uka Boulevard intersection is expected to service 32 vehicles and 170 vehicles during the AM and PM peak hours of traffic, respectively, and operate at LOS "A" conditions during both projected peak hours.

6. Ka Uka Boulevard at Ukee Street (east)

At the intersection with Ukee Street (east), the westbound approach of Ka Uka Boulevard is expected to service 632 vehicles during the AM peak hour of traffic with the left-turn movement operating at LOS "A". During the PM peak hour of traffic, the westbound Ka Uka Boulevard approach is expected to service a total of 1,164 vehicles with the left-turn movement operating at LOS "A" conditions.

The eastbound approach of Ka Uka Boulevard at the intersection with Ukee Street (east) is expected to service a total of 1,090 vehicles during the AM peak hour of traffic with the left-turn movement operating at LOS "A". During the PM peak hour of traffic, the eastbound approach would service a total of 851 vehicles with the left-turn movement operating at LOS "A" conditions.

The northbound approach of Ukee Street (east) at the Ka Uka Boulevard intersection is expected to service a total 78 vehicles during the AM peak hour of traffic and operate at LOS "B". During the PM peak hour of traffic, the northbound approach of Ukee Street (east) at Ka Uka Boulevard is expected to service 197 vehicles and operate at LOS "B". The southbound approach of Ukee Street (east) at the Ka Uka Boulevard intersection would service 20 vehicles during the AM peak hour and operate at LOS "B", while the southbound approach services 72 vehicles during the PM peak hour of traffic and operate at LOS "B".

7. Ka Uka Boulevard at Waipio Uka Street

At the intersection with Waipio Uka Street, the westbound approach of Ka Uka Boulevard is expected to service 510 vehicles during the AM peak hour of traffic with the left-turn, through, and right-turn movements all operating at LOS "A". During the PM peak hour of traffic, the westbound Ka Uka Boulevard approach would service a total of 1,065 vehicles with the left-turn, through, and right-turn movements also operating at LOS "A" conditions.

The eastbound approach of Ka Uka Boulevard at the intersection with Waipio Uka Street is expected to service a total of 1,112 vehicles and 846 vehicles during the projected AM and PM peak hour of traffic, respectively. During both peak periods, all traffic movement on the eastbound approach of Ka Uka Boulevard at the Waipio Uka Street intersection would operate at LOS "A" conditions.

The northbound approach of Waipio Uka Street at the Ka Uka Boulevard intersection is expected to service a total of 205 vehicles during the AM peak hour of traffic and would operate at LOS "B". During the PM peak hour of traffic, the northbound approach of Waipio Uka Street at Ka Uka Boulevard is expected to service 206 vehicles and also would operate at LOS "B" conditions. The southbound approach of Waipio Uka Street at the Ka Uka Boulevard intersection is expected to service 75 vehicles during the AM peak hour and operate at LOS "B", while the southbound approach is expected to service 165 vehicles during the PM peak hour of traffic and would also operate at LOS "B" conditions.

8. Ka Uka Boulevard at Ukee Street (west)

At the intersection with Ukee Street (west), the westbound approach of Ka Uka Boulevard is expected to service 530 vehicles during the AM peak hour of traffic with the left-turn movement operating at LOS "C" and the shared through/right-turn movements operating at LOS B". During the PM peak hour of traffic, the westbound Ka Uka Boulevard approach is expected to service a total of 1,181 vehicles with the left-turn movement operating at LOS "C" and the shared through and right-turn movements operating at LOS "B" conditions.

The eastbound approach of Ka Uka Boulevard at the intersection with Ukee Street (west) is expected to service a total of 928 vehicles during the AM peak hour of traffic with the left-turn movement operating at LOS "D" and the shared through/right-turn movement operating at LOS "B" conditions. During the PM peak hour of traffic, the eastbound approach is expected to service a total of 806 vehicles with the left-turn movement operating at LOS "D" conditions while the shared through/right-turn movements would operate at LOS "C".

The northbound approach of Ukee Street (west) at the Ka Uka Boulevard intersection is expected to service a total 413 vehicles during the AM peak hour of traffic and would operate at LOS "C". During the PM peak hour of traffic, the northbound approach of Ukee Street (west) at Ka Uka Boulevard is expected to service 346 vehicles and would operate at LOS "C". The southbound approach of Ukee Street (west) at the Ka Uka Boulevard intersection is expected to service 17 vehicles during the AM peak hour and operates at LOS "B", while the southbound approach is expected to service 142 vehicles during the PM peak hour of traffic and also would operate at LOS "B".

9. Ka Uka Boulevard at Kamehameha Highway

At the intersection with Ka Uka Boulevard and the Kamehameha Highway, the westbound approach of Ka Uka Boulevard is expected to service

477 vehicles during the AM peak hour of traffic with the shared left-turn/through movements operating at LOS "C" and the right-turn movement operating at LOS "B". During the PM peak hour of traffic, the westbound Ka Uka Boulevard approach is expected to service a total of 1,247 vehicles with the shared left-turn/through movements operating at LOS "D" and the right-turn movement operating at LOS "C" conditions. The eastbound approach of Ka Uka Boulevard at the intersection with Kamehameha Highway is expected to service a total of 44 vehicles during the AM peak hour of traffic resulting in LOS "D" conditions for both the individual eastbound left-turn and shared through/right-turn traffic movements, respectively. During the PM peak hour of traffic, the eastbound approach is expected to service 114 vehicles with all of the individual movements generally operating at LOS "D" conditions.

The northbound approach of Kamehameha Highway at the Ka Uka Boulevard intersection is expected to service a total 763 vehicles during the AM peak hour of traffic with the left-turn movement operating at LOS "D", and the through and right-turn movements both operating at LOS "C" conditions. During the PM peak hour of traffic, the northbound approach of Kamehameha Highway at the Ka Uka Boulevard intersection is expected to service a total of 1,395 vehicles with the left-turn movement operating at LOS "D", and the through movement and right-turn movement operating at LOS "C" conditions.

The southbound approach of Kamehameha Highway at the Ka Uka Boulevard intersection is expected to service 1,699 vehicles during the AM peak hour of traffic with the left-turn movement operating at LOS "C" conditions while the through and right-turn movements both would operate at LOS "B" or better. During the PM peak hour of traffic, the southbound approach of Kamehameha Highway at the Ka Uka Boulevard intersection is expected to service 1,133 vehicles with the left-turn movement operating at LOS "D", and the through and right-turn movements operating at LOS "B" conditions.

10. Kamehameha Highway at Waipio Uka Street

At the intersection with Kamehameha Highway, the westbound approach of Waipio Uka Street is expected to service 622 vehicles during the AM peak hour of traffic with the left-turn and through movements operating at LOS "C" conditions. During the PM peak hour of traffic, the westbound Waipio Uka Street approach is expected to service a total of 691 vehicles with the left-turn movement operating at LOS "D" and the through and right-turn movements also operate at LOS "C" conditions.

The eastbound approach of Waipio Uka Street at the intersection with Kamehameha Highway is expected to service a total of 14 vehicles during the AM peak hour of traffic resulting in LOS "D" conditions for the left-turn and through movements. During the PM peak hour of traffic, the eastbound approach is expected to service 64 vehicles with the left-turn and through movements also operating at LOS "D" conditions.

The northbound approach of Kamehameha Highway at the Waipio Uka Street intersection is expected to service a total 1,301 vehicles during the AM peak hour of traffic with the left-turn movement operating at LOS "D", and both the through and right-turn movements operating at LOS "B" conditions. During the PM peak hour of traffic, the northbound approach of Kamehameha Highway at the Waipio Uka Boulevard intersection is expected to service 2,249 vehicles with the left-turn movement operating at LOS "D", and the through and right-turn movements operating at LOS "C".

The southbound approach of Kamehameha Highway at the Waipio Uka Boulevard intersection is expected to service 1,216 vehicles during the AM peak hour of traffic with the left-turn movement operating at LOS "D", and the through and right-turn movement operating at LOS "B" conditions. During the PM peak hour of traffic, southbound Kamehameha Highway at the Waipio Uka Street intersection is expected to service 1,105 vehicles with the left-turn movement operating at LOS "D", and the through and right-turn movements operating at LOS "C" or better conditions.

11. Kamehameha Highway at Lumiaina Street

At the intersection with Kamehameha Highway, the westbound approach of Lumiaina Street is expected to service 169 vehicles during the AM peak hour of traffic with the left-turn and shared through/right-turn movements operating at LOS "D". During the PM peak hour of traffic, the westbound Lumiaina Street approach is expected to service a total of 105 vehicles with the left-turn, through, and right-turn movements also operating at LOS "D" conditions.

The eastbound approach of Lumiaina Street at the intersection with Kamehameha Highway is expected to service 600 vehicles during the AM peak hour of traffic resulting in LOS "D" conditions for the left-turn movements, and LOS "A" conditions for the right-turn movements. During the PM peak hour of traffic, the eastbound approach is expected to service 690 vehicles with the left-turn movement operating at LOS "D" while the right-turn movement operate at LOS "A".

The northbound approach of Kamehameha Highway at the Lumiaina Street intersection is expected to service a total 860 vehicles during the AM peak hour of traffic with the left-turn movement operating at LOS "D", and both the through and right-turn movements operating at LOS "B" conditions. During the PM peak hour of traffic, the northbound approach of Kamehameha Highway at the Lumiaina Street intersection is expected to service 1,970 vehicles with the left-turn movement operating at LOS "D", the through movement operating at LOS "C", and the right-turn movement operating at LOS "B".

The southbound approach of Kamehameha Highway at the Lumiaina Street intersection is expected to service 1,770 vehicles during the AM peak hour of traffic with the left-turn movement operating at LOS "D", the through movement operating at LOS "C", and the right-turn movement operating at LOS "A" conditions. During the PM peak hour of traffic, southbound Kamehameha Highway at the Lumiaina Street intersection is expected to service 1,700 vehicles with the left-turn movement operating at LOS "D", the through movement operating at LOS "C", and the right-turn movement operating at LOS "A" conditions.

12. Kamehameha Highway at Lumiauau Street

At the intersection with Kamehameha Highway, the westbound approach of Lumiauau Street is expected to service 198 vehicles during the AM peak hour of traffic with both the left-turn and shared through/right-turn movements operating at LOS "C" conditions. During the PM peak hour of traffic, the westbound Lumiaina Street approach is expected to service a total of 81 vehicles with the left-turn operating at LOD "D", and the shared through/right-turn movements also operating at LOS "D", conditions.

The eastbound approach of Lumiauau Street at the intersection with Kamehameha Highway is expected to service 449 vehicles during the AM peak hour of traffic resulting in LOS "C" conditions for the shared left-turn/through movements, and also LOS "C" conditions for the right-turn movement. During the PM peak hour of traffic, the eastbound approach is expected to service 97 vehicles with the shared left-turn/through movements operating at LOS "D" while the right-turn movement also operating at LOS "D". The northbound approach of Kamehameha Highway at the Lumiauau Street intersection is expected to service a total 814 vehicles during the AM peak hour of traffic with the left-turn movement operating at LOS "D", and both the through and right-turn movements operating at LOS "B" or better conditions. During the PM peak hour of traffic, the northbound approach of Kamehameha Highway at the Lumiauau Street intersection is expected to service 2,277 vehicles with the left-turn movement operating at LOS "C", and the through and right-turn movements operating at LOS "A".

The southbound approach of Kamehameha Highway at the Lumiauau Street intersection is expected to service 1,328 vehicles during the AM peak hour of traffic with the left-turn movement operating at LOS "D", the through movement operating at LOS "B", and the right-turn movement operating at

LOS "A" conditions. During the PM peak hour of traffic, southbound Kamehameha Highway at the Lumiauau Street intersection is expected to service 1,138 vehicles with the left-turn movement operating at LOS "D", the through movement operating at LOS "B", and the right-turn movement operating at LOS "A" conditions.

13. Kamehameha Highway at Waipahu Street

At the intersection with Kamehameha Highway, the eastbound approach of Waipahu Street is expected to service 737 vehicles during the AM peak hour of traffic with both the left-turn and right-turn movements both operating at LOS "D". During the PM peak hour of traffic, the eastbound Waipahu Street approach is expected to service a total of 709 vehicles with the left-turn and right-turn movements operating at LOS "D" and LOS "C", respectively.

The northbound approach of Kamehameha Highway at the Waipahu Street intersection is expected to service a total 833 vehicles during the AM peak hour of traffic with the left-turn movement operating at LOS "D", and the through movement operating at LOS "A" conditions. During the PM peak hour of traffic, the northbound approach of Kamehameha Highway at the Waipahu Street intersection is expected to service 2,320 vehicles with the left-turn movement also operating at LOS "D" and the through movement operating at LOS "B".

The southbound approach of Kamehameha Highway at the Waipahu Street intersection is expected to service 1,825 vehicles during the AM peak hour of traffic with the through movement operating at LOS "C" and the right-turn movement operating at LOS "B" conditions. During the PM peak hour of traffic, southbound Kamehameha Highway at the Waipahu Street intersection is expected to service 1,231 vehicles with the through movement operating at LOS "C" and the right-turn movement operating at LOS "B" conditions.

14. Kamehameha Highway at Project Access Road

During the projected Year 2016 AM and PM peak hours of traffic, the project access road is expected to carry eastbound traffic of 110 vehicles and 114 vehicles, respectively. The southbound approach of Kamehameha Highway would carry 9 vehicles turning left into the project access road and 1,603 vehicles proceeding through the intersection during the Year 2016 AM peak hour of traffic. During the projected PM peak hour, 22 southbound vehicles on Kamehameha Highway are expected to turn left while 1,008 vehicles proceed through the intersection. The northbound approach of Kamehameha Highway would carry 70 vehicles during the projected AM peak hour of traffic and 787 vehicles during the projected PM peak hours of traffic. Under unsignalized conditions, the westbound left-turn movement from the proposed project access road to southbound Kamehameha Highway would operate at LOS "F" conditions during both the projected Year 2016 AM and PM peak hours of traffic. The westbound right-turn movement and southbound left-turn movement would operate at LOS "C" or better during both projected Year 2016 peak hour periods. In anticipation of satisfying the appropriate traffic signal warrants at the Kamehameha Highway and Project Access Road intersection in the future, the eastbound left-turn movement from the project access road to southbound Kamehameha Highway is expected to improve from LOS "F" to LOS "C" under signalized conditions during both the projected AM and PM peak hours of traffic.

15. Interstate H-2 Freeway Segments

During the projected Year 2016 AM peak hour of traffic with the proposed project, the Interstate H-2 Freeway south of the Waipio Interchange would carry 3,832 vehicles northbound and 6,407 vehicles southbound. The northbound and southbound freeway segments along H-2 south of the Waipio Interchange would operate at LOS "B" and LOS "C" during the projected Year 2016 AM peak hour of traffic with the proposed project. Simulation modeling of traffic operations for this freeway segment resulted in no significant queuing. However, queuing further south as a result of spillback conditions from the Waiawa Interchange is expected to continue and is further discussed in later section of this report. No vehicular queuing is expected in the northbound direction during the projected Year 2016 AM peak hour of traffic.

North of the Waipio Interchange, the Interstate H-2 Freeway would carry approximately 2,854 vehicles northbound and 4,043 vehicles southbound during the projected morning peak hours of traffic and would operate at LOS "C" and LOS "B", respectively. Simulation modeling of traffic operations for this freeway segment resulted in no significant queuing during the projected morning peak periods.

During the PM peak hours of traffic, the Interstate H-2 Freeway south of the Waipio Interchange would carry 7,327 vehicles northbound and 5,195 vehicles southbound. The northbound and southbound Interstate H-2 Freeway segments south of the Waipio Interchange would operate at LOS "D" and LOS "C" during the projected Year 2016 PM peak hours of traffic with the project. No significant queuing is expected along this freeway segment during the projected Year 2016 PM peak hours of traffic without the proposed project.

North of the Waipio Interchange, the Interstate H-2 Freeway is expected to carry approximately 4,412 vehicles northbound and 3,185 vehicles during the projected PM peak hours of traffic. This freeway segment is expected to operate at LOS "C" and LOS "B", respectively, during the PM peak hours of traffic with the proposed project. Based on simulation modeling, no significant queuing is expected along this freeway segment during the projected Year 2016 PM peak hours of traffic with the project.

Further discussion on freeway segment operations and travel times during the morning and afternoon commute periods are presented in Section V of this report.

16. Waipio Interchange Ramp Merge/Diverge Operations

During projected Year 2016 AM peak hour traffic operations with the proposed project, the Interstate H-2 Freeway northbound off-ramp at the Waipio Interchange would operate at LOS "B" conditions with the implementation of the committed loop on-ramp identified in earlier sections of this document. The existing configuration of the northbound on-ramp to service westbound Ka Uka Boulevard traffic east of the interchange destined to areas north via the northbound Interstate H-2 Freeway would continue to operate at LOS "B" conditions while the northbound loop on-ramp operate at LOS "A". The southbound loop on-ramp would operate at LOS "C" during the projected Year 2016 with the project while the existing southbound on-ramp accommodating eastbound Ka Uka Boulevard destined to areas south via the Interstate H-2 Freeway would continue to operate at LOS "C" during the project Year 2016 AM peak hours of traffic with the project. The southbound off-ramp would continue to operate at LOS "C" conditions during the same period. With the committed improvement to extend the northbound off-ramp capacity, merge and diverge conditions at all of the ramps would operate well with no anticipated queuing at the ramp and freeway interfaces.

During the projected Year 2016 PM peak hour of traffic, the northbound off-ramp at the Waipio Interchange would operate at LOS "F" with queuing anticipated at the ramp junction. To accommodate ramp diverge conditions, and to accommodate the ramp 95th percentile projected queue, the ramp must be extended 800 feet upstream from the ramp gore. As a result, based on simulation modeling, no queuing effects would be anticipated on the freeway due to the proposed improvement to extend the ramp deceleration lane, including the committed improvement to provide two exclusive right-turn lanes downstream from the ramp and freeway interface. The northbound loop on-ramp would also operate well at LOS "B" during the projected Year 2016 PM peak hour of traffic with the project, while the existing configuration of the northbound on-ramp serving westbound traffic from areas east of the freeway also operate at LOS B" conditions.

The southbound loop on-ramp and existing southbound on-ramp configuration would both operate at LOS "C", while the southbound off-ramp also operate at LOS "C" during the projected Year 2016 PM peak hour of traffic with the project. Based on modeling and traffic simulations, the merge and diverge operations are not expected to result in queuing on to the freeway.

Table 5.1 summarizes the freeway segments and ramp operations along the Interstate H-2 Freeway and at the Waipio Interchange for Year 2016 with project conditions.

Table 5.1: Summary of Year 2016 (without and with project) Interstate H-2 Freeway Segment and Ramp LOS Operations

Freeway Segment/ Interchange Ramp	**2016 AM Peak**		**2016 PM Peak**	
	Without project	**With project**	**Without project**	**With project**
NB segment south of Waipio Interchange	B	B	D	D
NB segment north of Waipio Interchange	B	B	C	C
SB segment south of Waipio Interchange	C	D	C	C
SB segment north of Waipio Interchange	B	B	B	B
NB Off-ramp	A	B	D	F*
NB On-ramp	B	B	B	B
NB Loop On-ramp	A	A	B	B
SB On-ramp	C	D	C	C
SB Loop On-Ramp	C	C	C	C
SB Off-ramp	C	C	B	C

* Although LOS F conditions, queuing as a result of ramp diverge operation is accommodated with the proposed ramp extension improvement.

F. Koa Ridge Makai and Waiawa Year 2025 Site-Generated Traffic

1. Trip Generation Methodology

The trip generation methodology used in this phase of the project is also based upon generally accepted techniques developed by the Institute of Transportation Engineers (ITE) and published in "Trip Generation, 7th Edition," 2003. Similar to the Year 2016 projected analysis that is based on *Castle & Cooke Koa Ridge Makai and Waiawa Project, Alternative Transportation Components,* prepared by Weslin Consulting Services, Inc., dated November 2008, internal project trip capture as a result of enhanced transit service, Transportation Demand Management (TDM), and a variety of other strategies, may be greater than 50%. However, for the purpose of this development phase as well, 30% of site-generated trips were conservatively assumed as internal trips. Tables 6 and 7 summarize the net project site trip generation characteristics applied to the Year 2025 AM and PM peak hours of traffic.

Table 6: Koa Ridge Makai Peak Hour Trip Generation (External Trips Only)

YEAR 2025 (additional to Year 2016 projections)		
SINGLE-FAMILY DETACHED HOUSING INDEPENDENT VARIABLE: # of Dwelling Units = 575		
		PROJECTED TRIP ENDS
AM PEAK	ENTER	76
	EXIT	226
	TOTAL	302
PM PEAK	ENTER	256
	EXIT	151
	TOTAL	407
MULTI-FAMILY HOUSING (CONDOMINIUM/TOWNHOUSE) INDEPENDENT VARIABLE: # of Dwelling Units = 589		
		PROJECTED TRIP ENDS
AM PEAK	ENTER	31
	EXIT	151
	TOTAL	182
PM PEAK	ENTER	143
	EXIT	71
	TOTAL	214

Table 6: Koa Ridge Makai Peak Hour Trip Generation (Cont'd) (External Trips Only)

YEAR 2025 (additional to Year 2016 projections)		
MULTI-FAMILY HOUSING (APARTMENT)		
INDEPENDENT VARIABLE:		# of Dwelling Units = 945
		PROJECTED TRIP ENDS
AM PEAK	ENTER	67
	EXIT	270
	TOTAL	337
PM PEAK	ENTER	267
	EXIT	143
	TOTAL	410
RETAIL (SHOPPING CENTER)		
INDEPENDENT VARIABLE:		1,000 sf of development = 75
		PROJECTED TRIP ENDS
AM PEAK	ENTER	33
	EXIT	21
	TOTAL	54
PM PEAK	ENTER	95
	EXIT	102
	TOTAL	197
HOTEL		
INDEPENDENT VARIABLE:		# of Rooms = 150
		PROJECTED TRIP ENDS
AM PEAK	ENTER	36
	EXIT	23
	TOTAL	59
PM PEAK	ENTER	33
	EXIT	29
	TOTAL	62
HOSPITAL		
INDEPENDENT VARIABLE:		1,000 sf of development = 196
		PROJECTED TRIP ENDS
AM PEAK	ENTER	111
	EXIT	54
	TOTAL	165
PM PEAK	ENTER	53
	EXIT	109
	TOTAL	162

Table 6: Koa Ridge Makai Peak Hour Trip Generation (Cont'd)
(External Trips Only)

YEAR 2025 (additional to Year 2016 projections)		
GENERAL OFFICE BUILDING INDEPENDENT VARIABLE: 1,000 sf of development = 20		
		PROJECTED TRIP ENDS
AM PEAK	ENTER	19
	EXIT	3
	TOTAL	22
PM PEAK	ENTER	4
	EXIT	17
	TOTAL	21
GENERAL LIGHT INDUSTRIAL INDEPENDENT VARIABLE: 1,000 sf of development = 40		
		PROJECTED TRIP ENDS
AM PEAK	ENTER	22
	EXIT	3
	TOTAL	25
PM PEAK	ENTER	3
	EXIT	24
	TOTAL	27
YEAR 2025 TOTALS (additional to Year 2016 projections)		
		PROJECTED TRIP ENDS
AM PEAK	ENTER	395
	EXIT	751
	TOTAL	1146
PM PEAK	ENTER	854
	EXIT	646
	TOTAL	1500

Table 7: Waiawa Peak Hour Trip Generation
(External Trips Only)

YEAR 2025 (additional to Year 2016 projections)		
SINGLE-FAMILY DETACHED HOUSING INDEPENDENT VARIABLE: # of Dwelling Units = 255		
		PROJECTED TRIP ENDS
AM PEAK	ENTER	34
	EXIT	100
	TOTAL	134
PM PEAK	ENTER	113
	EXIT	67
	TOTAL	180

Table 7: Waiawa Peak Hour Trip Generation (Cont'd)
(External Trips Only)

YEAR 2025 (additional to Year 2016 projections)		
MULTI-FAMILY HOUSING (CONDOMINIUM/TOWNHOUSE) INDEPENDENT VARIABLE:	 # of Dwelling Units = 1,045	
		PROJECTED TRIP ENDS
AM PEAK	ENTER	55
	EXIT	267
	TOTAL	322
PM PEAK	ENTER	255
	EXIT	125
	TOTAL	380
RETAIL (SHOPPING CENTER) INDEPENDENT VARIABLE:	 1,000 sf of development = 30	
		PROJECTED TRIP ENDS
AM PEAK	ENTER	13
	EXIT	9
	TOTAL	22
PM PEAK	ENTER	38
	EXIT	41
	TOTAL	79
ELEMENTARY SCHOOL INDEPENDENT VARIABLE:	 Students = 375	
		PROJECTED TRIP ENDS
AM PEAK	ENTER	17
	EXIT	14
	TOTAL	31
PM PEAK	ENTER	7
	EXIT	8
	TOTAL	15
YEAR 2025 TOTALS (additional to Year 2016 projections)		
		PROJECTED TRIP ENDS
AM PEAK	ENTER	119
	EXIT	390
	TOTAL	509
PM PEAK	ENTER	413
	EXIT	241
	TOTAL	454

2. Trip Distribution

a. General

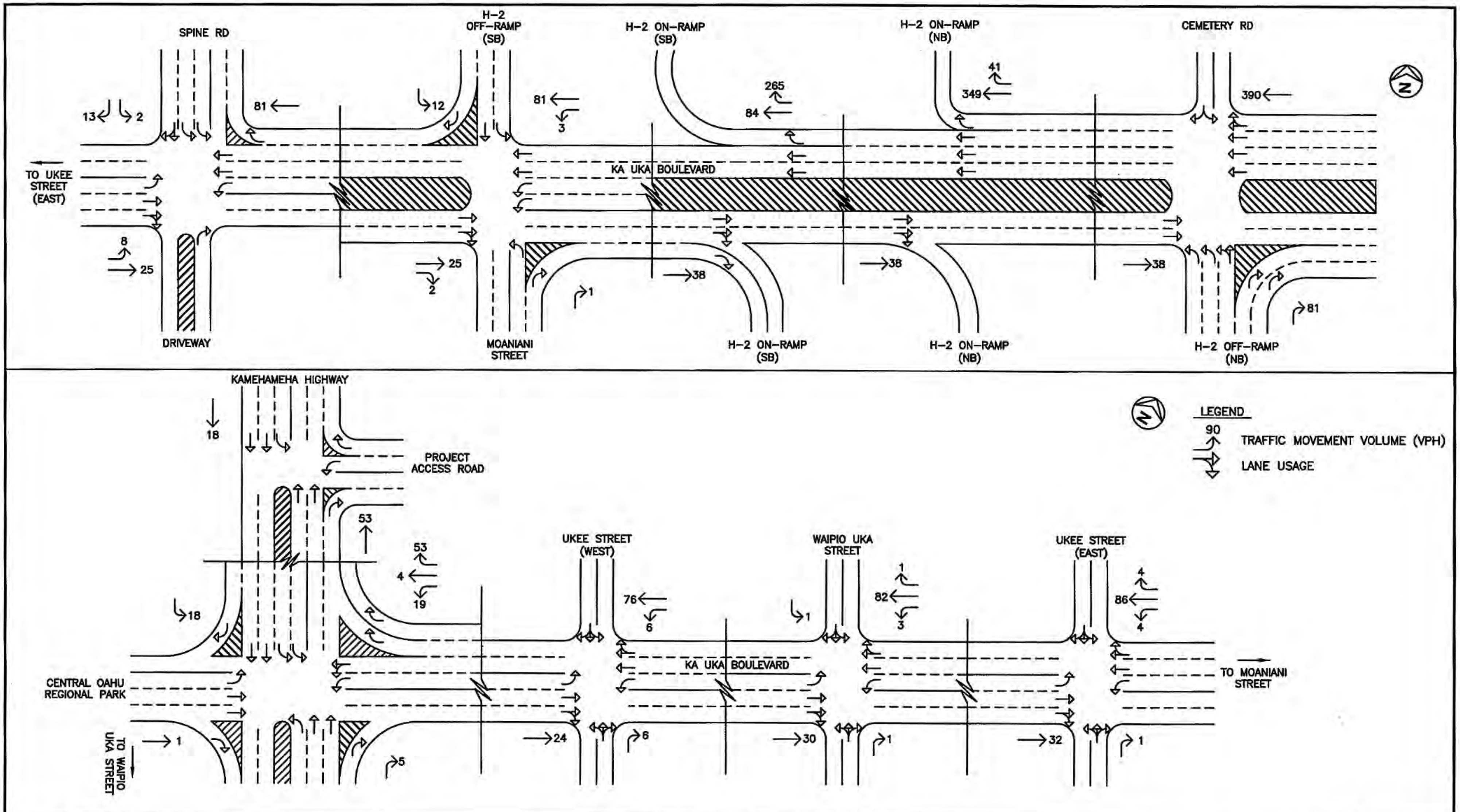
Figures 22 to 25 show the AM and PM peak hour distribution of project site-generated traffic at each of the study intersections for development build-out Year 2025.

b. Koa Ridge Makai

During the second phase of development for Year 2025, a new interchange for the Interstate H-2 Freeway is proposed to be constructed at the existing Pineapple Road overpass. Although this connection will provide the development a third access point, it is primarily expected to serve those portions of the project constructed during the second phase of development due to the proximity of the other access points to the areas developed during the first phase. As such, all site-generated vehicles associated with the Year 2025, or the second phase of the project, are assumed to utilize the new interchange to access the Interstate H-2 Freeway with the exception of internal trips within Waipio. Similar to those generated by the first phase of development, these vehicles are assumed to utilize the proposed Spine Road and Ka Uka Boulevard to access Moaniani Street, Ukee Street (East), Waipio Uka Street, or Ukee Street (West) since they provide a direct access to areas within Waipio and other project access points would result in the circuitous routing of project-related trips. The distribution of traffic between these local roadways was based upon the relative distribution of turning traffic at each of these roadways.

c. Waiawa

Vehicular access to the proposed Waiawa development for Year 2025 will continue to be provided via an extension of Ka Uka Boulevard. As with the first phase in Year 2016, the directional distribution of all site-generated vehicles is also based upon the distribution of population and activity centers on the island of Oahu.



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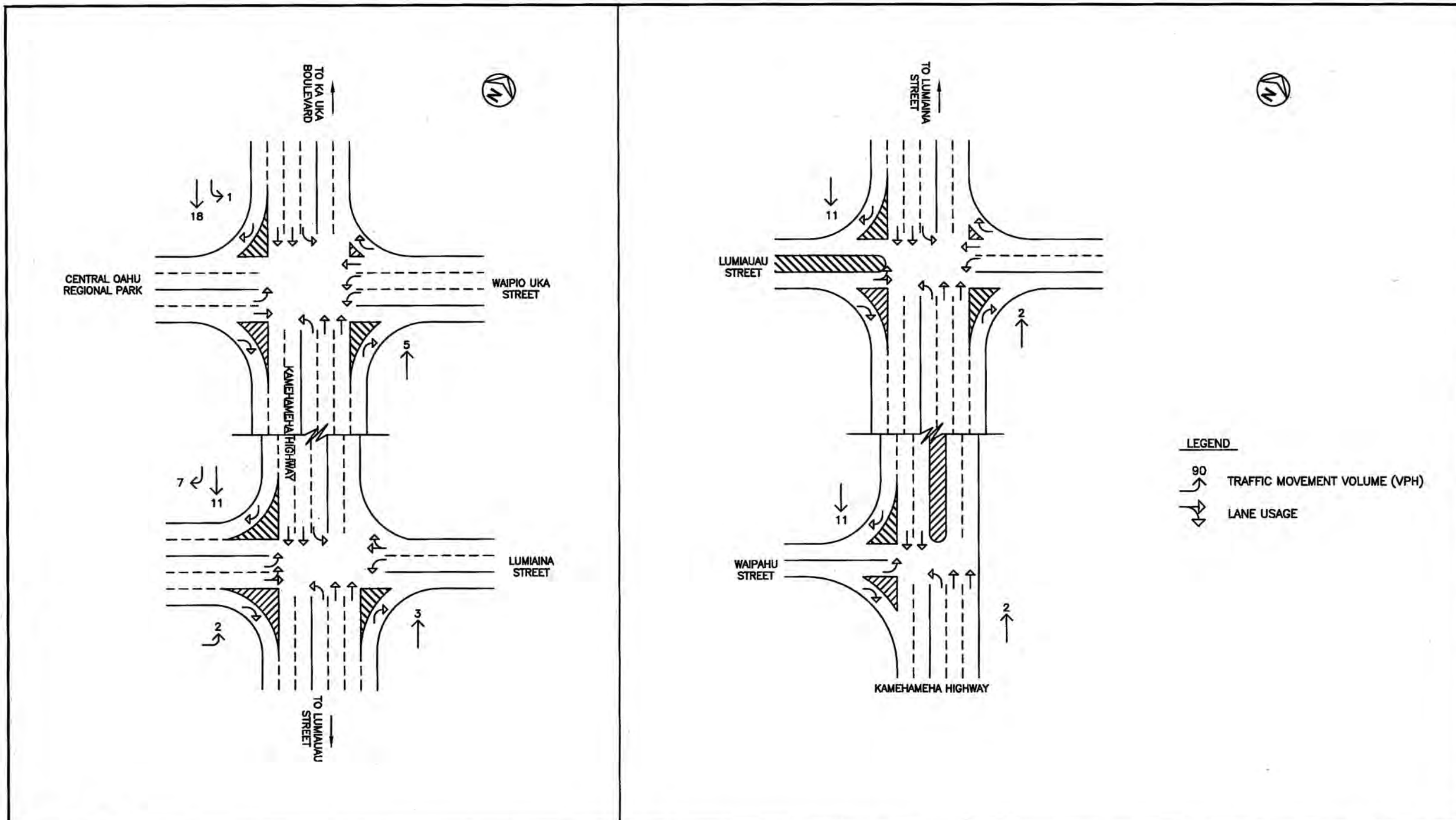
KOA RIDGE MAKAI AND WAIAWA DEVELOPMENT

YEAR 2025 DISTRIBUTION OF SITE - GENERATED VEHICLES
AM PEAK HOUR OF TRAFFIC - KA UKA BOULEVARD

FIGURE
22



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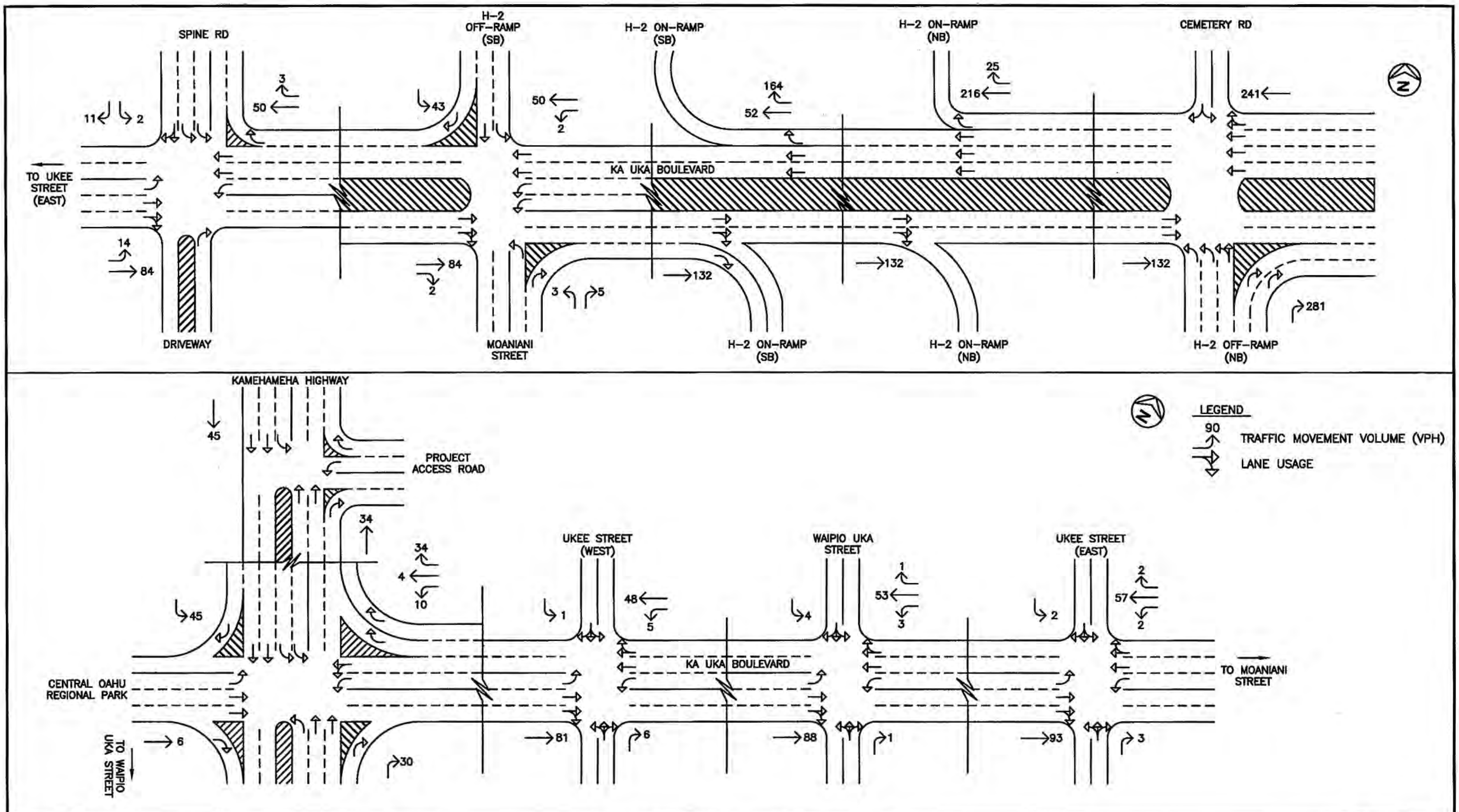
KOA RIDGE MAKAI AND WAIAWA DEVELOPMENT

YEAR 2025 DISTRIBUTION OF SITE - GENERATED VEHICLES
AM PEAK HOUR OF TRAFFIC - KAMEHAMEHA HIGHWAY

FIGURE 23



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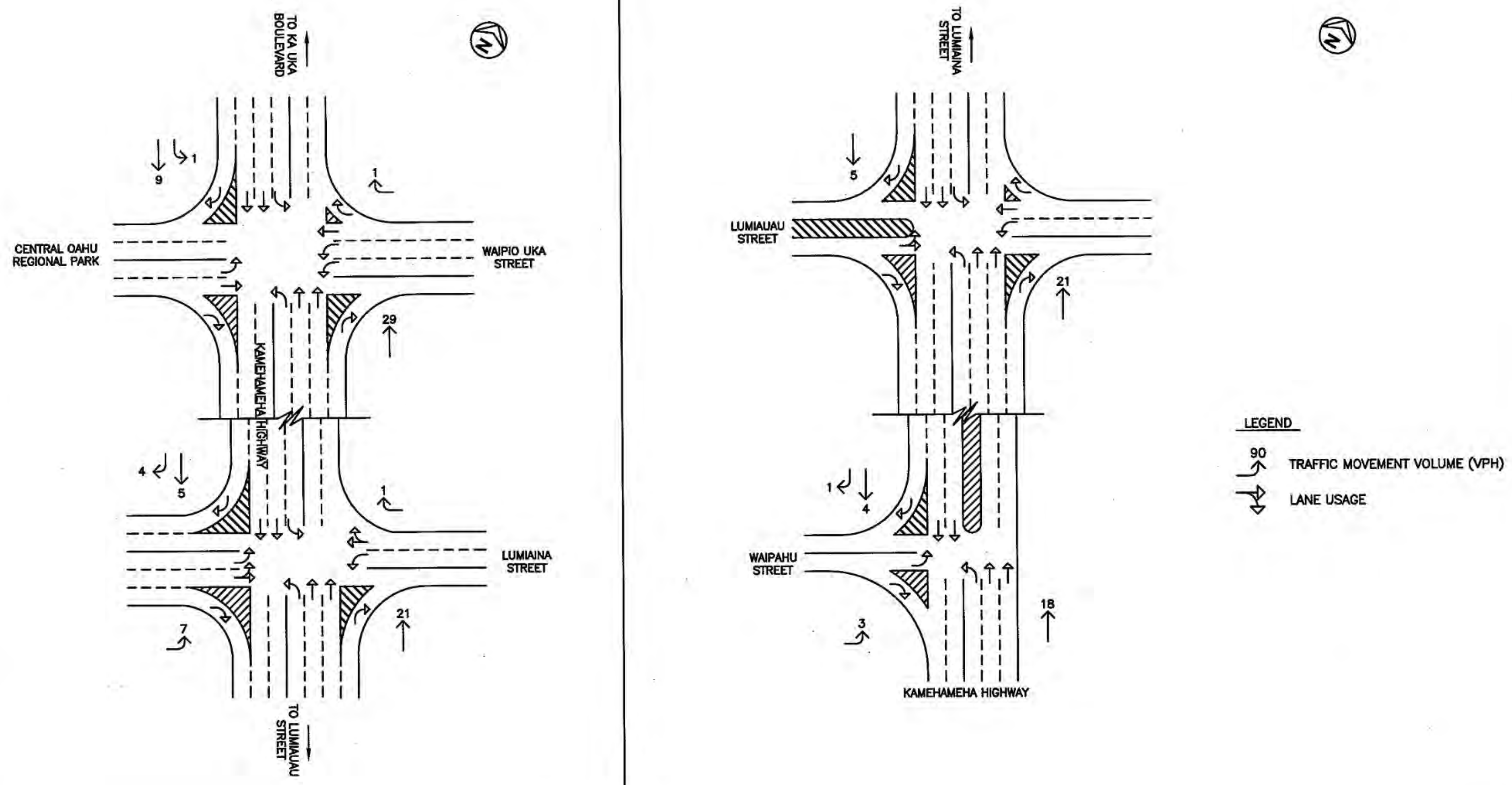
KOA RIDGE MAKAI AND WAIAWA DEVELOPMENT

YEAR 2025 DISTRIBUTION OF SITE - GENERATED VEHICLES
PM PEAK HOUR OF TRAFFIC - KA UKA BOULEVARD

FIGURE 24



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KOA RIDGE MAKAI AND WAIAWA DEVELOPMENT

YEAR 2025 DISTRIBUTION OF SITE - GENERATED VEHICLES
PM PEAK HOUR OF TRAFFIC - KAMEHAMEHA HIGHWAY

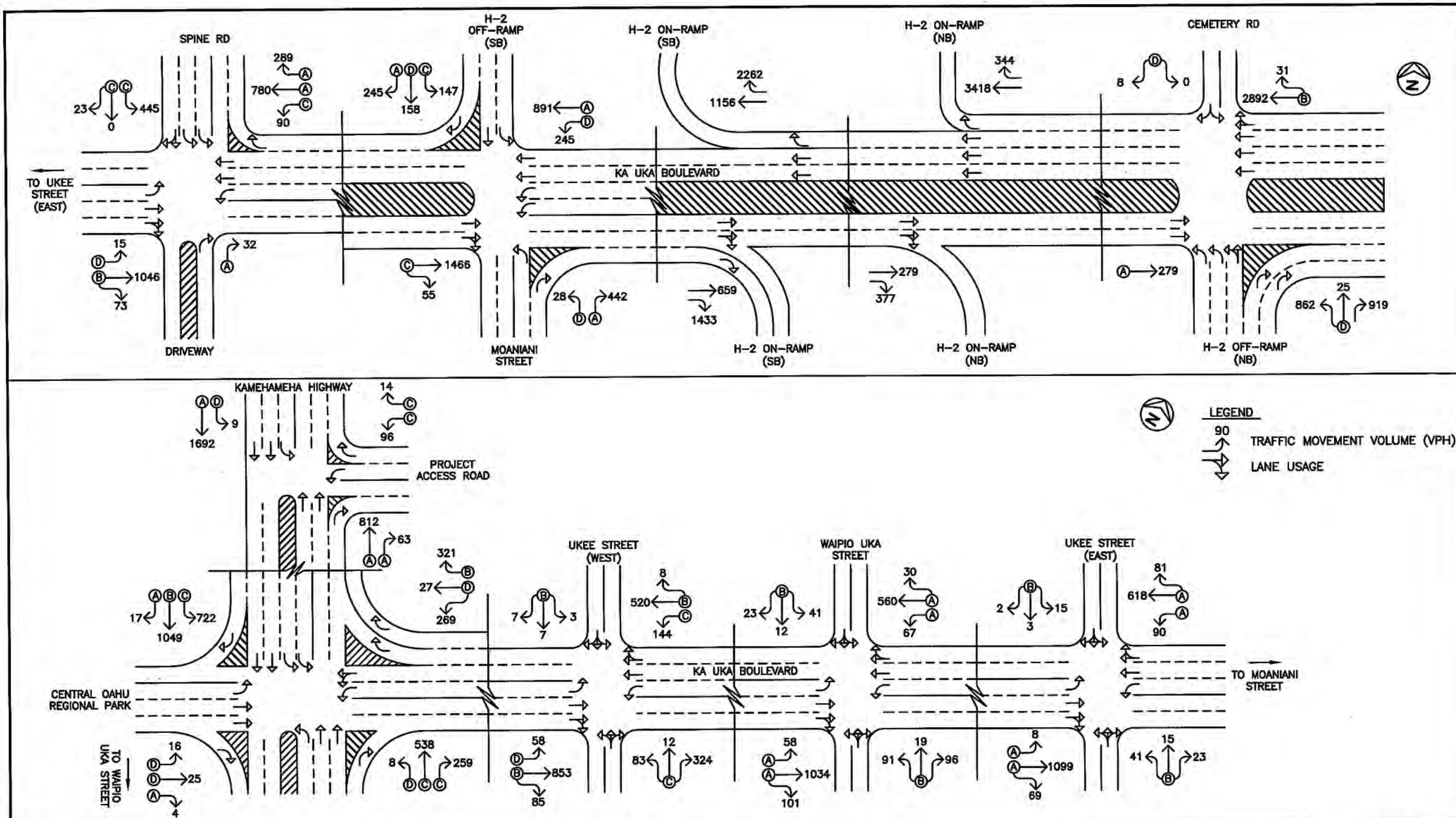
FIGURE 25

As such, approximately 13% of the vehicles are assumed to be traveling to/from areas to the north, approximately 85% are assumed to be traveling to/from areas to the south, and approximately 2% are assumed to be internal trips traveling to/from areas within Waipio. All vehicles traveling to/from areas outside of Waipio were distributed between the two north-south roadways in the vicinity, the Interstate H-2 Freeway and Kamehameha Highway, based upon the relative distribution of traffic between those two roadways. As such, approximately 80% of the vehicles were assumed to utilize the Interstate H-2 Freeway while approximately 20% of the vehicles were assumed to access Kamehameha Highway via Ka Uka Boulevard. For trips within Waipio, all vehicles were assumed to utilize Ka Uka Boulevard to access Moaniani Street, Ukee Street (East), Waipio Uka Street, or Ukee Street (West) since alternate routes would result in circuitous travel patterns. The distribution of traffic between these local roadways was based upon the relative distribution of turning traffic at each of these roadways. Figures 12.1 to 12.6 in previous sections of this report graphically illustrate the trip distribution patterns used for projected Year 2025 external trips.

G. Year 2025 Traffic Projections With Koa Ridge Makai and Waiawa Developments

1. General

The cumulative Year 2025 AM and PM peak hour traffic conditions resulting from the projected external traffic, ambient growth, other developments in the region, and the proposed Koa Ridge Makai and Waiawa developments are shown in Figures 26 to 29, and summarized in Table 8. The projected Year 2016 operating conditions with the proposed developments are provided for comparison purposes. The existing and projected Year 2016 operating conditions without the proposed project are shown on Table 2



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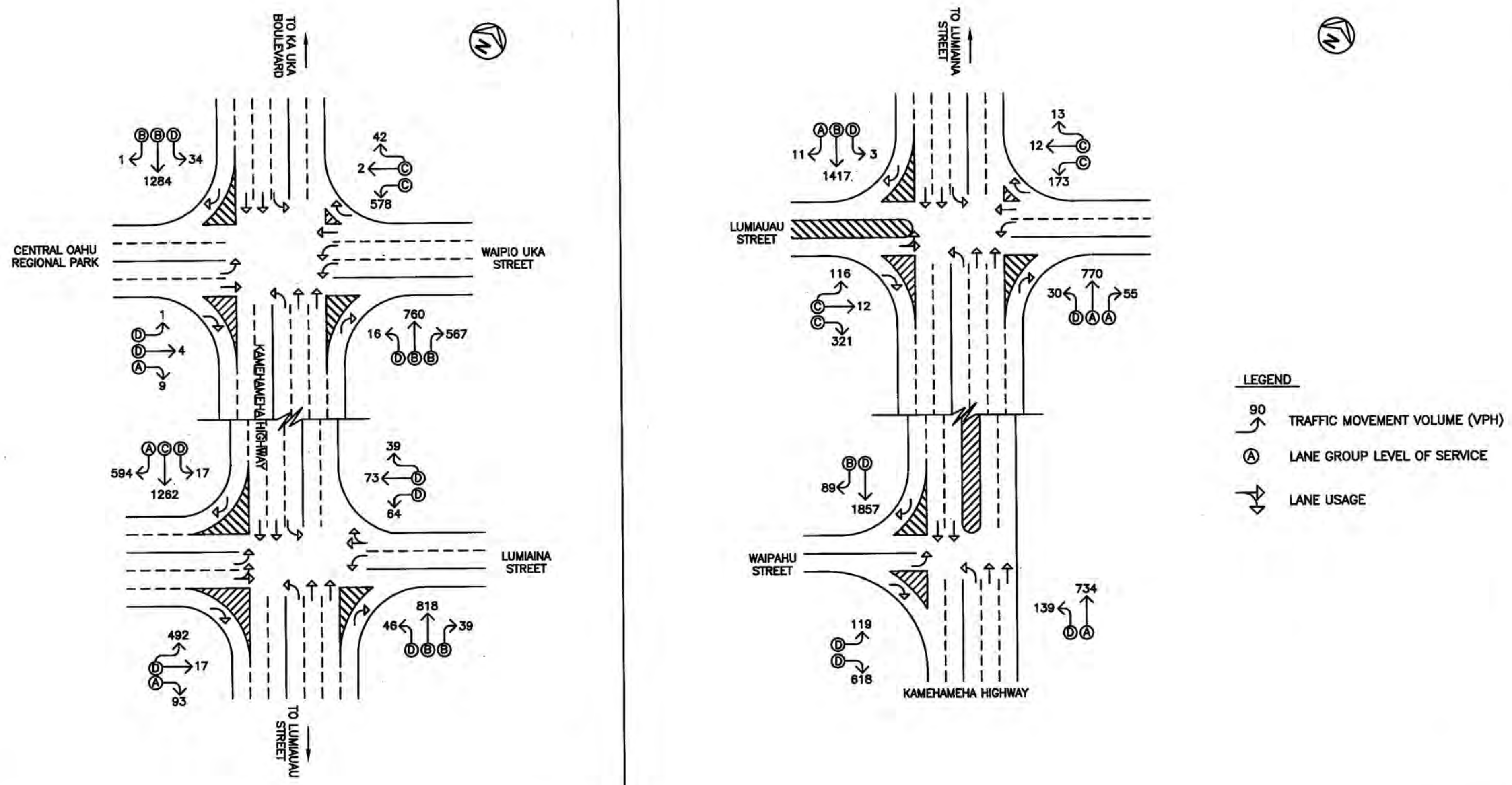
KOA RIDGE MAKAI AND WAIAWA DEVELOPMENT

YEAR 2025 AM PEAK HOUR OF TRAFFIC WITH PROJECT
KA UKA BOULEVARD

FIGURE 26



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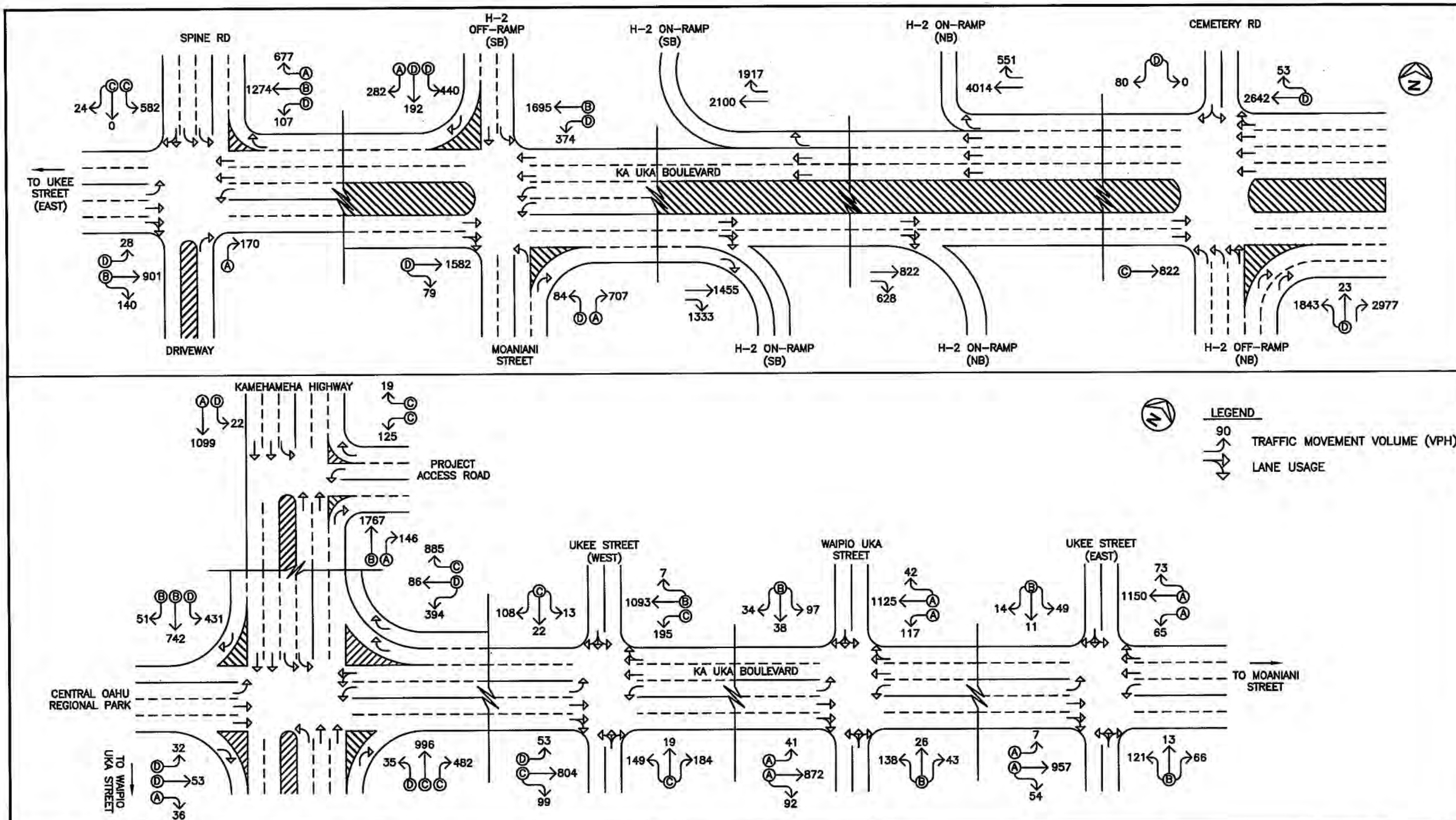
KOA RIDGE MAKAI AND WAIAWA DEVELOPMENT

YEAR 2025 AM PEAK HOUR OF TRAFFIC WITH PROJECT
KAMEHAMEHA HIGHWAY

FIGURE
27



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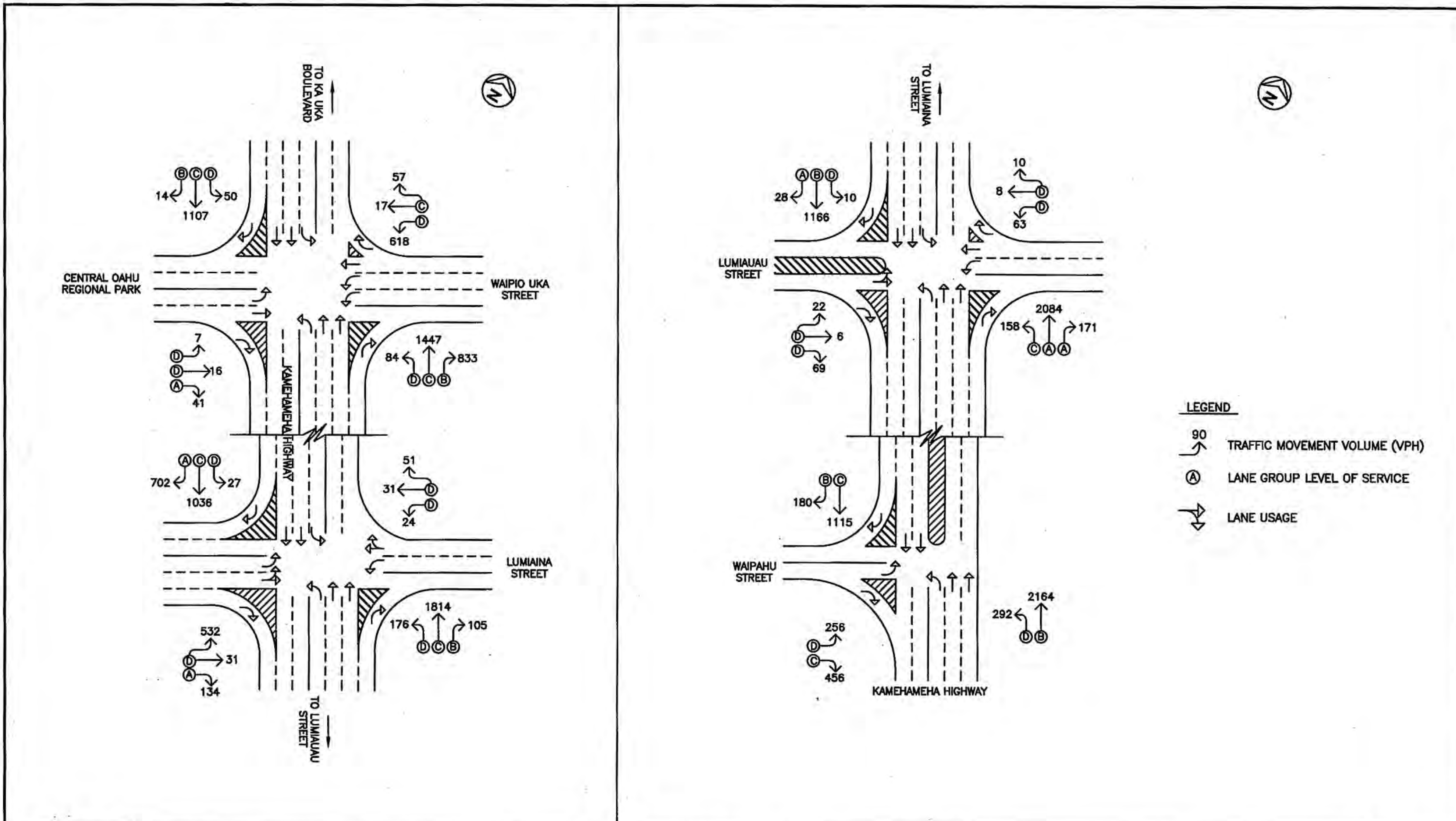
KOA RIDGE MAKAI AND WAIAWA DEVELOPMENT

YEAR 2025 PM PEAK HOUR OF TRAFFIC WITH PROJECT
KA UKA BOULEVARD

FIGURE 28



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KOA RIDGE MAKAI AND WAIAWA DEVELOPMENT

YEAR 2025 PM PEAK HOUR OF TRAFFIC WITH PROJECT
KAMEHAMEHA HIGHWAY

FIGURE 29

Table 8: Projected With Project (Year 2016 and Year 2025) Levels of Service

Intersection	Traffic Movement		AM Year 2016 w/ Proj	AM Year 2025 w/ Proj	PM Year 2016 w/ Proj	PM Year 2025 w/ Proj
Ka Uka Blvd/ Waipio IC NB Ramps/ Cemetery Road	Eastbound	TH	B	A	C	C
	Westbound	TH-RT	B	B	C	D
	Northbound	LT-TH	C	D	C	D
	Southbound	LT-RT	D	D	D	D
Ka Uka Blvd/ Moaniani St/ Waipio IC SB Off-Ramp	Eastbound	TH-RT	C	C	D	D
	Westbound	LT	D	D	D	D
		TH	A	A	B	B
	Northbound	LT	D	D	D	D
		RT	A	A	A	A
	Southbound	LT	C	C	D	D
		TH	D	D	D	D
		RT	A	A	A	A
Ka Uka Blvd/ Driveway*	Eastbound	LT	D	D	D	D
		TH-RT	B	B	B	B
	Westbound	LT	C	C	C	D
		TH	A	A	B	A
		RT	A	A	A	A
	Northbound	RT	A	A	A	A
	Southbound	LT	C	C	C	C
		TH-RT	C	C	B	C
Ka Uka Blvd/ Ukee St (East)	Eastbound	LT	A	A	A	A
		TH-RT	A	A	A	A
	Westbound	LT	A	A	A	A
		TH-RT	A	A	A	A
	Northbound	LT-TH-RT	B	B	B	B
	Southbound	LT-TH-RT	B	B	B	B
Ka Uka Blvd/ Waipio Uka St	Eastbound	LT	A	A	A	A
		TH-RT	A	A	A	A
	Westbound	LT	A	A	A	A
		TH-RT	A	A	A	A
	Northbound	LT-TH-RT	B	B	B	B
	Southbound	LT-TH-RT	B	B	B	B

Table 8: Projected With Project (Year 2016 and Year 2025) Levels of Service (Cont'd)

Intersection	Traffic Movement		AM		PM	
			Year 2016 w/ Proj	Year 2025 w/ Proj	Year 2016 w/ Proj	Year 2025 w/ Proj
Ka Uka Blvd/ Ukee St (West)	Eastbound	LT	D	D	D	D
		TH-RT	B	B	C	C
	Westbound	LT	C	C	C	C
		TH-RT	B	B	B	B
	Northbound	LT-TH-RT	C	C	C	C
	Southbound	LT-TH-RT	B	B	B	C
Ka Uka Blvd/ Kamehameha Hwy	Eastbound	LT	D	D	D	D
		TH	D	D	D	D
		RT	A	A	A	A
	Westbound	LT-TH	C	D	D	D
		RT	B	B	C	C
	Northbound	LT	D	D	D	D
		TH	C	C	C	C
		RT	C	C	C	C
	Southbound	LT	C	C	D	D
		TH	B	B	B	B
		RT	A	A	B	B
Kamehameha Hwy/ Waipio Uka St	Eastbound	LT	D	D	D	D
		TH	D	D	D	D
		RT	A	A	A	A
	Westbound	LT	C	C	D	D
		TH-RT	C	C	C	C
	Northbound	LT	D	D	D	D
		TH	B	B	C	C
		RT	B	B	C	B
	Southbound	LT	D	D	D	D
		TH	B	B	C	C
		RT	B	B	B	B
Kamehameha Hwy/ Lumiaina St	Eastbound	LT-TH	D	D	D	D
		RT	A	A	A	A
	Westbound	LT	D	D	D	D
		TH-RT	D	D	D	D

Table 8: Projected With Project (Year 2016 and Year 2025) Levels of Service (Cont'd)

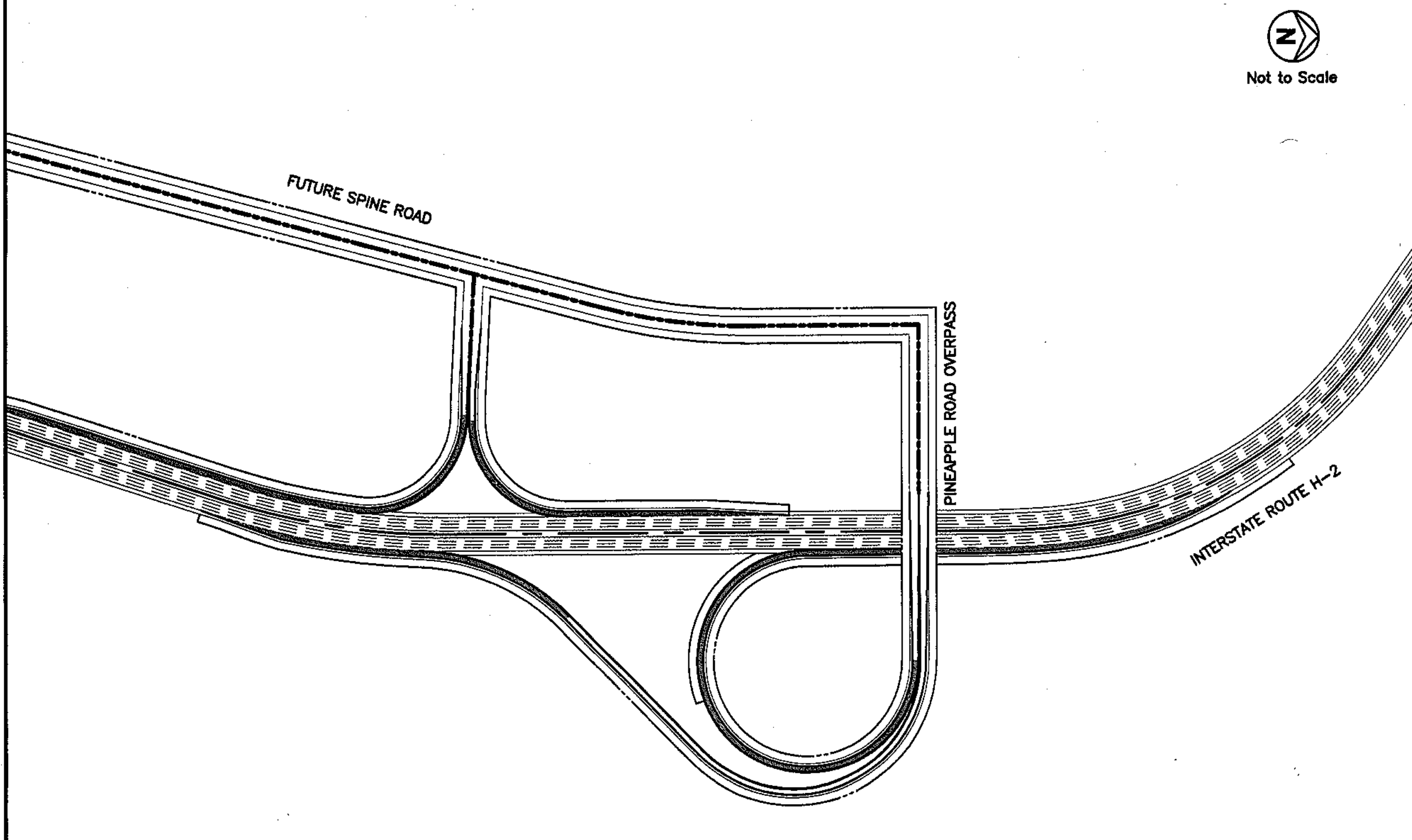
Intersection	Traffic Movement		AM		PM	
			Year 2016 w/ Proj	Year 2025 w/ Proj	Year 2016 w/ Proj	Year 2025 w/ Proj
Kamehameha Hwy/ Lumiaina St (Cont'd)	Northbound	LT	D	D	D	D
		TH	B	B	C	C
		RT	B	B	B	B
	Southbound	LT	D	D	D	D
		TH	C	C	C	C
		RT	A	A	A	A
Kamehameha Hwy/ Lumiauau St	Eastbound	LT-TH	C	C	D	D
		RT	C	C	D	D
	Westbound	LT	C	C	D	D
		TH-RT	C	C	D	D
	Northbound	LT	D	D	C	C
		TH	B	A	A	A
		RT	A	A	A	A
	Southbound	LT	D	D	D	D
		TH	B	B	B	B
		RT	A	A	A	A
Kamehameha Hwy/ Waipahu St	Eastbound	LT	D	D	D	D
		RT	D	D	C	C
	Northbound	LT	D	D	D	D
		TH	A	A	B	B
	Southbound	TH	C	D	C	C
		RT	B	B	B	B
Kamehameha Hwy/ Project Access Road	Westbound	LT	C	C	C	C
		RT	C	C	C	C
	Northbound	TH	A	A	B	B
		RT	A	A	A	A
	Southbound	LT	D	D	D	D
		TH	A	A	A	A

Note: Some improvements may occur between analyses scenarios resulting from the implementation of committed improvements.

located in previous sections of this report. The LOS calculations are included in Appendix H.

The cumulative volumes consist of site-generated traffic superimposed over Year 2025 projected traffic demands. The implementation of intersection and roadway improvements identified above for the *Year 2016 With and Without Koa Ridge Makai and Waiawa Developments* analysis scenario are also assumed since these improvements are expected to be funded and implemented by entities associated with developments in the vicinity. These development entities are currently formulating an Agreement to cost-share and schedule these improvements. The additional intersection and roadway improvements for the Year 2025 cumulative analysis include the proposed new Interstate H-2 Interchange at the existing Pineapple Road Overpass location. The operational and design analyses of the interchange shall be included in an Interstate Access Modifications Request report for consideration by the Federal Highway Administration. The request for modifications to the interstate system would be prepared by Castle & Cooke Homes Hawaii and administered through the State Department of Transportation (SDOT). Such a document should be identified in a Memorandum of Agreement (MOA) between both parties. Figure 30 shows a conceptual layout of the proposed interchange based on prior discussions with SDOT during the land planning stage of the project.

In addition, and given the anticipated poor operating conditions at the intersection Kamehameha Highway and the proposed project access road when considering unsignalized intersection controls, it is anticipated that the subject intersection would satisfy applicable traffic signal warrants in the future within the development of the project. Such warrants should be incrementally investigated as the project proceeds. Castle & Cooke Homes Hawaii has committed to install the traffic signal system at the intersection of Kamehameha Highway and the proposed project access road when warranted within the development of the project. As such, recognizing the anticipation



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PINEAPPLE ROAD INTERCHANGE CONCEPTUAL LAYOUT

FIGURE 30

of satisfying the traffic signal warrants prior to Year 2025, the intersection of Kamehameha Highway and the proposed project access road is herein analyzed under signalized conditions.

Traffic operations at the study intersections are expected to deteriorate to Year 2025 projected conditions with the development of the proposed project due to the anticipated increase in traffic in the vicinity. However, implementing additional intersection and roadway improvements identified above and previous sections of the report should alleviate much of the traffic operational deficiencies.

2. Interstate H-2 Freeway Segments

During the projected Year 2025 AM peak hour of traffic with the proposed project, the Interstate H-2 Freeway south of the Waipio Interchange would carry 4,562 vehicles northbound and 8,129 vehicles southbound. The northbound and southbound freeway segments along H-2 south of the Waipio Interchange would operate at LOS "B" and LOS "C" during the projected Year 2025 AM peak hour of traffic with the proposed project. Simulation modeling of traffic operations for this freeway segment resulted in no significant queuing. However, queuing further south as a result of spillback conditions from the Waiawa Interchange is expected to continue and is further discussed in later sections of this report. No vehicular queuing is expected in the northbound direction during the projected Year 2025 AM peak hour of traffic.

North of the Waipio Interchange, the Interstate H-2 Freeway would carry approximately 3,477 vehicles northbound and 4,984 vehicles southbound during the projected morning peak hours of traffic and would operate at LOS "B" and LOS "C", respectively. Simulation modeling of traffic operations for this freeway segment resulted in no significant queuing during the projected Year 2025 morning peak periods.

During the PM peak hours of traffic, the Interstate H-2 Freeway south of the Waipio Interchange would carry 9,193 vehicles northbound and 6,396 vehicles southbound. The northbound and southbound Interstate H-2 Freeway segments south of the Waipio Interchange would operate at LOS "E" and LOS "C" during the projected Year 2025 PM peak hours of traffic with the project. No significant queuing is expected along this freeway segment during the projected Year 2025 PM peak hours of traffic with the proposed project.

North of the Waipio Interchange, the Interstate H-2 Freeway is expected to carry approximately 5,529 vehicles northbound and 4,060 vehicles during the PM peak hours of traffic. This freeway segment is expected to operate at LOS "C" and LOS "B" for the northbound and southbound directions, respectively, during the PM peak hours of traffic. No significant queuing is expected along this freeway segment during the projected Year 2025 PM peak hours of traffic with the proposed project.

Further discussion on freeway segment operations and travel times during the morning and afternoon commute periods are presented in Section V of this report.

3. Waipio Interchange Ramp Merge/Diverge Operations

During projected Year 2025 AM peak hour traffic operations, the Interstate H-2 Freeway northbound off-ramp at the Waipio Interchange would operate at LOS "B", an improvement from existing conditions with the implementation of the committed loop on-ramp identified in earlier sections of this document. The existing configuration of the northbound on-ramp to service westbound Ka Uka Boulevard traffic east of the interchange destined to areas north via the northbound Interstate H-2 Freeway would continue to operate at LOS "B" conditions. The southbound loop on-ramp would operate at LOS "D" during the projected Year 2025 without the project while the existing southbound on-ramp accommodating eastbound Ka Uka Boulevard traffic destined to areas south via the Interstate H-2 Freeway would also operate at LOS "D". The southbound off-ramp would continue to operate at LOS "C" conditions during the same period. With the committed improvement to extend the northbound off-ramp capacity, merge and diverge conditions at all of the ramps would operate well with no anticipated queuing at the ramp and freeway interfaces for the projected Year 2025 AM peak hours of traffic with the proposed project.

During the projected PM peak hour of traffic, the northbound off-ramp at the Waipio Interchange would operate at LOS "F". To accommodate ramp diverge conditions, and to accommodate the ramp 95th percentile projected queue, the ramp must be extended 800 feet upstream from the ramp gore. As a result, based on simulation modeling, no resulting queuing effects would be anticipated on the freeway due to the proposed improvement to extend the ramp deceleration lane, including the committed improvement to provide two exclusive right-turn lanes downstream from the ramp and freeway interface. The northbound loop on-ramp would operate well at LOS "B" during the projected Year 2025 PM peak hour of traffic, while the existing configuration of the northbound on-ramp serving westbound traffic from areas east of the freeway also operate at LOS C" conditions.

The southbound loop on-ramp and existing southbound on-ramp configuration would both operate at LOS "C", while the southbound off-ramp also operate at LOS "C" during the projected Year 2025 PM peak hour of traffic. Based on modeling and traffic simulations, the merge and diverge operations are not expected to result in queuing on to the freeway.

Table 8.1 summarizes the freeway segments and ramp operations along the Interstate H-2 Freeway and at the Waipio Interchange for Year 2025 conditions with the proposed project.

Table 8.1: Summary of Year 2016 and 2025 (with project) Interstate H-2 Freeway Segment and Ramp LOS Operations

Freeway Segment/ Interchange Ramp	AM Peak		PM Peak	
	2016 w/ project	2025 w/ project	2016 w/ project	2025 w/ project
NB segment south of Waipio Interchange	B	B	D	E
NB segment north of Waipio Interchange	B	B	C	C
SB segment south of Waipio Interchange	D	D	C	C
SB segment north of Waipio Interchange	B	C	B	B
NB Off-ramp	B	B	F*	F*
NB On-ramp	B	B	B	C
NB Loop On-ramp	A	A	B	B
SB On-ramp	D	D	C	C
SB Loop On-Ramp	C	C	C	C
SB Off-ramp	C	C	C	C

* Although LOS F conditions, queuing as a result of ramp diverge operation is accommodated with the proposed ramp extension improvement.

V. COMMUTER TRAVEL TIME

A. General

South of the Waipio Interchange at approximately 2.5 miles along the Interstate H-2 Freeway is the Waiawa Interchange. The Waiawa Interchange represents the convergence and divergence of the Interstate H-1 and Interstate H-2 Freeways, serving traffic demands associated with the east, west, and north regions of the island. Connecting ramps are provided at the interchange as well as on- and off-ramps linking with the surrounding surface streets. The Interstate H-2 Freeway includes three lanes each in the northbound and southbound directions just north of the Waiawa Interchange, while the Interstate H-1 Freeway has three eastbound travel lanes west of the interchange and five eastbound travel lanes east of the interchange.

In the westbound direction, five lanes are provided east of the interchange and four lanes are provided on the west side. An additional eastbound shoulder lane is provided during the morning peak periods of traffic east of the interchange, and a concurrent eastbound zipper lane is provided beginning from a location west of the interchange and ending at the Keehi Interchange. Beyond the Keehi Interchange the zipper lane transitions to a contra-flow lane along Nimitz Highway until just before Pacific Street.

B. Existing Travel Times

The evaluation of the regional roadway facilities is based on traffic data collected by the State Department of Transportation in Year 2005, and supplemented with additional information collected or contained in other studies for the region. In addition, field investigations of freeway operations were conducted on various days of the week during the months of January and February 2008 including travel time survey between Mililani Interchange, through the Waipio Interchange, and Kaahumanu Street Overpass, just beyond the Waiau Interchange. The travel time analysis was limited to the freeway segments of the Interstate H-1 and H-2 freeways between the Mililani Interchange and the Kaahumanu Street Overpass to minimize external effects that are not associated with Central Oahu traffic demands. Beyond the travel time analysis limits, external effects can greatly influence travel time characteristics resulting n unreliable traffic simulations and possibly inaccurate traffic modeling and analysis techniques. The travel time data was collected utilizing Global Positioning System (GPS) devices connected to other devices storing continuous data throughout the travel time survey. Travel time survey run data is processed via the *PC-Travel* software developed by Jamar Technologies, Inc.

Travel time surveys were conducted in September 2008 at 15-minute intervals between the hours of 5:00 AM to 8:00 AM in the morning and between the hours of 3:00 PM and 6:00 PM in the afternoon. Table 9 shows the travel time data between the Mililani Interchange and the Kaahumanu Street Overpass along the Interstate H-1 and H-2 Freeways. The table includes travel time run surveys for both the northbound and southbound directions of the freeway.

Table 9: Existing Travel Time Data
Between Mililani IC (H-2) and Kaahumanu St OP (H-1)

AM Peak Period		
Start Time	**Travel Time (minutes)**	
	Northbound	**Southbound**
5:00 AM	6.95	8.03
5:15 AM	6.94	8.58
5:30 AM	6.76	9.30
5:45 AM	6.48	15.32
6:00 AM	6.71	10.07
6:15 AM	6.54	13.95
6:30 AM	7.14	15.82
6:45 AM	6.78	11.82
7:00 AM	6.78	9.95
7:15 AM	7.13	12.18
7:30 AM	8.66	9.57
7:45 AM	6.41	8.08
8:00 AM	6.65	7.87
PM Peak Period		
Start Time	**Travel Time (minutes)**	
	Northbound	**Southbound**
3:00 PM	7.75	7.85
3:15 PM	8.05	7.91
3:30 PM	8.00	8.12
3:45 PM	7.50	8.60
4:00 PM	7.88	8.16
4:15 PM	7.82	8.16
4:30 PM	8.50	8.47
4:45 PM	9.08	8.00
5:00 PM	8.48	8.11
5:15 PM	8.65	8.19
5:30 PM	7.90	8.59
5:45 PM	8.70	8.08
6:00 PM	8.15	7.94

Vehicular queuing occurs in the vicinity of the Waiawa Interchange during the morning commute periods, with the southbound Interstate H-2 Freeway queues extending approximately 4,300 feet from the interchange, or one-third the distance to the Waipio Interchange at Ka Uka Boulevard. This freeway segment services approximately 5,000 vehicles southbound during the peak morning traffic periods. Along the eastbound Interstate H-1 Freeway, just beyond the Waiawa Interchange, the freeway segment operates at LOS "E" during the morning peak periods and services 13,000 eastbound vehicles. At the H-1/H-2 merge of the Waiawa Interchange, queues along the eastbound Interstate H-1 Freeway oftentimes extend from the Waiawa Interchange to the Paiwa (Waikele) Interchange during the morning peak periods. This queue would extend beyond the Paiwa Interchange on occasions when an incident on the freeway impedes traffic flow.

During the afternoon peak periods of traffic, the predominant traffic volumes occur in the westbound direction. Along the westbound Interstate H-1 Freeway, traffic queues oftentimes extend upstream through the Waiau Interchange and beyond the Halawa Interchange. Just east of the Waiawa Interchange, the westbound lanes of the Interstate H-1 Freeway segment operate at LOS "E" during the afternoon peak periods of traffic and services approximately 10,500 vehicles during the peak hour.

C. Projected Traffic Conditions

Traffic demands for projected Year 2016 and Year 2025 conditions were simulated utilizing computer traffic simulation programs to identify travel time differences resulting from the addition of the Koa Ridge Makai and Waiawa developments. Traffic generation determined in the traffic impact analysis were superimposed over projected analysis year conditions and simulated to determine the differences in travel times between the control survey points. The simulations were conducted for the southbound direction on Interstate H-2 Freeway and the eastbound Interstate H-1 Freeway segments between the route termini points. The simulations were conducted for the projected AM peak period only representing the worse traffic flow condition traveling through the Waiawa Interchange. The traffic simulation assumes that the roadway network would remain the same as existing with no regional or localized transportation infrastructure modifications implemented to improve the traffic flow characteristics along the survey route. Travel time run simulations indicate an increase in travel times of approximately two to five minutes for the various 15-minute intervals throughout morning period for Year 2016 and approximately three to seven minutes over existing baseline conditions for Year 2025.

Table 10 shows the travel time simulation results for the route from the Mililani Interchange to the Kaahumanu Street Overpass along the Interstate H-2 and H-1 Freeways for projected morning commute conditions. The table includes travel time simulation results for the town-bound direction of the freeways.

Table 10: Existing and Projected Travel Time Between Mililani IC (H-2) and Kaahumanu St OP (H-1)

AM Peak Period – Southbound (Town-bound)			
Start Time	Travel Time (minutes)		
	Existing	Projected Year 2016	Projected Year 2025
5:00 AM	8.03	9.93	13.14
5:15 AM	8.58	11.07	15.01
5:30 AM	9.30	12.52	15.55
5:45 AM	15.32	20.42	22.60
6:00 AM	10.07	19.05	21.08
6:15 AM	13.95	19.06	21.00
6:30 AM	15.82	21.03	22.83
6:45 AM	11.82	16.87	17.32
7:00 AM	9.95	13.45	16.34
7:15 AM	12.18	16.38	17.88
7:30 AM	9.57	12.17	13.77
7:45 AM	8.08	10.38	11.02
8:00 AM	7.87	10.07	10.89

It should be noted that the projected travel time run results reflect conditions over the existing roadway network with no improvements to the roadway infrastructure or consideration of the ancillary benefits of the City and County of Honolulu Rail Transit project. It is expected that travel times would reduce when incorporating these factors. The travel time results, however, provide a measure of impacts associated with the proposed developments over the existing regional roadway network and existing traffic demands.

At the Waiawa Interchange, queuing would continue to occur in the vicinity during the morning commute periods with the southbound Interstate H-2 queues extending approximately 8,000 feet or about one-half the distance between the Waiawa Interchange and the Waipio Interchange in the Year 2016 with the proposed developments in the Central Oahu region. At Year 2025, the southbound Interstate H-2 queues would extend approximately 10,000 feet from the Waiawa Interchange, or approximately two-thirds of the distance to the Waipio Interchange. Both periods would operate at LOS "F" conditions. This freeway segment would service approximately 7,000 vehicles and approximately 8,700 vehicles during the projected peak morning traffic periods in years 2016 and 2025, respectively. Along the eastbound Interstate H-1 Freeway, just beyond the Waiawa Interchange, the freeway segment would also operate at LOS "F" during the projected morning peak periods and would service approximately 17,000 and 19,500 vehicles in years 2016 and 2025, respectively.

During the afternoon peak periods of traffic, the predominant traffic volumes would continue to occur in the westbound direction as a result of significant future developments expected on the west side of the island. Along the westbound Interstate H-1 Freeway, traffic queues would continue to extend upstream through the Waiau Interchange and beyond the Halawa Interchange. Just east of the Waiawa Interchange, the westbound lanes of the Interstate H-1 Freeway segment would operate at LOS "F" during the projected afternoon peak periods of traffic for both Year 2016 and Year 2025, and would service approximately 15,000 and 16,500 vehicles during the projected afternoon peak hours, respectively.

VI. RECOMMENDATIONS

A. General

Based on the analysis of the traffic projections, the following are general recommendations of this study associated with existing and projected conditions:

1. Consider formulating and executing a Memorandum of Agreement with the State Department of Transportation identifying the necessary mitigating measures as a result of the project, funding strategies and commitments, and implementation schedules.

2. Maintain sufficient sight distance for motorists to safely enter and exit all project driveways, intersections, and roadways.

3. Design all improvements following applicable standards as required by the governmental agencies and obtain approvals as applicable.

4. Minimize the number of median breaks along Ka Uka Boulevard to facilitate the movement of through traffic along the roadway. Where median breaks occur, provide auxiliary lanes to minimize the impact of turning vehicles on through traffic.

5. Consideration should be given to the required turning radius for large vehicles during the geometric design of the roadways to accommodate vehicles from the nearby industrial uses.

6. Ensure that all pedestrian facilities including walkways and crossings are ADA compliant.

B. Year 2016

1. Without Koa Ridge Makai and Waiawa Developments

Traffic conditions in the project vicinity are anticipated to deteriorate under *Year 2016 Without Koa Ridge and Waiawa Developments*. The analysis of the traffic data, which includes trips generated by other major developments in the region based on assumed development absorption schedules, result in the following recommendations to improve the projected *Year 2016 Without Project* traffic conditions:

At the intersection of Ka Uka Boulevard and the Interstate H-2 northbound on- and off-ramps, provide or construct the following:

- Two exclusive right-turn lanes on the Interstate H-2 northbound off-ramp approach.
- Northbound loop on-ramp in the southeast quadrant of the Waipio Interchange. Relocate the northbound off-ramp to accommodate the new loop on-ramp.
- Four eastbound lanes east of the Waipio Interchange northbound on- and off-ramps to accept two free-flow right-turn lanes from the off-ramp and two eastbound through lanes on Ka Uka Boulevard.
- Two through movement lanes and an exclusive right-turn lane on the westbound approach of Ka Uka Boulevard.
- Two through lanes on the eastbound approach of Ka Uka Boulevard.

- Widen the Interstate H-2 northbound off-ramp to two ramp diverge lanes to accommodate two northbound left-turn lanes and two exclusive right-turn lanes at the ramp junction of Ka Uka Boulevard.

At the intersection of Ka Uka Boulevard and the Interstate H-2 southbound on-ramps, provide or construct the following:

- Southbound loop on-ramp to the Interstate H-2 freeway in the northwest quadrant of the Waipio Interchange.
- One through lane, a shared through and right-turn lane, and an exclusive right-turn lane on the eastbound approach of Ka Uka Boulevard.
- One through lane and a shared through and right-turn lane on the westbound approach of Ka Uka Boulevard.

At the intersection of Ka Uka Boulevard with the Interstate H-2 southbound off-ramp and Moaniani Street, provide or construct the following:

- Two exclusive left-turn lanes and two through lanes on the westbound approach of Ka Uka Boulevard.
- Two southbound departure lanes along Moaniani Street to accept the double left-turn lanes from westbound Ka Uka Boulevard.
- Three lanes on the Interstate H-2 southbound off-ramp approach to accommodate an exclusive left-turn lane, a shared left-turn/through lane, and an exclusive right-turn lane.
- Widen Ka Uka Boulevard between Moaniani Street and the Interstate H-2 southbound on-ramp (from west) to accommodate an additional eastbound lane providing free-flow movement from northbound right-turn Moaniani Street.
- Modify the traffic signal phasing at the intersection to allow for simultaneous left-turn movements on the northbound and southbound approaches. Intersection geometry may need to be adjusted to provide adequate vehicle spacing to accommodate turning maneuvers.

At the intersection of Ka Uka Boulevard and Ukee Street (east), provide or construct the following:

- Install traffic signal system (2-phase). Coordinate with other traffic signal systems along Ka Uka Boulevard.

At the intersection of Ka Uka Boulevard and Kamehameha Highway, provide or construct the following:

- Modify the traffic signal phasing at the intersection to allow for simultaneous left-turn movements on the eastbound and westbound approaches.
- Provide an exclusive left-turn lane, a through lane, and two exclusive right-turn lanes on the westbound approach of Ka Uka Boulevard. Intersection geometry may need to be adjusted to accommodate the necessary approach laneage.

At the intersection of Lumiaina Street and Kamehameha Highway, provide or construct the following:

- Provide an additional eastbound left-turn lane that results in an exclusive left-turn lane, a shared left-turn/through lane, and an exclusive right-turn lane on the Lumiaina Street intersection approach.
- Modify traffic signal system operations to permit split phases for the eastbound and westbound approaches of Lumiaina Street.

At the intersection of Waipahu Street and Kamehameha Highway, provide or construct the following:

- Provide an additional eastbound left-turn lane on the eastbound approach of Waipahu Street that results in separate left-turn and right-turn lanes with a southbound intersection departure lane on Kamehameha Highway to accommodate the new eastbound right-turn lane.
- Modify traffic signal system operations to permit phasing for eastbound right-turn movements.

2. With Koa Ridge Makai and Waiawa Developments

The following are additional recommendations of this study to accommodate *Year 2016 With Castle & Cooke Project* conditions, and to improve traffic operations in the vicinity as a result of the proposed project and other projects in the region. These additional recommendations assume that committed improvements identified in the *without project* scenarios will be implemented with those listed below.

At the intersection of Ka Uka Boulevard with the Interstate H-2 northbound on- and off-ramps, provide or construct the following:

- Modify the existing Interstate H-2 northbound off-ramp to provide two exclusive left-turn lanes and a shared left-turn/through movement lane.
- Widen Ka Uka Boulevard west of the off-ramp junction at Ka Uka Boulevard to provide three westbound lanes.

- Extend off-ramp deceleration length 800 feet upstream from the ramp diverge point.

At the intersection of Ka Uka Boulevard with the Interstate H-2 southbound off-ramp and Moaniani Street, provide or construct the following:

- Modify southbound approach to include an exclusive left-turn lane, a through lane, and an exclusive right-turn lane.
- Modify the traffic signal phasing at the intersection to allow for simultaneous left-turn movements on the northbound and southbound approaches. Intersection geometry may need to be adjusted to provide adequate vehicle spacing to accommodate turning maneuvers.

At the intersection of Ka Uka Boulevard with the Commercial Driveway and New Spine Road, provide or construct the following:

- Three lanes on the southbound approach of the Spine Road to accommodate two exclusive left-turn lanes and a shared through and right-turn lane.
- Provide an exclusive right-turn lane on the westbound approach of Ka Uka Boulevard between the H-2 southbound off-ramp and Spine Road.
- Install traffic signal system with protected left-turn movements along Ka Uka Boulevard.

At the intersection of Kamehameha Highway and the Proposed Project Access Road, provide or construct the following:

- Construct intersection to provide separate turning lanes on the westbound approach of the Project Access Road, and separate turning lanes for southbound left-turn and northbound right-turn movements of Kamehameha Highway to maintain through traffic flow through the intersection.
- Monitor traffic operations at the intersection and install traffic signal system when warranted. The traffic signal warrant monitoring shall proceed at 3-year intervals from start of first occupancy and shall continue until occupancy at full-build-out or when the traffic signal is warranted, whichever occurs first. Coordinate warrant study with and obtain approval from the State Department of Transportation.
- Intersection geometric design shall be reviewed and approved by the State Department of Transportation and coordinated with the planning, design, and construction of the future widening by the State Department of Transportation of Kamehameha Highway in the vicinity of the proposed Project Access Road.

C. Year 2025 With Koa Ridge Makai and Waiawa Developments

The Year 2025 With Koa Ridge and Waiawa Developments will increase traffic demands in the project vicinity. However, in addition to the proposed new interchange at the Pineapple Road Overpass, improvements identified in the *Year 2016 with and without project* analyses should be able to accommodate the anticipated increases in traffic demand at the study intersections at Year 2025. Modifications to the interstate system require the preparation and approval of an Interstate Access Modifications Request by the State Department of Transportation, with ultimate approving authority by the Federal Highway Administration.

Further strategies to reduce traffic demands in the region and improve traffic operations are offered for consideration. These Transportation Demand Management (TDM) strategies are related to land use planning concepts and operations of the individual land uses. The following are TDM strategies for considerations that may be applied to commercial, office, or similar applicable land uses to further mitigate traffic impacts to the surrounding roadways in the vicinity:

1. Implement flexible or staggered work shift times for employees when possible to minimize trips during peak periods of traffic.

2. Establish a bus pass program for employees to encourage the use of public transit. This initiative may be in the form of a subsidized program as an incentive to attract employees to use public transit as a mode of travel.

3. Provide adequate and secure bicycle parking areas to encourage the use of alternate modes of travel.

4. Encourage ride-sharing and establish a program to identify employees of same work shifts and similar travel routes that potentially may carpool together. The program should be initiated by surveying the work force and coordinating the matching of employees desiring to participate in the ride-sharing program. The program may also consider the assignment of convenient parking stalls for carpooling vehicles, as well as, discounted parking rates as incentives.

5. Restrict deliveries to off-peak hours when possible to minimize trips during peak periods of traffic.

In addition, for the residential uses within the development, some or all of the following land use planning strategies and concepts could be considered:

1. Design mixed-use components within the project to reduce the use of regional transportation facilities.

2. Provide multiple or alternate routes within the project that promote connectivity concepts to lessen the reliance on specific travel routes.

3. Provide a system of safe and usable pedestrian routes.

4. Provide safe and secure bike facilities.

5. Consider park-and-ride lots on or in the vicinity of the project coinciding with supporting transit service.

Detailed discussions of these and other strategies are included in *Castle & Cooke Koa Ridge Makai and Waiawa Project, Alternative Transportation Components,* prepared by Weslin Consulting Services, Inc., dated November 2008, and included as Appendix F of this report.

VII. OTHER CONSIDERATIONS

A. City Rail System Benefits

The proposed Honolulu High-Capacity Transit Corridor Project is intended to increase east-west mobility on Oahu's most heavily congested corridor. As described in the November 2008 Draft EIS, the transit project is intended to:

- provide faster, more reliable public transportation service than can be achieved with buses operating in congested mixed-flow traffic
- provide reliable mobility in areas of the corridor having with people of limited income, an aging population and rapidly developing areas
- provide additional transit capacity and an alternative to the automobile, and
- moderate anticipated traffic congestion in conjunction with other improvements included in the Oahu Regional Transportation Plan 2030 (ORTP)

The rapid transit system alignment does not extend to Central Oahu, however, Central Oahu commuters would benefit to the extent that the Interstate H-1 freeway corridor from Kapolei to the Waiawa Interchange experiences capacity relief and there is a reduction in traffic congestion on the H-1 Freeway to and from the west. The transit's Draft EIS reports that total congestion would be reduced by 23 percent with the transit improvements.

Although not directly served by the rail system, Central Oahu commuters can make use of a complementary system to realize the benefits of travel mode choices afforded to those along the proposed route. This would be in the form of transit system feeder buses or shuttles traveling between established and planned park-and-ride facilities and the rail transit stations. The current community service and long haul bus routes would need to be modified to provide connections between users and these stations. Existing park-and-ride lots in Central Oahu and existing and proposed bus transit stations could be integrated with the high-capacity transit system with modified shuttle services supporting the high-capacity transit system.

A major transit station and supporting park-and-ride facility are planned in the vicinity of the Pearl Highlands Shopping Center (Kamehameha Highway at Kuala Street). The Pearl Highlands Station on approximately 11 acres will have a parking structure with 1,600 parking stalls for Park-and-Ride commuters. Central Oahu commuters will benefit from the construction of a new direct access ramp from the H-2 Freeway. The ramp connection will allow both bus transit vehicles and park-and-ride automobiles direct access with the proposed Pearl Highlands Transit Station park-and-ride lot. Of all the stations along the rail route, the Pearl Highlands Station is expected to have the highest number of boardings in the morning two-hour peak period. The Park-and-Ride Lot at Pearl Highlands with 1,600 stalls is the largest of four proposed park-and-ride lots, and is the only one with structure parking. Discussion on proposed modified bus service routes and system is included in *Castle & Cooke Koa Ridge Makai and Waiawa Project, Alternative Transportation Components,* prepared by Weslin Consulting Services, Inc.

The transit project's construction phasing has the East Kapolei to Pearl Highlands segment as the first of four phases of development. Central Oahu commuters thus would be one of the early beneficiaries of the rail transit project. Upon build-out in 2018, Central Oahu commuters can be expected to benefit from the following transit project effects:

- improved transit service mobility, reliability, equity, and access,
- decline in vehicle miles traveled, vehicle hours traveled, and vehicle hours of delay, and

- improved transit travel times between major employment centers in Downtown and West Oahu.

B. Regional Transportation Improvements and Issues

1. General

A number of regional transportation projects are planned in the vicinity that are in various stages of planning and implementation. These projects are identified in the Oahu Regional Transportation Plan, 2030 (ORTP), that serve as a planning document to address mobility issues and transportation needs for the island of Oahu. The plan is intended to integrate growth patterns of the island's communities recognizing available financial resources over the next 25 years. The plan identifies transportation projects and outlines an implementation program based on available transportation funds to incorporate mid- and long-range projects for the island. The following are transportation projects in the region identified in the ORTP.

2. H-1 Widening of Westbound lanes between Waiau Interchange and Waiawa Interchange

The proposed Interstate H-1 Freeway widening project of the westbound lanes between Waiau Interchange and the Waiawa Interchange includes improvements to provide an additional travel lane in the westbound direction for general-purpose use. This segment of the freeway includes five existing westbound lanes. An additional lane would provide a total of six westbound travel lanes east of the Waiawa Interchange. During the morning peak period of traffic, the deployment of the eastbound zipper lane utilizes two of the westbound lanes resulting in a total of three westbound lanes at this freeway section. Near the Waiawa Interchange, two of the resulting three westbound lanes are used for the Waipahu exit and connections to the northbound Interstate H-2 Freeway. The remaining single lane services all of the westbound traffic beyond the Waiawa Interchange during the morning peak periods of traffic. Immediately east of the Waiawa Interchange during eastbound zipper lane deployment, there are three westbound lanes. During periods other than the morning peak, the additional lane would provide a total of six westbound lanes immediately east of the Waiawa Interchange and four westbound lanes through the interchange, with two westbound lanes transitioning to the northbound Interstate H-2 Freeway. This widening project provides added westbound capacity through this section of the freeway at an estimated construction cost of $137,500,000 (2005 dollars). The ORTP identifies this project as a congestion relief project to be implemented within the 2006 and 2015 timeframe.

3. H-1 Widening of Westbound lanes between Waiawa Interchange and Paiwa Interchange

The proposed Interstate H-1 Freeway widening project of the westbound lanes between Waiawa Interchange and Paiwa Interchange includes improvements to provide an additional general-purpose travel lane in the westbound direction and accompanying freeway shoulder improvements. The additional lane would serve as a continuation of the westbound freeway widening efforts along the Interstate H-1 Freeway providing additional freeway capacity in that direction. During the morning peak periods of traffic when the eastbound zipper lane is deployed, two existing lanes near the Waiawa Interchange are provided to service westbound traffic. During other time periods, four existing westbound lanes are provided. The additional lane would result in a total of three westbound lanes during the morning peak periods and five westbound travel lanes during other periods of the day without the deployment of the eastbound zipper lane at this section of the freeway. The additional lane would improve westbound traffic flow through the freeway section during all periods of the day at an estimated construction cost of $6,900,000 (2005 dollars). The ORTP identifies this project as a congestion relief project to be implemented within the 2006 and 2015 timeframe.

4. H-1 PM Zipper Lane from Keehi Interchange to Kunia Interchange

The PM westbound zipper lane from the Keehi Interchange to Kunia Interchange along the Interstate H-1 Freeway during the afternoon peak periods would improve westbound traffic flow by creating additional freeway capacity. The westbound zipper lane would be deployed using moveable concrete barriers similar to those provided for the eastbound zipper lane along the Interstate H-1 freeway to service eastbound traffic flow during the morning peak periods. Previous studies indicate that traffic demand along the Interstate H-1 Freeway is expected to increase by approximately 1.5% to 2% per year based on historical trends. As such, future westbound operating conditions along the Interstate H-1 Freeway would operate poorly at LOS "E" or worse conditions. Deployment of an afternoon zipper lane would improve westbound operating conditions by providing added freeway capacity. However, an afternoon westbound zipper lane would generally utilize two eastbound lanes on the freeway. With the increase in traffic demands also occurring in the eastbound direction of the freeway, the use of two lanes in the eastbound direction to service westbound traffic flow would result in poor traffic operating conditions for eastbound commuters. Additional freeway capacity with the use of existing available shoulder lanes in the eastbound direction would be necessary to accommodate the use of eastbound lanes for a westbound zipper lane. Other improvements to the eastbound lanes of the freeway may be necessary to accommodate the afternoon zipper lanes along the Interstate H-1 Freeway. With the deployment of an afternoon zipper lane, and the use of an eastbound shoulder lane along the Interstate H-1 Freeway, the eastbound traffic flow would operate at LOS "E" or better conditions while considerable improvement to the operating levels of service for the westbound direction during the afternoon peak periods of traffic along the Interstate H-1 Freeway occur in the immediate future. The estimated cost of this project is $19,900,000 (2005 dollars) identified for construction within the 2006 and 2015 timeframe and described as a congestion relief project in the ORTP.

5. H-1 Waipahu Westbound off-ramp Widening

The Interstate H-1 Freeway Waipahu Street westbound off-ramp widening project includes the construction of an additional off-ramp lane to facilitate traffic movement exiting the freeway. The additional off-ramp lane would connect to westbound Kamehameha Highway/Farrington Highway with direct access to Waipahu town and surrounding communities. During the existing afternoon peak hours of traffic, the off-ramp is generally congested with vehicles exiting the freeway. The congestion oftentimes impedes traffic flow in the westbound and northbound directions. An additional off-ramp lane would provide increased capacity resulting in improvements to both westbound and northbound traffic flows of the Interstate H-1 and H-2 Freeways, respectively. The estimated cost of this project is $11,700,000 (2005 dollars) identified for construction within the 2006 and 2015 timeframe and described as a congestion relief project in the ORTP.

6. H-2 Waipio Interchange on- and off-ramps and Ka Uka Overpass Widening

The Interstate H-2 Waipio Interchange on- and off-ramps, and Ka Uka Overpass widening project includes the widening of the ramps to facilitate traffic movements through the interchange. These improvements include separate turning lanes and intersection modifications that will provide additional storage capacity and improved traffic flow at the ramp junctions of the interchange. In addition, this project includes the widening of the Ka Uka Overpass to include a total of seven lanes and includes the extension of existing turning lanes or provisions for separate turning lanes providing additional storage capacity at the on- and off-ramp intersections. These improvements are intended to improve intersection operations at the ramp junctions and provide additional capacity to accommodate increased traffic demands. The estimated cost of this project is $20,700,000 (2005 dollars) identified for construction within the 2006 and 2015 timeframe and described as a congestion relief project in the ORTP.

7. H-1/H-2 Merge Eastbound Transition Lane

The Interstate H-1/H-2 Merge Eastbound Transition Lane project is to improve the merging characteristics between the southbound Interstate H-2 Freeway and the eastbound Interstate H-1 Freeway with additional transition lanes. The Interstate H-1 and H-2 merge is the convergence of three southbound lanes on the Interstate H-2 freeway and three eastbound lanes on the Interstate H-2 to a total of five lanes. The bottleneck condition in addition to the eastbound Waipahu on-ramp traffic demands oftentimes result in queuing at the Waiawa Interchange on both the southbound Interstate H-2 and eastbound Interstate H-1 freeways during the morning peak periods of traffic. The removal of the bottleneck condition is expected to improve southbound and eastbound traffic flows on the freeways. The estimated cost of this project is $45,500,000 (2005 dollars) identified for construction within the 2006 and 2015 timeframe and described as a congestion relief project in the ORTP.

8. H-1 Widening of Eastbound lanes from Waiawa Interchange to Halawa Interchange

The proposed Interstate H-1 Freeway widening project of the eastbound lanes between Waiawa Interchange and the Halawa Interchange includes improvements to provide an additional general purpose travel lane in the eastbound direction and associated freeway shoulder improvements. Currently, portions within this section of freeway include a shoulder lane used by motorists during restricted morning peak periods of traffic, providing added freeway capacity. The existing shoulder lane will be upgraded to a general-purpose lane providing some increase in freeway capacity. Between the Waiau Interchange and Waiawa Interchange, the widening of the freeway viaduct may be necessary to accommodate an additional lane. New freeway shoulders will also be provided for clearances, drainage, and emergency uses. The new lane would be available to motorists throughout the day and is intended to improve traffic flow and increase safety through the freeway section for eastbound motorists. The estimated construction cost for this project is $251,300,000 (2005 dollars). The ORTP identifies this project as a congestion relief project to be implemented within the 2016 and 2030 timeframe.

9. Pineapple Road Interchange and Overpass Widening

The Pineapple Road Interchange and Overpass Widening project is located along the Interstate H-2 Freeway between the Waipio Interchange and the Mililani Interchange. The project entails the development of a full-service freeway interchange to accommodate future developments in Central Oahu and surrounding regions. The project also includes the widening of the Pineapple Road Overpass from two lanes to four lanes to accommodate anticipated traffic demands at the interchange. Although the Castle & Cooke Waiawa Development is not expected to connect directly with the proposed Pineapple Road Interchange since there is no feasible connection available, the Koa Ridge Makai development proposes the construction of interchange ramps at this location to facilitate access for the development and relieve traffic demand at the Waipio Interchange. Although the ORTP indicate an estimated cost of $50,000,000 to implement a full-service interchange at the Pineapple Road Overpass, that figure may be significantly under-estimated given the slope requirements of associated service ramps relative to the existing longitudinal grades of the freeway and existing terrain in the vicinity. The ORTP identifies this project as a congestion relief project to be implemented within the 2016 and 2030 timeframe.

10. Elevated reversible 2-lane highway from Waiawa Interchange to Keehi Interchange

A permanent elevated reversible 2-lane highway along the Interstate H-1 freeway between the Waiawa and Keehi Interchanges would function similar to a zipper lane deployment between the two interchanges to service unbalanced directional traffic flows. However, two lanes would provide double the operating capacity of a single zipper lane configuration. A reversible roadway is intended to service imbalanced traffic flows associated with daily commuter traffic periods without impacting opposing traffic flow, as would a zipper lane deployment. During the morning peak periods, the reversible roadway would service eastbound flow along the Interstate H-1 Freeway, and westbound flow during the afternoon peak periods. Permanent reversible lanes could also provide alternate routes, additional directional freeway capacity, and circulation improvements during freeway lane closures for construction or maintenance work in the associated general-purpose lanes, major events at the Halawa Stadium or other venues with high trip generating characteristics, as well as provide additional freeway capacity to facilitate evacuations or other emergencies. Since the elevated roadway would be a permanent structure, links and termini points of connections with the surface streets and freeway require special consideration that minimize impacting the movement, circulation, and safety of those facilities. The estimated construction cost for this project as identified in the ORTP is very high at $2,500,000,000 (2005 dollars). The ORTP also identifies this project as a congestion relief project and is characterized as an Illustrative Project. An Illustrative Project may be considered as a potential project in the regional transportation plan that could prove beneficial as a transportation improvement and is considered as a high priority project for potential inclusion to the regional transportation plan should funding become available. However, Illustrative Projects are not considered part of the official regional transportation plan. Therefore, no timeframe is set in the ORTP for these types of projects.

11. Central Mauka Road

The Central Mauka Road project is intended to provide a second or alternate route along the east side of the Interstate H-2 corridor between Waiawa and Mililani Mauka. The roadway would connect Kamehameha Highway in Pearl City and Meheula Parkway in Mililani Mauka with connections at available interchanges along the route. The roadway is planned as a four-lane roadway with channelized intersections along the alignment with connecting roads at the interchanges along the Interstate H-2 freeway. Several long bridges are expected given the existing terrain in the vicinity. The Central Mauka Road would provide additional capacity servicing north-south mobility. Such a roadway may also provide connectivity with other regions in Central Oahu, reduce future traffic demands along existing transportation facilities, and service as an additional or alternate route at times of emergency. The estimated construction cost for this project is $160,000,000 (2005 dollars). The ORTP identifies this project as a second access project to be implemented within the 2016 and 2030 timeframe. The major challenges facing the project are its high cost of construction in light of dwindling local resources, and because the proposed Central Mauka Road is not a part of the State Highway System and thus is not eligible for federal highways funding.

12. Kamehameha Highway Paiwa Road Connection

The Paiwa Road Extension project includes the northward extension of the roadway in Waipahu at Lumiauau Street in Waikele to the Kamehameha Highway intersection with Ka Uka Boulevard. The roadway extension would connect the immediate communities of Waipio, Waikele, and Waipahu. The roadway extension would provide an alternate route in the region and improve circulation in the vicinity, as well as provide connectivity and access between the existing roadway facilities. However, it is acknowledged and understood that the majority of the surrounding neighborhood residents do not support the project. The estimated construction cost for this project as identified in the ORTP is $15,000,000 (2005 dollars). The ORTP also identifies this project as a congestion relief project and is characterized as an Illustrative Project. An Illustrative Project may be considered as a potential project in the regional transportation plan that could prove beneficial as a transportation improvement and is considered as a high priority project for potential inclusion to the regional transportation plan should funding become available. However, Illustrative Projects are not considered part of the official regional transportation plan. Therefore, no timeframe is set in the ORTP for these types of projects.

13. Kamehameha Highway Widening

The State Department of Transportation is currently pursuing Kamehameha Highway widening project. The project includes the widening of the highway from a three-lane undivided roadway to a four lane divided roadway between Lanikuhana Avenue in Mililani and Ka Uka Boulevard in Waipio. The highway widening will provide added service capacity and improve safety along the alignment, and will provide a continuous four-lane roadway between Waipio and Mililani. The estimated construction cost for this project is $78,900,000 (2005 dollars). The ORTP identifies this project as a congestion relief project to be implemented within the 2006 and 2015 timeframe.

14. H-2 Park-and-Ride Facility

A park-and-ride facility has been considered within the median of the Interstate H-2 Freeway, just north of the Waipio Interchange. Such a facility was recommended in a 2003 Mililani Mauka Park-and-Ride study and also referenced in the 2006 Alternatives Analysis report for the City's Rail Transit project. In the City's most recent Draft EIS, however, this H-2 median park-and-ride facility was no longer being considered, as the Pearl Highlands Station incorporates a large 1,600-stall park-and-ride structure with a direct access ramp from the H-2 freeway.

The Alternative Transportation Components report (Weslin, 2008) considered the center median island as an option for an H-2 Freeway Flyer Transit Station. A regional bus station could be created in this median island between the Ka Uka Boulevard Bridge and the Pineapple Road bridge. The median island is up to 250 feet wide and 2,000 feet long providing an ample footprint for such a facility consistent with comparable projects in Seattle and Los Angeles without interference with other interchange traffic movements. An H-2 Freeway Flyer Transit Station would use direct access ramps from the existing H-2 HOV lanes. Access to the Station would be by a pedestrian and bicycle only bridge over H-2 with direct, curb-separated, safely designed pathway connections integrated with the Koa Ridge Makai site. Such pedestrian and bicycle only bridges are being increasingly used worldwide to connect major mixed use developments across both natural and manmade barriers.

C. Secondary and Cumulative Impacts on Transportation Infrastructure

Cumulative impacts are typically defined as the effects on the environment which result from the incremental impact of a project when added to past, present, and reasonably foreseeable future actions. The estimation of future impacts is important for cumulative impact analysis. However, the focus must be on "reasonably foreseeable" actions which are those that are likely to occur or probable, rather than those that are merely possible or subject to speculation. The prediction of reasonably foreseeable impacts thus requires judgment based on information obtained from reliable sources such as adopted plans and similar documents.

Based upon this framework, the methodology used in the traffic analysis does take into account and evaluate the cumulative impacts on transportation infrastructure. The methodology used in the traffic study utilizes an approach that is applicable to a reasonable approach in evaluating cumulative impacts which are explained below.

1. Establish the geographic scope for the analysis. The scope of the study was regional in nature and included several major intersections, interchanges, the Interstate H-2 Freeway, and Kamehameha Highway as described in Sections I and II of this report. This study area was also determined based upon consultations with the State DOT. An assessment was also undertaken of the Waiawa Interchange (H-1/H-2 merge) in terms of commuter travel time effects.
2. Establish the timeframe for the analysis. The timeframe for the analysis included the project's build-out year of 2025 along with an interim study year of 2016.

3. Characterize the infrastructure system. The existing transportation system and present levels of operation was discussed in Section III.
4. Identify other developments or improvements affecting the transportation infrastructure in the study area. The study fully incorporates the Waiawa Ridge Development's development schedule over the project period. Information from the ORTP was also utilized because it serves as a guide for the development of the major surface transportation facilities and programs to be implemented on Oahu. For longer range studies, use of the report's information more accurately reflects the anticipated impacts of traffic growth in the region than the use of historical traffic count data because it is based upon statewide population, employment, and visitor forecasts, and is thus a reliable source.
5. Define a baseline condition for the infrastructure system for which future impacts can be identified and evaluated. The traffic study developed future projections and established conditions without the project that serves as the baseline condition for which project related effects can be identified and evaluated.
6. Determine the magnitude and significance of cumulative effects. Traffic projections were then updated to include the project related traffic over the without project conditions to identify project impacts. Therefore, these results identify the cumulative effects of the project since it includes the impacts of other developments and growth affecting the study area.

    A number of regional highway improvements identified in the ORTP were discussed in this report. However, they could not be reasonably included in the analysis because: 1) implementation of the improvements is programmed based on available transportation funds and priorities which are difficult to establish; and 2) determining which of the many identified improvements would be completed by a certain timeframe is difficult to estimate. Nevertheless, the traffic analysis completed represents a more conservative assessment for determining impacts and necessary mitigation improvements. Having any of the regional improvements implemented within the study period would result in improved conditions over that indicated. Thus, the traffic analysis conducted already incorporates methods to assess the cumulative impacts associated with the proposed project.

Secondary effects, or otherwise referred to as indirect effects, are described as those effects caused by a project, but occur later in time or farther removed in distance than direct impacts. They may include impacts on environmental resources that occur as a result of the project's influence on land use. Secondary impact analyses are appropriately concerned with impacts that are sufficiently "likely" to occur and not with the speculation of any impact that can be conceived of or imagined.

The traffic methodology utilized accounts for likely secondary effects associated with the project. Information from the ORTP incorporates land use information on a regional scale that were factored into the traffic projections and subsequent analysis. The regional roadway network for this project was modeled using transportation software to develop the forecasts which thus accounted for changes in traffic assignments as development progressed out to the 2025 build-out year. Thus, secondary effects have been accounted for within the traffic impact analysis along with cumulative effects.

VIII. CONCLUSION

Traffic volumes along Ka Uka Boulevard are expected to increase significantly by the Year 2016 and even greater by the Year 2025 due to the development of the proposed project as well as other major developments in the region and immediate vicinity. In addition, commute travel times are expected to increase. All traffic-generating uses in the area contribute to the traffic loading of the roadway network in the vicinity. Although internal capture concepts for highly applicable land uses were incorporated in the analysis, the overall percentage assumed to represent internal trips used in the traffic analysis were considerably lower than the calculated percentage rate that can be realized through a variety of strategies and initiatives, resulting in an analysis that may be considered conservative. However, implementation of the recommended intersection and roadway modifications identified above for the applicable study intersections should minimize the traffic impacts associated with these projects. Roadway and intersection improvements were presented to understand the transportation needs of the region on a cumulative basis. The analysis scenarios however were segregated to identify specific needs for specific conditions, for specific periods of proposed development, and for specific time periods of development. Such an approach addresses the timing of necessary improvements and defines the general source of the resulting individual need. Roadway improvements identified in this report represents major investments by area developers that will not only mitigate project-related traffic, but would aid in the overall function of the transportation system for all users.

APPENDIX A

NEIGHBORHOOD BOARD NO. 25 RESOLUTION

DEC 27 2007

MILILANI/ WAIPIO/ MELEMANU NEIGHBORHOOD BOARD NO. 25

c/o NEIGHBORHOOD COMMISSION • 530 SOUTH KING STREET ROOM 400 • HONOLULU, HAWAII, 96813
PHONE (808) 527-5749 • FAX (808) 527-5760 • INTERNET: http://www.honolulu.gov

RESOLUTION REQUESTING THE INCLUSION OF A REGIONAL TRANSPORTATION SECONDARY AND CUMULATIVE IMPACT ANALYSIS AS PART OF THE FINAL ENVIRONMENTAL IMPACT STATEMENT (EIS) FOR CASTLE & COOKE WAIAWA

WHEREAS, up to 20,000 additional housing units are planned for development by the year 2030 in Central Oahu at Koa Ridge Makai, Mililani Mauka, Royal Kunia, Waiawa Castle & Cooke and, Waiawa Gentry; and

WHEREAS, the proposed Castle & Cooke Waiawa master planned community will include 1,500 single and multi-family housing units as described in the draft EIS for Castle & Cooke Waiawa; and

WHEREAS, the projected population of 189,000 in Central Oahu by 2030 will exceed the forecast of 185,000 for the so-called Secondary Urban Center (Kapolei and its environs) according to the City & County of Honolulu's Central Oahu Sustainable Communities Plan and the Ewa Development Plan; and

WHEREAS, the Oahu Metropolitan Planning Organization 2030 Regional Transportation Plan projects travel time during rush hour from Mililani to Ala Moana to exceed two hours each way by 2030; and

WHEREAS, the City and County of Honolulu's planned rapid transit (rail) system currently excludes an extension to Central Oahu; and

WHEREAS, while the traffic analysis for the draft EIS for Castle & Cooke Waiawa does indeed analyze traffic increases at the study intersections, it does not examine the proposed development's potential connected actions, secondary impacts, significant effects and cumulative impacts relative to Central Oahu transportation infrastructure; and

WHEREAS, in August 2007 the Hawaii State Supreme Court reversed the Sierra Club vs. the State Department of Transportation's (DOT) Circuit Court exemption decision of 2005 and mandated, as a matter of law, the State DOT to conduct an environmental assessment of the Hawaii Super Ferry **to include** an analysis of the secondary as well as the primary impacts generated by the operations of the Hawaii Super Ferry in Hawaiian waters; now therefore,

BE IT RESOLVED that Mililani/Waipio/MelemanuNeighborhood Board No. 25 requests that the final EIS for Castle & Cooke Waiawa development include an analysis of the primary, secondary, and cumulative impacts of the regional transportation infrastructure in Central Oahu, to include the identification of traffic and transportation needs, deficiencies, and appropriate mitigation measures; and

BE IT FURTHER RESOLVED that the transportation infrastructure analysis include as a minimum the following:

(1) the incremental effect on commuter travel time resulting from the construction of additional housing units in Central Oahu, and a determination as to what point in time proposed developments in Central Oahu will exceed the ability of the regional transportation infrastructure to accommodate such development at the time of occupancy under existing conditions, and

(2) the impact that a fully-developed rapid transit system on Oahu would have on Central Oahu commuter, and

(3) the individual and cumulative impact of the following proposed transportation improvements in Central Oahu on commuter travel times:

- the timing and construction of all new or improved H-2 interchanges identified in the OMPO 2030 Regional Transportation Plan;
- the timing and construction of the Central Mauka Road identified in the OMPO 2030 Regional Transportation Plan;
- the timing and construction of a road connecting Kamehameha Highway and Paiwa Road as identified in the OMPO 2030 Regional Transportation Plan;
- the timing and construction of the widening of Kamehameha Highway to four lanes between Ka Uka Boulevard and Lanikuhana Avenue as identified in the OMPO 2030 Regional Transportation Plan;
- the location of a Regional Park and Ride facility located on the H-2 corridor near Koa Ridge as identified in the Mililani Mauka Park and Ride Feasibility Study;
- the timing and construction of a southern access road connecting the Waiawa and Koa Ridge/Waiawa development to Kamehameha Highway and the H-1 via Pearl City or Seaview as an alternative to or in addition to the northern Ka Uka access road; and
- the timing and construction of adequate access to the rapid transit system assuming either a fixed rail Central Oahu spur or access via busses utilizing dedicated bus lanes connected to Central Oahu park and ride facilities;

BE IT FINALLY RESOLVED that copies of this resolution be transmitted to the Mayor and Councilmembers of the City & County of Honolulu, the City Departments of Planning and Permitting and Transportation Services, the State Land Use Commission, the State Department of Transportation, the State Office of Environmental Quality Control, the State Environmental Council, the State Office of Planning, area legislators, the Oahu Metropolitan Organization, Castle & Cooke Homes, Inc, Wilson Okamoto Corporation, the Hawaii Chapter of the Sierra Club, Attorney Isaac Hall, all members of Neighborhood Boards Nos. 21, 22, 26, and 35, and all neighborhood board chairs.

Adopted by Mililani-Waipio-Melemanu Neighborhood Board No. 25 at its regular meeting of November 28, 2007, by a vote of 22-0-1.

Richard G. Poirier, Chair

APPENDIX B

EXISTING TRAFFIC COUNT DATA

WILSON OKAMOTO CORPORATION
1907 S. Beretania Street Suite 400
Honolulu, Hi 96826

Counter:T-1841, D4-5676
Counted:ER, LF
Weather:Clear

File Name : Ka Uka - H-1 NB On-Ramp - H-1 NB Off-Ramp AM
Site Code : 00000001
Start Date : 9/9/2008
Page No : 1

Groups Printed- Unshifted

	Southbound	Ka Uka Blvd. Westbound				NB H-1 Off-Ramp Northbound				Ka Uka Blvd. Eastbound				
Start Time	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
06:00 AM	0	0	7	2	9	63	0	3	66	53	2	0	55	130
06:15 AM	0	0	3	3	6	71	0	1	72	64	8	0	72	150
06:30 AM	0	0	0	0	0	89	0	4	93	55	4	0	59	152
06:45 AM	0	0	1	0	1	94	0	3	97	80	3	0	83	181
Total	0	0	11	5	16	317	0	11	328	252	17	0	269	613
07:00 AM	0	0	3	0	3	122	0	4	126	74	1	0	75	204
07:15 AM	0	0	0	0	0	141	0	5	146	81	9	0	90	236
07:30 AM	0	0	1	0	1	135	0	8	143	73	12	0	85	229
07:45 AM	0	0	3	1	4	166	0	8	174	66	9	0	75	253
Total	0	0	7	1	8	564	0	25	589	294	31	0	325	922
08:00 AM	0	0	4	1	5	133	0	7	140	68	9	0	77	222
08:15 AM	0	0	7	0	7	131	0	7	138	62	5	0	67	212
08:30 AM	0	0	4	2	6	138	1	6	145	54	9	0	63	214
08:45 AM	0	0	6	1	7	115	0	14	129	74	13	0	87	223
Total	0	0	21	4	25	517	1	34	552	258	36	0	294	871
Grand Total	0	0	39	10	49	1398	1	70	1469	804	84	0	888	2406
Apprch %		0	79.6	20.4		95.2	0.1	4.8		90.5	9.5	0		
Total %	0	0	1.6	0.4	2	58.1	0	2.9	61.1	33.4	3.5	0	36.9	

	Southbound	Ka Uka Blvd. Westbound				NB H-1 Off-Ramp Northbound				Ka Uka Blvd. Eastbound				
Start Time	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
Peak Hour Analysis From 06:00 AM to 08:45 AM - Peak 1 of 1														
Peak Hour for Entire Intersection Begins at 07:15 AM														
07:15 AM	0	0	0	0	0	141	0	5	146	**81**	9	0	**90**	236
07:30 AM	0	0	1	0	1	135	0	**8**	143	73	**12**	0	85	229
07:45 AM	0	0	3	**1**	4	**166**	0	8	**174**	66	9	0	75	**253**
08:00 AM	0	0	**4**	1	**5**	133	0	7	140	68	9	0	77	222
Total Volume	0	0	8	2	10	575	0	28	603	288	39	0	327	940
% App. Total		0	80	20		95.4	0	4.6		88.1	11.9	0		
PHF	.000	.000	.500	.500	.500	.866	.000	.875	.866	.889	.813	.000	.908	.929

WILSON OKAMOTO CORPORATION
1907 S. Beretania Street Suite 400
Honolulu, Hi 96826

Counter:T-1841, D4-5676
Counted:ER, LF
Weather:Clear

File Name : Ka Uka - H-1 NB On-Ramp - H-1 NB Off-Ramp PM
Site Code : 00000001
Start Date : 9/9/2008
Page No : 1

Groups Printed- Unshifted

	Southbound	Ka Uka Blvd. Westbound				NB H-1 Off-Ramp Northbound				Ka Uka Blvd. Eastbound				
Start Time	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
03:00 PM	0	0	3	5	8	329	1	7	337	112	7	0	119	464
03:15 PM	0	0	10	1	11	349	0	5	354	89	11	0	100	465
03:30 PM	0	0	16	10	26	316	0	3	319	103	4	0	107	452
03:45 PM	0	0	4	3	7	282	0	5	287	120	6	0	126	420
Total	0	0	33	19	52	1276	1	20	1297	424	28	0	452	1801
04:00 PM	0	0	10	11	21	270	0	4	274	107	7	0	114	409
04:15 PM	0	0	7	3	10	295	0	5	300	121	4	0	125	435
04:30 PM	0	0	11	9	20	266	0	1	267	122	8	0	130	417
04:45 PM	0	0	15	5	20	311	1	4	316	116	14	0	130	466
Total	0	0	43	28	71	1142	1	14	1157	466	33	0	499	1727
05:00 PM	0	0	14	6	20	276	0	9	285	127	9	0	136	441
05:15 PM	0	0	10	10	20	297	0	9	306	146	22	0	168	494
05:30 PM	0	0	13	7	20	285	0	6	291	127	25	0	152	463
05:45 PM	0	0	13	8	21	281	0	17	298	88	14	0	102	421
Total	0	0	50	31	81	1139	0	41	1180	488	70	0	558	1819
Grand Total	0	0	126	78	204	3557	2	75	3634	1378	131	0	1509	5347
Apprch %		0	61.8	38.2		97.9	0.1	2.1		91.3	8.7	0		
Total %	0	0	2.4	1.5	3.8	66.5	0	1.4	68	25.8	2.4	0	28.2	

	Southbound	Ka Uka Blvd. Westbound				NB H-1 Off-Ramp Northbound				Ka Uka Blvd. Eastbound				
Start Time	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
Peak Hour Analysis From 03:00 PM to 05:45 PM - Peak 1 of 1														
Peak Hour for Entire Intersection Begins at 04:45 PM														
04:45 PM	0	0	**15**	5	**20**	**311**	**1**	4	**316**	116	14	0	130	466
05:00 PM	0	0	14	6	20	276	0	**9**	285	127	9	0	136	441
05:15 PM	0	0	10	**10**	20	297	0	9	306	**146**	22	0	**168**	**494**
05:30 PM	0	0	13	7	20	285	0	6	291	127	**25**	0	152	463
Total Volume	0	0	52	28	80	1169	1	28	1198	516	70	0	586	1864
% App. Total		0	65	35		97.6	0.1	2.3		88.1	11.9	0		
PHF	.000	.000	.867	.700	1.000	.940	.250	.778	.948	.884	.700	.000	.872	.943

WILSON OKAMOTO CORPORATION
1907 S. Beretania Street Suite 400
Honolulu, Hi 96826

Counter:D4-3888, D4-5673
Counted:RY, JY
Weather:Clear

File Name : SB H-2 On-Ramp AM
Site Code : 00000001
Start Date : 9/9/2008
Page No : 1

Groups Printed- Unshifted

	Construction Site Southbound				Ka Uka Blvd. Westbound				Northbound	Ka Uka Blvd. Eastbound				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	App. Total	Left	Thru	Right	App. Total	Int. Total
06:00 AM	0	0	0	0	6	63	1	70	0	1	63	290	354	424
06:15 AM	0	0	0	0	3	73	0	76	0	1	70	276	347	423
06:30 AM	0	0	0	0	0	86	3	89	0	0	55	236	291	380
06:45 AM	0	0	0	0	2	93	1	96	0	0	81	263	344	440
Total	0	0	0	0	11	315	5	331	0	2	269	1065	1336	1667
07:00 AM	0	0	0	0	3	122	0	125	0	0	75	264	339	464
07:15 AM	0	0	0	0	0	143	1	144	0	0	87	230	317	461
07:30 AM	0	0	1	1	1	137	0	138	0	1	84	239	324	463
07:45 AM	0	0	0	0	1	163	2	166	0	0	74	235	309	475
Total	0	0	1	1	5	565	3	573	0	1	320	968	1289	1863
08:00 AM	2	1	1	4	3	139	1	143	0	1	75	207	283	430
08:15 AM	1	0	0	1	5	134	0	139	0	1	62	185	248	388
08:30 AM	0	0	2	2	2	139	0	141	0	1	67	185	253	396
08:45 AM	0	0	0	0	4	119	0	123	0	1	82	207	290	413
Total	3	1	3	7	14	531	1	546	0	4	286	784	1074	1627
Grand Total	3	1	4	8	30	1411	9	1450	0	7	875	2817	3699	5157
Apprch %	37.5	12.5	50		2.1	97.3	0.6			0.2	23.7	76.2		
Total %	0.1	0	0.1	0.2	0.6	27.4	0.2	28.1	0	0.1	17	54.6	71.7	

	Construction Site Southbound				Ka Uka Blvd. Westbound				Northbound	Ka Uka Blvd. Eastbound				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	App. Total	Left	Thru	Right	App. Total	Int. Total
Peak Hour Analysis From 06:00 AM to 08:45 AM - Peak 1 of 1														
Peak Hour for Entire Intersection Begins at 07:00 AM														
07:00 AM	0	0	0	0	**3**	122	0	125	0	0	75	**264**	**339**	464
07:15 AM	0	0	0	0	0	143	1	144	0	0	**87**	230	317	461
07:30 AM	0	0	**1**	**1**	1	137	0	138	0	**1**	84	239	324	463
07:45 AM	0	0	0	0	1	**163**	**2**	**166**	0	0	74	235	309	**475**
Total Volume	0	0	1	1	5	565	3	573	0	1	320	968	1289	1863
% App. Total	0	0	100		0.9	98.6	0.5			0.1	24.8	75.1		
PHF	.000	.000	.250	.250	.417	.867	.375	.863	.000	.250	.920	.917	.951	.981

WILSON OKAMOTO CORPORATION
1907 S. Beretania Street Suite 400
Honolulu, Hi 96826

Counter:D4-3888, D4-5673
Counted:RY, JY
Weather:Clear

File Name : SB H-2 On-Ramp PM
Site Code : 00000001
Start Date : 9/9/2008
Page No : 1

Groups Printed- Unshifted

	Construction Site Southbound				Ka Uka Blvd. Westbound				Northbound	Ka Uka Blvd. Eastbound				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	App. Total	Left	Thru	Right	App. Total	Int. Total
03:00 PM	0	0	1	1	3	324	0	327	0	0	128	207	335	663
03:15 PM	0	0	0	0	5	344	0	349	0	2	94	178	274	623
03:30 PM	0	0	0	0	12	322	0	334	0	1	106	212	319	653
03:45 PM	1	0	0	1	7	286	0	293	0	0	121	173	294	588
Total	1	0	1	2	27	1276	0	1303	0	3	449	770	1222	2527
04:00 PM	0	0	0	0	3	280	0	283	0	0	129	200	329	612
04:15 PM	0	0	0	0	2	297	0	299	0	1	123	180	304	603
04:30 PM	0	2	3	5	5	276	0	281	0	1	128	233	362	648
04:45 PM	0	0	0	0	7	317	0	324	0	0	127	182	309	633
Total	0	2	3	5	17	1170	0	1187	0	2	507	795	1304	2496
05:00 PM	0	1	1	2	11	279	0	290	0	0	142	172	314	606
05:15 PM	0	0	0	0	2	302	0	304	0	2	142	160	304	608
05:30 PM	0	0	0	0	6	304	0	310	0	0	148	171	319	629
05:45 PM	0	1	0	1	7	293	0	300	0	0	116	147	263	564
Total	0	2	1	3	26	1178	0	1204	0	2	548	650	1200	2407
Grand Total	1	4	5	10	70	3624	0	3694	0	7	1504	2215	3726	7430
Apprch %	10	40	50		1.9	98.1	0			0.2	40.4	59.4		
Total %	0	0.1	0.1	0.1	0.9	48.8	0	49.7	0	0.1	20.2	29.8	50.1	

	Construction Site Southbound				Ka Uka Blvd. Westbound				Northbound	Ka Uka Blvd. Eastbound				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	App. Total	Left	Thru	Right	App. Total	Int. Total
Peak Hour Analysis From 03:00 PM to 05:45 PM - Peak 1 of 1														
Peak Hour for Entire Intersection Begins at 03:00 PM														
03:00 PM	0	0	**1**	**1**	**3**	324	0	327	0	0	**128**	207	**335**	**663**
03:15 PM	0	0	0	0	5	**344**	0	**349**	0	**2**	94	178	274	623
03:30 PM	0	0	0	0	**12**	322	0	334	0	1	106	**212**	319	653
03:45 PM	**1**	0	0	1	7	286	0	293	0	0	121	173	294	588
Total Volume	1	0	1	2	27	1276	0	1303	0	3	449	770	1222	2527
% App. Total	50	0	50		2.1	97.9	0			0.2	36.7	63		
PHF	.250	.000	.250	.500	.563	.927	.000	.933	.000	.375	.877	.908	.912	.953

WILSON OKAMOTO CORPORATION
1907 S. Beretania Street Suite 400
Honolulu, Hi 96826

Counter:D4-3890, D4-5674
Counted:DY, EK
Weather:Clear

File Name : UkaMoa AM
Site Code : 00000001
Start Date : 9/9/2008
Page No : 1

Groups Printed- Unshifted

	SB H-2 Off-Ramp Southbound				Ka Uka Blvd. Westbound				Moaniani Street Northbound				Ka Uka Blvd. Eastbound				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
06:00 AM	1	21	23	45	23	43	0	66	0	0	115	115	0	278	2	280	506
06:15 AM	6	20	41	67	26	42	0	68	0	0	115	115	0	262	6	268	518
06:30 AM	2	25	48	75	29	58	0	87	5	0	130	135	0	199	5	204	501
06:45 AM	2	30	51	83	32	51	0	83	3	0	113	116	0	249	5	254	536
Total	11	96	163	270	110	194	0	304	8	0	473	481	0	988	18	1006	2061
07:00 AM	0	31	44	75	53	80	0	133	9	0	133	142	0	245	12	257	607
07:15 AM	4	47	40	91	50	83	0	133	5	0	127	132	0	229	15	244	600
07:30 AM	3	35	56	94	63	82	0	145	4	0	97	101	0	254	13	267	607
07:45 AM	4	45	55	104	69	89	0	158	10	0	89	99	0	230	16	246	607
Total	11	158	195	364	235	334	0	569	28	0	446	474	0	958	56	1014	2421
08:00 AM	9	51	43	103	72	66	0	138	4	0	137	141	1	158	10	169	551
08:15 AM	5	37	34	76	72	67	0	139	4	0	90	94	0	166	14	180	489
08:30 AM	6	31	32	69	72	77	0	149	11	0	94	105	0	189	10	199	522
08:45 AM	8	30	31	69	38	74	0	112	9	0	117	126	0	197	15	212	519
Total	28	149	140	317	254	284	0	538	28	0	438	466	1	710	49	760	2081
Grand Total	50	403	498	951	599	812	0	1411	64	0	1357	1421	1	2656	123	2780	6563
Apprch %	5.3	42.4	52.4		42.5	57.5	0		4.5	0	95.5		0	95.5	4.4		
Total %	0.8	6.1	7.6	14.5	9.1	12.4	0	21.5	1	0	20.7	21.7	0	40.5	1.9	42.4	

	SB H-2 Off-Ramp Southbound				Ka Uka Blvd. Westbound				Moaniani Street Northbound				Ka Uka Blvd. Eastbound				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
Peak Hour Analysis From 06:00 AM to 08:45 AM - Peak 1 of 1																	
Peak Hour for Entire Intersection Begins at 07:00 AM																	
07:00 AM	0	31	44	75	53	80	0	133	9	0	**133**	**142**	0	245	12	257	**607**
07:15 AM	4	47	40	91	50	83	0	133	5	0	127	132	0	229	15	244	600
07:30 AM	3	35	**56**	94	63	82	0	145	4	0	97	101	0	**254**	13	**267**	607
07:45 AM	4	45	55	**104**	**69**	**89**	0	**158**	**10**	0	89	99	0	230	**16**	246	607
Total Volume	11	158	195	364	235	334	0	569	28	0	446	474	0	958	56	1014	2421
% App. Total	3	43.4	53.6		41.3	58.7	0		5.9	0	94.1		0	94.5	5.5		
PHF	.688	.840	.871	.875	.851	.938	.000	.900	.700	.000	.838	.835	.000	.943	.875	.949	.997

WILSON OKAMOTO CORPORATION
1907 S. Beretania Street Suite 400
Honolulu, Hi 96826

Counter:D4-3890, D4-5674
Counted:EK, DY
Weather:Clear

File Name : UkaMoa PM
Site Code : 00000001
Start Date : 9/9/2008
Page No : 1

Groups Printed- Unshifted

	SB H-2 Off-Ramp Southbound				Ka Uka Blvd. Westbound				Moaniani Sreet Northbound				Ka Uka Blvd. Eastbound				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
03:00 PM	0	41	38	79	127	213	0	340	18	0	193	211	0	172	13	185	815
03:15 PM	5	50	36	91	128	238	0	366	24	0	173	197	0	125	22	147	801
03:30 PM	4	36	43	83	106	213	0	319	29	0	181	210	0	150	22	172	784
03:45 PM	0	65	29	94	106	182	0	288	13	0	173	186	0	133	12	145	713
Total	9	192	146	347	467	846	0	1313	84	0	720	804	0	580	69	649	3113
04:00 PM	4	39	29	72	88	181	0	269	25	0	159	184	0	172	17	189	714
04:15 PM	2	43	49	94	116	227	0	343	15	0	210	225	0	130	12	142	804
04:30 PM	1	44	54	99	76	166	0	242	22	0	208	230	0	178	13	191	762
04:45 PM	10	45	37	92	108	233	0	341	12	0	157	169	0	156	27	183	785
Total	17	171	169	357	388	807	0	1195	74	0	734	808	0	636	69	705	3065
05:00 PM	1	66	43	110	86	181	0	267	25	0	173	198	0	160	16	176	751
05:15 PM	6	37	42	85	95	214	0	309	19	0	176	195	0	136	19	155	744
05:30 PM	11	38	42	91	92	229	0	321	18	0	174	192	0	184	16	200	804
05:45 PM	10	58	47	115	92	171	0	263	22	0	132	154	0	145	12	157	689
Total	28	199	174	401	365	795	0	1160	84	0	655	739	0	625	63	688	2988
Grand Total	54	562	489	1105	1220	2448	0	3668	242	0	2109	2351	0	1841	201	2042	9166
Apprch %	4.9	50.9	44.3		33.3	66.7	0		10.3	0	89.7		0	90.2	9.8		
Total %	0.6	6.1	5.3	12.1	13.3	26.7	0	40	2.6	0	23	25.6	0	20.1	2.2	22.3	

	SB H-2 Off-Ramp Southbound				Ka Uka Blvd. Westbound				Moaniani Sreet Northbound				Ka Uka Blvd. Eastbound				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
Peak Hour Analysis From 03:00 PM to 05:45 PM - Peak 1 of 1																	
Peak Hour for Entire Intersection Begins at 03:00 PM																	
03:00 PM	0	41	38	79	127	213	0	340	18	0	**193**	**211**	0	**172**	13	**185**	**815**
03:15 PM	**5**	50	36	91	**128**	**238**	0	**366**	24	0	173	197	0	125	**22**	147	801
03:30 PM	**4**	36	**43**	83	106	213	0	319	**29**	0	181	210	0	150	22	172	784
03:45 PM	0	**65**	29	**94**	106	182	0	288	13	0	173	186	0	133	12	145	713
Total Volume	9	192	146	347	467	846	0	1313	84	0	720	804	0	580	69	649	3113
% App. Total	2.6	55.3	42.1		35.6	64.4	0		10.4	0	89.6		0	89.4	10.6		
PHF	.450	.738	.849	.923	.912	.889	.000	.897	.724	.000	.933	.953	.000	.843	.784	.877	.955

WILSON OKAMOTO CORPORATION
1907 S. Beretania Street Suite 400
Honolulu, Hi 96826

Counter:D4-5677
Counted:TO
Weather:Clear

File Name : SpineUka AM
Site Code : 00000001
Start Date : 9/9/2008
Page No : 1

Groups Printed- Unshifted

	Spine Road Southbound					Ka Uka Blvd. Westbound					Shopping Center Northbound					Ka Uka Blvd. Eastbound					
Start Time	Left	Thru	Right	Peds	App. Total	Left	Thru	Right	Peds	App. Total	Left	Thru	Right	Peds	App. Total	Left	Thru	Right	Peds	App. Total	Int. Total
06:00 AM	1	0	0	0	1	9	0	0	0	9	2	0	7	0	9	0	0	15	0	15	34
06:15 AM	0	0	2	2	4	11	0	0	0	11	1	0	6	1	8	2	0	9	0	11	34
06:30 AM	1	0	1	0	2	11	0	0	0	11	1	0	2	4	7	4	0	9	0	13	33
06:45 AM	0	0	0	1	1	17	0	1	0	18	1	0	7	0	8	2	0	14	0	16	43
Total	2	0	3	3	8	48	0	1	0	49	5	0	22	5	32	8	0	47	0	55	144
07:00 AM	0	0	0	0	0	18	0	2	0	20	1	0	6	0	7	2	0	22	0	24	51
07:15 AM	0	0	0	0	0	25	0	0	0	25	2	0	10	3	15	3	0	26	0	29	69
07:30 AM	0	0	1	0	1	21	0	1	0	22	3	0	10	1	14	3	0	13	0	16	53
07:45 AM	0	0	0	0	0	25	0	0	0	25	2	0	4	2	8	4	0	24	0	28	61
Total	0	0	1	0	1	89	0	3	0	92	8	0	30	6	44	12	0	85	0	97	234
08:00 AM	0	1	0	0	1	20	0	0	0	20	1	1	9	1	12	4	0	24	0	28	61
08:15 AM	0	0	0	0	0	22	0	1	0	23	0	0	15	1	16	2	0	16	0	18	57
08:30 AM	0	1	0	0	1	24	0	1	0	25	1	0	18	2	21	0	0	16	0	16	63
08:45 AM	1	0	0	0	1	20	0	0	0	20	0	0	12	0	12	2	0	9	0	11	44
Total	1	2	0	0	3	86	0	2	0	88	2	1	54	4	61	8	0	65	0	73	225
Grand Total	3	2	4	3	12	223	0	6	0	229	15	1	106	15	137	28	0	197	0	225	603
Apprch %	25	16.7	33.3	25		97.4	0	2.6	0		10.9	0.7	77.4	10.9		12.4	0	87.6	0		
Total %	0.5	0.3	0.7	0.5	2	37	0	1	0	38	2.5	0.2	17.6	2.5	22.7	4.6	0	32.7	0	37.3	

	Spine Road Southbound				Ka Uka Blvd. Westbound				Shopping Center Northbound				Ka Uka Blvd. Eastbound				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
Peak Hour Analysis From 06:00 AM to 08:45 AM - Peak 1 of 1																	
Peak Hour for Entire Intersection Begins at 07:15 AM																	
07:15 AM	0	0	0	0	**25**	0	0	**25**	2	0	**10**	12	3	0	**26**	**29**	**66**
07:30 AM	0	0	**1**	**1**	21	0	**1**	22	**3**	0	10	**13**	3	0	13	16	52
07:45 AM	0	0	0	0	25	0	0	25	2	0	4	6	4	0	24	28	59
08:00 AM	0	**1**	0	**1**	20	0	0	20	1	**1**	9	11	4	0	24	28	60
Total Volume	0	1	1	2	91	0	1	92	8	1	33	42	14	0	87	101	237
% App. Total	0	50	50		98.9	0	1.1		19	2.4	78.6		13.9	0	86.1		
PHF	.000	.250	.250	.500	.910	.000	.250	.920	.667	.250	.825	.808	.875	.000	.837	.871	.898

WILSON OKAMOTO CORPORATION
1907 S. Beretania Street Suite 400
Honolulu, Hi 96826

Counter:D4-5677
Counted:TO
Weather:Clear

File Name : SpineUka PM
Site Code : 00000001
Start Date : 9/9/2008
Page No : 1

Groups Printed- Unshifted

	Spine Road Southbound				Ka Uka Blvd. Westbound				Shopping Center Northbound				Ka Uka Blvd. Eastbound				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
03:00 PM	0	0	1	1	33	0	0	33	2	0	30	32	5	0	20	25	91
03:15 PM	1	0	0	1	37	0	1	38	2	0	18	20	2	0	29	31	90
03:30 PM	0	0	0	0	26	0	1	27	2	0	22	24	3	0	19	22	73
03:45 PM	1	0	1	2	15	0	0	15	5	0	29	34	1	0	26	27	78
Total	2	0	2	4	111	0	2	113	11	0	99	110	11	0	94	105	332
04:00 PM	3	0	1	4	29	0	0	29	3	0	23	26	1	0	27	28	87
04:15 PM	0	0	1	1	33	0	0	33	1	0	31	32	2	0	27	29	95
04:30 PM	0	0	0	0	23	0	1	24	1	0	40	41	1	0	32	33	98
04:45 PM	1	2	0	3	31	0	1	32	2	0	48	50	1	0	41	42	127
Total	4	2	2	8	116	0	2	118	7	0	142	149	5	0	127	132	407
05:00 PM	0	0	1	1	31	0	0	31	0	1	39	40	3	0	32	35	107
05:15 PM	0	0	1	1	23	0	0	23	1	0	42	43	0	0	42	42	109
05:30 PM	0	0	2	2	28	0	1	29	0	0	33	33	2	0	42	44	108
05:45 PM	2	0	1	3	31	0	0	31	1	0	39	40	2	0	29	31	105
Total	2	0	5	7	113	0	1	114	2	1	153	156	7	0	145	152	429
Grand Total	8	2	9	19	340	0	5	345	20	1	394	415	23	0	366	389	1168
Apprch %	42.1	10.5	47.4		98.6	0	1.4		4.8	0.2	94.9		5.9	0	94.1		
Total %	0.7	0.2	0.8	1.6	29.1	0	0.4	29.5	1.7	0.1	33.7	35.5	2	0	31.3	33.3	

	Spine Road Southbound				Ka Uka Blvd. Westbound				Shopping Center Northbound				Ka Uka Blvd. Eastbound				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
Peak Hour Analysis From 03:00 PM to 05:45 PM - Peak 1 of 1																	
Peak Hour for Entire Intersection Begins at 04:45 PM																	
04:45 PM	1	2	0	3	31	0	1	32	2	0	48	50	1	0	41	42	127
05:00 PM	0	0	1	1	31	0	0	31	0	1	39	40	3	0	32	35	107
05:15 PM	0	0	1	1	23	0	0	23	1	0	42	43	0	0	42	42	109
05:30 PM	0	0	2	2	28	0	1	29	0	0	33	33	2	0	42	44	108
Total Volume	1	2	4	7	113	0	2	115	3	1	162	166	6	0	157	163	451
% App. Total	14.3	28.6	57.1		98.3	0	1.7		1.8	0.6	97.6		3.7	0	96.3		
PHF	.250	.250	.500	.583	.911	.000	.500	.898	.375	.250	.844	.830	.500	.000	.935	.926	.888

WILSON OKAMOTO CORPORATION
1907 S. Beretania Street Suite 400
Honolulu, Hi 96826

Counter:D4-5673, D4-3888
Counted:RY, JY
Weather:Clear

File Name : UkaUkee(East) AM
Site Code : 00000001
Start Date : 9/11/2008
Page No : 1

Groups Printed- Unshifted

	Ukee Street (East) Southbound				Ka Uka Blvd. Westbound				Ukee Street (East) Northbound				Ka Uka Blvd. Eastbound				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
06:00 AM	5	0	1	6	9	36	11	56	6	1	6	13	3	190	12	205	280
06:15 AM	0	2	0	2	20	54	16	90	8	3	7	18	3	205	17	225	335
06:30 AM	2	0	2	4	14	37	18	69	7	2	4	13	1	224	17	242	328
06:45 AM	3	0	1	4	21	65	17	103	12	2	5	19	1	189	18	208	334
Total	10	2	4	16	64	192	62	318	33	8	22	63	8	808	64	880	1277
07:00 AM	2	1	0	3	25	51	18	94	8	2	2	12	1	233	13	247	356
07:15 AM	2	1	0	3	20	73	25	118	11	5	8	24	1	219	22	242	387
07:30 AM	7	0	1	8	21	83	14	118	7	2	4	13	3	210	24	237	376
07:45 AM	2	1	1	4	14	80	16	110	15	6	4	25	3	176	23	202	341
Total	13	3	2	18	80	287	73	440	41	15	18	74	8	838	82	928	1460
08:00 AM	5	2	1	8	15	82	19	116	8	3	9	20	3	176	22	201	345
08:15 AM	2	0	3	5	14	61	11	86	12	4	5	21	2	145	16	163	275
08:30 AM	5	2	0	7	19	52	10	81	13	2	11	26	2	139	16	157	271
08:45 AM	2	4	0	6	16	66	7	89	9	4	11	24	0	144	12	156	275
Total	14	8	4	26	64	261	47	372	42	13	36	91	7	604	66	677	1166
Grand Total	37	13	10	60	208	740	182	1130	116	36	76	228	23	2250	212	2485	3903
Apprch %	61.7	21.7	16.7		18.4	65.5	16.1		50.9	15.8	33.3		0.9	90.5	8.5		
Total %	0.9	0.3	0.3	1.5	5.3	19	4.7	29	3	0.9	1.9	5.8	0.6	57.6	5.4	63.7	

	Ukee Street (East) Southbound				Ka Uka Blvd. Westbound				Ukee Street (East) Northbound				Ka Uka Blvd. Eastbound				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
Peak Hour Analysis From 06:00 AM to 08:45 AM - Peak 1 of 1																	
Peak Hour for Entire Intersection Begins at 07:00 AM																	
07:00 AM	2	**1**	0	3	**25**	51	18	94	8	2	2	12	1	**233**	13	**247**	356
07:15 AM	2	1	0	3	20	73	**25**	**118**	11	5	**8**	24	1	219	22	242	**387**
07:30 AM	7	0	**1**	**8**	21	**83**	14	118	7	2	4	13	3	210	**24**	237	376
07:45 AM	2	1	1	4	14	80	16	110	**15**	**6**	4	**25**	3	176	23	202	341
Total Volume	13	3	2	18	80	287	73	440	41	15	18	74	8	838	82	928	1460
% App. Total	72.2	16.7	11.1		18.2	65.2	16.6		55.4	20.3	24.3		0.9	90.3	8.8		
PHF	.464	.750	.500	.563	.800	.864	.730	.932	.683	.625	.563	.740	.667	.899	.854	.939	.943

WILSON OKAMOTO CORPORATION
1907 S. Beretania Street Suite 400
Honolulu, Hi 96826

Counter:D4-5673, D4-3888
Counted:RY, JY
Weather:Clear

File Name : UkaUkee(East) PM
Site Code : 00000001
Start Date : 9/11/2008
Page No : 1

Groups Printed- Unshifted

	Ukee Street (East) Southbound				Ka Uka Blvd. Westbound				Ukee Street (East) Northbound				Ka Uka Blvd. Eastbound				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
03:00 PM	17	3	5	25	27	194	14	235	38	3	15	56	4	128	15	147	463
03:15 PM	18	0	10	28	38	198	23	259	35	6	19	60	2	105	16	123	470
03:30 PM	15	1	7	23	32	223	17	272	29	6	11	46	2	118	16	136	477
03:45 PM	12	4	3	19	20	199	24	243	29	5	19	53	3	113	19	135	450
Total	62	8	25	95	117	814	78	1009	131	20	64	215	11	464	66	541	1860
04:00 PM	10	2	3	15	30	202	19	251	33	4	24	61	6	108	17	131	458
04:15 PM	7	2	2	11	18	191	12	221	34	4	15	53	1	112	24	137	422
04:30 PM	12	4	1	17	16	218	11	245	29	4	22	55	3	124	13	140	457
04:45 PM	10	3	4	17	20	224	23	267	24	3	10	37	2	127	14	143	464
Total	39	11	10	60	84	835	65	984	120	15	71	206	12	471	68	551	1801
05:00 PM	12	3	3	18	15	210	22	247	27	3	14	44	1	144	21	166	475
05:15 PM	9	1	6	16	11	181	15	207	35	3	12	50	1	126	6	133	406
05:30 PM	11	0	1	12	13	205	14	232	38	4	20	62	0	112	16	128	434
05:45 PM	1	0	0	1	23	230	14	267	27	0	15	42	5	128	11	144	454
Total	33	4	10	47	62	826	65	953	127	10	61	198	7	510	54	571	1769
Grand Total	134	23	45	202	263	2475	208	2946	378	45	196	619	30	1445	188	1663	5430
Apprch %	66.3	11.4	22.3		8.9	84	7.1		61.1	7.3	31.7		1.8	86.9	11.3		
Total %	2.5	0.4	0.8	3.7	4.8	45.6	3.8	54.3	7	0.8	3.6	11.4	0.6	26.6	3.5	30.6	

	Ukee Street (East) Southbound				Ka Uka Blvd. Westbound				Ukee Street (East) Northbound				Ka Uka Blvd. Eastbound				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
Peak Hour Analysis From 03:00 PM to 05:45 PM - Peak 1 of 1																	
Peak Hour for Entire Intersection Begins at 03:00 PM																	
03:00 PM	17	3	5	25	27	194	14	235	**38**	3	15	56	**4**	**128**	15	**147**	463
03:15 PM	**18**	0	**10**	**28**	**38**	198	23	259	35	**6**	**19**	**60**	2	105	16	123	470
03:30 PM	15	1	7	23	32	**223**	17	**272**	29	6	11	46	2	118	16	136	477
03:45 PM	12	**4**	3	19	20	199	**24**	243	29	5	19	53	3	113	**19**	135	450
Total Volume	62	8	25	95	117	814	78	1009	131	20	64	215	11	464	66	541	1860
% App. Total	65.3	8.4	26.3		11.6	80.7	7.7		60.9	9.3	29.8		2	85.8	12.2		
PHF	.861	.500	.625	.848	.770	.913	.813	.927	.862	.833	.842	.896	.688	.906	.868	.920	.975

WILSON OKAMOTO CORPORATION
1907 S. Beretania Street Suite 400
Honolulu, Hi 96826

Counter:D4-5676, D4-5675
Counted:JY, JM
Weather:Clear

File Name : KaUkaWai AM
Site Code : 00000203
Start Date : 5/7/2008
Page No : 1

Groups Printed- Unshifted

	Waipio Uka Street Southbound					Ka Uka Blvd. Westbound					Waipio Uka Street Northbound					Ka Uka Blvd. Eastbound					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
06:00 AM	3	10	12	0	25	12	60	2	1	75	27	4	15	2	48	6	227	13	3	249	397
06:15 AM	5	1	6	3	15	7	62	6	0	75	20	9	9	0	38	9	168	7	0	184	312
06:30 AM	3	1	6	0	10	6	150	9	0	165	22	2	16	0	40	16	212	10	2	240	455
06:45 AM	3	1	11	0	15	6	167	21	0	194	16	6	20	1	43	13	218	15	2	248	500
Total	14	13	35	3	65	31	439	38	1	509	85	21	60	3	169	44	825	45	7	921	1664
07:00 AM	5	4	7	0	16	5	164	17	0	186	17	4	22	0	43	18	253	18	2	291	536
07:15 AM	7	4	7	1	19	14	146	15	0	175	18	8	25	3	54	17	245	11	3	276	524
07:30 AM	4	1	12	1	18	2	129	15	3	149	19	3	28	3	53	33	217	10	2	262	482
07:45 AM	7	3	8	0	18	7	74	15	0	96	25	4	14	2	45	41	181	23	5	250	409
Total	23	12	34	2	71	28	513	62	3	606	79	19	89	8	195	109	896	62	12	1079	1951
08:00 AM	0	2	8	0	10	13	70	12	0	95	28	10	15	1	54	21	204	13	1	239	398
08:15 AM	8	7	12	0	27	12	68	12	0	92	28	3	11	0	42	8	154	5	1	168	329
08:30 AM	2	4	11	0	17	17	48	9	0	74	16	3	4	0	23	4	134	11	2	151	265
08:45 AM	3	4	12	0	19	15	60	7	1	83	26	3	13	0	42	7	141	4	0	152	296
Total	13	17	43	0	73	57	246	40	1	344	98	19	43	1	161	40	633	33	4	710	1288
Grand Total	50	42	112	5	209	116	1198	140	5	1459	262	59	192	12	525	193	2354	140	23	2710	4903
Apprch %	23.9	20.1	53.6	2.4		8	82.1	9.6	0.3		49.9	11.2	36.6	2.3		7.1	86.9	5.2	0.8		
Total %	1	0.9	2.3	0.1	4.3	2.4	24.4	2.9	0.1	29.8	5.3	1.2	3.9	0.2	10.7	3.9	48	2.9	0.5	55.3	

	Waipio Uka Street Southbound					Ka Uka Blvd. Westbound					Waipio Uka Street Northbound					Ka Uka Blvd. Eastbound					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
Peak Hour Analysis From 06:00 AM to 08:45 AM - Peak 1 of 1																					
Peak Hour for Entire Intersection Begins at 06:45 AM																					
06:45 AM	3	1	11	0	15	6	**167**	**21**	0	**194**	16	6	20	1	43	13	218	15	2	248	500
07:00 AM	5	**4**	7	0	16	5	164	17	0	186	17	4	22	0	43	18	**253**	**18**	2	**291**	**536**
07:15 AM	**7**	4	7	**1**	**19**	**14**	146	15	0	175	18	**8**	25	**3**	**54**	17	245	11	**3**	276	524
07:30 AM	4	1	**12**	1	18	2	129	15	**3**	149	**19**	3	**28**	3	53	**33**	217	10	2	262	482
Total Volume	19	10	37	2	68	27	606	68	3	704	70	21	95	7	193	81	933	54	9	1077	2042
% App. Total	27.9	14.7	54.4	2.9		3.8	86.1	9.7	0.4		36.3	10.9	49.2	3.6		7.5	86.6	5	0.8		
PHF	.679	.625	.771	.500	.895	.482	.907	.810	.250	.907	.921	.656	.848	.583	.894	.614	.922	.750	.750	.925	.952

WILSON OKAMOTO CORPORATION
1907 S. Beretania Street Suite 400
Honolulu, Hi 96826

Counter:D4-5676, D4-5675
Counted:JY, JM
Weather:Clear

File Name : KaUkaWai PM
Site Code : 00000203
Start Date : 5/7/2008
Page No : 1

Groups Printed- Unshifted

	Waipio Uka Street Southbound					Ka Uka Blvd. Westbound					Waipio Uka Street Northbound					Ka Uka Blvd. Eastbound					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
03:00 PM	8	3	8	0	19	10	199	17	0	226	19	6	19	0	44	17	104	8	0	129	418
03:15 PM	8	6	10	0	24	6	210	20	0	236	11	5	18	1	35	17	108	10	1	136	431
03:30 PM	12	4	24	0	40	8	186	18	0	212	10	9	34	0	53	26	126	5	0	157	462
03:45 PM	11	11	20	0	42	13	183	23	1	220	15	4	19	0	38	18	98	11	1	128	428
Total	39	24	62	0	125	37	778	78	1	894	55	24	90	1	170	78	436	34	2	550	1739
04:00 PM	4	7	17	1	29	4	219	19	0	242	13	8	16	0	37	30	126	7	4	167	475
04:15 PM	5	5	13	0	23	14	205	28	0	247	12	3	25	0	40	29	115	12	0	156	466
04:30 PM	6	15	34	0	55	3	180	19	0	202	9	5	34	10	58	16	131	9	3	159	474
04:45 PM	5	5	19	0	29	14	206	26	0	246	7	11	30	1	49	25	104	12	1	142	466
Total	20	32	83	1	136	35	810	92	0	937	41	27	105	11	184	100	476	40	8	624	1881
05:00 PM	15	10	23	0	48	9	224	36	2	271	12	3	28	0	43	23	119	10	0	152	514
05:15 PM	7	8	13	0	28	14	208	38	0	260	13	7	37	6	63	25	116	10	6	157	508
05:30 PM	3	2	24	1	30	9	215	32	0	256	11	1	28	0	40	22	110	9	0	141	467
05:45 PM	7	1	10	0	18	11	186	32	1	230	11	6	22	0	39	15	117	18	0	150	437
Total	32	21	70	1	124	43	833	138	3	1017	47	17	115	6	185	85	462	47	6	600	1926
Grand Total	91	77	215	2	385	115	2421	308	4	2848	143	68	310	18	539	263	1374	121	16	1774	5546
Apprch %	23.6	20	55.8	0.5		4	85	10.8	0.1		26.5	12.6	57.5	3.3		14.8	77.5	6.8	0.9		
Total %	1.6	1.4	3.9	0	6.9	2.1	43.7	5.6	0.1	51.4	2.6	1.2	5.6	0.3	9.7	4.7	24.8	2.2	0.3	32	

	Waipio Uka Street Southbound					Ka Uka Blvd. Westbound					Waipio Uka Street Northbound					Ka Uka Blvd. Eastbound					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
Peak Hour Analysis From 03:00 PM to 05:45 PM - Peak 1 of 1																					
Peak Hour for Entire Intersection Begins at 04:30 PM																					
04:30 PM	6	15	34	0	55	3	180	19	0	202	9	5	34	10	58	16	131	9	3	159	474
04:45 PM	5	5	19	0	29	14	206	26	0	246	7	11	30	1	49	25	104	12	1	142	466
05:00 PM	15	10	23	0	48	9	224	36	2	271	12	3	28	0	43	23	119	10	0	152	514
05:15 PM	7	8	13	0	28	14	208	38	0	260	13	7	37	6	63	25	116	10	6	157	508
Total Volume	33	38	89	0	160	40	818	119	2	979	41	26	129	17	213	89	470	41	10	610	1962
% App. Total	20.6	23.8	55.6	0		4.1	83.6	12.2	0.2		19.2	12.2	60.6	8		14.6	77	6.7	1.6		
PHF	.550	.633	.654	.000	.727	.714	.913	.783	.250	.903	.788	.591	.872	.425	.845	.890	.897	.854	.417	.959	.954

WILSON OKAMOTO CORPORATION
1907 S. Beretania Street Suite 400
Honolulu, Hi 96826

Counter:D4-5677, D4-5674
Counted:DY, TO
Weather:Clear

File Name : UkaUkee(West) AM
Site Code : 00000001
Start Date : 9/11/2008
Page No : 1

Groups Printed- Unshifted

	Ukee Street (West) Southbound				Ka Uka Blvd. Westbound				Ukee Street (West) Northbound				Ka Uka Blvd. Eastbound				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
06:00 AM	1	0	1	2	20	34	0	54	12	2	58	72	10	140	14	164	292
06:15 AM	0	0	1	1	12	44	0	56	18	6	55	79	6	150	14	170	306
06:30 AM	0	3	1	4	24	41	1	66	13	5	61	79	13	172	8	193	342
06:45 AM	0	5	4	9	31	47	0	78	22	2	48	72	11	142	9	162	321
Total	1	8	7	16	87	166	1	254	65	15	222	302	40	604	45	689	1261
07:00 AM	0	1	2	3	25	44	1	70	14	3	53	70	12	177	21	210	353
07:15 AM	0	4	3	7	36	68	1	105	16	4	62	82	12	167	14	193	387
07:30 AM	0	1	2	3	38	52	3	93	20	2	96	118	13	155	23	191	405
07:45 AM	3	1	0	4	39	44	3	86	27	3	76	106	23	147	30	200	396
Total	3	7	7	17	138	208	8	354	77	12	287	376	60	646	88	794	1541
08:00 AM	2	4	2	8	29	64	4	97	12	9	39	60	14	147	10	171	336
08:15 AM	1	5	2	8	13	58	1	72	20	4	31	55	9	126	10	145	280
08:30 AM	2	3	3	8	12	49	1	62	15	4	28	47	8	107	12	127	244
08:45 AM	0	4	2	6	28	62	5	95	15	2	27	44	16	110	10	136	281
Total	5	16	9	30	82	233	11	326	62	19	125	206	47	490	42	579	1141
Grand Total	9	31	23	63	307	607	20	934	204	46	634	884	147	1740	175	2062	3943
Apprch %	14.3	49.2	36.5		32.9	65	2.1		23.1	5.2	71.7		7.1	84.4	8.5		
Total %	0.2	0.8	0.6	1.6	7.8	15.4	0.5	23.7	5.2	1.2	16.1	22.4	3.7	44.1	4.4	52.3	

	Ukee Street (West) Southbound				Ka Uka Blvd. Westbound				Ukee Street (West) Northbound				Ka Uka Blvd. Eastbound				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
Peak Hour Analysis From 06:00 AM to 08:45 AM - Peak 1 of 1																	
Peak Hour for Entire Intersection Begins at 07:00 AM																	
07:00 AM	0	**1**	2	3	25	44	1	70	**14**	3	53	70	12	**177**	21	**210**	353
07:15 AM	0	**4**	**3**	**7**	36	**68**	1	**105**	16	**4**	62	82	12	167	14	193	387
07:30 AM	0	1	2	3	38	52	**3**	93	20	2	**96**	**118**	13	155	23	191	**405**
07:45 AM	**3**	1	0	4	**39**	44	3	86	**27**	3	76	106	**23**	147	**30**	200	396
Total Volume	3	7	7	17	138	208	8	354	77	12	287	376	60	646	88	794	1541
% App. Total	17.6	41.2	41.2		39	58.8	2.3		20.5	3.2	76.3		7.6	81.4	11.1		
PHF	.250	.438	.583	.607	.885	.765	.667	.843	.713	.750	.747	.797	.652	.912	.733	.945	.951

WILSON OKAMOTO CORPORATION
1907 S. Beretania Street Suite 400
Honolulu, Hi 96826

Counter:D4-5677, D4-5674
Counted:DY, TO
Weather:Clear

File Name : UkaUkee (West) PM
Site Code : 00000001
Start Date : 9/11/2008
Page No : 1

Groups Printed- Unshifted

	Ukee Street (West) Southbound					Ka Uka Blvd. Westbound					Ukee Street (West) Northbound					Ka Uka Blvd. Eastbound					
Start Time	Left	Thru	Right	Peds	App. Total	Left	Thru	Right	Peds	App. Total	Left	Thru	Right	Peds	App. Total	Left	Thru	Right	Peds	App. Total	Int. Total
03:00 PM	5	0	12	1	18	41	199	1	8	249	26	5	39	2	72	12	102	17	0	131	470
03:15 PM	3	6	15	0	24	37	186	3	1	227	49	3	33	1	86	13	98	16	0	127	464
03:30 PM	1	4	19	0	24	47	232	2	2	283	29	2	41	2	74	13	94	15	0	122	503
03:45 PM	3	7	24	0	34	50	186	2	0	238	32	9	49	1	91	26	89	14	0	129	492
Total	12	17	70	1	100	175	803	8	11	997	136	19	162	6	323	64	383	62	0	509	1929
04:00 PM	2	1	17	0	20	39	199	2	4	244	44	7	57	0	108	5	84	26	0	115	487
04:15 PM	4	5	20	0	29	44	199	1	4	248	32	3	46	1	82	10	105	14	0	129	488
04:30 PM	4	4	36	0	44	53	233	2	3	291	36	1	35	2	74	8	124	22	0	154	563
04:45 PM	2	6	15	0	23	44	182	2	7	235	41	8	48	1	98	16	103	23	0	142	498
Total	12	16	88	0	116	180	813	7	18	1018	153	19	186	4	362	39	416	85	0	540	2036
05:00 PM	3	10	35	0	48	52	202	1	7	262	31	7	52	0	90	16	106	24	0	146	546
05:15 PM	2	2	19	0	23	45	199	2	1	247	35	3	45	3	86	11	93	24	0	128	484
05:30 PM	1	8	15	0	24	58	189	2	0	249	31	3	55	2	91	17	85	16	0	118	482
05:45 PM	2	3	10	0	15	49	194	1	0	244	38	3	53	1	95	15	99	29	0	143	497
Total	8	23	79	0	110	204	784	6	8	1002	135	16	205	6	362	59	383	93	0	535	2009
Grand Total	32	56	237	1	326	559	2400	21	37	3017	424	54	553	16	1047	162	1182	240	0	1584	5974
Apprch %	9.8	17.2	72.7	0.3		18.5	79.5	0.7	1.2		40.5	5.2	52.8	1.5		10.2	74.6	15.2	0		
Total %	0.5	0.9	4	0	5.5	9.4	40.2	0.4	0.6	50.5	7.1	0.9	9.3	0.3	17.5	2.7	19.8	4	0	26.5	

	Ukee Street (West) Southbound					Ka Uka Blvd. Westbound					Ukee Street (West) Northbound					Ka Uka Blvd. Eastbound					
Start Time	Left	Thru	Right	Peds	App. Total	Left	Thru	Right	Peds	App. Total	Left	Thru	Right	Peds	App. Total	Left	Thru	Right	Peds	App. Total	Int. Total
Peak Hour Analysis From 03:00 PM to 05:45 PM - Peak 1 of 1																					
Peak Hour for Entire Intersection Begins at 04:15 PM																					
04:15 PM	4	5	20	0	29	44	199	1	4	248	32	3	46	**1**	82	10	105	14	0	129	488
04:30 PM	4	4	**36**	0	44	**53**	**233**	**2**	3	**291**	36	1	35	**2**	74	8	**124**	22	0	**154**	**563**
04:45 PM	2	6	15	0	23	44	182	2	7	235	**41**	**8**	48	1	**98**	**16**	103	23	0	142	498
05:00 PM	3	**10**	35	0	**48**	52	202	1	7	262	31	**7**	**52**	0	90	16	106	**24**	0	146	546
Total Volume	13	25	106	0	144	193	816	6	21	1036	140	19	181	4	344	50	438	83	0	571	2095
% App. Total	9	17.4	73.6	0		18.6	78.8	0.6	2		40.7	5.5	52.6	1.2		8.8	76.7	14.5	0		
PHF	.813	.625	.736	.000	.750	.910	.876	.750	.750	.890	.854	.594	.870	.500	.878	.781	.883	.865	.000	.927	.930

WILSON OKAMOTO CORPORATION
1907 S. Beretania Street Suite 400
Honolulu, Hi 96826

Counter:D4-5676, T-1841
Counted:ER, LF
Weather:Clear

File Name : KamUka AM
Site Code : 00000001
Start Date : 9/11/2008
Page No : 1

Groups Printed- Unshifted

	Kamehameha Highway Southbound				Ka Uka Blvd. Westbound				Kamehameha Highway Northbound				Oahu Regional Park Dwy. Eastbound				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
06:00 AM	142	227	3	372	25	6	17	48	3	34	32	69	0	1	2	3	492
06:15 AM	117	205	6	328	29	3	30	62	2	60	37	99	2	1	0	3	492
06:30 AM	138	209	1	348	20	5	29	54	3	76	53	132	1	1	0	2	536
06:45 AM	121	176	1	298	23	3	49	75	0	95	54	149	1	1	0	2	524
Total	518	817	11	1346	97	17	125	239	8	265	176	449	4	4	2	10	2044
07:00 AM	165	223	1	389	21	4	40	65	1	97	48	146	0	1	1	2	602
07:15 AM	160	184	2	346	25	7	60	92	5	93	37	135	11	6	1	18	591
07:30 AM	139	236	4	379	17	4	65	86	1	142	45	188	3	7	0	10	663
07:45 AM	152	219	10	381	20	2	62	84	1	82	30	113	2	6	2	10	588
Total	616	862	17	1495	83	17	227	327	8	414	160	582	16	20	4	40	2444
08:00 AM	120	192	5	317	32	5	52	89	2	93	34	129	1	2	6	9	544
08:15 AM	103	175	8	286	28	10	42	80	4	80	36	120	1	3	1	5	491
08:30 AM	101	181	6	288	28	5	45	78	3	57	27	87	1	5	1	7	460
08:45 AM	99	167	2	268	27	6	48	81	3	71	37	111	1	0	3	4	464
Total	423	715	21	1159	115	26	187	328	12	301	134	447	4	10	11	25	1959
Grand Total	1557	2394	49	4000	295	60	539	894	28	980	470	1478	24	34	17	75	6447
Apprch %	38.9	59.8	1.2		33	6.7	60.3		1.9	66.3	31.8		32	45.3	22.7		
Total %	24.2	37.1	0.8	62	4.6	0.9	8.4	13.9	0.4	15.2	7.3	22.9	0.4	0.5	0.3	1.2	

	Kamehameha Highway Southbound				Ka Uka Blvd. Westbound				Kamehameha Highway Northbound				Oahu Regional Park Dwy. Eastbound				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
Peak Hour Analysis From 06:00 AM to 08:45 AM - Peak 1 of 1																	
Peak Hour for Entire Intersection Begins at 07:00 AM																	
07:00 AM	**165**	223	1	**389**	21	**4**	40	65	1	97	**48**	146	0	1	1	2	602
07:15 AM	160	184	2	346	**25**	**7**	60	**92**	**5**	93	37	135	**11**	6	1	**18**	591
07:30 AM	139	**236**	4	379	17	4	**65**	86	1	**142**	45	**188**	3	**7**	0	10	**663**
07:45 AM	152	219	**10**	381	20	2	62	84	1	82	30	113	2	6	**2**	10	588
Total Volume	616	862	17	1495	83	17	227	327	8	414	160	582	16	20	4	40	2444
% App. Total	41.2	57.7	1.1		25.4	5.2	69.4		1.4	71.1	27.5		40	50	10		
PHF	.933	.913	.425	.961	.830	.607	.873	.889	.400	.729	.833	.774	.364	.714	.500	.556	.922

WILSON OKAMOTO CORPORATION
1907 S. Beretania Street Suite 400
Honolulu, Hi 96826

Counter:D4-5676, T-1841
Counted:ER, LF
Weather:Clear

File Name : KamUka PM
Site Code : 00000001
Start Date : 9/11/2008
Page No : 1

Groups Printed- Unshifted

	Kamehameha Highway Southbound				Ka Uka Blvd. Westbound				Kamehameha Highway Northbound				Oahu Regional Park Dwy. Eastbound				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
03:00 PM	62	140	1	203	38	17	169	224	12	157	62	231	4	5	2	11	669
03:15 PM	59	125	8	192	46	30	174	250	17	201	66	284	3	7	5	15	741
03:30 PM	62	162	5	229	64	31	209	304	14	213	60	287	2	6	2	10	830
03:45 PM	65	148	14	227	64	24	164	252	7	188	55	250	7	10	7	24	753
Total	248	575	28	851	212	102	716	1030	50	759	243	1052	16	28	16	60	2993
04:00 PM	65	129	16	210	48	35	172	255	13	191	49	253	3	12	4	19	737
04:15 PM	79	141	22	242	42	25	153	220	21	196	44	261	8	11	3	22	745
04:30 PM	80	165	20	265	63	22	206	291	11	208	65	284	16	20	10	46	886
04:45 PM	88	133	14	235	47	18	212	277	8	175	61	244	6	7	8	21	777
Total	312	568	72	952	200	100	743	1043	53	770	219	1042	33	50	25	108	3145
05:00 PM	89	135	7	231	61	24	170	255	9	152	53	214	8	7	9	24	724
05:15 PM	84	118	10	212	51	17	206	274	5	190	38	233	2	9	8	19	738
05:30 PM	61	162	8	231	43	19	173	235	11	144	45	200	5	5	5	15	681
05:45 PM	91	119	13	223	0	0	0	0	0	0	0	0	8	15	21	44	267
Total	325	534	38	897	155	60	549	764	25	486	136	647	23	36	43	102	2410
Grand Total	885	1677	138	2700	567	262	2008	2837	128	2015	598	2741	72	114	84	270	8548
Apprch %	32.8	62.1	5.1		20	9.2	70.8		4.7	73.5	21.8		26.7	42.2	31.1		
Total %	10.4	19.6	1.6	31.6	6.6	3.1	23.5	33.2	1.5	23.6	7	32.1	0.8	1.3	1	3.2	

	Kamehameha Highway Southbound				Ka Uka Blvd. Westbound				Kamehameha Highway Northbound				Oahu Regional Park Dwy. Eastbound				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
Peak Hour Analysis From 03:00 PM to 05:30 PM - Peak 1 of 1																	
Peak Hour for Entire Intersection Begins at 04:00 PM																	
04:00 PM	65	129	16	210	48	**35**	172	255	13	191	49	253	3	12	4	19	737
04:15 PM	79	141	**22**	242	42	25	153	220	**21**	196	44	261	8	11	3	22	745
04:30 PM	80	**165**	20	**265**	**63**	22	206	**291**	11	**208**	**65**	**284**	**16**	**20**	**10**	**46**	**886**
04:45 PM	**88**	133	14	235	47	18	**212**	277	8	175	61	244	6	7	8	21	777
Total Volume	312	568	72	952	200	100	743	1043	53	770	219	1042	33	50	25	108	3145
% App. Total	32.8	59.7	7.6		19.2	9.6	71.2		5.1	73.9	21		30.6	46.3	23.1		
PHF	.886	.861	.818	.898	.794	.714	.876	.896	.631	.925	.842	.917	.516	.625	.625	.587	.887

WILSON OKAMOTO CORPORATION
1907 S. Beretania Street Suite 400
Honolulu, Hi 96826

Counter:D4-3891, D4-5671
Counted:JY, RY
Weather:Clear

File Name : KamWaipioUka AM
Site Code : 00000001
Start Date : 9/10/2008
Page No : 1

Groups Printed- Unshifted

	Kamehameha Highway Southbound				Waipio Uka Westbound				Kamehameha Highway Northbound				Central Oahu Regional Park Dwy. Eastbound				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
06:00 AM	5	256	0	261	132	2	1	135	1	68	77	146	0	2	0	2	544
06:15 AM	4	256	0	260	136	1	4	141	4	100	71	175	0	0	0	0	576
06:30 AM	5	235	0	240	144	2	4	150	8	138	72	218	0	0	0	0	608
06:45 AM	3	246	0	249	123	0	5	128	2	152	89	243	1	0	2	3	623
Total	17	993	0	1010	535	5	14	554	15	458	309	782	1	2	2	5	2351
07:00 AM	6	217	0	223	146	0	6	152	4	111	114	229	1	2	2	5	609
07:15 AM	4	244	0	248	137	0	15	152	5	169	132	306	0	2	2	4	710
07:30 AM	10	266	0	276	124	1	9	134	5	181	166	352	0	0	2	2	764
07:45 AM	10	212	1	223	169	1	10	180	2	124	138	264	0	0	3	3	670
Total	30	939	1	970	576	2	40	618	16	585	550	1151	1	4	9	14	2753
08:00 AM	4	237	1	242	125	3	10	138	3	126	121	250	0	0	7	7	637
08:15 AM	7	205	0	212	131	2	7	140	2	81	71	154	0	1	2	3	509
08:30 AM	4	210	1	215	111	1	4	116	9	98	80	187	1	1	1	3	521
08:45 AM	4	193	0	197	100	2	11	113	5	124	82	211	0	1	3	4	525
Total	19	845	2	866	467	8	32	507	19	429	354	802	1	3	13	17	2192
Grand Total	66	2777	3	2846	1578	15	86	1679	50	1472	1213	2735	3	9	24	36	7296
Apprch %	2.3	97.6	0.1		94	0.9	5.1		1.8	53.8	44.4		8.3	25	66.7		
Total %	0.9	38.1	0	39	21.6	0.2	1.2	23	0.7	20.2	16.6	37.5	0	0.1	0.3	0.5	

	Kamehameha Highway Southbound				Waipio Uka Westbound				Kamehameha Highway Northbound				Central Oahu Regional Park Dwy. Eastbound				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
Peak Hour Analysis From 06:00 AM to 08:45 AM - Peak 1 of 1																	
Peak Hour for Entire Intersection Begins at 07:15 AM																	
07:15 AM	4	244	0	248	137	0	**15**	152	**5**	169	132	306	0	**2**	2	4	710
07:30 AM	**10**	**266**	0	**276**	124	**1**	9	134	5	**181**	**166**	**352**	0	0	2	2	**764**
07:45 AM	10	212	**1**	223	**169**	**1**	10	**180**	2	124	138	264	0	0	3	3	670
08:00 AM	4	237	1	242	125	**3**	10	138	3	126	121	250	0	0	**7**	**7**	637
Total Volume	28	959	2	989	555	5	44	604	15	600	557	1172	0	2	14	16	2781
% App. Total	2.8	97	0.2		91.9	0.8	7.3		1.3	51.2	47.5		0	12.5	87.5		
PHF	.700	.901	.500	.896	.821	.417	.733	.839	.750	.829	.839	.832	.000	.250	.500	.571	.910

WILSON OKAMOTO CORPORATION
1907 S. Beretania Street Suite 400
Honolulu, Hi 96826

Counter:
Counted:
Weather:

File Name : KamWaipioUka PM
Site Code : 00000001
Start Date : 9/10/2008
Page No : 1

Groups Printed- Unshifted

	Kamehameha Highway Southbound				Waipio Uka Westbound				Kamehameha Highway Northbound				Central Oahu Regional Park Dwy. Eastbound				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
03:00 PM	4	188	0	192	104	2	18	124	9	251	205	465	0	1	4	5	786
03:15 PM	2	175	0	177	136	2	10	148	4	278	195	477	0	0	2	2	804
03:30 PM	8	216	1	225	141	2	17	160	6	273	193	472	0	1	8	9	866
03:45 PM	9	170	4	183	131	2	7	140	8	246	184	438	1	3	4	8	769
Total	23	749	5	777	512	8	52	572	27	1048	777	1852	1	5	18	24	3225
04:00 PM	7	206	2	215	135	8	15	158	13	262	205	480	0	2	10	12	865
04:15 PM	13	174	2	189	138	9	9	156	23	253	216	492	2	6	12	20	857
04:30 PM	13	208	6	227	150	5	9	164	32	281	214	527	4	3	15	22	940
04:45 PM	11	179	2	192	156	6	10	172	20	234	201	455	2	3	8	13	832
Total	44	767	12	823	579	28	43	650	88	1030	836	1954	8	14	45	67	3494
05:00 PM	7	185	1	193	138	2	15	155	15	267	195	477	0	5	9	14	839
05:15 PM	13	183	3	199	141	4	18	163	16	250	203	469	0	5	7	12	843
05:30 PM	16	189	0	205	132	7	7	146	18	224	213	455	0	3	10	13	819
05:45 PM	6	159	2	167	150	3	6	159	18	236	194	448	2	1	9	12	786
Total	42	716	6	764	561	16	46	623	67	977	805	1849	2	14	35	51	3287
Grand Total	109	2232	23	2364	1652	52	141	1845	182	3055	2418	5655	11	33	98	142	10006
Apprch %	4.6	94.4	1		89.5	2.8	7.6		3.2	54	42.8		7.7	23.2	69		
Total %	1.1	22.3	0.2	23.6	16.5	0.5	1.4	18.4	1.8	30.5	24.2	56.5	0.1	0.3	1	1.4	

	Kamehameha Highway Southbound				Waipio Uka Westbound				Kamehameha Highway Northbound				Central Oahu Regional Park Dwy. Eastbound				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
Peak Hour Analysis From 03:00 PM to 05:45 PM - Peak 1 of 1																	
Peak Hour for Entire Intersection Begins at 04:00 PM																	
04:00 PM	**7**	206	2	215	135	8	**15**	158	13	262	205	480	0	2	10	12	865
04:15 PM	**13**	174	2	189	138	**9**	9	156	23	253	**216**	492	2	**6**	12	20	857
04:30 PM	13	**208**	**6**	**227**	150	5	9	164	**32**	**281**	214	**527**	4	3	**15**	**22**	**940**
04:45 PM	11	179	2	192	**156**	6	10	**172**	20	234	201	455	2	3	8	13	832
Total Volume	44	767	12	823	579	28	43	650	88	1030	836	1954	8	14	45	67	3494
% App. Total	5.3	93.2	1.5		89.1	4.3	6.6		4.5	52.7	42.8		11.9	20.9	67.2		
PHF	.846	.922	.500	.906	.928	.778	.717	.945	.688	.916	.968	.927	.500	.583	.750	.761	.929

WILSON OKAMOTO CORPORATION
1907 S. Beretania Street Suite 400
Honolulu, Hi 96826

Counter:D54-5672, D4-0525
Counted:EK, JM
Weather:Clear

File Name : KamLumiaina AM
Site Code : 00000002
Start Date : 9/10/2008
Page No : 1

Groups Printed- Unshifted

	Kam Highway Southbound				Lumiaina Street Westbound				Kam Highway Northbound				Lumiaina Street Eastbound				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
06:00 AM	2	295	109	406	23	9	3	35	6	53	2	61	94	5	43	142	644
06:15 AM	0	274	105	379	12	16	9	37	2	63	5	70	85	9	34	128	614
06:30 AM	2	226	132	360	15	14	6	35	7	93	6	106	114	3	31	148	649
06:45 AM	1	267	129	397	14	14	7	35	5	97	6	108	121	2	35	158	698
Total	5	1062	475	1542	64	53	25	142	20	306	19	345	414	19	143	576	2605
07:00 AM	6	240	119	365	17	14	13	44	11	83	7	101	147	4	28	179	689
07:15 AM	2	231	135	368	13	27	11	51	6	180	8	194	110	5	22	137	750
07:30 AM	4	247	148	399	21	15	11	47	12	203	8	223	142	5	15	162	831
07:45 AM	4	259	153	416	14	17	3	34	16	188	15	219	83	3	31	117	786
Total	16	977	555	1548	65	73	38	176	45	654	38	737	482	17	96	595	3056
08:00 AM	6	219	131	356	16	6	5	27	14	164	7	185	78	5	28	111	679
08:15 AM	3	236	110	349	9	6	4	19	11	100	6	117	57	6	27	90	575
08:30 AM	3	197	93	293	15	6	3	24	13	126	16	155	48	1	27	76	548
08:45 AM	5	204	87	296	15	1	2	18	14	150	6	170	67	6	30	103	587
Total	17	856	421	1294	55	19	14	88	52	540	35	627	250	18	112	380	2389
Grand Total	38	2895	1451	4384	184	145	77	406	117	1500	92	1709	1146	54	351	1551	8050
Apprch %	0.9	66	33.1		45.3	35.7	19		6.8	87.8	5.4		73.9	3.5	22.6		
Total %	0.5	36	18	54.5	2.3	1.8	1	5	1.5	18.6	1.1	21.2	14.2	0.7	4.4	19.3	

	Kam Highway Southbound				Lumiaina Street Westbound				Kam Highway Northbound				Lumiaina Street Eastbound				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
Peak Hour Analysis From 06:00 AM to 08:45 AM - Peak 1 of 1																	
Peak Hour for Entire Intersection Begins at 07:00 AM																	
07:00 AM	**6**	240	119	365	17	14	**13**	44	11	83	7	101	**147**	4	28	**179**	689
07:15 AM	2	231	135	368	13	**27**	11	**51**	6	180	8	194	110	**5**	22	137	750
07:30 AM	4	247	148	399	**21**	15	11	47	12	**203**	8	**223**	142	5	15	162	**831**
07:45 AM	4	**259**	**153**	**416**	14	17	3	34	**16**	188	**15**	219	83	3	**31**	117	786
Total Volume	16	977	555	1548	65	73	38	176	45	654	38	737	482	17	96	595	3056
% App. Total	1	63.1	35.9		36.9	41.5	21.6		6.1	88.7	5.2		81	2.9	16.1		
PHF	.667	.943	.907	.930	.774	.676	.731	.863	.703	.805	.633	.826	.820	.850	.774	.831	.919

WILSON OKAMOTO CORPORATION
1907 S. Beretania Street Suite 400
Honolulu, Hi 96826

Counter:D4-5672, D1-0525
Counted:EK, JM
Weather:Clear

File Name : KamLumiaina PM
Site Code : 00000002
Start Date : 9/10/2008
Page No : 1

Groups Printed- Unshifted

	Kamehameha Highway Southbound				Lumiaina Street Westbound				Kamehameha Highway Northbound				Lumiaina Street Eastbound				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
03:00 PM	3	163	133	299	9	10	6	25	53	324	36	413	108	7	26	141	878
03:15 PM	0	125	109	234	11	9	4	24	49	367	26	442	128	4	30	162	862
03:30 PM	2	152	175	329	12	9	5	26	40	319	30	389	154	7	35	196	940
03:45 PM	4	146	172	322	7	11	4	22	50	349	36	435	112	10	42	164	943
Total	9	586	589	1184	39	39	19	97	192	1359	128	1679	502	28	133	663	3623
04:00 PM	2	191	197	390	12	13	21	46	53	316	18	387	162	4	45	211	1034
04:15 PM	1	176	153	330	12	6	23	41	49	393	36	478	126	3	40	169	1018
04:30 PM	6	198	215	419	3	7	13	23	48	346	22	416	146	4	33	183	1041
04:45 PM	9	213	159	381	5	4	20	29	42	346	24	412	96	8	24	128	950
Total	18	778	724	1520	32	30	77	139	192	1401	100	1693	530	19	142	691	4043
05:00 PM	3	210	135	348	8	13	6	27	32	314	26	372	132	10	29	171	918
05:15 PM	8	193	168	369	9	7	9	25	46	316	28	390	124	9	52	185	969
05:30 PM	4	204	128	336	19	12	27	58	38	295	22	355	133	1	51	185	934
05:45 PM	2	212	161	375	5	2	1	8	48	296	22	366	134	3	42	179	928
Total	17	819	592	1428	41	34	43	118	164	1221	98	1483	523	23	174	720	3749
Grand Total	44	2183	1905	4132	112	103	139	354	548	3981	326	4855	1555	70	449	2074	11415
Apprch %	1.1	52.8	46.1		31.6	29.1	39.3		11.3	82	6.7		75	3.4	21.6		
Total %	0.4	19.1	16.7	36.2	1	0.9	1.2	3.1	4.8	34.9	2.9	42.5	13.6	0.6	3.9	18.2	

	Kamehameha Highway Southbound				Lumiaina Street Westbound				Kamehameha Highway Northbound				Lumiaina Street Eastbound				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
Peak Hour Analysis From 03:00 PM to 05:45 PM - Peak 1 of 1																	
Peak Hour for Entire Intersection Begins at 04:00 PM																	
04:00 PM	2	191	197	390	**12**	**13**	21	**46**	**53**	316	18	387	**162**	4	**45**	**211**	1034
04:15 PM	1	176	153	330	12	6	**23**	41	49	**393**	**36**	**478**	126	3	40	169	1018
04:30 PM	6	198	**215**	**419**	3	7	13	23	48	346	22	416	146	4	33	183	**1041**
04:45 PM	**9**	**213**	159	381	5	4	20	29	42	346	24	412	96	**8**	24	128	950
Total Volume	18	778	724	1520	32	30	77	139	192	1401	100	1693	530	19	142	691	4043
% App. Total	1.2	51.2	47.6		23	21.6	55.4		11.3	82.8	5.9		76.7	2.7	20.5		
PHF	.500	.913	.842	.907	.667	.577	.837	.755	.906	.891	.694	.885	.818	.594	.789	.819	.971

WILSON OKAMOTO CORPORATION
1907 S. Beretania Street Suite 400
Honolulu, Hi 96826

Counter:D4-3889, D1-0769
Counted:DY, TO
Weather:Clear

File Name : KamLumiauau AM
Site Code : 00000001
Start Date : 9/10/2008
Page No : 1

Groups Printed- Unshifted

	Kamehameha Highway Southbound				Lumiauau Street Westbound				Kamehameha Highway Northbound				Lumiauau Street Eastbound				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
06:00 AM	1	339	2	342	58	2	5	65	5	63	3	71	3	1	97	101	579
06:15 AM	1	369	3	373	50	1	1	52	7	72	5	84	1	1	87	89	598
06:30 AM	0	277	7	284	60	1	2	63	9	98	3	110	12	1	101	114	571
06:45 AM	2	293	2	297	64	1	0	65	6	88	9	103	15	1	82	98	563
Total	4	1278	14	1296	232	5	8	245	27	321	20	368	31	4	367	402	2311
07:00 AM	1	263	3	267	54	1	3	58	7	91	9	107	13	2	123	138	570
07:15 AM	1	269	1	271	49	6	6	61	2	137	10	149	42	2	76	120	601
07:30 AM	0	279	2	281	36	4	3	43	11	191	11	213	55	5	80	140	677
07:45 AM	1	279	4	284	37	1	1	39	10	221	24	255	5	3	48	56	634
Total	3	1090	10	1103	176	12	13	201	30	640	54	724	115	12	327	454	2482
08:00 AM	5	270	3	278	28	2	2	32	12	175	21	208	0	1	30	31	549
08:15 AM	1	279	3	283	25	3	0	28	11	136	23	170	2	0	34	36	517
08:30 AM	0	263	6	269	22	0	1	23	9	152	14	175	1	0	25	26	493
08:45 AM	0	230	1	231	26	1	2	29	5	173	14	192	3	0	38	41	493
Total	6	1042	13	1061	101	6	5	112	37	636	72	745	6	1	127	134	2052
Grand Total	13	3410	37	3460	509	23	26	558	94	1597	146	1837	152	17	821	990	6845
Apprch %	0.4	98.6	1.1		91.2	4.1	4.7		5.1	86.9	7.9		15.4	1.7	82.9		
Total %	0.2	49.8	0.5	50.5	7.4	0.3	0.4	8.2	1.4	23.3	2.1	26.8	2.2	0.2	12	14.5	

Peak Hour Analysis From 06:00 AM to 08:45 AM - Peak 1 of 1
Peak Hour for Entire Intersection Begins at 07:00 AM

	Kamehameha Highway Southbound				Lumiauau Street Westbound				Kamehameha Highway Northbound				Lumiauau Street Eastbound				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
07:00 AM	**1**	263	3	267	**54**	1	3	58	7	91	9	107	13	2	**123**	138	570
07:15 AM	1	269	1	271	49	**6**	**6**	**61**	2	137	10	149	42	2	76	120	601
07:30 AM	0	**279**	2	281	36	4	3	43	**11**	191	11	213	**55**	**5**	80	**140**	**677**
07:45 AM	1	279	4	**284**	37	1	1	39	10	**221**	**24**	**255**	5	3	48	56	634
Total Volume	3	1090	10	1103	176	12	13	201	30	640	54	724	115	12	327	454	2482
% App. Total	0.3	98.8	0.9		87.6	6	6.5		4.1	88.4	7.5		25.3	2.6	72		
PHF	.750	.977	.625	.971	.815	.500	.542	.824	.682	.724	.563	.710	.523	.600	.665	.811	.917

WILSON OKAMOTO CORPORATION
1907 S. Beretania Street Suite 400
Honolulu, Hi 96826

Counter:D4-3889, D1-0769
Counted:DY, TO
Weather:Clear

File Name : KamLumiauau PM
Site Code : 00000001
Start Date : 9/10/2008
Page No : 1

Groups Printed- Unshifted

	Kamehameha Highway Southbound				Lumiauau Street Westbound				Kamehameha Highway Northbound				Lumiauau Street Eastbound				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
03:00 PM	2	213	11	226	23	4	3	30	26	402	49	477	3	1	22	26	759
03:15 PM	3	200	5	208	18	3	1	22	44	396	44	484	6	1	25	32	746
03:30 PM	1	219	7	227	12	3	3	18	39	389	52	480	4	1	24	29	754
03:45 PM	3	207	1	211	29	2	1	32	24	390	46	460	2	1	20	23	726
Total	9	839	24	872	82	12	8	102	133	1577	191	1901	15	4	91	110	2985
04:00 PM	1	221	8	230	20	3	6	29	33	382	36	451	4	2	21	27	737
04:15 PM	6	230	6	242	12	2	5	19	43	434	44	521	5	3	28	36	818
04:30 PM	0	224	5	229	22	2	4	28	34	437	42	513	6	5	18	29	799
04:45 PM	5	218	4	227	15	4	3	22	41	404	39	484	3	0	22	25	758
Total	12	893	23	928	69	11	18	98	151	1657	161	1969	18	10	89	117	3112
05:00 PM	1	217	10	228	14	1	1	16	39	424	41	504	6	1	14	21	769
05:15 PM	4	223	7	234	13	1	1	15	42	396	45	483	7	0	16	23	755
05:30 PM	3	219	9	231	25	2	1	28	42	365	40	447	10	3	27	40	746
05:45 PM	1	252	6	259	24	4	3	31	45	388	42	475	3	4	21	28	793
Total	9	911	32	952	76	8	6	90	168	1573	168	1909	26	8	78	112	3063
Grand Total	30	2643	79	2752	227	31	32	290	452	4807	520	5779	59	22	258	339	9160
Apprch %	1.1	96	2.9		78.3	10.7	11		7.8	83.2	9		17.4	6.5	76.1		
Total %	0.3	28.9	0.9	30	2.5	0.3	0.3	3.2	4.9	52.5	5.7	63.1	0.6	0.2	2.8	3.7	

	Kamehameha Highway Southbound				Lumiauau Street Westbound				Kamehameha Highway Northbound				Lumiauau Street Eastbound				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
Peak Hour Analysis From 03:00 PM to 05:45 PM - Peak 1 of 1																	
Peak Hour for Entire Intersection Begins at 04:15 PM																	
04:15 PM	**6**	**230**	6	**242**	12	2	**5**	19	**43**	434	**44**	**521**	5	3	**28**	**36**	**818**
04:30 PM	0	224	5	229	**22**	2	4	**28**	34	**437**	42	513	**6**	**5**	18	29	799
04:45 PM	5	218	4	227	15	**4**	3	22	41	404	39	484	3	0	22	25	758
05:00 PM	1	217	**10**	228	14	1	1	16	39	424	41	504	6	1	14	21	769
Total Volume	12	889	25	926	63	9	13	85	157	1699	166	2022	20	9	82	111	3144
% App. Total	1.3	96	2.7		74.1	10.6	15.3		7.8	84	8.2		18	8.1	73.9		
PHF	.500	.966	.625	.957	.716	.563	.650	.759	.913	.972	.943	.970	.833	.450	.732	.771	.961

WILSON OKAMOTO CORPORATION
1907 S. Beretania Street Suite 400
Honolulu, Hi 96826

Counter:D4-5675, T-1839
Counted:ER, LF
Weather:Clear

File Name : KamWaipahu AM
Site Code : 00000001
Start Date : 9/10/2008
Page No : 1

Groups Printed- Unshifted

	Kamehameha Highway Southbound				Westbound	Kamehameha Highway Northbound				Waipahu Street Eastbound				
Start Time	Left	Thru	Right	App. Total	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
06:00 AM	0	439	5	444	0	19	50	0	69	18	0	98	116	629
06:15 AM	0	478	8	486	0	22	74	0	96	17	0	125	142	724
06:30 AM	0	427	14	441	0	12	90	0	102	14	0	145	159	702
06:45 AM	0	349	9	358	0	25	75	0	100	29	0	134	163	621
Total	0	1693	36	1729	0	78	289	0	367	78	0	502	580	2676
07:00 AM	0	456	15	471	0	26	90	0	116	15	0	103	118	705
07:15 AM	0	337	22	359	0	28	115	0	143	28	0	184	212	714
07:30 AM	0	356	21	377	0	39	185	0	224	21	0	158	179	780
07:45 AM	0	325	27	352	0	46	213	0	259	51	0	173	224	835
Total	0	1474	85	1559	0	139	603	0	742	115	0	618	733	3034
08:00 AM	0	321	34	355	0	40	184	0	224	27	0	148	175	754
08:15 AM	0	300	26	326	0	31	141	0	172	21	0	127	148	646
08:30 AM	0	271	16	287	0	26	157	0	183	26	0	155	181	651
08:45 AM	0	282	20	302	0	32	167	0	199	23	0	126	149	650
Total	0	1174	96	1270	0	129	649	0	778	97	0	556	653	2701
Grand Total	0	4341	217	4558	0	346	1541	0	1887	290	0	1676	1966	8411
Apprch %	0	95.2	4.8			18.3	81.7	0		14.8	0	85.2		
Total %	0	51.6	2.6	54.2	0	4.1	18.3	0	22.4	3.4	0	19.9	23.4	

	Kamehameha Highway Southbound				Westbound	Kamehameha Highway Northbound				Waipahu Street Eastbound				
Start Time	Left	Thru	Right	App. Total	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
Peak Hour Analysis From 06:00 AM to 08:45 AM - Peak 1 of 1														
Peak Hour for Entire Intersection Begins at 07:15 AM														
07:15 AM	0	337	22	359	0	28	115	0	143	28	0	**184**	212	714
07:30 AM	0	**356**	21	**377**	0	39	185	0	224	21	0	158	179	780
07:45 AM	0	325	27	352	0	**46**	**213**	0	**259**	**51**	0	173	**224**	**835**
08:00 AM	0	321	**34**	355	0	40	184	0	224	27	0	148	175	754
Total Volume	0	1339	104	1443	0	153	697	0	850	127	0	663	790	3083
% App. Total	0	92.8	7.2			18	82	0		16.1	0	83.9		
PHF	.000	.940	.765	.957	.000	.832	.818	.000	.820	.623	.000	.901	.882	.923

WILSON OKAMOTO CORPORATION
1907 S. Beretania Street Suite 400
Honolulu, Hi 96826

Counter:D4-5675, T-1839
Counted:ER, LF
Weather:Clear

File Name : KamWaipahu PM
Site Code : 00000001
Start Date : 9/10/2008
Page No : 1

Groups Printed- Unshifted

	Kamehameha Highway Southbound				Westbound	Kamehameha Highway Northbound				Waipahu Street Eastbound				
Start Time	Left	Thru	Right	App. Total	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
03:00 PM	0	209	41	250	0	61	451	0	512	41	0	114	155	917
03:15 PM	0	198	43	241	0	49	339	109	497	54	0	94	148	886
03:30 PM	0	198	50	248	0	73	362	74	509	51	0	122	173	930
03:45 PM	0	204	50	254	0	76	413	0	489	53	0	117	170	913
Total	0	809	184	993	0	259	1565	183	2007	199	0	447	646	3646
04:00 PM	0	195	50	245	0	72	427	0	499	58	0	125	183	927
04:15 PM	0	225	49	274	0	69	487	0	556	62	0	139	201	1031
04:30 PM	0	211	42	253	0	58	448	0	506	78	0	132	210	969
04:45 PM	0	198	61	259	0	99	456	0	555	45	0	114	159	973
Total	0	829	202	1031	0	298	1818	0	2116	243	0	510	753	3900
05:00 PM	0	185	39	224	0	69	437	0	506	55	0	96	151	881
05:15 PM	0	241	24	265	0	66	411	0	477	69	0	114	183	925
05:30 PM	0	222	50	272	0	51	413	0	464	44	0	125	169	905
05:45 PM	0	231	59	290	0	54	438	0	492	59	0	128	187	969
Total	0	879	172	1051	0	240	1699	0	1939	227	0	463	690	3680
Grand Total	0	2517	558	3075	0	797	5082	183	6062	669	0	1420	2089	11226
Apprch %	0	81.9	18.1			13.1	83.8	3		32	0	68		
Total %	0	22.4	5	27.4	0	7.1	45.3	1.6	54	6	0	12.6	18.6	

	Kamehameha Highway Southbound				Westbound	Kamehameha Highway Northbound				Waipahu Street Eastbound				
Start Time	Left	Thru	Right	App. Total	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
Peak Hour Analysis From 03:00 PM to 05:45 PM - Peak 1 of 1														
Peak Hour for Entire Intersection Begins at 04:00 PM														
04:00 PM	0	195	50	245	0	72	427	0	499	58	0	125	183	927
04:15 PM	0	**225**	49	**274**	0	69	**487**	0	**556**	62	0	**139**	201	**1031**
04:30 PM	0	211	42	253	0	58	448	0	506	**78**	0	132	**210**	969
04:45 PM	0	198	**61**	259	0	**99**	456	0	555	45	0	114	159	973
Total Volume	0	829	202	1031	0	298	1818	0	2116	243	0	510	753	3900
% App. Total	0	80.4	19.6			14.1	85.9	0		32.3	0	67.7		
PHF	.000	.921	.828	.941	.000	.753	.933	.000	.951	.779	.000	.917	.896	.946

APPENDIX C

LEVEL OF SERVICE DEFINITIONS

LEVEL OF SERVICE DEFINITIONS

LEVEL-OF-SERVICE CRITERIA FOR SIGNALIZED INTERSECTIONS

Level of Service (LOS) for signalized intersections is defined in terms of delay, which is a measure of driver discomfort, frustration, fuel consumption, and increased travel time. Specifically, level-of-service (LOS) criteria are stated in terms of the average control delay per vehicle, typically a 15-min analysis period. The criteria are given in the following table.

Table 1: Level-of-Service Criteria for Signalized Intersections

Level of Service	Control Delay per Vehicle (sec/veh)
A	≤10.0
B	>10.0 and ≤20.0
C	>20.0 and ≤35.0
D	>35.0 and ≤55.0
E	>55.0 and ≤80.0
F	>80.0

Delay is a complex measure and depends on a number of variables, including the quality of progression, the cycle length, the green ratio, and the v/c ratio for the lane group.

Level of Service A describes operations with low control delay, up to 10 sec per vehicle. This level of service occurs when progression is extremely favorable and most vehicles arrive during the green phase. Many vehicles do not stop at all. Short cycle lengths may tend to contribute to low delay values.

Level of Service B describes operations with control delay greater than 10 and up to 20 sec per vehicle. This level generally occurs with good progression, short cycle lengths, or both. More vehicles stop than with LOS A, causing higher levels of delay.

Level of Service C describes operations with control delay greater than 20 and up to 35 sec per vehicle. These higher delays may result from only fair progression, longer cycle lengths, or both. Individual cycle failures may begin to appear at this level. Cycle failure occurs when a given green phase does not serve queued vehicles and overflows occur. The number of vehicles stopping is significant at this level, though many still pass through the intersection without stopping.

Level of Service D describes operations with control delay greater than 35 and up to 55 sec per vehicle. At level of service D, the influence of congestion becomes more noticeable. Longer delays may result from some combination of unfavorable progression, long cycle lengths, or high v/c ratios. Many vehicles stop, and the proportion of vehicles not stopping declines. Individual cycle failures are noticeable.

"Highway Capacity Manual," Transportation Research Board, 2000.

Level of Service E describes operation with control delay greater than 55 and up to 80 sec per vehicle. These high delay values generally indicate poor progression, long cycle lengths, and high v/c ratios. Individual cycle failures are frequent.

Level of Service F describes operations with control delay in excess of 80 sec per vehicle. This level, considered to be unacceptable to most drivers, often occurs with oversaturation, that is, when arrival flow rates exceed the capacity lane groups. It may also occur at high v/c ratios with many individual cycle failures. Poor progression and long cycle lengths may also contribute significantly to high delay levels.

"Highway Capacity Manual," Transportation Research Board, 2000.

LEVEL OF SERVICE DEFINITIONS

LEVEL-OF-SERVICE CRITERIA FOR UNSIGNALIZED INTERSECTIONS

Level of Service (LOS) criteria are given in Table 1. As used here, control delay is defined as the total elapsed time from the time a vehicle stops at the end of the queue to the time required for the vehicle to travel from the last-in-queue position to the first-in-queue position, including deceleration of vehicles from free-flow speed to the speed of vehicles in the queue.

The average total delay for any particular minor movement is a function of the service rate or capacity of the approach and the degree of saturation. If the degree of saturation is greater than about 0.9, average control delay is significantly affected by the length of the analysis period.

Table 1: Level-of-Service Criteria for Unsignalized Intersections

Level of Service	Average Control Delay (Sec/Veh)
A	≤10.0
B	>10.0 and ≤15.0
C	>15.0 and ≤25.0
D	>25.0 and ≤35.0
E	>35.0 and ≤50.0
F	>50.0

"Highway Capacity Manual," Transportation Research Board, 2000.

APPENDIX D

CAPACITY ANALYSIS CALCULATIONS
EXISTING PEAK HOUR TRAFFIC ANALYSIS

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↰	↑			↑↱		↰	✥				
Volume (vph)	293	31	0	0	7	1	563	0	25	0	0	0
Ideal Flow (vphpl)	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
Total Lost time (s)	5.0	5.0			5.0		5.0	5.0				
Lane Util. Factor	1.00	1.00			0.95		0.95	0.95				
Frt	1.00	1.00			0.98		1.00	0.99				
Flt Protected	0.95	1.00			1.00		0.95	0.96				
Satd. Flow (prot)	1863	1961			3663		1770	1759				
Flt Permitted	0.75	1.00			1.00		0.95	0.96				
Satd. Flow (perm)	1473	1961			3663		1770	1759				
Peak-hour factor, PHF	0.50	0.50	0.50	0.90	0.90	0.90	0.85	0.85	0.85	0.92	0.92	0.92
Adj. Flow (vph)	586	62	0	0	8	1	662	0	29	0	0	0
RTOR Reduction (vph)	0	0	0	0	0	0	0	3	0	0	0	0
Lane Group Flow (vph)	586	62	0	0	9	0	344	344	0	0	0	0
Turn Type	Perm						Perm					
Protected Phases		4			8			2				
Permitted Phases	4						2					
Actuated Green, G (s)	29.8	29.8			29.8		18.0	18.0				
Effective Green, g (s)	29.8	29.8			29.8		18.0	18.0				
Actuated g/C Ratio	0.52	0.52			0.52		0.31	0.31				
Clearance Time (s)	5.0	5.0			5.0		5.0	5.0				
Vehicle Extension (s)	3.0	3.0			3.0		3.0	3.0				
Lane Grp Cap (vph)	759	1011			1889		551	548				
v/s Ratio Prot		0.03			0.00							
v/s Ratio Perm	c0.40						0.19	0.20				
v/c Ratio	0.77	0.06			0.00		0.62	0.63				
Uniform Delay, d1	11.3	7.0			6.8		17.0	17.0				
Progression Factor	1.00	1.00			1.00		1.00	1.00				
Incremental Delay, d2	4.9	0.0			0.0		2.2	2.2				
Delay (s)	16.2	7.0			6.8		19.2	19.3				
Level of Service	B	A			A		B	B				
Approach Delay (s)		15.3			6.8			19.2			0.0	
Approach LOS		B			A			B			A	

Intersection Summary			
HCM Average Control Delay	17.3	HCM Level of Service	B
HCM Volume to Capacity ratio	0.72		
Actuated Cycle Length (s)	57.8	Sum of lost time (s)	10.0
Intersection Capacity Utilization	49.6%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

	↗	→	↘	↙	←	↖	↖	↑	↗	↘	↓	↙
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lane Configurations	↰	↑			↑↱		↰	↰↑↱				
Volume (vph)	[illegible]	[illegible]	0	0	[illegible]	30	[illegible]	0	[illegible]	0	0	0
Ideal Flow (vphpl)	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
Total Lost time (s)	5.0	5.0			5.0		5.0	5.0				
Lane Util. Factor	1.00	1.00			0.95		0.95	0.95				
Frt	1.00	1.00			0.94		1.00	0.99				
Flt Protected	0.95	1.00			1.00		0.95	0.95				
Satd. Flow (prot)	1863	1961			3516		1770	1767				
Flt Permitted	0.70	1.00			1.00		0.95	0.95				
Satd. Flow (perm)	1377	1961			3516		1770	1767				
Peak-hour factor, PHF	0.84	0.84	0.84	1.00	1.00	1.00	0.93	0.93	0.93	0.92	0.92	0.92
Adj. Flow (vph)	605	63	0	0	50	30	1249	0	25	0	0	0
RTOR Reduction (vph)	0	0	0	0	16	0	0	2	0	0	0	0
Lane Group Flow (vph)	605	63	0	0	64	0	637	635	0	0	0	0
Turn Type	Perm						Perm					
Protected Phases		4			8			2				
Permitted Phases	4						2					
Actuated Green, G (s)	39.7	39.7			39.7		34.1	34.1				
Effective Green, g (s)	39.7	39.7			39.7		34.1	34.1				
Actuated g/C Ratio	0.47	0.47			0.47		0.41	0.41				
Clearance Time (s)	5.0	5.0			5.0		5.0	5.0				
Vehicle Extension (s)	3.0	3.0			3.0		3.0	3.0				
Lane Grp Cap (vph)	652	929			1666		720	719				
v/s Ratio Prot		0.03			0.02							
v/s Ratio Perm	c0.44						c0.36	0.36				
v/c Ratio	0.93	0.07			0.04		0.88	0.88				
Uniform Delay, d1	20.7	12.0			11.8		23.0	23.0				
Progression Factor	1.00	1.00			1.00		1.00	1.00				
Incremental Delay, d2	19.4	0.0			0.0		12.5	12.4				
Delay (s)	40.1	12.0			11.8		35.5	35.4				
Level of Service	D	B			B		D	D				
Approach Delay (s)		37.5			11.8			35.5			0.0	
Approach LOS		D			B			D			A	

Intersection Summary			
HCM Average Control Delay	35.2	HCM Level of Service	D
HCM Volume to Capacity ratio	0.91		
Actuated Cycle Length (s)	83.8	Sum of lost time (s)	10.0
Intersection Capacity Utilization	103.9%	ICU Level of Service	G
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	324	968	5	565	0	0
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.95	0.95	0.86	0.86	0.92	0.92
Hourly flow rate (vph)	341	1019	6	657	0	0
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)	516			638		
pX, platoon unblocked			0.75		0.75	0.75
vC, conflicting volume			341		681	341
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			0		405	0
tC, single (s)			4.1		6.8	6.9
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			100		100	100
cM capacity (veh/h)			1213		427	811

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	WB 3
Volume Total	681	679	6	328	328
Volume Left	0	0	6	0	0
Volume Right	340	679	0	0	0
cSH	1700	1700	1213	1700	1700
Volume to Capacity	0.40	0.40	0.00	0.19	0.19
Queue Length 95th (ft)	0	0	0	0	0
Control Delay (s)	0.0	0.0	8.0	0.0	0.0
Lane LOS			A		
Approach Delay (s)	0.0		0.1		
Approach LOS					

Intersection Summary			
Average Delay	0.0		
Intersection Capacity Utilization	49.6%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	561	767	25	1187	0	0
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.89	0.89	0.93	0.93	0.92	0.92
Hourly flow rate (vph)	630	862	27	1276	0	0
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)	516			638		
pX, platoon unblocked			0.81		0.81	0.81
vC, conflicting volume			630		1322	630
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			426		1281	426
tC, single (s)			4.1		6.8	6.9
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			97		100	100
cM capacity (veh/h)			915		124	467

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	WB 3
Volume Total	918	575	27	638	638
Volume Left	0	0	27	0	0
Volume Right	287	575	0	0	0
cSH	1700	1700	915	1700	1700
Volume to Capacity	0.54	0.34	0.03	0.38	0.38
Queue Length 95th (ft)	0	0	2	0	0
Control Delay (s)	0.0	0.0	9.1	0.0	0.0
Lane LOS			A		
Approach Delay (s)	0.0		0.2		
Approach LOS					

Intersection Summary			
Average Delay	0.1		
Intersection Capacity Utilization	89.9%	ICU Level of Service	E
Analysis Period (min)	15		

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lane Configurations												
Volume (vph)	0	844	52	236	330	0	28	0	437	11	158	191
Ideal Flow (vphpl)	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
Total Lost time (s)		5.0		5.0	5.0		5.0		6.0		5.0	
Lane Util. Factor		0.95		1.00	0.95		1.00		1.00		1.00	
Frt		0.99		1.00	1.00		1.00		0.85		0.93	
Flt Protected		1.00		0.95	1.00		0.95		1.00		1.00	
Satd. Flow (prot)		3693		1863	3725		1863		1667		1818	
Flt Permitted		1.00		0.95	1.00		0.95		1.00		1.00	
Satd. Flow (perm)		3693		1863	3725		1863		1667		1818	
Peak-hour factor, PHF	0.88	0.88	0.88	0.90	0.90	0.90	0.83	0.83	0.83	0.95	0.95	0.95
Adj. Flow (vph)	0	959	59	262	366	0	34	0	527	12	166	201
RTOR Reduction (vph)	0	3	0	0	0	0	0	0	482	0	34	0
Lane Group Flow (vph)	0	1015	0	262	366	0	34	0	45	0	345	0
Turn Type				Prot			Prot		custom	Split		
Protected Phases		4		3	8		5			6	6	
Permitted Phases									5			
Actuated Green, G (s)		33.3		18.2	56.5		9.9		9.9		23.9	
Effective Green, g (s)		33.3		18.2	56.5		9.9		8.9		23.9	
Actuated g/C Ratio		0.32		0.17	0.54		0.09		0.08		0.23	
Clearance Time (s)		5.0		5.0	5.0		5.0		5.0		5.0	
Vehicle Extension (s)		3.0		3.0	3.0		3.0		3.0		3.0	
Lane Grp Cap (vph)		1168		322	1999		175		141		413	
v/s Ratio Prot		c0.27		c0.14	0.10		0.02				c0.19	
v/s Ratio Perm									c0.03			
v/c Ratio		0.87		0.81	0.18		0.19		0.32		0.84	
Uniform Delay, d1		33.9		41.9	12.5		44.0		45.3		38.8	
Progression Factor		1.00		1.00	1.00		1.00		1.00		1.00	
Incremental Delay, d2		7.1		14.5	0.0		0.5		1.3		13.6	
Delay (s)		41.0		56.4	12.6		44.6		46.6		52.4	
Level of Service		D		E	B		D		D		D	
Approach Delay (s)		41.0			30.9			46.5			52.4	
Approach LOS		D			C			D			D	

Intersection Summary			
HCM Average Control Delay	41.4	HCM Level of Service	D
HCM Volume to Capacity ratio	[illegible]		
Actuated Cycle Length (s)	105.3	Sum of lost time (s)	21.0
Intersection Capacity Utilization	[illegible]	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↑↱		↰	↑↑		↰		↱		✥	
Volume (vph)	0	614	75	368	819	0	78	0	696	18	192	178
Ideal Flow (vphpl)	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
Total Lost time (s)		5.0		5.0	5.0		5.0		6.0		5.0	
Lane Util. Factor		0.95		1.00	0.95		1.00		1.00		1.00	
Frt		0.98		1.00	1.00		1.00		0.85		0.94	
Flt Protected		1.00		0.95	1.00		0.95		1.00		1.00	
Satd. Flow (prot)		3664		1863	3725		1863		1667		1835	
Flt Permitted		1.00		0.95	1.00		0.95		1.00		1.00	
Satd. Flow (perm)		3664		1863	3725		1863		1667		1835	
Peak-hour factor, PHF	0.92	0.92	0.92	0.85	0.85	0.85	0.86	0.86	0.86	0.88	0.88	0.88
Adj. Flow (vph)	0	667	82	433	964	0	91	0	809	20	218	202
RTOR Reduction (vph)	0	8	0	0	0	0	0	0	628	0	25	0
Lane Group Flow (vph)	0	741	0	433	964	0	91	0	181	0	415	0
Turn Type				Prot			Prot		custom	Split		
Protected Phases		4		3	8		5			6	6	
Permitted Phases									5			
Actuated Green, G (s)		24.1		28.0	57.1		17.0		17.0		27.8	
Effective Green, g (s)		24.1		28.0	57.1		17.0		16.0		27.8	
Actuated g/C Ratio		0.21		0.24	0.49		0.15		0.14		0.24	
Clearance Time (s)		5.0		5.0	5.0		5.0		5.0		5.0	
Vehicle Extension (s)		3.0		3.0	3.0		3.0		3.0		3.0	
Lane Grp Cap (vph)		755		446	1819		271		228		436	
v/s Ratio Prot		c0.20		c0.23	0.26		0.05				c0.23	
v/s Ratio Perm									c0.11			
v/c Ratio		0.98		0.97	0.53		0.34		0.79		0.95	
Uniform Delay, d1		46.2		44.0	20.6		44.9		48.8		43.9	
Progression Factor		1.00		1.00	1.00		1.00		1.00		1.00	
Incremental Delay, d2		28.0		34.9	0.3		0.7		17.0		30.9	
Delay (s)		74.2		79.0	20.9		45.6		65.8		74.7	
Level of Service		E		E	C		D		E		E	
Approach Delay (s)		74.2			38.9			63.8			74.7	
Approach LOS		E			D			E			E	

Intersection Summary			
HCM Average Control Delay	57.4	HCM Level of Service	E
HCM Volume to Capacity ratio	0.94		
Actuated Cycle Length (s)	116.9	Sum of lost time (s)	21.0
Intersection Capacity Utilization	93.6%	ICU Level of Service	F
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	864	73	90	458	0	32
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.90	0.90	0.75	0.75
Hourly flow rate (vph)	939	79	100	509	0	43
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)				648		
pX, platoon unblocked					0.99	
vC, conflicting volume			1018		1433	509
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			1018		1421	509
tC, single (s)			4.1		6.8	6.9
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			85		100	92
cM capacity (veh/h)			677		108	509

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1
Volume Total	626	392	270	339	43
Volume Left	0	0	100	0	0
Volume Right	0	79	0	0	43
cSH	1700	1700	677	1700	509
Volume to Capacity	0.37	0.23	0.15	0.20	0.08
Queue Length 95th (ft)	0	0	13	0	7
Control Delay (s)	0.0	0.0	5.3	0.0	12.7
Lane LOS			A		B
Approach Delay (s)	0.0		2.4		12.7
Approach LOS					B

Intersection Summary			
Average Delay	1.2		
Intersection Capacity Utilization	47.7%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations	↑↑›			↑↑		↱
Volume (veh/h)	519	140	107	968	0	170
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.89	0.89	0.91	0.91	0.88	0.88
Hourly flow rate (vph)	583	157	118	1064	0	193
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)				648		
pX, platoon unblocked					0.82	
vC, conflicting volume			740		1429	370
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			740		1092	370
tC, single (s)			4.1		6.8	6.9
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			86		100	69
cM capacity (veh/h)			862		149	627

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1
Volume Total	389	352	472	709	193
Volume Left	0	0	118	0	0
Volume Right	0	157	0	0	193
cSH	1700	1700	862	1700	627
Volume to Capacity	0.23	0.21	0.14	0.42	0.31
Queue Length 95th (ft)	0	0	12	0	33
Control Delay (s)	0.0	0.0	3.7	0.0	13.3
Lane LOS			A		B
Approach Delay (s)	0.0		1.5		13.3
Approach LOS					B

Intersection Summary			
Average Delay	2.0		
Intersection Capacity Utilization	54.6%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		✣			✣		↰	↑↱		↰	↑↱	
Volume (veh/h)	15	3	2	41	15	21	8	901	69	84	299	75
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.56	0.56	0.56	0.74	0.74	0.74	0.94	0.94	0.94	0.93	0.93	0.93
Hourly flow rate (vph)	27	5	4	55	20	28	9	959	73	90	322	81
Pedestrians												
Lane Width (ft)												
Walking Speed (ft/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (ft)								871				
pX, platoon unblocked												
vC, conflicting volume	1077	1591	201	1360	1595	516	402			1032		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	1077	1591	201	1360	1595	516	402			1032		
tC, single (s)	*5.5	*4.5	*4.9	*5.5	*4.5	*4.9	4.1			4.1		
tC, 2 stage (s)												
tF (s)	*2.5	*3.0	*2.3	*2.5	*3.0	*2.3	2.2			2.2		
p0 queue free %	92	98	100	77	92	97	99			86		
cM capacity (veh/h)	320	254	1269	244	254	910	1153			669		

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Volume Total	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Volume Left	27	55	9	0	0	90	0	0
Volume Right	4	28	0	0	73	0	0	81
cSH	332	308	1153	1700	1700	669	1700	1700
Volume to Capacity	0.11	0.34	0.01	0.38	0.23	0.14	0.13	0.11
Queue Length 95th (ft)	9	36	1	0	0	12	0	0
Control Delay (s)	17.1	22.6	8.1	0.0	0.0	11.2	0.0	0.0
Lane LOS	C	C	A			B		
Approach Delay (s)	17.1	22.6	0.1			2.1		
Approach LOS	C	C						

Intersection Summary			
Average Delay	2.4		
Intersection Capacity Utilization	44.6%	ICU Level of Service	A
Analysis Period (min)	15		

* User Entered Value

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		✥			✥		↰	↑↱		↰	↑↱	
Volume (veh/h)	45	11	14	121	13	61	7	553	54	61	839	68
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.94	0.94	0.94	0.85	0.85	0.85	0.88	0.88	0.88	0.90	0.90	0.90
Hourly flow rate (vph)	48	12	15	142	15	72	8	628	61	68	932	76
Pedestrians												
Lane Width (ft)												
Walking Speed (ft/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (ft)								871				
pX, platoon unblocked												
vC, conflicting volume	1515	1811	504	1297	1818	345	1008			690		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	1515	1811	504	1297	1818	345	1008			690		
tC, single (s)	*5.5	*4.5	*4.9	*5.5	*4.5	*4.9	4.1			4.1		
tC, 2 stage (s)												
tF (s)	*2.5	*3.0	*2.3	*2.5	*3.0	*2.3	2.2			2.2		
p0 queue free %	75	95	98	46	93	93	99			92		
cM capacity (veh/h)	190	221	922	266	219	1091	683			901		

Direction, Lane #	EB 1	WB 1	NB 1	NB 2	NB 3	SB 1	SB 2	SB 3
Volume Total	74	229	8	419	271	68	621	386
Volume Left	48	142	8	0	0	68	0	0
Volume Right	15	72	0	0	61	0	0	76
cSH	232	342	683	1700	1700	901	1700	1700
Volume to Capacity	0.32	0.67	0.01	0.25	0.16	0.08	0.37	0.23
Queue Length 95th (ft)	33	115	1	0	0	6	0	0
Control Delay (s)	27.7	34.6	10.3	0.0	0.0	9.3	0.0	0.0
Lane LOS	D	D	B			A		
Approach Delay (s)	27.7	34.6	0.1			0.6		
Approach LOS	D	D						

Intersection Summary			
Average Delay	5.2		
Intersection Capacity Utilization	50.4%	ICU Level of Service	A
Analysis Period (min)	15		

* User Entered Value

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		✥			✥		↰	↑↑↱		↰	↑↑↱	
Volume (vph)	39	12	23	91	19	94	58	845	101	62	252	28
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	2000	2000	2000	2000	2000	2000
Total Lost time (s)		5.0			5.0		5.0	5.0		5.0	5.0	
Lane Util. Factor		1.00			1.00		1.00	0.95		1.00	0.95	
Frt		0.96			0.94		1.00	0.98		1.00	0.98	
Flt Protected		0.97			0.98		0.95	1.00		0.95	1.00	
Satd. Flow (prot)		1738			1709		1863	3666		1863	3669	
Flt Permitted		0.80			0.82		0.54	1.00		0.22	1.00	
Satd. Flow (perm)		1427			1432		1067	3666		434	3669	
Peak-hour factor, PHF	0.96	0.96	0.96	0.92	0.92	0.92	0.92	0.92	0.92	0.81	0.81	0.81
Adj. Flow (vph)	41	12	24	99	21	102	63	918	110	77	311	35
RTOR Reduction (vph)	0	17	0	0	36	0	0	12	0	0	11	0
Lane Group Flow (vph)	0	60	0	0	186	0	63	1016	0	77	335	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4			8			2			6		
Actuated Green, G (s)		11.1			11.1		19.7	19.7		19.7	19.7	
Effective Green, g (s)		11.1			11.1		19.7	19.7		19.7	19.7	
Actuated g/C Ratio		0.27			0.27		0.48	0.48		0.48	0.48	
Clearance Time (s)		5.0			5.0		5.0	5.0		5.0	5.0	
Vehicle Extension (s)		3.0			3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)		388			390		515	1770		210	1772	
v/s Ratio Prot								c0.28			0.09	
v/s Ratio Perm		0.04			c0.13		0.06			0.18		
v/c Ratio		0.15			0.48		0.12	0.57		0.37	0.19	
Uniform Delay, d1		11.3			12.4		5.8	7.5		6.6	6.0	
Progression Factor		1.00			1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2		0.2			0.9		0.1	0.5		1.1	0.1	
Delay (s)		11.5			13.3		5.9	8.0		7.7	6.1	
Level of Service		B			B		A	A		A	A	
Approach Delay (s)		11.5			13.3			7.9			6.4	
Approach LOS		B			B			A			A	

Intersection Summary			
HCM Average Control Delay	8.3	HCM Level of Service	A
HCM Volume to Capacity ratio	[illegible]		
Actuated Cycle Length (s)	40.8	Sum of lost time (s)	10.0
Intersection Capacity Utilization	54.3%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

	↗	→	↘	↙	←	↖	↖	↑	↗	↘	↓	↙
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lane Configurations		✣			✣		↰	↑↑↱		↰	↑↑↱	
Volume (vph)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	2000	2000	2000	2000	2000	2000
Total Lost time (s)		[illegible]			[illegible]		[illegible]	[illegible]		[illegible]	[illegible]	
Lane Util. Factor		1.00			1.00		1.00	0.95		1.00	0.95	
Frt		0.97			0.97		1.00	0.98		1.00	0.99	
Flt Protected		0.97			0.97		0.95	1.00		0.95	1.00	
Satd. Flow (prot)		1761			1753		1863	3636		1863	3700	
Flt Permitted		0.74			0.71		0.23	1.00		0.42	1.00	
Satd. Flow (perm)		1344			1295		458	3636		825	3700	
Peak-hour factor, PHF	0.73	0.73	0.73	0.86	0.86	0.86	0.96	0.96	0.96	0.91	0.91	0.91
Adj. Flow (vph)	123	52	47	160	30	48	43	503	96	122	904	44
RTOR Reduction (vph)	0	12	0	0	11	0	0	19	0	0	4	0
Lane Group Flow (vph)	0	210	0	0	227	0	43	580	0	122	944	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4			8			2			6		
Actuated Green, G (s)		14.6			14.6		19.6	19.6		19.6	19.6	
Effective Green, g (s)		14.6			14.6		19.6	19.6		19.6	19.6	
Actuated g/C Ratio		0.33			0.33		0.44	0.44		0.44	0.44	
Clearance Time (s)		5.0			5.0		5.0	5.0		5.0	5.0	
Vehicle Extension (s)		3.0			3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)		444			428		203	1612		366	1641	
v/s Ratio Prot								0.16			c0.26	
v/s Ratio Perm		0.16			c0.18		0.09			0.15		
v/c Ratio		0.47			0.53		0.21	0.36		0.33	0.58	
Uniform Delay, d1		11.7			12.0		7.6	8.1		8.0	9.2	
Progression Factor		1.00			1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2		0.8			1.2		0.5	0.1		0.5	0.5	
Delay (s)		12.5			13.2		8.1	8.3		8.6	9.7	
Level of Service		B			B		A	A		A	A	
Approach Delay (s)		12.5			13.2			8.3			9.6	
Approach LOS		B			B			A			A	

Intersection Summary			
HCM Average Control Delay	9.9	HCM Level of Service	A
HCM Volume to Capacity ratio	0.56		
Actuated Cycle Length (s)	44.2	Sum of lost time (s)	10.0
Intersection Capacity Utilization	53.9%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↰	↑↑↱		↰	↑↑↱			✣			✣	
Volume (vph)	58	687	85	135	223	8	83	12	314	3	7	7
Ideal Flow (vphpl)	2000	2000	2000	2000	2000	2000	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0		5.0	5.0			5.0			5.0	
Lane Util. Factor	1.00	0.95		1.00	0.95			1.00			1.00	
Frt	1.00	0.98		1.00	0.99			0.90			0.94	
Flt Protected	0.95	1.00		0.95	1.00			0.99			0.99	
Satd. Flow (prot)	1863	3664		1863	3705			1653			1744	
Flt Permitted	0.95	1.00		0.95	1.00			0.92			0.94	
Satd. Flow (perm)	1863	3664		1863	3705			1542			1649	
Peak-hour factor, PHF	0.95	0.95	0.95	0.84	0.84	0.84	0.80	0.80	0.80	0.61	0.61	0.61
Adj. Flow (vph)	61	723	89	161	265	10	104	15	392	5	11	11
RTOR Reduction (vph)	0	9	0	0	2	0	0	101	0	0	8	0
Lane Group Flow (vph)	61	803	0	161	273	0	0	410	0	0	19	0
Turn Type	Prot			Prot			Perm			Perm		
Protected Phases	7	4		3	8			2			6	
Permitted Phases							2			6		
Actuated Green, G (s)	4.1	23.7		10.8	30.4			20.8			20.8	
Effective Green, g (s)	4.1	23.7		10.8	30.4			20.8			20.8	
Actuated g/C Ratio	0.06	0.34		0.15	0.43			0.30			0.30	
Clearance Time (s)	5.0	5.0		5.0	5.0			5.0			5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0			3.0			3.0	
Lane Grp Cap (vph)	109	1235		286	1602			456			488	
v/s Ratio Prot	0.03	c0.22		c0.09	0.07							
v/s Ratio Perm								c0.23			0.01	
v/c Ratio	0.56	0.65		0.56	0.17			0.77			0.04	
Uniform Delay, d1	32.2	19.8		27.6	12.2			22.6			17.6	
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Incremental Delay, d2	6.1	1.2		2.5	0.1			7.6			0.0	
Delay (s)	38.3	21.0		30.1	12.3			30.2			17.7	
Level of Service	D	C		C	B			C			B	
Approach Delay (s)		22.2			18.9			30.2			17.7	
Approach LOS		C			B			C			B	

Intersection Summary			
HCM Average Control Delay	23.5	HCM Level of Service	C
HCM Volume to Capacity ratio	0.68		
Actuated Cycle Length (s)	70.3	Sum of lost time (s)	15.0
Intersection Capacity Utilization	71.5%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]			[illegible]			[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ideal Flow (vphpl)	2000	2000	2000	2000	2000	2000	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0		5.0	5.0			5.0			5.0	
Lane Util. Factor	1.00	0.95		1.00	0.95			1.00			1.00	
Frt	1.00	0.97		1.00	1.00			0.93			0.90	
Flt Protected	0.95	1.00		0.95	1.00			0.98			1.00	
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]			[illegible]			[illegible]	
Flt Permitted	0.95	1.00		0.95	1.00			0.78			0.98	
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]			[illegible]			[illegible]	
Peak-hour factor, PHF	0.93	0.93	0.93	0.89	0.89	0.89	0.89	0.89	0.89	0.72	0.72	0.72
Adj. Flow (vph)	57	465	106	208	902	8	167	21	194	15	31	150
RTOR Reduction (vph)	0	20	0	0	1	0	0	47	0	0	101	0
Lane Group Flow (vph)	57	551	0	208	909	0	0	335	0	0	95	0
Turn Type	Prot			Prot			Perm			Perm		
Protected Phases	7	4		3	8			2			6	
Permitted Phases							2			6		
Actuated Green, G (s)	3.1	19.2		13.0	29.1			22.8			22.8	
Effective Green, g (s)	3.1	19.2		13.0	29.1			22.8			22.8	
Actuated g/C Ratio	0.04	0.27		0.19	0.42			0.33			0.33	
Clearance Time (s)	5.0	5.0		5.0	5.0			5.0			5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0			3.0			3.0	
Lane Grp Cap (vph)	83	993		346	1547			428			522	
v/s Ratio Prot	0.03	0.15		c0.11	c0.24							
v/s Ratio Perm								c0.25			0.06	
v/c Ratio	0.69	0.55		0.60	0.59			0.78			0.18	
Uniform Delay, d1	33.0	21.7		26.1	15.8			21.4			16.9	
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Incremental Delay, d2	21.0	0.7		2.9	0.6			9.0			0.2	
Delay (s)	54.0	22.4		29.1	16.4			30.4			17.1	
Level of Service	D	C		C	B			C			B	
Approach Delay (s)		25.3			18.7			30.4			17.1	
Approach LOS		C			B			C			B	

Intersection Summary			
HCM Average Control Delay	22.3	HCM Level of Service	C
HCM Volume to Capacity ratio	0.64		
Actuated Cycle Length (s)	70.0	Sum of lost time (s)	10.0
Intersection Capacity Utilization	69.6%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	16	20	4	78	16	219	8	438	172	638	878	17
Ideal Flow (vphpl)	1900	1900	1900	2000	2000	2000	2000	2000	2000	2000	2000	2000
Total Lost time (s)	5.0	5.0		5.0	5.0	4.0	5.0	5.0	5.0	5.0	5.0	6.0
Lane Util. Factor	1.00	0.95		1.00	1.00	1.00	1.00	0.95	1.00	0.97	0.95	1.00
Frt	1.00	0.98		1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1770	3453		1863	1961	1667	1863	3725	1667	3614	3725	1667
Flt Permitted	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	1770	3453		1863	1961	1667	1863	3725	1667	3614	3725	1667
Peak-hour factor, PHF	0.56	0.56	0.56	0.89	0.89	0.89	0.77	0.77	0.77	0.96	0.96	0.96
Adj. Flow (vph)	29	36	7	88	18	246	10	569	223	665	915	18
RTOR Reduction (vph)	0	7	0	0	0	0	0	0	152	0	0	8
Lane Group Flow (vph)	29	36	0	88	18	246	10	569	71	665	915	10
Turn Type	Split			Split		Free	Prot		Perm	Prot		Perm
Protected Phases	4	4		8	8		5	2		1	6	
Permitted Phases						Free			2			6
Actuated Green, G (s)	5.2	5.2		7.3	7.3	77.8	1.0	24.6	24.6	20.7	44.3	44.3
Effective Green, g (s)	5.2	5.2		7.3	7.3	77.8	1.0	24.6	24.6	20.7	44.3	43.3
Actuated g/C Ratio	0.07	0.07		0.09	0.09	1.00	0.01	0.32	0.32	0.27	0.57	0.56
Clearance Time (s)	5.0	5.0		5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	118	231		175	184	1667	24	1178	527	962	2121	928
v/s Ratio Prot	0.02	0.01		c0.05	0.01		0.01	c0.15		c0.18	0.25	
v/s Ratio Perm						c0.15			0.04			0.01
v/c Ratio	0.25	0.16		0.50	0.10	0.15	0.42	0.48	0.13	0.69	0.43	0.01
Uniform Delay, d1	34.4	34.2		33.5	32.2	0.0	38.1	21.5	19.0	25.7	9.6	7.7
Progression Factor	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	1.1	0.3		2.3	0.2	0.2	11.3	0.3	0.1	2.2	0.1	0.0
Delay (s)	35.5	34.6		35.8	32.5	0.2	49.4	21.8	19.1	27.8	9.7	7.7
Level of Service	D	C		D	C	A	D	C	B	C	A	A
Approach Delay (s)		34.9			10.7			21.4			17.2	
Approach LOS		C			B			C			B	

Intersection Summary			
HCM Average Control Delay	18.1	HCM Level of Service	B
HCM Volume to Capacity ratio	0.50		
Actuated Cycle Length (s)	77.8	Sum of lost time (s)	15.0
Intersection Capacity Utilization	52.1%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	32	41	36	220	78	762	35	783	220	323	569	51
Ideal Flow (vphpl)	1900	1900	1900	2000	2000	2000	2000	2000	2000	2000	2000	2000
Total Lost time (s)	5.0	5.0		5.0	5.0	4.0	5.0	5.0	5.0	5.0	5.0	6.0
Lane Util. Factor	1.00	0.95		1.00	1.00	1.00	1.00	0.95	1.00	0.97	0.95	1.00
Frt	1.00	0.93		1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1770	3290		1863	1961	1667	1863	3725	1667	3614	3725	1667
Flt Permitted	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	1770	3290		1863	1961	1667	1863	3725	1667	3614	3725	1667
Peak-hour factor, PHF	0.60	0.60	0.60	0.94	0.94	0.94	0.86	0.86	0.86	0.89	0.89	0.89
Adj. Flow (vph)	53	68	60	234	83	811	41	910	256	363	639	57
RTOR Reduction (vph)	0	54	0	0	0	0	0	0	166	0	0	31
Lane Group Flow (vph)	53	74	0	234	83	811	41	910	90	363	639	26
Turn Type	Split			Split		Free	Prot		Perm	Prot		Perm
Protected Phases	4	4		8	8		5	2		1	6	
Permitted Phases						Free			2			6
Actuated Green, G (s)	8.5	8.5		17.0	17.0	92.7	3.7	32.6	32.6	14.6	43.5	43.5
Effective Green, g (s)	8.5	8.5		17.0	17.0	92.7	3.7	32.6	32.6	14.6	43.5	42.5
Actuated g/C Ratio	0.09	0.09		0.18	0.18	1.00	0.04	0.35	0.35	0.16	0.47	0.46
Clearance Time (s)	5.0	5.0		5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	162	302		342	360	1667	74	1310	586	569	1748	764
v/s Ratio Prot	0.03	0.02		c0.13	0.04		0.02	c0.24		c0.10	0.17	
v/s Ratio Perm						c0.49			0.05			0.02
v/c Ratio	0.33	0.24		0.68	0.23	0.49	0.55	0.69	0.15	0.64	0.37	0.03
Uniform Delay, d1	39.4	39.1		35.3	32.3	0.0	43.7	25.8	20.6	36.6	15.8	13.8
Progression Factor	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	1.2	0.4		5.6	0.3	1.0	8.7	1.6	0.1	2.4	0.1	0.0
Delay (s)	40.6	39.5		40.9	32.6	1.0	52.4	27.4	20.7	38.9	15.9	13.8
Level of Service	D	D		D	C	A	D	C	C	D	B	B
Approach Delay (s)		39.8			11.6			26.8			23.7	
Approach LOS		D			B			C			C	

Intersection Summary			
HCM Average Control Delay	21.8	HCM Level of Service	C
HCM Volume to Capacity ratio	0.61		
Actuated Cycle Length (s)	92.7	Sum of lost time (s)	10.0
Intersection Capacity Utilization	60.1%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lane Configurations												
Volume (vph)	1	4	9	578	2	38	16	579	567	30	929	1
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	2000	2000	2000	2000	2000	2000
Total Lost time (s)	5.0	5.0	4.0	5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0
Lane Util. Factor	1.00	1.00	1.00	0.97	1.00		1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	1.00	0.85	1.00	0.86		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1770	1863	1583	3433	1595		1863	3725	1667	1863	3725	1667
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	1770	1863	1583	3433	1595		1863	3725	1667	1863	3725	1667
Peak-hour factor, PHF	0.70	0.70	0.70	0.86	0.86	0.86	0.82	0.82	0.82	0.88	0.88	0.88
Adj. Flow (vph)	1	6	13	672	2	44	20	706	691	34	1056	1
RTOR Reduction (vph)	0	0	0	0	31	0	0	0	429	0	0	1
Lane Group Flow (vph)	1	6	13	672	15	0	20	706	262	34	1056	0
Turn Type	Split		Free	Split			Prot		Perm	Prot		Perm
Protected Phases	4	4		8	8		5	2		1	6	
Permitted Phases			Free						2			6
Actuated Green, G (s)	0.8	0.8	73.5	21.3	21.3		1.5	27.9	27.9	3.5	29.9	29.9
Effective Green, g (s)	0.8	0.8	73.5	21.3	21.3		1.5	27.9	27.9	3.5	29.9	29.9
Actuated g/C Ratio	0.01	0.01	1.00	0.29	0.29		0.02	0.38	0.38	0.05	0.41	0.41
Clearance Time (s)	5.0	5.0		5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	19	20	1583	995	462		38	1414	633	89	1515	678
v/s Ratio Prot	0.00	c0.00		c0.20	0.01		0.01	0.19		c0.02	c0.28	
v/s Ratio Perm			c0.01						0.16			0.00
v/c Ratio	0.05	0.30	0.01	0.68	0.03		0.53	0.50	0.41	0.38	0.70	0.00
Uniform Delay, d1	36.0	36.1	0.0	23.0	18.7		35.6	17.5	16.8	34.0	18.0	12.9
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	1.2	8.3	0.0	1.8	0.0		12.5	0.3	0.4	2.7	1.4	0.0
Delay (s)	37.1	44.3	0.0	24.9	18.7		48.2	17.7	17.2	36.7	19.5	12.9
Level of Service	D	D	A	C	B		D	B	B	D	B	B
Approach Delay (s)		15.2			24.5			17.9			20.0	
Approach LOS		B			C			B			B	

Intersection Summary			
HCM Average Control Delay	20.1	HCM Level of Service	C
HCM Volume to Capacity ratio	0.63		
Actuated Cycle Length (s)	73.5	Sum of lost time (s)	15.0
Intersection Capacity Utilization	55.9%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	6	16	41	618	17	49	84	983	833	43	770	12
Ideal Flow (vphpl)	1900	1900	1900	2000	2000	2000	2000	2000	2000	2000	2000	2000
Total Lost time (s)	5.0	5.0	4.0	5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0
Lane Util. Factor	1.00	1.00	1.00	0.97	1.00		1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	1.00	0.85	1.00	0.89		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1770	1863	1583	3614	1742		1863	3725	1667	1863	3725	1667
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	1770	1863	1583	3614	1742		1863	3725	1667	1863	3725	1667
Peak-hour factor, PHF	0.69	0.69	0.69	0.94	0.94	0.94	0.91	0.91	0.91	0.89	0.89	0.89
Adj. Flow (vph)	9	23	59	657	18	52	92	1080	915	48	865	13
RTOR Reduction (vph)	0	0	0	0	39	0	0	0	494	0	0	8
Lane Group Flow (vph)	9	23	59	657	31	0	92	1080	421	48	865	5
Turn Type	Split		Free	Split			Prot		Perm	Prot		Perm
Protected Phases	4	4		8	8		5	2		1	6	
Permitted Phases			Free						2			6
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Effective Green, g (s)	3.7	3.7	90.6	23.3	23.3		7.8	39.4	39.4	4.2	35.8	35.8
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Clearance Time (s)	5.0	5.0		5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lane Grp Cap (vph)	72	76	1583	929	448		160	1620	725	86	1472	659
v/s Ratio Prot	0.01	c0.01		c0.18	0.02		c0.05	c0.29		0.03	0.23	
v/s Ratio Perm			0.04						0.25			0.00
v/c Ratio	0.12	0.30	0.04	0.71	0.07		0.57	0.67	0.58	0.56	0.59	0.01
Uniform Delay, d1	41.9	42.2	0.0	30.6	25.5		39.8	20.4	19.4	42.3	21.6	16.6
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.8	2.2	0.0	2.5	0.1		4.9	1.1	1.2	7.6	0.6	0.0
Delay (s)	42.7	44.4	0.0	33.0	25.5		44.7	21.4	20.5	49.9	22.2	16.6
Level of Service	D	D	A	C	C		D	C	C	D	C	B
Approach Delay (s)		15.5			32.3			22.1			23.5	
Approach LOS		B			C			C			C	

Intersection Summary			
HCM Average Control Delay	24.2	HCM Level of Service	C
[illegible]	[illegible]		
Actuated Cycle Length (s)	90.6	Sum of lost time (s)	20.0
[illegible]	[illegible]	[illegible]	C
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	466	17	93	64	73	37	46	659	39	16	948	552
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0	4.0	5.0	5.0		5.0	5.0	5.0	5.0	5.0	4.0
Lane Util. Factor		1.00	1.00	1.00	1.00		1.00	0.95	1.00	1.00	0.95	1.00
Frt		1.00	0.85	1.00	0.95		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected		0.95	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)		1777	1583	1770	1769		1770	3539	1583	1770	3539	1583
Flt Permitted		0.64	1.00	0.27	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)		1197	1583	511	1769		1770	3539	1583	1770	3539	1583
Peak-hour factor, PHF	0.83	0.83	0.83	0.86	0.86	0.86	0.83	0.83	0.83	0.93	0.93	0.93
Adj. Flow (vph)	561	20	112	74	85	43	55	794	47	17	1019	594
RTOR Reduction (vph)	0	0	0	0	15	0	0	0	31	0	0	0
Lane Group Flow (vph)	0	581	112	74	113	0	55	794	16	17	1019	594
Turn Type	Perm		Free	Perm			Prot		Perm	Prot		Free
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4		Free	8					2			Free
Actuated Green, G (s)		57.5	114.3	57.5	57.5		5.2	39.2	39.2	2.6	36.6	114.3
Effective Green, g (s)		57.5	114.3	57.5	57.5		5.2	39.2	39.2	2.6	36.6	114.3
Actuated g/C Ratio		0.50	1.00	0.50	0.50		0.05	0.34	0.34	0.02	0.32	1.00
Clearance Time (s)		5.0		5.0	5.0		5.0	5.0	5.0	5.0	5.0	
Vehicle Extension (s)		3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)		602	1583	257	890		81	1214	543	40	1133	1583
v/s Ratio Prot					0.06		c0.03	0.22		0.01	c0.29	
v/s Ratio Perm		c0.49	0.07	0.14					0.01			c0.38
v/c Ratio		0.97	0.07	0.29	0.13		0.68	0.65	0.03	0.42	0.90	0.38
Uniform Delay, d1		27.4	0.0	16.5	15.1		53.7	31.8	24.9	55.1	37.1	0.0
Progression Factor		1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2		27.9	0.1	0.6	0.1		20.3	1.3	0.0	7.1	9.6	0.7
Delay (s)		55.3	0.1	17.1	15.1		74.0	33.1	24.9	62.2	46.7	0.7
Level of Service		E	A	B	B		E	C	C	E	D	A
Approach Delay (s)		46.4			15.9			35.2			30.1	
Approach LOS		D			B			D			C	

Intersection Summary			
HCM Average Control Delay	33.9	HCM Level of Service	C
HCM Volume to Capacity ratio	0.94		
Actuated Cycle Length (s)	114.3	Sum of lost time (s)	15.0
Intersection Capacity Utilization	75.4%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lane Configurations		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ideal Flow (vphpl)	2000	2000	2000	1900	1900	1900	2000	2000	2000	2000	2000	2000
Total Lost time (s)		[illegible]	4.0	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lane Util. Factor		1.00	1.00	1.00	1.00		1.00	0.95	1.00	1.00	0.95	1.00
Frt		1.00	0.85	1.00	0.91		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected		0.96	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)		1873	1667	1770	1694		1863	3725	1667	1863	3725	1667
Flt Permitted		0.68	1.00	0.23	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)		1327	1667	429	1694		1863	3725	1667	1863	3725	1667
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.96	0.96	0.96	0.91	0.91	0.91
Adj. Flow (vph)	542	34	149	27	34	52	183	1422	109	27	834	709
RTOR Reduction (vph)	0	0	0	0	29	0	0	0	56	0	0	0
Lane Group Flow (vph)	0	576	149	27	57	0	183	1422	53	27	834	709
Turn Type	Perm		Free	Perm			Prot		Perm	Prot		Free
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4		Free	8					2			Free
Actuated Green, G (s)		52.2	116.7	52.2	52.2		14.1	46.6	46.6	2.9	35.4	116.7
Effective Green, g (s)		52.2	116.7	52.2	52.2		14.1	46.6	46.6	2.9	35.4	116.7
Actuated g/C Ratio		0.45	1.00	0.45	0.45		0.12	0.40	0.40	0.02	0.30	1.00
Clearance Time (s)		5.0		5.0	5.0		5.0	5.0	5.0	5.0	5.0	
Vehicle Extension (s)		3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)		594	1667	192	758		225	1487	666	46	1130	1667
v/s Ratio Prot					0.03		c0.10	c0.38		0.01	0.22	
v/s Ratio Perm		c0.43	0.09	0.06					0.03			0.43
v/c Ratio		0.97	0.09	0.14	0.08		0.81	0.96	0.08	0.59	0.74	0.43
Uniform Delay, d1		31.5	0.0	19.0	18.4		50.0	34.1	21.7	56.3	36.5	0.0
Progression Factor		1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2		29.0	0.1	0.3	0.0		19.7	14.2	0.1	17.7	2.6	0.8
Delay (s)		60.5	0.1	19.4	18.5		69.7	48.2	21.8	74.0	39.0	0.8
Level of Service		E	A	B	B		E	D	C	E	D	A
Approach Delay (s)		48.1			18.7			48.8			22.4	
Approach LOS		D			B			D			C	

Intersection Summary			
HCM Average Control Delay	37.8	HCM Level of Service	D
HCM Volume to Capacity ratio	0.98		
Actuated Cycle Length (s)	116.7	Sum of lost time (s)	15.0
Intersection Capacity Utilization	85.6%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↰↑	↱	↰	↑↱		↰	↑↑	↱	↰	↑↑	↱
Volume (vph)	111	12	321	173	12	13	30	620	55	3	1092	10
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	2000	2000	2000	2000	2000	2000
Total Lost time (s)		5.0	4.0	5.0	5.0		5.0	5.0	5.0	5.0	5.0	4.0
Lane Util. Factor		1.00	1.00	1.00	1.00		1.00	0.95	1.00	1.00	0.95	1.00
Frt		1.00	0.85	1.00	0.92		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected		0.96	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)		1782	1583	1770	1719		1863	3725	1667	1863	3725	1667
Flt Permitted		0.72	1.00	0.66	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)		1350	1583	1230	1719		1863	3725	1667	1863	3725	1667
Peak-hour factor, PHF	0.81	0.81	0.81	0.82	0.82	0.82	0.71	0.71	0.71	0.97	0.97	0.97
Adj. Flow (vph)	137	15	396	211	15	16	42	873	77	3	1126	10
RTOR Reduction (vph)	0	0	0	0	12	0	0	0	38	0	0	0
Lane Group Flow (vph)	0	152	396	211	19	0	42	873	39	3	1126	10
Turn Type	Perm		Free	Perm			Prot		Perm	Prot		Free
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4		Free	8					2			Free
Actuated Green, G (s)		20.1	72.5	20.1	20.1		3.4	36.9	36.9	0.5	34.0	72.5
Effective Green, g (s)		20.1	72.5	20.1	20.1		3.4	36.9	36.9	0.5	34.0	72.5
Actuated g/C Ratio		0.28	1.00	0.28	0.28		0.05	0.51	0.51	0.01	0.47	1.00
Clearance Time (s)		5.0		5.0	5.0		5.0	5.0	5.0	5.0	5.0	
Vehicle Extension (s)		3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)		374	1583	341	477		87	1896	848	13	1747	1667
v/s Ratio Prot					0.01		c0.02	0.23		0.00	c0.30	
v/s Ratio Perm		0.11	c0.25	c0.17					0.02			0.01
v/c Ratio		0.41	0.25	0.62	0.04		0.48	0.46	0.05	0.23	0.64	0.01
Uniform Delay, d1		21.3	0.0	22.9	19.2		33.7	11.4	9.0	35.8	14.7	0.0
Progression Factor		1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2		0.7	0.4	3.3	0.0		4.2	0.2	0.0	8.9	0.8	0.0
Delay (s)		22.1	0.4	26.2	19.2		37.9	11.6	9.0	44.7	15.5	0.0
Level of Service		C	A	C	B		D	B	A	D	B	A
Approach Delay (s)		6.4			25.3			12.5			15.4	
Approach LOS		A			C			B			B	

Intersection Summary			
HCM Average Control Delay	13.8	HCM Level of Service	B
HCM Volume to Capacity ratio	0.54		
Actuated Cycle Length (s)	72.5	Sum of lost time (s)	15.0
Intersection Capacity Utilization	53.2%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lane Configurations												
Volume (vph)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	2000	2000	2000	2000	2000	2000
Total Lost time (s)		5.0	4.0	5.0	5.0		5.0	5.0	5.0	5.0	5.0	4.0
Lane Util. Factor		1.00	1.00	1.00	1.00		1.00	0.95	1.00	1.00	0.95	1.00
Frt		1.00	0.85	1.00	0.92		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected		0.96	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)		1793	1583	1770	1717		1863	3725	1667	1863	3725	1667
Flt Permitted		0.76	1.00	0.74	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)		1413	1583	1372	1717		1863	3725	1667	1863	3725	1667
Peak-hour factor, PHF	0.84	0.84	0.84	0.72	0.72	0.72	0.97	0.97	0.97	0.98	0.98	0.98
Adj. Flow (vph)	25	7	82	88	11	12	163	1666	176	10	899	27
RTOR Reduction (vph)	0	0	0	0	11	0	0	0	60	0	0	0
Lane Group Flow (vph)	0	32	82	88	12	0	163	1666	116	10	899	27
Turn Type	Perm		Free	Perm			Prot		Perm	Prot		Free
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4		Free	8					2			Free
Actuated Green, G (s)		8.8	72.2	8.8	8.8		13.4	47.6	47.6	0.8	35.0	72.2
Effective Green, g (s)		8.8	72.2	8.8	8.8		13.4	47.6	47.6	0.8	35.0	72.2
Actuated g/C Ratio		0.12	1.00	0.12	0.12		0.19	0.66	0.66	0.01	0.48	1.00
Clearance Time (s)		5.0		5.0	5.0		5.0	5.0	5.0	5.0	5.0	
Vehicle Extension (s)		3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)		172	1583	167	209		346	2456	1099	21	1806	1667
v/s Ratio Prot					0.01		c0.09	c0.45		0.01	0.24	
v/s Ratio Perm		0.02	0.05	c0.06					0.07			0.02
v/c Ratio		0.19	0.05	0.53	0.06		0.47	0.68	0.11	0.48	0.50	0.02
Uniform Delay, d1		28.5	0.0	29.7	28.0		26.2	7.6	4.5	35.5	12.6	0.0
Progression Factor		1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2		0.5	0.1	3.0	0.1		1.0	0.8	0.0	16.0	0.2	0.0
Delay (s)		29.0	0.1	32.7	28.2		27.3	8.3	4.5	51.5	12.8	0.0
Level of Service		C	A	C	C		C	A	A	D	B	A
Approach Delay (s)		8.2			31.8			9.5			12.9	
Approach LOS		A			C			A			B	

Intersection Summary			
HCM Average Control Delay	11.3	HCM Level of Service	B
HCM Volume to Capacity ratio	0.67		
Actuated Cycle Length (s)	72.2	Sum of lost time (s)	15.0
Intersection Capacity Utilization	68.4%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lane Configurations						
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ideal Flow (vphpl)	2000	2000	2000	2000	2000	2000
Total Lost time (s)	5.0		5.0	5.0	5.0	5.0
Lane Util. Factor	1.00		1.00	0.95	0.95	1.00
Frt	0.89		1.00	1.00	1.00	0.85
Flt Protected	0.99		0.95	1.00	1.00	1.00
Satd. Flow (prot)	1724		1863	3725	3725	1667
Flt Permitted	0.99		0.95	1.00	1.00	1.00
Satd. Flow (perm)	1724		1863	3725	3725	1667
Peak-hour factor, PHF	0.82	0.82	0.72	0.72	0.83	0.83
Adj. Flow (vph)	139	754	193	821	1807	104
RTOR Reduction (vph)	115	0	0	0	0	43
Lane Group Flow (vph)	778	0	193	821	1807	62
Turn Type			Prot			Perm
Protected Phases	4		5	2	6	
Permitted Phases						6
Actuated Green, G (s)	43.0		10.0	67.0	52.0	52.0
Effective Green, g (s)	43.0		10.0	67.0	52.0	52.0
Actuated g/C Ratio	0.36		0.08	0.56	0.43	0.43
Clearance Time (s)	5.0		5.0	5.0	5.0	5.0
Vehicle Extension (s)	3.0		3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	618		155	2080	1614	722
v/s Ratio Prot	c0.45		c0.10	0.22	c0.49	
v/s Ratio Perm						0.04
v/c Ratio	1.26		1.25	0.39	1.12	0.09
Uniform Delay, d1	38.5		55.0	15.0	34.0	20.0
Progression Factor	1.00		1.00	1.00	1.00	1.00
Incremental Delay, d2	129.4		152.9	0.1	62.8	0.1
Delay (s)	167.9		207.9	15.1	96.8	20.1
Level of Service	F		F	B	F	C
Approach Delay (s)	167.9			51.8	92.6	
Approach LOS	F			D	F	

Intersection Summary			
HCM Average Control Delay	99.4	HCM Level of Service	F
HCM Volume to Capacity ratio	1.19		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	15.0
Intersection Capacity Utilization	101.4%	ICU Level of Service	G
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	241	456	292	1704	844	169
Ideal Flow (vphpl)	2000	2000	2000	2000	2000	2000
Total Lost time (s)	5.0		5.0	5.0	5.0	5.0
Lane Util. Factor	1.00		1.00	0.95	0.95	1.00
Frt	0.91		1.00	1.00	1.00	0.85
Flt Protected	0.98		0.95	1.00	1.00	1.00
Satd. Flow (prot)	1757		1863	3725	3725	1667
Flt Permitted	0.98		0.95	1.00	1.00	1.00
Satd. Flow (perm)	1757		1863	3725	3725	1667
Peak-hour factor, PHF	0.84	0.84	0.92	0.92	0.94	0.94
Adj. Flow (vph)	287	543	317	1852	898	180
RTOR Reduction (vph)	57	0	0	0	0	129
Lane Group Flow (vph)	773	0	317	1852	898	51
Turn Type			Prot			Perm
Protected Phases	4		5	2	6	
Permitted Phases						6
Actuated Green, G (s)	50.0		21.0	60.0	34.0	34.0
Effective Green, g (s)	50.0		21.0	60.0	34.0	34.0
Actuated g/C Ratio	0.42		0.18	0.50	0.28	0.28
Clearance Time (s)	5.0		5.0	5.0	5.0	5.0
Vehicle Extension (s)	3.0		3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	732		326	1863	1055	472
v/s Ratio Prot	c0.44		0.17	c0.50	0.24	
v/s Ratio Perm						0.03
v/c Ratio	1.06		0.97	0.99	0.85	0.11
Uniform Delay, d1	35.0		49.2	29.8	40.6	31.8
Progression Factor	1.00		1.00	1.00	1.00	1.00
Incremental Delay, d2	49.2		42.1	19.3	6.7	0.1
Delay (s)	84.2		91.4	49.2	47.3	31.9
Level of Service	F		F	D	D	C
Approach Delay (s)	84.2			55.3	44.8	
Approach LOS	F			E	D	

Intersection Summary			
HCM Average Control Delay	58.4	HCM Level of Service	E
HCM Volume to Capacity ratio	1.02		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	10.0
Intersection Capacity Utilization	92.4%	ICU Level of Service	F
Analysis Period (min)	15		
c Critical Lane Group			

HCS+: Ramps and Ramp Junctions Release 5.3

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: AM Peak
Freeway/Dir of Travel: H-2 Fwy NB Off-Ramp
Junction: H-2 Fwy/Ka Uka Blvd
Jurisdiction:
Analysis Year: Existing
Description:

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	2768	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	35.0	mph
Volume on ramp	588	vph
Length of first accel/decel lane	230	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent ramp	294	vph
Position of adjacent ramp	Downstream	
Type of adjacent ramp	On	
Distance to adjacent ramp	2930	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	2768		588		294	vph
Peak-hour factor, PHF	0.90		0.90		0.90	
Peak 15-min volume, v15	769		163		82	v
Trucks and buses	2		2		2	%
Recreational vehicles	0		0		0	%
Terrain type:	Rolling		Level		Level	
Grade	0.00	%	0.00	%	0.00	%
Length	0.00	mi	0.00	mi	0.00	mi
Trucks and buses PCE, ET	2.5		1.5		1.5	
Recreational vehicle PCE, ER	2.0		1.2		1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	3168	660	330	pcph

Estimation of V12 Diverge Areas

L_{EQ} = (Equation 25-8 or 25-9)

P_{FD} = 0.436 Using Equation 8

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 1753 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{Fi} = v_F$	3168	9400	No
$v_{FO} = v_F - v_R$	2508	9400	No
v_R	660	2000	No
v_3 or v_{av34}	707 pc/h	(Equation 25-15 or 25-16)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		No	
If yes, v_{12A} = 1753		(Equation 25-18)	

Flow Entering Diverge Influence Area

	Actual	Max Desirable	Violation?
v_{12}	1753	4400	No

Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\, v_{12} - 0.009\, L_D$ = 17.3 pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

Speed Estimation

Intermediate speed variable, D_S = 0.487

Space mean speed in ramp influence area, S_R = 53.8 mph

Space mean speed in outer lanes, S_0 = 71.3 mph

Space mean speed for all vehicles, S = 60.4 mph

HCS+: Ramps and Ramp Junctions Release 5.3

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: PM Peak
Freeway/Dir of Travel: H-2 Fwy NB Off-Ramp
Junction: H-2 Fwy/Ka Uka Blvd
Jurisdiction:
Analysis Year: Existing
Description:

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	4412	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	35.0	mph
Volume on ramp	1185	vph
Length of first accel/decel lane	230	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent ramp	538	vph
Position of adjacent ramp	Downstream	
Type of adjacent ramp	On	
Distance to adjacent ramp	2930	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	4412		1185		538	vph
Peak-hour factor, PHF	0.90		0.90		0.90	
Peak 15-min volume, v15	1226		329		149	v
Trucks and buses	2		2		2	%
Recreational vehicles	0		0		0	%
Terrain type:	Rolling		Level		Level	
Grade	0.00	%	0.00	%	0.00	%
Length	0.00	mi	0.00	mi	0.00	mi
Trucks and buses PCE, ET	2.5		1.5		1.5	
Recreational vehicle PCE, ER	2.0		1.2		1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	5049	1330	604	pcph

Estimation of V12 Diverge Areas

L_{EQ} = (Equation 25-8 or 25-9)

P_{FD} = 0.436 Using Equation 8

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 2951 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{Fi} = v_F$	5049	9400	No
$v_{FO} = v_F - v_R$	3719	9400	No
v_R	1330	2000	No
v_3 or v_{av34}	1049 pc/h	(Equation 25-15 or 25-16)	

Is v_3 or v_{av34} > 2700 pc/h? No

Is v_3 or v_{av34} > 1.5 v_{12}/2 No

If yes, v_{12A} = 2951 (Equation 25-18)

Flow Entering Diverge Influence Area

	Actual	Max Desirable	Violation?
v_{12}	2951	4400	No

Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\, v_{12} - 0.009\, L_D$ = 27.6 pc/mi/ln

Level of service for ramp-freeway junction areas of influence C

Speed Estimation

Intermediate speed variable, D_S = 0.548

Space mean speed in ramp influence area, S_R = 52.4 mph

Space mean speed in outer lanes, S_0 = 71.1 mph

Space mean speed for all vehicles, S = 58.8 mph

HCS+: Ramps and Ramp Junctions Release 5.3

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: AM Peak
Freeway/Dir of Travel: H-2 Fwy NB On Ramp
Junction: H-2 Fwy/Ka Uka Blvd
Jurisdiction:
Analysis Year: Existing
Description:

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	2180	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	35.0	mph
Volume on ramp	294	vph
Length of first accel/decel lane	700	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	588	vph
Position of adjacent Ramp	Upstream	
Type of adjacent Ramp	Off	
Distance to adjacent Ramp	2930	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	2180		294		588	vph
Peak-hour factor, PHF	0.90		0.90		0.90	
Peak 15-min volume, v15	606		82		163	v
Trucks and buses	2		2		2	%
Recreational vehicles	0		0		0	%
Terrain type:	Rolling		Level		Level	
Grade		%		%		%
Length		mi		mi		mi
Trucks and buses PCE, ET	2.5		1.5		1.5	
Recreational vehicle PCE, ER	2.0		1.2		1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	2495	330	660	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 25-2 or 25-3)

P_{FM} = 0.400 Using Equation 4

$v_{12} = v_F (P_{FM})$ = 997 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	2825	9400	No

v_3 or v_{av34} 749 pc/h (Equation 25-4 or 25-5)

Is v_3 or v_{av34} > 2700 pc/h? No

Is v_3 or v_{av34} > 1.5 v_{12} /2 Yes

If yes, v_{12A} = 998 (Equation 25-8)

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	998	4600	No

Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\, v_R + 0.0078\, v_{12} - 0.00627\, L_A$ = 11.3 pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

Speed Estimation

Intermediate speed variable, M_S = 0.287

Space mean speed in ramp influence area, S_R = 58.4 mph

Space mean speed in outer lanes, S_0 = 64.1 mph

Space mean speed for all vehicles, S = 61.3 mph

HCS+: Ramps and Ramp Junctions Release 5.3

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: PM Peak
Freeway/Dir of Travel: H-2 Fwy NB On Ramp
Junction: H-2 Fwy/Ka Uka Blvd
Jurisdiction:
Analysis Year: Existing
Description:

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	3227	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	35.0	mph
Volume on ramp	538	vph
Length of first accel/decel lane	700	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	1185	vph
Position of adjacent Ramp	Upstream	
Type of adjacent Ramp	Off	
Distance to adjacent Ramp	2930	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	3227		538		1185	vph
Peak-hour factor, PHF	0.90		0.90		0.90	
Peak 15-min volume, v15	896		149		329	v
Trucks and buses	2		2		2	%
Recreational vehicles	0		0		0	%
Terrain type:	Rolling		Level		Level	
Grade		%		%		%
Length		mi		mi		mi
Trucks and buses PCE, ET	2.5		1.5		1.5	
Recreational vehicle PCE, ER	2.0		1.2		1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	3693	604	1330	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 25-2 or 25-3)

P_{FM} = 0.142 Using Equation 4

$v_{12} = v_F (P_{FM})$ = 526 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	4297	9400	No
v_3 or v_{av34}	1583 pc/h	(Equation 25-4 or 25-5)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		Yes	
If yes, v_{12A} = 1477		(Equation 25-8)	

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	1477	4600	No

Level of Service Determination (if not F)

Density, $D = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$ = 17.0 pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

Speed Estimation

Intermediate speed variable, M_S = 0.303

Space mean speed in ramp influence area, S_R = 58.0 mph

Space mean speed in outer lanes, S_0 = 62.8 mph

Space mean speed for all vehicles, S = 60.4 mph

HCS+: Ramps and Ramp Junctions Release 5.3

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: AM Peak
Freeway/Dir of Travel: H-2 Fwy SB Off-Ramp
Junction: H-2 Fwy/Ka Uka Blvd.
Jurisdiction:
Analysis Year: Existing
Description:

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	3760	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	35.0	mph
Volume on ramp	360	vph
Length of first accel/decel lane	150	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent ramp	973	vph
Position of adjacent ramp	Downstream	
Type of adjacent ramp	On	
Distance to adjacent ramp	3450	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	3760		360		973	vph
Peak-hour factor, PHF	0.90		0.90		0.90	
Peak 15-min volume, v15	1044		100		270	v
Trucks and buses	2		2		2	%
Recreational vehicles	0		0		0	%
Terrain type:	Rolling		Level		Level	
Grade	0.00	%	0.00	%	0.00	%
Length	0.00	mi	0.00	mi	0.00	mi
Trucks and buses PCE, ET	2.5		1.5		1.5	
Recreational vehicle PCE, ER	2.0		1.2		1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	4303	404	1092	pcph

Estimation of V12 Diverge Areas

L_{EQ} = (Equation 25-8 or 25-9)

P_{FD} = 0.436 Using Equation 8

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 2104 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{Fi} = v_F$	4303	9400	No
$v_{FO} = v_F - v_R$	3899	9400	No
v_R	404	2000	No
v_3 or v_{av34}	1099 pc/h	(Equation 25-15 or 25-16)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		No	
If yes, v_{12A} = 2104		(Equation 25-18)	

Flow Entering Diverge Influence Area

	Actual	Max Desirable	Violation?
v_{12}	2104	4400	No

Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$ = 21.0 pc/mi/ln

Level of service for ramp-freeway junction areas of influence C

Speed Estimation

Intermediate speed variable, D_S = 0.464

Space mean speed in ramp influence area, S_R = 54.3 mph

Space mean speed in outer lanes, S_0 = 70.9 mph

Space mean speed for all vehicles, S = 61.7 mph

HCS+: Ramps and Ramp Junctions Release 5.3

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: PM Peak
Freeway/Dir of Travel: H-2 Fwy SB Off-Ramp
Junction: H-2 Fwy/Ka Uka Blvd
Jurisdiction:
Analysis Year: Existing
Description:

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	2695	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	35.0	mph
Volume on ramp	388	vph
Length of first accel/decel lane	150	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent ramp	792	vph
Position of adjacent ramp	Downstream	
Type of adjacent ramp	On	
Distance to adjacent ramp	3450	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	2695		388		792	vph
Peak-hour factor, PHF	0.90		0.90		0.90	
Peak 15-min volume, v15	749		108		220	v
Trucks and buses	2		2		2	%
Recreational vehicles	0		0		0	%
Terrain type:	Rolling		Level		Level	
Grade	0.00	%	0.00	%	0.00	%
Length	0.00	mi	0.00	mi	0.00	mi
Trucks and buses PCE, ET	2.5		1.5		1.5	
Recreational vehicle PCE, ER	2.0		1.2		1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	3084	435	889	pcph

Estimation of V12 Diverge Areas

L_{EQ} = (Equation 25-8 or 25-9)

P_{FD} = 0.436 Using Equation 8

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 1590 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{Fi} = v_F$	3084	9400	No
$v_{FO} = v_F - v_R$	2649	9400	No
v_R	435	2000	No
v_3 or v_{av34}	747 pc/h	(Equation 25-15 or 25-16)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		No	
If yes, v_{12A} = 1590		(Equation 25-18)	

Flow Entering Diverge Influence Area

	Actual	Max Desirable	Violation?
v_{12}	1590	4400	No

Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\, v_{12} - 0.009\, L_D$ = 16.6 pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

Speed Estimation

Intermediate speed variable, D_S = 0.467

Space mean speed in ramp influence area, S_R = 54.3 mph

Space mean speed in outer lanes, S_0 = 71.3 mph

Space mean speed for all vehicles, S = 61.4 mph

HCS+: Ramps and Ramp Junctions Release 5.3

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: AM Peak
Freeway/Dir of Travel: H-2 Fwy SB On Ramp
Junction: H-2 Fwy/Ka Uka Blvd
Jurisdiction:
Analysis Year: Existing
Description:

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	3400	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	35.0	mph
Volume on ramp	973	vph
Length of first accel/decel lane	820	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	360	vph
Position of adjacent Ramp	Upstream	
Type of adjacent Ramp	Off	
Distance to adjacent Ramp	3450	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	3400		973		360	vph
Peak-hour factor, PHF	0.90		0.90		0.90	
Peak 15-min volume, v15	944		270		100	v
Trucks and buses	2		2		2	%
Recreational vehicles	0		0		0	%
Terrain type:	Rolling		Level		Level	
Grade		%		%		%
Length		mi		mi		mi
Trucks and buses PCE, ET	2.5		1.5		1.5	
Recreational vehicle PCE, ER	2.0		1.2		1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	3891	1092	404	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 25-2 or 25-3)

P_{FM} = 0.081 Using Equation 4

$v_{12} = v_F (P_{FM})$ = 316 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	4983	9400	No

v_3 or v_{av34} 1787 pc/h (Equation 25-4 or 25-5)

Is v_3 or v_{av34} > 2700 pc/h? No

Is v_3 or v_{av34} > 1.5 v_{12}/2 Yes

If yes, v_{12A} = 1556 (Equation 25-8)

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	1556	4600	No

Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734 v_R + 0.0078 v_{12} - 0.00627 L_A$ = 20.5 pc/mi/ln

Level of service for ramp-freeway junction areas of influence C

Speed Estimation

Intermediate speed variable,	M_S = 0.319	
Space mean speed in ramp influence area,	S_R = 57.7	mph
Space mean speed in outer lanes,	S_0 = 62.6	mph
Space mean speed for all vehicles,	S = 59.9	mph

HCS+: Ramps and Ramp Junctions Release 5.3

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: PM Peak
Freeway/Dir of Travel: H-2 Fwy SB On Ramp
Junction: H-2 Fwy/Ka Uka Blvd
Jurisdiction:
Analysis Year: Existing
Description:

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	2307	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	35.0	mph
Volume on ramp	792	vph
Length of first accel/decel lane	820	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	388	vph
Position of adjacent Ramp	Upstream	
Type of adjacent Ramp	Off	
Distance to adjacent Ramp	3450	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	2307		792		388	vph
Peak-hour factor, PHF	0.90		0.90		0.90	
Peak 15-min volume, v15	641		220		108	v
Trucks and buses	2		2		2	%
Recreational vehicles	0		0		0	%
Terrain type:	Rolling		Level		Level	
Grade		%		%		%
Length		mi		mi		mi
Trucks and buses PCE, ET	2.5		1.5		1.5	
Recreational vehicle PCE, ER	2.0		1.2		1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	2640	889	435	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 25-2 or 25-3)

P_{FM} = 0.107 Using Equation 4

$v_{12} = v_F (P_{FM})$ = 282 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	3529	9400	No
v_3 or v_{av34}	1179 pc/h	(Equation 25-4 or 25-5)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		Yes	
If yes, v_{12A} = 1056		(Equation 25-8)	

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	1056	4600	No

Level of Service Determination (if not F)

Density, $D = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$ = 15.1 pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

Speed Estimation

Intermediate speed variable, M_S = 0.291

Space mean speed in ramp influence area, S_R = 58.3 mph

Space mean speed in outer lanes, S_0 = 63.9 mph

Space mean speed for all vehicles, S = 60.7 mph

HCS+: Basic Freeway Segments Release 5.3

Phone: Fax:
E-mail:

Operational Analysis

Analyst:
Agency or Company:
Date Performed: 2/26/2009
Analysis Time Period: AM Peak
Freeway/Direction: H-2 Fwy NB
From/To:
Jurisdiction:
Analysis Year: Existing
Description: South of Ka Uka Blvd

Flow Inputs and Adjustments

Volume, V	2768	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	769	v
Trucks and buses	2	%
Recreational vehicles	0	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.0	
Heavy vehicle adjustment, fHV	0.971	
Driver population factor, fp	1.00	
Flow rate, vp	792	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	4	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	1.5	mi/h
Free-flow speed, FFS	68.5	mi/h
	Urban Freeway	

LOS and Performance Measures

Flow rate, vp	792	pc/h/ln
Free-flow speed, FFS	68.5	mi/h
Average passenger-car speed, S	68.5	mi/h
Number of lanes, N	4	
Density, D	11.6	pc/mi/ln
Level of service, LOS	B	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Basic Freeway Segments Release 5.3

Phone: Fax:
E-mail:

Operational Analysis

Analyst:	
Agency or Company:	
Date Performed:	2/26/2009
Analysis Time Period:	PM Peak
Freeway/Direction:	H-2 Fwy NB
From/To:	
Jurisdiction:	
Analysis Year:	Existing
Description:	South of Ka Uka Blvd

Flow Inputs and Adjustments

Volume, V	4412	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1226	v
Trucks and buses	2	%
Recreational vehicles	0	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.0	
Heavy vehicle adjustment, fHV	0.971	
Driver population factor, fp	1.00	
Flow rate, vp	1262	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	4	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	1.5	mi/h
Free-flow speed, FFS	68.5	mi/h
	Urban Freeway	

LOS and Performance Measures

Flow rate, vp	1262	pc/h/ln
Free-flow speed, FFS	68.5	mi/h
Average passenger-car speed, S	68.5	mi/h
Number of lanes, N	4	
Density, D	18.4	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Basic Freeway Segments Release 5.3

Phone: Fax:
E-mail:

Operational Analysis

Analyst:
Agency or Company:
Date Performed: 2/26/2009
Analysis Time Period: AM Peak
Freeway/Direction: H-2 Fwy NB
From/To:
Jurisdiction:
Analysis Year: Existing
Description: North of Ka Uka Blvd

Flow Inputs and Adjustments

Volume, V	2474	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	687	v
Trucks and buses	2	%
Recreational vehicles	0	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.0	
Heavy vehicle adjustment, fHV	0.971	
Driver population factor, fp	1.00	
Flow rate, vp	708	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	4	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	1.5	mi/h
Free-flow speed, FFS	68.5	mi/h
	Urban Freeway	

LOS and Performance Measures

Flow rate, vp	708	pc/h/ln
Free-flow speed, FFS	68.5	mi/h
Average passenger-car speed, S	68.5	mi/h
Number of lanes, N	4	
Density, D	10.3	pc/mi/ln
Level of service, LOS	A	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Basic Freeway Segments Release 5.3

Phone: Fax:
E-mail:

Operational Analysis

Analyst:
Agency or Company:
Date Performed: 2/26/2009
Analysis Time Period: PM Peak
Freeway/Direction: H-2 Fwy NB
From/To:
Jurisdiction:
Analysis Year: Existing
Description: North of Ka Uka Blvd

Flow Inputs and Adjustments

Volume, V	3765	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1046	v
Trucks and buses	2	%
Recreational vehicles	0	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.0	
Heavy vehicle adjustment, fHV	0.971	
Driver population factor, fp	1.00	
Flow rate, vp	1077	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	4	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	1.5	mi/h
Free-flow speed, FFS	68.5	mi/h
	Urban Freeway	

LOS and Performance Measures

Flow rate, vp	1077	pc/h/ln
Free-flow speed, FFS	68.5	mi/h
Average passenger-car speed, S	68.5	mi/h
Number of lanes, N	4	
Density, D	15.7	pc/mi/ln
Level of service, LOS	B	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Basic Freeway Segments Release 5.3

Phone: Fax:
E-mail:

Operational Analysis

Analyst:	
Agency or Company:	
Date Performed:	2/26/2009
Analysis Time Period:	AM Peak
Freeway/Direction:	H-2 Fwy SB
From/To:	
Jurisdiction:	
Analysis Year:	Existing
Description:	North of Ka Uka Blvd

Flow Inputs and Adjustments

Volume, V	3760	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1044	v
Trucks and buses	2	%
Recreational vehicles	0	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.0	
Heavy vehicle adjustment, fHV	0.971	
Driver population factor, fp	1.00	
Flow rate, vp	1076	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	4	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	1.5	mi/h
Free-flow speed, FFS	68.5	mi/h
	Urban Freeway	

LOS and Performance Measures

Flow rate, vp	1076	pc/h/ln
Free-flow speed, FFS	68.5	mi/h
Average passenger-car speed, S	68.5	mi/h
Number of lanes, N	4	
Density, D	15.7	pc/mi/ln
Level of service, LOS	B	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Basic Freeway Segments Release 5.3

Phone: Fax:
E-mail:

Operational Analysis

Analyst:
Agency or Company:
Date Performed: 2/26/2009
Analysis Time Period: PM Peak
Freeway/Direction: H-2 Fwy SB
From/To:
Jurisdiction:
Analysis Year: Existing
Description: North of Ka Uka Blvd

Flow Inputs and Adjustments

Volume, V	2695	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	749	v
Trucks and buses	2	%
Recreational vehicles	0	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.0	
Heavy vehicle adjustment, fHV	0.971	
Driver population factor, fp	1.00	
Flow rate, vp	771	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	4	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	1.5	mi/h
Free-flow speed, FFS	68.5	mi/h
	Urban Freeway	

LOS and Performance Measures

Flow rate, vp	771	pc/h/ln
Free-flow speed, FFS	68.5	mi/h
Average passenger-car speed, S	68.5	mi/h
Number of lanes, N	4	
Density, D	11.3	pc/mi/ln
Level of service, LOS	B	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Basic Freeway Segments Release 5.3

Phone: Fax:
E-mail:

Operational Analysis

Analyst:
Agency or Company:
Date Performed: 2/26/2009
Analysis Time Period: AM Peak
Freeway/Direction: H-2 Fwy SB
From/To:
Jurisdiction:
Analysis Year: Existing
Description: South of Ka Uka Blvd

Flow Inputs and Adjustments

Volume, V	4373	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1215	v
Trucks and buses	2	%
Recreational vehicles	0	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.0	
Heavy vehicle adjustment, fHV	0.971	
Driver population factor, fp	1.00	
Flow rate, vp	1251	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	4	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	1.5	mi/h
Free-flow speed, FFS	68.5	mi/h
	Urban Freeway	

LOS and Performance Measures

Flow rate, vp	1251	pc/h/ln
Free-flow speed, FFS	68.5	mi/h
Average passenger-car speed, S	68.5	mi/h
Number of lanes, N	4	
Density, D	18.3	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Basic Freeway Segments Release 5.3

Phone: Fax:
E-mail:

Operational Analysis

Analyst:
Agency or Company:
Date Performed: 2/26/2009
Analysis Time Period: PM Peak
Freeway/Direction: H-2 Fwy SB
From/To:
Jurisdiction:
Analysis Year: Existing
Description: South of Ka Uka Blvd

Flow Inputs and Adjustments

Volume, V	3099	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	861	v
Trucks and buses	2	%
Recreational vehicles	0	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.0	
Heavy vehicle adjustment, fHV	0.971	
Driver population factor, fp	1.00	
Flow rate, vp	887	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	4	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	1.5	mi/h
Free-flow speed, FFS	68.5	mi/h
	Urban Freeway	

LOS and Performance Measures

Flow rate, vp	887	pc/h/ln
Free-flow speed, FFS	68.5	mi/h
Average passenger-car speed, S	68.5	mi/h
Number of lanes, N	4	
Density, D	12.9	pc/mi/ln
Level of service, LOS	B	

Overall results are not computed when free-flow speed is less than 55 mph.

APPENDIX E

CAPACITY ANALYSIS CALCULATIONS
PROJECTED YEAR 2016 PEAK HOUR TRAFFIC
ANALYSIS WITHOUT PROJECT

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↑↑			↑↑↑↱		↰	↰↑			✣	
Volume (vph)	0	205	0	0	1808	31	586	25	0	0	0	8
Ideal Flow (vphpl)	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
Total Lost time (s)		5.0			5.0		5.0	5.0			5.0	
Lane Util. Factor		0.95			0.91		0.95	0.95			1.00	
Frt		1.00			1.00		1.00	1.00			0.86	
Flt Protected		1.00			1.00		0.95	0.96			1.00	
Satd. Flow (prot)		3725			5339		1770	1781			1696	
Flt Permitted		1.00			1.00		0.95	0.96			1.00	
Satd. Flow (perm)		3725			5339		1770	1781			1696	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	0	216	0	0	1903	33	617	26	0	0	0	8
RTOR Reduction (vph)	0	0	0	0	1	0	0	0	0	0	8	0
Lane Group Flow (vph)	0	216	0	0	1935	0	321	322	0	0	0	0
Turn Type							Split			Split		
Protected Phases		4			8		2	2		6	6	
Permitted Phases												
Actuated Green, G (s)		42.1			42.1		22.2	22.2			0.8	
Effective Green, g (s)		42.1			42.1		22.2	22.2			0.8	
Actuated g/C Ratio		0.53			0.53		0.28	0.28			0.01	
Clearance Time (s)		5.0			5.0		5.0	5.0			5.0	
Vehicle Extension (s)		3.0			3.0		3.0	3.0			3.0	
Lane Grp Cap (vph)		1958			2806		491	494			17	
v/s Ratio Prot		0.06			c0.36		c0.18	0.18			c0.00	
v/s Ratio Perm												
v/c Ratio		0.11			0.69		0.65	0.65			0.00	
Uniform Delay, d1		9.6			14.1		25.6	25.5			39.3	
Progression Factor		1.00			1.00		1.00	1.00			1.00	
Incremental Delay, d2		0.0			0.7		3.1	3.1			0.1	
Delay (s)		9.6			14.9		28.7	28.6			39.4	
Level of Service		A			B		C	C			D	
Approach Delay (s)		9.6			14.9			28.6			39.4	
Approach LOS		A			B			C			D	

Intersection Summary			
HCM Average Control Delay	17.7	HCM Level of Service	B
HCM Volume to Capacity ratio	0.67		
Actuated Cycle Length (s)	80.1	Sum of lost time (s)	15.0
Intersection Capacity Utilization	64.9%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	549	0	0	2024	53	1208	23	0	0	0	80
Ideal Flow (vphpl)	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
Total Lost time (s)		5.0			5.0		5.0	5.0			5.0	
Lane Util. Factor		0.95			0.91		0.95	0.95			1.00	
Frt		1.00			1.00		1.00	1.00			0.86	
Flt Protected		1.00			1.00		0.95	0.95			1.00	
Satd. Flow (prot)		3725			5332		1770	1777			1696	
Flt Permitted		1.00			1.00		0.95	0.95			1.00	
Satd. Flow (perm)		3725			5332		1770	1777			1696	
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	0	549	0	0	2024	53	1208	23	0	0	0	80
RTOR Reduction (vph)	0	0	0	0	2	0	0	0	0	0	19	0
Lane Group Flow (vph)	0	549	0	0	2075	0	616	615	0	0	61	0
Turn Type							Split			Split		
Protected Phases		4			8		2	2		6	6	
Permitted Phases												
Actuated Green, G (s)		46.3			46.3		41.9	41.9			8.1	
Effective Green, g (s)		46.3			46.3		41.9	41.9			8.1	
Actuated g/C Ratio		0.42			0.42		0.38	0.38			0.07	
Clearance Time (s)		5.0			5.0		5.0	5.0			5.0	
Vehicle Extension (s)		3.0			3.0		3.0	3.0			3.0	
Lane Grp Cap (vph)		1550			2218		666	669			123	
v/s Ratio Prot		0.15			c0.39		c0.35	0.35			c0.04	
v/s Ratio Perm												
v/c Ratio		0.35			0.94		0.92	0.92			0.50	
Uniform Delay, d1		22.3			31.1		33.2	33.1			49.7	
Progression Factor		1.00			1.00		1.00	1.00			1.00	
Incremental Delay, d2		0.1			8.1		18.7	17.7			3.2	
Delay (s)		22.4			39.2		51.9	50.7			52.8	
Level of Service		C			D		D	D			D	
Approach Delay (s)		22.4			39.2			51.3			52.8	
Approach LOS		C			D			D			D	

Intersection Summary			
HCM Average Control Delay	40.9	HCM Level of Service	D
HCM Volume to Capacity ratio	0.89		
Actuated Cycle Length (s)	111.3	Sum of lost time (s)	15.0
Intersection Capacity Utilization	85.6%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↑↱		↰↰	↑↑		↰		↱	↰	↰↑	↱
Volume (vph)	0	946	52	240	483	0	28	0	441	114	158	199
Ideal Flow (vphpl)	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
Total Lost time (s)		5.0		5.0	5.0		4.0		5.0	5.0	5.0	6.0
Lane Util. Factor		0.95		0.97	0.95		1.00		1.00	0.95	0.95	1.00
Frt		0.99		1.00	1.00		1.00		0.85	1.00	1.00	0.85
Flt Protected		1.00		0.95	1.00		0.95		1.00	0.95	1.00	1.00
Satd. Flow (prot)		3696		3614	3725		1863		1667	1770	1856	1667
Flt Permitted		1.00		0.95	1.00		0.41		1.00	0.95	1.00	1.00
Satd. Flow (perm)		3696		3614	3725		809		1667	1770	1856	1667
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	0	996	55	253	508	0	29	0	464	120	166	209
RTOR Reduction (vph)	0	3	0	0	0	0	0	0	0	0	0	176
Lane Group Flow (vph)	0	1048	0	253	508	0	29	0	464	108	178	33
Turn Type				Prot			custom		Free	Split		Perm
Protected Phases		4		3	8					6	6	
Permitted Phases							2		Free			6
Actuated Green, G (s)		33.1		11.8	49.9		9.7		88.5	14.9	14.9	14.9
Effective Green, g (s)		33.1		11.8	49.9		9.7		88.5	14.9	14.9	13.9
Actuated g/C Ratio		0.37		0.13	0.56		0.11		1.00	0.17	0.17	0.16
Clearance Time (s)		5.0		5.0	5.0		4.0			5.0	5.0	5.0
Vehicle Extension (s)		3.0		3.0	3.0		3.0			3.0	3.0	3.0
Lane Grp Cap (vph)		1382		482	2100		89		1667	298	312	262
v/s Ratio Prot		c0.28		c0.07	0.14					0.06	c0.10	
v/s Ratio Perm							0.04		c0.28			0.02
v/c Ratio		0.76		0.52	0.24		0.33		0.28	0.36	0.57	0.13
Uniform Delay, d1		24.2		35.7	9.7		36.4		0.0	32.6	33.9	32.1
Progression Factor		1.00		1.00	1.00		1.00		1.00	1.00	1.00	1.00
Incremental Delay, d2		2.4		1.0	0.1		2.1		0.4	0.8	2.5	0.2
Delay (s)		26.6		36.8	9.8		38.5		0.4	33.3	36.4	32.3
Level of Service		C		D	A		D		A	C	D	C
Approach Delay (s)		26.6			18.8			2.7			34.0	
Approach LOS		C			B			A			C	

Intersection Summary			
HCM Average Control Delay	21.6	HCM Level of Service	C
HCM Volume to Capacity ratio	0.59		
Actuated Cycle Length (s)	88.5	Sum of lost time (s)	15.0
Intersection Capacity Utilization	60.0%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↑↑↱		↰↰	↑↑		↰		↱	↰	↰↑	↱
Volume (vph)	0	834	75	371	996	0	78	0	700	316	192	185
Ideal Flow (vphpl)	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
Total Lost time (s)		5.0		5.0	5.0		4.0		5.0	5.0	5.0	6.0
Lane Util. Factor		0.95		0.97	0.95		1.00		1.00	0.95	0.95	1.00
Frt		0.99		1.00	1.00		1.00		0.85	1.00	1.00	0.85
Flt Protected		1.00		0.95	1.00		0.95		1.00	0.95	0.99	1.00
Satd. Flow (prot)		3679		3614	3725		1863		1667	1770	1839	1667
Flt Permitted		1.00		0.95	1.00		0.11		1.00	0.95	0.99	1.00
Satd. Flow (perm)		3679		3614	3725		212		1667	1770	1839	1667
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	0	834	75	371	996	0	78	0	700	316	192	185
RTOR Reduction (vph)	0	5	0	0	0	0	0	0	0	0	0	156
Lane Group Flow (vph)	0	904	0	371	996	0	78	0	700	250	258	29
Turn Type				Prot			custom		Free	Split		Perm
Protected Phases		4		3	8					6	6	
Permitted Phases							2		Free			6
Actuated Green, G (s)		30.0		13.0	48.0		37.0		118.5	19.5	19.5	19.5
Effective Green, g (s)		30.0		13.0	48.0		37.0		118.5	19.5	19.5	18.5
Actuated g/C Ratio		0.25		0.11	0.41		0.31		1.00	0.16	0.16	0.16
Clearance Time (s)		5.0		5.0	5.0		4.0			5.0	5.0	5.0
Vehicle Extension (s)		3.0		3.0	3.0		3.0			3.0	3.0	3.0
Lane Grp Cap (vph)		931		396	1509		66		1667	291	303	260
v/s Ratio Prot		c0.25		c0.10	0.27					c0.14	0.14	
v/s Ratio Perm							c0.37		0.42			0.02
v/c Ratio		0.97		0.94	0.66		1.18		0.42	0.86	0.85	0.11
Uniform Delay, d1		43.8		52.3	28.6		40.8		0.0	48.2	48.1	42.9
Progression Factor		1.00		1.00	1.00		1.00		1.00	1.00	1.00	1.00
Incremental Delay, d2		22.5		29.4	1.1		168.1		0.8	21.4	19.9	0.2
Delay (s)		66.3		81.8	29.7		208.9		0.8	69.6	68.0	43.1
Level of Service		E		F	C		F		A	E	E	D
Approach Delay (s)		66.3			43.8			21.6			61.9	
Approach LOS		E			D			C			E	

Intersection Summary			
HCM Average Control Delay	48.0	HCM Level of Service	D
HCM Volume to Capacity ratio	1.02		
Actuated Cycle Length (s)	118.5	Sum of lost time (s)	19.0
Intersection Capacity Utilization	67.3%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations	[illegible]		[illegible]	[illegible]		[illegible]
Volume (veh/h)	967	73	90	617	0	32
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	1018	77	95	649	0	34
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)				648		
pX, platoon unblocked						
vC, conflicting volume			1095		1571	547
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			1095		1571	547
tC, single (s)			4.1		6.8	6.9
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			85		100	93
cM capacity (veh/h)			633		86	481

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Volume Total	679	416	95	325	325	34
Volume Left	0	0	95	0	0	0
Volume Right	0	77	0	0	0	34
cSH	1700	1700	633	1700	1700	481
Volume to Capacity	0.40	0.24	0.15	0.19	0.19	0.07
Queue Length 95th (ft)	0	0	13	0	0	6
Control Delay (s)	0.0	0.0	11.7	0.0	0.0	13.1
Lane LOS			B			B
Approach Delay (s)	0.0		1.5			13.1
Approach LOS						B

Intersection Summary			
Average Delay	0.8		
Intersection Capacity Utilization	40.7%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations	↑↱		↰	↑↑		↱
Volume (veh/h)	735	140	107	1150	0	170
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	774	147	113	1211	0	179
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)				648		
pX, platoon unblocked					0.79	
vC, conflicting volume			921		1678	461
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			921		1320	461
tC, single (s)			4.1		6.8	6.9
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			85		100	67
cM capacity (veh/h)			737		99	548

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	WB 3	NB 1
Volume Total	516	405	113	605	605	179
Volume Left	0	0	113	0	0	0
Volume Right	0	147	0	0	0	179
cSH	1700	1700	737	1700	1700	548
Volume to Capacity	0.30	0.24	0.15	0.36	0.36	0.33
Queue Length 95th (ft)	0	0	13	0	0	35
Control Delay (s)	0.0	0.0	10.8	0.0	0.0	14.7
Lane LOS			B			B
Approach Delay (s)	0.0		0.9			14.7
Approach LOS						B

Intersection Summary			
Average Delay	1.6		
Intersection Capacity Utilization	42.4%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		✣			✣		↰	↑↱		↰	↑↱	
Volume (vph)	15	3	2	41	15	21	8	1005	69	84	452	75
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	2000	2000	2000	2000	2000	2000
Total Lost time (s)		5.0			5.0		5.0	5.0		5.0	5.0	
Lane Util. Factor		1.00			1.00		1.00	0.95		1.00	0.95	
Frt		0.99			0.96		1.00	0.99		1.00	0.98	
Flt Protected		0.96			0.97		0.95	1.00		0.95	1.00	
Satd. Flow (prot)		1771			1748		1863	3689		1863	3646	
Flt Permitted		0.88			0.82		0.44	1.00		0.23	1.00	
Satd. Flow (perm)		1620			1476		871	3689		452	3646	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	16	3	2	43	16	22	8	1058	73	88	476	79
RTOR Reduction (vph)	0	2	0	0	17	0	0	6	0	0	17	0
Lane Group Flow (vph)	0	19	0	0	64	0	8	1125	0	88	538	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4			8			2			6		
Actuated Green, G (s)		4.0			4.0		23.2	23.2		23.2	23.2	
Effective Green, g (s)		4.0			4.0		23.2	23.2		23.2	23.2	
Actuated g/C Ratio		0.11			0.11		0.62	0.62		0.62	0.62	
Clearance Time (s)		5.0			5.0		5.0	5.0		5.0	5.0	
Vehicle Extension (s)		3.0			3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)		174			159		543	2301		282	2274	
v/s Ratio Prot								c0.30			0.15	
v/s Ratio Perm		0.01			c0.04		0.01			0.19		
v/c Ratio		0.11			0.40		0.01	0.49		0.31	0.24	
Uniform Delay, d1		15.0			15.5		2.7	3.8		3.3	3.1	
Progression Factor		1.00			1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2		0.3			1.7		0.0	0.2		0.6	0.1	
Delay (s)		15.3			17.2		2.7	4.0		3.9	3.1	
Level of Service		B			B		A	A		A	A	
Approach Delay (s)		15.3			17.2			3.9			3.2	
Approach LOS		B			B			A			A	

Intersection Summary			
HCM Average Control Delay	4.4	HCM Level of Service	A
HCM Volume to Capacity ratio	0.48		
Actuated Cycle Length (s)	37.2	Sum of lost time (s)	10.0
Intersection Capacity Utilization	49.9%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		✥			✥		↰	↑↱		↰	↑↱	
Volume (vph)	45	11	14	121	13	61	7	770	54	61	1016	68
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	2000	2000	2000	2000	2000	2000
Total Lost time (s)		5.0			5.0		5.0	5.0		5.0	5.0	
Lane Util. Factor		1.00			1.00		1.00	0.95		1.00	0.95	
Frt		0.97			0.96		1.00	0.99		1.00	0.99	
Flt Protected		0.97			0.97		0.95	1.00		0.95	1.00	
Satd. Flow (prot)		1756			1731		1863	3689		1863	3690	
Flt Permitted		0.78			0.77		0.19	1.00		0.29	1.00	
Satd. Flow (perm)		1414			1370		371	3689		574	3690	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	47	12	15	127	14	64	7	811	57	64	1069	72
RTOR Reduction (vph)	0	11	0	0	20	0	0	6	0	0	6	0
Lane Group Flow (vph)	0	63	0	0	185	0	7	862	0	64	1135	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4			8			2			6		
Actuated Green, G (s)		12.9			12.9		27.0	27.0		27.0	27.0	
Effective Green, g (s)		12.9			12.9		27.0	27.0		27.0	27.0	
Actuated g/C Ratio		0.26			0.26		0.54	0.54		0.54	0.54	
Clearance Time (s)		5.0			5.0		5.0	5.0		5.0	5.0	
Vehicle Extension (s)		3.0			3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)		366			354		201	1996		311	1997	
v/s Ratio Prot								0.23			c0.31	
v/s Ratio Perm		0.04			c0.14		0.02			0.11		
v/c Ratio		0.17			0.52		0.03	0.43		0.21	0.57	
Uniform Delay, d1		14.4			15.9		5.4	6.9		5.9	7.6	
Progression Factor		1.00			1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2		0.2			1.4		0.1	0.2		0.3	0.4	
Delay (s)		14.6			17.3		5.4	7.0		6.2	8.0	
Level of Service		B			B		A	A		A	A	
Approach Delay (s)		14.6			17.3			7.0			7.9	
Approach LOS		B			B			A			A	

Intersection Summary			
HCM Average Control Delay	8.6	HCM Level of Service	A
HCM Volume to Capacity ratio	0.55		
Actuated Cycle Length (s)	49.9	Sum of lost time (s)	10.0
Intersection Capacity Utilization	57.5%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	39	12	23	91	19	94	58	947	101	62	403	28
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	2000	2000	2000	2000	2000	2000
Total Lost time (s)		5.0			5.0		5.0	5.0		5.0	5.0	
Lane Util. Factor		1.00			1.00		1.00	0.95		1.00	0.95	
Frt		0.96			0.94		1.00	0.99		1.00	0.99	
Flt Protected		0.97			0.98		0.95	1.00		0.95	1.00	
Satd. Flow (prot)		1740			1709		1863	3672		1863	3690	
Flt Permitted		0.81			0.82		0.49	1.00		0.20	1.00	
Satd. Flow (perm)		1443			1431		962	3672		387	3690	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	41	13	24	96	20	99	61	997	106	65	424	29
RTOR Reduction (vph)	0	18	0	0	37	0	0	10	0	0	6	0
Lane Group Flow (vph)	0	60	0	0	178	0	61	1093	0	65	447	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4			8			2			6		
Actuated Green, G (s)		11.1			11.1		21.3	21.3		21.3	21.3	
Effective Green, g (s)		11.1			11.1		21.3	21.3		21.3	21.3	
Actuated g/C Ratio		0.26			0.26		0.50	0.50		0.50	0.50	
Clearance Time (s)		5.0			5.0		5.0	5.0		5.0	5.0	
Vehicle Extension (s)		3.0			3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)		378			375		483	1845		194	1854	
v/s Ratio Prot								c0.30			0.12	
v/s Ratio Perm		0.04			c0.12		0.06			0.17		
v/c Ratio		0.16			0.47		0.13	0.59		0.34	0.24	
Uniform Delay, d1		12.1			13.2		5.6	7.5		6.3	6.0	
Progression Factor		1.00			1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2		0.2			1.0		0.1	0.5		1.0	0.1	
Delay (s)		12.3			14.1		5.7	8.0		7.3	6.0	
Level of Service		B			B		A	A		A	A	
Approach Delay (s)		12.3			14.1			7.9			6.2	
Approach LOS		B			B			A			A	

Intersection Summary			
HCM Average Control Delay	8.3	HCM Level of Service	A
HCM Volume to Capacity ratio	0.55		
Actuated Cycle Length (s)	42.4	Sum of lost time (s)	10.0
Intersection Capacity Utilization	57.6%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	90	38	34	138	26	41	41	697	92	111	1000	40
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	2000	2000	2000	2000	2000	2000
Total Lost time (s)		5.0			5.0		5.0	5.0		5.0	5.0	
Lane Util. Factor		1.00			1.00		1.00	0.95		1.00	0.95	
Frt		0.97			0.97		1.00	0.98		1.00	0.99	
Flt Protected		0.97			0.97		0.95	1.00		0.95	1.00	
Satd. Flow (prot)		1761			1753		1863	3660		1863	3704	
Flt Permitted		0.76			0.75		0.19	1.00		0.30	1.00	
Satd. Flow (perm)		1371			1351		374	3660		589	3704	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	95	40	36	145	27	43	43	734	97	117	1053	42
RTOR Reduction (vph)	0	11	0	0	11	0	0	13	0	0	4	0
Lane Group Flow (vph)	0	160	0	0	204	0	43	818	0	117	1091	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4			8			2			6		
Actuated Green, G (s)		13.7			13.7		23.0	23.0		23.0	23.0	
Effective Green, g (s)		13.7			13.7		23.0	23.0		23.0	23.0	
Actuated g/C Ratio		0.29			0.29		0.49	0.49		0.49	0.49	
Clearance Time (s)		5.0			5.0		5.0	5.0		5.0	5.0	
Vehicle Extension (s)		3.0			3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)		402			396		184	1803		290	1824	
v/s Ratio Prot								0.22			c0.29	
v/s Ratio Perm		0.12			c0.15		0.11			0.20		
v/c Ratio		0.40			0.52		0.23	0.45		0.40	0.60	
Uniform Delay, d1		13.2			13.7		6.8	7.7		7.5	8.5	
Progression Factor		1.00			1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2		0.6			1.1		0.7	0.2		0.9	0.5	
Delay (s)		13.8			14.9		7.5	7.9		8.4	9.1	
Level of Service		B			B		A	A		A	A	
Approach Delay (s)		13.8			14.9			7.9			9.0	
Approach LOS		B			B			A			A	

Intersection Summary			
HCM Average Control Delay	9.5	HCM Level of Service	A
HCM Volume to Capacity ratio	0.57		
Actuated Cycle Length (s)	46.7	Sum of lost time (s)	10.0
Intersection Capacity Utilization	58.5%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

	↗	→	↘	↙	←	↖	↖	↑	↗	↘	↓	↙
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↰	↑↑↱		↰	↑↑↱			✣			✣	
Volume (vph)	58	783	85	135	373	8	83	12	314	3	7	7
Ideal Flow (vphpl)	2000	2000	2000	2000	2000	2000	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0		5.0	5.0			5.0			5.0	
Lane Util. Factor	1.00	0.95		1.00	0.95			1.00			1.00	
Frt	1.00	0.99		1.00	1.00			0.90			0.94	
Flt Protected	0.95	1.00		0.95	1.00			0.99			0.99	
Satd. Flow (prot)	1863	3671		1863	3714			1653			1744	
Flt Permitted	0.95	1.00		0.95	1.00			0.93			0.95	
Satd. Flow (perm)	1863	3671		1863	3714			1549			1670	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	61	824	89	142	393	8	87	13	331	3	7	7
RTOR Reduction (vph)	0	8	0	0	2	0	0	151	0	0	5	0
Lane Group Flow (vph)	61	905	0	142	399	0	0	280	0	0	12	0
Turn Type	Prot			Prot			Perm			Perm		
Protected Phases	7	4		3	8			2			6	
Permitted Phases							2			6		
Actuated Green, G (s)	4.0	25.4		8.3	29.7			17.6			17.6	
Effective Green, g (s)	4.0	25.4		8.3	29.7			17.6			17.6	
Actuated g/C Ratio	0.06	0.38		0.13	0.45			0.27			0.27	
Clearance Time (s)	5.0	5.0		5.0	5.0			5.0			5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0			3.0			3.0	
Lane Grp Cap (vph)	112	1406		233	1664			411			443	
v/s Ratio Prot	0.03	c0.25		c0.08	c0.11							
v/s Ratio Perm								c0.18			0.01	
v/c Ratio	0.54	0.64		0.61	0.24			0.68			0.03	
Uniform Delay, d1	30.3	16.7		27.5	11.3			21.8			18.0	
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Incremental Delay, d2	5.3	1.0		4.5	0.1			4.6			0.0	
Delay (s)	35.6	17.8		31.9	11.4			26.5			18.0	
Level of Service	D	B		C	B			C			B	
Approach Delay (s)		18.9			16.8			26.5			18.0	
Approach LOS		B			B			C			B	

Intersection Summary			
HCM Average Control Delay	20.0	HCM Level of Service	B
HCM Volume to Capacity ratio	0.71		
Actuated Cycle Length (s)	66.3	Sum of lost time (s)	20.0
Intersection Capacity Utilization	74.0%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↰	↑↱		↰	↑↱			✥			✥	
Volume (vph)	53	644	99	185	979	7	149	19	173	11	22	108
Ideal Flow (vphpl)	2000	2000	2000	2000	2000	2000	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0		5.0	5.0			5.0			5.0	
Lane Util. Factor	1.00	0.95		1.00	0.95			1.00			1.00	
Frt	1.00	0.98		1.00	1.00			0.93			0.90	
Flt Protected	0.95	1.00		0.95	1.00			0.98			1.00	
Satd. Flow (prot)	1863	3651		1863	3722			1698			1664	
Flt Permitted	0.95	1.00		0.95	1.00			0.80			0.96	
Satd. Flow (perm)	1863	3651		1863	3722			1384			1607	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	56	678	104	195	1031	7	157	20	182	12	23	114
RTOR Reduction (vph)	0	13	0	0	1	0	0	47	0	0	80	0
Lane Group Flow (vph)	56	769	0	195	1037	0	0	312	0	0	69	0
Turn Type	Prot			Prot			Perm			Perm		
Protected Phases	7	4		3	8			2			6	
Permitted Phases							2			6		
Actuated Green, G (s)	3.6	23.6		12.2	32.2			21.5			21.5	
Effective Green, g (s)	3.6	23.6		12.2	32.2			21.5			21.5	
Actuated g/C Ratio	0.05	0.33		0.17	0.45			0.30			0.30	
Clearance Time (s)	5.0	5.0		5.0	5.0			5.0			5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0			3.0			3.0	
Lane Grp Cap (vph)	93	1192		314	1658			412			478	
v/s Ratio Prot	0.03	0.21		c0.10	c0.28							
v/s Ratio Perm								c0.23			0.04	
v/c Ratio	0.60	0.65		0.62	0.63			0.76			0.14	
Uniform Delay, d1	33.6	20.8		27.9	15.4			23.0			18.6	
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Incremental Delay, d2	10.5	1.2		3.8	0.7			7.8			0.1	
Delay (s)	44.2	22.0		31.7	16.2			30.8			18.8	
Level of Service	D	C		C	B			C			B	
Approach Delay (s)		23.5			18.6			30.8			18.8	
Approach LOS		C			B			C			B	

Intersection Summary			
HCM Average Control Delay	21.9	HCM Level of Service	C
HCM Volume to Capacity ratio	0.70		
Actuated Cycle Length (s)	72.3	Sum of lost time (s)	15.0
Intersection Capacity Utilization	74.6%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	16	24	4	201	20	245	8	456	236	671	913	17
Ideal Flow (vphpl)	1900	1900	1900	2000	2000	2000	2000	2000	2000	2000	2000	2000
Total Lost time (s)	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	6.0
Lane Util. Factor	1.00	0.95	1.00	0.95	0.95	0.88	1.00	0.95	1.00	0.97	0.95	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	0.96	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1770	3539	1583	1770	1789	2933	1863	3725	1667	3614	3725	1667
Flt Permitted	0.95	1.00	1.00	0.95	0.96	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	1770	3539	1583	1770	1789	2933	1863	3725	1667	3614	3725	1667
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	17	25	4	212	21	258	8	480	248	706	961	18
RTOR Reduction (vph)	0	0	0	0	0	129	0	0	181	0	0	8
Lane Group Flow (vph)	17	25	4	117	116	129	8	480	67	706	961	10
Turn Type	Split		Free	Split		pt+ov	Prot		Perm	Prot		Perm
Protected Phases	4	4		8	8	8 1	5	2		1	6	
Permitted Phases			Free						2			6
Actuated Green, G (s)	3.5	3.5	79.7	11.6	11.6	39.7	0.8	21.5	21.5	23.1	43.8	43.8
Effective Green, g (s)	3.5	3.5	79.7	11.6	11.6	39.7	0.8	21.5	21.5	23.1	43.8	42.8
Actuated g/C Ratio	0.04	0.04	1.00	0.15	0.15	0.50	0.01	0.27	0.27	0.29	0.55	0.54
Clearance Time (s)	5.0	5.0		5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	78	155	1583	258	260	1461	19	1005	450	1047	2047	895
v/s Ratio Prot	c0.01	0.01		c0.07	0.06	0.04	0.00	0.13		c0.20	c0.26	
v/s Ratio Perm			0.00						0.04			0.01
v/c Ratio	0.22	0.16	0.00	0.45	0.45	0.09	0.42	0.48	0.15	0.67	0.47	0.01
Uniform Delay, d1	36.8	36.7	0.0	31.2	31.1	10.5	39.2	24.4	22.1	25.0	10.9	8.6
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	1.4	0.5	0.0	1.3	1.2	0.0	14.4	0.4	0.2	1.7	0.2	0.0
Delay (s)	38.2	37.2	0.0	32.4	32.3	10.5	53.6	24.8	22.3	26.7	11.1	8.6
Level of Service	D	D	A	C	C	B	D	C	C	C	B	A
Approach Delay (s)		34.3			20.9			24.2			17.6	
Approach LOS		C			C			C			B	

Intersection Summary			
HCM Average Control Delay	20.1	HCM Level of Service	C
HCM Volume to Capacity ratio	0.51		
Actuated Cycle Length (s)	79.7	Sum of lost time (s)	15.0
Intersection Capacity Utilization	55.1%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	32	45	36	352	81	810	35	814	396	360	592	51
Ideal Flow (vphpl)	1900	1900	1900	2000	2000	2000	2000	2000	2000	2000	2000	2000
Total Lost time (s)	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	6.0
Lane Util. Factor	1.00	0.95	1.00	0.95	0.95	0.88	1.00	0.95	1.00	0.97	0.95	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	0.97	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1770	3539	1583	1770	1806	2933	1863	3725	1667	3614	3725	1667
Flt Permitted	0.95	1.00	1.00	0.95	0.97	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	1770	3539	1583	1770	1806	2933	1863	3725	1667	3614	3725	1667
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	34	47	38	371	85	853	37	857	417	379	623	54
RTOR Reduction (vph)	0	0	0	0	0	245	0	0	275	0	0	29
Lane Group Flow (vph)	34	47	38	226	230	608	37	857	142	379	623	25
Turn Type	Split		Free	Split		pt+ov	Prot		Perm	Prot		Perm
Protected Phases	4	4		8	8	8 1	5	2		1	6	
Permitted Phases			Free						2			6
Actuated Green, G (s)	5.9	5.9	96.2	20.4	20.4	42.6	3.6	32.7	32.7	17.2	46.3	46.3
Effective Green, g (s)	5.9	5.9	96.2	20.4	20.4	42.6	3.6	32.7	32.7	17.2	46.3	45.3
Actuated g/C Ratio	0.06	0.06	1.00	0.21	0.21	0.44	0.04	0.34	0.34	0.18	0.48	0.47
Clearance Time (s)	5.0	5.0		5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	109	217	1583	375	383	1299	70	1266	567	646	1793	785
v/s Ratio Prot	c0.02	0.01		c0.13	0.13	c0.21	0.02	c0.23		c0.10	0.17	
v/s Ratio Perm			0.02						0.09			0.02
v/c Ratio	0.31	0.22	0.02	0.60	0.60	0.47	0.53	0.68	0.25	0.59	0.35	0.03
Uniform Delay, d1	43.2	43.0	0.0	34.2	34.2	18.8	45.5	27.2	22.9	36.2	15.5	13.7
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	1.6	0.5	0.0	2.7	2.6	0.3	7.0	1.5	0.2	1.4	0.1	0.0
Delay (s)	44.8	43.5	0.0	37.0	36.9	19.1	52.5	28.7	23.1	37.6	15.7	13.7
Level of Service	D	D	A	D	D	B	D	C	C	D	B	B
Approach Delay (s)		30.0			25.3			27.6			23.4	
Approach LOS		C			C			C			C	

Intersection Summary			
HCM Average Control Delay	25.7	HCM Level of Service	C
HCM Volume to Capacity ratio	0.58		
Actuated Cycle Length (s)	96.2	Sum of lost time (s)	15.0
Intersection Capacity Utilization	64.1%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	1	4	9	578	2	38	16	659	567	30	1086	1
Ideal Flow (vphpl)	1900	1900	1900	2000	2000	2000	2000	2000	2000	2000	2000	2000
Total Lost time (s)	5.0	5.0	4.0	5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0
Lane Util. Factor	1.00	1.00	1.00	0.97	1.00		1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	1.00	0.85	1.00	0.86		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1770	1863	1583	3614	1681		1863	3725	1667	1863	3725	1667
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	1770	1863	1583	3614	1681		1863	3725	1667	1863	3725	1667
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	1	4	9	608	2	40	17	694	597	32	1143	1
RTOR Reduction (vph)	0	0	0	0	29	0	0	0	354	0	0	1
Lane Group Flow (vph)	1	4	9	608	13	0	17	694	243	32	1143	0
Turn Type	Split		Free	Split			Prot		Perm	Prot		Perm
Protected Phases	4	4		8	8		5	2		1	6	
Permitted Phases			Free						2			6
Actuated Green, G (s)	0.8	0.8	70.6	19.1	19.1		1.4	28.7	28.7	2.0	29.3	29.3
Effective Green, g (s)	0.8	0.8	70.6	19.1	19.1		1.4	28.7	28.7	2.0	29.3	29.3
Actuated g/C Ratio	0.01	0.01	1.00	0.27	0.27		0.02	0.41	0.41	0.03	0.42	0.42
Clearance Time (s)	5.0	5.0		5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	20	21	1583	978	455		37	1514	678	53	1546	692
v/s Ratio Prot	0.00	c0.00		c0.17	0.01		0.01	0.19		c0.02	c0.31	
v/s Ratio Perm			c0.01						0.15			0.00
v/c Ratio	0.05	0.19	0.01	0.62	0.03		0.46	0.46	0.36	0.60	0.74	0.00
Uniform Delay, d1	34.5	34.6	0.0	22.6	18.9		34.2	15.3	14.6	33.9	17.4	12.1
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	1.0	4.4	0.0	1.2	0.0		8.8	0.2	0.3	17.9	1.9	0.0
Delay (s)	35.6	39.0	0.0	23.8	19.0		43.0	15.5	14.9	51.8	19.3	12.1
Level of Service	D	D	A	C	B		D	B	B	D	B	B
Approach Delay (s)		13.7			23.5			15.6			20.2	
Approach LOS		B			C			B			C	

Intersection Summary			
HCM Average Control Delay	18.9	HCM Level of Service	B
HCM Volume to Capacity ratio	0.63		
Actuated Cycle Length (s)	70.6	Sum of lost time (s)	15.0
Intersection Capacity Utilization	59.2%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↰	↑	↱	↰↰	↑↱		↰	↑↑	↱	↰	↑↑	↱
Volume (vph)	6	16	41	618	17	49	84	1190	833	43	924	12
Ideal Flow (vphpl)	1900	1900	1900	2000	2000	2000	2000	2000	2000	2000	2000	2000
Total Lost time (s)	5.0	5.0	4.0	5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0
Lane Util. Factor	1.00	1.00	1.00	0.97	1.00		1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	1.00	0.85	1.00	0.89		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1770	1863	1583	3614	1742		1863	3725	1667	1863	3725	1667
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	1770	1863	1583	3614	1742		1863	3725	1667	1863	3725	1667
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	6	17	43	651	18	52	88	1253	877	45	973	13
RTOR Reduction (vph)	0	0	0	0	39	0	0	0	398	0	0	8
Lane Group Flow (vph)	6	17	43	651	31	0	88	1253	479	45	973	5
Turn Type	Split		Free	Split			Prot		Perm	Prot		Perm
Protected Phases	4	4		8	8		5	2		1	6	
Permitted Phases			Free						2			6
Actuated Green, G (s)	2.4	2.4	91.3	22.7	22.7		7.7	42.3	42.3	3.9	38.5	38.5
Effective Green, g (s)	2.4	2.4	91.3	22.7	22.7		7.7	42.3	42.3	3.9	38.5	38.5
Actuated g/C Ratio	0.03	0.03	1.00	0.25	0.25		0.08	0.46	0.46	0.04	0.42	0.42
Clearance Time (s)	5.0	5.0		5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	47	49	1583	899	433		157	1726	772	80	1571	703
v/s Ratio Prot	0.00	c0.01		c0.18	0.02		c0.05	c0.34		0.02	0.26	
v/s Ratio Perm			0.03						0.29			0.00
v/c Ratio	0.13	0.35	0.03	0.72	0.07		0.56	0.73	0.62	0.56	0.62	0.01
Uniform Delay, d1	43.4	43.7	0.0	31.4	26.2		40.2	19.8	18.5	42.9	20.7	15.3
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	1.2	4.2	0.0	2.9	0.1		4.5	1.5	1.6	8.8	0.7	0.0
Delay (s)	44.7	47.9	0.0	34.3	26.3		44.7	21.4	20.0	51.6	21.4	15.3
Level of Service	D	D	A	C	C		D	C	C	D	C	B
Approach Delay (s)		16.4			33.6			21.8			22.6	
Approach LOS		B			C			C			C	

Intersection Summary			
HCM Average Control Delay	24.0	HCM Level of Service	C
HCM Volume to Capacity ratio	0.72		
Actuated Cycle Length (s)	91.3	Sum of lost time (s)	20.0
Intersection Capacity Utilization	70.5%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	466	17	93	64	73	37	46	742	39	16	1106	552
Ideal Flow (vphpl)	2000	2000	2000	1900	1900	1900	2000	2000	2000	2000	2000	2000
Total Lost time (s)	5.0	5.0	4.0	5.0	5.0		5.0	5.0	5.0	5.0	5.0	4.0
Lane Util. Factor	0.95	0.95	1.00	1.00	1.00		1.00	0.95	1.00	1.00	0.95	1.00
Frpb, ped/bikes	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	1.00	0.85	1.00	0.95		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	0.96	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1770	1780	1667	1770	1769		1863	3725	1667	1863	3725	1667
Flt Permitted	0.95	0.96	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	1770	1780	1667	1770	1769		1863	3725	1667	1863	3725	1667
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	466	17	93	64	73	37	46	742	39	16	1106	552
RTOR Reduction (vph)	0	0	0	0	16	0	0	0	22	0	0	0
Lane Group Flow (vph)	242	241	93	64	94	0	46	742	17	16	1106	552
Confl. Peds. (#/hr)							39					
Turn Type	Split		Free	Split			Prot		Perm	Prot		Free
Protected Phases	4	4		8	8		5	2		1	6	
Permitted Phases			Free						2			Free
Actuated Green, G (s)	18.3	18.3	88.5	10.7	10.7		3.9	38.0	38.0	1.5	35.6	88.5
Effective Green, g (s)	18.3	18.3	88.5	10.7	10.7		3.9	38.0	38.0	1.5	35.6	88.5
Actuated g/C Ratio	0.21	0.21	1.00	0.12	0.12		0.04	0.43	0.43	0.02	0.40	1.00
Clearance Time (s)	5.0	5.0		5.0	5.0		5.0	5.0	5.0	5.0	5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	366	368	1667	214	214		82	1599	716	32	1498	1667
v/s Ratio Prot	c0.14	0.14		0.04	0.05		c0.02	0.20		0.01	c0.30	
v/s Ratio Perm			0.06						0.01			c0.33
v/c Ratio	0.66	0.65	0.06	0.30	0.44		0.56	0.46	0.02	0.50	0.74	0.33
Uniform Delay, d1	32.3	32.2	0.0	35.5	36.1		41.5	18.0	14.6	43.1	22.5	0.0
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	4.4	4.2	0.1	0.8	1.4		8.5	0.2	0.0	11.8	1.9	0.5
Delay (s)	36.7	36.4	0.1	36.3	37.6		50.0	18.2	14.6	54.9	24.4	0.5
Level of Service	D	D	A	D	D		D	B	B	D	C	A
Approach Delay (s)		30.6			37.1			19.8			16.8	
Approach LOS		C			D			B			B	

Intersection Summary			
HCM Average Control Delay	21.1	HCM Level of Service	C
HCM Volume to Capacity ratio	0.63		
Actuated Cycle Length (s)	88.5	Sum of lost time (s)	15.0
Intersection Capacity Utilization	64.0%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↰	↰↑	↱	↰	↑↱		↰	↑↑	↱	↰	↑↑	↱
Volume (vph)	488	31	134	24	31	47	176	1587	105	25	912	645
Ideal Flow (vphpl)	2000	2000	2000	1900	1900	1900	2000	2000	2000	2000	2000	2000
Total Lost time (s)	5.0	5.0	4.0	5.0	5.0		5.0	5.0	5.0	5.0	5.0	4.0
Lane Util. Factor	0.95	0.95	1.00	1.00	1.00		1.00	0.95	1.00	1.00	0.95	1.00
Frpb, ped/bikes	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	1.00	0.85	1.00	0.91		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	0.96	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1770	1784	1667	1770	1696		1863	3725	1667	1863	3725	1667
Flt Permitted	0.95	0.96	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	1770	1784	1667	1770	1696		1863	3725	1667	1863	3725	1667
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	514	33	141	25	33	49	185	1671	111	26	960	679
RTOR Reduction (vph)	0	0	0	0	46	0	0	0	38	0	0	0
Lane Group Flow (vph)	272	275	141	25	36	0	185	1671	73	26	960	679
Confl. Peds. (#/hr)							39					
Turn Type	Split		Free	Split			Prot		Perm	Prot		Free
Protected Phases	4	4		8	8		5	2		1	6	
Permitted Phases			Free						2			Free
Actuated Green, G (s)	20.0	20.0	100.5	6.3	6.3		15.3	51.1	51.1	3.1	38.9	100.5
Effective Green, g (s)	20.0	20.0	100.5	6.3	6.3		15.3	51.1	51.1	3.1	38.9	100.5
Actuated g/C Ratio	0.20	0.20	1.00	0.06	0.06		0.15	0.51	0.51	0.03	0.39	1.00
Clearance Time (s)	5.0	5.0		5.0	5.0		5.0	5.0	5.0	5.0	5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	352	355	1667	111	106		284	1894	848	57	1442	1667
v/s Ratio Prot	0.15	c0.15		0.01	0.02		c0.10	c0.45		0.01	0.26	
v/s Ratio Perm			0.08						0.04			c0.41
v/c Ratio	0.77	0.77	0.08	0.23	0.34		0.65	0.88	0.09	0.46	0.67	0.41
Uniform Delay, d1	38.1	38.1	0.0	44.8	45.1		40.1	22.0	12.7	47.9	25.4	0.0
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	10.1	10.1	0.1	1.0	1.9		5.3	5.2	0.0	5.7	1.2	0.7
Delay (s)	48.2	48.2	0.1	45.8	47.0		45.4	27.3	12.7	53.6	26.6	0.7
Level of Service	D	D	A	D	D		D	C	B	D	C	A
Approach Delay (s)		38.4			46.7			28.1			16.5	
Approach LOS		D			D			C			B	

Intersection Summary			
HCM Average Control Delay	[illegible]	HCM Level of Service	[illegible]
HCM Volume to Capacity ratio	0.81		
Actuated Cycle Length (s)	[illegible]	Sum of lost time (s)	[illegible]
Intersection Capacity Utilization	77.8%	ICU Level of Service	D
Analysis Period (min)	[illegible]		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	111	12	321	173	12	13	30	701	55	3	1255	10
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	2000	2000	2000	2000	2000	2000
Total Lost time (s)		5.0	5.0	5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0
Lane Util. Factor		1.00	1.00	1.00	1.00		1.00	0.95	1.00	1.00	0.95	1.00
Frt		1.00	0.85	1.00	0.92		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected		0.96	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)		1783	1583	1770	1718		1863	3725	1667	1863	3725	1667
Flt Permitted		0.73	1.00	0.67	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)		1356	1583	1255	1718		1863	3725	1667	1863	3725	1667
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	117	13	338	182	13	14	32	738	58	3	1321	11
RTOR Reduction (vph)	0	0	73	0	10	0	0	0	27	0	0	5
Lane Group Flow (vph)	0	130	265	182	17	0	32	738	31	3	1321	6
Turn Type	Perm		Perm	Perm			Prot		Perm	Prot		Perm
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4		4	8					2			6
Actuated Green, G (s)		19.9	19.9	19.9	19.9		2.9	42.0	42.0	0.5	39.6	39.6
Effective Green, g (s)		19.9	19.9	19.9	19.9		2.9	42.0	42.0	0.5	39.6	39.6
Actuated g/C Ratio		0.26	0.26	0.26	0.26		0.04	0.54	0.54	0.01	0.51	0.51
Clearance Time (s)		5.0	5.0	5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0
Vehicle Extension (s)		3.0	3.0	3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)		349	407	323	442		70	2021	905	12	1906	853
v/s Ratio Prot					0.01		c0.02	0.20		0.00	c0.35	
v/s Ratio Perm		0.10	c0.17	0.15					0.02			0.00
v/c Ratio		0.37	0.65	0.56	0.04		0.46	0.37	0.03	0.25	0.69	0.01
Uniform Delay, d1		23.6	25.7	25.0	21.6		36.5	10.1	8.3	38.3	14.3	9.3
Progression Factor		1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2		0.7	3.7	2.2	0.0		4.7	0.1	0.0	10.7	1.1	0.0
Delay (s)		24.3	29.4	27.2	21.6		41.2	10.2	8.3	48.9	15.4	9.3
Level of Service		C	C	C	C		D	B	A	D	B	A
Approach Delay (s)		28.0			26.5			11.3			15.4	
Approach LOS		C			C			B			B	

Intersection Summary			
HCM Average Control Delay	17.1	HCM Level of Service	B
HCM Volume to Capacity ratio	0.67		
Actuated Cycle Length (s)	77.4	Sum of lost time (s)	15.0
Intersection Capacity Utilization	74.9%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	21	6	69	63	8	9	158	1848	171	10	1039	26
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	2000	2000	2000	2000	2000	2000
Total Lost time (s)		5.0	5.0	5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0
Lane Util. Factor		1.00	1.00	1.00	1.00		1.00	0.95	1.00	1.00	0.95	1.00
Frt		1.00	0.85	1.00	0.92		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected		0.96	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)		1792	1583	1770	1715		1863	3725	1667	1863	3725	1667
Flt Permitted		0.76	1.00	0.74	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)		1417	1583	1377	1715		1863	3725	1667	1863	3725	1667
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	22	6	73	66	8	9	166	1945	180	11	1094	27
RTOR Reduction (vph)	0	0	66	0	8	0	0	0	53	0	0	12
Lane Group Flow (vph)	0	28	7	66	9	0	166	1945	127	11	1094	15
Turn Type	Perm		Perm	Perm			Prot		Perm	Prot		Perm
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4		4	8					2			6
Actuated Green, G (s)		7.9	7.9	7.9	7.9		14.4	57.7	57.7	1.0	44.3	44.3
Effective Green, g (s)		7.9	7.9	7.9	7.9		14.4	57.7	57.7	1.0	44.3	44.3
Actuated g/C Ratio		0.10	0.10	0.10	0.10		0.18	0.71	0.71	0.01	0.54	0.54
Clearance Time (s)		5.0	5.0	5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0
Vehicle Extension (s)		3.0	3.0	3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)		137	153	133	166		329	2634	1179	23	2022	905
v/s Ratio Prot					0.01		c0.09	c0.52		0.01	0.29	
v/s Ratio Perm		0.02	0.00	c0.05					0.08			0.01
v/c Ratio		0.20	0.05	0.50	0.05		0.50	0.74	0.11	0.48	0.54	0.02
Uniform Delay, d1		34.0	33.4	35.0	33.5		30.4	7.3	3.8	40.0	12.1	8.6
Progression Factor		1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2		0.7	0.1	2.9	0.1		1.2	1.1	0.0	14.8	0.3	0.0
Delay (s)		34.7	33.6	37.9	33.6		31.6	8.4	3.8	54.9	12.4	8.6
Level of Service		C	C	D	C		C	A	A	D	B	A
Approach Delay (s)		33.9			37.0			9.8			12.7	
Approach LOS		C			D			A			B	

Intersection Summary			
HCM Average Control Delay	12.0	HCM Level of Service	B
HCM Volume to Capacity ratio	0.73		
Actuated Cycle Length (s)	81.6	Sum of lost time (s)	15.0
Intersection Capacity Utilization	74.5%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations	↰	↱	↰	↑↑	↑↑	↱
Volume (vph)	114	618	139	671	1680	86
Ideal Flow (vphpl)	2000	2000	2000	2000	2000	2000
Total Lost time (s)	5.0	5.0	5.0	5.0	5.0	5.0
Lane Util. Factor	1.00	1.00	1.00	0.95	0.95	1.00
Frt	1.00	0.85	1.00	1.00	1.00	0.85
Flt Protected	0.95	1.00	0.95	1.00	1.00	1.00
Satd. Flow (prot)	1863	1667	1863	3725	3725	1667
Flt Permitted	0.95	1.00	0.95	1.00	1.00	1.00
Satd. Flow (perm)	1863	1667	1863	3725	3725	1667
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	114	618	139	671	1680	86
RTOR Reduction (vph)	0	6	0	0	0	38
Lane Group Flow (vph)	114	612	139	671	1680	48
Turn Type		pt+ov	Prot			Perm
Protected Phases	4	4 5	5	2	6	
Permitted Phases						6
Actuated Green, G (s)	29.8	48.7	13.9	76.4	57.5	57.5
Effective Green, g (s)	29.8	48.7	13.9	76.4	57.5	57.5
Actuated g/C Ratio	0.26	0.42	0.12	0.66	0.49	0.49
Clearance Time (s)	5.0		5.0	5.0	5.0	5.0
Vehicle Extension (s)	3.0		3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	478	699	223	2449	1843	825
v/s Ratio Prot	0.06	c0.37	0.07	0.18	c0.45	
v/s Ratio Perm						0.03
v/c Ratio	0.24	0.87	0.62	0.27	0.91	0.06
Uniform Delay, d1	34.2	31.0	48.7	8.3	27.0	15.3
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.3	11.8	5.3	0.1	7.3	0.0
Delay (s)	34.5	42.8	54.0	8.4	34.3	15.3
Level of Service	C	D	D	A	C	B
Approach Delay (s)	41.5			16.2	33.4	
Approach LOS	D			B	C	

Intersection Summary			
HCM Average Control Delay	31.0	HCM Level of Service	C
HCM Volume to Capacity ratio	0.89		
Actuated Cycle Length (s)	116.2	Sum of lost time (s)	10.0
Intersection Capacity Utilization	88.8%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	241	456	292	1940	1001	169
Ideal Flow (vphpl)	2000	2000	2000	2000	2000	2000
Total Lost time (s)	5.0	5.0	5.0	5.0	5.0	5.0
Lane Util. Factor	1.00	1.00	1.00	0.95	0.95	1.00
Frt	1.00	0.85	1.00	1.00	1.00	0.85
Flt Protected	0.95	1.00	0.95	1.00	1.00	1.00
Satd. Flow (prot)	1863	1667	1863	3725	3725	1667
Flt Permitted	0.95	1.00	0.95	1.00	1.00	1.00
Satd. Flow (perm)	1863	1667	1863	3725	3725	1667
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	254	480	307	2042	1054	178
RTOR Reduction (vph)	0	19	0	0	0	104
Lane Group Flow (vph)	254	461	307	2042	1054	74
Turn Type		pm+ov	Prot			Perm
Protected Phases	4	5	5	2	6	
Permitted Phases		4				6
Actuated Green, G (s)	18.7	40.5	21.8	66.6	39.8	39.8
Effective Green, g (s)	18.7	40.5	21.8	66.6	39.8	39.8
Actuated g/C Ratio	0.20	0.42	0.23	0.70	0.42	0.42
Clearance Time (s)	5.0	5.0	5.0	5.0	5.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	366	796	426	2603	1556	696
v/s Ratio Prot	c0.14	0.13	0.16	c0.55	0.28	
v/s Ratio Perm		0.14				0.04
v/c Ratio	0.69	0.58	0.72	0.78	0.68	0.11
Uniform Delay, d1	35.6	20.9	33.9	9.6	22.5	16.9
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	5.6	1.0	5.9	1.6	1.2	0.1
Delay (s)	41.3	21.9	39.9	11.2	23.7	17.0
Level of Service	D	C	D	B	C	B
Approach Delay (s)	28.6			14.9	22.7	
Approach LOS	C			B	C	

Intersection Summary			
HCM Average Control Delay	19.5	HCM Level of Service	B
HCM Volume to Capacity ratio	0.76		
Actuated Cycle Length (s)	95.3	Sum of lost time (s)	10.0
Intersection Capacity Utilization	72.0%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

HCS+: Ramps and Ramp Junctions Release 5.3

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: AM Peak
Freeway/Dir of Travel: H-2 Fwy NB Off-Ramp
Junction: H-2 Fwy/Ka Uka Blvd
Jurisdiction:
Analysis Year: Year 2016 Without Project
Description:

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	3574	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	2	
Free-Flow speed on ramp	35.0	mph
Volume on ramp	1309	vph
Length of first accel/decel lane	800	ft
Length of second accel/decel lane	0	ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent ramp	305	vph
Position of adjacent ramp	Downstream	
Type of adjacent ramp	On	
Distance to adjacent ramp	1300	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	3574		1309		305	vph
Peak-hour factor, PHF	0.90		0.90		0.90	
Peak 15-min volume, v15	993		364		85	v
Trucks and buses	2		2		2	%
Recreational vehicles	0		0		0	%
Terrain type:	Rolling		Level		Level	
Grade	0.00	%	0.00	%	0.00	%
Length	0.00	mi	0.00	mi	0.00	mi
Trucks and buses PCE, ET	2.5		1.5		1.5	
Recreational vehicle PCE, ER	2.0		1.2		1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	4090	1469	342	pcph

Estimation of V12 Diverge Areas

L_{EQ} = (Equation 25-8 or 25-9)

P_{FD} = 0.260 Using Equation 0

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 2150 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{Fi} = v_F$	4090	9400	No
$v_{FO} = v_F - v_R$	2621	9400	No
v_R	1469	3800	No
v_3 or v_{av34}	970 pc/h	(Equation 25-15 or 25-16)	

Is v_3 or v_{av34} > 2700 pc/h? No

Is v_3 or v_{av34} > 1.5 v_{12}/2 No

If yes, v_{12A} = 2150 (Equation 25-18)

Flow Entering Diverge Influence Area

	Actual	Max Desirable	Violation?
v_{12}	2150	4400	No

Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\, v_{12} - 0.009\, L_D$ = 8.3 pc/mi/ln

Level of service for ramp-freeway junction areas of influence A

Speed Estimation

Intermediate speed variable, D_S = 0.560

Space mean speed in ramp influence area, S_R = 52.1 mph

Space mean speed in outer lanes, S_0 = 71.3 mph

Space mean speed for all vehicles, S = 59.7 mph

HCS+: Ramps and Ramp Junctions Release 5.3

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: PM Peak
Freeway/Dir of Travel: H-2 Fwy NB Off-Ramp
Junction: H-2 Fwy/Ka Uka Blvd
Jurisdiction:
Analysis Year: Year 2016 Without Project
Description:

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	6712	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	2	
Free-Flow speed on ramp	35.0	mph
Volume on ramp	3358	vph
Length of first accel/decel lane	800	ft
Length of second accel/decel lane	0	ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent ramp	528	vph
Position of adjacent ramp	Downstream	
Type of adjacent ramp	On	
Distance to adjacent ramp	1300	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	6712		3358		528	vph
Peak-hour factor, PHF	0.90		0.90		0.90	
Peak 15-min volume, v15	1864		933		147	v
Trucks and buses	2		2		2	%
Recreational vehicles	0		0		0	%
Terrain type:	Rolling		Level		Level	
Grade	0.00	%	0.00	%	0.00	%
Length	0.00	mi	0.00	mi	0.00	mi
Trucks and buses PCE, ET	2.5		1.5		1.5	
Recreational vehicle PCE, ER	2.0		1.2		1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	7682	3768	593	pcph

Estimation of V12 Diverge Areas

L_{EQ} = (Equation 25-8 or 25-9)

P_{FD} = 0.260 Using Equation 0

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 4786 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{Fi} = v_F$	7682	9400	No
$v_{FO} = v_F - v_R$	3914	9400	No
v_R	3768	3800	No
v_3 or v_{av34}	1448 pc/h	(Equation 25-15 or 25-16)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		No	
If yes, v_{12A} = 4786		(Equation 25-18)	

Flow Entering Diverge Influence Area

	Actual	Max Desirable	Violation?
v_{12}	4786	4400	Yes

Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\, v_{12} - 0.009\, L_D$ = 31.0 pc/mi/ln

Level of service for ramp-freeway junction areas of influence D

Speed Estimation

Intermediate speed variable, D_S = 0.767

Space mean speed in ramp influence area, S_R = 47.4 mph

Space mean speed in outer lanes, S_0 = 69.6 mph

Space mean speed for all vehicles, S = 53.8 mph

HCS+: Ramps and Ramp Junctions Release 5.3

Phone: Fax:
E-mail:

Merge Analysis

Analyst:	
Agency/Co.:	
Date performed:	2/24/2009
Analysis time period:	AM Peak
Freeway/Dir of Travel:	H-2 Fwy NB On Ramp Loop
Junction:	H-2 Fwy/Ka Uka Blvd
Jurisdiction:	
Analysis Year:	Year 2016 Without Project
Description:	(Analysis with NB Off-Ramp)

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	2265	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	35.0	mph
Volume on ramp	305	vph
Length of first accel/decel lane	1500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	1309	vph
Position of adjacent Ramp	Upstream	
Type of adjacent Ramp	Off	
Distance to adjacent Ramp	1300	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	2265		305		1309	vph
Peak-hour factor, PHF	0.90		0.90		0.90	
Peak 15-min volume, v15	629		85		364	v
Trucks and buses	2		2		2	%
Recreational vehicles	0		0		0	%
Terrain type:	Rolling		Level		Level	
Grade		%		%		%
Length		mi		mi		mi
Trucks and buses PCE, ET	2.5		1.5		1.5	
Recreational vehicle PCE, ER	2.0		1.2		1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	2592	342	1469	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 25-2 or 25-3)

P_{FM} = 0.175 Using Equation 4

$v_{12} = v_F \ (P_{FM})$ = 454 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	2934	9400	No
v_3 or v_{av34}	1069 pc/h	(Equation 25-4 or 25-5)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		Yes	
If yes, v_{12A} = 1036		(Equation 25-8)	

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	1036	4600	No

Level of Service Determination (if not F)

Density, $D = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$ = 6.7 pc/mi/ln

Level of service for ramp-freeway junction areas of influence A

Speed Estimation

Intermediate speed variable, M_S = 0.231

Space mean speed in ramp influence area, S_R = 59.7 mph

Space mean speed in outer lanes, S_0 = 64.0 mph

Space mean speed for all vehicles, S = 61.9 mph

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Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: PM Peak
Freeway/Dir of Travel: H-2 Fwy NB On Ramp Loop
Junction: H-2 Fwy/Ka Uka Blvd
Jurisdiction:
Analysis Year: Year 2016 Without Project
Description: (Analysis with NB Off-Ramp)

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	3354	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	35.0	mph
Volume on ramp	528	vph
Length of first accel/decel lane	1500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	3358	vph
Position of adjacent Ramp	Upstream	
Type of adjacent Ramp	Off	
Distance to adjacent Ramp	1300	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	3354		528		3358	vph
Peak-hour factor, PHF	0.90		0.90		0.90	
Peak 15-min volume, v15	932		147		933	v
Trucks and buses	2		2		2	%
Recreational vehicles	0		0		0	%
Terrain type:	Rolling		Level		Level	
Grade		%		%		%
Length		mi		mi		mi
Trucks and buses PCE, ET	2.5		1.5		1.5	
Recreational vehicle PCE, ER	2.0		1.2		1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	3838	593	3768	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 25-2 or 25-3)

P_{FM} = 0.144 Using Equation 4

$v_{12} = v_F (P_{FM})$ = 551 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	4431	9400	No
v_3 or v_{av34}	1643 pc/h	(Equation 25-4 or 25-5)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12} /2		Yes	
If yes, v_{12A} = 1535		(Equation 25-8)	

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	1535	4600	No

Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\, v_R + 0.0078\, v_{12} - 0.00627\, L_A$ = 12.4 pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

Speed Estimation

Intermediate speed variable, M_S = 0.249

Space mean speed in ramp influence area, S_R = 59.3 mph

Space mean speed in outer lanes, S_0 = 62.7 mph

Space mean speed for all vehicles, S = 61.0 mph

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Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: AM Peak
Freeway/Dir of Travel: H-2 Fwy NB On Ramp Loop
Junction: H-2 Fwy/Ka Uka Blvd
Jurisdiction:
Analysis Year: Year 2016 Without Project
Description: (Analysis with NB On-Ramp)

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	2265	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	35.0	mph
Volume on ramp	305	vph
Length of first accel/decel lane	1500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	220	vph
Position of adjacent Ramp	Downstream	
Type of adjacent Ramp	On	
Distance to adjacent Ramp	1700	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	2265	305	220	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	629	85	61	v
Trucks and buses	2	2	2	%
Recreational vehicles	0	0	0	%
Terrain type:	Rolling	Level	Level	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	2.5	1.5	1.5	
Recreational vehicle PCE, ER	2.0	1.2	1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	2592	342	247	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 25-2 or 25-3)

P_{FM} = 0.175 Using Equation 4

$v_{12} = v_F (P_{FM})$ = 454 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	2934	9400	No
v_3 or v_{av34}	1069 pc/h	(Equation 25-4 or 25-5)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		Yes	
If yes, v_{12A} = 1036		(Equation 25-8)	

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	1036	4600	No

Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$ = 6.7 pc/mi/ln

Level of service for ramp-freeway junction areas of influence A

Speed Estimation

Intermediate speed variable, M_S = 0.231

Space mean speed in ramp influence area, S_R = 59.7 mph

Space mean speed in outer lanes, S_0 = 64.0 mph

Space mean speed for all vehicles, S = 61.9 mph

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Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: PM Peak
Freeway/Dir of Travel: H-2 Fwy NB On Ramp Loop
Junction: H-2 Fwy/Ka Uka Blvd
Jurisdiction:
Analysis Year: Year 2016 Without Project
Description: (Analysis with NB On-Ramp)

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	3354	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	35.0	mph
Volume on ramp	528	vph
Length of first accel/decel lane	1500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	450	vph
Position of adjacent Ramp	Downstream	
Type of adjacent Ramp	On	
Distance to adjacent Ramp	1700	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	3354	528	450	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	932	147	125	v
Trucks and buses	2	2	2	%
Recreational vehicles	0	0	0	%
Terrain type:	Rolling	Level	Level	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	2.5	1.5	1.5	
Recreational vehicle PCE, ER	2.0	1.2	1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	3838	593	505	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 25-2 or 25-3)

P_{FM} = 0.144 Using Equation 4

$v_{12} = v_F (P_{FM})$ = 551 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	4431	9400	No
v_3 or v_{av34}	1643 pc/h	(Equation 25-4 or 25-5)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		Yes	
If yes, v_{12A} = 1535		(Equation 25-8)	

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	1535	4600	No

Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\, v_R + 0.0078\, v_{12} - 0.00627\, L_A$ = 12.4 pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

Speed Estimation

Intermediate speed variable, M_S = 0.249

Space mean speed in ramp influence area, S_R = 59.3 mph

Space mean speed in outer lanes, S_0 = 62.7 mph

Space mean speed for all vehicles, S = 61.0 mph

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Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: AM Peak
Freeway/Dir of Travel: H-2 Fwy NB On Ramp
Junction: H-2 Fwy/Ka Uka Blvd
Jurisdiction:
Analysis Year: Year 2016 Without Project
Description:

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	2570	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	35.0	mph
Volume on ramp	220	vph
Length of first accel/decel lane	700	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	305	vph
Position of adjacent Ramp	Upstream	
Type of adjacent Ramp	On	
Distance to adjacent Ramp	1700	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	2570	220	305	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	714	61	85	v
Trucks and buses	2	2	2	%
Recreational vehicles	0	0	0	%
Terrain type:	Rolling	Level	Level	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	2.5	1.5	1.5	
Recreational vehicle PCE, ER	2.0	1.2	1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	2941	247	342	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 25-2 or 25-3)

P_{FM} = 0.187 Using Equation 4

$v_{12} = v_F (P_{FM})$ = 550 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	3188	9400	No
v_3 or v_{av34}	1195 pc/h	(Equation 25-4 or 25-5)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12} /2		Yes	
If yes, v_{12A} = 1176		(Equation 25-8)	

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	1176	4600	No

Level of Service Determination (if not F)

Density, $D = 5.475 + 0.00734\, v_R + 0.0078\, v_{12} - 0.00627\, L_A$ = 12.1 pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

Speed Estimation

Intermediate speed variable, M_S = 0.288

Space mean speed in ramp influence area, S_R = 58.4 mph

Space mean speed in outer lanes, S_0 = 63.6 mph

Space mean speed for all vehicles, S = 61.2 mph

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Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: PM Peak
Freeway/Dir of Travel: H-2 Fwy NB On Ramp
Junction: H-2 Fwy/Ka Uka Blvd
Jurisdiction:
Analysis Year: Year 2016 Without Project
Description:

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	3882	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	35.0	mph
Volume on ramp	450	vph
Length of first accel/decel lane	700	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	528	vph
Position of adjacent Ramp	Upstream	
Type of adjacent Ramp	On	
Distance to adjacent Ramp	1700	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	3882		450		528	vph
Peak-hour factor, PHF	0.90		0.90		0.90	
Peak 15-min volume, v15	1078		125		147	v
Trucks and buses	2		2		2	%
Recreational vehicles	0		0		0	%
Terrain type:	Rolling		Level		Level	
Grade		%		%		%
Length		mi		mi		mi
Trucks and buses PCE, ET	2.5		1.5		1.5	
Recreational vehicle PCE, ER	2.0		1.2		1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	4443	505	593	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 25-2 or 25-3)

P_{FM} = 0.155 Using Equation 4

$v_{12} = v_F (P_{FM})$ = 687 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	4948	9400	No
v_3 or v_{av34}	1878 pc/h	(Equation 25-4 or 25-5)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		Yes	
If yes, v_{12A} = 1777		(Equation 25-8)	

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	1777	4600	No

Level of Service Determination (if not F)

Density, $D = 5.475 + 0.00734\, v_R + 0.0078\, v_{12} - 0.00627\, L_A$ = 18.7 pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

Speed Estimation

Intermediate speed variable,	M_S = 0.310	
Space mean speed in ramp influence area,	S_R = 57.9	mph
Space mean speed in outer lanes,	S_0 = 62.0	mph
Space mean speed for all vehicles,	S = 60.0	mph

HCS+: Ramps and Ramp Junctions Release 5.3

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:	
Agency/Co.:	
Date performed:	2/24/2009
Analysis time period:	AM Peak
Freeway/Dir of Travel:	H-2 Fwy SB Off-Ramp
Junction:	H-2 Fwy/Ka Uka Blvd
Jurisdiction:	
Analysis Year:	Year 2016 Without Project
Description:	

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	4004	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	35.0	mph
Volume on ramp	471	vph
Length of first accel/decel lane	150	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent ramp	1449	vph
Position of adjacent ramp	Downstream	
Type of adjacent ramp	On	
Distance to adjacent ramp	1900	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	4004		471		1449	vph
Peak-hour factor, PHF	0.90		0.90		0.90	
Peak 15-min volume, v15	1112		131		403	v
Trucks and buses	2		2		2	%
Recreational vehicles	0		0		0	%
Terrain type:	Rolling		Level		Level	
Grade	0.00	%	0.00	%	0.00	%
Length	0.00	mi	0.00	mi	0.00	mi
Trucks and buses PCE, ET	2.5		1.5		1.5	
Recreational vehicle PCE, ER	2.0		1.2		1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	4582	529	1626	pcph

Estimation of V12 Diverge Areas

L_{EQ} = (Equation 25-8 or 25-9)

P_{FD} = 0.436 Using Equation 8

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 2296 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{Fi} = v_F$	4582	9400	No
$v_{FO} = v_F - v_R$	4053	9400	No
v_R	529	2000	No
v_3 or v_{av34}	1143 pc/h	(Equation 25-15 or 25-16)	

Is v_3 or v_{av34} > 2700 pc/h? No

Is v_3 or v_{av34} > 1.5 v_{12}/2 No

If yes, v_{12A} = 2296 (Equation 25-18)

Flow Entering Diverge Influence Area

	Actual	Max Desirable	Violation?
v_{12}	2296	4400	No

Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$ = 22.6 pc/mi/ln

Level of service for ramp-freeway junction areas of influence C

Speed Estimation

Intermediate speed variable, D_S = 0.476

Space mean speed in ramp influence area, S_R = 54.1 mph

Space mean speed in outer lanes, S_0 = 70.7 mph

Space mean speed for all vehicles, S = 61.3 mph

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Phone: Fax:
E-mail:

Diverge Analysis

Analyst:	
Agency/Co.:	
Date performed:	2/24/2009
Analysis time period:	PM Peak
Freeway/Dir of Travel:	H-2 Fwy SB Off-Ramp
Junction:	H-2 Fwy/Ka Uka Blvd
Jurisdiction:	
Analysis Year:	Year 2016 Without Project
Description:	

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	3091	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	35.0	mph
Volume on ramp	693	vph
Length of first accel/decel lane	150	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent ramp	1482	vph
Position of adjacent ramp	Downstream	
Type of adjacent ramp	On	
Distance to adjacent ramp	1900	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	3091		693		1482	vph
Peak-hour factor, PHF	0.90		0.90		0.90	
Peak 15-min volume, v15	859		193		412	v
Trucks and buses	2		2		2	%
Recreational vehicles	0		0		0	%
Terrain type:	Rolling		Level		Level	
Grade	0.00	%	0.00	%	0.00	%
Length	0.00	mi	0.00	mi	0.00	mi
Trucks and buses PCE, ET	2.5		1.5		1.5	
Recreational vehicle PCE, ER	2.0		1.2		1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	3537	778	1663	pcph

Estimation of V12 Diverge Areas

L_{EQ} = (Equation 25-8 or 25-9)

P_{FD} = 0.436 Using Equation 8

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 1981 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{Fi} = v_F$	3537	9400	No
$v_{FO} = v_F - v_R$	2759	9400	No
v_R	778	2000	No
v_3 or v_{av34}	778 pc/h	(Equation 25-15 or 25-16)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		No	
If yes, v_{12A} = 1981		(Equation 25-18)	

Flow Entering Diverge Influence Area

	Actual	Max Desirable	Violation?
v_{12}	1981	4400	No

Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\, v_{12} - 0.009\, L_D$ = 19.9 pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

Speed Estimation

Intermediate speed variable, D_S = 0.498

Space mean speed in ramp influence area, S_R = 53.5 mph

Space mean speed in outer lanes, S_0 = 71.3 mph

Space mean speed for all vehicles, S = 60.1 mph

HCS+: Ramps and Ramp Junctions Release 5.3

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: AM Peak
Freeway/Dir of Travel: H-2 Fwy SB On Ramp Loop
Junction: H-2 Fwy/Ka Uka Blvd
Jurisdiction:
Analysis Year: Year 2016 Without Project
Description: (Analysis with SB Off-Ramp)

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	3533	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	35.0	mph
Volume on ramp	1449	vph
Length of first accel/decel lane	650	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	471	vph
Position of adjacent Ramp	Upstream	
Type of adjacent Ramp	Off	
Distance to adjacent Ramp	1900	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	3533	1449	471	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	981	403	131	v
Trucks and buses	2	2	2	%
Recreational vehicles	0	0	0	%
Terrain type:	Rolling	Level	Level	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	2.5	1.5	1.5	
Recreational vehicle PCE, ER	2.0	1.2	1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	4043	1626	529	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 25-2 or 25-3)

P_{FM} = 0.015 Using Equation 4

$v_{12} = v_F (P_{FM})$ = 59 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	5669	9400	No
v_3 or v_{av34}	1992 pc/h	(Equation 25-4 or 25-5)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		Yes	
If yes, v_{12A} = 1617		(Equation 25-8)	

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	1617	4600	No

Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\, v_R + 0.0078\, v_{12} - 0.00627\, L_A$ = 25.9 pc/mi/ln

Level of service for ramp-freeway junction areas of influence C

Speed Estimation

Intermediate speed variable, M_S = 0.375

Space mean speed in ramp influence area, S_R = 56.4 mph

Space mean speed in outer lanes, S_0 = 62.4 mph

Space mean speed for all vehicles, S = 58.8 mph

HCS+: Ramps and Ramp Junctions Release 5.3

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: PM Peak
Freeway/Dir of Travel: H-2 Fwy SB On Ramp Loop
Junction: H-2 Fwy/Ka Uka Blvd
Jurisdiction:
Analysis Year: Year 2016 Without Project
Description: (Analysis with SB Off Ramp)

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	2398	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	35.0	mph
Volume on ramp	1482	vph
Length of first accel/decel lane	650	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	693	vph
Position of adjacent Ramp	Upstream	
Type of adjacent Ramp	Off	
Distance to adjacent Ramp	1900	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	2398		1482		693	vph
Peak-hour factor, PHF	0.90		0.90		0.90	
Peak 15-min volume, v15	666		412		193	v
Trucks and buses	2		2		2	%
Recreational vehicles	0		0		0	%
Terrain type:	Rolling		Level		Level	
Grade		%		%		%
Length		mi		mi		mi
Trucks and buses PCE, ET	2.5		1.5		1.5	
Recreational vehicle PCE, ER	2.0		1.2		1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	2744	1663	778	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 25-2 or 25-3)

P_{FM} = 0.010 Using Equation 4

$v_{12} = v_F (P_{FM})$ = 27 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	4407	9400	No

v_3 or v_{av34} 1358 pc/h (Equation 25-4 or 25-5)

Is v_3 or v_{av34} > 2700 pc/h? No

Is v_3 or v_{av34} > 1.5 v_{12}/2 Yes

If yes, v_{12A} = 1097 (Equation 25-8)

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	1097	4600	No

Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734 v_R + 0.0078 v_{12} - 0.00627 L_A$ = 22.2 pc/mi/ln

Level of service for ramp-freeway junction areas of influence C

Speed Estimation

Intermediate speed variable,	M_S = 0.337	
Space mean speed in ramp influence area,	S_R = 57.2	mph
Space mean speed in outer lanes,	S_0 = 63.8	mph
Space mean speed for all vehicles,	S = 59.5	mph

HCS+: Ramps and Ramp Junctions Release 5.3

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: AM Peak
Freeway/Dir of Travel: H-2 Fwy SB On Ramp Loop
Junction: H-2 Fwy/Ka Uka Blvd
Jurisdiction:
Analysis Year: Year 2016 Without Project
Description: (Analysis with SB On-Ramp)

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	3533	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	35.0	mph
Volume on ramp	1449	vph
Length of first accel/decel lane	650	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	1007	vph
Position of adjacent Ramp	Downstream	
Type of adjacent Ramp	On	
Distance to adjacent Ramp	1600	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	3533		1449		1007	vph
Peak-hour factor, PHF	0.90		0.90		0.90	
Peak 15-min volume, v15	981		403		280	v
Trucks and buses	2		2		2	%
Recreational vehicles	0		0		0	%
Terrain type:	Rolling		Level		Level	
Grade		%		%		%
Length		mi		mi		mi
Trucks and buses PCE, ET	2.5		1.5		1.5	
Recreational vehicle PCE, ER	2.0		1.2		1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	4043	1626	1130	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 25-2 or 25-3)

P_{FM} = 0.015 Using Equation 4

$v_{12} = v_F (P_{FM})$ = 59 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	5669	9400	No
v_3 or v_{av34}	1992 pc/h	(Equation 25-4 or 25-5)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		Yes	
If yes, v_{12A} = 1617		(Equation 25-8)	

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	1617	4600	No

Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$ = 25.9 pc/mi/ln

Level of service for ramp-freeway junction areas of influence C

Speed Estimation

Intermediate speed variable, M_S = 0.375

Space mean speed in ramp influence area, S_R = 56.4 mph

Space mean speed in outer lanes, S_0 = 62.4 mph

Space mean speed for all vehicles, S = 58.8 mph

HCS+: Ramps and Ramp Junctions Release 5.3

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: PM Peak
Freeway/Dir of Travel: H-2 Fwy SB On Ramp Loop
Junction: H-2 Fwy/Ka Uka Blvd
Jurisdiction:
Analysis Year: Year 2016 Without Project
Description: (Analysis with SB On Ramp)

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	2398	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	35.0	mph
Volume on ramp	1482	vph
Length of first accel/decel lane	650	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	798	vph
Position of adjacent Ramp	Downstream	
Type of adjacent Ramp	On	
Distance to adjacent Ramp	1600	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	2398	1482	798	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	666	412	222	v
Trucks and buses	2	2	2	%
Recreational vehicles	0	0	0	%
Terrain type:	Rolling	Level	Level	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	2.5	1.5	1.5	
Recreational vehicle PCE, ER	2.0	1.2	1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	2744	1663	896	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 25-2 or 25-3)

P_{FM} = 0.010 Using Equation 4

$v_{12} = v_F (P_{FM})$ = 27 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	4407	9400	No
v_3 or v_{av34}	1358 pc/h	(Equation 25-4 or 25-5)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		Yes	
If yes, v_{12A} = 1097		(Equation 25-8)	

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	1097	4600	No

Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\, v_R + 0.0078\, v_{12} - 0.00627\, L_A$ = 22.2 pc/mi/ln

Level of service for ramp-freeway junction areas of influence C

Speed Estimation

Intermediate speed variable,	M_S = 0.337	
Space mean speed in ramp influence area,	S_R = 57.2	mph
Space mean speed in outer lanes,	S_0 = 63.8	mph
Space mean speed for all vehicles,	S = 59.5	mph

HCS+: Ramps and Ramp Junctions Release 5.3

Phone: Fax:
E-mail:

______________________Merge Analysis______________________

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: AM Peak
Freeway/Dir of Travel: H-2 Fwy SB On Ramp
Junction: H-2 Fwy/Ka Uka Blvd
Jurisdiction:
Analysis Year: Year 2016 Without Project
Description:

______________________Freeway Data______________________

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	4982	vph

______________________On Ramp Data______________________

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	35.0	mph
Volume on ramp	1007	vph
Length of first accel/decel lane	820	ft
Length of second accel/decel lane		ft

______________________Adjacent Ramp Data (if one exists)______________________

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	1449	vph
Position of adjacent Ramp	Upstream	
Type of adjacent Ramp	On	
Distance to adjacent Ramp	1600	ft

______________________Conversion to pc/h Under Base Conditions______________________

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	4982	1007	1449	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	1384	280	403	v
Trucks and buses	2	2	2	%
Recreational vehicles	0	0	0	%
Terrain type:	Rolling	Level	Level	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	2.5	1.5	1.5	
Recreational vehicle PCE, ER	2.0	1.2	1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	5702	1130	1626	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 25-2 or 25-3)

P_{FM} = 0.077 Using Equation 4

$v_{12} = v_F (P_{FM})$ = 436 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	6832	9400	No
v_{3} or v_{av34}	2633 pc/h	(Equation 25-4 or 25-5)	
Is v_{3} or v_{av34} > 2700 pc/h?		No	
Is v_{3} or v_{av34} > 1.5 v_{12} /2		Yes	
If yes, v_{12A} = 2280		(Equation 25-8)	

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	2280	4600	No

Level of Service Determination (if not F)

Density, $D = 5.475 + 0.00734\, v_R + 0.0078\, v_{12} - 0.00627\, L_A$ = 26.4 pc/mi/ln

Level of service for ramp-freeway junction areas of influence C

Speed Estimation

Intermediate speed variable,	M_S = 0.382	
Space mean speed in ramp influence area,	S_R = 56.2	mph
Space mean speed in outer lanes,	S_0 = 60.6	mph
Space mean speed for all vehicles,	S = 58.4	mph

HCS+: Ramps and Ramp Junctions Release 5.3

Phone: Fax:
E-mail:

Merge Analysis

Analyst:	
Agency/Co.:	
Date performed:	2/24/2009
Analysis time period:	PM Peak
Freeway/Dir of Travel:	H-2 Fwy SB On Ramp
Junction:	H-2 Fwy/Ka Uka Blvd
Jurisdiction:	
Analysis Year:	Year 2016 Without Project
Description:	

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	3880	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	35.0	mph
Volume on ramp	798	vph
Length of first accel/decel lane	820	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	1482	vph
Position of adjacent Ramp	Upstream	
Type of adjacent Ramp	On	
Distance to adjacent Ramp	1600	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	3880		798		1482	vph
Peak-hour factor, PHF	0.90		0.90		0.90	
Peak 15-min volume, v15	1078		222		412	v
Trucks and buses	2		2		2	%
Recreational vehicles	0		0		0	%
Terrain type:	Rolling		Level		Level	
Grade		%		%		%
Length		mi		mi		mi
Trucks and buses PCE, ET	2.5		1.5		1.5	
Recreational vehicle PCE, ER	2.0		1.2		1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	4440	896	1663	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 25-2 or 25-3)

P_{FM} = 0.106 Using Equation 4

$v_{12} = v_F (P_{FM})$ = 470 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	5336	9400	No
v_3 or v_{av34}	1985 pc/h	(Equation 25-4 or 25-5)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12} /2		Yes	
If yes, v_{12A} = 1776		(Equation 25-8)	

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	1776	4600	No

Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$ = 20.8 pc/mi/ln

Level of service for ramp-freeway junction areas of influence C

Speed Estimation

Intermediate speed variable, M_S = 0.320

Space mean speed in ramp influence area, S_R = 57.6 mph

Space mean speed in outer lanes, S_0 = 62.0 mph

Space mean speed for all vehicles, S = 59.7 mph

HCS+: Basic Freeway Segments Release 5.3

Phone: Fax:
E-mail:

Operational Analysis

Analyst:
Agency or Company:
Date Performed: 2/26/2009
Analysis Time Period: AM Peak
Freeway/Direction: H-2 Fwy NB
From/To:
Jurisdiction:
Analysis Year: Year 2016 Without Project
Description: South of Ka Uka Blvd

Flow Inputs and Adjustments

Volume, V	3574	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	993	v
Trucks and buses	2	%
Recreational vehicles	0	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.0	
Heavy vehicle adjustment, fHV	0.971	
Driver population factor, fp	1.00	
Flow rate, vp	1023	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	4	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	1.5	mi/h
Free-flow speed, FFS	68.5	mi/h
	Urban Freeway	

LOS and Performance Measures

Flow rate, vp	1023	pc/h/ln
Free-flow speed, FFS	68.5	mi/h
Average passenger-car speed, S	68.5	mi/h
Number of lanes, N	4	
Density, D	14.9	pc/mi/ln
Level of service, LOS	B	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Basic Freeway Segments Release 5.3

Phone: Fax:
E-mail:

Operational Analysis

Analyst:
Agency or Company:
Date Performed: 2/26/2009
Analysis Time Period: PM Peak
Freeway/Direction: H-2 Fwy NB
From/To:
Jurisdiction:
Analysis Year: Year 2016 Without Project
Description: South of Ka Uka Blvd

Flow Inputs and Adjustments

Volume, V	6712	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1864	v
Trucks and buses	2	%
Recreational vehicles	0	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.0	
Heavy vehicle adjustment, fHV	0.971	
Driver population factor, fp	1.00	
Flow rate, vp	1920	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	4	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	1.5	mi/h
Free-flow speed, FFS	68.5	mi/h
	Urban Freeway	

LOS and Performance Measures

Flow rate, vp	1920	pc/h/ln
Free-flow speed, FFS	68.5	mi/h
Average passenger-car speed, S	65.2	mi/h
Number of lanes, N	4	
Density, D	29.5	pc/mi/ln
Level of service, LOS	D	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Basic Freeway Segments Release 5.3

Phone: Fax:
E-mail:

Operational Analysis

Analyst:	
Agency or Company:	
Date Performed:	2/26/2009
Analysis Time Period:	AM Peak
Freeway/Direction:	H-2 Fwy NB
From/To:	
Jurisdiction:	
Analysis Year:	Year 2016 Without Project
Description:	North of Ka Uka Blvd

Flow Inputs and Adjustments

Volume, V	2790	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	775	v
Trucks and buses	2	%
Recreational vehicles	0	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.0	
Heavy vehicle adjustment, fHV	0.971	
Driver population factor, fp,	1.00	
Flow rate, vp	798	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	4	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	1.5	mi/h
Free-flow speed, FFS	68.5	mi/h
	Urban Freeway	

LOS and Performance Measures

Flow rate, vp	798	pc/h/ln
Free-flow speed, FFS	68.5	mi/h
Average passenger-car speed, S	68.5	mi/h
Number of lanes, N	4	
Density, D	11.6	pc/mi/ln
Level of service, LOS	B	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Basic Freeway Segments Release 5.3

Phone: Fax:
E-mail:

Operational Analysis

Analyst:
Agency or Company:
Date Performed: 2/26/2009
Analysis Time Period: PM Peak
Freeway/Direction: H-2 Fwy NB
From/To:
Jurisdiction:
Analysis Year: Year 2016 Without Project
Description: North of Ka Uka Blvd

Flow Inputs and Adjustments

Volume, V	4332	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1203	v
Trucks and buses	2	%
Recreational vehicles	0	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.0	
Heavy vehicle adjustment, fHV	0.971	
Driver population factor, fp	1.00	
Flow rate, vp	1239	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	4	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	1.5	mi/h
Free-flow speed, FFS	68.5	mi/h
	Urban Freeway	

LOS and Performance Measures

Flow rate, vp	1239	pc/h/ln
Free-flow speed, FFS	68.5	mi/h
Average passenger-car speed, S	68.5	mi/h
Number of lanes, N	4	
Density, D	18.1	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Basic Freeway Segments Release 5.3

Phone: Fax:
E-mail:

Operational Analysis

Analyst:	
Agency or Company:	
Date Performed:	2/26/2009
Analysis Time Period:	AM Peak
Freeway/Direction:	H-2 Fwy SB
From/To:	
Jurisdiction:	
Analysis Year:	Year 2016 Without Project
Description:	North of Ka Uka Blvd

Flow Inputs and Adjustments

Volume, V	4004	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1112	v
Trucks and buses	2	%
Recreational vehicles	0	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.0	
Heavy vehicle adjustment, fHV	0.971	
Driver population factor, fp,	1.00	
Flow rate, vp	1146	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	4	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	1.5	mi/h
Free-flow speed, FFS	68.5	mi/h
	Urban Freeway	

LOS and Performance Measures

Flow rate, vp	1146	pc/h/ln
Free-flow speed, FFS	68.5	mi/h
Average passenger-car speed, S	68.5	mi/h
Number of lanes, N	4	
Density, D	16.7	pc/mi/ln
Level of service, LOS	B	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Basic Freeway Segments Release 5.3

Phone: Fax:
E-mail:

Operational Analysis

Analyst:
Agency or Company:
Date Performed: 2/26/2009
Analysis Time Period: PM Peak
Freeway/Direction: H-2 Fwy SB
From/To:
Jurisdiction:
Analysis Year: Year 2016 Without Project
Description: North of Ka Uka Blvd

Flow Inputs and Adjustments

Volume, V	3091	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	859	v
Trucks and buses	2	%
Recreational vehicles	0	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.0	
Heavy vehicle adjustment, fHV	0.971	
Driver population factor, fp,	1.00	
Flow rate, vp	884	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	4	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	1.5	mi/h
Free-flow speed, FFS	68.5	mi/h
	Urban Freeway	

LOS and Performance Measures

Flow rate, vp	884	pc/h/ln
Free-flow speed, FFS	68.5	mi/h
Average passenger-car speed, S	68.5	mi/h
Number of lanes, N	4	
Density, D	12.9	pc/mi/ln
Level of service, LOS	B	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Basic Freeway Segments Release 5.3

Phone: Fax:
E-mail:

Operational Analysis

Analyst:	
Agency or Company:	
Date Performed:	2/26/2009
Analysis Time Period:	AM Peak
Freeway/Direction:	H-2 Fwy SB
From/To:	
Jurisdiction:	
Analysis Year:	Year 2016 Without Project
Description:	South of Ka Uka Blvd

Flow Inputs and Adjustments

Volume, V	5989	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1664	v
Trucks and buses	2	%
Recreational vehicles	0	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.0	
Heavy vehicle adjustment, fHV	0.971	
Driver population factor, fp,	1.00	
Flow rate, vp	1714	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	4	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	1.5	mi/h
Free-flow speed, FFS	68.5	mi/h
	Urban Freeway	

LOS and Performance Measures

Flow rate, vp	1714	pc/h/ln
Free-flow speed, FFS	68.5	mi/h
Average passenger-car speed, S	67.5	mi/h
Number of lanes, N	4	
Density, D	25.4	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Basic Freeway Segments Release 5.3

Phone: Fax:
E-mail:

Operational Analysis

Analyst:	
Agency or Company:	
Date Performed:	2/26/2009
Analysis Time Period:	PM Peak
Freeway/Direction:	H-2 Fwy SB
From/To:	
Jurisdiction:	
Analysis Year:	Year 2016 Without Project
Description:	South of Ka Uka Blvd

Flow Inputs and Adjustments

Volume, V	4678	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1299	v
Trucks and buses	2	%
Recreational vehicles	0	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.0	
Heavy vehicle adjustment, fHV	0.971	
Driver population factor, fp	1.00	
Flow rate, vp	1338	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	4	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	1.5	mi/h
Free-flow speed, FFS	68.5	mi/h
	Urban Freeway	

LOS and Performance Measures

Flow rate, vp	1338	pc/h/ln
Free-flow speed, FFS	68.5	mi/h
Average passenger-car speed, S	68.5	mi/h
Number of lanes, N	4	
Density, D	19.5	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

APPENDIX F

ALTERNATIVE TRANSPORTATION COMPONENTS

Castle & Cooke Koa Ridge Makai and Waiawa Project

Alternative Transportation Components

Prepared For

Castle & Cooke Homes Hawaii, Inc.

Prepared By

Weslin Consulting Services, Inc.

TABLE OF CONTENTS

I. Introduction

This Waiawa and Koa Ridge Makai Alternative Transportation Components Report is being prepared in support of the master plan process for the Koa Ridge community and in support of identifying possible transportation projects and programs designed to reduce the impacts that might otherwise be caused by additional vehicle trips affiliated with the project.

The master plan for the Koa Ridge community consists of separate development areas known as Koa Ridge Makai and Waiawa. The combined project is a master planned, mixed-use residential community in Central Oahu with commercial, light industrial and health care components.

Plans to move forward with the current development were initiated in the late 1990s to meet anticipated future demand for a wide range of housing opportunities in a new master planned community in Central Oahu. A petition was submitted to the State Land Use Commission together with a preparation notice for a combined EIS for the Koa Ridge Makai and Waiawa developments. The forthcoming EIS is being prepared in support of a State Land Use District Boundary Amendment petition and a subsequent zone change application for the Koa Ridge Makai and Waiawa areas.

This report is prepared with the insight gained from previous technical analyses of potential transportation impacts, consideration of possible mitigation measures and extensive community outreach. It is intended that the types of alternative transportation projects and programs normally offered as mitigations to vehicle trip demands at the end of the master planning and environmental impact assessment process be given rigorous consideration at the beginning of the planning process such that their effectiveness is optimized to the maximum extent possible.

II. Project Description

The proposed site of the master-planned community is located in Waipio and Waiawa, Oahu. It consists of approximately 766 acres of land in two separate areas: Waiawa and Koa Ridge Makai. The Waiawa area is located east of the H-2 Freeway, east of the Waipio Interchange, and adjacent to and northwest of the proposed Waiawa Ridge development. The Koa Ridge Makai area is located north of the Waipio Business Park and west of the H-2 Freeway.

The proposed master planned community will include a mix of approximately 5,000 single-family homes and multi-family units, school sites, neighborhood and community commercial sites, light industrial uses, church/day care centers, recreational centers, community parks, park and ride facilities, and a health care component. The development will feature generous landscaping and open space. The new community will be one that is safe and walkable, where residents can live, work and recreate in a vibrant and healthy master-planned, sustainable community encompassing principles consistent with "smart growth".

Koa Ridge Makai

Koa Ridge Makai provides a master-planned mixed use community that features a health care component providing comprehensive health care and wellness services and facilities. The development encompasses approximately 575 acres and will include approximately 3,500 homes balanced by the employment-generating health care, commercial, light industrial, and educational facilities. A mix of multi-family and single-family homes is planned. Multi-family housing is planned near the village center, employment centers, schools and services and in close proximity to the entry points at the makai and mauka ends of the site.

A key element of the community is the mixed-use "Village Center" area that is planned as the social and community focus. The commercial and health care components will be integrated with the village center, which in turn will be linked by pedestrian pathways to the residential areas. This will provide for easy, pleasant walking to retail establishments and public spaces. A mix of uses and higher densities around the village center encourage walking and bicycling rather than the use of the private automobile. Senior housing is an integral part of the village center to facilitate convenient access to retail services and health care. Neighborhoods designed around planned schools, community centers and churches also increase the opportunity to walk rather than drive for short trips.

Koa Ridge Makai features substantial open space and recreation. Open space and pedestrian access will be provided along the edge of Kipapa Gulch and within utility easements and link to neighborhood parks. A well-landscaped spine road with pedestrian and bike trails alongside will link the makai end of Koa Ridge Makai to the mauka end of the property. Portions of the spine road will travel through adjacent open space and parks.

The health care component will encompass approximately 28 acres for medical and health care facilities, which may include a hospital, skilled nursing, physicians' office building, diagnostic and testing center, and other medical and wellness facilities.

Waiawa

Waiawa encompasses approximately 191 acres adjacent to the proposed Waiawa Ridge development. Primary access to the community is provided along a spine road that has dramatic views at the entry towards the Waianae Mountains. The central portion of the site will feature a community center with neighborhood retail, a neighborhood park, and an elementary school site to provide a concentration of pedestrian-oriented activities. Some 1,200 multi-family homes are located within convenient walking distance of these activities. Lower density homes consisting of approximately 300 single-family residences are located along the spine road extending to the mauka end of the site. The development of Waiawa is dependent on the progress of infrastructure development at the adjacent Waiawa Ridge community that will serve both projects.

III. Existing Transportation Infrastructure and Services

This section of the report presents the existing transportation infrastructure and services relevant to the project.

Freeways, Arterials and Roadways

Freeways, arterials, and roadways are the basic street transportation network elements responsible for the movement of people and goods on O'ahu. All types of vehicles, public and private transit services, bicycles, and pedestrians use this network. O'ahu's roadway system is maintained by HDOT and the City and County of Honolulu Department of Facility Maintenance (DFM).

The State's existing highway system includes all freeways and major highways connecting various parts of the island. It consists of approximately 280 route miles and 940 lane miles.

O'ahu's interstate freeways are dedicated transportation facilities. They are fully grade separated and access controlled. Access to the interstate system is restricted to dedicated ramps, which minimizes disruptions to the flow of traffic. The two freeways serving the project area are H-1 and H-2:

- The H-1 Freeway is the major east-west highway that connects the Central Oahu Area to Honolulu to the east and to the Ewa and Waianae districts to the west. East of the Waiawa Interchange, the H-1 Freeway provides five travel lanes in each direction with one lane in each direction designated as a HOV lane during the peak commute periods. West of the Waiawa Interchange, the H-1

Freeway has four travel lanes in each direction. In the morning peak period, the shoulder lane of the H-1 Freeway provides a sixth eastbound lane from east of the Waiawa Interchange. Also during the morning peak period, an additional eastbound HOV lane is provided from west of the Paiwa Interchange to the Pearl Harbor Interchange by provision of a contra-flow (zipper) lane.

- The H-2 Freeway traverses in a north-south direction through Central Oahu and connects to the H-1 Freeway to the south at the Waiawa Interchange. The northern terminus of the H-2 Freeway is just south of Wahiawa at the junction with Kamehameha Highway and Wilikina Drive. The H-2 Freeway provides four lanes in each direction from the Waiawa Interchange to Mililani, where it transitions to two lanes in each direction. Through the project area, one lane in each direction is designated as a high-occupancy vehicle (HOV) lane during the peak commute traffic periods.

The major arterial serving the Central Oahu region is Kamehameha Highway.

- Kamehameha Highway is a major roadway serving north-south traffic between the north and south shores of Oahu. It is generally parallel to and one-half to one mile west of the H-2 Freeway. Kamehameha Highway is a four-lane divided highway, with separate left- and right-turn lanes at intersections from the H-1 Freeway to north of Ka Uka Boulevard.

Major roadways providing access to the commercial and residential areas in the nearby vicinity of the proposed project include Ka Uka Boulevard, Paiwa Street, and Lumiaina Street.

- Ka Uka Boulevard is an east-west roadway connecting the H-2 Freeway with Kamehameha Highway. It provides access to the Waipio Gentry Business Park and residential areas. It is a four-lane roadway with a median divider and left-turn lanes at cross streets.

- Paiwa Street connects the Waipahu community to Waikele and provides both communities with access to the H-1 Freeway. It is a four-lane divided roadway from the H-1 Freeway Interchange to the northern boundary of the Waikele community where it presently dead-ends.

- Lumiaina Street is an east-west street servicing the Waikele community and the Waikele Center retail complex. Lumiaina Street is a four-lane divided roadway between Paiwa Street and

Kamehameha Highway.

Interconnecting these major freeways, arterials and roadways are several interchanges:

- The Waipio (Ka Uka Boulevard) and Paiwa Interchanges are conventional diamond-type interchanges, except the southbound off-ramp of the Waipio Interchange has been aligned to permit future construction of a loop on-ramp for the movement from westbound Ka Uka Boulevard to southbound H-2 Freeway.

- The Waiawa Interchange provides ramp connections for all movements between the H-1 and H2 Freeways, as well as most movements to and from Kamehameha Highway and Farrington Highway. No ramp connection is provided from makai-bound Kamehameha Highway onto the Ewa-bound H-1 Freeway.

There is a large directional imbalance in traffic volumes on the roadways in the morning peak hour. Honolulu-bound volumes on most roadways generally double or more the volumes in the opposing direction. The highest traffic volumes on major streets are on Kamehameha Highway along the sections across Kipapa Gulch and makai of Waipio Uka Street. Congested conditions and extensive vehicle queues occur in the vicinity of the Waiawa Interchange due to the large volumes of vehicles merging Honolulu-bound in the morning.

The traffic volumes in the afternoon peak hour are higher than those in the morning peak hour at most locations. Peak travel direction is reversed from the morning period.

Public Transportation

Public transportation on O’ahu is the responsibility of the City and County of Honolulu, Department of Transportation Services (DTS). The service is popularly known as TheBus for fixed route operations, TheHandi-Van for demand-responsive curb-to-curb service for Americans with Disabilities Act of 1990 (ADA) paratransit-eligible individuals and TheBoat, a recently inaugurated ferry service connecting West O’ahu with downtown Honolulu.

DTS plans, designs, operates and maintains transportation systems; locates, selects, installs and maintains traffic control facilities, devices and street lighting systems; approves plans and designs for construction, reconstruction and widening of public streets and roads; administers rules and regulations for the use of streets and roadways; and, manages the City's contract for bus and paratransit operations. Within DTS, the Public

Transit Division (PTD) is the division responsible for managing the City's contract for bus and paratransit operations. The current contractor is O'ahu Transit Services (OTS), a private, non-profit corporation that operates and maintains TheBus and TheHandi-Van services.

TheBus consists of 98 fixed routes, two (2) deviation routes (operated by the paratransit division) and five (5) feeder routes for TheBoat for a total of 105 routes. Of these, four (4) are limited stop routes (CityExpress! A, CityExpress! B, CountryExpress! C and CountryExpress! E) and 32 are peak-period, peak-direction-only express routes. The 105 routes serve about 3,800 bus stops. Passenger amenities include approximately 980 passenger shelters and 2,400 benches.

Bus routes fall within seven route classifications. These classifications and their function are described below.

- Rapid Bus – Rapid bus includes CityExpress! and CountryExpress! designated routes. These routes provide limited stop express service in both directions. Service is provided all day on weekdays, Saturdays and Sundays on heavily traveled corridors. The CityExpress! Routes A and B offer 15-minute service; CountyExpress! Routes typically provide 30-minute service.

- Urban Trunk – Urban trunk routes provide frequent, direct service connecting neighborhoods within the Primary Urban Center operating along the major Ewa/Diamond Head corridors. Urban trunk routes typically have 15-minute or less service frequencies (headways).

- Urban Feeder – Urban feeder routes connect the mauka/makai neighborhoods within the Urban Center. These routes serving the hills and valleys of Honolulu connect residents to the urban trunk and limited-stop express routes as well as providing service to major destinations such as downtown Honolulu, the University of Hawaii at Manoa and Waikiki.

- Suburban Trunk – Suburban trunk routes provide all day service from outlying communities to the urban center. These routes also provide connections between the suburban communities connecting with community circulators at transit centers. Routes stop at all local bus stops and operate all day, every day. Suburban trunk routes typically provide 30-minute service. Many of the suburban trunk routes operate along the same major corridors such as Kamehameha Highway, Nimitz Highway and Dillingham Boulevard. Service levels along these corridors are much higher due to the combined number of trips provided by the routes.

- Community Circulators – These routes provide circulation within their established community. They connect at a neighborhood hub or transit center after completing their single cycle trip. Community circulators provide timed connections to other circulators and suburban trunk routes. These routes stop at all local bus stops and frequently operate with loops and branches. Community circulator routes currently fall into three general categories of service provision. Higher demand routes offer 30-minute service; lower demand routes provide 60-minute service and some routes offer intermittent or peak-period-only service such as those operating in Pearl City Aiea today.

- Community Access – These routes operate on a standard schedule serving regular bus stops utilizing the Handi-Van vehicles. Handi-Van type service is provided for registered Handi-Van customers with a 24-hour advance notice within ½ mile of the service route. These routes provide 60-minute service. Time is needed in the schedule to allow for route deviations.

- Peak Express – Peak period expresses routes serve predominantly home-to-work trips by connecting specific neighborhoods to employment centers. These trips are provided in the peak period, peak direction only with minimal scheduled departures. A subset of the Peak Express classification is the feeder services designed for TheBoat. These routes operate as peak expresses connecting passengers to TheBoat service during the peak period. Routes predominantly serving TheBoat are designated with an “F” preceding the route number.

Table III.1 lists those current routes operating in the vicinity of the project area. These routes include the following types of routes: Suburban Trunk, Peak Express and Community Circulator. The characteristics of these routes are included in the Transit Rider Database compiled by the Public Transit Division of the Department of Transportation Services. Routes 52 and 62 are examples of suburban trunk routes operating near Koa Ridge. They serve a mix of trip purposes. Routes 83, 83a, 84, 84a, 96 and 98 are examples of peak express services. Typically, over 80% of the riders on these routes are on work trips. Some of the express routes also serve many school or college trips. Seventeen percent of the riders on Route 84a, service between Mililani and University of Hawaii at Manoa, are on a school or college trip.

Table III.1: TheBus Existing Bus Service Characteristics
For Those Routes Operating In The AM Peak Period (5:00 AM to 8:00 AM)
In The Vicinity Of Koa Ridge

Route	Service	Frequency	Inbound Trips Through Area	Inbound Trips Serving Area	Inbound Trips Bypassing Area	Description
52	ST	30 min	-	-	5	H-2 (3 outbound trips)
62 [1]	ST	15 min	-	10	-	Kamehameha (9 outbound trips)
83	PE	-	-	-	7	H-2
83A	PE	-	-	-	2	H-2 (1 trip); Kamehameha (1 trip)
84/84A	PE	-	-	-	8	H-2
96	PE	-	-	-	2	H-2 & Ka Uka
98	PE	-	-	-	3	H-2
98A	PE	-	-	-	2	H-2
433 [2]	CC	30 min	-	0	-	Ka Uka (first trip at 8:00 am)

Legend: ST = Suburban Trunk local route
PE = Peak Express route with weekday peak period only service
CC = Community Circulator

Notes: [1] Route 62 is planned to be renamed Route 51; characteristics are basically the same.
[2] Route 433 provides service to Waipio starting at 8:00 AM.

Alternative Transportation

Alterative transportation involves a wide range of projects and programs designed to manage both the demand for our overall transportation system and the capacity offered by the system. Two major categories of alternative transportation are Transportation Demand Management (TDM) and Transportation Systems Management (TSM).

Transportation Demand Management

TDM is the application of strategies and policies to influence traveler behavior with the aim of reducing automobile travel demand, or redistributing this demand. Current TDM programs include carpools and vanpools, as well as incentive programs to encourage ridesharing. One goal of the 2030 O'ahu Regional Transportation Plan (ORTP) is to maintain and further develop aggressive TDM programs such as real-time online carpool matching, outreach promotion and marketing of alternative transportation, emergency rideshare home program, employer based commuter programs, and emerging and innovative strategies like car sharing.

Examples of successful TDM are the programs provided by the Leeward O'ahu Transportation Management Association (LOTMA), a non-profit organization consisting of public and private landowners and developers serving 'Ewa and Central O'ahu. LOTMA is a transportation resource center that provides the following services: carpool matching, a commuter express service and an emergency ride home program.

Residents of Leeward, Central, and North Shore O'ahu are eligible to participate in LOTMA's carpool matching program. This program is provided free of charge to participants and matches potential carpoolers by residence and work locations. Registered participants are provided a list of potential carpoolers residing and working in the general same locations. Participants are able to contact and set up carpools that work to their best advantage.

LOTMA contracts with Polynesian Adventure Tours Gray Line Hawai'i to provide commuter service for Central O'ahu to Downtown Honolulu and Waikiki using a tour bus. This service is provided weekdays only offering the round trip schedule and stops listed in Table III-2.

Table III.2: LOTMA Commuter Express Bus Schedule

Outbound Time	Location	Inbound Time
6:05 AM	Waipi'o Gentry Shopping Center	5:50 PM
6:15	Mililani Mauka Park-and-Ride	6:05
7:05	Nimitz - Pier 35	5:20
7:10	Dole Cannery	5:15
7:15	King and Bishop	
7:17	King and Richards	
7:19	Punchbowl and King	
7:21	Federal Building	5:00
7:26*	Ala Moana Hotel	4:40
7:31*	Hale Koa Hotel	
7:35	Sheraton Waikiki	4:30

* Stops made upon request

Current fares for this commuter service include unlimited monthly passes ($95.00), 20-trip monthly passes ($55.00) and one-way fares ($3.50). Free transfers to TheBus are available from LOTMA for Commuter Express passengers.

LOTMA provides an emergency ride home program free of charge to registered commuters living or working in Leeward, Central, or North Shore O'ahu. This program is available to commuters who carpool or ride LOTMA's Commuter Express at least once a week.

HDOT supports a statewide vanpool program and a carpool matching service. HDOT contracts with Vanpool Hawai'i to provide a statewide vanpool program. A monthly fee of $55.00 plus sharing gas and parking expenses is available to participants on O'ahu. Both 7 -passenger and 15-passenger vehicles are available. Vanpool Hawai'i offers a "Cool Pool" program for $70.00 a month, using a sport utility vehicle. The monthly fee covers insurance, maintenance, and road assistance. There are about 240 vanpools on O'ahu. The State provides a matching service for potential carpoolers, similar to LOTMA's program. It uses residence and work locations to provide potential matches for residents islandwide.

Transportation System Management

TSM creates more efficient use of transportation facilities by improving the operation and management of vehicles and roads. Examples of TSM measures specific to the island of O'ahu include contraflow operations, special traffic and high-occupancy vehicle (HOV) lanes, and Intelligent Transportation Systems (ITS).

Contraflow lanes are a TSM strategy where a lane that typically provides vehicle travel in one direction is reversed during peak traffic periods. Contraflow facilities operated by the State are restricted to buses, vanpools, and vehicles with three or more occupants. HDOT provides the following contraflow operations: the H-1 Zipper Lane operating as a contraflow lane in the Koko Head-direction from Managers Drive in Waipahu to the Ke'ehi interchange; and, the Nimitz Highway (Route 92) contraflow lane operating in the Koko Head-direction contraflow beginning in the vicinity of the Ke'ehi Interchange. Both of these are open to High Occupancy Vehicles (HOVs) only and operate in the morning peak period only.

The City and County of Honolulu operates contraflow lanes along a few congested corridors during specific peak periods. These do not have HOV restrictions. The City's contraflow lanes operate during both the morning and afternoon peak periods. City locations with reversible lane operations include: Kapi'olani Boulevard from the H-1 Freeway near South King Street to 'Ewa of Ward Avenue in the a.m. peak period, and from Pensacola Street to McCully Street during the p.m. peak period; Ward Avenue from Lunalilo Street to makai of South King Street during the a.m. peak period; Atkinson Drive from Kona Street to Kapi'olani during the a.m. peak period; and, Wai'alae Avenue from Kapahulu Avenue to 8th Avenue during the p.m. peak period.

ITS applications are another form of TDM. Centralized traffic signal control systems are a widely used ITS application. This group of technologies and communication protocols allows multiple agencies to manage O'ahu’s transportation network through a centralized control center. By tailoring traffic controls to operating conditions, a roadway's efficiency can be improved by networking signalized intersections, traffic surveillance, and centralized traffic signal control.

DTS currently operates a centralized signal control system, referred to as the Traffic Control Center (TCC). The TCC offers signal coordination and preemption through live video surveillance provided by a closed-circuit television system. Live surveillance is available along most major arterial corridors.

The DTS ITS program is being broadened to include signal pre-emption for transit vehicles, known as Transit Signal Priority (TSP). DTS has investigated TSP installations in Seattle, Bremerton, Tacoma, Portland and Los Angeles and concluded that such applications are appropriate for immediate deployment on O'ahu. The intent is to offer transit vehicle operations an ability to modify traffic signal cycles so that general purpose traffic can be bypassed. This becomes very effective in maintaining schedule reliability when used at multiple locations along the same bus route; especially, in conjunction with dedicated traffic lane treatments such as exist on Hotel Street and Kalakaua Avenue.

HDOT operates a Traffic Management Center (TMC) that provides live surveillance much like DTS's TCC. The TMC monitors H-1 and H-3 and TCC monitors everything else. The following ITS infrastructure is currently available on O'ahu: 750 signalized intersections on O'ahu and 400 signalized intersections controlled by the City's TCC and 202 closed-circuit cameras on O'ahu: 141 controlled by the City's TCC and 61 controlled by the State's TMC.

IV. Baseline Future Transportation Infrastructure and Services

The City plans to improve bus system service within area neighborhoods as part of its Bus Service Improvement Program. These intended improvements are used as a future baseline for planning purposes. The Bus Service Improvement Plan for Central Oahu is anticipated to serve Mililani, Waipio and Mililani Mauka as outlined in correspondence from DTS to the City Council dated October 25, 2005 and provided in the appendix to this report.

The City's transit plans are based upon fulfilling the expectations and guidelines established in the Central Oahu Sustainable Communities Plan.

The Central Oahu Sustainable Communities Plan

The Central Oahu Sustainable Communities Plan was adopted by City and County of Honolulu Ordinance 02-62 on December 20, 2002. This section highlights the most pertinent excerpts from the plan that relate to the development of bus transit services in the project area.

Chapter 3 of the Central Oahu Sustainable Communities Plan includes land use policies, principles and guidelines to be used in the review and approval of public and private projects to help implement the vision for Central Oahu's development.

Some of the policies address particular locations and make specific reference to transit. These include the following:

> "A transit linkage should be established between Waikele Center and Waipahu Town."[1]

The above explicit policy statement is very helpful in delineating transit routes, but no such statement exists that would pertain to Koa Ridge Other general policies are less explicit such as the following:

> "Street patterns and rights-of-way should be designed to accommodate mass transit (bus) service and make it convenient to access for as many households as possible."[2]

[1] Central Oahu Sustainable Communities Plan as adopted by City and County of Honolulu Ordinance 02-62 on December 20, 2002; Chapter 3, Land Use Policies, Principles, and Guidelines, Section 3.4.3.2 Waipahu Sugar Mill Environs Methods of Preservation; page 3-28.

[2] Ibid, Section 3.8.1.5 Transit-Oriented Streets; page 3-56.

The above policy is too vague to be of adequate value when developing specific routes and schedules. Fortunately, the Central Oahu Sustainable Communities Plan provides some specificity in Section 3.8.2. Guidelines. Under Subsection 3.8.2.4. Circulation System, sufficiently specific guidelines are listed including the following statements:

> “Potential transit routes should be identified by the developer such that at least 85% of all proposed residential housing units are within 1/4 mile of a proposed transit stop, unless localized topographic conditions make such a requirement impractical.
>
> “All development should be within 1/2 mile of a transit stop, unless localized topographic conditions make such a requirement impractical.
>
> “All commercial development with more than 1,000 square feet, and all employment sites with more than ten employees, should be within 1/8th mile of a transit stop.
>
> “The developer should construct all necessary transit stops in accordance with DTS design standards.
>
> “Proposed transit routes should have two different access points into the proposed development. The route alignment should seek to achieve optimal operational efficiency between the two access points.”[3]

These guidelines were used for designing new bus routes to serve Central Oahu. The guideline “The route alignment should seek to achieve optimal operational efficiency between the two access points.” was further refined to define the word “optimal” to be quantifiably specific. The guideline used was to delineate transit routes that have two different access points into the proposed development with a bus route alignment that measures no more than 1.2 times the airline distance between the two access points. This approach avoids circuitous bus routing which becomes expensive, operationally inefficient and unattractive to intending riders.

The standard rule of the transit industry is that areas within a "five-minute walk" of a transit bus stop, or approximately one quarter mile, are considered "served by transit." Beyond the five-minute walk radius, the experience in the United States has been that the percent of persons desiring transit drops due to their unwillingness or inability to walk greater distances. It is intended that the bus route design for Koa Ridge exceed the guidelines in the Central Oahu Sustainable Plan by having more of the development within one quarter mile of proposed bus stops.

[3] Ibid, Section 3.8.1.5 Transit-Oriented Streets; page 3-56.

The intent for Koa Ridge is to avoid circuitous streets, cul-de-sacs, walls around neighborhoods and other barriers that can serve as obstacles to providing efficient transit service. The design of the roadways and location of land uses will be planned to emphasize a safe, pedestrian-oriented environment and direct access to bus stops.

The Central Oahu Bus Service Plan

DTS has prepared and routinely updates a Bus Service Improvement Plan. Oahu's future bus services are addressed geographically including Central Oahu. Service reliability and productivity are Issues addressed by the Central Oahu Bus Service Plan.

Service reliability issues are a growing challenge. Many un-served and under-served areas make using current routes difficult. Current peak express routes emphasize peak-period, peak-direction service making travel at other times and in other directions impossible. Long routes serving local needs are delayed in traffic at other parts of the island.

Service productivity issues need to be resolved. The development pattern in Central Oahu creates challenges to offer properly structured services. Transit routes have been planned to provide better efficiency using a combination of restructured and new routes. The Central Oahu Bus Service Plan is constantly being revised and refined to reflect current infrastructure, conditions and opportunities.

The Central Oahu Bus Service Plan has been awaiting the completion of transit centers. The completion of those facilities allows for the introduction of new, three-tiered routes that have been the subject of advanced planning discussions for over five years. Routes representing each tier have been planned such that they can serve Koa Ridge effectively and timely under the right circumstances.

Routes operating with the greatest spacing between stops to achieve the highest reasonable and safe operating speed are known as Tier I routes. Their primary function is to connect transit hubs. They are designed to connect transit centers as directly as possible with frequent service and no route deviations from the most expedient alignment possible. Intermediate stops are served only when expedient to do so: the stop has the potential of high boarding utilization and the riders using the route are not significantly delayed or inconvenienced. These routes provide all-day, two-directional, high-capacity service seven days a week. Examples include CityExpress!, CountryExpress! and limited-stop local routes.

The Tier I route that could serve Koa Ridge is a CountryExpress! Route D. This route has not been implemented due to funding constraints, but it has consistently been viewed by transit planners as a reasonable and necessary service improvement for Central Oahu. The possible alignment of this proposed route has varied slightly during the past five years, but it has always connected transit centers in Wahiawa and Mililani with downtown Honolulu using H-2 and H-1 for the middle part of the trip.

CountryExpress! Route D would operate along the H-2 HOV lanes. This tier I route could serve Koa Ridge via a flyer stop accessed via the H-2 HOV lanes using direct access ramps serving the isolated H-2 island mauka of Ka Uka Boulevard. Transit riders could access the flyer stop via an H-2 pedestrian overpass connected directly into Koa Ridge. Examples of such flyer stops can be found in Seattle and Los Angeles.

Tier II routes operate with an average to greater than the average distance between stops to achieve a higher reasonable and safe operating speed. Their primary function is to connect transit hubs while also providing direct service along major development corridors. They are designed to connect hubs with frequent service and only deviate from the most expedient alignment possible when the majority of passengers on board are served by the destinations requiring the deviation. These routes provide all-day, two-directional, regular-capacity service seven days a week.

The Tier II service that could best serve Koa Ridge is the proposed Route 50. Route 50's primary function is to connect the Mililani, Waipahu and Kapolei transit centers. Proposed alignments have most often included Ka Uka Boulevard and H-2, but not direct service into Koa Ridge.

Routes operating with the average to less than average distance between stops to achieve the highest degree of access to neighborhoods and community destinations are Tier III services. Their primary function is to serve one transit hub within one major geographic area. They deviate from the most expedient alignment possible when neighborhood access is required. These routes provide service designed to meet the needs of the community provided that certain levels of productivity are maintained. Examples include shuttles, community circulators, community access routes and feeders. These routes often do not provide frequent service, but operate such that they make timed connections at their assigned transit hub to minimize wait times either between tier III routes or with other higher frequency tier I and II routes.

Existing Tier III Route 433 currently is anchored at the Waipahu transit center. It serves Waipio and has been extended to operate along Ka Uka Boulevard. Route 433 has been viewed as a route that would possibly be extended into Koa Ridge Mauka to serve future development as it evolves. Other Tier III routes have been envisioned to serve Waiawa and connect to a future Pearl Highlands station.

Routes operating to serve the particular needs of a single target market group are considered as special services. Routes are often designed without particular regard to stop spacing or directness of service to meet the needs of a single trip purpose without significant consideration to other possible travel markets. The primary function is to satisfy the needs of a premium travel demand. These routes tend to be the most expensive to operate on a per person trip basis. Examples include commuter express routes and special event services such as the football express. Ferry bus feeder routes designed solely to accommodate commuters connecting to the ferry are classified as special services.

Routes 83, 83a, 84, 84a, 96, 98 and 98a are peak express operations falling into the special services tier. All of these routes except for the 96 operate along H-2 HOV lanes. There has been no consideration to use any of the H-2 peak express routes, or to create any new peak express operations, to serve Koa Ridge with the exception of the allowing these routes to stop at a H-2 freeway flyer transit station should one ever be created.

V. Potential TheBus Transit Service Options

A traffic impact study is being conducted for the Draft EIS which will update the October 2007 traffic study for Waiawa prepared by Wilson Okamoto Corporation, as supplemented in March 2008 in response to a Mililani Neighborhood Board resolution. The traffic impact study analyzes potential traffic impacts on the roadway system within the project vicinity including regional impacts resulting from the proposed development and identifies appropriate mitigation measures that may be required. Additional comments provided by the Mililani Neighborhood Board regarding the March 2008 Supplement are also addressed.

The forthcoming traffic impact study responds to neighborhood board comments by using a wide array of mobility alternatives to reduce vehicle trips generated by the project. Alternative transportation programs include transit, pedestrian, bicycle and Transportation Demand Management (TDM) options. The transit, pedestrian and bicycle transportation investment options involve the infrastructure necessary to provide an attractive environment wherein vehicle trips can be reduced because people choose not drive their vehicle. The TDM options offer the incentives necessary to provide an additional motivation to residents and employees to not drive their vehicle.

Transit service is likely the most promising transportation option with the ability to significantly reduce vehicle trips. Table V.1 identifies the characteristics of six potential transit service options developed to serve the Koa Ridge area. Characteristics are identified for those routes operating in the morning peak period (5:00 AM to 8:00 AM). Three types of morning peak period inbound trips are listed:

1) Through Area -- inbound bus trips that go through Koa Ridge and serve future bus stops located in close proximity to future development.

Table V.1: Potential TheBus Transit Service Option Characteristics
For Those Routes Operating In The AM Peak Period (5:00 AM to 8:00 AM)
In The Vicinity Of Koa Ridge In 2025

OPTIONS		AM PEAK PERIOD INBOUND BUS TRIPS				
No.	Name	Through Area	Serving Area	Bypassing Area	Total	DESCRIPTION
1	Existing Transit Services	0	10	29	39	Maintains 2008 bus services.
2	Transit Services With Bus Improvements	16	19	33	68	Routine bus improvements only, no rail, no new interchange.
3	Transit Services With Bus & Rail Improvements	18	22	71	111	Bus improvements consistent with a rail system investment, no new interchange.
4	Transit Services With TDM, Bus & Rail Improvements	36	10	65	111	Assumes TDM and bus improvements consistent with rail system and new interchange used by buses.
5	Transit Services With H-2 Station, TDM, Bus & Rail Improvements	18	93	0	111	Assumes H-2 freeway flyer station served by either ped/bike bridge or direct access ramps to H-2 HOV ramps, TDM & bus improvements consistent with rail, no new general purpose traffic interchange.
6	Transit Services With H-2 Station, TDM, Bus & No Rail	16	52	0	68	Assumes H-2 freeway flyer station, TDM & routine bus improvements with no rail, no new general purpose traffic interchange.

2) Serving Area – inbound bus trips that do not go through Koa Ridge, but serve the area by traveling along either Ka Uka Boulevard or Kamehameha Avenue and serve existing bus stops.

3) Bypassing Area – inbound bus trips that neither go through Koa Ridge nor serve the area because no existing bus stop exists even though the routes operate along H-2 and other urban areas have introduced freeway flyer stops in such situations.

Each of the six potential transit service options developed to serve the Koa Ridge area summarized in Table V.1 is derived from more detailed descriptions of the transit service characteristics of each route as part of the options in Tables V.2 through V.7. The detailed characteristics of existing services described in the previous section are shown in Table V.2 below. These are presented as Option #1. This option assumes no rail service is implemented and no bus transit services are changed by the year 2025.

Table V.2: OPTION #1
Potential TheBus Transit Service Option Characteristics
For Those Routes Operating In The AM Peak Period (5:00 AM to 8:00 AM)
In The Vicinity Of Koa Ridge
Assuming No Rail Service In 2025

Route	Service	Frequency	Inbound Trips Through Area	Inbound Trips Serving Area	Inbound Trips Bypassing Area	Description
52	ST	30 min	-	-	5	H-2 (3 outbound trips)
62 [1]	ST	15 min	-	10	-	Kamehameha (9 outbound trips)
83	PE	-	-	-	7	H-2
83A	PE	-	-	-	2	H-2 (1 trip); Kamehameha (1 trip)
84/84A	PE	-	-	-	8	H-2
96	PE	-	-	-	2	H-2 & Ka Uka
98	PE	-	-	-	3	H-2
98A	PE	-	-	-	2	H-2
433 [2]	CC	30 min	-	0	-	Ka Uka (first trip at 8:00 am)

Legend: ST = Suburban Trunk local route
PE = Peak Express route with weekday peak period only service
CC = Community Circulator

Notes: [1] Route 62 is planned to be renamed Route 51; characteristics are basically the same.
[2] Route 433 provides service to Waipio starting at 8:00 AM.

Table V.3 depicts Option #2. This table includes the potential bus transit service characteristics for those routes operating in the AM peak period in the vicinity of Koa Ridge assuming previously planned bus service are in place in 2025.

Table V.3: OPTION #2
Potential TheBus Transit Service Option Characteristics
For Those Routes Operating In The AM Peak Period (5:00 AM to 8:00 AM)
In The Vicinity Of Koa Ridge
Assuming Added Bus Service In 2025

Route	Service	Frequency	Inbound Trips Through Area	Inbound Trips Serving Area	Inbound Trips Bypassing Area	Description
CE [1]	RB	30 min	-	-	6	H-2 (6 outbound trips)
50 [2]	ST	30 min	-	6	-	H-2 & Ka Uka (6 outbound trips)
51 [3]	ST	15 min	-	10	-	Kamehameha (9 outbound trips)
52	ST	30 min	-	-	6	H-2 (3 outbound trips)
83	PE	-	-	-	7	H-2
83A	PE	-	-	1	1	H-2 (1 trip); Kamehameha (1 trip)
84/84A	PE	-	-	-	8	H-2
96	PE	-	-	2	-	H-2 & Ka Uka
98	PE	-	-	-	3	H-2
98A	PE	-	-	-	2	H-2
433 [4]	CC	30 min	6	-	-	Serves KR (6 outbound trips)
441	CC	30 min	6	-	-	Serves KR TC (6 outbound trips)
441X	PE	-	4	-	-	Serves KR TC

Legend: RB = Rapid Bus limited stop service on Country Express route
ST = Suburban Trunk local route
PE = Peak Express route with weekday peak period only service
CC = Community Circulator

Notes: [1] Country Express is a high quality service with limited stops.
[2] Planned new route with potential to pass through KR after new H-2 interchange is constructed.
[3] Existing Route 62 is planned to be renamed Route 51; characteristics are basically the same.
[4] Route 433 provides service to Waipio starting at 8:00 AM.

Option #2 includes the following bus routes added to those in Option #1:

CountryExpress (CE) – This Tier I route Rapid Bus (RB) service connects Wahiawa and Mililani with the Pearl Highlands transit center and rail station via H-2 with 6 inbound trips bypassing Koa Ridge because no freeway flyer stop exists for passengers to access this premium service.

Route 50 – This Tier II route, suburban trunk service, connects the existing Mililani transit center with the Waipahu transit center and rail station via H-2 with 6 trips serving Koa Ridge via Ka Uka Boulevard.

Route 441 – This Tier III route, community circulator service, connects Koa Ridge Makai and Waiawa with Pearl Highlands with 6 trips through the areas.

Route 441X – This Tier IV route, peak express service, connects Koa Ridge Makai and Waiawa with downtown Honolulu with 4 trips through the areas.

Option #2 introduces 16 inbound bus trips going through Koa Ridge serving future bus stops located in close proximity to future development. The 10 bus trips serving Koa Ridge Makai are increased to 19 inbound bus trips. These 19 routes do not go through Koa Ridge, but serve the area by traveling along either Ka Uka Boulevard or Kamehameha Avenue and serve existing bus stops. The 29 inbound bus trips that neither go through Koa Ridge nor serve the area because no bus station exists along H-2 increases to 33. Option #2 is consistent with ongoing bus planning.

Option #3 is defined by the bus routes and service characteristics presented in Table V.4. Rail service is introduced with bus connections from Koa Ridge Makai and Waiawa to rail stations at Waipahu and Pearl Highlands. Routes CE, 50 and 441 all have peak period frequency improved from 30 to 15 minute service intervals. Routes 51, 52 and 433 continue to offer the same level of service included in Option #2. Peak express routes are reconfigured to connect with rail stations with inbound trips doubling, but all would be bypassing the area under Option #3.

Option #3 inbound bus trips going through Koa Ridge Makai increase from 16 to 18. Inbound bus trips serving Koa Ridge Makai are increased from 19 to 22. The number of inbound bus trips that neither go through Koa Ridge nor serve the area because no bus station exists along H-2 increases from 33 to 71. Option #3 is consistent with planning assumptions made during the Alternatives Analysis study. This will be confirmed upon the release of the HHCTCP DEIS in October 2008.

Table V.4: OPTION #3
Potential TheBus Transit Service Option Characteristics
For Those Routes Operating In The AM Peak Period (5:00 AM to 8:00 AM)
In The Vicinity Of Koa Ridge
Assuming Bus and Rail Investments In 2025

Route	Service	Frequency	Inbound Trips Through Area	Inbound Trips Serving Area	Inbound Trips Bypassing Area	Description
CE [1]	RB	15 min	-	-	12	H-2 (12 outbound trips)
50 [2]	ST	15 min	-	12	-	H-2 & Ka Uka (12 outbound trips)
51 [3]	ST	15 min	-	10	-	Kamehameha (9 outbound trips)
52	ST	30 min	-	-	6	H-2 (3 outbound trips)
83/83A	PE	-	-	-	30	H-2
84/84A	PE	-	-	-	17	H-2
98	PE	-	-	-	6	H-2
433	CC	30 min	6	-	-	Serves KR (6 outbound trips)
441	CC	15 min	12	-	-	Serves KR TC (12 outbound trips)

Legend:
RB = Rapid Bus limited stop service on Country Express route
ST = Suburban Trunk local route
PE = Peak Express route with weekday peak period only service
CC = Community Circulator

Notes:
[1] Country Express is a high quality service with limited stops.
[2] Planned new route with potential to pass through KR after new H-2 interchange is constructed.
[3] Existing Route 62 is planned to be renamed Route 51; characteristics are basically the same.

Option #4 is defined by the bus routes and service characteristics presented in Table V.5. Option #3 and #4 both have 111 total morning peak period inbound trips, but bus service through Koa Ridge Makai is doubled with Option #4. This is achieved based upon the creation of a new H-2 interchange located between the Mililani and Waipio interchanges.

Table V.5: OPTION #4
Potential TheBus Transit Service Option Characteristics
For Those Routes Operating In The AM Peak Period (5:00 AM to 8:00 AM)
In The Vicinity Of Koa Ridge
Assuming TDM In 2025 With Bus and Rail Investments

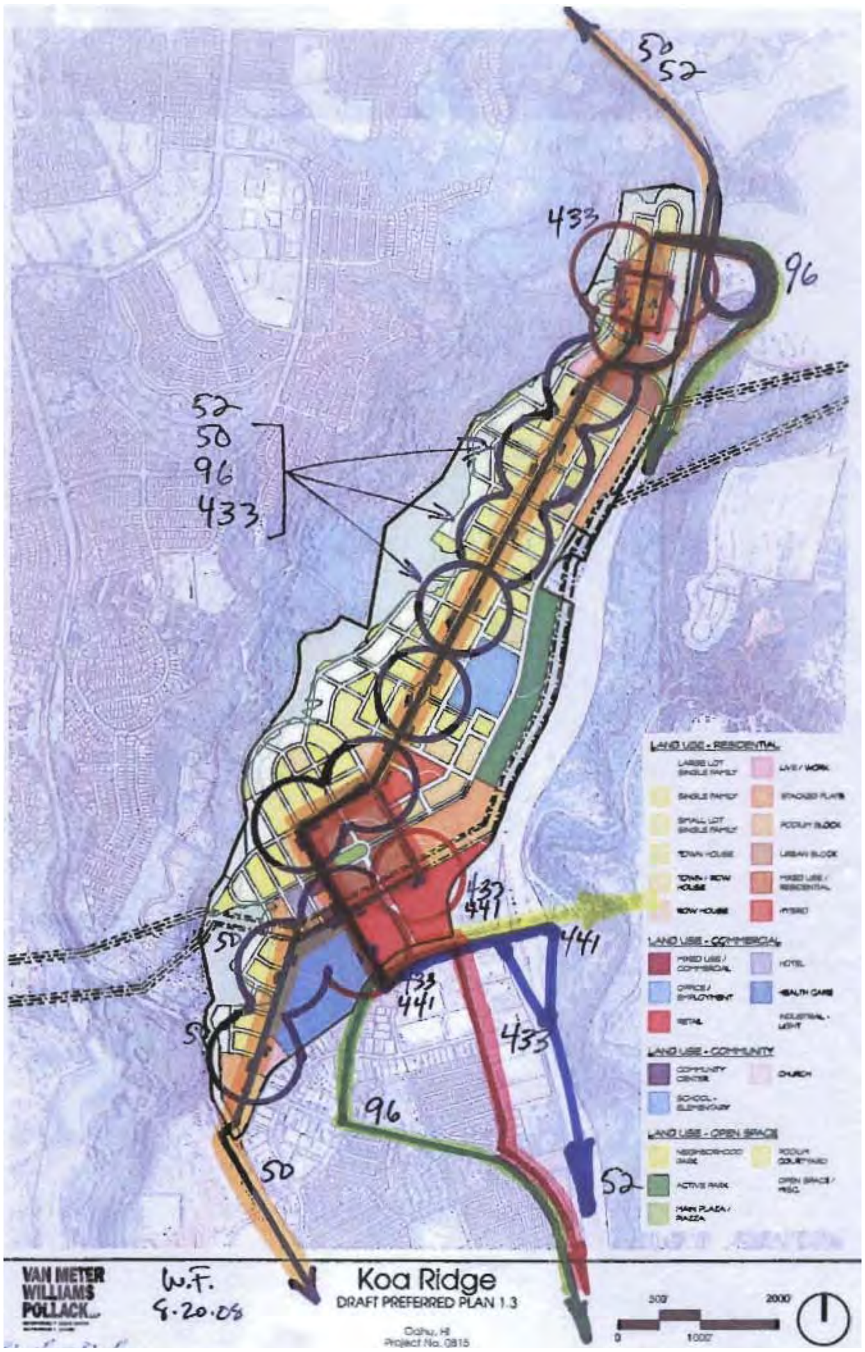
Route	Service	Frequency	Inbound Trips Through Area	Inbound Trips Serving Area	Inbound Trips Bypassing Area	Description
CE [1]	RB	15 min	-	-	12	H-2 (12 outbound trips)
50 [2]	ST	15 min	12	-	-	H-2 & Ka Uka (12 outbound trips)
51 [3]	ST	15 min	-	10	-	Kamehameha (9 outbound trips)
52	ST	30 min	6	-	-	H-2 (3 outbound trips)
83/83A	PE	-	-	-	30	H-2
84/84A	PE	-	-	-	17	H-2
98	PE	-	-	-	6	H-2
433	CC	30 min	6	-	-	Serves KR TC (6 outbound trips)
441	CC	15 min	12	-	-	Serves KR (12 outbound trips)

Legend:
RB = Rapid Bus limited stop service on Country Express route
ST = Suburban Trunk local route
PE = Peak Express route with weekday peak period only service
CC = Community Circulator

Notes:
[1] Country Express is a high quality service with limited stops.
[2] Planned new route with potential to pass through KR after new H-2 interchange is constructed.
[3] Existing Route 62 is planned to be renamed Route 51; characteristics are basically the same.

Routes 50 and 52 are realigned to take advantage of the new interchange to serve through Koa Ridge Makai as depicted in Figure V.1. Route 50's 12 inbound trips that previously served Koa Ridge only along Ka Uka Boulevard now traverse main roadways through Koa Ridge. Route 52's 6 inbound trips that previously bypassed the area now also traverse main roadways through Koa Ridge. The TDM agreement proposed in the next section of this report is intended to assure the provision of these bus route services.

Figure V.1: Potential TheBus Route Alignments
Through Koa Ridge



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Option #5 is defined by the bus routes and service characteristics presented in Table V.6. Like Options #3 and #4, Option #5 offers a total of 111 total morning peak period inbound trips. However, 71 inbound trips in Option #3 and 65 in Option #4 bypassed the area. All 111 inbound bus trips in Option #5 either go through or serve Koa Ridge.

Table V.6: OPTION #5
Potential TheBus Transit Service Option Characteristics
For Those Routes Operating In The AM Peak Period (5:00 AM to 8:00 AM)
In The Vicinity Of Koa Ridge
Assuming TDM In 2025 With Bus and Rail Investments
And An H-2 Freeway Flyer Transit Station

Route	Service	Frequency	Inbound Trips Through Area	Inbound Trips Serving Area	Inbound Trips Bypassing Area	Description
CE [1]	RB	15 min	-	12	-	H-2 (12 outbound trips)
50 [2]	ST	15 min	12	-	-	H-2 & Ka Uka (12 outbound trips)
51 [3]	ST	15 min	-	10	-	Kamehameha (9 outbound trips)
52	ST	30 min	6	-	-	H-2 (3 outbound trips)
83/83A	PE	-	-	30	-	H-2
84/84A	PE	-	-	17	-	H-2
98	PE	-	-	6	-	H-2
433	CC	30 min	6	-	-	Serves KR TC (6 outbound trips)
441	CC	15 min	12	-	-	Serves KR (12 outbound trips)

Legend: RB = Rapid Bus limited stop service on Country Express route
ST = Suburban Trunk local route
PE = Peak Express route with weekday peak period only service
CC = Community Circulator

Notes: [1] Country Express is a high quality service with limited stops.
[2] Planned new route with potential to pass through KR after new H-2 interchange is constructed.
[3] Existing Route 62 is planned to be renamed Route 51; characteristics are basically the same.

Options #5 and #6 capture the very high level of service that would otherwise bypass Koa Ridge by creating a Central Oahu Regional Bus Transit Station in the H-2 center median between the Plantation Road bridge over H-2 and the Ka Uka Boulevard bridge over H-2. This median island is up to 250 feet wide and 2000 feet long providing an ample footprint for such a facility consistent with comparable projects in Seattle and Los Angeles without interference with other interchange traffic movements.

Figure V.2 depicts a relatively flat site. It is shaped like an 'S' with narrow ends and a wide middle. The width is over 200 feet for over 1,000 feet of the length of the median. HDOT researched the history of the site and could find no documented reasons for its existence. The speculation is that the roadway simply followed the contour of the land in this location since the cost of even minor cut and fill grading would be greater than the cost of the land at the time of construction. In previous investigations HDOT could find no evidence of any environmental or other reasons for avoiding the site.

Figure V.2: Potential Central Oahu Regional Bus Transit Station Site

The potential Central Oahu Regional Bus Transit Station site is shaped like an 'S' with narrow ends and a wide middle. The width is over 200 feet for over 1,000 feet of the length of the median.

The site is immediately adjacent to HOV lanes in each direction allowing direct access from and to the HOV lanes. An additional three general purpose traffic lanes are on the outside cross-section of the freeway.

The proposed Central Oahu Regional Bus Transit Station is located in the heart of the Waiawa Koa Ridge Makai developments and is situated to serve most of the housing units and employment planned for the area within reasonable walk and bicycle distances. Figure V.3. illustrates how the Rosecrans Bus Station is configured to serve bus routes on I-110 in Los Angeles. Sidewalks on the Rosecrans overpass provide pedestrian access. Such an overpass on H-2 need only be designed to serve pedestrians and bicyclists.

Figure V.3: Example Of Regional Bus Transit Station On I-110 In Los Angeles

The proposed Central Oahu Regional Bus Transit Station would use direct access ramps from the existing H-2 HOV lanes. Figure V.4. illustrates how the Seattle area has designed these facilities in close proximity to other freeway ramp connections to I-405

Figure V.4: Example Of Direct Access Ramps On I-405 In Bellevue

Bridges for pedestrians are being used throughout the developed world as depicted in Figures V.5, V.6 and V.7. The most recent major bridges in London (the Millennium Bridge across the Thames River opened in 2000) and Paris (across the Seine River opened in 1999) are pedestrian only bridges.

The Millennium Bridge shown in Figure V.5. is London's first pedestrian only crossing of the Thames. The bridge connects St. Paul's Cathedral with the regenerating London Borough of Southwark.

The Passerelle Leopold-Sedar Senghor across the Seine is pictured in Figure V.5. This is one of three pedestrian only bridges in central Paris. It connects the Tuileries Gardens with the d'Orsay museum.

Figure V.6. shows some of the pedestrian and bicycle only bridges in Dublin. Four of the last five bridges built in Dublin (across the River Liffey) are pedestrian and bicycle only bridges. The massive Docklands redevelopment area in Dublin is divided by River Liffey. The primary transportation connection between the predominately mixed use residential construction projects is a pedestrian bridge.

The most recent bridge across the Missouri River is a pedestrian and bicycle only bridge. The bridge in Omaha is shown in Figure V.7 under construction in 2008. The bridge is funded by a special Federal program for such projects. The access created by the bridge will be used by major mixed use development projects being constructed on both sides of the river.

The potential Central Oahu Regional Bus Transit Station site might be best served by the types of pedestrian and bicycle only bridges being increasingly used worldwide to connect major mixed used developments across both natural and manmade barriers. Such bridges are functional, iconic and significantly less expensive than a crossing designed for private vehicular traffic. Options #5 and #6 are predicated on application of these types of approaches that place a priority on coordinated pedestrian, bicycle and transit solutions over accommodation of vehicular movements.

Option #6 is defined by the bus routes and service characteristics presented in Table V.7. Like Option #5, Option #6 is based upon capturing the very high level of transit service that would otherwise bypass Koa Ridge by creating a Central Oahu Regional Bus Transit Station in the H-2 center median between the Plantation Road bridge over H-2 and the Ka Uka Boulevard bridge over H-2. Access to the Central Oahu Regional Bus Transit Station would be by a pedestrian and bicycle only bridge over H-2 with direct, curb-separated, safely-designed and highly-functional alternative transportation pathway connections fully integrated into the Koa Ridge site plan.

Figure V.5: Example Of Pedestrian Only Bridges In London and Paris

The Millennium Bridge across the Thames River pictured to the right as shown in the May 2008 issue of Civil Engineering is the most recent bridge in London. The Millennium Bridge is London's first pedestrian only crossing of the Thames. The bridge connects St. Paul's Cathedral with the regenerating London Borough of Southwark.

The Passerelle Leopold-Sedar Senghor across the Seine is pictured to the right and below. This is one of three pedestrian only bridges in central Paris. It connects the Tuileries Gardens with the d'Orsay museum.

Figure V.6: Example Of Pedestrian And Bicycle Only Bridges In Dublin

The massive Docklands redevelopment area in Dublin is divided by River Liffey. The primary transportation connection between the predominately mixed use residential construction projects is a pedestrian bridge, shown to the right.

Four of the last five bridges built in Dublin (across the River Liffey) are pedestrian and bicycle only bridges. The potential Central Oahu Regional Bus Transit Station site might be best served by such a bridge.

Figure V.7: Example Of Pedestrian and Bicycle Only Bridges In Omaha

The most recent bridge across the Missouri River is a pedestrian and bicycle only bridge in Omaha funded by a special Federal program for such projects. The access created by the bridge will be used by major mixed use development projects being constructed on both sides of the river.

Table V.7: OPTION #6
Potential TheBus Transit Service Option Characteristics
For Those Routes Operating In The AM Peak Period (5:00 AM to 8:00 AM)
In The Vicinity Of Koa Ridge
Assuming TDM In 2025 With Bus Investments
And An H-2 Freeway Flyer Transit Station

Route	Service	Frequency	Inbound Trips Through Area	Inbound Trips Serving Area	Inbound Trips Bypassing Area	Description
CE [1]	RB	30 min	-	6	-	H-2 (6 outbound trips)
50 [2]	ST	30 min	6	-	-	H-2 & Ka Uka (6 outbound trips)
51 [3]	ST	15 min	-	10	-	Kamehameha (9 outbound trips)
52	ST	30 min	-	6	-	H-2 (3 outbound trips)
83	PE	-	-	7	-	H-2
83A	PE	-	-	2	-	H-2 (1 trip); Kamehameha (1 trip)
84/84A	PE	-	-	8	-	H-2
96	PE	-	-	2	-	H-2 & Ka Uka
98	PE	-	-	3	-	H-2
98A	PE	-	-	2	-	H-2
433	CC	30 min	6	-	-	Serves KR TC (6 outbound trips)
441	CC	30 min	6	-	-	Serves KR (6 outbound trips)
441X	PE	-	4	-	-	Serves KR

Legend: RB = Rapid Bus limited stop service on Country Express route
ST = Suburban Trunk local route
PE = Peak Express route with weekday peak period only service
CC = Community Circulator

Notes: [1] Country Express is a high quality service with limited stops.
[2] Planned new route with potential to pass through KR after new H-2 interchange is constructed.
[3] Existing Route 62 is planned to be renamed Route 51; characteristics are basically the same.

Option #6 is designed to illustrate what might happen if the anticipated rail system included in Options #3, 4 and 5 does not occur. Option #6 uses the transit services assumed in Option #2. Therefore, a total of 68 morning inbound bus trips are projected. However, instead of 33 of these bus trips bypassing Koa Ridge, the number of inbound morning bus trips serving Koa Ridge is increased from the 19 in Option #2 to 52. This is almost a bus trip every three minutes during the three hour peak period – comparable to, or even better than, the level of service offered on most new U.S. rail systems.

VI. Vehicle Trip Generation Reductions

The standard approach for determining the transportation implications of a proposed development is to conduct a traffic impact analysis. Such studies have been used consistently for decades to make decisions about maximum land use holding capacity and minimum street network design requirements. The emphasis has been on analyzing the number of vehicle trips generated by the new development and the consequential impact on the level of service of critical roadways and intersections. The traffic impact study has evolved as the single tool used to determine roadway widths, street and intersection design and the financial contributions that are reasonable for those sponsoring the development requiring changes to the transportation system.

Traffic impact studies vary in their range of detail and complexity. Many states are becoming more regulatory in how traffic impact studies are to be conducted. Some jurisdictions have incorporated technical procedures, vehicle trip generation rates and allowable adjustments and reductions to those rates into ordinances and permit regulations. The Institute of Transportation Engineers (ITE) Trip Generation Handbook and User's Guide (7th Edition, 3 volumes) have been the definitive technical references for estimating vehicle traffic for a development project. However, development projects have changed. ITE's procedures are useful for vehicle-oriented, single-land use projects. The vast majority of ITE vehicle trip data was collected for these types of sites.

ITE has found that vehicle trip generation estimates should be reduced for multi-land use projects. This is referred to as an adjustment for "internal capture" vehicle trips. These are vehicle trips that have both vehicle trip ends within a multi- or mixed- land use project, they are captured within the proposed project.

ITE has found that not all vehicle trips are new vehicle trips caused by the development being surveyed. Typical vehicle trip generation rates are derived from driveway counts. For many land uses, vehicle trips being counted are already on the road for other trip purposes and would "pass-by" the land use for other reasons even if it did not exist.

ITE advises areas with good public transportation to adjust the vehicle rates to account for reduced vehicle use. Adjustments and reductions are also made for pedestrian, bicycle and TDM programs. Care must be used to be sure the vehicle trip rate adjustments for all of these factors are not double counted.

The state of the art in traffic impact studies is evolving. Now, they are becoming referred to as "transportation" rather than "traffic" impact analyses, transcending the past emphasis on vehicle traffic toward more consideration given to accessibility and mobility for people.

Koa Ridge embodies the factors that are bringing about this change in how major multi-use projects are evaluated. Environmental movements toward sustainable development have placed emphasis on the use of alternative transportation programs. These alternative transportation programs include fully integrating public transportation, bicycle and pedestrian modes using a wide variety of cost-effective and practical approaches. Some of these approaches may be found on Oahu, more are being used in mainland cities and many more have been time-tested and extensively vetted in European cities where transportation system design excellence is commonplace.

Future development projects such as Koa Ridge Makai and Waiawa must reflect an awareness of where best transportation system design practices are to be found. Continuing European research reveals that Oahu, and developments such as Koa Ridge Makai and Waiawa, are ideal locations to plan to do what most European and other world-class international cities have already achieved. The Koa Ridge projects already reflect the fundamentals of what needs to be done. Such things as a neighborhood center no further than one-half mile from any home has tremendous implication upon creating an alternative transportation culture. The development layout will be designed to facilitate transit, walking and bicycling.

Oddly enough, European cities do not use the term Transit-Oriented Design (TOD). That is because virtually all existing urban transportation function and form in Europe is already configured and composed in a manner we attempt to emulate at a few TOD locations. The Koa Ridge Makai and Waiawa projects already reflect the required basic elements of TOD. Koa Ridge highlights neighborhood clusters connected via landscaped sidewalks and bicycle paths that, together with public transportation, will create mobility options that mean residents can leave their car at home making the Koa Ridge Makai and Waiawa projects highly competitive with any future TOD project on Oahu. Such TOD projects have been found to result in vehicle trip reduction rates that are 44% to 49% less that would otherwise be observed using unadjusted ITE vehicle trip generation rates.[4]

The success of TOD projects is rooted in fundamentals that apply to Koa Ridge Makai and Waiawa. The right kind of transportation facilities and programs, using the right kind of cross-sectional design in the right locations, will result in significant reductions on the reliance in the private vehicle. These transportation facilities and programs will be a magnet for the type of utilization these transportation features routinely obtain in Europe, but not as often in the U.S., even at our heralded TOD projects. The guiding principles for Koa Ridge Makai and Waiawa are the same most critical ones used to attain the European success: creating a walkable community with parks linked by pedestrian and bicycle paths and assuring connectivity in roadways but discouraging through traffic.

[4] TCRP Report 128; Effects of TOD on Housing, Parking, and Travel; 2008; page 4.

This section of the Koa Ridge Makai and Waiawa Project Alternative Transportation Component Report applies the guiding principles for Koa Ridge Makai and Waiawa to alternative transportation components of the projects within the context of the traditional traffic impact study methodology.

Vehicle trip generation rate calculations and adjustment factors were applied to each land use type. The most applicable unit of measurement was used for each land use – square feet of floor area, number of dwelling units or number of students. Two sets of five page tables are included in the Appendix with detailed calculations for the years 2016 and 2025. The results of these calculations is presented in Table VI.1 for 2025.

Table VI.1: SUMMARY TABLE
Koa Ridge Vehicle Trip Generation Adjustments And Reductions
By Type and Time Of Day In 2025

	VEHICLE TRIPS BY TIME PERIOD					
	Daily		AM Peak Hour		PM Peak Hour	
VEHICLE TRIP ADJUSTMENT CATEGORY	No.	%	No.	%	No.	%
Maximum External Vehicle Trips	67,247	100.00	5,125	100.00	6,557	100.00
Vehicle Trip Adjustments and Reductions:						
Internal Capture	14,331	0.21	1,416	0.28	1,563	0.24
Pass-By	3,113	0.05	75	0.01	272	0.04
Transit	5,664	0.08	398	0.08	532	0.08
Pedestrian and Bicycle	1,853	0.03	190	0.04	195	0.03
TDM	11,365	0.17	798	0.16	1,071	0.16
Total Vehicle Trip Adjustments	36,336	0.54	2,886	0.56	3,643	0.56
Estimated Vehicle Trips	30,911	0.46	2,239	0.44	2,913	0.44
Note: See Appendix of this report for detailed notes regarding sources, assumptions and calculations.						

Maximum External Vehicle Trips

The first row in Table VI.1 presents the maximum external vehicle trip calculation based upon the average ITE vehicle trip generation rates included in the ITE Trip Generation Manual, 7th edition. ITE vehicle trip generation rates are used for every land use category to be consistent with the methodologies used in the source documents for the actual vehicle trip adjustments and reductions as specified. Alternative trip generation rates are now being used in Hawaii for other projects showing much lower vehicle trips. These may be appropriate when not placing emphasis on alternative transportation modes, but this analysis gave preference to ITE sanctioned methods.

Vehicle Trip Adjustments: Internal Capture

The second row in Table VI.1 contains the vehicle trip adjustment for those trips that have both their origin and destination within the project. The larger the development project and the more balanced the mix of land uses, the more trips will be internally captured regardless of the mode used for the trip. The Koa Ridge Makai and Waiawa Project represent a very balanced mix of land uses with great consideration given to the type of land use and the placement of each land use within the project to encourage the use of alternative transportation modes.

The Commonwealth of Virginia is one of those states that has refined ITE traffic impact study methodology by promulgating rigid administrative guidelines.[5] The Virginia Department of Transportation (VDOT) allows a 15% adjustment to ITE vehicle trip generation rates for residential components of a mixed-use development. The VDOT is the source of the adjustment factor applied to only the residential components of the Koa Ridge Makai and Waiawa project.

The Florida Department of Transportation (FDOT) sponsored a study of key quantitative databases of vehicle trip characteristics at six major multi-use sites. The results of this study are included as Appendix C in the ITE Trip Generation Handbook, 2nd Edition.[6] It was determined that the internal capture rate for multi-use development averaged 36%. The FDOT evaluation published by ITE is the source for the adjustment factor applied to only the commercial components of the Koa Ridge Makai and Waiawa project.

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[5] VDOT, Required Elements Of A Traffic Impact Analysis – Administrative Guidelines; July, 2008.
[6] ITE Trip Generation Handbook, 2nd Edition; June 2004; Appendix C; pages 129 to 132.

Other land use components of the project were determined to have high internal capture rates because they are land uses designed specifically to serve other land uses within the project. These include community centers, schools, churches and parks.

The overall internal capture rate for the project for all daily trips was calculated to be 21%. This rate is validated by independent research conducted for North Carolina.[7] The research was for Traditional Neighborhood Developments (TNDs), projects comparable to that envisioned for Koa Ridge Makai and Waiawa with a balanced mix of land uses and great consideration given to the use of alternative transportation modes. The best ITE land use code for a TND is a multi-use development. ITE defines multi-use developments as “typically a single real-estate project that consists of two or more ITE land use classifications between which trips can be made without using the off-site road system.”

TNDs, like Koa Ridge Makai and Waiawa, are expected to encourage the use of alternative transportation modes; thereby, increasing internal trip capture rates. The study found that TND households substituted driving trips with alternative modes. The TND examined in the study internally captured 20.2% of all trips, very comparable to the 21.3% computed for this analysis using different data sources.

Vehicle Trip Adjustments: Pass-By

The third row in Table VI.1 contains the vehicle trip adjustment for those trips that are assumed to pass-by the site even if no development were to occur. This is a relatively minor vehicle trip generation adjustment, especially for morning peak hour conditions.

The Koa Ridge Makai and Waiawa Project included no pass-by vehicle trip adjustment factor with just one exception – commercial land uses to be located along Ka Uka Boulevard. The VDOT administrative guidelines allow for a 25% pass-by trip reduction for shopping centers which was applied to the big box and retail land uses along Ka Uka Boulevard. Retail land uses located within the project were not given any pass-by reduction.

[7] Traditional Neighborhood Development Trip Generation Study; Khattak et al; February 2005; page v.

Vehicle Trip Reductions: Transit

The fourth row in Table VI.1 contains the vehicle trip generation rate adjustment for those person trips that use public transportation rather than a vehicle. Table V.1 summarized six potential TheBus transit service options serving Koa Ridge Makai and Waiawa in the year 2025. Variables included various assumptions regarding bus routing, rail services and a possible H-2 Central Oahu Regional Bus Transit Station.

The Central Oahu Regional Bus Transit Station would be located in the H-2 center median between the Plantation Road bridge over H-2 and the Ka Uka Boulevard bridge over H-2. Access to the Central Oahu Regional Bus Transit Station would be by a pedestrian and bicycle only bridge over H-2 with direct, curb-separated, safely-designed and highly-functional alternative transportation pathway connections fully integrated into the Koa Ridge site plan. Such a scheme would certainly attract an extraordinary percent of person trips away from personal vehicle trips regardless of whether a rail system exists or not given the current and anticipated levels of bus service that would be available via such an endeavor. ITE 's Transportation Impact Analysis for Site Development report offers the following guidance: "…bus transit corridors can provide vehicle trip reductions in the range of 2 to 10 percent…around transit centers…can provide vehicle trip reductions in the range of 5 to 20 percent."[8] Options #5 and #6 are believed to be able to produce such a 20 percent reduction, especially in the peak hour.

Option #4 was selected for the purposes of this traffic impact analysis because it represents the most predictable transit outcome in the year 2025 given current circumstances on Oahu. Option #4 is defined by the bus routes and service characteristics presented in Table V.5. Option #4 assumes the creation of a new H-2 interchange located between the Mililani and Waipio interchanges. Option #4 assumes Routes 50 and 52 are realigned to take advantage of the new interchange to serve through Koa Ridge Makai.

The distinction between the ITE vehicle trip reduction achieved within the "transit" category and the additional ITE vehicle trip reduction achieved in the "TDM" category is that the "transit" category only seeks credit for the provision of transit service to a level comparable to most of the areas of Oahu developed before 1970. Developments on Oahu after 1970 sometimes disregarded good alternative transportation infrastructure and program design practices and were designed to be auto-oriented. The standard, unadjusted ITE rates may have been appropriate in these situations. But, Koa Ridge Makai and Waiawa in the year 2025 will benefit from improved practices with regard to the provision of transit services. This is reflected in the transit adjustments included under the "transit" category.

[8] Transportation Impact Analyses for Site Development; ITE Proposed Recommended Practice; 2005; Page 72.

ITE trip generation rates assume little or no transit service. Option #4 reflects a comparable level of transit service enjoyed by areas of Oahu where the transit mode split is over eight percent. The trip adjustment factor applied for “transit” ranged from zero to ten percent depending upon the land use consistent with the “bus transit corridors can provide vehicle trip reductions in the range of 2 to 10 percent” cited in the ITE publication.

The “TDM” agreement proposed later in this report is intended to assure the provision of these bus route services in a timely manner in conjunction with aggressive incentive programs designed to boost the shift from use of a private vehicle to alternative forms of transportation including transit beyond the ITE trip generation rate reductions used under the “transit” classification which will occur without the “TDM” ITE vehicle trip generation reductions.

Vehicle Trip Reductions: Pedestrian and Bicycle

The fifth row in Table VI.1 contains the vehicle trip generation rate adjustment for those person trips that use pedestrian and bicycle transportation rather than a vehicle. These adjustments assume high level of service pedestrian and bicycle infrastructure investments including some connection such as might be provided by the Central Oahu Regional Bus Transit Station pedestrian and bicycle bridge even if the transit component of this concept is not implemented.

Access to the Central Oahu Regional Bus Transit Station would be by a pedestrian and bicycle only bridge over H-2 with direct, curb-separated, safely-designed and highly-functional alternative transportation pathway connections fully integrated into the Koa Ridge site plan. This linkage would attract person trips away from vehicle travel regardless of whether the transit connection exists. The function of such a crossing, whether located as proposed or in some other place, is to provide a safe passage way for both recreational and more functional trip purposes.

The functional trip purposes served by a properly designed H-2 pedestrian and bicycle crossing would include work, shop or school trips between Waiawa and Koa Ridge Makai and other destinations such as the commercial establishments makai of Ka Uka Boulevard. The ITE vehicle trip reductions used might be difficult to fully justify if a safe and functional pathway doesn’t exist that is carefully integrated into a meaningful regional pedestrian and bicycle network, although most ITE based methods only require a mere “accommodation” of pedestrian and bicycle movements to warrant vehicle trip generation reductions.

VDOT defines a pedestrian “accommodation” as “…sidewalks, intersection treatments and exclusive, or shared (with bicyclists) off-street trails or paths.” VDOT defines a bicycle “accommodation” as “…on-street bike lanes, paved shoulders of roadways that are not part of the designated travel way for vehicles, or exclusive, and shared (with pedestrians) off-street bicycle paths.”

VDOT requires that the traffic impact analysis provide both the route and segment quality of service as determined using procedures offered by one of three documents.[9] The Koa Ridge Makai and Waiawa Project will equal or exceed the “accommodation” standards set forth in such procedures with a Level of Service “A” standard.

VDOT’s administrative procedures for traffic impact studies are the most recent (published July 2008) and one of the most rigorous known to comprehensively address alternative transportation components using the best documentation available from FHWA, ITE, TRB and other state DOTs. These administrative procedures allow for a 4% reduction from ITE vehicle trip generation rates when a level of service A exists for pedestrian travel. It allows for a 3% reduction from ITE vehicle trip generation rates when a level of service A exists for bicycle travel. This is an overall combined reduction of 7% for both pedestrian and bicycle modes. Table VI.1 shows an overall reduction of 3% for daily and PM peak hour vehicle trips and 4% for AM peak hour vehicle trips. This is about half of what is allowed to avoid double counting credit taken for land use classifications inherent in using a “high-rise” code and adjustments made for internal trips.

The application of the pedestrian and bicycle vehicle trip reductions took into consideration other current best practices used in other states to reflect excellence and high quality in pedestrian and bicycle infrastructure design. Research for the Florida Department of Transportation has shown existence of statistically significant factors correlating with the quality of pedestrian and bicycle network design. These include sidewalk and pathway network completeness. The California practices allow for up to a 9% reduction to ITE vehicle trip generation rates.[10]

There are both bad and good examples of pedestrian and bicycle infrastructure on Oahu as shown in Figure VI.1. The Appendix includes a section on alternative transportation component terms and definitions with emphasis on many examples of high quality pedestrian and bicycle modal accommodation. These international best practices are the types of design features envisioned for Koa Ridge Makai and Waiawa when using the vehicle trip reductions noted in this report.

[9] Note: The three documents are: 1) The Bicycle Compatibility Index: A Level of Service Concept, Implementation Manual (FHWA); 2) Bicycle and Pedestrian Level of Service Performance Measures and Standards for Congestion Management Systems; TRB 1538 (Quality/Level of Service Handbook (FDOT); and, 3) TRB Transit Capacity and Quality of Service Manual.

[10] Crediting Low-Traffic Developments, Adjusting Site-Level Vehicle Trip Generation Using URBEMIS; August 2005; page 14.

Figure VI.1: Examples Of Pedestrian and Bicycle Infrastructure On Oahu

Sections of excellent pedestrian and bicycle facilities exist near the Koa Ridge Makai and Waiawa project such as the euro-style cycle track in Waikele (left) and the Pearl Harbor Historic Trail (above).

Sections of sub-standard pedestrian and bicycle facilities exist on Oahu such as the Farrington bicycle route (right). Mokuola's bike lane needs to be better maintained and enforced (both bottom pictures).

Vehicle Trip Reductions: TDM

The sixth row in Table VI.1 contains the vehicle trip generation rate adjustment for those person trips that participate in the project TDM program rather than use a vehicle. These adjustments assume a TDM program more aggressive than any other ever proposed for Hawaii and superior to most of those found on the mainland.

The ITE Trip Generation Handbook, 2nd Edition, Appendix B, includes guidelines based on a number of documents with the following statement: “TDM programs with economic incentives to not drive alone were found to reduce the number of commuter vehicles generated by an employment site (not in number of vehicle-trips) by an average of 16 percent.[11] Table VI.1. shows that the calculation for the project for the AM and PM peak hours resulted in a 16% vehicle trip rate reduction.

The ITE Trip Generation Handbook, 2nd Edition, Appendix B, also included the following statement: “TDM programs that combine economic incentives with transportation services produce the most significant effect on commuter vehicles (not vehicle-trips) generated by a site (an average 24 percent reduction at survey sites).” Table VI.1. shows that the calculation for the project for the AM and PM peak hours resulted in a 24% vehicle trip rate reduction when transit and TDM are combined.

Other sources have found TDM programs with reductions in employee vehicle trips of up to 38%.[12] These are often the result of such TDM programs being part of a legally enforceable agreement (such as the Unilateral Agreements entered into by developers in Hawaii) that guarantees the TDM program will be implemented. Three types of TDM elements have been found to have the greatest impact on travel behavior: 1) parking pricing attains up to a 25% trip reduction with a $6.00 daily charge, 2) free transit passes attain up to 25% where good transit service is available and 3) work schedule programs including telecommuting, flextime or compressed work schedules can attain up to a 25% trip reduction. These vehicle trip adjustments have been observed from different sources and careful attention must be given to avoid double counting.

[11] Referenced documents include: NCHRP Report 323, Travel Characteristics at Large-Scale Suburban Activity Centers; TCRP Project B-4; ITE Recommended Practice Traditional Neighborhood Development Street Design Guidelines, 1999; ODOT/DLCD Transportation and Growth Management Program; and, LACMTA (Los Angeles County Metropolitan Transportation Authority), 1993.

[12] Crediting Low-Traffic Developments, Adjusting Site-Level Vehicle Trip Generation Using URBEMIS; August 2005; page 16.

ITE vehicle trip generation rates for office buildings assume multi-tenant space with typical suburban work schedule variations. These rates do not reflect trip generation that will occur if all employees worked the same schedules. However, these rates also assume little or no transit service. Again, careful understanding of the interaction of the variables available to adjust and reduce the ITE vehicle trip generation rates is essential to producing an objective and credible traffic impact analysis.

The role of TDM in this alternative transportation component report to the Koa Ridge Makai and Waiawa project is to provide a comprehensive program wherein, at a minimum, residents and employees are encouraged to use the excellent transit service provided through the additional incentive of a free transit pass for every resident and every employee.

Although a wide array of other TDM program elements are to be included in the TDM program, the reduction to ITE vehicle trip generation rates is technically only being linked to a transit pass program. Those other TDM program elements, while very worthwhile and included in the Koa Ridge Makai project, tend not to have been proven to have a significant impact on travel behavior. Such TDM program elements, many illustrated in the Appendix, include the following:

- bike sharing and rental programs
- secure and ample bicycle parking
- guaranteed ride home and taxi scrip insurance
- car club and sharing programs
- carpool and vanpool brokering services
- real time traveler information and trip planning

The detailed vehicle trip adjustment calculations used a 25% vehicle trip reduction for residential land uses based on a subsidized transit pass program provided by the developer wherein new residents use a transit pass or a comparable set of related subsidized TDM benefits (such as participation in the bike sharing program).

The detailed vehicle trip adjustment calculations used a vehicle trip reduction ranging from 0 to 25% depending upon the land use based on a subsidized transit pass program wherein new employees use a transit pass or a comparable set of related subsidized TDM benefits such participation in a vanpooling program up to the maximum value of the TDM program benefit. Employers are responsible to support the TDM program, except those with less than 25 employees.

APPENDIX A: TheBus Routes

The following are TheBus route schedules and maps for those services in proximity to Koa Ridge Makai and Waiawa

Route 52 Schedule -- 6 pages

Route 62 Schedule -- 6 pages

Route 83 Schedule -- 1 page

Route 83A Schedule -- 1 page

Route 84 Schedule -- 1 page

Route 84A Schedule -- 1 page

Route 96 Schedule -- 1 page

Route 98 Schedule -- 1 page

Route 433 Schedule -- 1 page

Route 52 Map -- 1 page

Route 62 Map -- 1 page

Route 433 Map -- 1 page

Route 83, 83A, 84, 84A, 96 and 98 Map -- 1 page

Route 52 - Wahiawa Circle Isle / Route 55 - Kaneohe Circle Isle / 88A - North Shore Express

Effective 8/24/08

Weekday: Westbound: Via H-1/H-2 to Mililani/Wahiawa/North Shore/Kaneohe/Honolulu

O Ala Moana Center Kona St	M Downtown Alapai/Hotel	N Downtown Beretania/Punchbowl	I Downtown King/Beretania	H Kalihi Kam Hwy/Middle	G Mililani Park & Ride	F Mililani Transit Center	E Mililani Kam Hwy/Kuahelani	D Wahiawa California/Cane	C Haleiwa Beach Park	B Pupukea Beach Park	A Turtle Bay Resort	V Laie/Polynesian Cultural Center	U Hauula Elementary School	T Kaaawa Beach Park	S Kahaluu Kam/Kahekili	R Kaneohe Kam/Heeia	P Kaneohe Kam/Likelike	J Downtown Bishop/Hotel	O Ala Moana Center Kona St
88A EXPRESS		.....	.....	.....	.....	.....	● 415a	417a	434a	442a	459a	513a	519a	533a	547a	EXPRESS	.....	618a	631a
88A EXPRESS		.....	.....	.....	❤ 408a via Kam Hwy		427a	434a	451a	459a	516a	530a	536a	550a	603a	EXPRESS	.....	634a	647a
.....	.....	.....	.....	.....	❤ 438a via Kam Hwy		454a	505a	525a	533a	548a	602a	607a	622a	637a	649a	702a	732a	747a
.....	.....	.....	.....	.....	❤ 503a via Kam Hwy		519a	530a	550a	558a	621a	635a	640a	655a	710a	722a	735a	805a	820a
.....	.....	.....	.....	.....	.....	.....	● 606a	608a	628a	636a	655a	710a	717a	732a	747a	758a	810a	835a	848a
.....	.....	.....	.....	.....	617a	622a	626a	637a	657a	705a	732a	748a	755a	809a	824a	834a	846a	911a	924a
.....	.....	.....	.....	.....	.....	.....	.....	709a	733a	741a	810a	827a	834a	847a	901a	910a	922a	947a	1000a
630a	642a	644a	650a	659a	719a	724a	728a	739a	803a	811a	845a	902a	909a	922a	936a	945a	957a	1022a	1035a
700a	712a	714a	720a	729a	749a	754a	758a	809a	833a	841a	920a	937a	944a	957a	1011a	1020a	1032a	1057a	1110a
735a	747a	749a	755a	804a	824a	829a	833a	844a	908a	916a	955a	1012a	1019a	1032a	1046a	1055a	1107a	1132a	1145a
810a	822a	824a	830a	839a	859a	904a	908a	919a	943a	951a	1025a	1042a	1049a	1102a	1116a	1125a	1137a	1202p	1215p
845a	857a	859a	905a	914a	934a	939a	943a	954a	1020a	1030a	1100a	1117a	1124a	1137a	1151a	1200p	1212p	1237p	1250p
916a	928a	930a	936a	945a	1005a	1010a	1014a	1025a	1051a	1101a	1130a	1147a	1154a	1207p	1221p	1230p	1242p	107p	120p
951a	1003a	1005a	1011a	1020a	1040a	1045a	1049a	1100a	1126a	1136a	1205p	1222p	1229p	1242p	1256p	105p	117p	142p	155p
1021a	1033a	1035a	1041a	1050a	1110a	1115a	1119a	1130a	1156a	1206p	1235p	1252p	1259p	112p	126p	135p	147p	212p	235p
1054a	1106a	1108a	1114a	1125a	1145a	1150a	1154a	1205p	1231p	1241p	110p	127p	134p	147p	201p	209p	221p	245p	308p
.....	.....	.....	.....	.....	.....	.....	.....	Wednesday school days only -			✖ 135p	144p	151p	204p	218p	.....	.....	.....	.....
1123a	1135a	1138a	1144a	1155a	1215p	1220p	1224p	1235p	101p	111p	140p	157p	204p	217p	231p	239p	251p	315p	338p
.....	.....	.....	.....	.....	.....	.....	Mon-Tues-Thur-Fri school days only -				✖ 225p	237p	244p	257p	311p	.....	.....	.....	.....
1158a	1210p	1213p	1219p	1230p	1250p	1255p	1259p	110p	136p	146p	220p	240p	247p	300p	314p	322p	334p	358p	421p
1228p	1240p	1243p	1249p	100p	120p	125p	129p	140p	204p	214p	245p	305p	312p	325p	339p	347p	359p	423p	447p
1258p	110p	113p	119p	130p	150p	156p	202p	216p	240p	250p	320p	339p	346p	401p	415p	423p	435p	459p	519p
129p	141p	144p	151p	202p	222p	228p	234p	248p	312p	322p	359p	418p	425p	440p	454p	502p	514p	538p	558p
213p	226p	229p	237p	248p	308p	314p	320p	334p	359p	409p	430p	448p	455p	508p	521p	529p	541p	604p	622p
239p	252p	255p	303p	314p	341p	347p	353p	407p	432p	442p	505p	523p	532p	544p	557p	604p	613p	634p	652p
301p	314p	317p	325p	338p	407p	413p	419p	433p	458p	507p	535p	553p	602p	614p	626p	633p	642p	703p	721p
332p	345p	348p	356p	409p	438p	444p	450p	504p	529p	538p	605p	618p	625p	637p	649p	656p	705p	726p	744p
410p	423p	426p	434p	447p	516p	522p	528p	542p	605p	614p	635p	648p	655p	707p	719p	726p	735p	756p	814p
436p	449p	452p	500p	513p	542p	548p	552p	606p	629p	638p	705p	718p	725p	737p	749p	756p	805p	826p	844p
515p	528p	531p	539p	552p	619p	624p	628p	639p	659p	708p	740p	753p	800p	812p	824p	831p	840p	901p	919p
615p	627p	629p	635p	647p	707p	712p	716p	727p	747p	756p	820p	833p	840p	852p	904p	911p	920p	941p	959p
715p	727p	729p	735p	746p	806p	811p	814p	824p	844p	853p	915p	928p	935p	947p	959p	1006p	1015p	1036p	1054p
815p	826p	828p	833p	843p	903p	908p	911p	921p	941p	950p	1010p	1023p	1030p	1042p	1054p	1101p	1110p	1131p	1149p

Route 52 & 55 Circle Isle Destination Signs:

Westbound: To Circle Isle via Mililani & Wahiawa - 52 MILILANI WAHIAWA CIRCLE ISLE
To Ala Moana Center - 55 HONOLULU ALA MOANA
To Bishop/King or Alakea/King - 55 DOWNTOWN BISHOP ST
Eastbound: To Circle Isle via Pali Hwy - 55 KANEOHE CIRCLE ISLE
To Ala Moana Center - 52 or 62 HONOLULU VIA PEARLRIDGE (see note)
To Kam/Honomanu - 52 or 62 PEARLRIDGE (see note)
To Alapai Street - 52 or 62 ALAPAI ST (see note)
(Note: Several p.m. buses leaving Wahiawa will continue along Kamehameha Hwy to Pearlridge, Alapai Street or Ala Moana. In Wahiawa, buses will change their signs to read either 62 PEARLRIDGE, 62 ALAPAI ST OR 62 HONOLULU ALA MOANA.)

Route 88A Destination Signs:

AM: From Kam/Honomanu & Kam/Avocado - 52 WAHIAWA CIRCLE ISLE
From Turtle Bay Resort - 88A EXPRESS DOWNTOWN VIA KAHEKILI
From Pali/Vineyard - 55 HONOLULU ALA MOANA
PM: From Ala Moana Center - 88A EXPRESS NORTH SHORE VIA KAHEKILI
From Kam/Kahekili - 55 KANEOHE CIRCLE ISLE
From Turtle Bay Resort - 52 ALAPAI ST or 52 PEARLRIDGE
**NOTE: Route 88A will also run on State Holidays

Bold indicates PM service.
Schedule to change without notice.
All buses are lift and bicycle rack equipped.

Route 52/55 Symbols

❤ - Starts/ends at Kamehameha Hwy/Honomanu
● - Starts at Kamehameha Hwy/Avocado
✖- Starts at Kamehameha/Pualalea Road

Route 52 - Wahiawa Circle Isle / Route 55 - Kaneohe Circle Isle / 88A - North Shore Express

Effective 8/24/08

Weekday: Eastbound: Via Pali Hwy/Kam Hwy to Kaneohe/North Shore/Wahiawa/Mililani/Honolulu

	O Ala Moana Center Kona St	K Downtown Alakea/Hotel	P Kaneohe Kam Hwy/Likelike	Q Kaneohe Kam Hwy/Haiku	S Kahaluu Kam Hwy/Kahekili	T Kaaawa Beach Park	U Hauula Elementary School	V Laie/Polynesian Cultural Center	A Turtle Bay Resort	B Pupukea Beach Park	C Haleiwa Beach Park	D Wahiawa California/Cane	E Mililani Kam Hwy/Kuahelani	F Mililani Transit Center	G Mililani Park & Ride	H Kalihi Kam Hwy/Middle	I Downtown King/Beretania	L Downtown Kapiolani/South	O Ala Moana Center Kona St
									430a	439a	447a	507a	518a	521a	525a	544a	553a	600a	605a
	.....	.....	408a	414a	425a	438a	451a	455a	510a	519a	527a	551a	602a	606a	610a	630a	640a	650a	657a
	.....	.....	453a	459a	510a	523a	536a	540a	555a	608a	616a	638a	649a	653a	657a	723a	739a	749a	759a
	.....	.....	518a	524a	535a	548a	601a	605a	625a	638a	646a	708a	719a	723a	730a	751a	807a	818a	828a
	.....	▲ 510a	532a	538a	549a	603a	617a	622a	645a	658a	706a	728a	739a	743a	748a	809a	825a	836a	846a
	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	750a	806a	810a	814a	833a	849a	900a	.....
	.....	▲ 545a	607a	613a	624a	638a	652a	657a	725a	738a	746a	811a	824a	828a	832a	851a	907a	918a	928a
	555a	608a	631a	638a	650a	705a	720a	725a	800a	813a	822a	849a	900a	904a	908a	927a	943a	954a	1004a
	625a	638a	701a	708a	721a	736a	751a	756a	830a	844a	853a	920a	931a	935a	939a	958a	1014a	1025a	1035a
	655a	708a	731a	739a	752a	807a	820a	827a	905a	919a	928a	955a	1006a	1010a	1014a	1033a	1049a	1100a	1110a
	725a	740a	805a	813a	825a	838a	851a	858a	935a	949a	958a	1025a	1036a	1040a	1044a	1103a	1119a	1130a	1140a
	805a	820a	845a	853a	905a	918a	931a	938a	1010a	1024a	1033a	1100a	1111a	1115a	1119a	1138a	1154a	**1205p**	**1215p**
	840a	855a	920a	928a	940a	953a	1006a	1013a	1040a	1054a	1103a	1130a	1141a	1145a	1149a	**1208p**	**1220p**	**1231p**	**1241p**
	915a	930a	955a	1003a	1015a	1028a	1041a	1048a	1115a	1129a	1138a	**1205p**	**1216p**	**1220p**	**1224p**	**1243p**	**1255p**	**106p**	**116p**
	945a	1000a	1025a	1033a	1045a	1058a	1111a	1118a	1145a	1159a	**1209p**	**1236p**	**1247p**	**1251p**	**1255p**	**114p**	**126p**	**137p**	**147p**
	1020a	1035a	1100a	1108a	1120a	1133a	1146a	1153a	**1220p**	**1234p**	**1244p**	**111p**	**122p**	**126p**	**130p**	**149p**	**201p**	**213p**	**223p**
	1050a	1105a	1130a	1138a	1150a	**1203p**	**1216p**	**1223p**	**1250p**	**104p**	**114p**	**141p**	**152p**	**156p**	**200p**	**219p**	**231p**	**243p**	**253p**
	1125a	1140a	**1205p**	**1213p**	**1225p**	**1238p**	**1251p**	**1258p**	**125p**	**139p**	**149p**	**216p**	**227p**	**231p**	**235p**	**254p**	**306p**	**318p**	**328p**
	1155a	**1210p**	**1235p**	**1243p**	**1255p**	**108p**	**121p**	**128p**	**155p**	**210p**	**220p**	**247p**	**258p**	**302p**	**306p**	**325p**	**337p**	**349p**	**359p**
	1230p	**1245p**	**110p**	**118p**	**130p**	**143p**	**156p**	**203p**	**230p**	**245p**	**255p**	**322p**	**333p**	**337p**	**341p**	**400p**	**412p**	**424p**	**434p**
	100p	**115p**	**140p**	**148p**	**200p**	**213p**	**226p**	**233p**	**300p**	**315p**	**325p**	**352p**	**403p**	**407p**	**411p**	**430p**	**442p**	**454p**	**504p**
	135p	**150p**	**215p**	**223p**	**235p**	**248p**	**301p**	**308p**	**335p**	**350p**	**400p**	**427p**	**438p**	**442p**	**446p**	**505p**	**517p**	**529p**	**539p**
	203p	**218p**	**243p**	**251p**	**303p**	**315p**	**328p**	**334p**	**410p**	**425p**	**435p**	**502p**	**513p**	**517p**	**521p**	**540p**	**548p**	**600p**	**610p**
	230p	**245p**	**310p**	**318p**	**330p**	**344p**	**358p**	**404p**	**440p**	**455p**	**505p**	**531p**	**542p**	**546p**	**550p**	**609p**	**617p**	**627p**	**637p**
	308p	**325p**	**350p**	**358p**	**411p**	**425p**	**439p**	**445p**	**510p**	**525p**	**535p**	**601p**	**612p**	**616p**	**620p**	**639p**	**647p**	**657p**	**705p**
	338p	**355p**	**420p**	**428p**	**441p**	**455p**	**508p**	**514p**	**545p**	**600p**	**610p**	**635p**	**646p**	**650p**	**654p**	**712p**	**719p**	**726p**	**733p**
**88A	**415p**	**435p**	**EXPRESS**	**.....**	**513p**	**526p**	**543p**	**548p**	**605p**	**618p**	**628p**	**652p**	**701p**	**.....**	Kam Hwy	**737p**	**743p**	■ **748p**	**.....**
	447p	**505p**	**530p**	**538p**	**551p**	**605p**	**618p**	**624p**	**652p**	**705p**	**714p**	**734p**	**745p**	**749p**	**753p**	**811p**	**818p**	**825p**	**832p**
**88A	**500p**	**530p**	**EXPRESS**	**.....**	**608p**	**621p**	**635p**	**643p**	**702p**	**721p**	**732p**	**752p**	**800p**	**.....**	Kam Hwy	❤ **821p**	**.....**	**.....**	**.....**
	540p	**601p**	**626p**	**632p**	**645p**	**657p**	**710p**	**715p**	**745p**	**758p**	**807p**	**827p**	**838p**	.....	Kam Hwy	**910p**	**917p**	**924p**	**931p**
	635p	**654p**	**717p**	**723p**	**735p**	**747p**	**800p**	**805p**	**825p**	**838p**	**847p**	**907p**	**918p**	.....	Kam Hwy	**950p**	**957p**	**1004p**	**101p**
	750p	**808p**	**831p**	**837p**	**849p**	**901p**	**914p**	**919p**	**945p**	**958p**	**1007p**	**1027p**	**1038p**	.....	Kam Hwy	**1110p**	**117p**	■ **1124p**	**.....**
	900p	**918p**	**941p**	**947p**	**959p**	**1011p**	**1024p**	**1029p**	**1050p**	**1103p**	**1112p**	**1132p**	**1143p**	.....	Kam Hwy	1215a	1222a	■ 1229p	.....
	1015p	**1033p**	**1056p**	**1102p**	**1114p**	**1126p**	**1139p**	**1144p**	1212a	1225a	1234a	1254a	105a	.....	Kam Hwy	▼ 117a	.....	.....	.....

Route 52 & 55 Circle Isle Destination Signs:

Westbound: To Circle Isle via Mililani & Wahiawa - 52 MILILANI WAHIAWA CIRCLE ISLE
To Ala Moana Center - 55 HONOLULU ALA MOANA
To Bishop/King or Alakea/King - 55 DOWNTOWN BISHOP ST
Eastbound: To Circle Isle via Pali Hwy - 55 KANEOHE CIRCLE ISLE
To Ala Moana Center - 52 or 62 HONOLULU VIA PEARLRIDGE (see note)
To Kam/Honomanu - 52 or 62 PEARLRIDGE (see note)
To Alapai Street - 52 or 62 ALAPAI ST (see note)
(Note: Several p.m. buses leaving Wahiawa will continue along Kamehameha Hwy to Pearlridge, Alapai Street or Ala Moana. In Wahiawa, buses will change their signs to read either 62 PEARLRIDGE, 62 ALAPAI ST OR 62 HONOLULU ALA MOANA.)

Route 88A Destination Signs:

AM: From Kam/Honomanu & Kam/Avocado - 52 WAHIAWA CIRCLE ISLE
From Turtle Bay Resort - 88A EXPRESS DOWNTOWN VIA KAHEKILI
From Pali/Vineyard - 55 HONOLULU ALA MOANA
PM: From Ala Moana Center - 88A EXPRESS NORTH SHORE VIA KAHEKILI
From Kam/Kahekili - 55 KANEOHE CIRCLE ISLE
From Turtle Bay Resort - 52 ALAPAI ST or 52 PEARLRIDGE
**NOTE: Route 88A will also run on State Holidays

Bold indicates PM service.
Schedule to change without notice.
All buses are lift and bicycle rack equipped.

Route 52/55 Symbols

▲ - Starts at Alakea/Queen 1 minute earlier
■ - Ends at Alapai St
❤ - Starts/ends at Kamehameha Hwy/Honomanu

Route 52 - Wahiawa Circle Isle / Route 55 - Kaneohe Circle Isle / 88A - North Shore Express

Effective 8/24/08

Saturday/State Holiday: Westbound: Via H-1/H-2 to Mililani/Wahiawa/North Shore/Kaneohe/Honolulu

Ala Moana Center Kona St (O)	Downtown Alapai/Hotel (M)	Downtown Beretania/Punchbowl (N)	Downtown King/Beretania (I)	Kalihi Kam Hwy/Middle (H)	Mililani Park & Ride (G)	Mililani Transit Center (F)	Mililani Kam Hwy/Kuahelani (E)	Wahiawa California/Cane (D)	Haleiwa Beach Park (C)	Pupukea Beach Park (B)	Turtle Bay Resort (A)	Laie/Polynesian Cultural Center (V)	Hauula Elementary School (U)	Kaaawa Beach Park (T)	Kahaluu Kam/Kahekili (S)	Kaneohe Kam/Heeia (R)	Kaneohe Kam/Likelike (P)	Downtown Bishop/Hotel (J)	Ala Moana Center Kona St (O)
**88A	.....	.....	.....	.....	.....	.....	★ ● 415a	★ 417a	★ 434a	★ 442a	★ 459a	★ 513a	★ 519a	★ 533a	★ 547a	EXPRESS	.....	★ 618a	★ 631a
**88A	.....	.....	.....		★ ❤ 408a via Kam Hwy		★ 427a	★ 434a	★ 451a	★ 459a	★ 516a	★ 530a	★ 536a	★ 550a	★ 603a	EXPRESS	.....	★ 634a	★ 647a
.....	.....	.....	.....		★ ❤ 430a via Kam Hwy		★ 455a	★ 505a	★ 525a	★ 534a	★ 550a	★ 605a	★ 610a	★ 622a	★ 635a	★ 643a	★ 652a	★ 714a	★ 733a
.....	.....	.....	.....		❤ 500a via Kam Hwy		525a	535a	555a	604a	625a	640a	645a	657a	710a	718a	728a	751a	810a
.....	.....	.....	.....	.....	.....	.....	● 607a	609a	629a	638a	700a	715a	720a	733a	746a	754a	805a	828a	847a
.....	.....	.....	.....	.....	.....	.....	.....	631a	651a	700a	730a	745a	750a	803a	816a	824a	836a	859a	918a
.....	.....	.....	.....	.....	.....	.....	● 707a	709a	729a	738a	801a	817a	822a	835a	848a	856a	908a	931a	950a
635a	645a	647a	652a	702a	722a	726a	729a	740a	800a	809a	834a	850a	855a	908a	921a	929a	941a	1004a	1023a
700a	710a	712a	718a	729a	749a	753a	756a	807a	827a	836a	906a	922a	928a	941a	954a	1002a	1014a	1037a	1056a
730a	740a	742a	748a	759a	819a	823a	826a	837a	857a	906a	939a	955a	1001a	1014a	1027a	1035a	1047a	1110a	1129a
803a	813a	815a	821a	832a	852a	856a	859a	910a	934a	943a	1012a	1028a	1034a	1047a	1100a	1108a	1120a	1143a	**1202p**
834a	844a	846a	852a	903a	923a	928a	932a	943a	1007a	1017a	1045a	1101a	1107a	1120a	1133a	1141a	1153a	**1216p**	**1235p**
904a	917a	919a	925a	936a	956a	1001a	1005a	1016a	1040a	1050a	1118a	1134a	1140a	1153a	**1206p**	**1214p**	**1226p**	**1249p**	**108p**
937a	950a	952a	958a	1009a	1029a	1034a	1038a	1049a	1113a	1123a	1151a	**1207p**	**1213p**	**1226p**	**1239p**	**1247p**	**1259p**	**122p**	**141p**
1006a	1020a	1023a	1030a	1041a	1101a	1106a	1110a	1122a	1146a	1156a	**1224p**	**1240p**	**1246p**	**1259p**	**112p**	**120p**	**132p**	**155p**	**214p**
1037a	1051a	1054a	1101a	1112a	1132a	1138a	1143a	1155a	**1219p**	**1229p**	**1257p**	**113p**	**119p**	**132p**	**145p**	**153p**	**205p**	**228p**	**247p**
1110a	1124a	1127a	1134a	1145a	**1205p**	**1211p**	**1216p**	**1228p**	**1252p**	**102p**	**130p**	**146p**	**152p**	**205p**	**218p**	**226p**	**238p**	**301p**	**320p**
1143a	1157a	**1200p**	**1207p**	**1218p**	**1238p**	**1244p**	**1249p**	**101p**	**125p**	**139p**	**203p**	**219p**	**225p**	**238p**	**251p**	**259p**	**311p**	**334p**	**353p**
1216p	**1230p**	**1233p**	**1240p**	**1251p**	**111p**	**117p**	**122p**	**134p**	**158p**	**212p**	**236p**	**252p**	**258p**	**311p**	**324p**	**332p**	**344p**	**407p**	**426p**
1249p	**103p**	**106p**	**113p**	**124p**	**144p**	**150p**	**155p**	**207p**	**231p**	**245p**	**309p**	**325p**	**331p**	**344p**	**357p**	**405p**	**417p**	**440p**	**459p**
120p	**137p**	**139p**	**146p**	**157p**	**217p**	**223p**	**228p**	**240p**	**304p**	**318p**	**342p**	**358p**	**404p**	**417p**	**430p**	**438p**	**450p**	**513p**	**532p**
153p	**210p**	**212p**	**219p**	**230p**	**250p**	**256p**	**301p**	**313p**	**337p**	**351p**	**415p**	**431p**	**437p**	**450p**	**503p**	**511p**	**523p**	**546p**	**605p**
226p	**243p**	**245p**	**252p**	**303p**	**323p**	**329p**	**334p**	**346p**	**410p**	**424p**	**448p**	**504p**	**510p**	**523p**	**536p**	**544p**	**556p**	**617p**	**636p**
257p	**314p**	**316p**	**323p**	**334p**	**356p**	**402p**	**407p**	**419p**	**443p**	**457p**	**522p**	**538p**	**544p**	**557p**	**610p**	**618p**	**627p**	✚ **647p**	.....
327p	**344p**	**346p**	**353p**	**404p**	**429p**	**435p**	**440p**	**452p**	**516p**	**524p**	**558p**	**613p**	**618p**	**630p**	**643p**	**651p**	**700p**	**720p**	**739p**
403p	**420p**	**422p**	**429p**	**440p**	**504p**	**510p**	**515p**	**525p**	**549p**	**557p**	**631p**	**646p**	**651p**	**703p**	**716p**	**724p**	**733p**	✚ **753p**	.....
442p	**457p**	**459p**	**506p**	**517p**	**537p**	**543p**	**548p**	**558p**	**620p**	**628p**	**705p**	**720p**	**725p**	**737p**	**750p**	**758p**	**807p**	**827p**	**846p**
520p	**532p**	**534p**	**541p**	**552p**	**612p**	**617p**	**621p**	**631p**	**653p**	**701a**	**735p**	**750p**	**755p**	**807p**	**820p**	**828p**	**837p**	**857p**	**910p**
610p	**622p**	**624p**	**631p**	**639p**	**659p**	**704p**	**708p**	**718p**	**740p**	**748a**	**805p**	**820p**	**825p**	**837p**	**850p**	**858p**	**907p**	**927p**	**939p**
710p	**722p**	**724p**	**731p**	**739p**	**759p**	**804p**	**808p**	**818p**	**840p**	**848p**	**905p**	**920p**	**925p**	**937p**	**950p**	**958p**	**1007p**	**1027p**	**1039p**
810p	**822p**	**824p**	**831p**	**839p**	**859p**	**904p**	**908p**	**918p**	**940p**	**948a**	**1000p**	**1015p**	**1020p**	**1032p**	**1045p**	**1053p**	**1102p**	**1122p**	**1134p**

Route 52 & 55 Circle Isle Destination Signs:

Westbound: To Circle Isle via Mililani & Wahiawa - 52 MILILANI WAHIAWA CIRCLE ISLE
To Ala Moana Center - 55 HONOLULU ALA MOANA
To Bishop/King or Alakea/King - 55 DOWNTOWN BISHOP ST
Eastbound: To Circle Isle via Pali Hwy - 55 KANEOHE CIRCLE ISLE
To Ala Moana Center - 52 or 62 HONOLULU VIA PEARLRIDGE (see note)
To Kam/Honomanu - 52 or 62 PEARLRIDGE (see note)
To Alapai Street - 52 or 62 ALAPAI ST (see note)
(Note: Several p.m. buses leaving Wahiawa will continue along Kamehameha Hwy to Pearlridge, Alapai Street or Ala Moana. In Wahiawa, buses will change their signs to read either 62 PEARLRIDGE, 62 ALAPAI ST OR 62 HONOLULU ALA MOANA.)

Bold indicates PM service.
Schedule to change without notice.
All buses are lift and bicycle rack equipped.

Route 88A Destination Signs:

AM: From Kam/Honomanu & Kam/Avocado -
52 WAHIAWA CIRCLE ISLE
From Turtle Bay Resort -
88A EXPRESS DOWNTOWN VIA KAHEKILI
From Pali/Vineyard -
55 HONOLULU ALA MOANA
PM: From Ala Moana Center -
88A EXPRESS NORTH SHORE VIA KAHEKILI
From Kam/Kahekili - 55 KANEOHE CIRCLE ISLE
From Turtle Bay Resort - 52 ALAPAI ST or 52 PEARLRIDGE
**NOTE: Route 88A will also run on State Holidays

❖ - Ends at Kamehameha Hwy/Pali Momi

Route 52/55 Symbols

▲ - Starts at Alakea/Queen 1 minute earlier
✚ - Ends at Bishop/King 1 minute later
■ - Ends at Alapai St
✔ - Starts at Beretania/Punchbowl
❤ - Starts/ends at Kamehameha Hwy/Honomanu
● - Starts at Kamehameha Hwy/Avocado
✖ - Starts at Kamehameha/Pualalea Road
◆ - School holiday operation only
★ - State holiday operation only
❍ - Saturday operation only. Does not run on State holidays
❐ - Does not service bus stop fronting Windward City Shopping Center

Route 52 - Wahiawa Circle Isle / Route 55 - Kaneohe Circle Isle / 88A - North Shore Express

Effective 8/24/08

Saturday/State Holiday: Eastbound: Via Pali Hwy/Kam Hwy to Kaneohe/North Shore/Wahiawa/Mililani/Honolulu

O Ala Moana Center Kona St	K Downtown Alakea/Hotel	P Kaneohe Kam Hwy/Likelike	Q Kaneohe Kam Hwy/Haiku	S Kahaluu Kam Hwy/Kahekili	T Kaaawa Beach Park	U Hauula Elementary School	V Laie/Polynesian Cultural Center	A Turtle Bay Resort	B Pupukea Beach Park	C Haleiwa Beach Park	D Wahiawa California/Cane	E Mililani Kam Hwy/Kuahelani	F Mililani Transit Center	G Mililani Park & Ride	H Kalihi Kam Hwy/Middle	I Downtown King/Beretania	L Downtown Kapiolani/South	O Ala Moana Center Kona St
.....	.....	.....	.....	.....	.....	.....	.....	★ 428a	★ 441a	★ 450a	★ 513a	★ 523a	★ 527a	★ 533a	★ 552a	★ 602a	★ 607a	★ 613a
.....	.....	❏ ★ 405a	★ 410a	★ 422a	★ 436a	★ 449a	★ 455a	★ 510a	★ 523a	★ 532a	★ 555a	★ 605a	★ 609a	★ 615a	★ 634a	★ 644a	★ 649a	★ 655a
.....	.....	❏ 445a	450a	502a	516a	529a	535a	555a	608a	617a	640a	650a	654a	700a	719a	729a	737a	743a
.....	.....	❏ ★ 510a	★ 515a	★ 527a	★ 541a	★ 554a	★ 600a	★ 625a	★ 638a	★ 647a	★ 710a	★ 721a	★ 725a	★ 731a	★ 750a	★ 800a	★ 808a	★ 814a
.....	▲ 510a	531a	536a	548a	602a	615a	621a	650a	703a	712a	735a	746a	750a	756a	815a	825a	833a	839a
.....	▲ 545a	606a	611a	623a	637a	650a	656a	720a	733a	742a	805a	816a	820a	826a	845a	855a	906a	914a
555a	608a	629a	634a	646a	700a	713a	719a	747a	800a	809a	832a	843a	847a	853a	912a	924a	935a	943a
620a	633a	654a	659a	711a	725a	738a	744a	820a	833a	842a	905a	916a	920a	926a	945a	957a	1008a	1016a
650a	703a	724a	729a	741a	755a	808a	814a	850a	906a	915a	938a	949a	953a	959a	1018a	1030a	1041a	1049a
720a	733a	754a	759a	811a	825a	838a	844a	922a	938a	947a	1011a	1022a	1026a	1032a	1051a	1103a	1114a	1122a
750a	804a	825a	832a	844a	858a	911a	917a	950a	1006a	1018a	1044a	1055a	1059a	1105a	1124a	1136a	1147a	1155a
821a	837a	858a	905a	917a	931a	944a	950a	1023a	1039a	1051a	1117a	1128a	1132a	1138a	1157a	1209p	1220p	1228p
852a	908a	931a	938a	950a	1004a	1017a	1023a	1056a	1112a	1124a	1150a	1203p	1207p	1213p	1232p	1244p	1255p	103p
925a	941a	1004a	1011a	1023a	1037a	1050a	1056a	1129a	1145a	1157a	1223p	1236p	1240p	1246p	105p	117p	128p	136p
958a	1014a	1037a	1044a	1056a	1110a	1123a	1129a	1202p	1218p	1230p	1256p	109p	113p	119p	138p	150p	201p	209p
1031a	1047a	1110a	1117a	1129a	1143a	1156a	1202p	1235p	1251p	103p	129p	142p	146p	152p	211p	223p	234p	242p
1104a	1120a	1143a	1150a	1202p	1216p	1229p	1235p	108p	124p	136p	202p	215p	219p	225p	244p	256p	307p	315p
1137a	1153a	1216p	1223p	1235p	1249p	102p	108p	141p	157p	209p	235p	248p	252p	258p	317p	329p	337p	345p
1210p	1226p	1249p	1256p	108p	122p	135p	141p	214p	230p	242p	308p	321p	325p	331p	356p	407p	415p	423p
1243p	1259p	122p	129p	141p	155p	208p	214p	247p	303p	315p	341p	354p	358p	404p	429p	440p	448p	456p
116p	132p	155p	202p	214p	228p	241p	247p	320p	336p	348p	414p	425p	429p	435p	454p	505p	513p	521p
149p	205p	228p	235p	247p	301p	314p	320p	353p	409p	421p	447p	458p	502p	508p	527p	538p	■ 546p	.....
216p	238p	301p	308p	320p	334p	347p	353p	426p	442p	454p	520p	531p	535p	541p	600p	609p	■ 617p	.....
249p	311p	334p	341p	353p	407p	420p	426p	459p	515p	527p	553p	604p	608p	614p	633p	642p	■ 650p	.....
322p	344p	407p	414p	426p	440p	453p	459p	535p	551p	603p	626p	637p	641p	647p	706p	715p	722p	729p
355p	417p	440p	447p	459p	513p	526p	532p	610p	626p	638p	701p	712p	716p	722p	741p	750p	757p	804p
★ 415p	★ 435p	EXPRESS	.....	★ 513p	★ 526p	★ 543p	★ 548p	★ 605p	★ 618p	★ 628p	★ 652p	★ 701p	.....	Kam Hwy	★ 737p	★ 743p	■ 748p	.....
428p	450p	513p	520p	532p	546p	559p	605p	645p	701p	713p	731p	742p	.....	Kam Hwy	❖ 806p	.....	.....	.....
★ 500p	★ 530p	EXPRESS	.....	★ 608p	★ 621p	★ 635p	★ 643p	★ 702p	★ 721p	★ 732p	★ 752p	★ 800p	.....	Kam Hwy	★❤ 821p	.....	.....	.....
525p	547p	609p	616p	628p	642p	655p	701p	720p	734p	746p	804p	813p	.....	Kam Hwy	844p	853a	900p	907p
635p	649p	710p	717p	729p	743p	756p	802p	825p	839p	847p	905p	914p	.....	Kam Hwy	945p	954p	1001p	1008p
745p	759p	820p	827p	839p	853p	906p	912p	930p	944p	952p	1010p	1019p	.....	Kam Hwy	1047p	1056p	■ 1103p	.....
900p	914p	935p	942p	954p	1008p	1021p	1027p	1045p	1059p	1107p	1125p	1134p	.....	Kam Hwy	1202a	1211a	■ 1218a	.....
1010p	1024p	1045p	1052p	1104p	1118p	1131p	1137p	1155p	1209a	1217a	1235a	1244a	.....	Kam Hwy	112a	121a	■ 128a	.....

Route 52 & 55 Circle Isle Destination Signs:

Westbound: To Circle Isle via Mililani & Wahiawa - 52 MILILANI WAHIAWA CIRCLE ISLE

To Ala Moana Center - 55 HONOLULU ALA MOANA

To Bishop/King or Alakea/King - 55 DOWNTOWN BISHOP ST

Eastbound: To Circle Isle via Pali Hwy - 55 KANEOHE CIRCLE ISLE

To Ala Moana Center - 52 or 62 HONOLULU VIA PEARLRIDGE (see note)

To Kam/Honomanu - 52 or 62 PEARLRIDGE (see note)

To Alapai Street - 52 or 62 ALAPAI ST (see note)

(Note: Several p.m. buses leaving Wahiawa will continue along Kamehameha Hwy to Pearlridge, Alapai Street or Ala Moana. In Wahiawa, buses will change their signs to read either 62 PEARLRIDGE, 62 ALAPAI ST OR 62 HONOLULU ALA MOANA.)

Route 88A Destination Signs:

AM: From Kam/Honomanu & Kam/Avocado -

52 WAHIAWA CIRCLE ISLE

From Turtle Bay Resort -

88A EXPRESS DOWNTOWN VIA KAHEKILI

From Pali/Vineyard -

55 HONOLULU ALA MOANA

PM: From Ala Moana Center -

88A EXPRESS NORTH SHORE VIA KAHEKILI

From Kam/Kahekili - 55 KANEOHE CIRCLE ISLE

From Turtle Bay Resort - 52 ALAPAI ST or 52 PEARLRIDGE

**NOTE: Route 88A will also run on State Holidays

Route 52/55 Symbols

▲ - Starts at Alakea/Queen 1 minute earlier

■ - Ends at Alapai St

★ - State holiday operation only

❏ - Does not service bus stop fronting Windward City Shopping Center

❖ - Ends at Kamehameha Hwy/Pali Momi

Bold indicates PM service.

Schedule to change without notice.

All buses are lift and bicycle rack equipped.

Route 52 - Wahiawa Circle Isle / Route 55 - Kaneohe Circle Isle / 88A - North Shore Express

Effective 8/24/08

Sunday: Westbound: Via H-1/H-2 to Mililani/Wahiawa/North Shore/Kaneohe/Honolulu

Ala Moana Center Kona St (O)	Downtown Alapai/Hotel (M)	Downtown Beretania/Punchbowl (N)	Downtown King/Beretania (I)	Kalihi Kam Hwy/Middle (H)	Mililani Park & Ride (G)	Mililani Transit Center (F)	Mililani Kam Hwy/Kuahelani (E)	Wahiawa California/Cane (D)	Haleiwa Beach Park (C)	Pupukea Beach Park (B)	Turtle Bay Resort (A)	Laie/Polynesian Cultural Center (V)	Hauula Elementary School (U)	Kaaawa Beach Park (T)	Kahaluu Kam/Kahekili (S)	Kaneohe Kam/Heeia (R)	Kaneohe Kam/Likelike (P)	Downtown Bishop/Hotel (J)	Ala Moana Center Kona St (O)
.....	.....	.....	.....	.....	.....	.....	● 543a	545a	603a	614a	634a	648a	653a	707a	721a	730a	738a	800a	812a
.....	.....	.....	.....	.....	.....	.....	● 637a	639a	657a	708a	732a	746a	751a	806a	821a	832a	842a	907a	920a
.....	.....	.....	.....	.....	.....	.....	● 707a	709a	727a	738a	802a	816a	821a	836a	851a	902a	912a	937a	950a
636a	646a	648a	654a	702a	721a	726a	729a	739a	758a	809a	832a	846a	851a	906a	921a	932a	942a	1007a	1020a
700a	712a	714a	720a	729a	749a	754a	758a	809a	829a	840a	902a	916a	921a	936a	951a	1002a	1012a	1037a	1050a
Then every 30 minutes from Ala Moana Center until																			
230p	**242p**	**244p**	**250p**	**259p**	**319p**	**324p**	**328p**	**339p**	**359p**	**410p**	**432p**	**446p**	**451p**	**504p**	**517p**	**525p**	**534p**	**556p**	**608p**
300p	**312p**	**314p**	**320p**	**329p**	**349p**	**354p**	**358p**	**409p**	**429p**	**440p**	**505p**	**519p**	**524p**	**536p**	**548p**	**556p**	**605p**	**627p**	**639p**
330p	**342p**	**344p**	**350p**	**359p**	**419p**	**424p**	**428p**	**439p**	**459p**	**510p**	**535p**	**549p**	**554p**	**606p**	**618p**	**626p**	**635p**	**657p**	**709p**
400p	**412p**	**414p**	**420p**	**429p**	**449p**	**454p**	**458p**	**509p**	**529p**	**540p**	**605p**	**619p**	**624p**	**636p**	**648p**	**656p**	**705p**	**✚ 727p**	**.....**
430p	**442p**	**444p**	**450p**	**459p**	**519p**	**524p**	**528p**	**539p**	**558p**	**609p**	**630p**	**644p**	**649p**	**701p**	**713p**	**721p**	**730p**	**✚ 752p**	**.....**
500p	**512p**	**514p**	**520p**	**529p**	**549p**	**554p**	**558p**	**608p**	**627p**	**638p**	**700p**	**714p**	**719p**	**731p**	**743p**	**751p**	**800p**	**822p**	**834p**
530p	**542p**	**544p**	**550p**	**559p**	**618p**	**623p**	**626p**	**636p**	**655p**	**706p**	**730p**	**744p**	**749p**	**801p**	**813p**	**821p**	**830p**	**852p**	**904p**
615p	**625p**	**627p**	**633p**	**641p**	**700p**	**705p**	**708p**	**718p**	**737p**	**748p**	**805p**	**819p**	**824p**	**836p**	**848p**	**856p**	**905p**	**927p**	**939p**
715p	**725p**	**727p**	**733p**	**741p**	**800p**	**805p**	**808p**	**818p**	**837p**	**848p**	**905p**	**919p**	**924p**	**936p**	**948p**	**956p**	**1005p**	**1027p**	**1039p**
815p	**824p**	**826p**	**831p**	**839p**	**856p**	**900p**	**903p**	**913p**	**931p**	**942p**	**1000p**	**1014p**	**1019p**	**1031p**	**1043p**	**1051p**	**1100p**	**1122p**	**1134p**

Route 52 & 55 Circle Isle Destination Signs:

Westbound: To Circle Isle via Mililani & Wahiawa - 52 MILILANI WAHIAWA CIRCLE ISLE
To Ala Moana Center - 55 HONOLULU ALA MOANA
To Bishop/King or Alakea/King - 55 DOWNTOWN BISHOP ST
Eastbound: To Circle Isle via Pali Hwy - 55 KANEOHE CIRCLE ISLE
To Ala Moana Center - 52 or 62 HONOLULU VIA PEARLRIDGE (see note)
To Kam/Honomanu - 52 or 62 PEARLRIDGE (see note)
To Alapai Street - 52 or 62 ALAPAI ST (see note)
(Note: Several p.m. buses leaving Wahiawa will continue along Kamehameha Hwy to Pearlridge, Alapai Street or Ala Moana. In Wahiawa, buses will change their signs to read either 62 PEARLRIDGE, 62 ALAPAI ST OR 62 HONOLULU ALA MOANA.)

Bold indicates PM service.
Schedule to change without notice.
All buses are lift and bicycle rack equipped.

Route 88A Destination Signs:

AM: From Kam/Honomanu & Kam/Avocado -
52 WAHIAWA CIRCLE ISLE
From Turtle Bay Resort -
88A EXPRESS DOWNTOWN VIA KAHEKILI
From Pali/Vineyard -
55 HONOLULU ALA MOANA
PM: From Ala Moana Center -
88A EXPRESS NORTH SHORE VIA KAHEKILI
From Kam/Kahekili - 55 KANEOHE CIRCLE ISLE
From Turtle Bay Resort - 52 ALAPAI ST or 52 PEARLRIDGE
**NOTE: Route 88A will also run on State Holidays

Route 52/55 Symbols

▲ - Starts at Alakea/Queen 1 minute earlier
✚ - Ends at Bishop/King 1 minute later
■ - Ends at Alapai St
✔ - Starts at Beretania/Punchbowl
❤ - Starts/ends at Kamehameha Hwy/Honomanu
● - Starts at Kamehameha Hwy/Avocado
✖ - Starts at Kamehameha/Pualalea Road
◆ - School holiday operation only
★ - State holiday operation only
❍ - Saturday operation only. Does not run on State holidays
❒ - Does not service bus stop fronting Windward City Shopping Center
❖ - Ends at Kamehameha Hwy/Pali Momi

Route 52 - Wahiawa Circle Isle / Route 55 - Kaneohe Circle Isle / 88A - North Shore Express

Effective 8/24/08

Sunday: Eastbound: Via Pali Hwy/Kam Hwy to Kaneohe/North Shore/Wahiawa/Mililani/Honolulu

Ala Moana Center Kona St (O)	Downtown Alakea/Hotel (K)	Kaneohe Kam Hwy/Likelike (P)	Kaneohe Kam Hwy/Haiku (Q)	Kahaluu Kam Hwy/Kahekili (S)	Kaaawa Beach Park (T)	Hauula Elementary School (U)	Laie/Polynesian Cultural Center (V)	Turtle Bay Resort (A)	Pupukea Beach Park (B)	Haleiwa Beach Park (C)	Wahiawa California/Cane (D)	Mililani Kam Hwy/Kuahelani (E)	Mililani Transit Center (F)	Mililani Park & Ride (G)	Kalihi Kam Hwy/Middle (H)	Downtown King/Beretania (I)	Downtown Kapiolani/South (L)	Ala Moana Center Kona St (O)
.....	.....	❑ 453a	459a	510a	523a	536a	540a	555a	609a	620a	640a	651a	654a	700a	719a	728a	736a	742a
.....	▲ 510a	532a	538a	549a	603a	617a	622a	652a	706a	717a	737a	748a	751a	757a	816a	825a	833a	839a
.....	▲ 545a	607a	613a	624a	638a	652a	657a	722a	736a	747a	807a	818a	821a	827a	846a	855a	903a	909a
555a	608a	631a	638a	650a	705a	720a	725a	752a	806a	817a	837a	848a	851a	857a	916a	925a	933a	939a
625a	638a	701a	708a	720a	735a	750a	755a	822a	836a	847a	907a	918a	921a	927a	946a	955a	1003a	1009a
649a	702a	725a	732a	745a	800a	814a	819a	852a	906a	917a	937a	948a	951a	957a	1016a	1025a	1033a	1039a
719a	734a	759a	807a	820a	833a	846a	851a	922a	936a	947a	1007a	1018a	1021a	1027a	1046a	1055a	1103a	1109a
749a	804a	829a	837a	850a	903a	916a	921a	952a	1006a	1017a	1037a	1048a	1051a	1057a	1116a	1125a	1133a	1139a
819a	834a	859a	907a	920a	933a	946a	951a	1022a	1036a	1047a	1107a	1118a	1121a	1127a	1146a	1155a	1203p	1209p
849a	904a	929a	937a	950a	1003a	1016a	1021a	1052a	1106a	1117a	1137a	1148a	1151a	1157a	1216p	1225p	1233p	1239p
919a	934a	959a	1007a	1020a	1033a	1046a	1051a	1122a	1136a	1147a	1207p	1218p	1221p	1227p	1246p	1255p	103p	109p
949a	1004a	1029a	1037a	1050a	1103a	1116a	1121a	1152a	1206p	1217p	1237p	1248p	1251p	1257p	116p	125p	133p	139p
1019a	1034a	1059a	1107a	1120a	1133a	1146a	1151a	1222p	1236p	1247p	107p	118p	121p	127p	146p	155p	203p	209p
1049a	1104a	1129a	1137a	1150a	1203p	1216p	1221p	1252p	106p	117p	137p	148p	151p	157p	216p	225p	233p	239p
1119a	1134a	1159a	1207p	1220p	1233p	1246p	1251p	122p	136p	147p	207p	218p	221p	227p	246p	255p	303p	309p
1149a	1204p	1229p	1237p	1250p	103p	116p	121p	152p	206p	217p	237p	248p	251p	257p	316p	325p	333p	339p
1219p	1234p	1259p	107p	120p	133p	146p	151p	222p	236p	247p	307p	318p	321p	327p	346p	355p	403p	409p
1249p	104p	129p	137p	150p	203p	216p	221p	252p	306p	317p	337p	348p	351p	357p	416p	425p	433p	439p
119p	134p	159p	207p	220p	233p	246p	251p	322p	336p	347p	407p	418p	421p	427p	446p	455p	503p	509p
149p	204p	229p	237p	250p	303p	316p	321p	352p	406p	417p	437p	448p	451p	457p	516p	525p	■ 533p	.....
219p	234p	259p	307p	320p	333p	346p	351p	422p	436p	447p	507p	518p	521p	527p	546p	555p	■ 603p	.....
249p	304p	329p	337p	350p	403p	416p	421p	452p	506p	517p	537p	548p	551p	557p	616p	623p	■ 633p	.....
319p	334p	359p	407p	420p	433p	446p	451p	522p	536p	547p	607p	617p	620p	624p	644p	650p	■ 703p	.....
349p	404p	429p	437p	450p	503p	516p	521p	552p	605p	616p	635p	647p	.....	Kam Hwy	❖ 705p	.....	.....	.....
419p	434p	459p	507p	520p	533p	546p	551p	622p	635p	646p	705p	715p	718p	722p	739p	748p	755p	800p
449p	504p	529p	537p	548p	600p	613p	617p	652p	705p	715p	733p	744p	.....	Kam Hwy	❖ 802p	.....	.....	.....
535p	548p	611p	617p	628p	640p	653p	657p	725p	737p	747p	805p	814p	.....	Kam Hwy	843p	851p	857p	902p
635p	648p	710p	716p	727p	739p	752p	756p	825p	837p	847p	905p	914p	.....	Kam Hwy	943p	951p	957p	1002p
745p	758p	820p	826p	837p	849p	902p	906p	932p	944p	954p	1012p	1021p	.....	Kam Hwy	1050p	1058p	■ 1104p	.....
900p	913p	935p	941p	952p	1004p	1017p	1021p	1040p	1052p	1102p	1120p	1129p	.....	Kam Hwy	1158p	1206a	■ 1212a	.....
1010p	1023p	1045p	1051p	1102p	1114p	1127p	1131p	1155p	1207a	1217a	1235a	1244a	.....	Kam Hwy	113a	121a	■ 127a	.....

Route 52 & 55 Circle Isle Destination Signs:

Westbound: To Circle Isle via Mililani & Wahiawa - 52 MILILANI WAHIAWA CIRCLE ISLE
To Ala Moana Center - 55 HONOLULU ALA MOANA
To Bishop/King or Alakea/King - 55 DOWNTOWN BISHOP ST
Eastbound: To Circle Isle via Pali Hwy - 55 KANEOHE CIRCLE ISLE
To Ala Moana Center - 52 or 62 HONOLULU VIA PEARLRIDGE (see note)
To Kam/Honomanu - 52 or 62 PEARLRIDGE (see note)
To Alapai Street - 52 or 62 ALAPAI ST (see note)
(Note: Several p.m. buses leaving Wahiawa will continue along Kamehameha Hwy to Pearlridge, Alapai Street or Ala Moana. In Wahiawa, buses will change their signs to read either 62 PEARLRIDGE, 62 ALAPAI ST OR 62 HONOLULU ALA MOANA.)

Route 88A Destination Signs:

AM: From Kam/Honomanu & Kam/Avocado -
52 WAHIAWA CIRCLE ISLE
From Turtle Bay Resort -
88A EXPRESS DOWNTOWN VIA KAHEKILI
From Pali/Vineyard -
55 HONOLULU ALA MOANA
PM: From Ala Moana Center -
88A EXPRESS NORTH SHORE VIA KAHEKILI
From Kam/Kahekili - 55 KANEOHE CIRCLE ISLE
From Turtle Bay Resort - 52 ALAPAI ST or 52 PEARLRIDGE
**NOTE: Route 88A will also run on State Holidays

Route 52/55 Symbols

▲ - Starts at Alakea/Queen 1 minute earlier
■ - Ends at Alapai St
❖ - Ends at Kamehameha Hwy/Pali Momi
❑ - Does not service bus stop fronting Windward City Shopping Center

Bold indicates PM service.
Schedule to change without notice.
All buses are lift and bicycle rack equipped.

Route 62 - Wahiawa Heights and 62 - Wahiawa **Effective 8/24/08**

Weekday: Eastbound: To Honolulu

A Wahiawa Heights Calfornia/Grand View	B Wahiawa California/Cane	C Mililani Kam Hwy/ Kuahelani	D Waikele Kam Hwy/ Lumiauau	E Kam Hwy Opp Pearl City Shopping Ctr	F Opp Pearlridge Kam/Pali Momi	G Aiea Kam Hwy/Salt Lake	H Rodgers Nimitz	I Kalihi Kam Hwy/Middle	K Downtown King St/ Beretania	L Downtown Kapiolani/ South	Q Ala Moana Center Kona St
440a	450a	500a	507a	511a	516a	518a	526a	531a	540a	547a	552a
.....	◆ 500a	510a	517a	521a	526a	528a	536a	541a	550a	557a	602a
510a	520a	531a	538a	543a	548a	551a	559a	604a	614a	624a	629a
.....	◆ 535a	546a	555a	601a	608a	611a	621a	627a	637a	647a	654a
540a	550a	603a	615a	621a	630a	633a	643a	650a	702a	712a	722a
605a	615a	627a	639a	645a	654a	657a	709a	716a	732a	742a	752a
.....	628a	639a	651a	657a	706a	709a	720a	727a	743a	754a	804a
633a	645a	656a	708a	714a	724a	727a	737a	744a	800a	811a	821a
704a	715a	726a	738a	744a	754a	757a	807a	814a	830a	841a	851a
730a	740a	754a	806a	812a	822a	825a	835a	842a	858a	909a-Alapai	
750a	800a	816a	828a	834a	844a	847a	857a	904a	916a	927a	937a
816a	826a	842a	854a	900a	910a	913a	923a	930a	942a	953a	1003a
851a	901a	917a	929a	935a	945a	948a	958a	1005a	1017a	1028a	1038a
926a	936a	952a	1004a	1010a	1020a	1023a	1033a	1040a	1052a	1103a	1113a
958a	1008a	1024a	1036a	1042a	1052a	1055a	1105a	1112a	1124a	1135a	1145a
1031a	1041a	1057a	1109a	1115a	1125a	1128a	1138a	1145a	1157a	**1208p**	**1218p**
1103a	1113a	1129a	1141a	1147a	1157a	**1200p**	**1210p**	**1217p**	**1229p**	**1240p**	**1250p**
1136a	1146a	**1202p**	**1214p**	**1220p**	**1230p**	**1233p**	**1243p**	**1250p**	**102p**	**114p**	**124p**
1208p	**1218p**	**1234p**	**1246p**	**1252p**	**102p**	**105p**	**115p**	**122p**	**134p**	**146p**	**156p**
1241p	**1251p**	**105p**	**117p**	**123p**	**133p**	**136p**	**146p**	**153p**	**205p**	**217p**	**227p**
113p	**123p**	**134p**	**146p**	**152p**	**202p**	**205p**	**215p**	**222p**	**234p**	**246p**	**256p**
146p	**156p**	**207p**	**219p**	**225p**	**235p**	**238p**	**248p**	**255p**	**307p**	**319p**	**329p**
218p	**228p**	**239p**	**251p**	**257p**	**307p**	**310p**	**320p**	**327p**	**339p**	**351p**	**401p**
255p	**305p**	**316p**	**328p**	**334p**	**344p**	**347p**	**357p**	**404p**	**416p**	**428p**	**438p**
333p	**343p**	**354p**	**406p**	**412p**	**422p**	**425p**	**435p**	**442p**	**454p**	**506p**	**516p**
405p	**415p**	**426p**	**438p**	**444p**	**454p**	**457p**	**507p**	**514p**	**526p**	**538p**	**548p**
411p	**421p**	**422p**-Kam/Olive		.....	.....	.....	.....	.....	.....	.....	.....
440p	**450p**	**501p**	**513p**	**519p**	**529p**	**532p**	**542p**	**549p**	**557p**	**608p**	**618p**
517p	**527p**	**538p**	**550p**	**555p**	**602p**	.....	.....	.....	.....	.....	.....
555p	**604p**	**615p**	**626p**	**631p**	**638p**	**640p**	**648p**	**653p**	**701p**	**708p**	**715p**
610p	**619p**	**630p**	**641p**	**646p**	**653p**	.....	.....	.....	.....	.....	.....
642p	**651p**	**702p**	**710p**	**715p**	**720p**	.....	.....	.....	.....	.....	.....
715p	**724p**	**735p**	**743p**	**748p**	**753p**	.....	.....	.....	.....	.....	.....
815p	**824p**	**825p**-Kam/Olive		**831p**-Schofield		**839p**-Foote Gate		**(FRIDAY ONLY)**		.....	.....
815p	**824p**	**825p**-Kam/Olive		**(MONDAY-THURSDAY ONLY)**			.....	.....	.....	.....	.....
.....	**827p**	**838p**	**846p**	**851p**	**856p**	**858p**	**905p**	**910p**	**917p**	**924p**	**931p**
.....	**907p**	**918p**	**926p**	**931p**	**936p**	**938p**	**945p**	**950p**	**957p**	**1004p**	**1011p**
910p	**919p**	**920p**-Kam/Olive		.....	.....	.....	.....	.....	.....	.....	.....
.....	**1027p**	**1038p**	**1046p**	**1051p**	**1056p**	**1058p**	**1105p**	**1110p**	**1117p**	**1124p**-Alapai	
.....	**1132p**	**1143p**	**1151p**	**1156p**	1201a	1203a	1210a	1215a	1222a	1229a-Alapai	
1145p	**1154p**	**1155p**-Kam/Olive		1201a-Schofield		1209a-Foote Gate		**(FRIDAY ONLY)**		.....	.....
1145p	**1154p**	**1155p**-Kam/Olive		**(MONDAY-THURSDAY ONLY)**			.....	.....	.....	.....	.....
.....	1254a	105a	113a	117a-Kam/Acacia		.....	.....	.....	.....	.....	.....

Route 62 Wahiawa Heights & 62 Wahiawa Destination Signs:

Westbound:

To Wahiawa Heights - 62 WAHIAWA HEIGHTS

To Wahiawa Only - 62 WAHIAWA

To Wahiawa Hts ending in Schofield -

62 WAHIAWA HEIGHTS SCHOFIELD

Eastbound:

To Ala Moana Center - 62 HONOLULU ALA MOANA

To Kam Hwy/Olive - 62 WAHIAWA HEIGHTS

To Kam/Honomanu - 62 PEARLRIDGE

To Alapai Street - 62 ALAPAI ST

Route 62 Symbols

◆ - Starts Lehua St 1 minute earlier

★ - State Holiday operation only

❍ - Saturday operation only, does not run on State holidays

% - Runs one minute earlier on State Holidays

- Ends at Kam/Olive 1 minute later Monday-Thursday and runs to Schofield on Fridays only

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Route 62 - Wahiawa Heights and 62 - Wahiawa

Effective 8/24/08

Weekday: Westbound: To Wahiawa Heights

Q Ala Moana Center Kona St	P Alapai/ King	O Beretania Punchbowl	K Downtown King Street/ Beretania	I Kalihi Kam Hwy/Middle	H Rodgers Nimitz	G Aiea Kam Hwy/Salt Lake	F Pearlridge Kam & Pali Momi	E Pearl City Shopping Ctr	D Waikele Kam Hwy/ Lumiauau	C Mililani Kam Hwy/ Kuahelani	B Wahiawa California/Cane	A Wahiawa Heights
.....	.....	.....	.....	.....	.....	.....	.....	Kam Hwy/Avocado-		426a	428a	439a
.....	.....	.....	.....	.....	.....	.....	.....	Kam Hwy/Avocado-		456a	458a	509a
.....	.....	.....	.....	.....	.....	.....	.....	Kam Hwy/Avocado-		526a	528a	539a
.....	453a	455a	501a	510a	515a	523a	526a	531a	535a	542a	553a	604a
.....	.....	.....	.....	.....	.....	.....	.....	Kam Hwy/Avocado-		620a	622a	633a
.....	527a	529a	535a	544a	549a	557a	600a	606a	610a	617a	628a	.....
.....	.....	.....	.....	.....	.....	.....	.....	Kam Hwy/Avocado-		647a	649a	701a
535a	547a	549a	555a	604a	610a	619a	623a	630a	636a	648a	659a	.....
.....	.....	.....	.....	.....	.....	.....	.....	Kam Hwy/Avocado-		716a	718a	730a
600a	612a	614a	620a	629a	635a	644a	648a	655a	701a	713a	724a	736a
629a	641a	643a	649a	658a	704a	713a	717a	724a	730a	742a	753a	805a
704a	716a	718a	724a	733a	739a	748a	752a	759a	805a	817a	828a	840a
739a	751a	753a	759a	808a	814a	823a	827a	834a	840a	852a	903a	915a
814a	826a	828a	834a	843a	849a	858a	902a	909a	915a	927a	938a	950a
846a	858a	900a	906a	915a	921a	930a	934a	941a	947a	959a	1010a	1022a
919a	931a	933a	939a	948a	954a	1003a	1007a	1014a	1020a	1032a	1043a	1055a
951a	1003a	1005a	1011a	1020a	1026a	1035a	1039a	1046a	1052a	1104a	1115a	1126a
1023a	1035a	1037a	1043a	1052a	1058a	1107a	1111a	1120a	1125a	1137a	1148a	1159a
1051a	1103a	1105a	1111a	1121a	1128a	1137a	1141a	1152a	1157a	**1209p**	**1220p**	**1231p**
1119a	1131a	1134a	1140a	1151a	1158a	**1207p**	**1211p**	**1222p**	**1227p**	**1239p**	**1250p**	**101p**
1149a	**1201p**	**1204p**	**1210p**	**1221p**	**1228p**	**1237p**	**1241p**	**1252p**	**1257p**	**109p**	**120p**	**131p**
1225p	**1237p**	**1240p**	**1246p**	**1257p**	**104p**	**113p**	**117p**	**128p**	**133p**	**145p**	**159p**	**210p**
100p	**112p**	**115p**	**121p**	**132p**	**139p**	**148p**	**152p**	**207p**	**213p**	**226p**	**240p**	**251p**
135p	**147p**	**150p**	**158p**	**209p**	**216p**	**225p**	**229p**	**244p**	**250p**	**303p**	**317p**	**327p**
159p	**212p**	**215p**	**223p**	**234p**	**241p**	**250p**	**254p**	**309p**	**315p**	**328p**	**342p**	**352p**
.....	.....	.....	.....	.....	.....	.....	**313p**	**328p**	**333p**	**346p**	**400p**	**410p**
235p	**248p**	**251p**	**259p**	**310p**	**317p**	**328p**	**332p**	**347p**	**352p**	**405p**	**419p**	**429p**
255p	**308p**	**311p**	**319p**	**332p**	**340p**	**351p**	**355p**	**410p**	**415p**	**428p**	**442p**	**452p**
318p	**331p**	**334p**	**342p**	**355p**	**403p**	**414p**	**418p**	**433p**	**438p**	**451p**	**505p**	**515p**
341p	**354p**	**357p**	**405p**	**418p**	**426p**	**437p**	**441p**	**456p**	**501p**	**514p**	**528p**	**538p**
404p	**417p**	**420p**	**428p**	**441p**	**449p**	**500p**	**504p**	**519p**	**524p**	**537p**	**551p**	**601p**
428p	**441p**	**444p**	**452p**	**505p**	**513p**	**524p**	**528p**	**543p**	**548p**	**601p**	**615p**	**624p**
450p	**503p**	**506p**	**514p**	**527p**	**535p**	**546p**	**550p**	**605p**	**610p**	**622p**	**633p**	**642p**
530p	**543p**	**546p**	**554p**	**607p**	**615p**	**624p**	**628p**	**639p**	**643p**	**655p**	**706p**	**715p**
637p	**649p**	**651p**	**657p**	**709p**	**715p**	**724p**	**728p**	**739p**	**743p**	**754p**	**804p**	**813p**
745p	**756p**	**758p**	**803p**	**813p**	**818p**	**826p**	**829p**	**836p**	**840p**	**851p**	**901p**	**910p**
915p	**926p**	**928p**	**933p**	**943p**	**948p**	**956p**	**959p**	**1006p**	**1010p**	**1021p**	**1031p**	**1040p**
1020p	**1031p**	**1033p**	**1038p**	**1048p**	**1053p**	**1101p**	**1104p**	**1111p**	**1115p**	**1126p**	**1136p**	**1145p**

Route 62 Wahiawa Heights & 62 Wahiawa Destination Signs:

Westbound:

To Wahiawa Heights - 62 WAHIAWA HEIGHTS

To Wahiawa Only - 62 WAHIAWA

To Wahiawa Hts ending in Schofield -
62 WAHIAWA HEIGHTS SCHOFIELD

Eastbound:

To Ala Moana Center - 62 HONOLULU ALA MOANA

To Kam Hwy/Olive - 62 WAHIAWA HEIGHTS

To Kam/Honomanu - 62 PEARLRIDGE

To Alapai Street - 62 ALAPAI ST

Route 62 Symbols

◆ - Starts Lehua St 1 minute earlier

★ - State Holiday operation only

❍ - Saturday operation only, does not run on State holidays

% - Runs one minute earlier on State Holidays

- Ends at Kam/Olive 1 minute later Monday-Thursday and runs to Schofield on Fridays only

Bold indicates PM service.
Schedule to change without notice.
All buses are lift and bicycle rack equipped.

Route 62 - Wahiawa Heights and 62 - Wahiawa

Effective 8/24/08

Saturday/State Holiday: Eastbound: To Honolulu

A Wahiawa Heights Calfornia/Grand View	B Wahiawa California/Cane	C Mililani Kam Hwy/ Kuahelani	D Waikele Kam Hwy/ Lumiauau	E Kam Hwy Opp Pearl City Shopping Ctr	F Opp Pearlridge Kam/Pali Momi	G Aiea Kam Hwy/Salt Lake	H Rodgers Nimitz	I Kalihi Kam Hwy/Middle	K Downtown King St/ Beretania	L Downtown Kapiolani/ South	Q Ala Moana Center Kona St
440a	449a	459a	509a	515a	521a	523a	529a	533a	543a	548a	554a
.....	★ ◆ 505a	★ 515a	★ 525a	★ 531a	★ 537a	★ 539a	★ 545a	★ 549a	★ 559a	★ 604a	★ 610a
510a	520a	530a	540a	546a	552a	554a	600a	604a	614a	619a	625a
.....	★ ◆ 535a	★ 545a	★ 555a	★ 601a	★ 607a	★ 609a	★ 615a	★ 619a	★ 629a	★ 634a	★ 640a
540a	550a	600a	610a	616a	622a	624a	630a	634a	644a	649a	655a
.....	★ ◆ 605a	★ 615a	★ 625a	★ 631a	★ 637a	★ 639a	★ 645a	★ 649a	★ 659a	★ 704a	★ 710a
610a	620a	630a	640a	646a	652a	654a	700a	704a	714a	721a	727a
.....	★ ◆ 630a	★ 640a	★ 650a	★ 656a	★ 702a	★ 704a	★ 710a	★ 714a	★ 724a	★ 732a	★ 738a
640a	650a	700a	710a	716a	722a	724a	730a	734a	744a	752a	758a
.....	❍ ◆ 705a	❍ 715a	❍ 725a	❍ 731a	❍ 737a	❍ 739a	❍ 745a	❍ 749a	❍ 759a	❍ 807a	❍ 813a
710a	721a	732a	742a	748a	754a	756a	803a	808a	818a	826a	832a
745a	756a	807a	817a	824a	832a	834a	843a	848a	858a	909a	917a
815a	827a	838a	848a	855a	903a	905a	914a	919a	931a	942a	950a
855a	907a	918a	930a	940a	948a	950a	959a	1004a	1016a	1027a	1035a
935a	947a	958a	1010a	1020a	1028a	1030a	1039a	1044a	1056a	1107a	1115a
1015a	1027a	1038a	1050a	1100a	1108a	1110a	1119a	1124a	1136a	1147a	1155a
1055a	1107a	1118a	1130a	1140a	1148a	1150a	1159a	**1204p**	**1216p**	**1227p**	**1235p**
1135a	1147a	**1200p**	**1212p**	**1222p**	**1230p**	**1232p**	**1241p**	**1246p**	**1258p**	**109p**	**117p**
1215p	**1227p**	**1240p**	**1252p**	**102p**	**110p**	**112p**	**121p**	**126p**	**138p**	**149p**	**157p**
1255p	**107p**	**120p**	**132p**	**142p**	**150p**	**152p**	**201p**	**206p**	**218p**	**229p**	**237p**
135p	**147p**	**200p**	**212p**	**222p**	**229p**	**231p**	**240p**	**245p**	**257p**	**308p**	**316p**
215p	**227p**	**240p**	**252p**	**302p**	**309p**	**311p**	**320p**	**325p**	**336p**	**344p**	**352p**
255p	**307p**	**320p**	**332p**	**342p**	**349p**	**351p**	**400p**	**405p**	**416p**	**424p**	**432p**
335p	**347p**	**400p**	**412p**	**422p**	**429p**	**431p**	**440p**	**445p**	**456p**	**504p**	**512p**
415p	**427p**	**438p**	**450p**	**457p**	**504p**	**506p**	**515p**	**520p**	**531p**	**539p**	**547p**
455p	**506p**	**517p**	**529p**	**536p**	**543p**	**545p**	**554p**	**559p**	**608p**	**616p**	**624p**
535p	**545p**	**556p**	**608p**	**615p**	**622p**	**624p**	**631p**	**635p**	**644p**	**652p**	**700p**
615p	**625p**	**636p**	**648p**	**655p**	**702p**	**704p**	**711p**	**715p**	**724p**	**731p**	**738p**
623p	**633p**	**634p**	-Kam/Olive	**.....**	**.....**	**.....**	**.....**	**.....**	**.....**	**.....**	**.....**
659p	**709p**	**710p**	-Kam/Olive	**.....**	**.....**	**.....**	**.....**	**.....**	**.....**	**.....**	**.....**
.....	**731p**	**742p**	**754p**	**801p**	**806p**	**.....**	**.....**	**.....**	**.....**	**.....**	**.....**
733p	**743p**	**744p**	-Kam/Olive	**.....**	**.....**	**.....**	**.....**	**.....**	**.....**	**.....**	
.....	**804p**	**813p**	**822p**	**829p**	**834p**	**836p**	**841p**	**844p**	**853p**	**900p**	**907p**
815p	**825p**	**832p**	-Schofield	**840p**	-Foote Gate	**.....**	**.....**	**.....**	**.....**	**.....**	**.....**
.....	**905p**	**914p**	**923p**	**930p**	**935p**	**937p**	**942p**	**945p**	**954p**	**1001p**	**1008p**
913p	**923p**	**924p**	-Kam/Olive	**.....**	**.....**	**.....**	**.....**	**.....**	**.....**	**.....**	**.....**
.....	**%1016p**	**%1025p**	**%1034p**	**%1037p**	-Kam/Acacia	**.....**	**.....**	**.....**	**.....**	**.....**	
★ 1037p	**★ 1047p**	**★ 1054p**	-Schofield	**★ 1102p**	-Foote Gate	**.....**	**.....**	**.....**	**.....**	**.....**	**.....**
.....	**1125p**	**1134p**	**1143p**	**1147p**	**1152p**	**1154p**	**1159p**	1202a	1211a	1218a	-Alapai
1137p	**1147p**	**1154p**	-Schofield	1202a	-Foote Gate	.....	.....	.....	.....	.....	.....
.....	1244a	1253a	102a	105a	-Kam/Acacia	.....	.....	.....	.....	.....	

Route 62 Wahiawa Heights & 62 Wahiawa Destination Signs:

Westbound:

To Wahiawa Heights - 62 WAHIAWA HEIGHTS

To Wahiawa Only - 62 WAHIAWA

To Wahiawa Hts ending in Schofield - 62 WAHIAWA HEIGHTS SCHOFIELD

Eastbound:

To Ala Moana Center - 62 HONOLULU ALA MOANA

To Kam Hwy/Olive - 62 WAHIAWA HEIGHTS

To Kam/Honomanu - 62 PEARLRIDGE

To Alapai Street - 62 ALAPAI ST

Route 62 Symbols

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Route 62 - Wahiawa Heights and 62 - Wahiawa **Effective 8/24/08**

Saturday/State Holiday: Westbound: To Wahiawa Heights

Ala Moana Center Kona St (Q)	Alapai/ King (P)	Beretania Punchbowl (O)	Downtown King Street/ Beretania (K)	Kalihi Kam Hwy/Middle (I)	Rodgers Nimitz (H)	Aiea Kam Hwy/Salt Lake (G)	Pearlridge Kam & Pali Momi (F)	Pearl City Shopping Ctr (E)	Waikele Kam Hwy/ Lumiauau (D)	Mililani Kam Hwy/ Kuahelani (C)	Wahiawa California/Cane (B)	Wahiawa Heights (A)
.....	.....	.....	.....	.....	.....	.....	.....	Kam Hwy/Avocado-		430a	432a	439a
.....	.....	.....	.....	.....	.....	.....	.....	Kam Hwy/Avocado-		500a	502a	509a
.....	.....	.....	.....	.....	.....	.....	.....	Kam Hwy/Avocado-		530a	532a	539a
.....	453a	455a	500a	510a	516p	524a	527a	534a	541a	551a	601a	608a
513a	523a	525a	530a	540a	546p	554a	557a	604a	611a	621a	631a	.....
.....	.....	.....	.....	.....	.....	.....	.....	Kam Hwy/Avocado-		629a	631a	638a
.....	553a	555a	600a	610a	616p	624a	627a	634a	641a	651a	701a	708a
610a	620a	622a	627a	637a	643p	651a	654a	701a	708a	718a	729a	736a
640a	650a	652a	657a	708a	714p	722a	725a	732a	739a	749a	800a	807a
705a	715a	717a	723a	734a	740p	748a	751a	758a	805a	815a	826a	833a
745a	755a	757a	803a	814a	820p	828a	831a	838a	845a	855a	906a	913a
825a	835a	837a	843a	854a	900p	908a	911a	918a	925a	935a	946a	953a
859a	912a	914a	920a	931a	937p	945a	948a	955a	1003a	1016a	1027a	1034a
925a	938a	940a	946a	957a	1003p	1013a	1016a	1026a	1038a	1051a	1102a	1109a
1010a	1024a	1027a	1034a	1045a	1051p	1101a	1104a	1114a	1126a	1139a	1151a	1158a
1050a	1104a	1107a	1114a	1125a	1131p	1141a	1144a	1154a	**1206p**	**1219p**	**1231p**	**1238p**
1130a	1144a	1147a	1154a	**1205p**	**1211p**	**1221p**	**1224p**	**1234p**	**1246p**	**1259p**	**111p**	**118p**
1210p	**1224p**	**1227p**	**1234p**	**1245p**	**1251p**	**101p**	**104p**	**114p**	**126p**	**139p**	**151p**	**158p**
1250p	**104p**	**107p**	**114p**	**125p**	**131p**	**141p**	**144p**	**154p**	**206p**	**219p**	**231p**	**239p**
130p	**147p**	**149p**	**156p**	**207p**	**213p**	**223p**	**226p**	**236p**	**248p**	**301p**	**313p**	**321p**
210p	**227p**	**229p**	**236p**	**247p**	**253p**	**303p**	**306p**	**316p**	**328p**	**341p**	**353p**	**401p**
250p	**307p**	**309p**	**316p**	**327p**	**333p**	**343p**	**346p**	**356p**	**408p**	**421p**	**433p**	**441p**
330p	**347p**	**349p**	**356p**	**407p**	**413p**	**423p**	**426p**	**433p**	**441p**	**454p**	**506p**	**514p**
410p	**426p**	**428p**	**435p**	**446p**	**452p**	**502p**	**505p**	**512p**	**520p**	**533p**	**545p**	**553p**
445p	**500p**	**502p**	**509p**	**520p**	**526p**	**536p**	**539p**	**546p**	**554p**	**605p**	**615p**	**623p**
525p	**540p**	**542p**	**549p**	**600p**	**605p**	**613p**	**616p**	**622p**	**630p**	**641p**	**651p**	**659p**
605p	**617p**	**619p**	**626p**	**634p**	**639p**	**647p**	**650p**	**656p**	**704p**	**715p**	**725p**	**733p**
645p	**657p**	**659p**	**706p**	**714p**	**719p**	**727p**	**730p**	**736p**	**744p**	**755p**	**805p**	**813p**
745p	**757p**	**759p**	**806p**	**814p**	**819p**	**827p**	**830p**	**836p**	**844p**	**855p**	**905p**	**913p**
915p	**925p**	**927p**	**932p**	**940p**	**945p**	**953p**	**956p**	**1002p**	**1008p**	**1019p**	**1029p**	★ **1037p**
1015p	**1025p**	**1027p**	**1032p**	**1040p**	**1045p**	**1053p**	**1056p**	**1102p**	**1108p**	**1119p**	**1129p**	**1137p**

Route 62 Wahiawa Heights & 62 Wahiawa Destination Signs:

Westbound:

To Wahiawa Heights - 62 WAHIAWA HEIGHTS

To Wahiawa Only - 62 WAHIAWA

To Wahiawa Hts ending in Schofield -

62 WAHIAWA HEIGHTS SCHOFIELD

Eastbound:

To Ala Moana Center - 62 HONOLULU ALA MOANA

To Kam Hwy/Olive - 62 WAHIAWA HEIGHTS

To Kam/Honomanu - 62 PEARLRIDGE

To Alapai Street - 62 ALAPAI ST

Route 62 Symbols

◆ - Starts Lehua St 1 minute earlier

★ - State Holiday operation only

❍ - Saturday operation only, does not run on State holidays

% - Runs one minute earlier on State Holidays

- Ends at Kam/Olive 1 minute later Monday-Thursday and runs to Schofield on Fridays only

Bold indicates PM service.
Schedule to change without notice.
All buses are lift and bicycle rack equipped.

Route 62 - Wahiawa Heights and 62 - Wahiawa

Effective 8/24/08

Sunday: Eastbound: To Honolulu

A Wahiawa Heights California/Grand View	B Wahiawa California/Cane	C Mililani Kam Hwy/ Kuahelani	D Waikele Kam Hwy/ Lumiauau	E Kam Hwy Opp Pearl City Shopping Ctr	F Opp Pearlridge Kam/Pali Momi	G Aiea Kam Hwy/Salt Lake	H Rodgers Nimitz	I Kalihi Kam Hwy/Middle	K Downtown King St/ Beretania	L Downtown Kapiolani/ South	Q Ala Moana Center Kona St
510a	520a	530a	537a	541a	546a	548a	556a	601a	610a	617a	622a
540a	550a	600a	607a	611a	616a	618a	626a	631a	640a	647a	652a
610a	620a	630a	637a	641a	646a	648a	656a	701a	710a	717a	722a
640a	650a	701a	708a	713a	718a	720a	728a	733a	744a	752a	758a
712a	722a	733a	740a	745a	750a	752a	800a	805a	817a	828a	835a
742a	752a	803a	810a	815a	826a	828a	837a	842a	854a	905a	912a
812a	823a	833a	840a	845a	856a	858a	907a	912a	924a	935a	942a
845a	856a	906a	913a	918a	929a	931a	940a	945a	957a	1008a	1015a
920a	931a	941a	948a	953a	1004a	1006a	1015a	1020a	1032a	1043a	1050a
955a	1006a	1016a	1023a	1028a	1039a	1041a	1050a	1055a	1107a	1118a	1125a
1030a	1041a	1051a	1058a	1103a	1114a	1116a	1125a	1130a	1142a	1153p	**1200p**
1105a	1116a	1126a	1133a	1138a	1149a	1151a	**1200p**	**1205p**	**1217p**	**1228p**	**1235p**
1140a	1151a	**1201p**	**1208p**	**1213p**	**1224p**	**1226p**	**1235p**	**1240p**	**1252p**	**103p**	**110p**
1215p	**1226p**	**1236p**	**1243p**	**1248p**	**1259p**	**101p**	**110p**	**115p**	**127p**	**138p**	**145p**
1250p	**101p**	**111p**	**118p**	**123p**	**134p**	**136p**	**145p**	**150p**	**202p**	**213p**	**220p**
125p	**136p**	**146p**	**153p**	**158p**	**209p**	**211p**	**220p**	**225p**	**237p**	**248p**	**255p**
200p	**211p**	**221p**	**228p**	**233p**	**244p**	**246p**	**255p**	**300p**	**312p**	**323p**	**330p**
235p	**246p**	**256p**	**303p**	**308p**	**319p**	**321p**	**330p**	**335p**	**347p**	**358p**	**405p**
310p	**321p**	**331p**	**338p**	**343p**	**354p**	**356p**	**405p**	**410p**	**422p**	**433p**	**440p**
345p	**356p**	**406p**	**413p**	**418p**	**429p**	**431p**	**440p**	**445p**	**457p**	**508p**	**515p**
420p	**431p**	**441p**	**448p**	**453p**	**504p**	**506p**	**515p**	**520p**	**530p**	**538p**	**544p**
513p	**524p**	**534p**	**541p**	**545p**	**550p**	**552p**	**600p**	**605p**	**614p**	**621p**	**626p**
548p	**558p**	**608p**	**615p**	**619p**	**624p**	**626p**	**634p**	**639p**	**648p**	**655p**	**700p**
623p	**633p**	**643p**	**650p**	**654p**	**659p**	**701p**	**709p**	**714p**	**723p**	**730p**	**735p**
.....	**637p**	**647p**	**654p**	**658p**	**705p**	.....	.....	.....	.....	.....	.....
639p	**649p**	**650p**	-Kam/Olive	.....	.....	.....	.....	.....	.....	.....	.....
.....	**734p**	**744p**	**751p**	**755p**	**802p**	.....	.....	.....	.....	.....	
725p	**735p**	**736p**	-Kam/Olive	.....	.....	.....	.....	.....	.....	.....	.....
.....	**805p**	**814p**	**820p**	**824p**	**828p**	**830p**	**838p**	**843p**	**851p**	**857p**	**902p**
815p	**824p**	**831p**		**839p**		.....	.....	.....	.....	.....	.....
.....	**905p**	**914p**	**920p**	**924p**	**928p**	**930p**	**938p**	**943p**	**951a**	**957p**	**1002p**
903p	**912p**	**913p**	-Kam/Olive	.....	.....	.....	.....	.....	.....	.....	.....
.....	**1019p**	**1028p**	**1034p**	**1037p**	-Kam/Acacia	.....	.....	.....	.....	.....	
.....	**1120p**	**1129p**	**1135p**	**1139p**	**1143p**	**1145p**	**1153p**	**1158p**	**1206a**	**1212a**	-Alapai
1132p	**1141p**	**1148p**	-Schofield	**1156p**	-Foote Gate	.....	.....	.....	.....	.....	.....
.....	1247a	1256a	102a	105a	-Kam/Acacia	.....	.....	.....	.....	.....	.....

Route 62 Wahiawa Heights & 62 Wahiawa Destination Signs:

Westbound:

To Wahiawa Heights - 62 WAHIAWA HEIGHTS

To Wahiawa Only - 62 WAHIAWA

To Wahiawa Hts ending in Schofield - 62 WAHIAWA HEIGHTS SCHOFIELD

Eastbound:

To Ala Moana Center - 62 HONOLULU ALA MOANA

To Kam Hwy/Olive - 62 WAHIAWA HEIGHTS

To Kam/Honomanu - 62 PEARLRIDGE

To Alapai Street - 62 ALAPAI ST

Route 62 Symbols

◆ - Starts Lehua St 1 minute earlier

★ - State Holiday operation only

❍ - Saturday operation only, does not run on State holidays

% - Runs one minute earlier on State Holidays

- Ends at Kam/Olive 1 minute later Monday-Thursday and runs to Schofield on Fridays only

Bold indicates PM service.
Schedule to change without notice.
All buses are lift and bicycle rack equipped.

Route 62 - Wahiawa Heights and 62 - Wahiawa **Effective 8/24/08**

Sunday: Westbound: To Wahiawa Heights

Q Ala Moana Center Kona St	P Alapai/ King	O Beretania Punchbowl	K Downtown King Street/ Beretania	I Kalihi Kam Hwy/Middle	H Rodgers Nimitz	G Aiea Kam Hwy/Salt Lake	F Pearlridge Kam & Pali Momi	E Pearl City Shopping Ctr	D Waikele Kam Hwy/ Lumiauau	C Mililani Kam Hwy/ Kuahelani	B Wahiawa California/Cane	A Wahiawa Heights
.....	.....	.....	.....	.....	.....	.....	.....	Kam Hwy/Avocado-		456a	458a	509a
.....	.....	.....	.....	.....	.....	.....	.....	Kam Hwy/Avocado-		526a	528a	539a
.....	.....	.....	.....	.....	.....	.....	.....	Kam Hwy/Avocado-		556a	558a	609a
.....	529a	531a	537a	545a	550p	558a	601a	606a	610a	617a	627a	638a
.....	559a	601a	607a	615a	620a	628a	631a	636a	640a	647a	657a	708a
613a	623a	625a	631a	641a	646a	654a	657a	702a	706a	713a	723a	735a
643a	653a	655a	701a	711a	716a	724a	727a	733a	737a	744a	754a	806a
706a	718a	720a	726a	736a	742a	751a	754a	801a	806a	813a	824a	835a
736a	748a	750a	756a	807a	813a	821a	824a	834a	839a	846a	857a	908a
806a	818a	820a	826a	838a	844a	852a	855a	905a	910a	917a	928a	939a
845a	857a	859a	905a	917a	923a	931a	934a	944a	949a	956a	1007a	1018a
920a	932a	934a	940a	952a	958a	1006a	1009a	1019a	1024a	1031a	1042a	1053a
955a	1007a	1009a	1015a	1027a	1033a	1041a	1044a	1054a	1059a	1106a	1117a	1128a
1030a	1042a	1044a	1050a	1102a	1108a	1116a	1119a	1129a	1134a	1141a	1152a	**1203p**
1105a	1117a	1119a	1125a	1137a	1143a	1151a	1154a	**1204p**	**1209p**	**1216p**	**1227p**	**1238p**
1140a	1152a	1154a	**1200p**	**1212p**	**1219p**	**1226p**	**1229p**	**1239p**	**1244p**	**1251p**	**102p**	**113p**
1215p	**1227p**	**1229p**	**1235p**	**1247p**	**1253p**	**101p**	**104p**	**114p**	**119p**	**126p**	**137p**	**148p**
1250p	**102p**	**104p**	**110p**	**122p**	**128p**	**136p**	**139p**	**149p**	**154p**	**201p**	**212p**	**223p**
125p	**137p**	**139p**	**145p**	**157p**	**203p**	**211p**	**214p**	**224p**	**229p**	**236p**	**247p**	**258p**
200p	**212p**	**214p**	**220p**	**232p**	**238p**	**246p**	**249p**	**259p**	**304p**	**311p**	**322p**	**333p**
235p	**247p**	**249p**	**255p**	**307p**	**313p**	**321p**	**324p**	**334p**	**339p**	**346p**	**357p**	**408p**
310p	**322p**	**324p**	**330p**	**342p**	**348p**	**356p**	**359p**	**409p**	**414p**	**421p**	**432p**	**443p**
345p	**357p**	**359p**	**405p**	**417p**	**423p**	**431p**	**434p**	**441p**	**446p**	**453p**	**504p**	**515p**
420p	**432p**	**434p**	**440p**	**452p**	**458p**	**506p**	**509p**	**516p**	**521p**	**528p**	**539p**	**550p**
455p	**507p**	**509p**	**515p**	**527p**	**533p**	**541p**	**544p**	**551p**	**556p**	**603p**	**614p**	**625p**
523p	**535p**	**537p**	**543p**	**555p**	**601p**	**609p**	**612p**	**618p**	**623p**	**630p**	**641p**	**653p**
550p	**602p**	**604p**	**610p**	**622p**	**628p**	**636p**	**639p**	**645p**	**649p**	**656p**	**707p**	**719p**
645p	**655p**	**657p**	**703p**	**713p**	**718p**	**726p**	**729p**	**735p**	**739p**	**746p**	**756p**	**808p**
745p	**754p**	**756p**	**801p**	**809p**	**814p**	**822p**	**825p**	**831p**	**835p**	**842p**	**852p**	**903p**
915p	**924p**	**926p**	**931p**	**939p**	**944p**	**952p**	**955p**	**1000p**	**1004p**	**1011p**	**1021p**	.....
1015p	**1024p**	**1026p**	**1031p**	**1039p**	**1044p**	**1052p**	**1055p**	**1100p**	**1104p**	**1111p**	**1121p**	**1132p**

Route 62 Wahiawa Heights & 62 Wahiawa Destination Signs:

Westbound:

To Wahiawa Heights - 62 WAHIAWA HEIGHTS

To Wahiawa Only - 62 WAHIAWA

To Wahiawa Hts ending in Schofield -

62 WAHIAWA HEIGHTS SCHOFIELD

Eastbound:

To Ala Moana Center - 62 HONOLULU ALA MOANA

To Kam Hwy/Olive - 62 WAHIAWA HEIGHTS

To Kam/Honomanu - 62 PEARLRIDGE

To Alapai Street - 62 ALAPAI ST

Route 62 Symbols

◆ - Starts Lehua St 1 minute earlier

★ - State Holiday operation only

❍ - Saturday operation only, does not run on State holidays

% - Runs one minute earlier on State Holidays

- Ends at Kam/Olive 1 minute later Monday-Thursday and runs to Schofield on Fridays only

Bold indicates PM service.
Schedule to change without notice.
All buses are lift and bicycle rack equipped.

Route 83 - Wahiawa Town Express (Downtown/University of Hawaii)

Effective 8/25/08

A.M. Weekday Only: To Downtown Honolulu and University of Hawaii at Manoa

B Waialua Kam Hwy & Weed Circle	C Haleiwa Kam Hwy & Achiu Ln	F Wahiawa Hts California & Grand View	D Wahiawa California & Cane	G Wheeler Kam Hwy & Wright Gate	H Wahiawa Park & Ride (Armory)	Y Vineyard & Palama	C Downtown Alapai & King	Z Beretania & Punchbowl	a King & Cooke	e Makiki Wilder & Makiki	h U of H University & Metcalf
.....	.....	.....	◆ 500a	505a	507a	535a	545a	547a	.....	.....	.....
.....	.....	514a	524a	529a	531a	559a	.....	.....	611a	626a	630a
458a	520a	.....	◆ 540a	545a	547a	621a	631a	633a	.....	.....	.....
.....	.....	547a	557a	602a	604a	642a	.....	.....	654a	709a	713a
528a	550a	.....	◆ 610a	615a	617a	655a	705a	707a	.....	.....	.....
.....	.....	617a	628a	633a	635a	713a	.....	.....	725a	740a	744a
.....	.....	.....	◆ 645a	650a	652a	730a	740a	742a	.....	.....	.....

State Holiday

B	C	F	D	G	H	Y	C	Z	a	e	h
.....	.....	.....	◆ 500a	505a	507a	535a	545a	546a	.....	.....	.....
458a	520a	.....	540a	545a	547a	622a	632a	633a	.....	.....	.....
528a	550a	.....	610a	615a	617a	657a	707a	708a	.....	.....	.....
.....	.....	617a	625a	630a	632a	708a	718a	719a	.....	.....	.....

P.M. Weekday Only: To Wahiawa/Wahiawa Heights/Waialua/Haleiwa

d Alapai Transit Center	Z Beretania & Punchbowl	Y Vineyard & Palama	H Wahiawa Park & Ride (Armory)	D Wahiawa California & Cane	F Wahiawa Hts California & Grand View	E Wahiawa Kam Hwy & Olive Ave	A Waialua Goodale & Nahoa	B Waialua Kam Hwy & Weed Circle
340p	345p	355p	432p	439p	.....	444p	.....	.....
405p	410p	420p	500p	507p	517p	526p	.....	.....
425p	430p	442p	522p	529p	.....	.....	552p	611p
435p	440p	452p	532p	539p	549p	558p	.....	.....
450p	455p	507p	547p	554p	604p	613p	.....	.....
510p	515p	527p	607p	614p	.....	.....	637p	656p
540p	545p	557p	637p	644p	.....	649p	.....	.....

State Holiday

d	Z	Y	H	D	F	E	A	B
400p	404p	412p	445p	453p	503p	514p	.....	.....
420p	424p	432p	505p	513p	.....	.....	533p	550p
450p	454p	502p	535p	543p	553p	604p	.....	.....
510p	514p	522p	555p	603p	.....	.....	623p	640p

Route 83 Destination Signs

AM:

To Downtown & UH - 83 EXPRESS DOWNTOWN UNIVERSITY

To Downtown Only - 83 EXPRESS DOWNTOWN

PM:

To Waialua/Haleiwa - 83 EXPRESS WAHIAWA WAIALUA HALEIWA

To Wahiawa Heights - 83 EXPRESS WAHIAWA HEIGHTS

To Wahiawa Only - 83 EXPRESS WAHIAWA

Route 83 Symbols

◆ - Begins Lehua/California one minute earlier

Bold indicates PM service.
Schedule to change without notice.
All buses are lift and bicycle rack equipped.

Route 83A - Wahiawa - Mililani Express (Pearl Harbor)

Revised 3/5/07

A.M. Weekday Only: To Pearl Harbor

F Wahiawa Hts California & Grand View	D Wahiawa California & Cane	G Wheeler Kam Hwy & Wright Gate	J Waipio Acres Kam Hwy & Waikalani	L Mililani Kam Hwy & Kuahelani	T Waipio Gentry Kam Hwy & Waipio Uka	U Crestview Kam Hwy & Lumiaina	K Mililani Park & Ride	Q Mililani Kamaio & Polapola	M Mililani Meheula & Kuahelani	X Pearl Harbor Nimitz Gate	V Navy Supply Center
▲ 515a	▲ 529a	▲ 534a	▲ 539a	▲ 541a	▲ 546a	▲ 547a	.....	.....	.....	▲ 604a	▲ 619a
.....	.....	.....	.....	.....	.....	.....	▲ 510a	▲ 525a	▲ 535a	▲ 555a	▲ 610a

State Holiday

F	D	G	J	L	T	U	K	Q	M	X	V
515a	525a	530a	535a	537a	542a	543a	.....	.....	.....	600a	615a
.....	.....	.....	.....	.....	.....	.....	510a	525a	535a	555a	610a

P.M. Weekday Only: To Mililani/Wahiawa/Wahiawa Heights

W Pearl Harbor Safeguard & Club	V Navy Supply Center	U Crestview Kam Hwy & Lumiaina	T Waipio Gentry Kam Hwy & Waipio Uka	L Mililani Kam Hwy & Kuahelani	N Mililani Ainamakua & Meheula Parkway	P Mililani Lanikuhana & Kauakapuu	M Mililani Meheula Parkway & Kuahelani	D Wahiawa California & Cane	F Wahiawa Hts California & Grand View	E Wahiawa Kamehameha & Olive Street
▲ **310p**	▲ **324p**	▲ **339p**	▲ **340p**	▲ **350p**	.....	.....	.....	▲ **400p**	▲ **410p**	▲ **419p**
▲ **310p**	▲ **324p**	.....	.....	.....	▲ **345p**	▲ **359p**	▲ **410p**	.....	.....	.....

State Holiday

W	V	U	T	L	N	P	M	D	F	E
310p	**324p**	**339p**	**340p**	**350p**	.....	.....	.....	**400p**	**412p**	**423p**
310p	**324p**	.....	.....	.....	**345p**	**359p**	**410p**	.....	.....	.....

Route 83A Destination Signs

AM:

To Pearl Harbor via H-2 Frwy - 83A EXPRESS PEARL HARBOR

To Pearl Harbor via Kamehameha Hwy - 83A EXPRESS PEARL HARBOR VIA KAM HWY

PM:

To Wahiawa Heights - 83A EXPRESS WAHIAWA HEIGHTS (At Kamehameha Hwy and Lumiauau Street, sign will change to 62 WAHIAWA HEIGHTS

To Mililani - 83A EXPRESS MILILANI

Route 83A Symbols

▲ - Service on Route 83A does not operate on New Year's Day, Presidents' Day, Memorial Day, Independence Day, Labor Day, Discoverers' Day, Veterans' Day, Thanksgiving Day, Christmas Day and during emergency military base closures.

◆ - Regular local service along Kamehameha Hwy via Route 52

Note: State Holiday Express service operating on Martin Luther King Jr. Day, Kuhio Day, Good Friday, Kamehameha Day, Admission Day and Election Day holidays.

Bold indicates PM service.
Schedule to change without notice.
All buses are lift and bicycle rack equipped.

Route 84 - Mililani Express (Downtown/University of Hawaii) Revised 8/2508

A.M. Weekday Only: To Downtown Honolulu and University of Hawaii at Manoa

Wahiawa Armory (H)	Waipio Acres (J)	Mililani Lanikuhana & Kauakapuu (P)	Mililani Meheula & Kuahelani (M)	Downtown Vineyard & Palama (Y)	Downtown Alapai & King (c)	Downtown Beretania & Punchbowl (Z)	King & Cooke (a)	Makiki Wilder & Alexander (f)	U of H University & Dole (i)
455a	458a	506a	521a	548a	558a	600a	.....	.....	.....
525a	528a	536a	551a	625a	635a	637a	.....	.....	.....
550a	553a	601a	616a	653a	.....	.....	708a	718a	722a
620a	623a	631a	646a	723a	733a	735a	.....	.....	.....

State Holiday

Wahiawa Armory (H)	Waipio Acres (J)	Mililani Lanikuhana & Kauakapuu (P)	Mililani Meheula & Kuahelani (M)	Downtown Vineyard & Palama (Y)	Downtown Alapai & King (c)	Downtown Beretania & Punchbowl (Z)	King & Cooke (a)	Makiki Wilder & Alexander (f)	U of H University & Dole (i)
455a	458a	506a	520a	547a	557a	558a	.....	.....	.....
555a	558a	606a	620a	652a	702a	703a	.....	.....	.....

P.M. Weekday Only: To Mililani

Alapai Transit Center (d)	Downtown Beretania & Punchbowl (Z)	Vineyard & Palama (Y)	Mililani Meheula & Kuahelani (M)	Mililani Kamaio & Polapola (Q)	Waipio Acres (J)	Wahiawa Armory (H)
345p	**350p**	**400p**	**437p**	**451p**	**459p**	**501p**
415p	**420p**	**430p**	**509p**	**523p**	**531p**	**533p**
445p	**450p**	**502p**	**540p**	**554p**	**602p**	**604p**
515p	**520p**	**532p**	**608p**	**622p**	**630p**	**632p**

State Holiday

Alapai Transit Center (d)	Downtown Beretania & Punchbowl (Z)	Vineyard & Palama (Y)	Mililani Meheula & Kuahelani (M)	Mililani Kamaio & Polapola (Q)	Waipio Acres (J)	Wahiawa Armory (H)
435p	**438p**	**445p**	**517p**	**531p**	**539p**	**542p**
515p	**518p**	**525p**	**557p**	**611p**	**619p**	**622p**

Route 84 Destination Signs

AM:

84 EXPRESS DOWNTOWN or DOWNTOWN/UNIVERSITY

PM:

84 EXPRESS MILILANI

Bold indicates PM service.
Schedule to change without notice.
All buses are lift and bicycle rack equipped.

Route 84A - Mililani Express (Downtown/University of Hawaii)

Revised 8/25/08

A.M. Weekday Only: To Downtown Honolulu and University of Hawaii at Manoa

M Mililani Meheula & Kuahelani	R Mililani Meheula & Keaoopua	O Mililani Meheula & Lanikuhana	M Mililani Meheula & Kuahelani	Y Downtown Vineyard & Palama	C Downtown Alapai & King	Z Downtown Beretania & Punchbowl	b King & Cooke	f Makiki Wilder & Alexander	h U of H University & Dole
510a	519a	526a	527a	554a	604a	606a	.....	.....	.....
540a	549a	556a	557a	633a	643a	645a			
610a	619a	626a	627a	704a	.....	.....	719a	729a	733a
640a	649a	656a	657a	734a	.....	.....	749a	759a	803a

State Holiday

M	R	O	M	Y	C	Z	b	f	h
510a	521a	529a	530a	557a	607a	608a	.....	.....	.....
610a	621a	629a	630a	702a	712a	713a	.....	.....	.....

P.M. Weekday Only: To Mililani

d Alapai Transit Center	Z Downtown Beretania & Punchbowl	Y Downtown Vineyard & Palama	M Mililani Meheula & Kuahelani	O Mililani Meheula & Lanikuhana	R Mililani Meheula & Keaoopua	M Mililani Meheula & Kuahelani
405p	**410p**	**420p**	**459p**	**500p**	**508p**	**519p**
435p	**440p**	**452p**	**531p**	**532p**	**540p**	**551p**
505p	**510p**	**522p**	**559p**	**600p**	**608p**	**619p**
535p	**540p**	**552p**	**628p**	**629p**	**637p**	**648p**

State Holiday

d	Z	Y	M	O	R	M
435p	**438p**	**445p**	**517p**	**518p**	**526p**	**537p**
535p	**538p**	**545p**	**617p**	**618p**	**626p**	**637p**

Route 84A Destination Signs

AM:

84A EXPRESS DOWNTOWN or DOWNTOWN/UNIVERSITY

PM:

84A EXPRESS MILILANI

Bold indicates PM service.
Schedule to change without notice.
All buses are lift and bicycle rack equipped.

Route 96 - Waipio Gentry Express (Downtown)

Revised 12/3/07

A.M. Weekday Only: To Downtown Honolulu

S Waipio Uka Blvd & Ukee	T Kamehameha Hwy & Waipio Uka Blvd	Y Downtown Vineyard & Palama	d Downtown Alapai & Hotel	Z Downtown Beretania & Punchbowl
545a	552a	617a	627a	629a
615a	622a	647a	657a	659a
State Holiday				
545a	552a	617a	627a	628a

P.M. Weekday Only: To Waipio Gentry

d Alapai Transit Center	Z Downtown Beretania & Punchbowl	Y Downtown Vineyard & Palama	U Kamehameha Hwy & Lumiauau	S Waipio Uka Blvd & Ukee	T Kamehameha Hwy & Waipio Uka Blvd
430p	**435p**	**447p**	**513p**	**515p**	**522p**
500p	**505p**	**517p**	**543p**	**545p**	**552p**
State Holiday					
500p	**503p**	**512p**	**533p**	**535p**	**542p**

Route 96 Destination Signs

AM:

96 EXPRESS DOWNTOWN

PM:

96 EXPRESS WAIPIO GENTRY

Note: State Holiday Express service operating on Martin Luther King Jr. Day, Kuhio Day, Good Friday, Kamehameha Day, Admission Day and Election Day holidays.

Bold indicates PM service.
Schedule to change without notice.
All buses are lift and bicycle rack equipped.

Route 98 - Wahiawa/Mililani Park and Ride Express and Route 98A Kunia/Wahiawa/Mililani/Waikiki Express

Effective 8/25/08

A.M. Weekday Only: To Downtown Honolulu/Waikiki

Route	Kunia Kunia Drive & Kunia Road (I)	Mililani Meheula & Kuahelani (M)	Waipio Acres Kam Hwy & Waikalani (J)	Wahiawa Park & Ride (Armory) (H)	Mililani Transit Center (O)	Mililani Park & Ride (K)	Downtown Vineyard & Palama (Y)	Downtown Alapai & King (C)	Downtown Beretania & Punchbowl (Z)	Kapiolani & South (b)	Ala Moana Blvd Ala Moana Center (g)	Monsarrat & Kalakaua (j)
98A	449a	.....	.....	458a	508a	513a	541a	.....	.....	551a	556a	613a
98	.....	518a	523a	525a	.....	532a	600a	610a	612a	.....	.....	.....
98A	527a	.....	.....	536a	546a	551a	619a	.....	.....	631a	636a	653a
98	.....	548a	553a	555a	.....	602a	634a	644a	646a	.....	.....	.....
98	.....	618a	623a	625a	.....	632a	712a	722a	724a	.....	.....	.....
State Holiday												
98A	449a	.....	.....	458a	508a	513a	541a	.....	.....	551a	556a	613a
98	.....	518a	523a	525a	.....	532a	600a	610a	611a	.....	.....	.....
98A	529a	.....	.....	538a	548a	553a	621a	.....	.....	631a	636a	653a
98	.....	603a	608a	610a	.....	617a	656a	706a	707a	.....	.....	.....

P.M. Weekday Only: To Mililani/Wahiawa/Kunia

Route	Waikiki Monsarrat & Kalakaua (j)	Ala Moana Blvd Ala Moana Center (g)	Downtown Alapai & King (c)	Downtown Beretania & Punchbowl (Z)	Downtown Vineyard & Palama (Y)	Mililani Park & Ride (K)	Mililani Transit Center (O)	Wahiawa Park & Ride (Armory) (H)	Waipio Acres Kam Hwy & Waikalani (J)	Mililani Meheula & Kuahelani (M)	Kunia Kunia Drive & Kunia Road (I)
98	.....	.....	415p	420p	430p	508p	.....	513p	515p	520p	.....
98A	400p	427p	436p	441p	453p	527p	532p	542p	.....	.....	552p
98	.....	.....	445p	450p	502p	535p	.....	540p	542p	547p	.....
98A	440p	507p	516p	521p	533p	606p	611p	621p	.....	.....	631p
98	.....	.....	525p	530p	542p	615p	.....	620p	622p	627p	.....
State Holiday											
98	.....	.....	430p	434p	442p	515p	.....	520p	522p	527p	.....
98A	400p	427p	436p	440p	448p	521p	526p	536p	.....	.....	546p
98A	440p	507p	516p	520p	528p	601p	606p	616p	.....	.....	626p
98	.....	.....	525p	529p	537p	610p	.....	615p	617p	622p	.....

Route 98 and Route 98A Destination Signs

AM:

To Beretania/Punchbowl: 98 EXPRESS DOWNTOWN

To Monsarrat/Kalakaua: 98A EXPRESS DOWNTOWN WAIKIKI

PM:

To Mililani: 98 EXPRESS MILILANI-WAHIAWA PARK & RIDE

To Kunia Dr/Kunia Rd: 98A EXPRESS MILILANI WAHIAWA KUNIA CAMP

Route 98A Local and Express Service

Eastbound from Kunia to Downtown Honolulu/Ala Moana/Waikiki

Buses will service all local stops from Kunia to Mililani, then "EXPRESS" from H-2 South to H-1 East, exiting at Vineyard Blvd. Buses will service all local stops from Vineyard Blvd. to Kapiolani Blvd./South St., then "EXPRESS" to Ala Moana Blvd. opposite Ala Moana Center. Buses will service all local stops from opposite Ala Moana Center into Waikiki, ending at Monsarrat Ave./Kalakaua Ave.

Westbound from Waikiki to Kunia

Buses will service all local stops from Waikiki to Ala Moana Blvd. fronting Ala Moana Center, then "EXPRESS" to Alapai Transit Center. Buses will service all local stops from Beretania Street to Vineyard Blvd./Palama St., then "EXPRESS" from H-1 West to H-2 North, exiting at Meheula Parkway. Buses will service all local stops through Mililani, ending at Kunia Dr.

Bold indicates PM service.
Schedule to change without notice.
All buses are lift and bicycle rack equipped.

Route 433 Waipahu - Waikele Shopping Center

Effective 6/8/08

Weekday: To Waikele /Waipio/Waipahu

Waipahu Transit Center (A)	Kamehameha Hwy & Lumiaina (H)	Kamehameha Hwy & Lumiauau (O)	Moaniani & Ukee (U)	Kamehameha Hwy & Lumiaina (H)	Waipahu Transit Center (A)
500a	513a	.....	.....	513a	526a
530a	543a	.....	.....	543a	556a
600a	613a	.....	.....	613a	626a
630a	643a	.....	.....	643a	656a
700a	713a	.....	.....	713a	726a
730a	743a	.....	.....	743a	756a
800a	.....	816a	825a	839a	855a
830a	.....	846a	855a	909a	925a
900a	.....	916a	925a	939a	955a
930a	.....	946a	955a	1009a	1025a
1000a	.....	1016a	1025a	1039a	1055a
1030a	.....	1046a	1055a	1109a	1125a
1100a	.....	1116a	1125a	1139a	1155a
1130a	.....	1146a	1155a	1209p	1225p
1200p	.....	1216p	1225p	1239p	1255p
1230p	.....	1246p	1255p	109p	125p
100p	.....	116p	125p	139p	155p
130p	.....	146p	155p	209p	225p
200p	.....	216p	225p	239p	255p
230p	.....	246p	255p	309p	325p
300p	.....	316p	325p	339p	355p
330p	.....	346p	355p	409p	425p
400p	.....	416p	425p	439p	455p
430p	.....	446p	455p	509p	525p
500p	.....	516p	525p	539p	555p
530p	.....	546p	555p	609p	625p
600p	.....	616p	625p	639p	655p
630p	643p	.....	.....	.....	.....
700p	713p	.....	.....	713p	726p
730p	743p	.....	.....	743p	756p
800p	813p	.....	.....	813p	826p
900p	913p	.....	.....	913p	926p
1000p	1013p	.....	.....	1013p	1026p
1105p	1118p	.....	.....	1118p	1131p

Saturday/State Holiday: To Waikele/Waipio/Waipahu

Waipahu Transit Center (A)	Kamehameha Hwy & Lumiaina (H)	Kamehameha Hwy & Lumiauau (O)	Moaniani & Ukee (U)	Kamehameha Hwy & Lumiaina (H)	Waipahu Transit Center (A)
500a	513a	.....	.....	513a	526a
600a	613a	.....	.....	613a	626a
700a	713a	.....	.....	713a	726a
800a	.....	816a	825a	839a	855a
900a	.....	916a	925a	939a	955a
1000a	.....	1016a	1025a	1039a	1055a
1030a	.....	1046a	1055a	1109a	1125a
1100a	.....	1116a	1125a	1139a	1155a
1130a	.....	1146a	1155a	1209p	1225p
1200p	.....	1216p	1225p	1239p	1255p
1230p	.....	1246p	1255p	109p	125p
100p	.....	116p	125p	139p	155p
130p	.....	146p	155p	209p	225p
200p	.....	216p	225p	239p	255p
230p	.....	246p	255p	309p	325p
300p	.....	316p	325p	339p	355p
330p	.....	346p	355p	409p	425p
400p	.....	416p	425p	439p	455p
430p	.....	446p	455p	509p	525p
500p	.....	516p	525p	539p	555p
530p	.....	546p	555p	609p	625p
600p	.....	616p	625p	639p	655p
630p	.....	646p	.....	.....	.....
700p	713p	.....	.....	713p	726p
800p	813p	.....	.....	813p	826p
900p	913p	.....	.....	913p	926p
1000p	1013p	.....	.....	1013p	1026p
1100p	1113p	.....	.....	1113p	1126p

Sunday: To Waikele/Waipahu

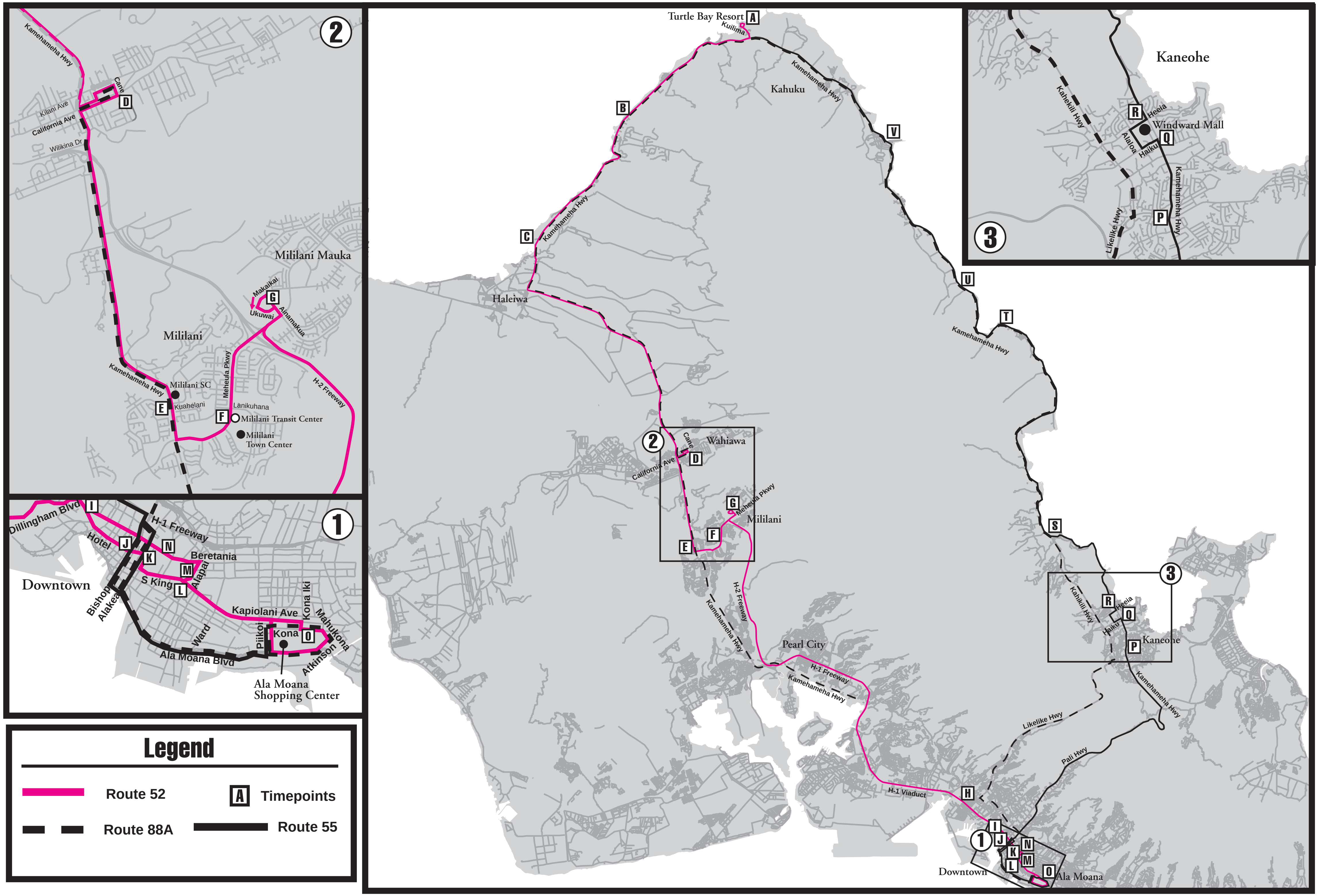
Waipahu Transit Center (A)	Kamehameha Hwy & Lumiaina (O)	Waipahu Transit Center (A)
500a	513a	526a
600a	613a	626a
700a	713a	726a
800a	813a	826a
900a	913a	926a
1000a	1013a	1026a
1030a	1043a	1056a
1100a	1113a	1126a
1130a	1143a	1156a
1200p	1213p	1226p
1230p	1243p	1256p
100p	113p	126p
130p	143p	156p
200p	213p	226p
230p	243p	256p
300p	313p	326p
330p	343p	356p
400p	413p	426p
430p	443p	456p
500p	513p	526p
530p	543p	556p
600p	613p	626p
630p	643p	656p
700p	713p	726p
800p	813p	826p
900p	913p	926p
1000p	1013p	1026p
1100p	1113p	1126p

Route 433 Destination Signs

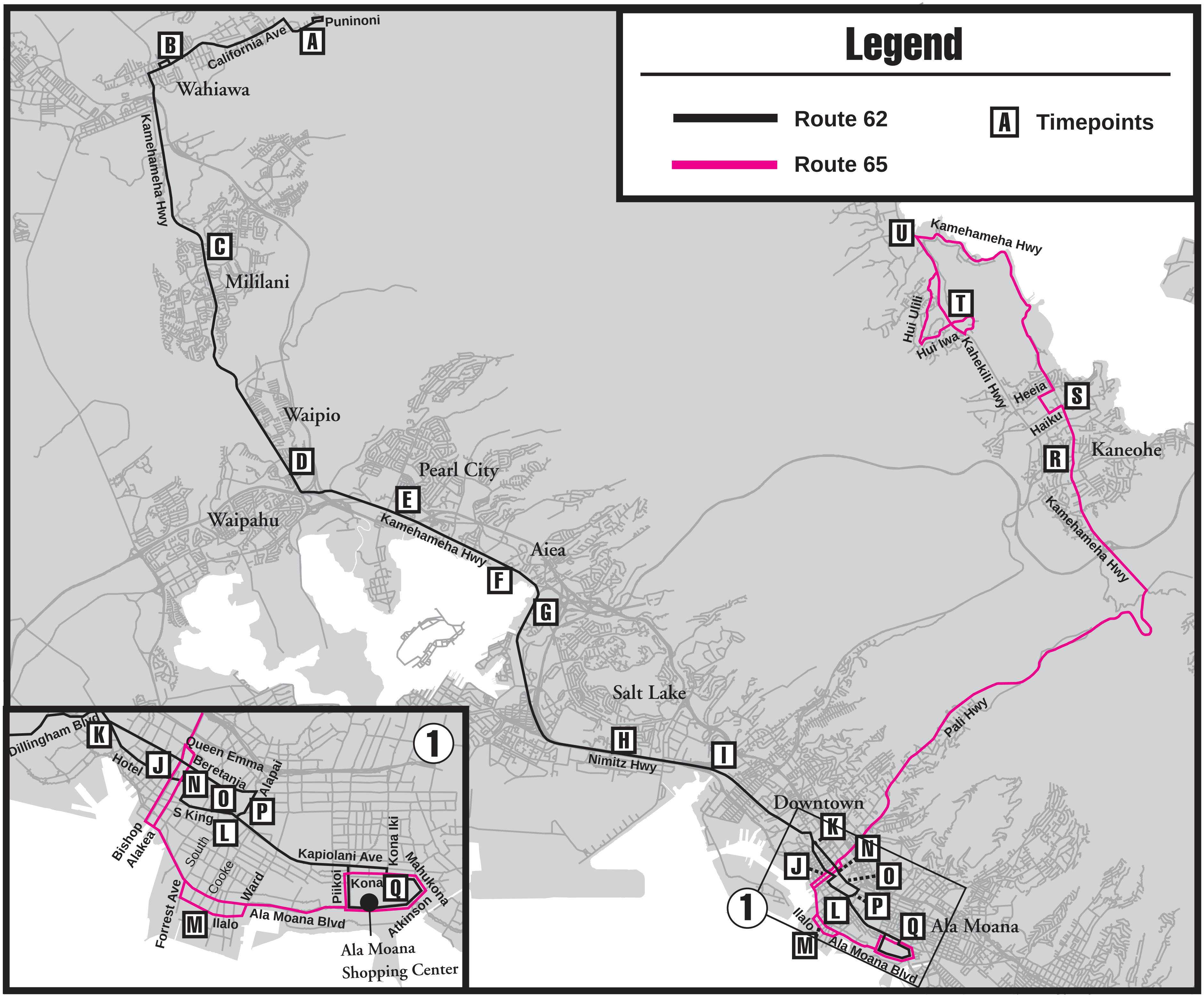
To Waikele:
433 WAIKELE
To Waipahu Transit Center:
433 WAIPAHU TRANSIT CENTER

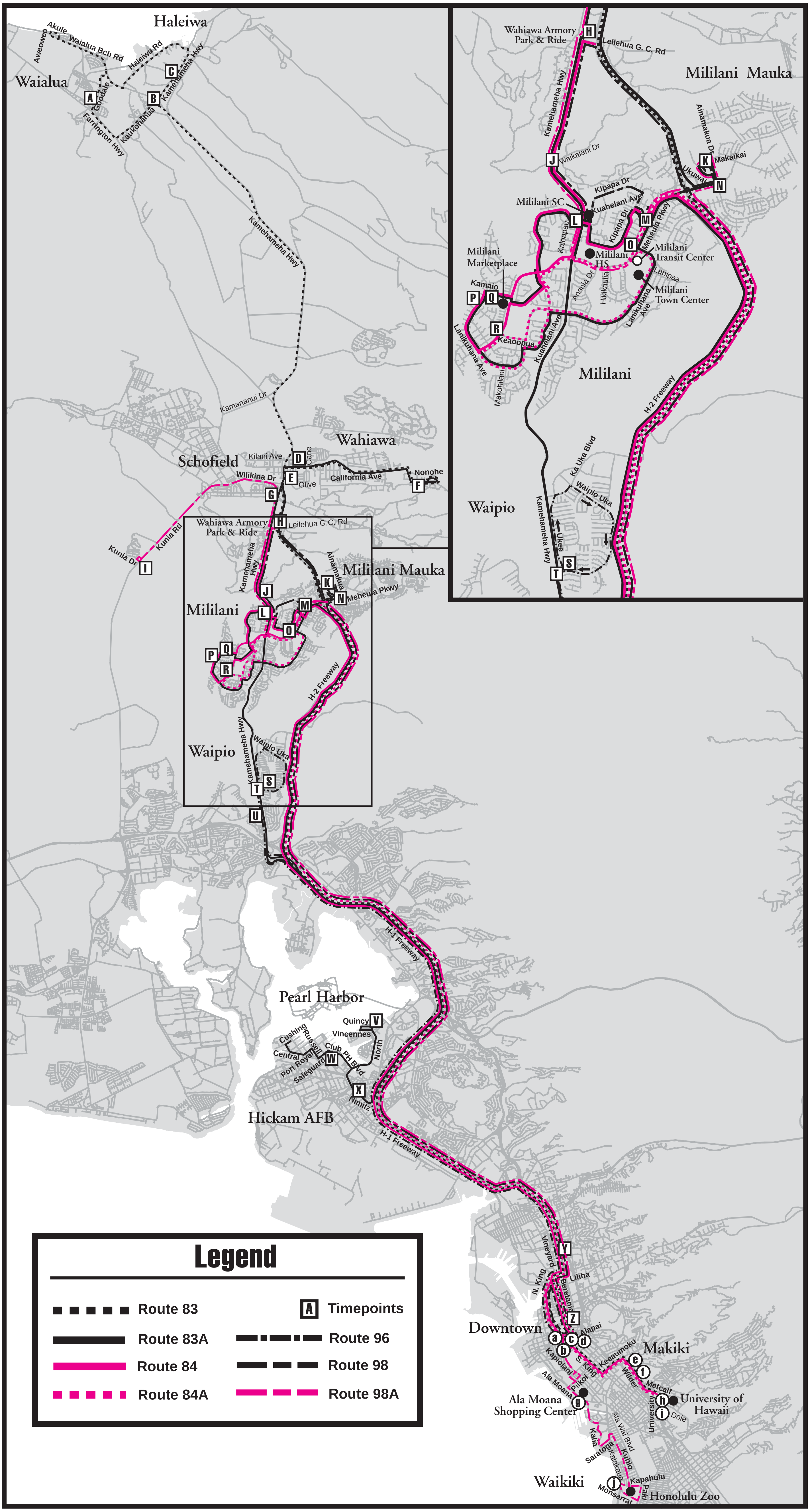
State holiday service operating on Martin Luther King Jr. Day, Kuhio Day, Good Friday, Kamehameha Day, Admission Day and Election Day holidays

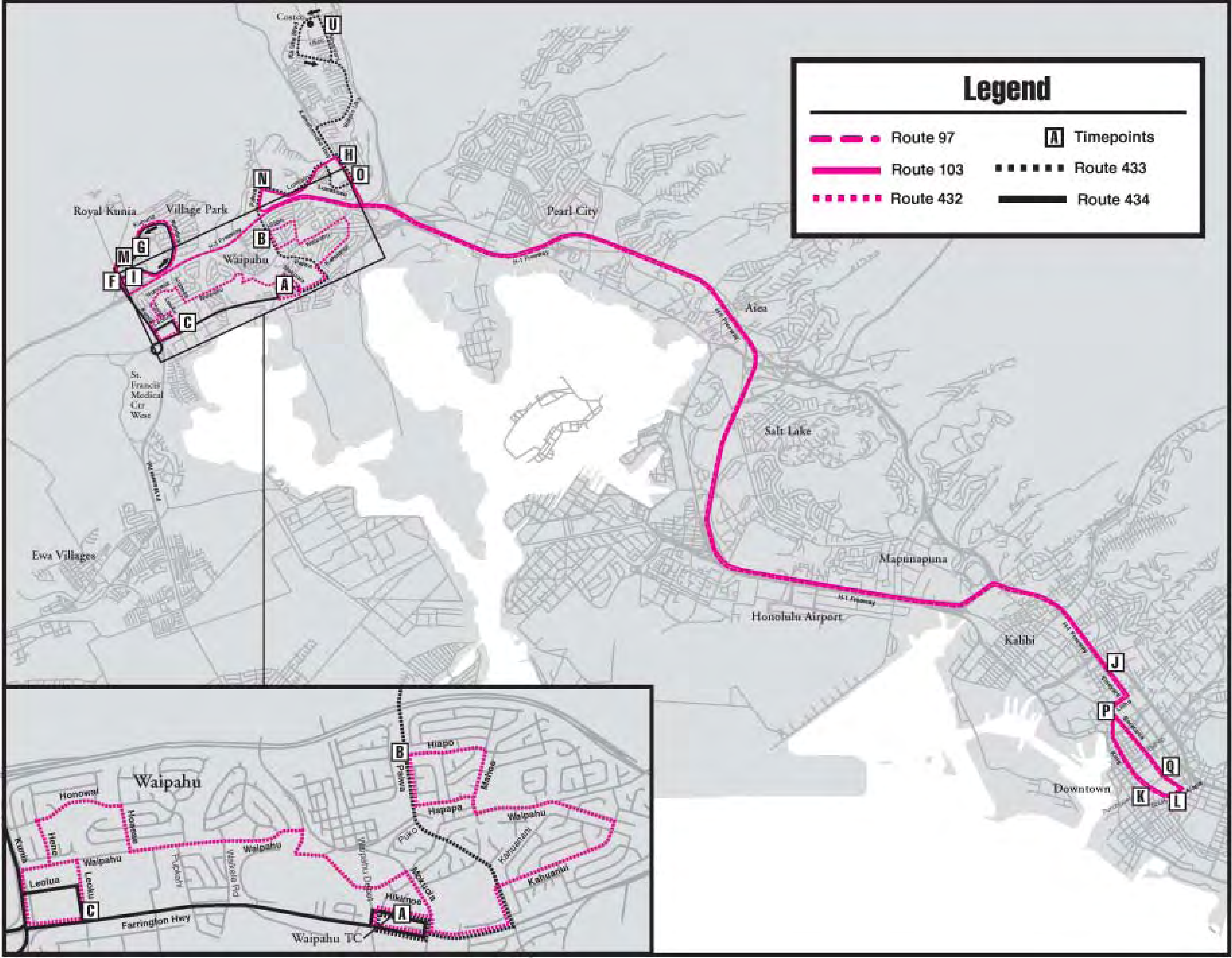
Bold indicates PM service. Schedule to change without notice. All buses are lift and bicycle rack equipped.



Turtle Bay Resort
Kuilima
Kahuku
Kamehameha Hwy
Haleiwa
Wahiawa
California Ave
Cane
Meheula Pkwy
Mililani
H-2 Freeway
Pearl City
H-1 Freeway
H-1 Viaduct
Likelike Hwy
Pali Hwy
Kahekili Hwy
Heeia
Haiku
Kaneohe
Downtown
Ala Moana
Kamehameha Hwy
Kilani Ave
California Ave
Wilikina Dr
Mililani Mauka
Makaikai
Ukuwai
Ainamakua
Meheula Pkwy
Mililani SC
Kuahelani
Lanikuhana
Mililani Transit Center
Mililani Town Center
Dillingham Blvd
H-1 Freeway
Hotel
Beretania
Alapai
S King
Downtown
Bishop
Alakea
Kapiolani Ave
Kona Iki
Mahukona
Piikoi
Kona
Ward
Ala Moana Blvd
Atkinson
Ala Moana Shopping Center
Windward Mall
Alaloa
Likelike Hwy
Legend
Route 52
Timepoints
Route 88A
Route 55


Legend
Route 62
Route 65
A Timepoints
Puninoni
California Ave
Wahiawa
Kamehameha Hwy
Mililani
Waipio
Pearl City
Waipahu
Kamehameha Hwy
Aiea
Salt Lake
Nimitz Hwy
Downtown
Ala Moana
Ala Moana Blvd
Ilalo
Kamehameha Hwy
Hui Ulili
Hui Iwa
Kahekili Hwy
Heeia
Haiku
Kaneohe
Kamehameha Hwy
Pali Hwy
Dillingham Blvd
Hotel
Queen Emma
Beretania
Alapai
S King
Bishop
Alakea
South
Cooke
Ward
Forrest Ave
Ilalo
Ala Moana Blvd
Kapiolani Ave
Kona Iki
Mahukona
Piikoi
Kona
Atkinson
Ala Moana Shopping Center


Haleiwa
Waialua
Akule
Aweoweo
Waialua Bch Rd
Haleiwa Rd
Kamehameha Hwy
Goodale
Farrington Hwy
Kaukonahua
Kamananui Dr
Wahiawa
Schofield
Kilani Ave
Cane
California Ave
Nonohe
Olive
Wilikina Dr
Kunia Rd
Kunia Dr
Wahiawa Armory Park & Ride
Leilehua G.C. Rd
Mililani Mauka
Ainamakua
Meheula Pkwy
Mililani
Waipio
Waipio Uka
H-2 Freeway
H-1 Freeway
Pearl Harbor
Quincy
Vincennes
Cushing
Russell
Central
Club
PH Blvd
Port Royal
Safeguard
North
Nimitz
Hickam AFB
Mililani SC
Kipapa Dr
Kuahelani Ave
Mililani Marketplace
Kaloapau
Mililani HS
Mililani Transit Center
Lanipaa
Mililani Town Center
Kamaio
Keaoopua
Lanikuhana Ave
Makohilani
Anania Dr
Hikikaulia
Ukuwai
Makaikai
Ainamakua Dr
Waikalani Dr
Leilehua G. C. Rd
Ka Uka Blvd
Ukee
Vineyard
N. King
Liliha
Beretania
Alapai
Downtown
Makiki
Keeaumoku
S. King
Kapiolani
Wilder
Metcalf
University of Hawaii
Dole
University
Ala Moana
Piikoi
Ala Moana Shopping Center
Ala Wai Blvd
Kalia
Saratoga
Kalakaua
Kuhio
Waikiki
Kapahulu
Paki
Monsarrat
Honolulu Zoo
Legend
Route 83
Route 83A
Route 84
Route 84A
Timepoints
Route 96
Route 98
Route 98A


Legend
Route 97
Route 103
Route 432
Timepoints
Route 433
Route 434
Costco
Royal Kunia
Village Park
Waipahu
Pearl City
Aiea
Salt Lake
Mapunapuna
Honolulu Airport
Kalihi
Downtown
St. Francis Medical Ctr West
Ewa Villages
Hiapo
Paiwa
Mahoe
Hapapa
Waipahu
Honowai
Hoaeae
Hene
Leolua
Leoku
Kunia
Farrington Hwy
Waipahu Depot
Kahuanani
Kahuamui
Hikimoe
Mokuola
Puko
Waikele Rd
Waipahu TC
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APPENDIX B: TheBus Route Profiles

The following are TheBus route profiles from the Transit Rider Database (TRD) for those services in proximity to Koa Ridge Makai and Waiawa:

Note: The data was collected in 2004 and Route 433 did not exist at that time.

TheBus Route 52

TURTLE BAY-ALA MOANA

Key Rider Characteristics For Route 52 (with 55, 62 & 65)

53.0 %	Are licensed drivers
25.2 %	Have a vehicle available
27.2 %	Are students
47.0 %	Are employed full-time
8.3 %	Are visitors or tourists
80.5 %	Are Title VI minorities
49.8 %	Have household incomes $25,000 or less
15.2 %	Are 18 years of age or younger
7.5 %	Are 65 years of age or older
26.1 %	Have been riding for 15 years or more
76.4 %	Rate TheBus as being good or better

Connecting Mode To And From The Route

	Percent By Mode		
	Walk	Bus	Other
To TheBus	66.0%	22.9%	11.1%
From TheBus	75.0%	18.5%	6.5%

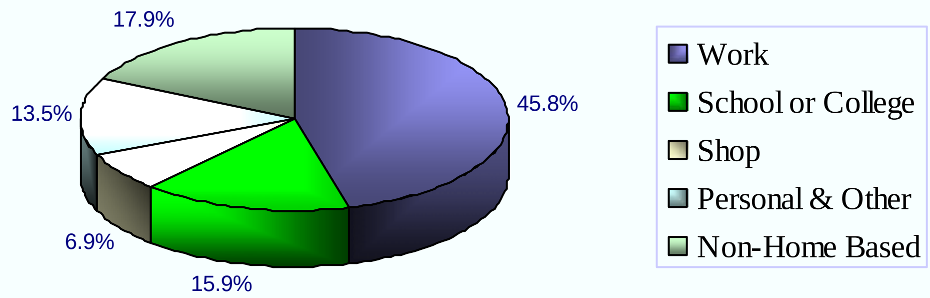
Distance Walked To And From Bus Stop Along Route

	Percent By Number Of Blocks		
	One or Less	Two or Three	Four or More
To TheBus	38.6%	44.7%	16.4%
From TheBus	43.6%	37.8%	18.6%

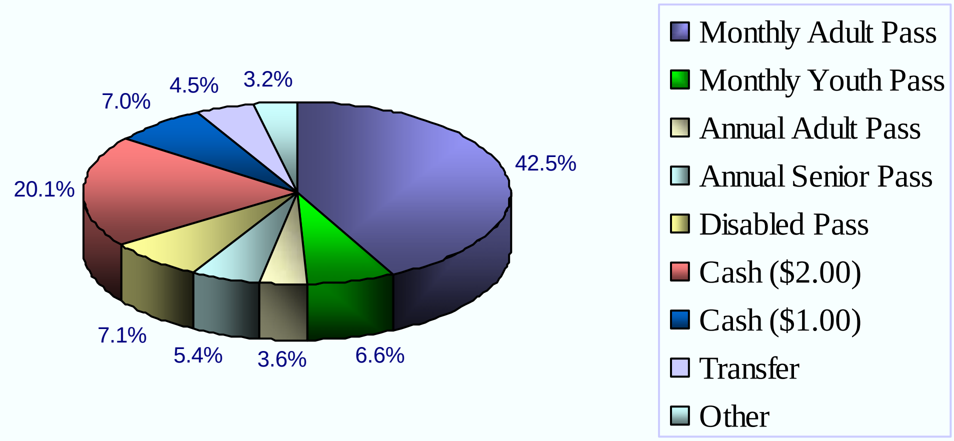
Route Sample

727 Valid Surveys
16,953 Weekday Ridership Expansion Total

Trip Purpose



Fare Payment



TheBus Route 62

WAHIAWA-ALA MOANA

Key Rider Characteristics For Route 62 (with 52, 55 & 65)

53.0	%	Are licensed drivers
25.2	%	Have a vehicle available
27.2	%	Are students
47.0	%	Are employed full-time
8.3	%	Are visitors or tourists
80.5	%	Are Title VI minorities
49.8	%	Have household incomes $25,000 or less
15.2	%	Are 18 years of age or younger
7.5	%	Are 65 years of age or older
26.1	%	Have been riding for 15 years or more
76.4	%	Rate TheBus as being good or better

Connecting Mode To And From The Route

	Percent By Mode		
	Walk	Bus	Other
To TheBus	66.0%	22.9%	11.1%
From TheBus	75.0%	18.5%	6.5%

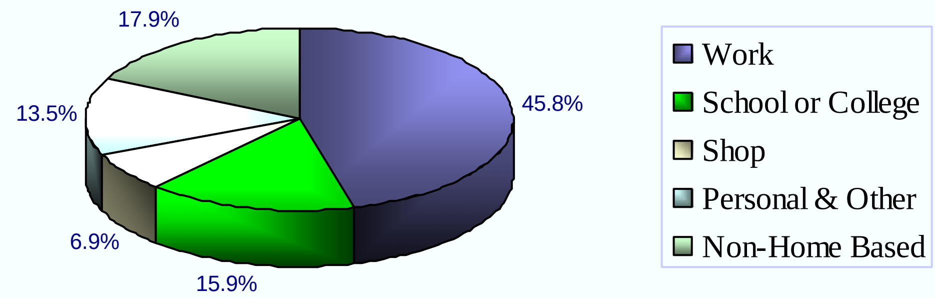
Distance Walked To And From Bus Stop Along Route

	Percent By Number Of Blocks		
	One or Less	Two or Three	Four or More
To TheBus	38.6%	44.7%	16.4%
From TheBus	43.6%	37.8%	18.6%

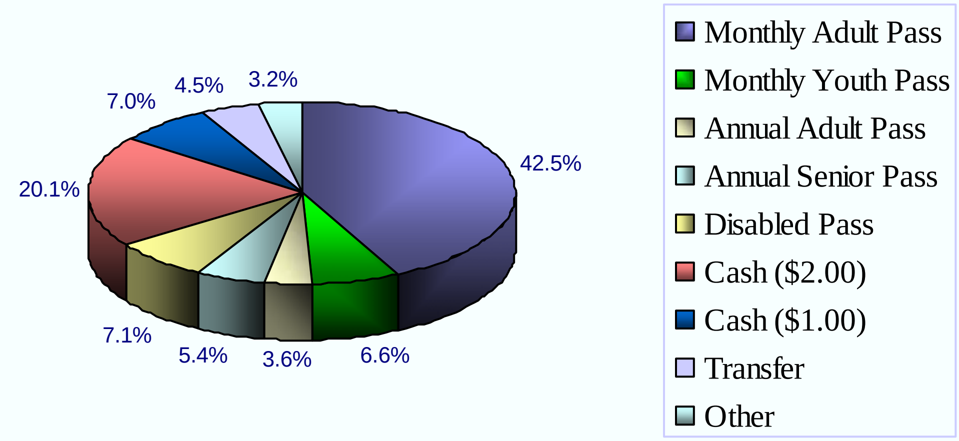
Route Sample

727	Valid Surveys
16,953	Weekday Ridership Expansion Total

Trip Purpose



Fare Payment



TheBus Route 83

WAIALUA-WAHIAWA-DOWNTOWN-U.H.

Key Rider Characteristics For Route 83

59.4	%	Are licensed drivers
60.2	%	Have a vehicle available
13.1	%	Are students
77.6	%	Are employed full-time
0.0	%	Are visitors or tourists
86.3	%	Are Title VI minorities
39.3	%	Have household incomes $25,000 or less
7.0	%	Are 18 years of age or younger
4.5	%	Are 65 years of age or older
23.2	%	Have been riding for 15 years or more
85.1	%	Rate TheBus as being good or better

Connecting Mode To And From The Route

	Percent By Mode		
	Walk	Bus	Other
To TheBus	63.6%	13.0%	23.4%
From TheBus	68.5%	18.3%	13.2%

Distance Walked To And From Bus Stop Along Route

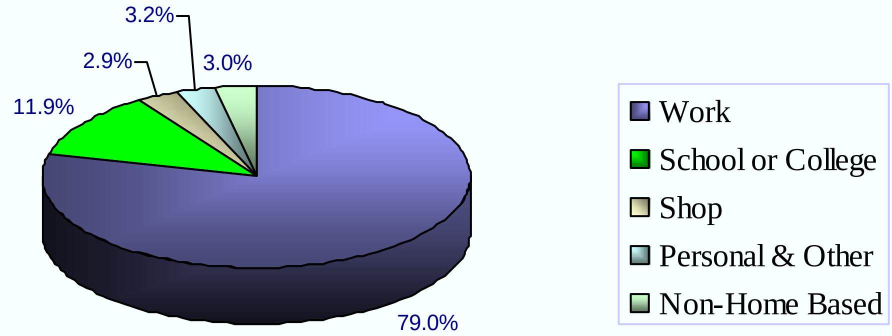
	Percent By Number Of Blocks		
	One or Less	Two or Three	Four or More
To TheBus	71.1%	19.8%	9.1%
From TheBus	45.7%	51.6%	2.7%

Route Sample

312 Valid Surveys

615 Weekday Ridership Expansion Total

Trip Purpose



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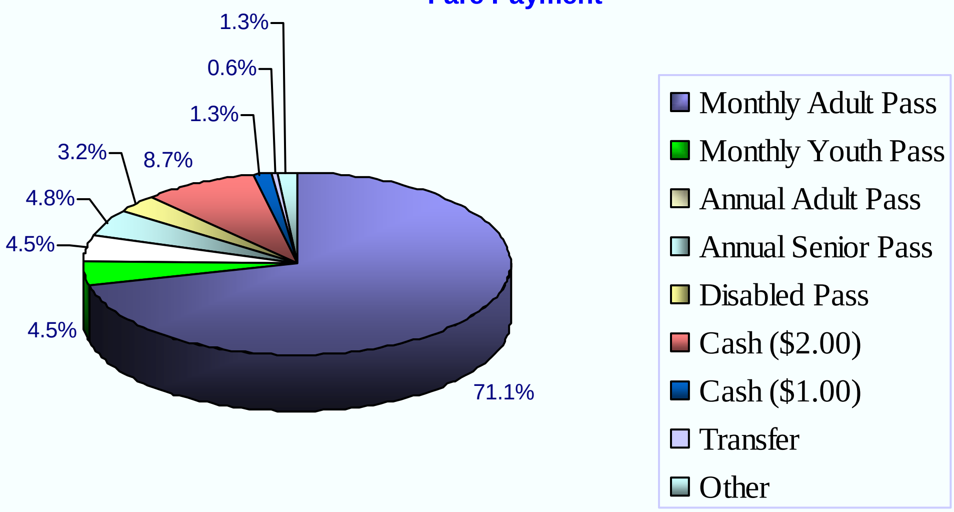


TheBus Route 83a

WAHIAWA-PEARL HARBOR

Key Rider Characteristics For Route 83A

84.2	%	Are licensed drivers
73.7	%	Have a vehicle available
15.8	%	Are students
100.0	%	Are employed full-time
0.0	%	Are visitors or tourists
100.0	%	Are Title VI minorities
5.6	%	Have household incomes $25,000 or less
0.0	%	Are 18 years of age or younger
0.0	%	Are 65 years of age or older
10.5	%	Have been riding for 15 years or more
100.0	%	Rate TheBus as being good or better

Connecting Mode To And From The Route

	Percent By Mode		
	Walk	Bus	Other
To TheBus	84.2%	0.0%	15.8%
From TheBus	89.5%	0.0%	10.5%

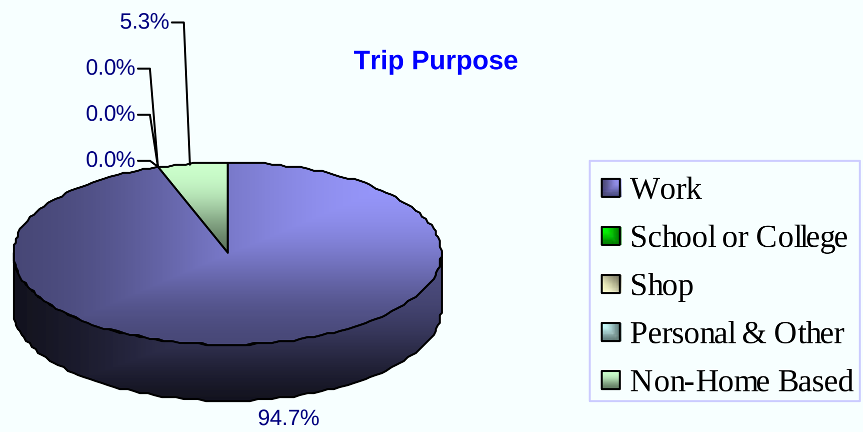
Distance Walked To And From Bus Stop Along Route

	Percent By Number Of Blocks		
	One or Less	Two or Three	Four or More
To TheBus	75.0%	16.6%	8.4%
From TheBus	61.6%	15.4%	23.0%

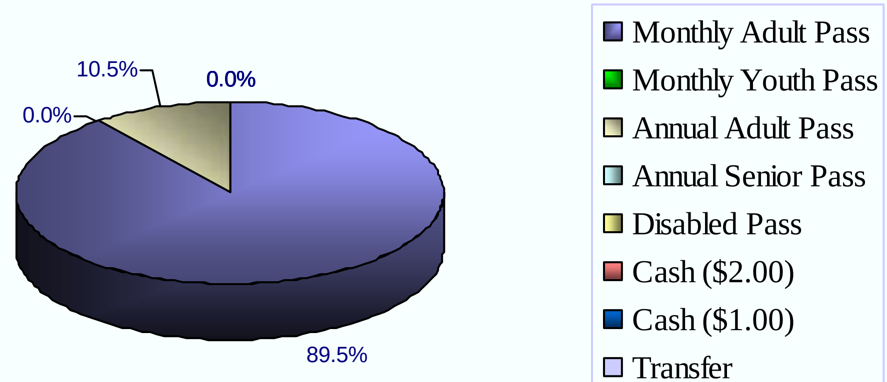
Route Sample

19	Valid Surveys
105	Weekday Ridership Expansion Total

Trip Purpose



Fare Payment



TheBus Route 84

WAHIAWA ARMORY-U.H.

Key Rider Characteristics For Route 84

62.3	%	Are licensed drivers
51.9	%	Have a vehicle available
6.5	%	Are students
90.7	%	Are employed full-time
0.0	%	Are visitors or tourists
91.3	%	Are Title VI minorities
52.0	%	Have household incomes $25,000 or less
1.3	%	Are 18 years of age or younger
5.3	%	Are 65 years of age or older
15.6	%	Have been riding for 15 years or more
90.9	%	Rate TheBus as being good or better

Connecting Mode To And From The Route

	Percent By Mode		
	Walk	Bus	Other
To TheBus	74.0%	15.6%	10.4%
From TheBus	89.5%	0.0%	10.5%

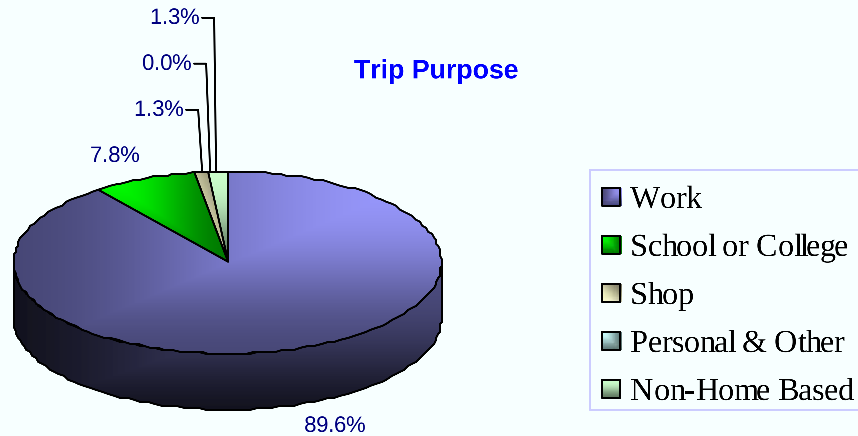
Distance Walked To And From Bus Stop Along Route

	Percent By Number Of Blocks		
	One or Less	Two or Three	Four or More
To TheBus	79.6%	16.4%	4.0%
From TheBus	37.8%	52.8%	9.4%

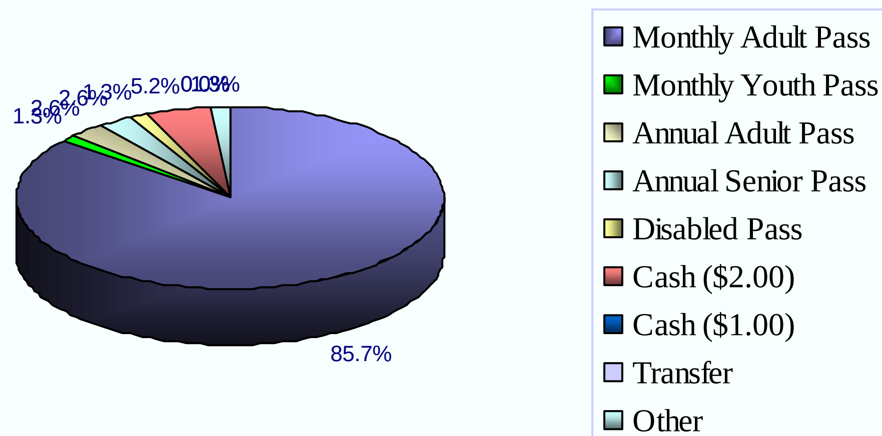
Route Sample

207	Valid Surveys
752	Weekday Ridership Expansion Total

Trip Purpose



Fare Payment



TheBus Route 84a

MILILANI-U.H.

Key Rider Characteristics For Route 84A

73.9	%	Are licensed drivers
58.3	%	Have a vehicle available
20.8	%	Are students
79.2	%	Are employed full-time
0.0	%	Are visitors or tourists
91.7	%	Are Title VI minorities
23.9	%	Have household incomes $25,000 or less
9.1	%	Are 18 years of age or younger
4.5	%	Are 65 years of age or older
29.2	%	Have been riding for 15 years or more
81.8	%	Rate TheBus as being good or better

Connecting Mode To And From The Route

	Percent By Mode		
	Walk	Bus	Other
To TheBus	83.3%	0.0%	16.7%
From TheBus	66.7%	25.0%	8.3%

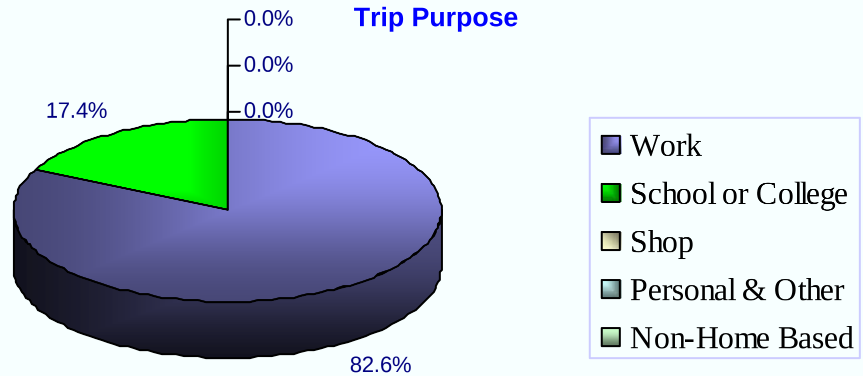
Distance Walked To And From Bus Stop Along Route

	Percent By Number Of Blocks		
	One or Less	Two or Three	Four or More
To TheBus	61.5%	23.1%	15.4%
From TheBus	63.7%	36.3%	0.0%

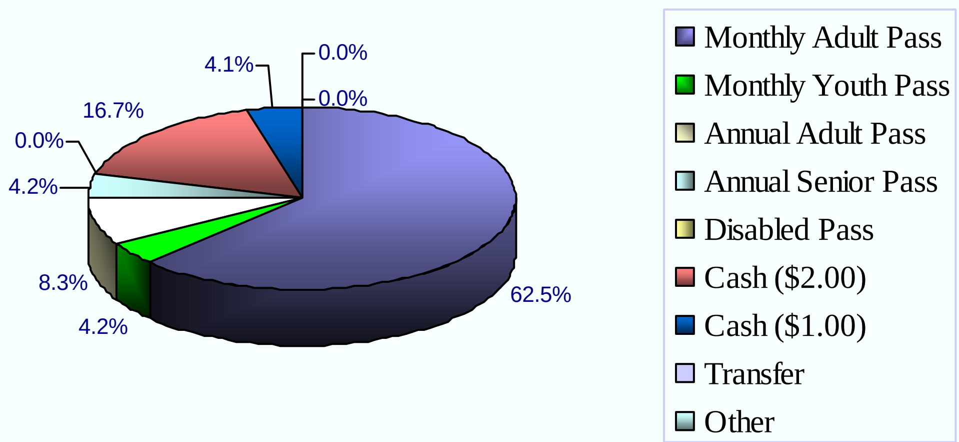
Route Sample

24 Valid Surveys
Weekday Ridership Expansion Total

Trip Purpose



Fare Payment



TheBus Route 96

WAIPIO GENTRY-DOWNTOWN

Key Rider Characteristics For Route 96

82.2	%	Are licensed drivers
64.6	%	Have a vehicle available
8.9	%	Are students
92.1	%	Are employed full-time
0.0	%	Are visitors or tourists
86.6	%	Are Title VI minorities
13.2	%	Have household incomes $25,000 or less
5.6	%	Are 18 years of age or younger
5.6	%	Are 65 years of age or older
26.3	%	Have been riding for 15 years or more
90.8	%	Rate TheBus as being good or better

Connecting Mode To And From The Route

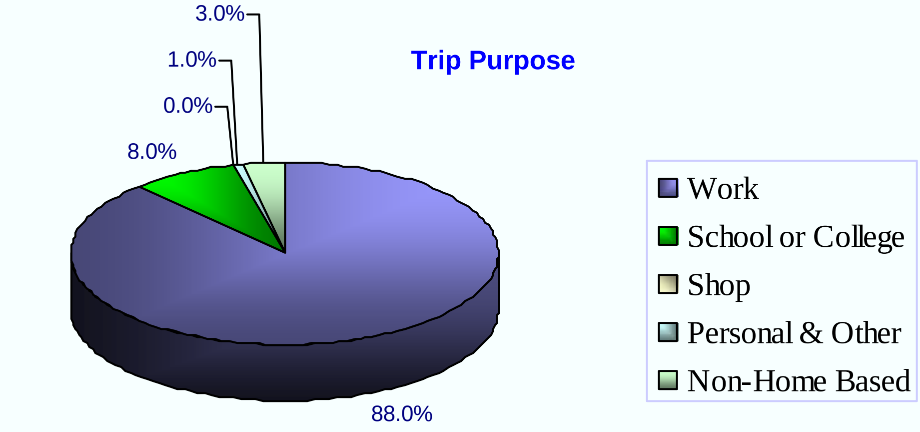
	Percent By Mode		
	Walk	Bus	Other
To TheBus	69.0%	23.0%	8.0%
From TheBus	90.1%	7.9%	2.0%

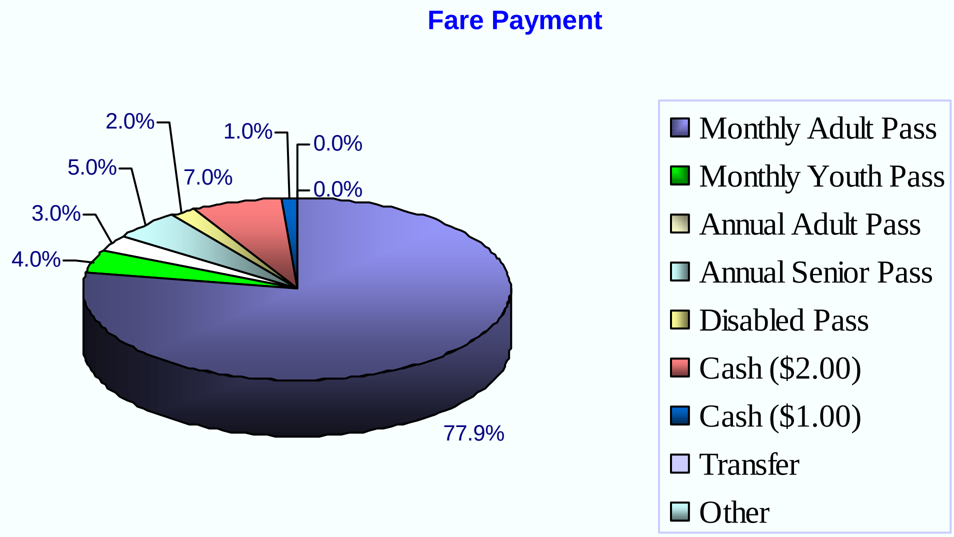
Distance Walked To And From Bus Stop Along Route

	Percent By Number Of Blocks		
	One or Less	Two or Three	Four or More
To TheBus	42.9%	46.9%	10.2%
From TheBus	42.2%	42.2%	15.6%

Route Sample

101 Valid Surveys
144 Weekday Ridership Expansion Total





TheBus Route 98

WAHIAWA PARK AND RIDE-MILILANI PARK AND RIDE-DOWNTOWN

Key Rider Characteristics For Route 98

91.1	%	Are licensed drivers
81.4	%	Have a vehicle available
7.1	%	Are students
92.1	%	Are employed full-time
0.0	%	Are visitors or tourists
84.8	%	Are Title VI minorities
8.9	%	Have household incomes $25,000 or less
2.6	%	Are 18 years of age or younger
5.8	%	Are 65 years of age or older
26.0	%	Have been riding for 15 years or more
87.6	%	Rate TheBus as being good or better

Connecting Mode To And From The Route

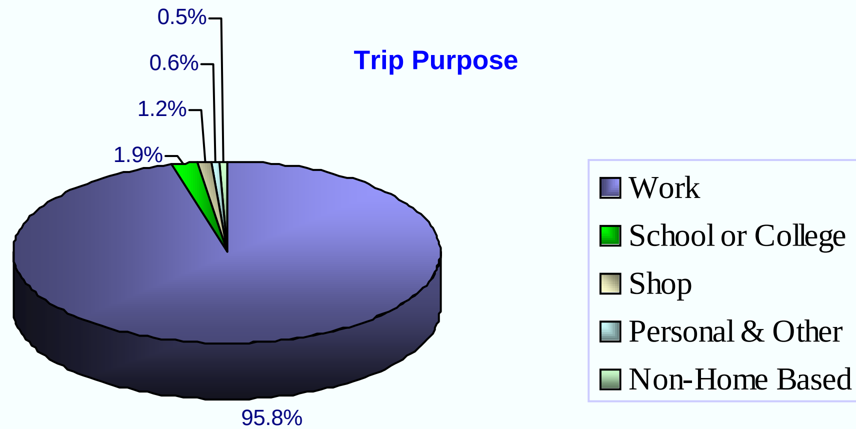
	Percent By Mode		
	Walk	Bus	Other
To TheBus	46.7%	6.5%	46.8%
From TheBus	69.6%	11.3%	19.1%

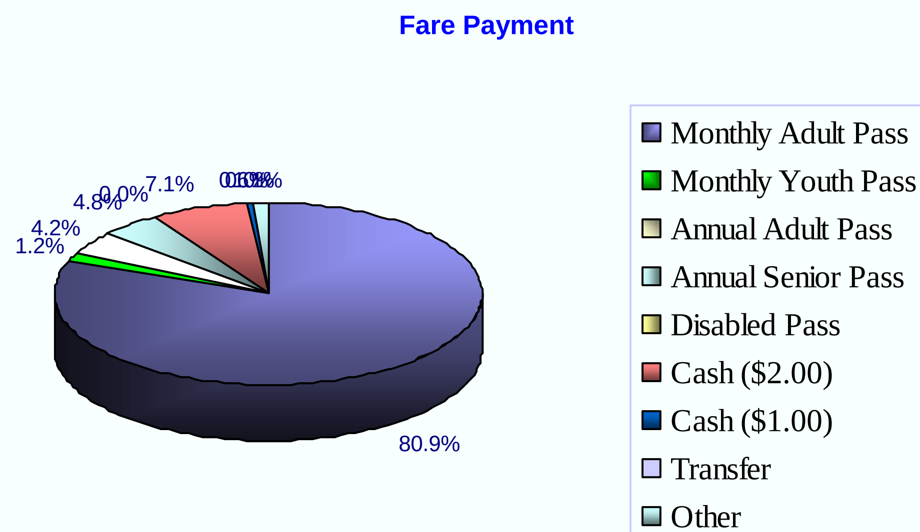
Distance Walked To And From Bus Stop Along Route

	Percent By Number Of Blocks		
	One or Less	Two or Three	Four or More
To TheBus	34.0%	48.0%	18.0%
From TheBus	50.7%	39.1%	10.2%

Route Sample

168 Valid Surveys
214 Weekday Ridership Expansion Total





APPENDIX C: DTS Central Oahu Bus Service Plan

The following correspondence from DTS to the Honolulu City Council dated October 21, 2005 presents the Central Oahu Bus Service Plan.

DEPARTMENT OF TRANSPORTATION SERVICES
CITY AND COUNTY OF HONOLULU
650 SOUTH KING STREET, 3RD FLOOR
HONOLULU, HAWAII 96813
Phone: (808) 523-4529 • Fax: (808) 523-4730 • Internet: www.co.honolulu.hi.us

MUFI HANNEMANN
MAYOR

ALFRED A. TANAKA, P.E.
ACTING DIRECTOR

October 21, 2005

The Honorable Donovan M. Dela Cruz, Chair
and Members of the City Council
City and County of Honolulu
530 South King Street
Honolulu, Hawaii 96813

Dear Chair Dela Cruz and Councilmembers:

Subject: Resolution No. 05-248 Urging the Department of Transportation Services to Evaluate and Improve Bus Service for Central Oahu

Please find attached our Central Oahu Bus Service Plan. This report reviews the current services in Central Oahu and discusses our proposed plan and implementation phases. We also reviewed the proposed service recommendations as outlined in Resolution No. 05-248. This plan does not include express bus services.

Our service plan was developed based on ridership analysis and surveys, as well as comments and input received at various community forums conducted in the past.

Sincerely,

ALFRED A. TANAKA, P.E.
Acting Director

Attachment

APPROVED:

JEFF COELHO
Managing Director

Dept. Com. No. 1012

Central Oahu Bus Service Plan

This report reviews the current services in Central Oahu and discusses our proposed plan and implementation phases. We also reviewed the proposed service recommendations as outlined in Resolution 05-248. This plan does not include express bus services.

Our service plan was developed based on ridership analysis and surveys as well as comments and input received at various community forums conducted in the past.

The Central Oahu Bus Service Plan service area extends from Waipio Gentry to Haleiwa. It includes Waipio Gentry, Mililani (North and South), Waikalani, Launani, Wheeler/Schofield, Wahiawa, Whitmore, Haleiwa, and Waialua.

Exhibit I shows the current services.

Route 52 – Wahiawa-Circle Island is an all-day, every day service. It traverses in local service between Haleiwa, Wahiawa, and Mililani. Route 52 travels on the freeway between Mililani and Downtown Honolulu.

Route 62 – Wahiawa/Wahiawa Heights-Ala Moana Center is a local service that travels between Wahiawa to Ala Moana Center. Route 62 travels on Kamehameha Highway between Wahiawa and Downtown Honolulu.

Route 72 – Wahiawa-Schofield-Whitmore is a shuttle service between Schofield and Whitmore through Wahiawa. Limited service is provided to the Naval Computers and Telecommunications Area Master Station (NCTAMS) Pacific.

Route 76 – Waialua-Haleiwa is a shuttle service between Waialua and Haleiwa.

Route 503 – Mililani-Waikalani-Launani is a community access shuttle. This shuttle service uses a Handi-Van type vehicle to provide shuttle service between Launani Valley, Waikalani, and Mililani.

Exhibit II is our proposed service plan.

This service plan shows service operating from three hub locations.

Routes 50, 501, 502, 503, 504, and 505 originate and terminate at the Mililani hub at the Mililani Town Center.

ENCL TO D 1012

Routes 51, 511, 512, and 513 originate and terminate at the Wahiawa hub at the Wahiawa Civic Center.

Route 52 is a through route serving both the Mililani and Wahiawa hubs as well as the Haleiwa hub.

We propose to implement the Central Oahu Service Plan in four phases.

Phase 1:

Extension of Route 433 – Waipahu Transit Center-Waikele to Waipio (Moaniani). This service was funded in the Fiscal Year 2006 budget and provides service to the Kaiser Clinic/Costco area in Waipio.

Anticipated Implementation Date: December 2005

Phase 2: Assumes no additional funding.

Route 51 – Honolulu to Wahiawa is implemented, with the exception of the Mililani via Meheula and Lanikuhana extension. Route 62 is discontinued.

Route 511 – Wahiawa Heights shuttle to the Wahiawa hub is implemented.

Routes 512/513 – Wahiawa-Whitmore and Wahiawa-Schofield from the Wahiawa hub is implemented. The Route 72 one-bus operation is discontinued.

Route 521/522 – Haleiwa-Waialua Beach and Haleiwa-Mokuleia Beach from the Haleiwa hub is implemented. The Route 76 one bus operation is discontinued.

Anticipated Implementation Date: June 2006

Phase 3: Requires about 40,500 additional service hours.

If we assume a service hour to cost $65.00, this means implementation of Phase 3 will cost at least $2,632,500 at today's prices. Phase 3 implements Route 50. Route 50 provides service between the Mililani hub, Waipahu Transit Center, and the Kapolei Transit Center. Since Route 50 will provide service along Lumiaina through Waikele, Route 433 will be modified to provide service to upper Waikele and Manager's Drive. Schedule adjustment modifications to Route 52 are also planned in Phase 3.

Anticipated Implementation Date: December 2006 Pending Funding

Phase 4:

Implements Mililani Shuttle Routes 501, 502, and 504. This is about 19,000 additional service hours. Again, if we assume a service hour to cost $65, then Phase 4 costs at least $1,235,000 at today's prices.

Phase 4 also modifies Route 51 to include service to Mililani via Meheula and Lanikuhana.

Anticipated Implementation Date: June 2007 Pending Funding

Resolution No. 05-248 proposes the following service modifications.

1. Modify Route 62 to operate as a shuttle between the end of the route and the California, Lehua, Center, and N. Cane block, eliminates bus service to and from Honolulu. This is not recommended.

2. Adding an extension to the Wahiawa Heights shuttle that would provide service to Whitmore Village and Schofield Barracks duplicates service that is currently provided by Route 72 - Schofield/Wahiawa/Whitmore. This is not recommended.

3. Replacing the current handivan vehicles that are being used to service Route 503 Launani Valley, Waikalani, and Mililani with 40 foot buses will for all intents and purposes eliminate this service. A 40 foot transit bus cannot safely operate on a regular schedule in Launani Valley and Waikalani.

4. The Mililani Trolley, a privately operated public transportation service, provides shuttle services to the Mililani Mauka area, from 7:00 a.m. till 4:00 p.m. Monday through Saturday. Extended hours services are recommended to provide connections from regular Routes 52, and 62 and from commuter express route 84, 84A and 98.

This concludes discussion of our Central Oahu Bus Service Plan and review of proposed service recommendations in Resolution No. 05-248.

Comments received in support of Resolution No. 05-248 are attached.

EXHIBIT I

Central Oahu Bus Service Plan
Current Service

Route	Service Area	Service Span (Time)	Headway (minutes)	Average daily Riders	Annualized Bus Hours
52	Wahiawa-Circle Isle	430a-130a	32.5	16,152*	88,486.40+
62	Wahiawa /Wahiawa Heights	430a-1145p	32.5	16,152*	83,576.00++
72	Schofield/Wahiawa/Whitmore	527a-656p	60	450	9,424.00
76	Waialua/Haleiwa	600a-715p	40	295	10,106.00
503	Mililani-Waikalani-Launani (Community Access Shuttle)	433a-753p	60	128	12,573.60

*Total average daily ridership for Routes 52/55/62/65

EXHIBIT II

Central Oahu Bus Service Plan
Proposed Service

Route	Service Area	Service Span (Time)	Headway (minutes)	Annualized Bus Hours
50	Mililani-Waipahu-Kapolei *(New Route)*	500a-1100p	30	40,261
501	Mililani Mauka *(New Route)*	530a-1000p	30	13,068
502	Mililani-Lanikuhana (*New Route)*			
503	Mililani-Waikalani-Launani			
504	Mililani-Makaunulau-Kuahelani (*New Route)*	530a-700p	60	5,367
505	Mililani Mauka-Ainamakua (*New Route)*			
51	Honolulu-Wahiawa	430a-1200a	30	43,781
511	Wahiawa Heights	430a-1130p	30	7,114
512	Wahiawa-California-Kilani-Whitmore	500a-800p	30	5,647
513	Wahiawa-Wilikina-Schofield	500a-800p	60	5,647
52	Honolulu-Mililani-Wahiawa	430a-1200a	30	58,375
521	Haleiwa-Waialua Beach	500a-800p	60	5,647
522	Haleiwa-Mokuleia	500a-800p	60	

Shaded routes are interlined

APPENDIX D: DTS Bus Service Improvement Plan

The following are routes proposed by DTS as part of the recent Bus Service Improvement Plan:

Route 50 Mililani Transit Center – Kapolei Transit Center -- 1 page

Route 51 Wahiawa Transit Center – Ala Moana Transit Center -- 1 page

Route 52 Haleiwa Transit Hub – Ala Moana Transit Center -- 1 page

TheBus Route 50

Mililani Transit Center – Kapolei Transit Center

Bus Service Improvement Plan

Route Restructuring Proposal

Description: Route 50 provides daily local service between the Mililani and Kapolei Transit Centers.

Classification Suburban Trunk

Route Turning Movements:

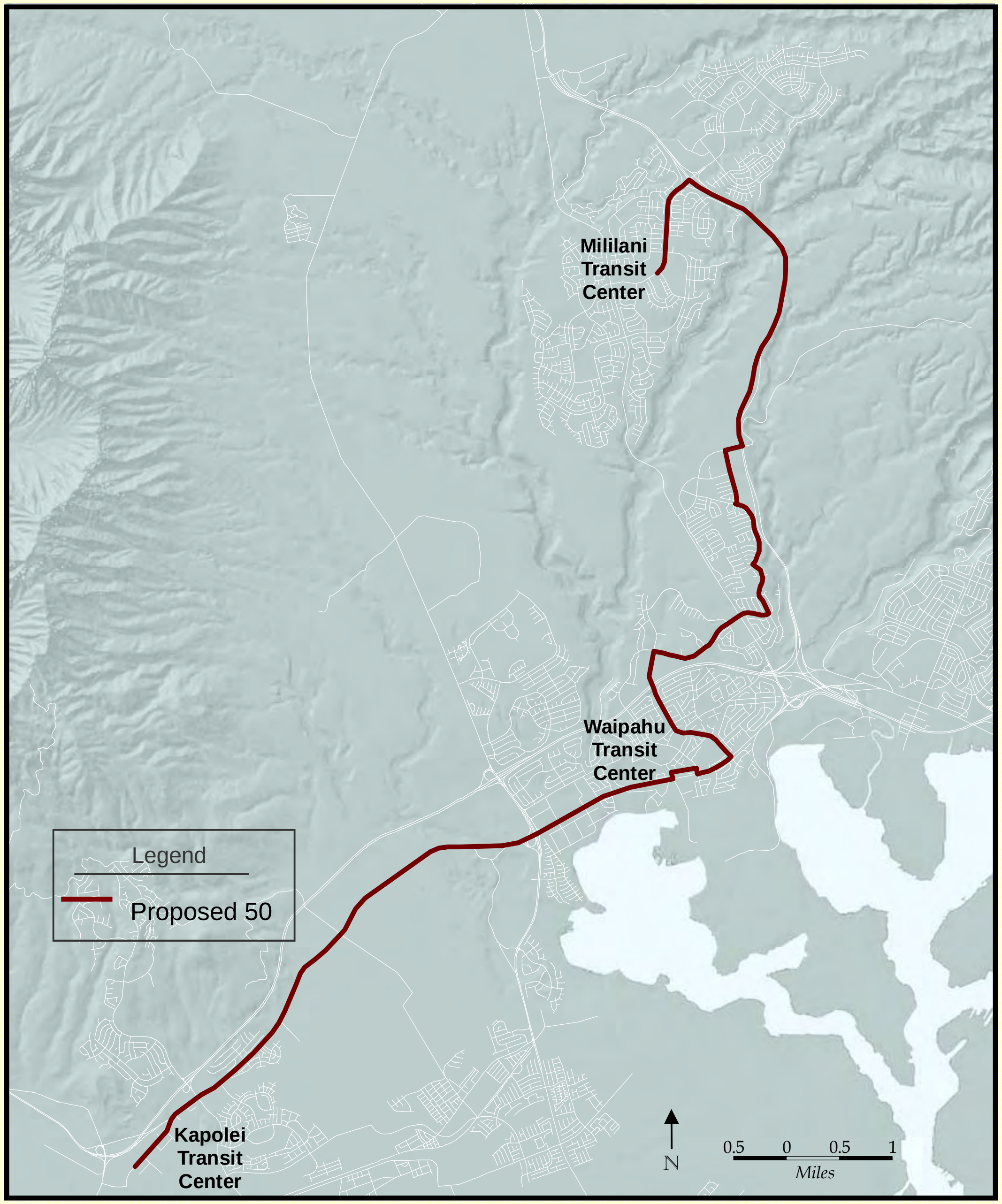
Eastbound: From Kapolei Transit Center, Kamokila, Farrington, Old Farrington, Farrington, lf Waipahu Depot, rt Hikimoe, rt Mokuola, lf Farrington, lf Paiwa, rt Lumiaina, lf Lumikula, rt Waipio Uka, rt Moaniani, rt Ka Uka, lf H-2 North ONRAMP, H-2 North, EXIT 5B "MILILANI TOWN", rt Meheula to Mililani Transit Center.

Westbound: From Mililani Transit Center, Meheula, rt H-2 South ONRAMP, H-2 South, EXIT 2 "KA UKA BLVD/WAIPIO", Moaniani, lf Waipio Uka, lf Lumikula, rt Lumiaina, lf Paiwa, rt Farrington, rt Mokuola, lf Hikimoe, lf Waiapahu Depot, rt Farrington, Old Farrington, Farrington, Kamokila to Kapolei Transit Center.

Route Characteristics:

Day	Service Frequency (minutes)				
	AM	Mid	PM	Eve	Owl
Weekday	30	30	30	30	-----
Saturday	30	30	30	30	-----
Sunday	30	30	30	30	-----

Day	Span of Service	Trips	Cycle Time
Weekday	5:00A - 11:00P	36	150
Saturday	5:00A - 11:00P	34	150
Sunday	5:00A - 11:00P	34	150



TheBus Route 51

Wahiawa Transit Center – Ala Moana Transit Center

Bus Service Improvement Plan

Route Restructuring Proposal

Description: Route 51 provides daily local service between the Wahiawa Transit Center and Ala Moana Transit Center.

Classification: Suburban Trunk

Route Turning Movements:

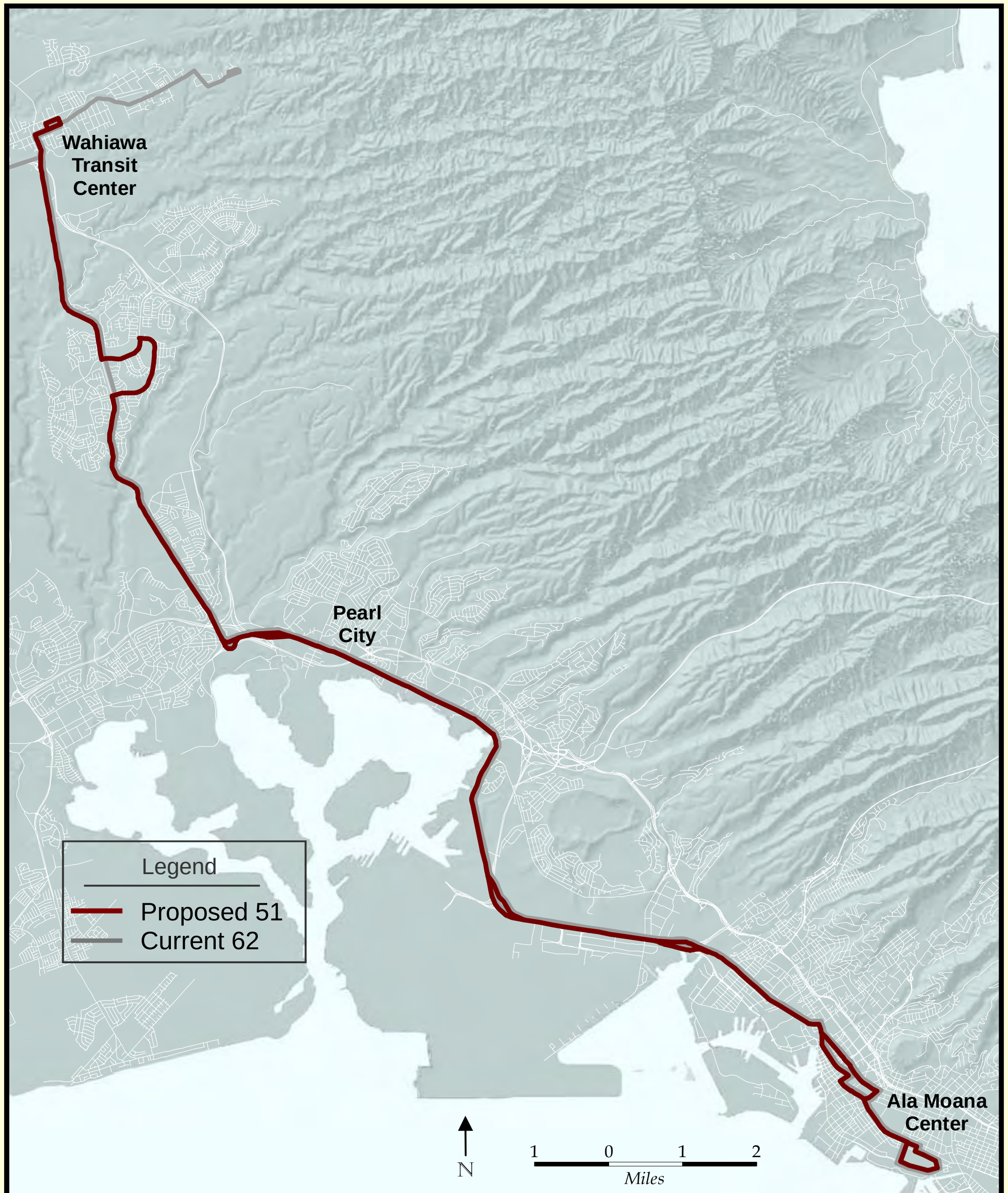
Eastbound: From California/Cane, California, lf Kamehameha, lf Meheula, rt Lanikuhana, lf Kamehameha, Nimitz, Kamehameha, Dillingham, rt King, Hotel, rt Richards, lf King, Kapiolani, rt Kona Iki, lf Kona to Kona/Kona Iki.

Westbound: From Kona/Keeaumoku, Kona, rt Mahukona, rt Atkinson, rt Piikoi, lf Kapiolani, rt South, Alapai, lf Beretania, King, lf Dillingham, Kamehameha, Nimitz, Kamehameha, rt Lanikuhana, lf Meheula, Mililani Transit Center, Meheula, rt Kamehameha, rt California, lf Lehua, rt Center, rt Cane, lf California to California/Cane.

Route Characteristics:

Day	Service Frequency (minutes)				
	AM	Mid	PM	Eve	Owl
Weekday	15	30	15	30	90
Saturday	30	30	30	30	90
Sunday	30	30	30	30	90

Day	Span of Service	Trips	Cycle Time
Weekday	4:30A - 12:00 A	42	210
Saturday	4:30A - 12:00 A	34	210
Sunday	4:30A - 12:00 A	34	210



TheBus Route 52

Haleiwa Transit Hub – Ala Moana Transit Center

Bus Service Improvement Plan

Route Restructuring Proposal

Description: Route 52 provides daily local service between the Haleiwa Transit Hub and and Ala Moana Transit Center.

Classification: Urban Trunk

Route Turning Movements:

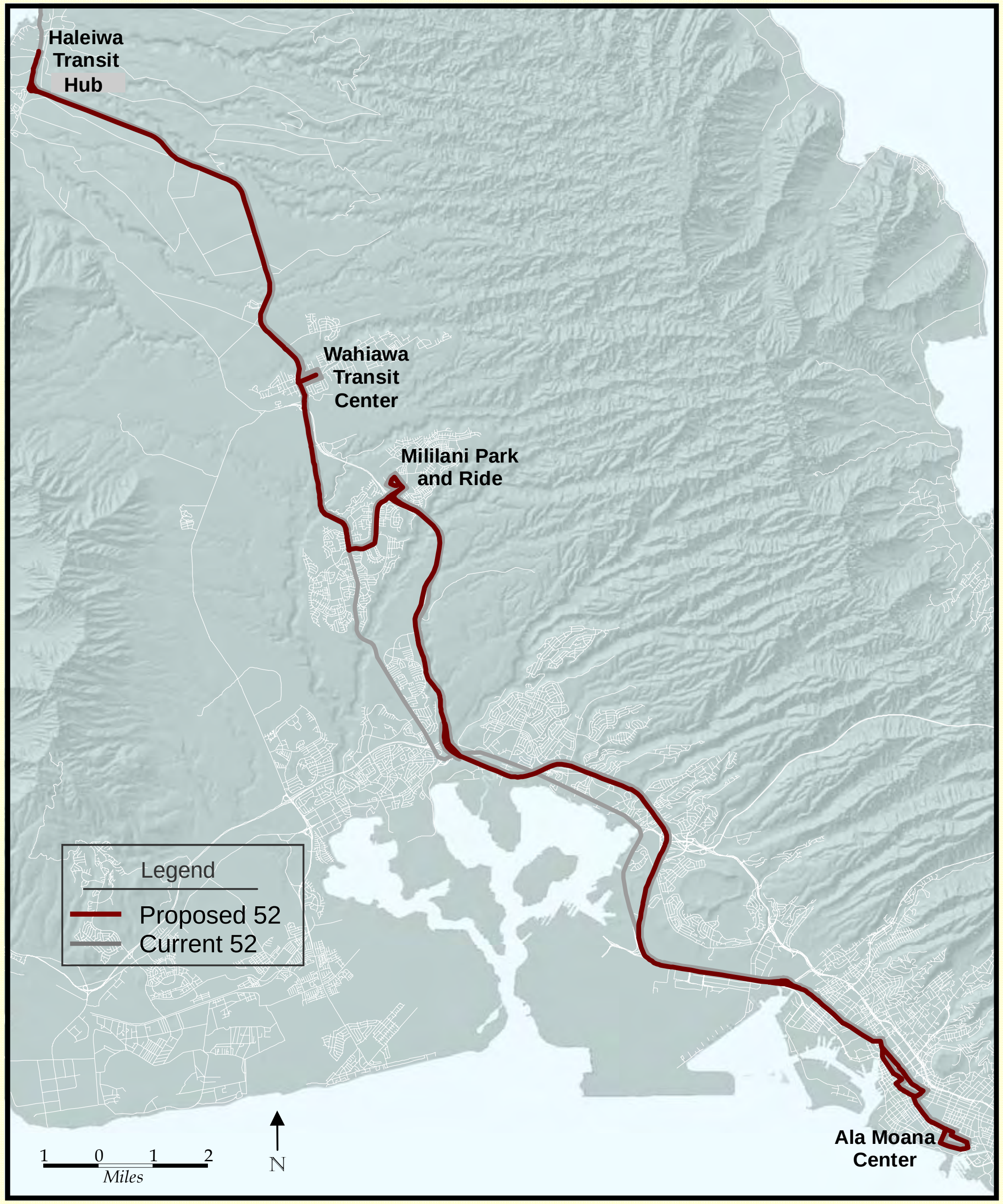
Eastbound: Haleiwa Transit Hub, lf Kamehameha, lf California, lf Lehua, rt Center, rt Cane, rt California, lf Kamehameha, lf Meheula, lf Ainamakua, lf Ukuwai, rt Makaikai, rt Ainamakua, entrance H-2 South, H-2 South, exit Dillingham, Dillingham, rt King, Hotel, lf Richards, rt King, rt Kapiolani, rt Kona Iki, lf Kona to Ala Moana Transit Center.

Westbound: Ala Moana Transit Center, Kona, rt Mahukona, rt Atkinson, rt Ala Moana, rt Piikoi, lf Kapiolani, rt Alapai, lf Beretania, King, lf Dillingham, entrance H-1 West, H-1 West, exit Mililani Mauka, rt Meheula, lf Ainamakua, lf Ukuwai, rt Makaikai, rt Ainamakua, rt Meheula, rt Kamehameha, rt California, lf Lehua, rt Center, rt Cane, rt California, rt Kamehameha to Haleiwa Transit Hub

Route Characteristics:

Day	Service Frequency (minutes)				
	AM	Mid	PM	Eve	Owl
Weekday	30	30	30	30	90
Saturday	30	30	30	30	90
Sunday	30	30	30	30	90

Day	Span of Service	Trips	Cycle Time
Weekday	24 hour	40	180
Saturday	24 hour	40	180
Sunday	24 hour	40	180



APPENDIX E: Koa Ridge Vehicle Trip Generation and Adjustments By Project Preferred Program Land Use Type

The following is a five page table with vehicle trip calculations for the year 2016:

Size of Development and ITE Vehicle Trip Generation Rates -- 1 page

Year 2016 Weekday Daily Trips -- 1 page

Year 2016 Weekday AM Peak Hour Trips -- 1 page

Year 2016 Weekday PM Peak Hour Trips -- 1 page

Notes On Sources And Assumptions -- 1 page

Koa Ridge - Vehicle Trip Generation and Adjustments By Project Preferred Program Land Use Type

PROJECT PREFERRED PROGRAM	YEAR 2016 SIZE OF DEVELOPMENT				ITE VEHICLE TRIP GENERATION RATE [2]				
	AREA [1]			UNITS [1]					
LAND USE TYPE [1]	Total Land *(Square Feet)*	Floor Area *(Square Feet)*	Total *(Acres)*	Number	Code	Type	Weekday	AM Weekday Peak Hour	PM Weekday Peak Hour
Residential - Koa Ridge									
Single Family				479	210	Single-Family Detached Housing	9.57/DU	0.77/DU	1.02/DU
Multi-Family				573	230	Residential Condominium/Townhouse	5.86/DU	0.44/DU	0.52/DU
High Density Multi Family				339	232	High-Rise Residential Condominium/Townhouse	4.18/DU	0.34/DU	0.38/DU
Residential Total				1,391					
Commercial - Koa Ridge									
Big Box		150,000			820	Shopping Center [13][18]	.04294/sq.ft.	.00103/sq.ft.	.00375/sq.ft.
Retail (in residential area)		30,000			820	Shopping Center [13][18]	.04294/sq.ft.	.00103/sq.ft.	.00375/sq.ft.
Retail (near Ka Uka)		95,000			820	Shopping Center [13][18]	.04294/sq.ft.	.00103/sq.ft.	.00375/sq.ft.
Office		10,000			710	General Office Building	.01101/sq.ft.	.00155/sq.ft.	.00149/sq.ft.
Hotel - 150 rooms				0	310	Hotel [4][18]	8.62/room	0.56/room	0.59/room
Industrial - Light		43,000			110	General Light Industrial	.00697/sq.ft.	.00101/sq.ft.	.00108/sq.ft.
Commercial Total		328,000							
Other - Koa Ridge									
Health Care [11]	1,191,294	255,277	10.00		610	Hospital	.01757/sq.ft.	.00147/sq.ft.	.00161/sq.ft.
Elementary School [7]	523,582	130,896	12.00	550	520	Elementary School	1.29/student	0.42/student	0.28/student
District Park (restricted) [9]					412	County Park	2.28/acre	0.52/acre	0.59/acre
Community Center (restricted) [5]	32,370	16,185	1.00		495	Recreational Community Center	.02288/sq.ft. [6]	.00162/sq.ft.	.00164/sq.ft.
Church	68,397	22,571	2.00		560	Church	.00911/sq.ft.	.00072/sq.ft.	.00066/sq.ft.
Other Total	1,815,643	424,929							
Residential - Waiawa									
Single Family				0	210	Single-Family Detached Housing	9.57/DU	0.77/DU	1.02/DU
Multi-Family				200	230	Residential Condominium/Townhouse	5.86/DU	0.44/DU	0.52/DU
Residential Total				200					
Commercial - Waiawa									
Retail (in residential area)		0			820	Shopping Center [13][18]	.04294/sq.ft.	.00103/sq.ft.	.00375/sq.ft.
Commercial Total		0							
Other - Waiawa									
Elementary School [7]		0	0.00		520	Elementary School	.01449/sq.ft.	.00469/sq.ft.	.00313/sq.ft.
Other Total		0							
Totals									

Koa Ridge - Vehicle Trip Generation and Adjustments By Project Preferred Program Land Use Type

PROJECT PREFERRED PROGRAM	YEAR 2016 WEEKDAY DAILY TRIPS														
	A	B	C		D		E		F		G		H	I	J
			ADJUSTMENTS TO ITE VEHICLE TRIPS (calculated as a percent of column "B")												
LAND USE TYPE (1)	ITE Vehicle Trip Generation Rate *(Vehicle Trips Per Day Per Measurement Unit)*	Maximum External Vehicle Trips *(Vehicle Trips Per Day)*	Internal Capture Vehicle Trips (14)(18)(19)		Pass-By Vehicle Trips (13) (19)		Transit Mode Reduction (15) (17) (20) (22)		Pedestrian and Bicycle Mode Reduction (21)(23)		Other TDM Alternative Mode Reduction (15) (16) (22)		Total External Vehicle Trip Adjustments *(C+D+E+F+G)*	Overall Trip Reduction Rate	Project Estimated External Vehicle Trips *(B-H)*
			%	No.	%	No.	%	No.	%	No.	%	No.			
Residential - Koa Ridge															
Single Family	9.57	4,584	0.15	688	0.00	0	0.10	458	0.00	0	0.25	1,146	2,292	0.50	2,292
Multi-Family	5.86	3,358	0.15	504	0.00	0	0.10	336	0.00	0	0.25	839	1,679	0.50	1,679
High Density Multi Family	4.18	1,417	0.15	213	0.00	0	0.10	142	0.00	0	0.25	354	709	0.50	709
Residential Total		9,359	0.15	1,404	0.00	0	0.10	936	0.00	0	0.25	2,340	4,679	0.50	4,679
Commercial - Koa Ridge															
Big Box	0.04294	6,441	0.36	2,319	0.25	1,610	0.05	322	0.00	0	0.05	322	4,574	0.71	1,867
Retail (in residential area)	0.04294	1,288	0.36	464	0.00	0	0.05	64	0.09	116	0.25	322	967	0.75	321
Retail (near Ka Uka)	0.04294	4,079	0.10	408	0.25	1,020	0.10	408	0.00	0	0.10	408	2,244	0.55	1,835
Office	0.01101	110	0.10	11	0.00	0	0.10	11	0.00	0	0.10	11	33	0.30	77
Hotel - 150 rooms	8.62	0	0.30	0	0.00	0	0.05	0	0.00	0	0.10	0	0	-	0
Industrial - Light	0.00700	301	0.36	108	0.00	0	0.10	30	0.00	0	0.10	30	169	0.56	132
Commercial Total		12,220	0.27	3,310	0.22	2,630	0.07	836	0.01	116	0.09	1,093	7,988	0.65	4,232
Other - Koa Ridge															
Health Care (11)	0.01757	4,485	0.10	449	0.00	0	0.10	449	0.09	404	0.10	449	1,750	0.39	2,736
Elementary School (7)	1.290	710	0.80	568	0.00	0	0.00	0	0.09	64	0.00	0	632	0.89	77
District Park (restricted) (9)	2.280	0	0.80	0	0.00	0	0.00	0	0.09	0	0.00	0	1	-	-1
Community Center (restricted)(5)	0.02288	370	0.80	296	0.00	0	0.00	0	0.09	33	0.00	0	330	0.89	40
Church	0.00911	206	0.80	164	0.00	0	0.00	0	0.09	19	0.00	0	184	0.89	22
Other Total		5,771	0.26	1,477	0.00	0	0.08	449	0.09	519	0.08	449	2,897	0.50	2,873
Residential - Waiawa															
Single Family	9.57	0	0.15	0	0.00	0	0.10	0	0.00	0	0.25	0	1	-	-1
Multi-Family	5.86	1,172	0.15	176	0.00	0	0.10	117	0.00	0	0.25	293	587	0.50	586
Residential Total		1,172	0.15	176	0.00	0	0.10	117	0.00	0	0.25	293	587	0.50	585
Commercial - Waiawa															
Retail (in residential area)	0.04294	0	0.36	0	0.00	0	0.00	0	0.09	0	0.25	0	1	-	-1
Commercial Total		0	-	0	-	0	-	0	-	0	-	0	1	-	-1
Other - Waiawa															
Elementary School (7)	0.01449	0	0.80	0	0.00	0	0.00	0	0.09	0	0.00	0	1	-	-1
Other Total		0	-	0	-	0	0.00	0	0.00	0	0.00	0	1	-	-1
Totals		28,521	0.22	6,366	0.09	2,630	0.08	2,337	0.02	635	0.15	4,174	16,153	0.57	12,368

Koa Ridge - Vehicle Trip Generation and Adjustments By Project Preferred Program Land Use Type

PROJECT PREFERRED PROGRAM	YEAR 2016 WEEKDAY AM PEAK HOUR TRIPS														
	A	B	C		D		E		F		G		H	I	J
	ITE Vehicle Trip Generation Rate *(Vehicle Trips Per AM Peak Hour Per Measurement Unit)*	Maximum Vehicle Trips *(Vehicle Trips Per Hour)*	ADJUSTMENTS TO ITE VEHICLE TRIPS (calculated as a percent of column "B")										Total External Vehicle Trip Adjustments *(C+D+E+F+G)*	Overall Trip Reduction Rate	Project Estimated External Vehicle Trips *(B-H)*
			Internal Capture Vehicle Trips (14)(18)(19)		Pass-By Vehicle Trips (13) (19)		Transit Mode Reduction (15) (17) (20) (22)		Pedestrian and Bicycle Mode Reduction (21)(23)		Other TDM Alternative Mode Reduction (15) (16) (22)				
LAND USE TYPE (1)			%	No.	%	No.	%	No.	%	No.	%	No.			
Residential - Koa Ridge															
Single Family	0.77	369	0.15	55	0.00	0	0.10	37	0.00	0	0.25	92	184	0.50	184
Multi-Family	0.44	252	0.15	38	0.00	0	0.10	25	0.00	0	0.25	63	126	0.50	126
High Density Multi Family	0.34	115	0.15	17	0.00	0	0.10	12	0.00	0	0.25	29	58	0.50	58
Residential Total		736	0.15	110	0.00	0	0.10	74	0.00	0	0.25	184	368	0.50	368
Commercial - Koa Ridge															
Big Box	0.00103	155	0.36	56	0.25	39	0.05	8	0.00	0	0.05	8	110	0.71	44
Retail (in residential area)	0.00103	31	0.36	11	0.00	0	0.05	2	0.09	3	0.25	8	24	0.77	7
Retail (near Ka Uka)	0.00103	98	0.10	10	0.25	24	0.10	10	0.00	0	0.10	10	54	0.56	43
Office	0.00155	16	0.10	2	0.00	0	0.10	2	0.00	0	0.10	2	5	0.32	11
Hotel - 150 rooms	0.56	84	0.30	25	0.00	0	0.05	4	0.00	0	0.10	8	38	0.46	46
Industrial - Light	0.00101	43	0.36	16	0.00	0	0.10	4	0.00	0	0.10	4	25	0.57	19
Commercial Total		426	0.28	119	0.15	63	0.07	29	0.01	3	0.09	40	257	0.60	169
Other - Koa Ridge															
Health Care (11)	0.00147	375	0.10	38	0.00	0	0.10	38	0.09	34	0.10	38	147	0.39	229
Elementary School (7)	0.420	231	0.80	185	0.00	0	0.00	0	0.09	21	0.00	0	206	0.89	25
District Park (restricted) (9)	0.520	0	0.80	0	0.00	0	0.00	0	0.09	0	0.00	0	1	-	-1
Community Center (restricted)(5)	0.00162	26	0.80	21	0.00	0	0.00	0	0.09	2	0.00	0	24	0.92	2
Church	0.00072	16	0.80	13	0.00	0	0.00	0	0.09	1	0.00	0	15	0.94	1
Other Total		649	0.40	256	0.00	0	0.06	38	0.09	58	0.06	38	394	0.61	255
Residential - Waiawa															
Single Family	0.77	0	0.15	0	0.00	0	0.10	0	0.00	0	0.25	0	1	-	-1
Multi-Family	0.44	88	0.15	13	0.00	0	0.10	9	0.00	0	0.25	22	45	0.51	44
Residential Total		88	0.15	13	0.00	0	0.10	9	0.00	0	0.25	22	45	0.51	43
Commercial - Waiawa															
Retail (in residential area)	0.00103	0	0.36	0	0.00	0	0.00	0	0.09	0	0.25	0	1	-	-1
Commercial Total		0	-	0	-	0	-	0	-	0	-	0	1	-	-1
Other - Waiawa															
Elementary School (7)	0.00469	0	0.80	0	0.00	0	0.00	0	0.09	0	0.00	0	1	-	-1
Other Total		0	-	0	-	0	0.00	0	0.00	0	0.00	0	1	-	-1
Totals		1,899	0.26	499	0.03	63	0.08	149	0.03	61	0.15	283	1,065	0.56	834

Koa Ridge - Vehicle Trip Generation and Adjustments By Project Preferred Program Land Use Type

PROJECT PREFERRED PROGRAM	YEAR 2016 WEEKDAY PM PEAK HOUR TRIPS														
	A	B	C		D		E		F		G		H	I	J
	ITE Vehicle Trip Generation Rate *(Vehicle Trips Per PM Peak Hour Per Measurement Unit)*	Maximum Vehicle Trips *(Vehicle Trips Per Hour)*	ADJUSTMENTS TO ITE VEHICLE TRIPS (calculated as a percent of column "B")										Total External Vehicle Trip Adjustments *(C+D+E+F+G)*	Overall Trip Reduction Rate	Project Estimated External Vehicle Trips *(B-H)*
			Internal Capture Vehicle Trips (14)(18)(19)		Pass-By Vehicle Trips (13) (19)		Transit Mode Reduction (15) (17) (20) (22)		Pedestrian and Bicycle Mode Reduction (21)(23)		Other TDM Alternative Mode Reduction (15) (16) (22)				
LAND USE TYPE (1)			%	No.	%	No.	%	No.	%	No.	%	No.			
Residential - Koa Ridge															
Single Family	1.02	489	0.15	73	0.00	0	0.10	49	0.00	0	0.25	122	244	0.50	244
Multi-Family	0.52	298	0.15	45	0.00	0	0.10	30	0.00	0	0.25	74	149	0.50	149
High Density Multi Family	0.38	129	0.15	19	0.00	0	0.10	13	0.00	0	0.25	32	64	0.50	64
Residential Total		915	0.15	137	0.00	0	0.10	92	0.00	0	0.25	229	458	0.50	458
Commercial - Koa Ridge															
Big Box	0.00375	563	0.36	203	0.25	141	0.05	28	0.00	0	0.05	28	400	0.71	162
Retail (in residential area)	0.00375	113	0.36	41	0.00	0	0.05	6	0.09	10	0.25	28	85	0.76	27
Retail (near Ka Uka)	0.00375	356	0.10	36	0.25	89	0.10	36	0.00	0	0.10	36	196	0.55	160
Office	0.00149	15	0.10	1	0.00	0	0.10	1	0.00	0	0.10	1	5	0.32	10
Hotel - 150 rooms	0.59	89	0.30	27	0.00	0	0.05	4	0.00	0	0.10	9	40	0.46	48
Industrial - Light	0.00108	46	0.36	17	0.00	0	0.10	5	0.00	0	0.10	5	27	0.57	20
Commercial Total		1,181	0.27	323	0.19	230	0.07	80	0.01	10	0.09	107	753	0.64	428
Other - Koa Ridge															
Health Care (11)	0.00161	411	0.10	41	0.00	0	0.10	41	0.09	37	0.10	41	161	0.39	250
Elementary School (7)	0.280	154	0.80	123	0.00	0	0.00	0	0.09	14	0.00	0	138	0.90	16
District Park (restricted) (9)	0.590	0	0.80	0	0.00	0	0.00	0	0.09	0	0.00	0	1	-	-1
Community Center (restricted)(5)	0.00164	27	0.80	21	0.00	0	0.00	0	0.09	2	0.00	0	25	0.92	2
Church	0.00066	15	0.80	12	0.00	0	0.00	0	0.09	1	0.00	0	14	0.95	1
Other Total		606	0.33	197	0.00	0	0.07	41	0.09	55	0.07	41	338	0.56	268
Residential - Waiawa															
Single Family	1.02	0	0.15	0	0.00	0	0.10	0	0.00	0	0.25	0	1	-	-1
Multi-Family	0.52	104	0.15	16	0.00	0	0.10	10	0.00	0	0.25	26	53	0.50	52
Residential Total		104	0.15	16	0.00	0	0.10	10	0.00	0	0.25	26	53	0.51	51
Commercial - Waiawa															
Retail (in residential area)	0.00375	0	0.36	0	0.00	0	0.00	0	0.09	0	0.25	0	1	-	-1
Commercial Total		0	-	0	-	0	-	0	-	0	-	0	1	-	-1
Other - Waiawa															
Elementary School (7)	0.00313	0	0.80	0	0.00	0	0.00	0	0.09	0	0.00	0	1	-	-1
Other Total		0	-	0	-	0	0.00	0	0.00	0	0.00	0	1	-	-1
Totals		2,807	0.24	674	0.08	230	0.08	223	0.02	65	0.14	403	1,604	0.57	1,203

Koa Ridge - Vehicle Trip Generation and Adjustments By Project Preferred Program Land Use Type

Notes:
1) Source: Koa Ridge Mauka and Waiawa Traffic Absorption; September 2, 2008.
2) Source: ITE Trip Generation 7th Edition.
3) Assumption: Weekday rate for ITE code 231 not available, used weekday rate for ITE code 230.
4) Assumption: ITE code 310 uses number of rooms, size of hotel is 150 rooms.
5) Assumption: Adjustments to ITE rates assume facility use is essentially restricted to residents and employees from within the project, external use is negligible.
6) Source: One study in ITE Manual (page 881). Caution noted in using small sample data.
7) Assumptions: ITE rates are based on student enrollment of 550. Adjustments to ITE rates assume introduction of "walking bus", "safe routes to school" and other school transportation programs.
8) Assumption: ITE code 411 had no peak period data, used code ITE code 412 vehicle trip generation rates for peak period.
9) Assumption: Open Space use is essentially restricted to residents and employees from within project, external use is negligible.
10) Assumption: Open Space use of plaza/piazza is essentially restricted to residents and employees from within project, however external use is included in vehicle trip calculations.
11) Assumption: Health Care land area converted to building floor area using an FAR of 0.6
12) Assumption: School-Elementary land area converted to building floor area using an FAR of 0.6. Internal capture is 80%.
13) Source: VDOT, Required Elements Of A Traffic Impact Analysis - Administrative Guidelines; July 2008; page 10. 25% of vehicle trips may be considered pass-by for shopping centers.
14) Source: VDOT, Required Elements Of A Traffic Impact Analysis - Administrative Guidelines; July 2008; page 9. 15% of vehicle trips may be internal for mixed-use residential components.
15) Source: Adjusting Site-Level Vehicle Trip Generation Using URBEMIS; Nelson/Nygaard Consulting Associates; August 2005; page 3.
16) Source: Transportation Impact Analyses for Site Development; ITE; 2005; pages 71-72. 25% of vehicle trips in peak periods if conditions specified are achieved.
17) Source: ITE Trip Generation Handbook Second Edition; June 2004; Appendix B (ODOT/DLCD); page 125. 10% of vehicle trips may be considered to be by transit if specified conditions are satisfied.
18) Source: ITE Trip Generation Handbook Second Edition; June 2004; Appendix C (FDOT); page 129-131. 36% of vehicle trips may be considered internal trips if comparable conditions are proposed.
19) Source: Traditional Neighborhood Development Trip Generation Study; Khattak et al; February 2005; page v. 20.2% internal capture observed for TND, comparable to the project's concept.
20) Source: TCRP Report 128, Effects of TOD on Housing, Parking, and Travel; pages 69-80.
21) Source: Adjusting Site-Level Vehicle Trip Generation Using URBEMIS; Nelson/Nygaard Consulting Associates; August 2005; pages14-15.
22) Assumption: Maximum vehicle trip reduction possible is reduced to avoid double counting with other related variables.
23) Assumption: Many pedestrian and bicycle trips have already been accounted for through the use of "high-rise" ITE land use codes and adjustment for internal trips in column C.

APPENDIX F: Koa Ridge Vehicle Trip Generation and Adjustments By Project Preferred Program Land Use Type

The following is a five page table with vehicle trip calculations for the year 2025:

Size of Development and ITE Vehicle Trip Generation Rates -- 1 page

Year 2025 Weekday Daily Trips -- 1 page

Year 2025 Weekday AM Peak Hour Trips -- 1 page

Year 2025 Weekday PM Peak Hour Trips -- 1 page

Notes On Sources And Assumptions -- 1 page

Koa Ridge - Vehicle Trip Generation and Adjustments By Project Preferred Program Land Use Type

PROJECT PREFERRED PROGRAM	YEAR 2025 SIZE OF DEVELOPMENT				ITE VEHICLE TRIP GENERATION RATE [2]				
	AREA [1]			UNITS [1]					
LAND USE TYPE [1]	Total Land *(Square Feet)*	Floor Area *(Square Feet)*	Total *(Acres)*	Number	Code	Type	Weekday	AM Weekday Peak Hour	PM Weekday Peak Hour
Residential - Koa Ridge									
Single Family				1,054	210	Single-Family Detached Housing	9.57/DU	0.77/DU	1.02/DU
Multi-Family				1,162	230	Residential Condominium/Townhouse	5.86/DU	0.44/DU	0.52/DU
High Density Multi Family				1,284	232	High-Rise Residential Condominium/Townhouse	4.18/DU	0.34/DU	0.38/DU
Residential Total				3,500					
Commercial - Koa Ridge									
Big Box		150,000			820	Shopping Center [13][18]	.04294/sq.ft.	.00103/sq.ft.	.00375/sq.ft.
Retail (in residential area)		60,000			820	Shopping Center [13][18]	.04294/sq.ft.	.00103/sq.ft.	.00375/sq.ft.
Retail (near Ka Uka)		140,000			820	Shopping Center [13][18]	.04294/sq.ft.	.00103/sq.ft.	.00375/sq.ft.
Office		30,000			710	General Office Building	.01101/sq.ft.	.00155/sq.ft.	.00149/sq.ft.
Hotel - 150 rooms				150	310	Hotel [4][18]	8.62/room	0.56/room	0.59/room
Industrial - Light		83,000			110	General Light Industrial	.00697/sq.ft.	.00101/sq.ft.	.00108/sq.ft.
Commercial Total		463,000							
Other - Koa Ridge									
Health Care [11]	1,191,294	714,776	28.00		610	Hospital	.01757/sq.ft.	.00147/sq.ft.	.00161/sq.ft.
Elementary School [7]	523,582	130,896	12.00	550	520	Elementary School	1.29/student	0.42/student	0.28/student
District Park (restricted) [9]	840,942		17.00		412	County Park	2.28/acre	0.52/acre	0.59/acre
Community Center (restricted) [5]	97,109	48,555	3.00		495	Recreational Community Center	.02288/sq.ft. [6]	.00162/sq.ft.	.00164/sq.ft.
Church	136,793	45,142	4.00		560	Church	.00911/sq.ft.	.00072/sq.ft.	.00066/sq.ft.
Other Total	2,789,720	939,369							
Residential - Waiawa									
Single Family				255	210	Single-Family Detached Housing	9.57/DU	0.77/DU	1.02/DU
Multi-Family				1,245	230	Residential Condominium/Townhouse	5.86/DU	0.44/DU	0.52/DU
Residential Total				1,500					
Commercial - Waiawa									
Retail (in residential area)		30,000			820	Shopping Center [13][18]	.04294/sq.ft.	.00103/sq.ft.	.00375/sq.ft.
Commercial Total		30,000							
Other - Waiawa									
Elementary School [7]	523,582	130,896	12.00		520	Elementary School	.01449/sq.ft.	.00469/sq.ft.	.00313/sq.ft.
Other Total		130,896							
Totals									

Koa Ridge - Vehicle Trip Generation and Adjustments By Project Preferred Program Land Use Type

PROJECT PREFERRED PROGRAM	YEAR 2025 (BUILD OUT) WEEKDAY DAILY TRIPS														
	A	B	C		D		E		F		G		H	I	J
			ADJUSTMENTS TO ITE VEHICLE TRIPS (calculated as a percent of column "B")												
LAND USE TYPE (1)	ITE Vehicle Trip Generation Rate *(Vehicle Trips Per Day Per Measurement Unit)*	Maximum External Vehicle Trips *(Vehicle Trips Per Day)*	Internal Capture Vehicle Trips (14)(18)(19)		Pass-By Vehicle Trips (13) (19)		Transit Mode Reduction (15) (17) (20) (22)		Pedestrian and Bicycle Mode Reduction (21)(23)		Other TDM Alternative Mode Reduction (15) (16) (22)		Total External Vehicle Trip Adjustments *(C+D+E+F+G)*	Overall Trip Reduction Rate	Project Estimated External Vehicle Trips *(B-H)*
			%	No.	%	No.	%	No.	%	No.	%	No.			
Residential - Koa Ridge															
Single Family	9.57	10,087	0.15	1,513	0.00	0	0.10	1,009	0.00	0	0.25	2,522	5,043	0.50	5,043
Multi-Family	5.86	6,809	0.15	1,021	0.00	0	0.10	681	0.00	0	0.25	1,702	3,405	0.50	3,405
High Density Multi Family	4.18	5,367	0.15	805	0.00	0	0.10	537	0.00	0	0.25	1,342	2,684	0.50	2,684
Residential Total		22,263	0.15	3,339	0.00	0	0.10	2,226	0.00	0	0.25	5,566	11,132	0.50	11,132
Commercial - Koa Ridge															
Big Box	0.04294	6,441	0.36	2,319	0.25	1,610	0.05	322	0.00	0	0.05	322	4,574	0.71	1,867
Retail (in residential area)	0.04294	2,576	0.36	928	0.00	0	0.05	129	0.09	232	0.25	644	1,933	0.75	643
Retail (near Ka Uka)	0.04294	6,012	0.10	601	0.25	1,503	0.10	601	0.00	0	0.10	601	3,307	0.55	2,705
Office	0.01101	330	0.10	33	0.00	0	0.10	33	0.00	0	0.10	33	99	0.30	231
Hotel - 150 rooms	8.62	1,293	0.30	388	0.00	0	0.05	65	0.00	0	0.10	129	582	0.45	711
Industrial - Light	0.00700	581	0.36	209	0.00	0	0.10	58	0.00	0	0.10	58	326	0.56	255
Commercial Total		17,233	0.26	4,478	0.18	3,113	0.07	1,208	0.01	232	0.10	1,788	10,821	0.63	6,412
Other - Koa Ridge															
Health Care (11)	0.01757	12,559	0.10	1,256	0.00	0	0.10	1,256	0.09	1,130	0.10	1,256	4,898	0.39	7,660
Elementary School (7)	1.290	710	0.80	568	0.00	0	0.00	0	0.09	64	0.00	0	632	0.89	77
District Park (restricted) (9)	2.280	39	0.80	31	0.00	0	0.00	0	0.09	3	0.00	0	35	0.91	3
Community Center (restricted)(5)	0.02288	1,111	0.80	889	0.00	0	0.00	0	0.09	100	0.00	0	990	0.89	121
Church	0.00911	411	0.80	329	0.00	0	0.00	0	0.09	37	0.00	0	367	0.89	44
Other Total		14,829	0.21	3,072	0.00	0	0.08	1,256	0.09	1,335	0.08	1,256	6,923	0.47	7,907
Residential - Waiawa															
Single Family	9.57	2,440	0.15	366	0.00	0	0.10	244	0.00	0	0.25	610	1,221	0.50	1,220
Multi-Family	5.86	7,296	0.15	1,094	0.00	0	0.10	730	0.00	0	0.25	1,824	3,648	0.50	3,647
Residential Total		9,736	0.15	1,460	0.00	0	0.10	974	0.00	0	0.25	2,434	4,869	0.50	4,867
Commercial - Waiawa															
Retail (in residential area)	0.04294	1,288	0.36	464	0.00	0	0.00	0	0.09	116	0.25	322	902	0.70	386
Commercial Total		1,288	0.36	464	0.00	0	0.00	0	0.09	116	0.25	322	902	0.70	386
Other - Waiawa															
Elementary School (7)	0.01449	1,897	0.80	1,517	0.00	0	0.00	0	0.09	171	0.00	0	1,689	0.89	208
Other Total		1,897	0.80	1,517	0.00	0	0.00	0	0.00	171	0.00	0	1,689	0.89	208
Totals		67,247	0.21	14,331	0.05	3,113	0.08	5,664	0.03	1,853	0.17	11,365	36,336	0.54	30,911

Koa Ridge - Vehicle Trip Generation and Adjustments By Project Preferred Program Land Use Type

PROJECT PREFERRED PROGRAM	YEAR 2025 (BUILD OUT) AM WEEKDAY PEAK HOUR TRIPS														
	A	B	C		D		E		F		G		H	I	J
			ADJUSTMENTS TO ITE VEHICLE TRIPS (calculated as a percent of column "B")												
LAND USE TYPE [1]	ITE Vehicle Trip Generation Rate *(Vehicle Trips Per AM Peak Hour Per Measurement Unit)*	Maximum Vehicle Trips *(Vehicle Trips Per Hour)*	Internal Capture Vehicle Trips [14][18][19]		Pass-By Vehicle Trips [13][19]		Transit Mode Reduction [15][17][20][22]		Pedestrian and Bicycle Mode Reduction [21][23]		Other TDM Alternative Mode Reduction [15][16][22]		Total External Vehicle Trip Adjustments *(C+D+E+F+G)*	Overall Trip Reduction Rate	Project Estimated External Vehicle Trips *(B-H)*
			%	No.	%	No.	%	No.	%	No.	%	No.			
Residential - Koa Ridge															
Single Family	0.77	812	0.15	122	0.00	0	0.10	81	0.00	0	0.25	203	406	0.50	406
Multi-Family	0.44	511	0.15	77	0.00	0	0.10	51	0.00	0	0.25	128	256	0.50	256
High Density Multi Family	0.34	437	0.15	65	0.00	0	0.10	44	0.00	0	0.25	109	218	0.50	218
Residential Total		1,759	0.15	264	0.00	0	0.10	176	0.00	0	0.25	440	880	0.50	880
Commercial - Koa Ridge															
Big Box	0.00103	155	0.36	56	0.25	39	0.05	8	0.00	0	0.05	8	110	0.71	44
Retail (in residential area)	0.00103	62	0.36	22	0.00	0	0.05	3	0.09	6	0.25	15	47	0.76	15
Retail (near Ka Uka)	0.00103	144	0.10	14	0.25	36	0.10	14	0.00	0	0.10	14	80	0.55	64
Office	0.00155	47	0.10	5	0.00	0	0.10	5	0.00	0	0.10	5	14	0.31	32
Hotel - 150 rooms	0.56	84	0.30	25	0.00	0	0.05	4	0.00	0	0.10	8	38	0.46	46
Industrial - Light	0.00101	84	0.36	30	0.00	0	0.10	8	0.00	0	0.10	8	48	0.57	36
Commercial Total		575	0.26	152	0.13	75	0.07	42	0.01	6	0.10	59	337	0.59	237
Other - Koa Ridge															
Health Care [11]	0.00147	1,051	0.10	105	0.00	0	0.10	105	0.09	95	0.10	105	410	0.39	641
Elementary School [7]	0.420	231	0.80	185	0.00	0	0.00	0	0.09	21	0.00	0	206	0.89	25
District Park (restricted) [9]	0.520	9	0.80	7	0.00	0	0.00	0	0.09	1	0.00	0	9	0.99	0
Community Center (restricted)[5]	0.00162	79	0.80	63	0.00	0	0.00	0	0.09	7	0.00	0	71	0.90	8
Church	0.00072	33	0.80	26	0.00	0	0.00	0	0.09	3	0.00	0	30	0.92	3
Other Total		1,402	0.28	386	0.00	0	0.07	105	0.09	126	0.07	105	726	0.52	676
Residential - Waiawa															
Single Family	0.77	196	0.15	29	0.00	0	0.10	20	0.00	0	0.25	49	99	0.50	98
Multi-Family	0.44	548	0.15	82	0.00	0	0.10	55	0.00	0	0.25	137	274	0.50	273
Residential Total		744	0.15	112	0.00	0	0.10	74	0.00	0	0.25	186	373	0.50	371
Commercial - Waiawa															
Retail (in residential area)	0.00103	31	0.36	11	0.00	0	0.00	0	0.09	3	0.25	8	22	0.72	9
Commercial Total		31	0.36	11	0.00	0	0.00	0	0.09	3	0.25	8	22	0.72	9
Other - Waiawa															
Elementary School [7]	0.00469	614	0.80	491	0.00	0	0.00	0	0.09	55	0.00	0	547	0.89	67
Other Total		614	0.80	491	0.00	0	0.00	0	0.00	55	0.00	0	547	0.89	67
Totals		5,125	0.28	1,416	0.01	75	0.08	398	0.04	190	0.16	798	2,886	0.56	2,239

Koa Ridge - Vehicle Trip Generation and Adjustments By Project Preferred Program Land Use Type

PROJECT PREFERRED PROGRAM	YEAR 2025 (BUILD OUT) PM WEEKDAY PEAK HOUR TRIPS														
	A	B	C		D		E		F		G		H	I	J
			ADJUSTMENTS TO ITE VEHICLE TRIPS (calculated as a percent of column "B")												
LAND USE TYPE [1]	ITE Vehicle Trip Generation Rate *(Vehicle Trips Per PM Peak Hour Per Measurement Unit)*	Maximum Vehicle Trips *(Vehicle Trips Per Hour)*	Internal Capture Vehicle Trips [14][18][19]		Pass-By Vehicle Trips [13] [19]		Transit Mode Reduction [15] [17] [20] [22]		Pedestrian and Bicycle Mode Reduction [21][23]		Other TDM Alternative Mode Reduction [15] [16] [22]		Total External Vehicle Trip Adjustments *(C+D+E+F+G)*	Overall Trip Reduction Rate	Project Estimated External Vehicle Trips *(B-H)*
			%	No.	%	No.	%	No.	%	No.	%	No.			
Residential - Koa Ridge															
Single Family	1.02	1,075	0.15	161	0.00	0	0.10	108	0.00	0	0.25	269	538	0.50	538
Multi-Family	0.52	604	0.15	91	0.00	0	0.10	60	0.00	0	0.25	151	302	0.50	302
High Density Multi Family	0.38	488	0.15	73	0.00	0	0.10	49	0.00	0	0.25	122	244	0.50	244
Residential Total		2,167	0.15	325	0.00	0	0.10	217	0.00	0	0.25	542	1,084	0.50	1,084
Commercial - Koa Ridge															
Big Box	0.00375	563	0.36	203	0.25	141	0.05	28	0.00	0	0.05	28	400	0.71	162
Retail (in residential area)	0.00375	225	0.36	81	0.00	0	0.05	11	0.09	20	0.25	56	170	0.75	56
Retail (near Ka Uka)	0.00375	525	0.10	53	0.25	131	0.10	53	0.00	0	0.10	53	289	0.55	236
Office	0.00149	45	0.10	4	0.00	0	0.10	4	0.00	0	0.10	4	14	0.31	31
Hotel - 150 rooms	0.59	89	0.30	27	0.00	0	0.05	4	0.00	0	0.10	9	40	0.46	48
Industrial - Light	0.00108	90	0.36	32	0.00	0	0.10	9	0.00	0	0.10	9	51	0.57	39
Commercial Total		1,535	0.26	399	0.18	272	0.07	110	0.01	20	0.10	159	964	0.63	572
Other - Koa Ridge															
Health Care [11]	0.00161	1,151	0.10	115	0.00	0	0.10	115	0.09	104	0.10	115	449	0.39	702
Elementary School [7]	0.280	154	0.80	123	0.00	0	0.00	0	0.09	14	0.00	0	138	0.90	16
District Park (restricted) [9]	0.590	10	0.80	8	0.00	0	0.00	0	0.09	1	0.00	0	10	0.98	0
Community Center (restricted)[5]	0.00164	80	0.80	64	0.00	0	0.00	0	0.09	7	0.00	0	72	0.90	8
Church	0.00066	30	0.80	24	0.00	0	0.00	0	0.09	3	0.00	0	27	0.92	2
Other Total		1,424	0.23	334	0.00	0	0.08	115	0.09	128	0.08	115	696	0.49	728
Residential - Waiawa															
Single Family	1.02	260	0.15	39	0.00	0	0.10	26	0.00	0	0.25	65	131	0.50	130
Multi-Family	0.52	647	0.15	97	0.00	0	0.10	65	0.00	0	0.25	162	324	0.50	323
Residential Total		908	0.15	136	0.00	0	0.10	91	0.00	0	0.25	227	455	0.50	453
Commercial - Waiawa															
Retail (in residential area)	0.00375	113	0.36	41	0.00	0	0.00	0	0.09	10	0.25	28	79	0.71	33
Commercial Total		113	0.36	41	0.00	0	0.00	0	0.09	10	0.25	28	79	0.71	33
Other - Waiawa															
Elementary School [7]	0.00313	410	0.80	328	0.00	0	0.00	0	0.09	37	0.00	0	366	0.89	44
Other Total		410	0.80	328	0.00	0	0.00	0	0.00	37	0.00	0	366	0.89	44
Totals		6,557	0.24	1,563	0.04	272	0.08	532	0.03	195	0.16	1,071	3,643	0.56	2,913

Koa Ridge - Vehicle Trip Generation and Adjustments By Project Preferred Program Land Use Type

Notes:
1) Source: Koa Ridge Mauka and Waiawa Traffic Absorption; September 2, 2008.
2) Source: ITE Trip Generation 7th Edition.
3) Assumption: Weekday rate for ITE code 231 not available, used weekday rate for ITE code 230.
4) Assumption: ITE code 310 uses number of rooms, size of hotel is 150 rooms.
5) Assumption: Adjustments to ITE rates assume facility use is essentially restricted to residents and employees from within the project, external use is negligible.
6) Source: One study in ITE Manual (page 881). Caution noted in using small sample data.
7) Assumptions: ITE rates are based on student enrollment of 550. Adjustments to ITE rates assume introduction of "walking bus", "safe routes to school" and other school transportation programs.
8) Assumption: ITE code 411 had no peak period data, used code ITE code 412 vehicle trip generation rates for peak period.
9) Assumption: Open Space use is essentially restricted to residents and employees from within project, external use is negligible.
10) Assumption: Open Space use of plaza/piazza is essentially restricted to residents and employees from within project, however external use is included in vehicle trip calculations.
11) Assumption: Health Care land area converted to building floor area using an FAR of 0.6
12) Assumption: School-Elementary land area converted to building floor area using an FAR of 0.6. Internal capture is 80%.
13) Source: VDOT, Required Elements Of A Traffic Impact Analysis - Administrative Guidelines; July 2008; page 10. 25% of vehicle trips may be considered pass-by for shopping centers.
14) Source: VDOT, Required Elements Of A Traffic Impact Analysis - Administrative Guidelines; July 2008; page 9. 15% of vehicle trips may be internal for mixed-use residential components.
15) Source: Adjusting Site-Level Vehicle Trip Generation Using URBEMIS; Nelson/Nygaard Consulting Associates; August 2005; page 3.
16) Source: Transportation Impact Analyses for Site Development; ITE; 2005; pages 71-72. 25% of vehicle trips in peak periods if conditions specified are achieved.
17) Source: ITE Trip Generation Handbook Second Edition; June 2004; Appendix B (ODOT/DLCD); page 125. 10% of vehicle trips may be considered to be by transit if specified conditions are satisfied.
18) Source: ITE Trip Generation Handbook Second Edition; June 2004; Appendix C (FDOT); page 129-131. 36% of vehicle trips may be considered internal trips if comparable conditions are proposed.
19) Source: Traditional Neighborhood Development Trip Generation Study; Khattak et al; February 2005; page v. 20.2% internal capture observed for TND, comparable to the project's concept.
20) Source: TCRP Report 128, Effects of TOD on Housing, Parking, and Travel; pages 69-80.
21) Source: Adjusting Site-Level Vehicle Trip Generation Using URBEMIS; Nelson/Nygaard Consulting Associates; August 2005; pages14-15.
22) Assumption: Maximum vehicle trip reduction possible is reduced to avoid double counting with other related variables.
23) Assumption: Many pedestrian and bicycle trips have already been accounted for through the use of "high-rise" ITE land use codes and adjustment for internal trips in column C.

APPENDIX G: Terms and Definitions

The following defines terms used in this technical memorandum

A.1.1. Trip Chaining

Trip chaining traces an individual's daily movement by trip mode and by trip purpose. Trip chaining has two components:

- **Personal Travel Trip Chaining Demand** -- Refers to the places travelers want to visit and the sequence of those visits.

- **Trip Chaining Modal Accommodation** -- Refers to the capacity (and level of service in some instances) of the transportation system and its ability to provide safe and expedient passage to those making chained trips by alternative modes.

A front page example of trip chaining was provided on September 25, 2006 in the Seattle Times of how Trip Chain Modal Accommodation doesn't support at least one individual's Personal Travel Trip Chaining Demand. The headline read: "Denise Dougan, Kingston to Seattle: Car. Bus. Ferry. Feet. Bus. Train. Ferry. Bus. Car."[1] The article quoted the traveler as concluding, "No mystery to me why public transportation in the Puget Sound is not used by more people." [2]

A.1.2. Pedestrian Modal Accommodation

Pedestrian modal accommodation involves a wide array of traditional and innovative techniques to offer priority treatments for those who walk. One distinct difference between U.S. and non-U.S. approaches is that our crosswalks, sidewalks and other pedestrian treatments tend to be highly standardized with an emphasis on how the pedestrian is accommodated to the degree possible after consideration is given to the minimum roadway and intersection requirements to support optimum vehicle flow.

Non-U.S. approaches to pedestrian traffic tend to be less standardized with an emphasis on how the roadway and intersection is designed, or should be redesigned, to give priority to the safety of the pedestrian with less evident regard for optimum vehicle

[1] The amazing race to work: Four commuters' stories; The Seattle Times; Mike Lindblom; September 25, 2006; page A-1.

[2] For a technical explanation of trip chaining see: A Simultaneous Model of Household Activity Participation and Trip Chain Generation; Thomas F. Golob; Institute of Transportation Studies, University of California; July 1997 or Examining Trip-Chaining Behavior, A comparison of Travel by Men and Women; Nancy McGucklin and Elaine Murakami; Federal Highway Administration.

flow. There are many variations to the following list of approaches found more often in non-U.S. applications, but with increasing use in the U.S., including Oahu.

- **Zebra Crossings --** Refers to the use of stripes across the road with dashed lines used to mark the crosswalk on both sides. Best Oahu example is on Kalia Road in Waikiki. Examples in London add "Belisha Beacons" (poles with flashing orange lights) placed on each side of the crosswalk. These crossings are installed at selected mid-block locations (rarely at intersections as is the case on Kalia). At zebra crossings, pedestrians have the right of way, and drivers must yield (i.e., slow or stop) to pedestrians in the crosswalk. Zebra crossings are preceded by zigzag pavement markings next to the curb on the vehicle approach.

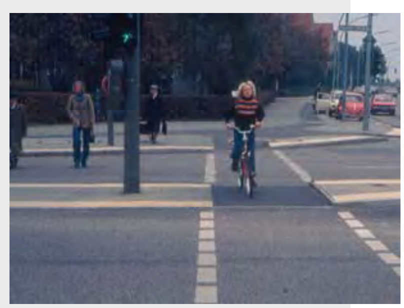
- **Pelican Crossings** -- Refers to crossings controlled by traffic signals and push-button pedestrian signals. Best Oahu example is on Punchbowl between Honolulu Hale and the state capital building. The push-button hardware lights up and conveys specific messages to pedestrians during each interval. A walking green man symbol and a standing red man are displayed. A flashing green man indicates pedestrian clearance. A flashing green man on the pedestrian approach concurrent with flashing amber and red balls on the vehicle approach precedes the green ball indication on the vehicle approach in some applications. Other applications use a countdown warning to advise pedestrians of the time remaining. Pelican crossings may have dashed or solid parallel lines to mark the crosswalk. They may have a mid-crossing island with an offset.

- **Toucan Crossings --** Refers to shared crossings for pedestrians and bicyclists (cyclists "too can" cross together) at selected crossings at the intersection of roadways with pedestrian and bicycle paths. Common on Oahu, but without special provisions. The preferred layout includes a tactile warning surface, audible beepers or tactile rotating knobs, pushbuttons with WAIT displayed in each corner of the crossing, infrared lamp monitoring, and vehicle detection on all approaches. The desirable crosswalk width is twelve feet; the minimum acceptable width is ten feet. Signal indications include standing red man, walking green man, and green bicycle. The flashing amber with the red ball indication is not used for the vehicle approach. Crosswalk lines are delineated by various colored squares and lines to separate pedestrians and bicyclists whenever possible.

A **Zebra Crossing** is shown at the intersection of Kalia and Maluhia (left). Examples in Renton, Washington (below, left) and London (below, right) include "**Belisha Beacons**" poles with flashing lights triggered when the crosswalk is occupied.

London offers many examples of **Pelican** and **Pufin Crossings**. These also feature the use of fences to force pedestrians to use crosswalks

Toucan Crossings examples are shown for Koln, Bonn, Antwerp, Heidelberg, Strasbourg and Brugge (clockwise starting from the top right corner of the page).



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- **Pufin Crossings --** Refers to Pedestrian User- Friendly INtersection (PUFIN) crossings, generally installed at intersections, consist of traffic and pedestrian signals with red push-button devices and infrared or pressure mat detectors. After a pedestrian pushes the button (or stands on the mat), a detector verifies their presence. If a pedestrian is present at the end of a vehicle cycle, the red traffic signal is indicated to motorists, and pedestrians see the green man (i.e., WALK display). A separate motion detector extends the green interval (if needed) to ensure that slower pedestrians have time to cross safely. If a pedestrian pushes the button, but fails to wait for the green man symbol, the detector will sense that no pedestrian is waiting and will not stop motor vehicle traffic needlessly. Pufin crossings are recent developments and are said to improve pedestrian safety and reduce unnecessary vehicle delay. Since the motion detector can detect only those pedestrians walking within the crosswalk lines, physical barriers are used on the curbs to channel pedestrians into the crosswalks. At some crossings, tactile surfaces have been introduced that guide a visually impaired person to the crosswalk. Pufin crossings are currently used at 27 demonstration sites in England.

- **Pedestrian Zones --** Refers to areas involving several connected streets which can sometimes be used by cyclists during off-peak hours. These have been established on many downtown streets throughout Europe and are most often referred to as "Pedestrianized Zones". Not only are there fewer modal conflicts, but the presence of pedestrian and bicycle traffic helped eliminate crime and added an element of personal safety. The pedestrian zone sometimes allows bus, bike, goods delivery and taxi travel at certain times of the day only. The Fort Street Pedestrian Mall is not a pedestrian zone since it only involves one street. There are no examples of pedestrian zones on Oahu. Over ninety percent of all cities in Europe have pedestrian zones.

- **Pedestrian/Bicycle Ways** -- Refers to exclusive roadways for both pedestrians and cyclists sometimes with separate lanes for bicycles designed within a wide right-of-way and with full grade separation when warranted by high conflicting traffic conditions. Eindhoven is the best example of grade separated pedestrian/bicycle ways.[3]

[3] A Field Report: The Phileas Transit System In Eindhoven, Netherlands; Wes Frysztacki, Weslin Consulting Services, Inc.; December 2007; pages 10-15.

Pedestrian Zones exist in almost all European cities. These examples are from Brussels, Malmo, Ghent, Copenhagen, Amsterdam, Bath, Koln and London (in clockwise order starting with the picture at the top left of the page). Cyclists must dismount in most pedestrian zones at certain times of the day. Goods delivery usually occurs in the morning until 11:00 a.m.

Pedestrian/Bicycle Ways in Eindhoven radiate from Central Station. The parked bicycles pictured to the left completely encircle the station. The violet red colored streets on the map are pedestrianized. Yellow streets include general purpose traffic and exclusive bus lanes. The public "Markt" located in the heart of the network of pedestrianized streets is toward the bottom of the map.

- **Woonerf Zone** -- Refers to a protected environment with street space shared equally among pedestrians, bicyclists and transit vehicles proceeding at a walking pace. Pedestrians and bicyclists have priority over motor vehicles in a Woonerf zone. Woonerf zones have no formal traffic signals or lane markings.

- **Pedestrian Friendly Design** -- Refers predominately to the aesthetic and urban design amenities associated with pedestrian facilities such as landscaping, lighting, benches, artwork, arbors, water features and pavement treatments. It normally does not refer to the functional traffic design needed to achieve safe and modal priority treatment for people to walk who might otherwise choose to drive a car.

A.1.3. Bicycle Modal Accommodation

There is a tremendous difference between how the United States views the bicycle mode as compared to the rest of the world. The following offers examples from outside of the U.S. and uses terminology to draw distinctions.[4]

- **Bicycle Lanes** -- Refers to the accommodation of the bicycle within the right-of-way originally established for vehicle traffic. A lane marked on the roadway is designated for bicycle use. Many excellent examples exist of where this has been done effectively on Oahu and throughout the world. However, some countries view bicycle lanes as a temporary measure, "a quick and cheap first stage whenever possible."[5] In the U.S. it is the highest standard for non-recreational cycling, in Europe it is the lowest standard for non-recreational cycling.

- **Community Bike Program** -- Refers to the type of program in Copenhagen, Amsterdam and Paris where bicycles are stationed at strategic locations throughout a zone and may be borrowed at one location and returned to another.

[4] This document uses definitions for planning and policy development purposes. More engineering based definitions and design specifications may be found in Bike Lane Design Guide; Chicago Department of Transportation.

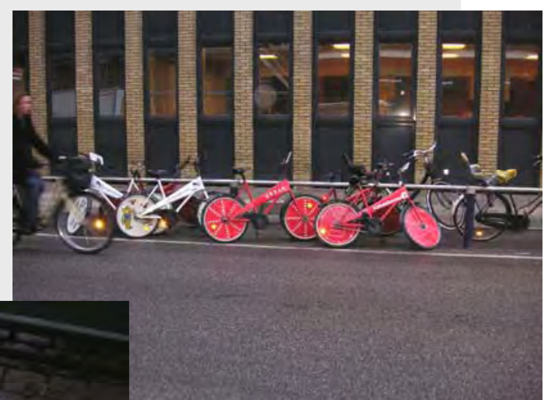
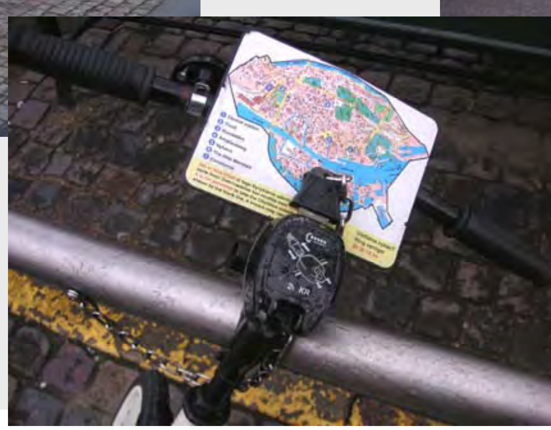
[5] Cycle Policy 2002 - 2012 (Danish title: Cykelpolitik 2002-2012); City of Copenhagen, Building and Construction Administration, Roads and Parks Department; page 22.

These pictures highlight a **Woonerf Zone** at the central square in Baden-Baden. Buses and pedestrians mingle with no traffic control signals or pavement markings. Transit vehicles must proceed through the zone at the speed of pedestrians who have the right-of-way. The use of this approach is increasing in Europe. This traffic treatment allows **Pedestrian Friendly Design** to flourish.



Bicycle Lanes are shown above in Vancouver (at the Burnaby Skytrain station), Hannover and London. North American practice is to place the bike lane on the road whereas European practice tends to favor placing bike lanes within sidewalks.

Community Bike Programs have existed in Copenhagen for decades as shown in the pictures below. The middle picture shows the lock that can be released with a single refundable coin deposit and a map of the city's cycle track system

- **Euro-Style Bicycle Lanes** -- Refers to the accommodation of the bicycle within the right-of-way originally established for vehicle traffic. A lane marked on the roadway is designated for bicycle use but the lane is positioned between the sidewalk and a parking lane instead of between a parking lane and a vehicle traffic lane. Also known as the “Copenhagen Treatment”.

- **Bicycle Paths** --Refers to the accommodation of the bicycle in its own exclusive right-of-way or in a shared right-of-way established for low-speed recreational travel by people on bicycles. Bicycle paths are often created along abandoned rail right-of-way such as the Pearl Harbor Bike Path.

- **Bicycle Tracks or Cycle Tracks** --Refers to the accommodation of the bicycle in its own curb or barrier separated pathway within the overall street right-of-way. The pathway is designed for high-speed functional travel by people on bicycles. Cyclists on the pathway have right-of-way over other modes except where otherwise delineated by a variety of traffic lane markings and control techniques. Several excellent examples of this standard European treatment exist near Waipahu in the vicinity of the Waikele Shopping Center along Paiwa and Lumiaina Streets.

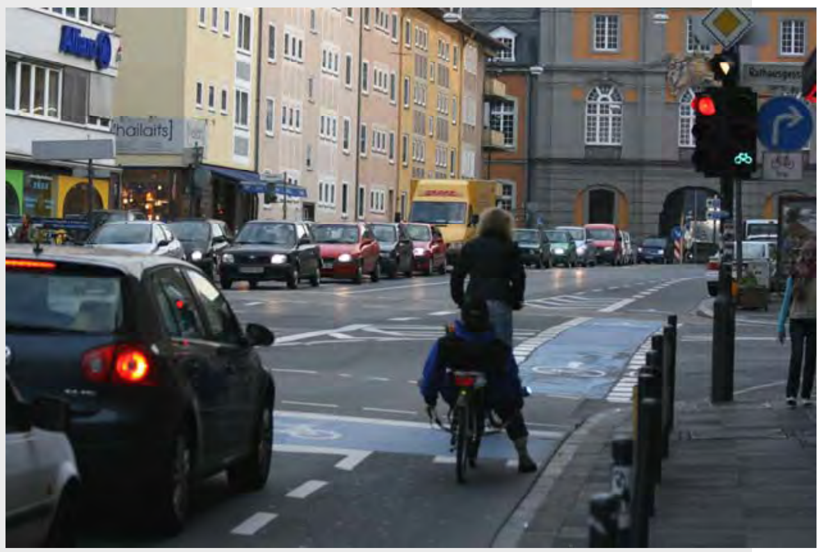
- **Bicycle Shed** -- Refers to a stand alone fully enclosed bicycle storage facility with key card control available in conjunction with special transportation pass programs.

- **Bicycle Stations** -- Refers to a facility where bicycles and other alternative transportation devices may be stored, repaired and rented. Larger facilities include rentals of electric cars, car sharing club counters, showers and other commuter services.

- **Bicycle Streets** -- Refers to a street for the exclusive use by bicyclists.

- **Bike Racks On Taxis** -- Refers to the requirement that any taxi using the premium taxi stand waiting area must be equipped with a bicycle rack.

Euro-Style Bicycle Lanes are shown in Budapest and Copenhagen (top left and right). The bicycle lane at the right in Bonn includes an advance holding box (in blue) for bicycles which are also given an advance green traffic signal.



Honolulu's Pearl Harbor Bike Path is a good example of a **Bicycle Path** (see pictures below).

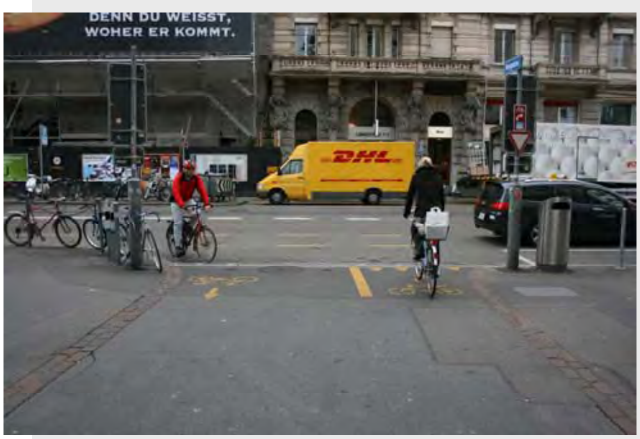
The examples of **Cycle Tracks** on this page are from Copenhagen, Leiden, Eindhoven and Freiburg (clockwise starting from top left).

Several excellent examples of this standard European treatment exist near Waipahu in the vicinity of the Waikele Shopping Center along Paiwa and Lumiaina Streets.

Bicycle Sheds are shown in Amsterdam and Leiden (top left and right).

Bicycle Stations are shown in Long Beach (below) and Seattle (right).

Bike Streets exist in many European cities. These examples are from Brugge, Amsterdam, Hannover, Strasbourg and Zurich (in clockwise order starting with the picture at the top left of the page). Cyclists have the right of way, but must abide by traffic signals designed explicitly for cyclists.



A.1.4. Street Network Terminology

The Waipahu Neighborhood TOD Plan offers new streets. Today, both Waipahu station areas are dominated by mega blocks. These tend to concentrate vehicular traffic on a few streets and intersections. The concentration of traffic is in conflict with the ability to provide safe pedestrian and bicycle access.

Pedestrian environments may be achieved by creating smaller blocks with wide sidewalks. All modes have more choices in selecting their travel path and more opportunities are created for on street parking. The following offers examples of some of the terminology emanating from the experiences with designing land use with smaller blocks:

- **TND's** -- Traditional Neighborhood Development's have been associated with the urbanist movement advocating designs for reducing resident's reliance on the automobile by creating compact, mixed use and pedestrian-friendly development.

- **Internal Capture** – The amount or percent of person trips not using a personal vehicle because the desired trip can now be made by an alternative mode within the development area.

- **Pass-By Trips** – The amount or percent of vehicle traffic diverted into a development because the trips already existed on adjacent streets and are not generated by new development.

- **Modal Share** – The amount or percent of trips made by all modes available to those person trips associated with a development or transportation facility.

A.1.5. Station Area Terminology

Different stations serve different functions. The plan of each station area needs to be different to properly serve the priority given to the access modes best suited to use each station. The process used to determine those priorities uses the following terminology:

- **Standard Access Modes** --Refers to the access modes that have traditionally served the greatest portion of station area passenger demands. These are primarily auto and bus.

- **Standard Egress Modes** -- Refers to the egress modes that have traditionally served the greatest portion of station area passenger demands. These are primarily walk and bus.

- **Alternative Access and Egress Modes** -- Refers to the non-standard modes providing station area access and egress such as bicycle travel and car sharing programs.

- **Car Sharing** -- Refers to those programs with a membership who shares the use of a group of private vehicles.

- **Catchment Shed** -- Refers to the geographic area within which the vast majority of transit passengers are traveling, especially by private vehicle, to a particular station or from that station. This includes the resident location of those who drive and park at a station.

- **Catchment Zone** -- Refers to the geographic area within which the vast majority of those using non-private vehicle alternative access and egress modes are traveling to a particular station or from that station. This includes the resident location of those who would bike using bicycle tracks.

- **Modal Share Projection** -- Refers to the output of the Travel Demand Forecasting Model based upon trends, national modeling standards and forecasts of socio-economic characteristics.

- **Modal Share Targets** -- Refers to policy targets developed based upon review of modal share projections, a policy analysis of influencing factors likely to produce better outcomes and extensive community interaction regarding the desired future.

- **Modal Hierarchy** -- Refers to the policy of designating which modes have priority over others within a station access plan area.

- **Personal Transporters** – Refers primarily to Segway human transporters and some electric bikes that can operate at a speed of no more than eight miles per hour. This term also includes roller blades and scooters when used in a non-recreational context.

- **Parking Management** -- Refers to the use of various parking policies to govern the supply and use of parking such as shared parking, unbundled parking and maximum parking requirements.

Car Sharing Programs or clubs as shown in Lucerne and Bellingham (top left and right).

Personal Transporters include the Segway as seen in Amsterdam (below). There are increasing sightings of these in Waikiki (right).

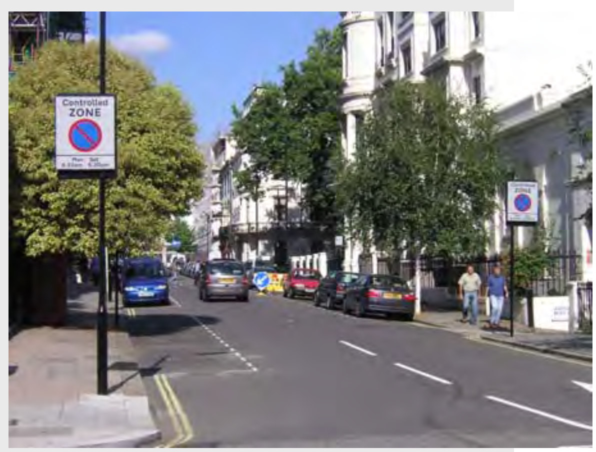
- **Shared Parking** -- A reduction of the minimum number of parking spaces required based upon the ability of mixed land uses with different peak parking demands to share parking spaces. Reduced parking creates higher alternative access mode expectations.
- **Unbundled Parking** -- Refers to the ability to allow tenants and homeowners to purchase parking separately, or not at all.
- **Traffic Cells** -- Refers to an arrangement of zones which limit automobile traffic movement. Vehicle traffic restrictions increase in the vicinity of a **Central Cell.** The central cell severely limits or prohibits vehicle traffic. The central cell may be a city center, public square, historical area, residential zone, park or transit station. Pedestrians and bicyclists are always given access. Traffic cell boundary techniques force vehicles to turn but allow bicycles and pedestrians to travel into the zone. The central cell is often a large pedestrianized zone where cyclists must often dismount.
- **Transition Plaza** -- Refers to an open area that connects and supports people transitioning from one mode to another.
- **Transportation Demand Management (TDM)** -- Refers to the collection of programs, policies and tactics designed to reduce the demand for private vehicle travel by influencing when people travel, how they travel and how far those people travel to access their desired destination.

A.1.6. Transit Station Functional Classification

Different stations serve different functions. This report uses the following transit station functional classification definitions:

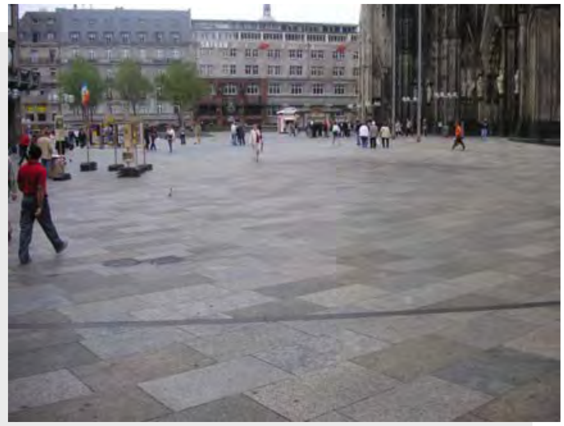
- **Park And Ride Station** -- Refers to the accommodation of the private vehicle over other access modes at a particular station, but not to the exclusion of other modes.
- **Transit Transfer Station** -- Refers to the accommodation of *TheBus* operations, private shuttles and taxis over other alternative modes at a particular station, but not to the exclusion of other modes.
- **Alternative Mode Access Station** -- Refers to the accommodation of pedestrian and bicycle modes at a particular station and throughout the station area, but not to the exclusion of other modes.

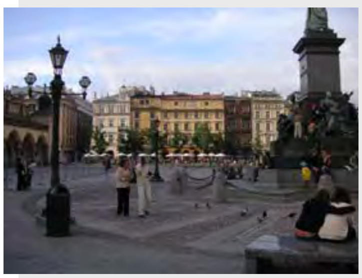
Traffic cells are widely observed in Europe but contradict common U.S. auto-connectivity design techniques. All of these examples are from London and illustrate the following traffic cell boundary applications: two closed streets diverting vehicles, the central zone where congestion charging is invoked, a restricted neighborhood traffic only zone and a residential area prohibiting vehicle access into an adaptive wharf area reuse district (clockwise starting from the top right).



Traffic Cells of various types in Vancouver, Brussels, Gouda, Bonn, Eindhoven and Strasbourg (clockwise starting from the top right). Traffic cells or zones are widely observed in Europe but contradict common U.S. auto-connectivity design techniques.

Central Cells in Prague, Koln, Brugge, Krakow and Brussels (clockwise starting from the top left).





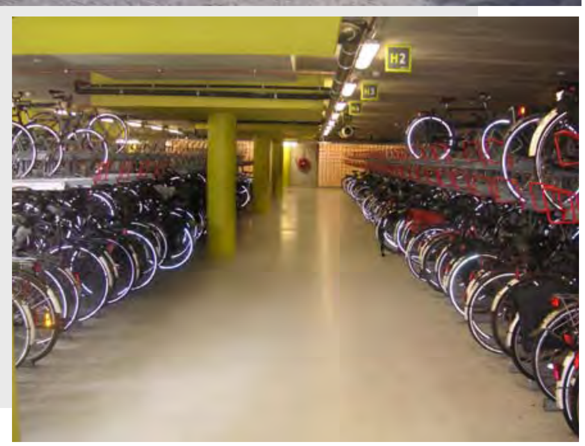
The Prague central cell excludes all motorized vehicles including tourist buses. Tour groups use the metro. (top left)

The Koln central cell was a complicated intersection designed to give priority to vehicles forty years ago. Over the years the pedestrianized zone has been continuously expanded. Today, the metro is underneath the plaza shown. (above)

The Krakow and Brussels central zones include popular historic districts. (left)

A cycle track and bus lane travel along a park which is an integral part of the central cell in Brugge. (below)

Transition Plazas located in Amsterdam, Bonn and at Amsterdam's new World Trade Center in Zuid (counterclockwise starting from the top left corner). The picture to the right is of the exit from the bike station. The escalator below is just for cyclists who are retrieving their cycle from storage located under the transition plaza located in the center of the World Trade Center.



APPENDIX G

CAPACITY ANALYSIS CALCULATIONS
PROJECTED YEAR 2016 PEAK HOUR TRAFFIC
ANALYSIS WITH PROJECT

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lane Configurations												
[illegible]	0	[illegible]	0	0	[illegible]	31	837	25	0	0	0	8
Ideal Flow (vphpl)	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
Total Lost time (s)		5.0			5.0		5.0	5.0			5.0	
Lane Util. Factor		0.95			0.86		0.91	0.91			1.00	
Frt		1.00			1.00		1.00	1.00			0.86	
Flt Protected		1.00			1.00		0.95	0.96			1.00	
Satd. Flow (prot)		3725			6729		3390	1706			1696	
Flt Permitted		1.00			1.00		0.95	0.96			1.00	
Satd. Flow (perm)		3725			6729		3390	1706			1696	
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	0	208	0	0	1859	31	837	25	0	0	0	8
RTOR Reduction (vph)	0	0	0	0	2	0	0	0	0	0	8	0
Lane Group Flow (vph)	0	208	0	0	1888	0	578	284	0	0	0	0
Turn Type							Split			Split		
Protected Phases		4			8		2	2		6	6	
Permitted Phases												
Actuated Green, G (s)		35.0			35.0		22.3	22.3			0.8	
Effective Green, g (s)		35.0			35.0		22.3	22.3			0.8	
Actuated g/C Ratio		0.48			0.48		0.31	0.31			0.01	
Clearance Time (s)		5.0			5.0		5.0	5.0			5.0	
Vehicle Extension (s)		3.0			3.0		3.0	3.0			3.0	
Lane Grp Cap (vph)		1784			3222		1034	520			19	
v/s Ratio Prot		0.06			c0.28		c0.17	0.17			c0.00	
v/s Ratio Perm												
v/c Ratio		0.12			0.59		0.56	0.55			0.00	
Uniform Delay, d1		10.5			13.8		21.3	21.2			35.8	
Progression Factor		1.00			1.00		1.00	1.00			1.00	
Incremental Delay, d2		0.0			0.3		0.7	1.2			0.1	
Delay (s)		10.5			14.1		21.9	22.4			35.9	
Level of Service		B			B		C	C			D	
Approach Delay (s)		10.5			14.1			22.1			35.9	
Approach LOS		B			B			C			D	

[illegible]			
HCM Average Control Delay	18.2	HCM Level of Service	B
[illegible]	[illegible]		
Actuated Cycle Length (s)	73.1	Sum of lost time (s)	15.0
[illegible]	[illegible]	[illegible]	[illegible]
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↑↑			↑↑↑↱		↰↰	↰↑			↰↑↱	
Volume (vph)	0	565	0	0	2048	53	1790	23	0	0	0	80
Ideal Flow (vphpl)	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
Total Lost time (s)		5.0			5.0		4.0	4.0			5.0	
Lane Util. Factor		0.95			0.86		0.91	0.91			1.00	
Frt		1.00			1.00		1.00	1.00			0.86	
Flt Protected		1.00			1.00		0.95	0.95			1.00	
Satd. Flow (prot)		3725			6720		3390	1702			1696	
Flt Permitted		1.00			1.00		0.95	0.95			1.00	
Satd. Flow (perm)		3725			6720		3390	1702			1696	
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	0	565	0	0	2048	53	1790	23	0	0	0	80
RTOR Reduction (vph)	0	0	0	0	3	0	0	0	0	0	37	0
Lane Group Flow (vph)	0	565	0	0	2098	0	1199	614	0	0	43	0
Turn Type							Split			Split		
Protected Phases		4			8		2	2		6	6	
Permitted Phases												
Actuated Green, G (s)		40.5			40.5		47.1	47.1			7.0	
Effective Green, g (s)		40.5			40.5		47.1	47.1			7.0	
Actuated g/C Ratio		0.37			0.37		0.43	0.43			0.06	
Clearance Time (s)		5.0			5.0		4.0	4.0			5.0	
Vehicle Extension (s)		3.0			3.0		3.0	3.0			3.0	
Lane Grp Cap (vph)		1389			2506		1470	738			109	
v/s Ratio Prot		0.15			c0.31		0.35	c0.36			c0.03	
v/s Ratio Perm												
v/c Ratio		0.41			0.84		0.82	0.83			0.39	
Uniform Delay, d1		25.2			31.0		26.9	27.2			48.8	
Progression Factor		1.00			1.00		1.00	1.00			1.00	
Incremental Delay, d2		0.2			2.6		3.6	8.0			2.3	
Delay (s)		25.4			33.6		30.6	35.2			51.1	
Level of Service		C			C		C	D			D	
Approach Delay (s)		25.4			33.6			32.1			51.1	
Approach LOS		C			C			C			D	

Intersection Summary			
HCM Average Control Delay	32.3	HCM Level of Service	C
HCM Volume to Capacity ratio	0.80		
Actuated Cycle Length (s)	108.6	Sum of lost time (s)	14.0
Intersection Capacity Utilization	75.5%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lane Configurations												
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ideal Flow (vphpl)	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
[illegible]		[illegible]		[illegible]	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
Lane Util. Factor		0.95		0.97	0.95		1.00		1.00	1.00	1.00	1.00
Frt		0.99		1.00	1.00		1.00		0.85	1.00	1.00	0.85
Flt Protected		1.00		0.95	1.00		0.95		1.00	0.95	1.00	1.00
Satd. Flow (prot)		3705		3614	3725		1863		1667	1863	1961	1667
Flt Permitted		1.00		0.95	1.00		0.95		1.00	0.95	1.00	1.00
[illegible]		[illegible]		[illegible]	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
RTOR Reduction (vph)	0	3	0	0	0	0	0	0	0	0	0	0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Turn Type				Prot			Prot		Free	Prot		Free
Protected Phases		4		3	8		5			1	6	
Permitted Phases									Free			Free
Actuated Green, G (s)		44.9		11.5	61.4		3.0		92.9	21.5	13.5	92.9
Effective Green, g (s)		44.9		11.5	61.4		3.0		92.9	21.5	13.5	92.9
Actuated g/C Ratio		0.48		0.12	0.66		0.03		1.00	0.23	0.15	1.00
Clearance Time (s)		5.0		5.0	5.0		5.0			5.0	5.0	
Vehicle Extension (s)		3.0		3.0	3.0		3.0			3.0	3.0	
Lane Grp Cap (vph)		1791		447	2462		60		1667	431	285	1667
v/s Ratio Prot		c0.39		c0.07	0.20		0.02			0.06	c0.08	
v/s Ratio Perm									c0.26			0.14
v/c Ratio		0.80		0.54	0.30		0.47		0.26	0.27	0.55	0.14
Uniform Delay, d1		20.3		38.2	6.7		44.2		0.0	29.2	36.9	0.0
Progression Factor		1.00		1.00	1.00		1.00		1.00	1.00	1.00	1.00
Incremental Delay, d2		2.7		1.2	0.1		5.6		0.4	0.3	2.3	0.2
Delay (s)		23.0		39.4	6.7		49.8		0.4	29.6	39.2	0.2
Level of Service		C		D	A		D		A	C	D	A
Approach Delay (s)		23.0			14.7			3.3			18.9	
Approach LOS		C			B			A			B	

Intersection Summary			
HCM Average Control Delay	17.3	HCM Level of Service	B
HCM Volume to Capacity ratio	0.67		
Actuated Cycle Length (s)	92.9	Sum of lost time (s)	15.0
Intersection Capacity Utilization	71.7%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↑↑↱		↰↰	↑↑		↰		↱	↰	↑	↱
Volume (vph)	0	1422	77	371	1583	0	81	0	701	321	192	274
Ideal Flow (vphpl)	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
Total Lost time (s)		5.0		5.0	5.0		5.0		5.0	5.0	5.0	5.0
Lane Util. Factor		0.95		0.97	0.95		1.00		1.00	1.00	1.00	1.00
Frt		0.99		1.00	1.00		1.00		0.85	1.00	1.00	0.85
Flt Protected		1.00		0.95	1.00		0.95		1.00	0.95	1.00	1.00
Satd. Flow (prot)		3697		3614	3725		1863		1667	1863	1961	1667
Flt Permitted		1.00		0.95	1.00		0.95		1.00	0.95	1.00	1.00
Satd. Flow (perm)		3697		3614	3725		1863		1667	1863	1961	1667
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	0	1422	77	371	1583	0	81	0	701	321	192	274
RTOR Reduction (vph)	0	3	0	0	0	0	0	0	0	0	0	0
Lane Group Flow (vph)	0	1496	0	371	1583	0	81	0	701	321	192	274
Turn Type				Prot			Prot		Free	Prot		Free
Protected Phases		4		3	8		5			1	6	
Permitted Phases									Free			Free
Actuated Green, G (s)		48.6		15.4	69.0		8.2		109.0	30.0	16.8	109.0
Effective Green, g (s)		48.6		15.4	69.0		8.2		109.0	30.0	16.8	109.0
Actuated g/C Ratio		0.45		0.14	0.63		0.08		1.00	0.28	0.15	1.00
Clearance Time (s)		5.0		5.0	5.0		5.0			5.0	5.0	
Vehicle Extension (s)		3.0		3.0	3.0		3.0			3.0	3.0	
Lane Grp Cap (vph)		1648		511	2358		140		1667	513	302	1667
v/s Ratio Prot		c0.40		0.10	c0.42		0.04			c0.17	0.10	
v/s Ratio Perm									0.42			0.16
v/c Ratio		[illegible]		[illegible]	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
Uniform Delay, d1		28.1		44.8	12.8		48.7		0.0	34.6	43.2	0.0
Progression Factor		[illegible]		[illegible]	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
Incremental Delay, d2		7.6		5.1	0.8		5.7		0.8	2.4	4.3	0.2
Delay (s)		[illegible]		[illegible]	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
Level of Service		D		D	B		D		A	D	D	A
Approach Delay (s)		35.7			20.4			6.3			26.8	
Approach LOS		D			C			A			C	

Intersection Summary			
HCM Average Control Delay	23.8	HCM Level of Service	C
HCM Volume to Capacity ratio	0.80		
Actuated Cycle Length (s)	109.0	Sum of lost time (s)	15.0
Intersection Capacity Utilization	80.3%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	7	[illegible]	73	90	628	289	0	0	32	443	0	10
Ideal Flow (vphpl)	2000	2000	2000	2000	2000	2000	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	6.0		6.0	6.0	4.0			5.0	5.0	5.0	
Lane Util. Factor	1.00	0.95		1.00	0.95	1.00			1.00	0.97	1.00	
Frt	1.00	0.99		1.00	1.00	0.85			0.86	1.00	0.85	
Flt Protected	0.95	1.00		0.95	1.00	1.00			1.00	0.95	1.00	
Satd. Flow (prot)	1863	3686		1863	3725	1667			1611	3433	1583	
Flt Permitted	0.95	1.00		0.95	1.00	1.00			1.00	0.95	1.00	
Satd. Flow (perm)	1863	3686		1863	3725	1667			1611	3433	1583	
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	7	969	73	90	628	289	0	0	32	443	0	10
RTOR Reduction (vph)	0	5	0	0	0	0	0	0	0	0	8	0
Lane Group Flow (vph)	7	1037	0	90	628	289	0	0	32	443	2	0
Turn Type	Prot			Prot		Free			Free	Prot		
Protected Phases	7	4		3	8					1	6	
Permitted Phases						Free			Free			
Actuated Green, G (s)	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	
Effective Green, g (s)	1.0	29.4		6.2	35.6	67.8			67.8	15.2	15.2	
Actuated g/C Ratio	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	
Clearance Time (s)	5.0	5.0		5.0	5.0					5.0	5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0					3.0	3.0	
Lane Grp Cap (vph)	27	1598		170	1956	1667			1611	770	355	
v/s Ratio Prot	0.00	c0.28		c0.05	0.17					c0.13	0.00	
v/s Ratio Perm						0.17			0.02			
v/c Ratio	0.26	0.65		0.53	0.32	0.17			0.02	0.58	0.01	
Uniform Delay, d1	33.0	15.1		29.4	9.2	0.0			0.0	23.4	20.4	
Progression Factor	1.00	1.00		1.00	1.00	1.00			1.00	1.00	1.00	
Incremental Delay, d2	5.1	0.9		3.0	0.1	0.2			0.0	1.0	0.0	
Delay (s)	38.1	16.1		32.4	9.3	0.2			0.0	24.5	20.4	
Level of Service	D	B		C	A	A			A	C	C	
Approach Delay (s)		16.2			8.8			0.0			24.4	
Approach LOS		B			A			A			C	

Intersection Summary			
HCM Average Control Delay	14.5	HCM Level of Service	B
HCM Volume to Capacity ratio	0.61		
Actuated Cycle Length (s)	67.8	Sum of lost time (s)	17.0
Intersection Capacity Utilization	59.2%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↰	↑↑↱		↰	↑↑	↱			↱	↰↰	↑↱	
Volume (vph)	14	745	140	107	1155	674	0	0	170	580	0	13
Ideal Flow (vphpl)	2000	2000	2000	2000	2000	2000	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0		5.0	5.0	4.0			5.0	5.0	5.0	
Lane Util. Factor	1.00	0.95		1.00	0.95	1.00			1.00	0.97	1.00	
Frt	1.00	0.98		1.00	1.00	0.85			0.86	1.00	0.85	
Flt Protected	0.95	1.00		0.95	1.00	1.00			1.00	0.95	1.00	
Satd. Flow (prot)	1863	3637		1863	3725	1667			1611	3433	1583	
Flt Permitted	0.95	1.00		0.95	1.00	1.00			1.00	0.95	1.00	
Satd. Flow (perm)	1863	3637		1863	3725	1667			1611	3433	1583	
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	14	745	140	107	1155	674	0	0	170	580	0	13
RTOR Reduction (vph)	0	13	0	0	0	0	0	0	0	0	10	0
Lane Group Flow (vph)	14	872	0	107	1155	674	0	0	170	580	3	0
Turn Type	Prot			Prot		Free			Free	Prot		
Protected Phases	7	4		3	8					1	6	
Permitted Phases						Free			Free			
Actuated Green, G (s)	1.0	28.6		8.0	35.6	70.2			70.2	18.6	18.6	
Effective Green, g (s)	1.0	27.6		7.0	34.6	70.2			70.2	18.6	18.6	
Actuated g/C Ratio	0.01	0.39		0.10	0.49	1.00			1.00	0.26	0.26	
Clearance Time (s)	5.0	5.0		5.0	5.0					5.0	5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0					3.0	3.0	
Lane Grp Cap (vph)	27	1430		186	1836	1667			1611	910	419	
v/s Ratio Prot	0.01	0.24		0.06	c0.31					c0.17	0.00	
v/s Ratio Perm						c0.40			0.11			
v/c Ratio	0.52	0.61		0.58	0.63	0.40			0.11	0.64	0.01	
Uniform Delay, d1	34.4	17.0		30.2	13.1	0.0			0.0	22.8	19.0	
Progression Factor	1.00	1.00		1.00	1.00	1.00			1.00	1.00	1.00	
Incremental Delay, d2	15.8	0.7		4.3	0.7	0.7			0.1	1.5	0.0	
Delay (s)	50.2	17.7		34.4	13.8	0.7			0.1	24.3	19.0	
Level of Service	D	B		C	B	A			A	C	B	
Approach Delay (s)		18.3			10.4			0.1			24.2	
Approach LOS		B			B			A			C	

Intersection Summary			
HCM Average Control Delay	14.1	HCM Level of Service	B
HCM Volume to Capacity ratio	0.61		
Actuated Cycle Length (s)	70.2	Sum of lost time (s)	11.0
Intersection Capacity Utilization	63.5%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		✥			✥		↰	↑↱		↰	↑↱	
Volume (vph)	15	3	2	41	15	22	8	1013	69	86	469	77
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	2000	2000	2000	2000	2000	2000
Total Lost time (s)		5.0			5.0		5.0	5.0		5.0	5.0	
Lane Util. Factor		1.00			1.00		1.00	0.95		1.00	0.95	
Frt		0.99			0.96		1.00	0.99		1.00	0.98	
Flt Protected		0.96			0.97		0.95	1.00		0.95	1.00	
Satd. Flow (prot)		1771			1746		1863	3690		1863	3647	
Flt Permitted		0.88			0.82		0.44	1.00		0.23	1.00	
Satd. Flow (perm)		1620			1477		854	3690		448	3647	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	16	3	2	43	16	23	8	1066	73	91	494	81
RTOR Reduction (vph)	0	2	0	0	18	0	0	6	0	0	16	0
Lane Group Flow (vph)	0	19	0	0	64	0	8	1133	0	91	559	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4			8			2			6		
Actuated Green, G (s)		4.0			4.0		23.5	23.5		23.5	23.5	
Effective Green, g (s)		4.0			4.0		23.5	23.5		23.5	23.5	
Actuated g/C Ratio		0.11			0.11		0.63	0.63		0.63	0.63	
Clearance Time (s)		5.0			5.0		5.0	5.0		5.0	5.0	
Vehicle Extension (s)		3.0			3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)		173			158		535	2312		281	2285	
v/s Ratio Prot								c0.31			0.15	
v/s Ratio Perm		0.01			c0.04		0.01			0.20		
v/c Ratio		0.11			0.41		0.01	0.49		0.32	0.24	
Uniform Delay, d1		15.1			15.6		2.6	3.8		3.3	3.1	
Progression Factor		1.00			1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2		0.3			1.7		0.0	0.2		0.7	0.1	
Delay (s)		15.4			17.3		2.6	3.9		4.0	3.1	
Level of Service		B			B		A	A		A	A	
Approach Delay (s)		15.4			17.3			3.9			3.3	
Approach LOS		B			B			A			A	

Intersection Summary			
HCM Average Control Delay	4.4	HCM Level of Service	A
HCM Volume to Capacity ratio	0.48		
Actuated Cycle Length (s)	37.5	Sum of lost time (s)	10.0
Intersection Capacity Utilization	50.2%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		✥			✥		↰	↑↑↱		↰	↑↑↱	
Volume (vph)	47	11	14	121	13	63	7	790	54	63	1030	71
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	2000	2000	2000	2000	2000	2000
Total Lost time (s)		5.0			5.0		5.0	5.0		5.0	5.0	
Lane Util. Factor		1.00			1.00		1.00	0.95		1.00	0.95	
Frt		0.97			0.96		1.00	0.99		1.00	0.99	
Flt Protected		0.97			0.97		0.95	1.00		0.95	1.00	
Satd. Flow (prot)		1756			1730		1863	3690		1863	3689	
Flt Permitted		0.77			0.77		0.19	1.00		0.28	1.00	
Satd. Flow (perm)		1403			1370		363	3690		558	3689	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	49	12	15	127	14	66	7	832	57	66	1084	75
RTOR Reduction (vph)	0	11	0	0	21	0	0	6	0	0	6	0
Lane Group Flow (vph)	0	65	0	0	186	0	7	883	0	66	1153	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4			8			2			6		
Actuated Green, G (s)		13.1			13.1		28.2	28.2		28.2	28.2	
Effective Green, g (s)		13.1			13.1		28.2	28.2		28.2	28.2	
Actuated g/C Ratio		0.26			0.26		0.55	0.55		0.55	0.55	
Clearance Time (s)		5.0			5.0		5.0	5.0		5.0	5.0	
Vehicle Extension (s)		3.0			3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)		358			350		200	2028		307	2028	
v/s Ratio Prot								0.24			c0.31	
v/s Ratio Perm		0.05			c0.14		0.02			0.12		
v/c Ratio		0.18			0.53		0.04	0.44		0.21	0.57	
Uniform Delay, d1		14.9			16.5		5.3	6.8		5.9	7.6	
Progression Factor		1.00			1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2		0.2			1.6		0.1	0.2		0.4	0.4	
Delay (s)		15.2			18.0		5.4	7.0		6.3	7.9	
Level of Service		B			B		A	A		A	A	
Approach Delay (s)		15.2			18.0			7.0			7.8	
Approach LOS		B			B			A			A	

Intersection Summary			
HCM Average Control Delay	8.6	HCM Level of Service	A
HCM Volume to Capacity ratio	0.56		
Actuated Cycle Length (s)	51.3	Sum of lost time (s)	10.0
Intersection Capacity Utilization	57.9%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

[illegible]	↗	→	↘	↙	←	↖	↖	↑	↗	↘	↓	↙
Lane Configurations		↔			↔		↰	↑↑↱		↰	↑↑↱	
[illegible]	[illegible]	[illegible]	23	91	[illegible]	[illegible]	[illegible]	[illegible]	101	[illegible]	417	[illegible]
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	2000	2000	2000	2000	2000	2000
Total Lost time (s)		5.0			5.0		5.0	5.0		5.0	5.0	
Lane Util. Factor		1.00			1.00		1.00	0.95		1.00	0.95	
Frt		0.96			0.94		1.00	0.99		1.00	0.99	
Flt Protected		0.97			0.98		0.95	1.00		0.95	1.00	
Satd. Flow (prot)		1740			1708		1863	3672		1863	3689	
Flt Permitted		0.81			0.82		0.48	1.00		0.20	1.00	
Satd. Flow (perm)		1441			1431		946	3672		383	3689	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	42	13	24	96	20	100	61	1003	106	67	439	31
RTOR Reduction (vph)	0	18	0	0	37	0	0	10	0	0	7	0
Lane Group Flow (vph)	0	61	0	0	179	0	61	1099	0	67	463	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4			8			2			6		
Actuated Green, G (s)		11.2			11.2		21.5	21.5		21.5	21.5	
Effective Green, g (s)		11.2			11.2		21.5	21.5		21.5	21.5	
Actuated g/C Ratio		0.26			0.26		0.50	0.50		0.50	0.50	
Clearance Time (s)		5.0			5.0		5.0	5.0		5.0	5.0	
Vehicle Extension (s)		3.0			3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)		378			375		476	1849		193	1857	
v/s Ratio Prot								c0.30			0.13	
v/s Ratio Perm		0.04			c0.13		0.06			0.18		
v/c Ratio		0.16			0.48		0.13	0.59		0.35	0.25	
Uniform Delay, d1		12.1			13.3		5.6	7.5		6.4	6.0	
Progression Factor		1.00			1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2		0.2			1.0		0.1	0.5		1.1	0.1	
Delay (s)		12.3			14.2		5.7	8.0		7.5	6.1	
Level of Service		B			B		A	A		A	A	
Approach Delay (s)		12.3			14.2			7.9			6.3	
Approach LOS		B			B			A			A	

Intersection Summary			
HCM Average Control Delay	8.3	HCM Level of Service	A
HCM Volume to Capacity ratio	0.55		
Actuated Cycle Length (s)	42.7	Sum of lost time (s)	10.0
Intersection Capacity Utilization	57.8%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		✥			✥		↰	↑↑↱		↰	↑↑↱	
Volume (vph)	93	38	34	138	26	42	41	713	92	114	1010	41
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	2000	2000	2000	2000	2000	2000
Total Lost time (s)		5.0			5.0		5.0	5.0		5.0	5.0	
Lane Util. Factor		1.00			1.00		1.00	0.95		1.00	0.95	
Frt		0.97			0.97		1.00	0.98		1.00	0.99	
Flt Protected		0.97			0.97		0.95	1.00		0.95	1.00	
Satd. Flow (prot)		1761			1753		1863	3662		1863	3704	
Flt Permitted		0.75			0.74		0.19	1.00		0.29	1.00	
Satd. Flow (perm)		1361			1345		368	3662		573	3704	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	98	40	36	145	27	44	43	751	97	120	1063	43
RTOR Reduction (vph)	0	11	0	0	11	0	0	12	0	0	4	0
Lane Group Flow (vph)	0	163	0	0	205	0	43	836	0	120	1102	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4			8			2			6		
Actuated Green, G (s)		14.0			14.0		23.7	23.7		23.7	23.7	
Effective Green, g (s)		14.0			14.0		23.7	23.7		23.7	23.7	
Actuated g/C Ratio		0.29			0.29		0.50	0.50		0.50	0.50	
Clearance Time (s)		5.0			5.0		5.0	5.0		5.0	5.0	
Vehicle Extension (s)		3.0			3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)		399			395		183	1819		285	1840	
v/s Ratio Prot								0.23			c0.30	
v/s Ratio Perm		0.12			c0.15		0.12			0.21		
v/c Ratio		0.41			0.52		0.23	0.46		0.42	0.60	
Uniform Delay, d1		13.5			14.0		6.8	7.8		7.6	8.6	
Progression Factor		1.00			1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2		0.7			1.2		0.7	0.2		1.0	0.5	
Delay (s)		14.2			15.2		7.5	8.0		8.6	9.1	
Level of Service		B			B		A	A		A	A	
Approach Delay (s)		14.2			15.2			8.0			9.1	
Approach LOS		B			B			A			A	

Intersection Summary			
HCM Average Control Delay	9.6	HCM Level of Service	A
HCM Volume to Capacity ratio	0.57		
Actuated Cycle Length (s)	47.7	Sum of lost time (s)	10.0
Intersection Capacity Utilization	58.7%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lane Configurations												
Volume (vph)	58	785	85	138	384	8	83	12	318	3	7	7
Ideal Flow (vphpl)	2000	2000	2000	2000	2000	2000	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0		5.0	5.0			5.0			5.0	
Lane Util. Factor	1.00	0.95		1.00	0.95			1.00			1.00	
Frt	1.00	0.99		1.00	1.00			0.90			0.94	
Flt Protected	0.95	1.00		0.95	1.00			0.99			0.99	
Satd. Flow (prot)	1863	3671		1863	3715			1653			1744	
Flt Permitted	0.95	1.00		0.95	1.00			0.93			0.95	
Satd. Flow (perm)	1863	3671		1863	3715			1549			1670	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	61	826	89	145	404	8	87	13	335	3	7	7
RTOR Reduction (vph)	0	8	0	0	2	0	0	153	0	0	5	0
Lane Group Flow (vph)	61	907	0	145	410	0	0	282	0	0	12	0
Turn Type	Prot			Prot			Perm			Perm		
Protected Phases	7	4		3	8			2			6	
Permitted Phases							2			6		
Actuated Green, G (s)	4.0	25.6		8.3	29.9			17.7			17.7	
Effective Green, g (s)	4.0	25.6		8.3	29.9			17.7			17.7	
Actuated g/C Ratio	0.06	0.38		0.12	0.45			0.27			0.27	
Clearance Time (s)	5.0	5.0		5.0	5.0			5.0			5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0			3.0			3.0	
Lane Grp Cap (vph)	112	1411		232	1668			412			444	
v/s Ratio Prot	0.03	c0.25		c0.08	c0.11							
v/s Ratio Perm								c0.18			0.01	
v/c Ratio	0.54	0.64		0.63	0.25			0.68			0.03	
Uniform Delay, d1	30.4	16.8		27.7	11.4			21.9			18.1	
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Incremental Delay, d2	5.3	1.0		5.2	0.1			4.7			0.0	
Delay (s)	35.7	17.8		32.8	11.4			26.6			18.1	
Level of Service	D	B		C	B			C			B	
Approach Delay (s)		18.9			17.0			26.6			18.1	
Approach LOS		B			B			C			B	

Intersection Summary			
HCM Average Control Delay	20.1	HCM Level of Service	C
HCM Volume to Capacity ratio	0.71		
Actuated Cycle Length (s)	66.6	Sum of lost time (s)	20.0
Intersection Capacity Utilization	74.4%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↰	↑↱		↰	↑↱			✣			✣	
Volume (vph)	53	654	99	190	984	7	149	19	178	17	22	108
Ideal Flow (vphpl)	2000	2000	2000	2000	2000	2000	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0		5.0	5.0			5.0			5.0	
Lane Util. Factor	1.00	0.95		1.00	0.95			1.00			1.00	
Frt	1.00	0.98		1.00	1.00			0.93			0.90	
Flt Protected	0.95	1.00		0.95	1.00			0.98			1.00	
Satd. Flow (prot)	1863	3652		1863	3722			1697			1664	
Flt Permitted	0.95	1.00		0.95	1.00			0.80			0.96	
Satd. Flow (perm)	1863	3652		1863	3722			1383			1606	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	56	688	104	200	1036	7	157	20	187	18	23	114
RTOR Reduction (vph)	0	12	0	0	1	0	0	48	0	0	80	0
Lane Group Flow (vph)	56	780	0	200	1042	0	0	316	0	0	70	0
Turn Type	Prot			Prot			Perm			Perm		
Protected Phases	7	4		3	8			2			6	
Permitted Phases							2			6		
Actuated Green, G (s)	3.6	23.7		12.7	32.8			21.7			21.7	
Effective Green, g (s)	3.6	23.7		12.7	32.8			21.7			21.7	
Actuated g/C Ratio	0.05	0.32		0.17	0.45			0.30			0.30	
Clearance Time (s)	5.0	5.0		5.0	5.0			5.0			5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0			3.0			3.0	
Lane Grp Cap (vph)	92	1184		324	1670			411			477	
v/s Ratio Prot	0.03	0.21		c0.11	c0.28							
v/s Ratio Perm								c0.23			0.04	
v/c Ratio	0.61	0.66		0.62	0.62			0.77			0.15	
Uniform Delay, d1	34.1	21.2		28.0	15.4			23.4			18.9	
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Incremental Delay, d2	10.9	1.3		3.5	0.7			8.4			0.1	
Delay (s)	45.0	22.6		31.4	16.2			31.8			19.0	
Level of Service	D	C		C	B			C			B	
Approach Delay (s)		24.0			18.6			31.8			19.0	
Approach LOS		C			B			C			B	

Intersection Summary			
HCM Average Control Delay	22.3	HCM Level of Service	C
HCM Volume to Capacity ratio	0.70		
Actuated Cycle Length (s)	73.1	Sum of lost time (s)	15.0
Intersection Capacity Utilization	75.5%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lane Configurations	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Volume (vph)	[illegible]	[illegible]	[illegible]	[illegible]	21	252	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ideal Flow (vphpl)	1900	1900	1900	2000	2000	2000	2000	2000	2000	2000	2000	2000
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lane Util. Factor	1.00	0.95	1.00	0.95	0.95	0.88	1.00	0.95	1.00	0.97	0.95	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	0.96	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1770	3539	1583	1770	1790	2933	1863	3725	1667	3614	3725	1667
Flt Permitted	0.95	1.00	1.00	0.95	0.96	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	1770	3539	1583	1770	1790	2933	1863	3725	1667	3614	3725	1667
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	17	25	4	215	22	265	8	546	248	708	1062	18
RTOR Reduction (vph)	0	0	0	0	0	135	0	0	177	0	0	8
Lane Group Flow (vph)	17	25	4	118	119	130	8	546	71	708	1062	10
Turn Type	Split		Free	Split		pt+ov	Prot		Perm	Prot		Perm
Protected Phases	4	4		8	8	8 1	5	2		1	6	
Permitted Phases			Free						2			6
Actuated Green, G (s)	3.5	3.5	83.1	11.8	11.8	40.7	1.0	23.9	23.9	23.9	46.8	46.8
Effective Green, g (s)	3.5	3.5	83.1	11.8	11.8	40.7	1.0	23.9	23.9	23.9	46.8	45.8
Actuated g/C Ratio	0.04	0.04	1.00	0.14	0.14	0.49	0.01	0.29	0.29	0.29	0.56	0.55
Clearance Time (s)	5.0	5.0		5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	75	149	1583	251	254	1436	22	1071	479	1039	2098	919
v/s Ratio Prot	c0.01	0.01		c0.07	0.07	0.04	0.00	0.15		c0.20	c0.29	
v/s Ratio Perm			0.00						0.04			0.01
v/c Ratio	0.23	0.17	0.00	0.47	0.47	0.09	0.36	0.51	0.15	0.68	0.51	0.01
Uniform Delay, d1	38.5	38.4	0.0	32.8	32.8	11.3	40.7	24.7	22.0	26.2	11.1	8.4
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	1.5	0.5	0.0	1.4	1.4	0.0	9.9	0.4	0.1	1.9	0.2	0.0
Delay (s)	40.0	38.9	0.0	34.2	34.1	11.3	50.7	25.1	22.2	28.1	11.3	8.4
Level of Service	D	D	A	C	C	B	D	C	C	C	B	A
Approach Delay (s)		36.0			22.1			24.4			17.9	
Approach LOS		D			C			C			B	

[illegible]			
HCM Average Control Delay	20.5	HCM Level of Service	C
HCM Volume to Capacity ratio	0.53		
Actuated Cycle Length (s)	83.1	Sum of lost time (s)	15.0
Intersection Capacity Utilization	56.9%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	32	46	36	353	81	813	35	960	400	365	717	51
Ideal Flow (vphpl)	1900	1900	1900	2000	2000	2000	2000	2000	2000	2000	2000	2000
Total Lost time (s)	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	6.0
Lane Util. Factor	1.00	0.95	1.00	0.95	0.95	0.88	1.00	0.95	1.00	0.97	0.95	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	0.97	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1770	3539	1583	1770	1806	2933	1863	3725	1667	3614	3725	1667
Flt Permitted	0.95	1.00	1.00	0.95	0.97	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	1770	3539	1583	1770	1806	2933	1863	3725	1667	3614	3725	1667
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	34	48	38	372	85	856	37	1011	421	384	755	54
RTOR Reduction (vph)	0	0	0	0	0	237	0	0	253	0	0	28
Lane Group Flow (vph)	34	48	38	227	230	619	37	1011	168	384	755	26
Turn Type	Split		Free	Split		pt+ov	Prot		Perm	Prot		Perm
Protected Phases	4	4		8	8	8 1	5	2		1	6	
Permitted Phases			Free						2			6
Actuated Green, G (s)	5.9	5.9	100.8	20.4	20.4	42.5	4.2	37.4	37.4	17.1	50.3	50.3
Effective Green, g (s)	5.9	5.9	100.8	20.4	20.4	42.5	4.2	37.4	37.4	17.1	50.3	49.3
Actuated g/C Ratio	0.06	0.06	1.00	0.20	0.20	0.42	0.04	0.37	0.37	0.17	0.50	0.49
Clearance Time (s)	5.0	5.0		5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	104	207	1583	358	366	1237	78	1382	619	613	1859	815
v/s Ratio Prot	c0.02	0.01		c0.13	0.13	c0.21	0.02	c0.27		c0.11	0.20	
v/s Ratio Perm			0.02						0.10			0.02
v/c Ratio	0.33	0.23	0.02	0.63	0.63	0.50	0.47	0.73	0.27	0.63	0.41	0.03
Uniform Delay, d1	45.5	45.3	0.0	36.8	36.7	21.4	47.2	27.4	22.2	38.9	15.9	13.4
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	1.8	0.6	0.0	3.6	3.4	0.3	4.5	2.0	0.2	2.0	0.1	0.0
Delay (s)	47.4	45.9	0.0	40.4	40.1	21.7	51.7	29.4	22.4	40.9	16.0	13.4
Level of Service	D	D	A	D	D	C	D	C	C	D	B	B
Approach Delay (s)		31.8			28.2			28.0			23.9	
Approach LOS		C			C			C			C	

Intersection Summary			
HCM Average Control Delay	26.9	HCM Level of Service	C
HCM Volume to Capacity ratio	0.62		
Actuated Cycle Length (s)	100.8	Sum of lost time (s)	15.0
Intersection Capacity Utilization	68.1%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lane Configurations												
Volume (vph)	1	4	[illegible]	[illegible]	2	42	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1
Ideal Flow (vphpl)	1900	1900	1900	2000	2000	2000	2000	2000	2000	2000	2000	2000
Total Lost time (s)	5.0	5.0	4.0	5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0
Lane Util. Factor	1.00	1.00	1.00	0.97	1.00		1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	1.00	0.85	1.00	0.86		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1770	1863	1583	3614	1679		1863	3725	1667	1863	3725	1667
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	1770	1863	1583	3614	1679		1863	3725	1667	1863	3725	1667
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	1	4	9	608	2	44	17	756	597	35	1244	1
RTOR Reduction (vph)	0	0	0	0	33	0	0	0	346	0	0	1
Lane Group Flow (vph)	1	4	9	608	13	0	17	756	251	35	1244	0
Turn Type	Split		Free	Split			Prot		Perm	Prot		Perm
Protected Phases	4	4		8	8		5	2		1	6	
Permitted Phases			Free						2			6
Actuated Green, G (s)	0.8	0.8	74.9	19.5	19.5		1.5	31.5	31.5	3.1	33.1	33.1
Effective Green, g (s)	0.8	0.8	74.9	19.5	19.5		1.5	31.5	31.5	3.1	33.1	33.1
Actuated g/C Ratio	0.01	0.01	1.00	0.26	0.26		0.02	0.42	0.42	0.04	0.44	0.44
Clearance Time (s)	5.0	5.0		5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	19	20	1583	941	437		37	1567	701	77	1646	737
v/s Ratio Prot	0.00	c0.00		c0.17	0.01		0.01	0.20		c0.02	c0.33	
v/s Ratio Perm			c0.01						0.15			0.00
v/c Ratio	0.05	0.20	0.01	0.65	0.03		0.46	0.48	0.36	0.45	0.76	0.00
Uniform Delay, d1	36.7	36.7	0.0	24.6	20.7		36.3	15.8	14.8	35.1	17.5	11.7
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	1.2	4.9	0.0	1.5	0.0		8.8	0.2	0.3	4.2	2.0	0.0
Delay (s)	37.8	41.6	0.0	26.2	20.7		45.1	16.0	15.1	39.3	19.5	11.7
Level of Service	D	D	A	C	C		D	B	B	D	B	B
Approach Delay (s)		14.6			25.8			16.0			20.1	
Approach LOS		B			C			B			C	

Intersection Summary			
HCM Average Control Delay	19.5	HCM Level of Service	B
HCM Volume to Capacity ratio	0.65		
Actuated Cycle Length (s)	74.9	Sum of lost time (s)	15.0
Intersection Capacity Utilization	61.7%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	7	16	41	618	17	56	84	1332	833	49	1042	14
Ideal Flow (vphpl)	1900	1900	1900	2000	2000	2000	2000	2000	2000	2000	2000	2000
Total Lost time (s)	5.0	5.0	4.0	5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0
Lane Util. Factor	1.00	1.00	1.00	0.97	1.00		1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	1.00	0.85	1.00	0.89		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1770	1863	1583	3614	1735		1863	3725	1667	1863	3725	1667
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	1770	1863	1583	3614	1735		1863	3725	1667	1863	3725	1667
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	7	17	43	651	18	59	88	1402	877	52	1097	15
RTOR Reduction (vph)	0	0	0	0	45	0	0	0	363	0	0	8
Lane Group Flow (vph)	7	17	43	651	32	0	88	1402	514	52	1097	7
Turn Type	Split		Free	Split			Prot		Perm	Prot		Perm
Protected Phases	4	4		8	8		5	2		1	6	
Permitted Phases			Free						2			6
Actuated Green, G (s)	3.7	3.7	98.5	22.8	22.8		7.8	46.9	46.9	5.1	44.2	44.2
Effective Green, g (s)	3.7	3.7	98.5	22.8	22.8		7.8	46.9	46.9	5.1	44.2	44.2
Actuated g/C Ratio	0.04	0.04	1.00	0.23	0.23		0.08	0.48	0.48	0.05	0.45	0.45
Clearance Time (s)	5.0	5.0		5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	66	70	1583	837	402		148	1774	794	96	1672	748
v/s Ratio Prot	0.00	c0.01		c0.18	0.02		c0.05	c0.38		0.03	0.29	
v/s Ratio Perm			0.03						0.31			0.00
v/c Ratio	0.11	0.24	0.03	0.78	0.08		0.59	0.79	0.65	0.54	0.66	0.01
Uniform Delay, d1	45.8	46.0	0.0	35.5	29.6		43.8	21.7	19.5	45.6	21.2	15.0
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.7	1.8	0.0	4.6	0.1		6.3	2.5	1.8	6.1	0.9	0.0
Delay (s)	46.5	47.8	0.0	40.1	29.7		50.1	24.2	21.4	51.7	22.2	15.0
Level of Service	D	D	A	D	C		D	C	C	D	C	B
Approach Delay (s)		17.0			39.0			24.1			23.4	
Approach LOS		B			D			C			C	

Intersection Summary			
HCM Average Control Delay	26.3	HCM Level of Service	C
HCM Volume to Capacity ratio	0.77		
Actuated Cycle Length (s)	98.5	Sum of lost time (s)	20.0
Intersection Capacity Utilization	74.2%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Movement	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lane Configurations												
Volume (vph)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ideal Flow (vphpl)	2000	2000	2000	1900	1900	1900	2000	2000	2000	2000	2000	2000
Total Lost time (s)	5.0	5.0	4.0	5.0	5.0		5.0	5.0	5.0	5.0	5.0	4.0
Lane Util. Factor	0.95	0.95	1.00	1.00	1.00		1.00	0.95	1.00	1.00	0.95	1.00
Frpb, ped/bikes	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	1.00	0.85	1.00	0.95		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	0.96	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1770	1780	1667	1770	1765		1863	3725	1667	1863	3725	1667
Flt Permitted	0.95	0.96	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	1770	1780	1667	1770	1765		1863	3725	1667	1863	3725	1667
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	490	17	93	64	73	39	46	775	39	17	1166	587
RTOR Reduction (vph)	0	0	0	0	16	0	0	0	22	0	0	0
Lane Group Flow (vph)	255	252	93	64	96	0	46	775	17	17	1166	587
Confl. Peds. (#/hr)							39					
Turn Type	Split		Free	Split			Prot		Perm	Prot		Free
Protected Phases	4	4		8	8		5	2		1	6	
Permitted Phases			Free						2			Free
Actuated Green, G (s)	19.6	19.6	92.0	11.0	11.0		4.0	39.5	39.5	1.9	37.4	92.0
Effective Green, g (s)	19.6	19.6	92.0	11.0	11.0		4.0	39.5	39.5	1.9	37.4	92.0
Actuated g/C Ratio	0.21	0.21	1.00	0.12	0.12		0.04	0.43	0.43	0.02	0.41	1.00
Clearance Time (s)	5.0	5.0		5.0	5.0		5.0	5.0	5.0	5.0	5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	377	379	1667	212	211		81	1599	716	38	1514	1667
v/s Ratio Prot	c0.14	0.14		0.04	0.05		0.02	0.21		0.01	c0.31	
v/s Ratio Perm			0.06						0.01			c0.35
v/c Ratio	0.68	0.66	0.06	0.30	0.46		0.57	0.48	0.02	0.45	0.77	0.35
Uniform Delay, d1	33.3	33.2	0.0	37.0	37.7		43.2	18.9	15.1	44.5	23.6	0.0
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	4.8	4.4	0.1	0.8	1.6		8.8	0.2	0.0	8.2	2.5	0.6
Delay (s)	38.0	37.5	0.1	37.8	39.3		52.0	19.1	15.1	52.7	26.1	0.6
Level of Service	D	D	A	D	D		D	B	B	D	C	A
Approach Delay (s)		31.9			38.7			20.7			17.9	
Approach LOS		C			D			C			B	

Intersection Summary				
HCM Average Control Delay	22.2	HCM Level of Service		C
HCM Volume to Capacity ratio	0.62			
Actuated Cycle Length (s)	92.0	Sum of lost time (s)		10.0
Intersection Capacity Utilization	64.6%	ICU Level of Service		C
Analysis Period (min)	15			

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↰	↰↑	↱	↰	↑↱		↰	↑↑	↱	↰	↑↑	↱
Volume (vph)	525	31	134	24	31	50	176	1689	105	27	975	698
Ideal Flow (vphpl)	2000	2000	2000	1900	1900	1900	2000	2000	2000	2000	2000	2000
Total Lost time (s)	5.0	5.0	4.0	5.0	5.0		5.0	5.0	5.0	5.0	5.0	4.0
Lane Util. Factor	0.95	0.95	1.00	1.00	1.00		1.00	0.95	1.00	1.00	0.95	1.00
Frpb, ped/bikes	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	1.00	0.85	1.00	0.91		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	0.96	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1770	1784	1667	1770	1690		1863	3725	1667	1863	3725	1667
Flt Permitted	0.95	0.96	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	1770	1784	1667	1770	1690		1863	3725	1667	1863	3725	1667
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	525	31	134	24	31	50	176	1689	105	27	975	698
RTOR Reduction (vph)	0	0	0	0	47	0	0	0	36	0	0	0
Lane Group Flow (vph)	278	278	134	24	34	0	176	1689	69	27	975	698
Confl. Peds. (#/hr)							39					
Turn Type	Split		Free	Split			Prot		Perm	Prot		Free
Protected Phases	4	4		8	8		5	2		1	6	
Permitted Phases			Free						2			Free
Actuated Green, G (s)	20.2	20.2	101.6	6.2	6.2		14.8	52.1	52.1	3.1	40.4	101.6
Effective Green, g (s)	20.2	20.2	101.6	6.2	6.2		14.8	52.1	52.1	3.1	40.4	101.6
Actuated g/C Ratio	0.20	0.20	1.00	0.06	0.06		0.15	0.51	0.51	0.03	0.40	1.00
Clearance Time (s)	5.0	5.0		5.0	5.0		5.0	5.0	5.0	5.0	5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	352	355	1667	108	103		271	1910	855	57	1481	1667
v/s Ratio Prot	c0.16	0.16		0.01	0.02		c0.09	c0.45		0.01	0.26	
v/s Ratio Perm			0.08						0.04			c0.42
v/c Ratio	0.79	0.78	0.08	0.22	0.33		0.65	0.88	0.08	0.47	0.66	0.42
Uniform Delay, d1	38.7	38.6	0.0	45.4	45.7		41.0	22.1	12.6	48.4	25.0	0.0
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	11.2	10.8	0.1	1.0	1.9		5.3	5.3	0.0	6.1	1.1	0.8
Delay (s)	49.9	49.4	0.1	46.4	47.6		46.2	27.3	12.6	54.5	26.0	0.8
Level of Service	D	D	A	D	D		D	C	B	D	C	A
Approach Delay (s)		40.0			47.3			28.2			16.1	
Approach LOS		D			D			C			B	

Intersection Summary			
HCM Average Control Delay	25.9	HCM Level of Service	C
HCM Volume to Capacity ratio	0.81		
Actuated Cycle Length (s)	101.6	Sum of lost time (s)	15.0
Intersection Capacity Utilization	81.4%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↰	↱	↰	↱		↰	↑↑	↱	↰	↑↑	↱
Volume (vph)	116	12	321	173	12	13	30	729	55	3	1314	11
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	2000	2000	2000	2000	2000	2000
Total Lost time (s)		5.0	5.0	5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0
Lane Util. Factor		1.00	1.00	1.00	1.00		1.00	0.95	1.00	1.00	0.95	1.00
Frt		1.00	0.85	1.00	0.92		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected		0.96	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)		1782	1583	1770	1718		1863	3725	1667	1863	3725	1667
Flt Permitted		0.73	1.00	0.67	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)		1354	1583	1249	1718		1863	3725	1667	1863	3725	1667
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	122	13	338	182	13	14	32	767	58	3	1383	12
RTOR Reduction (vph)	0	0	70	0	10	0	0	0	26	0	0	6
Lane Group Flow (vph)	0	135	268	182	17	0	32	767	32	3	1383	6
Turn Type	Perm		Perm	Perm			Prot		Perm	Prot		Perm
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4		4	8					2			6
Actuated Green, G (s)		20.6	20.6	20.6	20.6		2.9	45.0	45.0	0.5	42.6	42.6
Effective Green, g (s)		20.6	20.6	20.6	20.6		2.9	45.0	45.0	0.5	42.6	42.6
Actuated g/C Ratio		0.25	0.25	0.25	0.25		0.04	0.55	0.55	0.01	0.53	0.53
Clearance Time (s)		5.0	5.0	5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0
Vehicle Extension (s)		3.0	3.0	3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)		344	402	317	436		67	2067	925	11	1957	876
v/s Ratio Prot					0.01		c0.02	0.21		0.00	c0.37	
v/s Ratio Perm		0.10	c0.17	0.15					0.02			0.00
v/c Ratio		0.39	0.67	0.57	0.04		0.48	0.37	0.03	0.27	0.71	0.01
Uniform Delay, d1		25.1	27.2	26.4	22.8		38.4	10.1	8.2	40.1	14.5	9.2
Progression Factor		1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2		0.7	4.1	2.5	0.0		5.3	0.1	0.0	13.0	1.2	0.0
Delay (s)		25.8	31.3	28.9	22.8		43.6	10.2	8.2	53.1	15.7	9.2
Level of Service		C	C	C	C		D	B	A	D	B	A
Approach Delay (s)		29.7			28.1			11.3			15.7	
Approach LOS		C			C			B			B	

Intersection Summary			
HCM Average Control Delay	17.6	HCM Level of Service	B
HCM Volume to Capacity ratio	0.68		
Actuated Cycle Length (s)	81.1	Sum of lost time (s)	15.0
Intersection Capacity Utilization	76.5%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

[illegible]												
Lane Configurations												
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	2000	2000	2000	2000	2000	2000
Total Lost time (s)		5.0	5.0	5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0
Lane Util. Factor		1.00	1.00	1.00	1.00		1.00	0.95	1.00	1.00	0.95	1.00
Frt		1.00	0.85	1.00	0.91		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected		0.96	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)		1792	1583	1770	1701		1863	3725	1667	1863	3725	1667
Flt Permitted		0.76	1.00	0.74	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)		1411	1583	1375	1701		1863	3725	1667	1863	3725	1667
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	23	6	73	66	8	11	166	2051	180	11	1158	29
RTOR Reduction (vph)	0	0	66	0	10	0	0	0	50	0	0	13
Lane Group Flow (vph)	0	29	7	66	9	0	166	2051	130	11	1158	16
Turn Type	Perm		Perm	Perm			Prot		Perm	Prot		Perm
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4		4	8					2			6
Actuated Green, G (s)		7.8	7.8	7.8	7.8		14.2	60.7	60.7	1.1	47.6	47.6
Effective Green, g (s)		7.8	7.8	7.8	7.8		14.2	60.7	60.7	1.1	47.6	47.6
Actuated g/C Ratio		0.09	0.09	0.09	0.09		0.17	0.72	0.72	0.01	0.56	0.56
Clearance Time (s)		5.0	5.0	5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0
Vehicle Extension (s)		3.0	3.0	3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)		130	146	127	157		313	2673	1196	24	2096	938
v/s Ratio Prot					0.01		c0.09	c0.55		0.01	0.31	
v/s Ratio Perm		0.02	0.00	c0.05					0.08			0.01
v/c Ratio		0.22	0.05	0.52	0.06		0.53	0.77	0.11	0.46	0.55	0.02
Uniform Delay, d1		35.6	35.0	36.6	35.0		32.2	7.5	3.7	41.5	11.7	8.2
Progression Factor		1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2		0.9	0.1	3.6	0.2		1.7	1.4	0.0	13.2	0.3	0.0
Delay (s)		36.5	35.1	40.2	35.2		33.9	8.9	3.7	54.7	12.1	8.2
Level of Service		D	D	D	D		C	A	A	D	B	A
Approach Delay (s)		35.5			39.1			10.2			12.4	
Approach LOS		D			D			B			B	

[illegible]			
HCM Average Control Delay	12.2	HCM Level of Service	B
[illegible]	[illegible]		
Actuated Cycle Length (s)	84.8	Sum of lost time (s)	15.0
[illegible]	[illegible]	[illegible]	[illegible]
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations	↰	↱	↰	↑↑	↑↑	↱
Volume (vph)	119	618	139	694	1736	89
Ideal Flow (vphpl)	2000	2000	2000	2000	2000	2000
Total Lost time (s)	5.0	5.0	5.0	5.0	5.0	5.0
Lane Util. Factor	1.00	1.00	1.00	0.95	0.95	1.00
Frt	1.00	0.85	1.00	1.00	1.00	0.85
Flt Protected	0.95	1.00	0.95	1.00	1.00	1.00
Satd. Flow (prot)	1863	1667	1863	3725	3725	1667
Flt Permitted	0.95	1.00	0.95	1.00	1.00	1.00
Satd. Flow (perm)	1863	1667	1863	3725	3725	1667
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	119	618	139	694	1736	89
RTOR Reduction (vph)	0	7	0	0	0	39
Lane Group Flow (vph)	119	611	139	694	1736	50
Turn Type		pt+ov	Prot			Perm
Protected Phases	4	4 5	5	2	6	
Permitted Phases						6
Actuated Green, G (s)	28.1	47.4	14.3	79.3	60.0	60.0
Effective Green, g (s)	28.1	47.4	14.3	79.3	60.0	60.0
Actuated g/C Ratio	0.24	0.40	0.12	0.68	0.51	0.51
Clearance Time (s)	5.0		5.0	5.0	5.0	5.0
Vehicle Extension (s)	3.0		3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	446	673	227	2516	1904	852
v/s Ratio Prot	0.06	c0.37	0.07	0.19	c0.47	
v/s Ratio Perm						0.03
v/c Ratio	0.27	0.91	0.61	0.28	0.91	0.06
Uniform Delay, d1	36.3	33.0	48.9	7.6	26.3	14.5
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.3	16.1	4.8	0.1	7.1	0.0
Delay (s)	36.6	49.0	53.7	7.7	33.4	14.5
Level of Service	D	D	D	A	C	B
Approach Delay (s)	47.0			15.3	32.5	
Approach LOS	D			B	C	

Intersection Summary			
HCM Average Control Delay	31.4	HCM Level of Service	C
HCM Volume to Capacity ratio	0.91		
Actuated Cycle Length (s)	117.4	Sum of lost time (s)	10.0
Intersection Capacity Utilization	90.3%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

	↗	↘	↖	↑	↓	↙
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lane Configurations	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ideal Flow (vphpl)	2000	2000	2000	2000	2000	2000
Total Lost time (s)	5.0	5.0	5.0	5.0	5.0	5.0
Lane Util. Factor	1.00	1.00	1.00	0.95	0.95	1.00
Frt	1.00	0.85	1.00	1.00	1.00	0.85
Flt Protected	0.95	1.00	0.95	1.00	1.00	1.00
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Flt Permitted	0.95	1.00	0.95	1.00	1.00	1.00
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	266	480	307	2135	1107	188
RTOR Reduction (vph)	0	15	0	0	0	108
Lane Group Flow (vph)	266	465	307	2135	1107	80
Turn Type		pm+ov	Prot			Perm
Protected Phases	4	5	5	2	6	
Permitted Phases		4				6
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Effective Green, g (s)	20.0	42.5	22.5	70.2	42.7	42.7
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Clearance Time (s)	5.0	5.0	5.0	5.0	5.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	372	790	418	2610	1587	710
v/s Ratio Prot	c0.14	0.13	0.16	c0.57	0.30	
v/s Ratio Perm		0.15				0.05
v/c Ratio	0.72	0.59	0.73	0.82	0.70	0.11
Uniform Delay, d1	37.4	22.1	36.1	10.5	23.5	17.3
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	6.4	1.1	6.6	2.1	1.4	0.1
Delay (s)	43.8	23.3	42.6	12.6	24.8	17.4
Level of Service	D	C	D	B	C	B
Approach Delay (s)	30.6			16.4	23.8	
Approach LOS	C			B	C	

Intersection Summary			
HCM Average Control Delay	20.9	HCM Level of Service	C
HCM Volume to Capacity ratio	0.80		
Actuated Cycle Length (s)	100.2	Sum of lost time (s)	10.0
Intersection Capacity Utilization	74.9%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

HCS+: Ramps and Ramp Junctions Release 5.3

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: AM Peak
Freeway/Dir of Travel: H-2 Fwy NB Off-Ramp
Junction: H-2 Fwy/Ka Uka Blvd
Jurisdiction:
Analysis Year: Year 2016 With Project
Description:

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	3832	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	2	
Free-Flow speed on ramp	35.0	mph
Volume on ramp	1567	vph
Length of first accel/decel lane	800	ft
Length of second accel/decel lane	0	ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent ramp	364	vph
Position of adjacent ramp	Downstream	
Type of adjacent ramp	On	
Distance to adjacent ramp	1300	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	3832		1567		364	vph
Peak-hour factor, PHF	0.90		0.90		0.90	
Peak 15-min volume, v15	1064		435		101	v
Trucks and buses	2		2		2	%
Recreational vehicles	0		0		0	%
Terrain type:	Rolling		Level		Level	
Grade	0.00	%	0.00	%	0.00	%
Length	0.00	mi	0.00	mi	0.00	mi
Trucks and buses PCE, ET	1.5*		1.5		1.5	
Recreational vehicle PCE, ER	2.0		1.2		1.2	

Heavy vehicle adjustment, fHV	0.990	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	4300	1759	408	pcph

Estimation of V12 Diverge Areas

L_{EQ} = (Equation 25-8 or 25-9)

P_{FD} = 0.260 Using Equation 0

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 2420 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{Fi} = v_F$	4300	9400	No
$v_{FO} = v_F - v_R$	2541	9400	No
v_R	1759	3800	No
v_{3} or v_{av34}	940 pc/h	(Equation 25-15 or 25-16)	
Is v_{3} or v_{av34} > 2700 pc/h?		No	
Is v_{3} or v_{av34} > 1.5 v_{12}/2		No	
If yes, v_{12A} = 2420		(Equation 25-18)	

Flow Entering Diverge Influence Area

	Actual	Max Desirable	Violation?
v_{12}	2420	4400	No

Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\, v_{12} - 0.009\, L_D$ = 10.7 pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

Speed Estimation

Intermediate speed variable,	D_S = 0.586	
Space mean speed in ramp influence area,	S_R = 51.5	mph
Space mean speed in outer lanes,	S_0 = 71.3	mph
Space mean speed for all vehicles,	S = 58.6	mph

HCS+: Ramps and Ramp Junctions Release 5.3

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: PM Peak
Freeway/Dir of Travel: H-2 Fwy NB Off-Ramp
Junction: H-2 Fwy/Ka Uka Blvd
Jurisdiction:
Analysis Year: Year 2016 With Project
Description:

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	7327	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	2	
Free-Flow speed on ramp	35.0	mph
Volume on ramp	3973	vph
Length of first accel/decel lane	800	ft
Length of second accel/decel lane	0	ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent ramp	605	vph
Position of adjacent ramp	Downstream	
Type of adjacent ramp	On	
Distance to adjacent ramp	1300	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	7327		3973		605	vph
Peak-hour factor, PHF	0.90		0.90		0.90	
Peak 15-min volume, v15	2035		1104		168	v
Trucks and buses	2		2		2	%
Recreational vehicles	0		0		0	%
Terrain type:	Rolling		Level		Level	
Grade	0.00	%	0.00	%	0.00	%
Length	0.00	mi	0.00	mi	0.00	mi
Trucks and buses PCE, ET	2.5		1.5		1.5	
Recreational vehicle PCE, ER	2.0		1.2		1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	8385	4459	679	pcph

Estimation of V12 Diverge Areas

L_{EQ} = (Equation 25-8 or 25-9)

P_{FD} = 0.260 Using Equation 0

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 5480 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{Fi} = v_F$	8385	9400	No
$v_{FO} = v_F - v_R$	3926	9400	No
v_R	4459	3800	Yes
v_{3} or v_{av34}	1452 pc/h	(Equation 25-15 or 25-16)	
Is v_{3} or v_{av34} > 2700 pc/h?		No	
Is v_{3} or v_{av34} > 1.5 v_{12}/2		No	
If yes, v_{12A} = 5480		(Equation 25-18)	

Flow Entering Diverge Influence Area

	Actual	Max Desirable	Violation?
v_{12}	5480	4400	Yes

Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086 v_{12} - 0.009 L_D$ = 37.0 pc/mi/ln

Level of service for ramp-freeway junction areas of influence F

Speed Estimation

Intermediate speed variable, D_S = 0.829

Space mean speed in ramp influence area, S_R = 45.9 mph

Space mean speed in outer lanes, S_0 = 69.5 mph

Space mean speed for all vehicles, S = 52.0 mph

HCS+: Ramps and Ramp Junctions Release 5.3

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: AM Peak
Freeway/Dir of Travel: H-2 Fwy NB On Ramp Loop
Junction: H-2 Fwy/Ka Uka Blvd
Jurisdiction:
Analysis Year: Year 2016 With Project
Description: (Analysis with NB Off Ramp)

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	2265	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	35.0	mph
Volume on ramp	364	vph
Length of first accel/decel lane	1500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	1567	vph
Position of adjacent Ramp	Upstream	
Type of adjacent Ramp	Off	
Distance to adjacent Ramp	1300	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	2265		364		1567	vph
Peak-hour factor, PHF	0.90		0.90		0.90	
Peak 15-min volume, v15	629		101		435	v
Trucks and buses	2		2		2	%
Recreational vehicles	0		0		0	%
Terrain type:	Rolling		Level		Level	
Grade		%		%		%
Length		mi		mi		mi
Trucks and buses PCE, ET	2.5		1.5		1.5	
Recreational vehicle PCE, ER	2.0		1.2		1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	2592	408	1759	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 25-2 or 25-3)

P_{FM} = 0.167 Using Equation 4

$v_{12} = v_F (P_{FM})$ = 432 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	3000	9400	No
v_3 or v_{av34}	1080 pc/h	(Equation 25-4 or 25-5)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12} /2		Yes	
If yes, v_{12A} = 1036		(Equation 25-8)	

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	1036	4600	No

Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$ = 7.1 pc/mi/ln

Level of service for ramp-freeway junction areas of influence A

Speed Estimation

Intermediate speed variable, M_S = 0.233

Space mean speed in ramp influence area, S_R = 59.7 mph

Space mean speed in outer lanes, S_0 = 64.0 mph

Space mean speed for all vehicles, S = 61.8 mph

HCS+: Ramps and Ramp Junctions Release 5.3

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: PM Peak
Freeway/Dir of Travel: H-2 Fwy NB On Ramp Loop
Junction: H-2 Fwy/Ka Uka Blvd
Jurisdiction:
Analysis Year: Year 2016 With Project
Description: (Analysis with NB Off Ramp)

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	3354	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	35.0	mph
Volume on ramp	605	vph
Length of first accel/decel lane	1500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	3973	vph
Position of adjacent Ramp	Upstream	
Type of adjacent Ramp	Off	
Distance to adjacent Ramp	1300	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	3354		605		3973	vph
Peak-hour factor, PHF	0.90		0.90		0.90	
Peak 15-min volume, v15	932		168		1104	v
Trucks and buses	2		2		2	%
Recreational vehicles	0		0		0	%
Terrain type:	Rolling		Level		Level	
Grade		%		%		%
Length		mi		mi		mi
Trucks and buses PCE, ET	2.5		1.5		1.5	
Recreational vehicle PCE, ER	2.0		1.2		1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	3838	679	4459	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 25-2 or 25-3)

P_{FM} = 0.133 Using Equation 4

$v_{12} = v_F (P_{FM})$ = 510 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	4517	9400	No
v_3 or v_{av34}	1664 pc/h	(Equation 25-4 or 25-5)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		Yes	
If yes, v_{12A} = 1535		(Equation 25-8)	

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	1535	4600	No

Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$ = 13.0 pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

Speed Estimation

Intermediate speed variable, M_S = 0.252

Space mean speed in ramp influence area, S_R = 59.2 mph

Space mean speed in outer lanes, S_0 = 62.7 mph

Space mean speed for all vehicles, S = 60.9 mph

HCS+: Ramps and Ramp Junctions Release 5.3

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: AM Peak
Freeway/Dir of Travel: H-2 Fwy NB On Ramp Loop
Junction: H-2 Fwy/Ka Uka Blvd
Jurisdiction:
Analysis Year: Year 2016 With Project
Description: (Analysis with NB On Ramp)

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	2265	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	35.0	mph
Volume on ramp	364	vph
Length of first accel/decel lane	1500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	225	vph
Position of adjacent Ramp	Downstream	
Type of adjacent Ramp	On	
Distance to adjacent Ramp	1700	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	2265		364		225	vph
Peak-hour factor, PHF	0.90		0.90		0.90	
Peak 15-min volume, v15	629		101		63	v
Trucks and buses	2		2		2	%
Recreational vehicles	0		0		0	%
Terrain type:	Rolling		Level		Level	
Grade		%		%		%
Length		mi		mi		mi
Trucks and buses PCE, ET	2.5		1.5		1.5	
Recreational vehicle PCE, ER	2.0		1.2		1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	2592	408	253	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 25-2 or 25-3)

P_{FM} = 0.167 Using Equation 4

$v_{12} = v_F (P_{FM})$ = 432 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	3000	9400	No
v_3 or v_{av34}	1080 pc/h	(Equation 25-4 or 25-5)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		Yes	
If yes, v_{12A} = 1036		(Equation 25-8)	

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	1036	4600	No

Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\, v_R + 0.0078\, v_{12} - 0.00627\, L_A$ = 7.1 pc/mi/ln

Level of service for ramp-freeway junction areas of influence A

Speed Estimation

Intermediate speed variable,	M_S = 0.233	
Space mean speed in ramp influence area,	S_R = 59.7	mph
Space mean speed in outer lanes,	S_0 = 64.0	mph
Space mean speed for all vehicles,	S = 61.8	mph

HCS+: Ramps and Ramp Junctions Release 5.3

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: PM Peak
Freeway/Dir of Travel: H-2 Fwy NB On Ramp Loop
Junction: H-2 Fwy/Ka Uka Blvd
Jurisdiction:
Analysis Year: Year 2016 With Project
Description: (Analysis with NB On Ramp)

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	3354	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	35.0	mph
Volume on ramp	605	vph
Length of first accel/decel lane	1500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	453	vph
Position of adjacent Ramp	Downstream	
Type of adjacent Ramp	On	
Distance to adjacent Ramp	1700	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	3354		605		453	vph
Peak-hour factor, PHF	0.90		0.90		0.90	
Peak 15-min volume, v15	932		168		126	v
Trucks and buses	2		2		2	%
Recreational vehicles	0		0		0	%
Terrain type:	Rolling		Level		Level	
Grade		%		%		%
Length		mi		mi		mi
Trucks and buses PCE, ET	2.5		1.5		1.5	
Recreational vehicle PCE, ER	2.0		1.2		1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	3838	679	508	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 25-2 or 25-3)

P_{FM} = 0.133 Using Equation 4

$v_{12} = v_F (P_{FM})$ = 510 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	4517	9400	No

v_3 or v_{av34} 1664 pc/h (Equation 25-4 or 25-5)

Is v_3 or v_{av34} > 2700 pc/h? No

Is v_3 or v_{av34} > 1.5 v_{12}/2 Yes

If yes, v_{12A} = 1535 (Equation 25-8)

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	1535	4600	No

Level of Service Determination (if not F)

Density, $D = 5.475 + 0.00734 v_R + 0.0078 v_{12} - 0.00627 L_A$ = 13.0 pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

Speed Estimation

Intermediate speed variable,	M_S = 0.252		
Space mean speed in ramp influence area,	S_R = 59.2	mph	
Space mean speed in outer lanes,	S_0 = 62.7	mph	
Space mean speed for all vehicles,	S = 60.9	mph	

HCS+: Ramps and Ramp Junctions Release 5.3

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: AM Peak
Freeway/Dir of Travel: H-2 Fwy NB On Ramp
Junction: H-2 Fwy/Ka Uka Blvd
Jurisdiction:
Analysis Year: Year 2016 With Project
Description:

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	2629	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	35.0	mph
Volume on ramp	225	vph
Length of first accel/decel lane	700	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	364	vph
Position of adjacent Ramp	Upstream	
Type of adjacent Ramp	On	
Distance to adjacent Ramp	1700	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	2629	225	364	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	730	63	101	v
Trucks and buses	2	2	2	%
Recreational vehicles	0	0	0	%
Terrain type:	Rolling	Level	Level	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	2.5	1.5	1.5	
Recreational vehicle PCE, ER	2.0	1.2	1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	3009	253	408	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 25-2 or 25-3)

P_{FM} = 0.186 Using Equation 4

$v_{12} = v_F (P_{FM})$ = 560 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	3262	9400	No

v_3 or v_{av34} 1224 pc/h (Equation 25-4 or 25-5)

Is v_3 or v_{av34} > 2700 pc/h? No

Is v_3 or v_{av34} > 1.5 v_{12}/2 Yes

If yes, v_{12A} = 1203 (Equation 25-8)

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	1203	4600	No

Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\, v_R + 0.0078\, v_{12} - 0.00627\, L_A$ = 12.3 pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

Speed Estimation

Intermediate speed variable, M_S = 0.289

Space mean speed in ramp influence area, S_R = 58.4 mph

Space mean speed in outer lanes, S_0 = 63.5 mph

Space mean speed for all vehicles, S = 61.1 mph

HCS+: Ramps and Ramp Junctions Release 5.3

Phone: Fax:
E-mail:

Merge Analysis

Analyst:	
Agency/Co.:	
Date performed:	2/24/2009
Analysis time period:	PM Peak
Freeway/Dir of Travel:	H-2 Fwy NB On Ramp
Junction:	H-2 Fwy/Ka Uka Blvd
Jurisdiction:	
Analysis Year:	Year 2016 With Project
Description:	

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	3959	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	35.0	mph
Volume on ramp	453	vph
Length of first accel/decel lane	700	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	605	vph
Position of adjacent Ramp	Upstream	
Type of adjacent Ramp	On	
Distance to adjacent Ramp	1700	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	3959		453		605	vph
Peak-hour factor, PHF	0.90		0.90		0.90	
Peak 15-min volume, v15	1100		126		168	v
Trucks and buses	2		2		2	%
Recreational vehicles	0		0		0	%
Terrain type:	Rolling		Level		Level	
Grade		%		%		%
Length		mi		mi		mi
Trucks and buses PCE, ET	2.5		1.5		1.5	
Recreational vehicle PCE, ER	2.0		1.2		1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	4531	508	679	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 25-2 or 25-3)

P_{FM} = 0.154 Using Equation 4

$v_{12} = v_F (P_{FM})$ = 699 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	5039	9400	No
v_3 or v_{av34}	1916 pc/h	(Equation 25-4 or 25-5)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		Yes	
If yes, v_{12A} = 1812		(Equation 25-8)	

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	1812	4600	No

Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$ = 18.9 pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

Speed Estimation

Intermediate speed variable, M_S = 0.312

Space mean speed in ramp influence area, S_R = 57.8 mph

Space mean speed in outer lanes, S_0 = 61.9 mph

Space mean speed for all vehicles, S = 60.0 mph

HCS+: Ramps and Ramp Junctions Release 5.3

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: AM Peak
Freeway/Dir of Travel: H-2 Fwy SB Off-Ramp
Junction: H-2 Fwy/Ka Uka Blvd
Jurisdiction:
Analysis Year: Year 2016 With Project
Description:

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	4043	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	35.0	mph
Volume on ramp	510	vph
Length of first accel/decel lane	150	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent ramp	1484	vph
Position of adjacent ramp	Downstream	
Type of adjacent ramp	On	
Distance to adjacent ramp	1900	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	4043		510		1484	vph
Peak-hour factor, PHF	0.90		0.90		0.90	
Peak 15-min volume, v15	1123		142		412	v
Trucks and buses	2		2		2	%
Recreational vehicles	0		0		0	%
Terrain type:	Rolling		Level		Level	
Grade	0.00	%	0.00	%	0.00	%
Length	0.00	mi	0.00	mi	0.00	mi
Trucks and buses PCE, ET	2.5		1.5		1.5	
Recreational vehicle PCE, ER	2.0		1.2		1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	4627	572	1665	pcph

Estimation of V12 Diverge Areas

L_{EQ} = (Equation 25-8 or 25-9)

P_{FD} = 0.436 Using Equation 8

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 2340 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{Fi} = v_F$	4627	9400	No
$v_{FO} = v_F - v_R$	4055	9400	No
v_R	572	2000	No
v_3 or v_{av34}	1143 pc/h	(Equation 25-15 or 25-16)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		No	
If yes, v_{12A} = 2340		(Equation 25-18)	

Flow Entering Diverge Influence Area

	Actual	Max Desirable	Violation?
v_{12}	2340	4400	No

Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$ = 23.0 pc/mi/ln

Level of service for ramp-freeway junction areas of influence C

Speed Estimation

Intermediate speed variable, D_S = 0.479

Space mean speed in ramp influence area, S_R = 54.0 mph

Space mean speed in outer lanes, S_0 = 70.7 mph

Space mean speed for all vehicles, S = 61.1 mph

HCS+: Ramps and Ramp Junctions Release 5.3

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:	
Agency/Co.:	
Date performed:	2/24/2009
Analysis time period:	PM Peak
Freeway/Dir of Travel:	H-2 Fwy SB Off-Ramp
Junction:	H-2 Fwy/Ka Uka Blvd
Jurisdiction:	
Analysis Year:	Year 2016 With Project
Description:	

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	3091	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	35.0	mph
Volume on ramp	787	vph
Length of first accel/decel lane	150	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent ramp	1498	vph
Position of adjacent ramp	Downstream	
Type of adjacent ramp	On	
Distance to adjacent ramp	1900	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	3091		787		1498	vph
Peak-hour factor, PHF	0.90		0.90		0.90	
Peak 15-min volume, v15	859		219		416	v
Trucks and buses	2		2		2	%
Recreational vehicles	0		0		0	%
Terrain type:	Rolling		Level		Level	
Grade	0.00	%	0.00	%	0.00	%
Length	0.00	mi	0.00	mi	0.00	mi
Trucks and buses PCE, ET	2.5		1.5		1.5	
Recreational vehicle PCE, ER	2.0		1.2		1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	3537	883	1681	pcph

Estimation of V12 Diverge Areas

L_{EQ} = (Equation 25-8 or 25-9)

P_{FD} = 0.436 Using Equation 8

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 2040 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{Fi} = v_F$	3537	9400	No
$v_{FO} = v_F - v_R$	2654	9400	No
v_R	883	2000	No
v_3 or v_{av34}	748 pc/h	(Equation 25-15 or 25-16)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		No	
If yes, v_{12A} = 2040		(Equation 25-18)	

Flow Entering Diverge Influence Area

	Actual	Max Desirable	Violation?
v_{12}	2040	4400	No

Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\, v_{12} - 0.009\, L_D$ = 20.4 pc/mi/ln

Level of service for ramp-freeway junction areas of influence C

Speed Estimation

Intermediate speed variable, D_S = 0.507

Space mean speed in ramp influence area, S_R = 53.3 mph

Space mean speed in outer lanes, S_0 = 71.3 mph

Space mean speed for all vehicles, S = 59.7 mph

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Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: AM Peak
Freeway/Dir of Travel: H-2 Fwy SB On Ramp Loop
Junction: H-2 Fwy/Ka Uka Blvd
Jurisdiction:
Analysis Year: Year 2016 With Project
Description: (Analysis with SB Off-Ramp)

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	3533	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	35.0	mph
Volume on ramp	1484	vph
Length of first accel/decel lane	650	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	510	vph
Position of adjacent Ramp	Upstream	
Type of adjacent Ramp	Off	
Distance to adjacent Ramp	1900	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	3533	1484	510	vph
Peak-hour factor, PHF	0.90	0.90	0.90	
Peak 15-min volume, v15	981	412	142	v
Trucks and buses	2	2	2	%
Recreational vehicles	0	0	0	%
Terrain type:	Rolling	Level	Level	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	2.5	1.5	1.5	
Recreational vehicle PCE, ER	2.0	1.2	1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	4043	1665	572	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 25-2 or 25-3)

P_{FM} = 0.010 Using Equation 4

$v_{12} = v_F (P_{FM})$ = 39 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	5708	9400	No
v_3 or v_{av34}	2002 pc/h	(Equation 25-4 or 25-5)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		Yes	
If yes, v_{12A} = 1617		(Equation 25-8)	

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	1617	4600	No

Level of Service Determination (if not F)

Density, $D = 5.475 + 0.00734 v_R + 0.0078 v_{12} - 0.00627 L_A$ = 26.2 pc/mi/ln

Level of service for ramp-freeway junction areas of influence C

Speed Estimation

Intermediate speed variable,	M_S = 0.379	
Space mean speed in ramp influence area,	S_R = 56.3	mph
Space mean speed in outer lanes,	S_0 = 62.4	mph
Space mean speed for all vehicles,	S = 58.7	mph

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Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: PM Peak
Freeway/Dir of Travel: H-2 Fwy SB On Ramp Loop
Junction: H-2 Fwy/Ka Uka Blvd
Jurisdiction:
Analysis Year: Year 2016 With Project
Description: (Analysis with SB Off-Ramp)

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	2398	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	35.0	mph
Volume on ramp	1498	vph
Length of first accel/decel lane	650	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	787	vph
Position of adjacent Ramp	Upstream	
Type of adjacent Ramp	Off	
Distance to adjacent Ramp	1900	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	2398		1498		787	vph
Peak-hour factor, PHF	0.90		0.90		0.90	
Peak 15-min volume, v15	666		416		219	v
Trucks and buses	2		2		2	%
Recreational vehicles	0		0		0	%
Terrain type:	Rolling		Level		Level	
Grade		%		%		%
Length		mi		mi		mi
Trucks and buses PCE, ET	2.5		1.5		1.5	
Recreational vehicle PCE, ER	2.0		1.2		1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	2744	1681	883	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 25-2 or 25-3)

P_{FM} = 0.008 Using Equation 4

$v_{12} = v_F (P_{FM})$ = 21 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	4425	9400	No
v_3 or v_{av34}	1361 pc/h	(Equation 25-4 or 25-5)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		Yes	
If yes, v_{12A} = 1097		(Equation 25-8)	

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	1097	4600	No

Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\, v_R + 0.0078\, v_{12} - 0.00627\, L_A$ = 22.3 pc/mi/ln

Level of service for ramp-freeway junction areas of influence C

Speed Estimation

Intermediate speed variable, M_S = 0.338

Space mean speed in ramp influence area, S_R = 57.2 mph

Space mean speed in outer lanes, S_0 = 63.8 mph

Space mean speed for all vehicles, S = 59.5 mph

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Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: AM Peak
Freeway/Dir of Travel: H-2 Fwy SB On Ramp Loop
Junction: H-2 Fwy/Ka Uka Blvd
Jurisdiction:
Analysis Year: Year 2016 With Project
Description: (Analysis with SB On-Ramp)

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	3533	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	35.0	mph
Volume on ramp	1484	vph
Length of first accel/decel lane	650	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	1390	vph
Position of adjacent Ramp	Downstream	
Type of adjacent Ramp	On	
Distance to adjacent Ramp	1600	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	3533		1484		1390	vph
Peak-hour factor, PHF	0.90		0.90		0.90	
Peak 15-min volume, v15	981		412		386	v
Trucks and buses	2		2		2	%
Recreational vehicles	0		0		0	%
Terrain type:	Rolling		Level		Level	
Grade		%		%		%
Length		mi		mi		mi
Trucks and buses PCE, ET	2.5		1.5		1.5	
Recreational vehicle PCE, ER	2.0		1.2		1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	4043	1665	1560	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 25-2 or 25-3)

P_{FM} = 0.010 Using Equation 4

$v_{12} = v_F (P_{FM})$ = 39 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	5708	9400	No
v_3 or v_{av34}	2002 pc/h	(Equation 25-4 or 25-5)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		Yes	
If yes, v_{12A} = 1617		(Equation 25-8)	

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	1617	4600	No

Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\, v_R + 0.0078\, v_{12} - 0.00627\, L_A$ = 26.2 pc/mi/ln

Level of service for ramp-freeway junction areas of influence C

Speed Estimation

Intermediate speed variable,	M_S = 0.379	
Space mean speed in ramp influence area,	S_R = 56.3	mph
Space mean speed in outer lanes,	S_0 = 62.4	mph
Space mean speed for all vehicles,	S = 58.7	mph

HCS+: Ramps and Ramp Junctions Release 5.3

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: PM Peak
Freeway/Dir of Travel: H-2 Fwy SB On Ramp Loop
Junction: H-2 Fwy/Ka Uka Blvd
Jurisdiction:
Analysis Year: Year 2016 With Project
Description: (Analysis with SB On-Ramp)

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	2398	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	35.0	mph
Volume on ramp	1498	vph
Length of first accel/decel lane	650	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	1299	vph
Position of adjacent Ramp	Downstream	
Type of adjacent Ramp	On	
Distance to adjacent Ramp	1600	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	2398		1498		1299	vph
Peak-hour factor, PHF	0.90		0.90		0.90	
Peak 15-min volume, v15	666		416		361	v
Trucks and buses	2		2		2	%
Recreational vehicles	0		0		0	%
Terrain type:	Rolling		Level		Level	
Grade		%		%		%
Length		mi		mi		mi
Trucks and buses PCE, ET	2.5		1.5		1.5	
Recreational vehicle PCE, ER	2.0		1.2		1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	2744	1681	1458	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 25-2 or 25-3)

P_{FM} = 0.008 Using Equation 4

$v_{12} = v_F (P_{FM})$ = 21 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	4425	9400	No
v_3 or v_{av34}	1361 pc/h	(Equation 25-4 or 25-5)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		Yes	
If yes, v_{12A} = 1097		(Equation 25-8)	

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	1097	4600	No

Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\, v_R + 0.0078\, v_{12} - 0.00627\, L_A$ = 22.3 pc/mi/ln

Level of service for ramp-freeway junction areas of influence C

Speed Estimation

Intermediate speed variable, M_S = 0.338

Space mean speed in ramp influence area, S_R = 57.2 mph

Space mean speed in outer lanes, S_0 = 63.8 mph

Space mean speed for all vehicles, S = 59.5 mph

HCS+: Ramps and Ramp Junctions Release 5.3

Phone: Fax:
E-mail:

Merge Analysis

Analyst:	
Agency/Co.:	
Date performed:	2/24/2009
Analysis time period:	AM Peak
Freeway/Dir of Travel:	H-2 Fwy SB On Ramp
Junction:	H-2 Fwy/Ka Uka Blvd
Jurisdiction:	
Analysis Year:	Year 2016 With Project
Description:	

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	5017	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	35.0	mph
Volume on ramp	1390	vph
Length of first accel/decel lane	820	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	1484	vph
Position of adjacent Ramp	Upstream	
Type of adjacent Ramp	On	
Distance to adjacent Ramp	1600	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	5017		1390		1484	vph
Peak-hour factor, PHF	0.90		0.90		0.90	
Peak 15-min volume, v15	1394		386		412	v
Trucks and buses	2		2		2	%
Recreational vehicles	0		0		0	%
Terrain type:	Rolling		Level		Level	
Grade		%		%		%
Length		mi		mi		mi
Trucks and buses PCE, ET	2.5		1.5		1.5	
Recreational vehicle PCE, ER	2.0		1.2		1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	5742	1560	1665	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 25-2 or 25-3)

P_{FM} = 0.023 Using Equation 4

$v_{12} = v_F (P_{FM})$ = 131 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	7302	9400	No
v_3 or v_{av34}	2805 pc/h	(Equation 25-4 or 25-5)	
Is v_3 or v_{av34} > 2700 pc/h?		Yes	
Is v_3 or v_{av34} > 1.5 v_{12}/2		Yes	
If yes, v_{12A} = 2296		(Equation 25-8)	

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	2296	4600	No

Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734 v_R + 0.0078 v_{12} - 0.00627 L_A$ = 29.7 pc/mi/ln

Level of service for ramp-freeway junction areas of influence D

Speed Estimation

Intermediate speed variable,	M_S = 0.448	
Space mean speed in ramp influence area,	S_R = 54.7	mph
Space mean speed in outer lanes,	S_0 = 60.6	mph
Space mean speed for all vehicles,	S = 57.3	mph

HCS+: Ramps and Ramp Junctions Release 5.3

Phone: Fax:
E-mail:

Merge Analysis

Analyst:	
Agency/Co.:	
Date performed:	2/24/2009
Analysis time period:	PM Peak
Freeway/Dir of Travel:	H-2 Fwy SB On Ramp
Junction:	H-2 Fwy/Ka Uka Blvd
Jurisdiction:	
Analysis Year:	Year 2016 With Project
Description:	

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	3896	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	35.0	mph
Volume on ramp	1299	vph
Length of first accel/decel lane	820	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	1498	vph
Position of adjacent Ramp	Upstream	
Type of adjacent Ramp	On	
Distance to adjacent Ramp	1600	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	3896		1299		1498	vph
Peak-hour factor, PHF	0.90		0.90		0.90	
Peak 15-min volume, v15	1082		361		416	v
Trucks and buses	2		2		2	%
Recreational vehicles	0		0		0	%
Terrain type:	Rolling		Level		Level	
Grade		%		%		%
Length		mi		mi		mi
Trucks and buses PCE, ET	2.5		1.5		1.5	
Recreational vehicle PCE, ER	2.0		1.2		1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	4459	1458	1681	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 25-2 or 25-3)

P_{FM} = 0.036 Using Equation 4

$v_{12} = v_F\ (P_{FM})$ = 159 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	5917	9400	No
v_3 or v_{av34}	2150 pc/h	(Equation 25-4 or 25-5)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		Yes	
If yes, v_{12A} = 1783		(Equation 25-8)	

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	1783	4600	No

Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$ = 24.9 pc/mi/ln

Level of service for ramp-freeway junction areas of influence C

Speed Estimation

Intermediate speed variable,	M_S = 0.363	
Space mean speed in ramp influence area,	S_R = 56.6	mph
Space mean speed in outer lanes,	S_0 = 62.0	mph
Space mean speed for all vehicles,	S = 58.9	mph

Intersection: 22: H-2 (N) & H-2 NB Off Ramp

Movement	NB	NB	NB
Directions Served	T	TR	R
Maximum Queue (ft)	505	578	523
Average Queue (ft)	233	317	126
95th Queue (ft)	576	696	448
Link Distance (ft)	856	856	856
Upstream Blk Time (%)			
Queuing Penalty (veh)			
Storage Bay Dist (ft)			
Storage Blk Time (%)			
Queuing Penalty (veh)			

HCS+: Basic Freeway Segments Release 5.3

Phone: Fax:
E-mail:

Operational Analysis

Analyst:
Agency or Company:
Date Performed: 2/26/2009
Analysis Time Period: AM Peak
Freeway/Direction: H-2 Fwy NB
From/To:
Jurisdiction:
Analysis Year: Year 2016 With Project
Description: South of Ka Uka Blvd

Flow Inputs and Adjustments

Volume, V	3832	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1064	v
Trucks and buses	2	%
Recreational vehicles	0	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.0	
Heavy vehicle adjustment, fHV	0.971	
Driver population factor, fp,	1.00	
Flow rate, vp	1096	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	4	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	1.5	mi/h
Free-flow speed, FFS	68.5	mi/h
	Urban Freeway	

LOS and Performance Measures

Flow rate, vp	1096	pc/h/ln
Free-flow speed, FFS	68.5	mi/h
Average passenger-car speed, S	68.5	mi/h
Number of lanes, N	4	
Density, D	16.0	pc/mi/ln
Level of service, LOS	B	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Basic Freeway Segments Release 5.3

Phone: Fax:
E-mail:

Operational Analysis

Analyst:
Agency or Company:
Date Performed: 2/26/2009
Analysis Time Period: PM Peak
Freeway/Direction: H-2 Fwy NB
From/To:
Jurisdiction:
Analysis Year: Year 2016 With Project
Description: South of Ka Uka Blvd

Flow Inputs and Adjustments

Volume, V	7327	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	2035	v
Trucks and buses	2	%
Recreational vehicles	0	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.0	
Heavy vehicle adjustment, fHV	0.971	
Driver population factor, fp	1.00	
Flow rate, vp	2096	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	4	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	1.5	mi/h
Free-flow speed, FFS	68.5	mi/h
	Urban Freeway	

LOS and Performance Measures

Flow rate, vp	2096	pc/h/ln
Free-flow speed, FFS	68.5	mi/h
Average passenger-car speed, S	61.9	mi/h
Number of lanes, N	4	
Density, D	33.9	pc/mi/ln
Level of service, LOS	D	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Basic Freeway Segments Release 5.3

Phone: Fax:
E-mail:

Operational Analysis

Analyst:
Agency or Company:
Date Performed: 2/26/2009
Analysis Time Period: AM Peak
Freeway/Direction: H-2 Fwy NB
From/To:
Jurisdiction:
Analysis Year: Year 2016 With Project
Description: North of Ka Uka Blvd

Flow Inputs and Adjustments

Volume, V	2854	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	793	v
Trucks and buses	2	%
Recreational vehicles	0	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.0	
Heavy vehicle adjustment, fHV	0.971	
Driver population factor, fp,	1.00	
Flow rate, vp	817	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	4	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	1.5	mi/h
Free-flow speed, FFS	68.5	mi/h
	Urban Freeway	

LOS and Performance Measures

Flow rate, vp	817	pc/h/ln
Free-flow speed, FFS	68.5	mi/h
Average passenger-car speed, S	68.5	mi/h
Number of lanes, N	4	
Density, D	11.9	pc/mi/ln
Level of service, LOS	B	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Basic Freeway Segments Release 5.3

Phone: Fax:
E-mail:

Operational Analysis

Analyst:
Agency or Company:
Date Performed: 2/26/2009
Analysis Time Period: PM Peak
Freeway/Direction: H-2 Fwy NB
From/To:
Jurisdiction:
Analysis Year: Year 2016 With Project
Description: North of Ka Uka Blvd

Flow Inputs and Adjustments

Volume, V	4412	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1226	v
Trucks and buses	2	%
Recreational vehicles	0	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.0	
Heavy vehicle adjustment, fHV	0.971	
Driver population factor, fp,	1.00	
Flow rate, vp	1262	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	4	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	1.5	mi/h
Free-flow speed, FFS	68.5	mi/h
	Urban Freeway	

LOS and Performance Measures

Flow rate, vp	1262	pc/h/ln
Free-flow speed, FFS	68.5	mi/h
Average passenger-car speed, S	68.5	mi/h
Number of lanes, N	4	
Density, D	18.4	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Basic Freeway Segments Release 5.3

Phone: Fax:
E-mail:

Operational Analysis

Analyst:
Agency or Company:
Date Performed: 2/26/2009
Analysis Time Period: AM Peak
Freeway/Direction: H-2 Fwy SB
From/To:
Jurisdiction:
Analysis Year: Year 2016 With Project
Description: North of Ka Uka Blvd

Flow Inputs and Adjustments

Volume, V	4043	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1123	v
Trucks and buses	2	%
Recreational vehicles	0	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.0	
Heavy vehicle adjustment, fHV	0.971	
Driver population factor, fp,	1.00	
Flow rate, vp	1157	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	4	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	1.5	mi/h
Free-flow speed, FFS	68.5	mi/h
	Urban Freeway	

LOS and Performance Measures

Flow rate, vp	1157	pc/h/ln
Free-flow speed, FFS	68.5	mi/h
Average passenger-car speed, S	68.5	mi/h
Number of lanes, N	4	
Density, D	16.9	pc/mi/ln
Level of service, LOS	B	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Basic Freeway Segments Release 5.3

Phone: Fax:
E-mail:

Operational Analysis

Analyst:
Agency or Company:
Date Performed: 2/26/2009
Analysis Time Period: PM Peak
Freeway/Direction: H-2 Fwy SB
From/To:
Jurisdiction:
Analysis Year: Year 2016 With Project
Description: North of Ka Uka Blvd

Flow Inputs and Adjustments

Volume, V	3185	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	885	v
Trucks and buses	2	%
Recreational vehicles	0	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.0	
Heavy vehicle adjustment, fHV	0.971	
Driver population factor, fp,	1.00	
Flow rate, vp	911	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	4	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	1.5	mi/h
Free-flow speed, FFS	68.5	mi/h
	Urban Freeway	

LOS and Performance Measures

Flow rate, vp	911	pc/h/ln
Free-flow speed, FFS	68.5	mi/h
Average passenger-car speed, S	68.5	mi/h
Number of lanes, N	4	
Density, D	13.3	pc/mi/ln
Level of service, LOS	B	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Basic Freeway Segments Release 5.3

Phone: Fax:
E-mail:

Operational Analysis

Analyst:	
Agency or Company:	
Date Performed:	2/26/2009
Analysis Time Period:	AM Peak
Freeway/Direction:	H-2 Fwy SB
From/To:	
Jurisdiction:	
Analysis Year:	Year 2016 With Project
Description:	South of Ka Uka Blvd

Flow Inputs and Adjustments

Volume, V	6407	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1780	v
Trucks and buses	2	%
Recreational vehicles	0	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.0	
Heavy vehicle adjustment, fHV	0.971	
Driver population factor, fp	1.00	
Flow rate, vp	1833	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	4	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	1.5	mi/h
Free-flow speed, FFS	68.5	mi/h
	Urban Freeway	

LOS and Performance Measures

Flow rate, vp	1833	pc/h/ln
Free-flow speed, FFS	68.5	mi/h
Average passenger-car speed, S	66.3	mi/h
Number of lanes, N	4	
Density, D	27.6	pc/mi/ln
Level of service, LOS	D	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Basic Freeway Segments Release 5.3

Phone: Fax:
E-mail:

Operational Analysis

Analyst:	
Agency or Company:	
Date Performed:	2/26/2009
Analysis Time Period:	PM Peak
Freeway/Direction:	H-2 Fwy SB
From/To:	
Jurisdiction:	
Analysis Year:	Year 2016 With Project
Description:	South of Ka Uka Blvd

Flow Inputs and Adjustments

Volume, V	5195	veh/h
Peak-hour factor, PHF	0.90	
Peak 15-min volume, v15	1443	v
Trucks and buses	2	%
Recreational vehicles	0	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.0	
Heavy vehicle adjustment, fHV	0.971	
Driver population factor, fp,	1.00	
Flow rate, vp	1486	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	4	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	1.5	mi/h
Free-flow speed, FFS	68.5	mi/h
	Urban Freeway	

LOS and Performance Measures

Flow rate, vp	1486	pc/h/ln
Free-flow speed, FFS	68.5	mi/h
Average passenger-car speed, S	68.4	mi/h
Number of lanes, N	4	
Density, D	21.7	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

APPENDIX H

CAPACITY ANALYSIS CALCULATIONS
PROJECTED YEAR 2025 PEAK HOUR TRAFFIC
ANALYSIS WITH PROJECT

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↑↑			↑↑↑↑		↖↖	↰			✥	
Volume (vph)	0	279	0	0	2892	31	862	25	0	0	0	8
Ideal Flow (vphpl)	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
Total Lost time (s)		5.0			5.0		5.0	5.0			5.0	
Lane Util. Factor		0.95			0.86		0.91	0.91			1.00	
Frt		1.00			1.00		1.00	1.00			0.86	
Flt Protected		1.00			1.00		0.95	0.96			1.00	
Satd. Flow (prot)		3725			6734		3390	1706			1696	
Flt Permitted		1.00			1.00		0.95	0.96			1.00	
Satd. Flow (perm)		3725			6734		3390	1706			1696	
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	0	279	0	0	2892	31	862	25	0	0	0	8
RTOR Reduction (vph)	0	0	0	0	1	0	0	0	0	0	4	0
Lane Group Flow (vph)	0	279	0	0	2922	0	595	292	0	0	4	0
Turn Type							Split			Split		
Protected Phases		4			8		2	2		6	6	
Permitted Phases												
Actuated Green, G (s)		58.3			58.3		23.3	23.3			1.2	
Effective Green, g (s)		58.3			58.3		23.3	23.3			1.2	
Actuated g/C Ratio		0.60			0.60		0.24	0.24			0.01	
Clearance Time (s)		5.0			5.0		5.0	5.0			5.0	
Vehicle Extension (s)		3.0			3.0		3.0	3.0			3.0	
Lane Grp Cap (vph)		2221			4014		808	406			21	
v/s Ratio Prot		0.07			c0.43		c0.18	0.17			c0.00	
v/s Ratio Perm												
v/c Ratio		0.13			0.73		0.74	0.72			0.19	
Uniform Delay, d1		8.6			14.1		34.4	34.2			47.8	
Progression Factor		1.00			1.00		1.00	1.00			1.00	
Incremental Delay, d2		0.0			0.7		3.5	6.0			4.4	
Delay (s)		8.6			14.8		37.9	40.2			52.3	
Level of Service		A			B		D	D			D	
Approach Delay (s)		8.6			14.8			38.7			52.3	
Approach LOS		A			B			D			D	

Intersection Summary			
HCM Average Control Delay	19.6	HCM Level of Service	B
HCM Volume to Capacity ratio	0.72		
Actuated Cycle Length (s)	97.8	Sum of lost time (s)	15.0
Intersection Capacity Utilization	70.9%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

	↗	→	↘	↙	←	↖	↖	↑	↗	↘	↓	↙
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↑↑			↑↑↑↱		↰↰	↰			↲↱	
Volume (vph)	0	822	0	0	2642	53	1843	23	0	0	0	80
Ideal Flow (vphpl)	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
Total Lost time (s)		5.0			5.0		5.0	5.0			5.0	
Lane Util. Factor		0.95			0.86		0.91	0.91			1.00	
Frt		1.00			1.00		1.00	1.00			0.86	
Flt Protected		1.00			1.00		0.95	0.95			1.00	
Satd. Flow (prot)		3725			6725		3390	1702			1696	
Flt Permitted		1.00			1.00		0.95	0.95			1.00	
Satd. Flow (perm)		3725			6725		3390	1702			1696	
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	0	822	0	0	2642	53	1843	23	0	0	0	80
RTOR Reduction (vph)	0	0	0	0	2	0	0	0	0	0	19	0
Lane Group Flow (vph)	0	822	0	0	2693	0	1235	631	0	0	61	0
Turn Type							Split			Split		
Protected Phases		4			8		2	2		6	6	
Permitted Phases												
Actuated Green, G (s)		44.2			44.2		44.2	44.2			8.1	
Effective Green, g (s)		44.2			44.2		44.2	44.2			8.1	
Actuated g/C Ratio		0.40			0.40		0.40	0.40			0.07	
Clearance Time (s)		5.0			5.0		5.0	5.0			5.0	
Vehicle Extension (s)		3.0			3.0		3.0	3.0			3.0	
Lane Grp Cap (vph)		1477			2666		1344	675			123	
v/s Ratio Prot		0.22			c0.40		0.36	c0.37			c0.04	
v/s Ratio Perm												
v/c Ratio		0.56			1.01		0.92	0.93			0.50	
Uniform Delay, d1		26.1			33.6		31.9	32.3			49.7	
Progression Factor		1.00			1.00		1.00	1.00			1.00	
Incremental Delay, d2		0.5			20.0		10.2	20.1			3.2	
Delay (s)		26.5			53.6		42.1	52.4			52.9	
Level of Service		C			D		D	D			D	
Approach Delay (s)		26.5			53.6			45.6			52.9	
Approach LOS		C			D			D			D	

Intersection Summary			
HCM Average Control Delay	46.8	HCM Level of Service	D
HCM Volume to Capacity ratio	0.93		
Actuated Cycle Length (s)	111.5	Sum of lost time (s)	15.0
Intersection Capacity Utilization	85.5%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↑↑↱		↰↰	↑↑		↰		↱	↰	↑	↱
Volume (vph)	0	1466	55	245	891	0	28	0	442	147	158	245
Ideal Flow (vphpl)	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
Total Lost time (s)		5.0		5.0	5.0		5.0		5.0	5.0	5.0	5.0
Lane Util. Factor		0.95		0.97	0.95		1.00		1.00	1.00	1.00	1.00
Frt		0.99		1.00	1.00		1.00		0.85	1.00	1.00	0.85
Flt Protected		1.00		0.95	1.00		0.95		1.00	0.95	1.00	1.00
Satd. Flow (prot)		3705		3614	3725		1863		1667	1863	1961	1667
Flt Permitted		1.00		0.95	1.00		0.95		1.00	0.95	1.00	1.00
Satd. Flow (perm)		3705		3614	3725		1863		1667	1863	1961	1667
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	0	1466	55	245	891	0	28	0	442	147	158	245
RTOR Reduction (vph)	0	2	0	0	0	0	0	0	0	0	0	0
Lane Group Flow (vph)	0	1519	0	245	891	0	28	0	442	147	158	245
Turn Type				Prot			Prot		Free	Prot		Free
Protected Phases		4		3	8		5			1	6	
Permitted Phases									Free			Free
Actuated Green, G (s)		48.0		11.6	64.6		3.0		96.3	21.7	13.7	96.3
Effective Green, g (s)		48.0		11.6	64.6		3.0		96.3	21.7	13.7	96.3
Actuated g/C Ratio		0.50		0.12	0.67		0.03		1.00	0.23	0.14	1.00
Clearance Time (s)		5.0		5.0	5.0		5.0			5.0	5.0	
Vehicle Extension (s)		3.0		3.0	3.0		3.0			3.0	3.0	
Lane Grp Cap (vph)		1847		435	2499		58		1667	420	279	1667
v/s Ratio Prot		c0.41		c0.07	0.24		0.02			0.08	c0.08	
v/s Ratio Perm									c0.27			0.15
v/c Ratio		0.82		0.56	0.36		0.48		0.27	0.35	0.57	0.15
Uniform Delay, d1		20.5		40.0	6.9		45.9		0.0	31.4	38.5	0.0
Progression Factor		1.00		1.00	1.00		1.00		1.00	1.00	1.00	1.00
Incremental Delay, d2		3.1		1.7	0.1		6.2		0.4	0.5	2.6	0.2
Delay (s)		23.6		41.6	6.9		52.1		0.4	31.9	41.2	0.2
Level of Service		C		D	A		D		A	C	D	A
Approach Delay (s)		23.6			14.4			3.5			20.4	
Approach LOS		C			B			A			C	

Intersection Summary			
HCM Average Control Delay	17.7	HCM Level of Service	B
HCM Volume to Capacity ratio	0.69		
Actuated Cycle Length (s)	96.3	Sum of lost time (s)	15.0
Intersection Capacity Utilization	73.9%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	1582	79	374	1695	0	84	0	707	440	192	282
Ideal Flow (vphpl)	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
Total Lost time (s)		5.0		5.0	5.0		5.0		5.0	5.0	5.0	5.0
Lane Util. Factor		0.95		0.97	0.95		1.00		1.00	1.00	1.00	1.00
Frt		0.99		1.00	1.00		1.00		0.85	1.00	1.00	0.85
Flt Protected		1.00		0.95	1.00		0.95		1.00	0.95	1.00	1.00
Satd. Flow (prot)		3699		3614	3725		1863		1667	1863	1961	1667
Flt Permitted		1.00		0.95	1.00		0.95		1.00	0.95	1.00	1.00
Satd. Flow (perm)		3699		3614	3725		1863		1667	1863	1961	1667
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	0	1582	79	374	1695	0	84	0	707	440	192	282
RTOR Reduction (vph)	0	3	0	0	0	0	0	0	0	0	0	0
Lane Group Flow (vph)	0	1658	0	374	1695	0	84	0	707	440	192	282
Turn Type				Prot			Prot		Free	Prot		Free
Protected Phases		4		3	8		5			1	6	
Permitted Phases									Free			Free
Actuated Green, G (s)		50.3		15.4	70.7		8.9		112.4	31.7	17.8	112.4
Effective Green, g (s)		50.3		15.4	70.7		8.9		112.4	31.7	17.8	112.4
Actuated g/C Ratio		0.45		0.14	0.63		0.08		1.00	0.28	0.16	1.00
Clearance Time (s)		5.0		5.0	5.0		5.0			5.0	5.0	
Vehicle Extension (s)		3.0		3.0	3.0		3.0			3.0	3.0	
Lane Grp Cap (vph)		1655		495	2343		148		1667	525	311	1667
v/s Ratio Prot		c0.45		0.10	c0.45		0.05			c0.24	0.10	
v/s Ratio Perm									0.42			0.17
v/c Ratio		1.00		0.76	0.72		0.57		0.42	0.84	0.62	0.17
Uniform Delay, d1		31.1		46.7	14.2		49.9		0.0	37.9	44.1	0.0
Progression Factor		1.00		1.00	1.00		1.00		1.00	1.00	1.00	1.00
Incremental Delay, d2		22.6		6.5	1.1		4.9		0.8	11.2	3.6	0.2
Delay (s)		53.6		53.2	15.3		54.8		0.8	49.1	47.7	0.2
Level of Service		D		D	B		D		A	D	D	A
Approach Delay (s)		53.6			22.2			6.5			33.8	
Approach LOS		D			C			A			C	

Intersection Summary			
HCM Average Control Delay	31.5	HCM Level of Service	C
HCM Volume to Capacity ratio	0.92		
Actuated Cycle Length (s)	112.4	Sum of lost time (s)	15.0
Intersection Capacity Utilization	89.7%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lane Configurations												
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ideal Flow (vphpl)	2000	2000	2000	2000	2000	2000	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	6.0		6.0	6.0	4.0			5.0	5.0	5.0	
Lane Util. Factor	1.00	0.95		1.00	0.95	1.00			1.00	0.97	1.00	
Frt	1.00	0.99		1.00	1.00	0.85			0.86	1.00	0.85	
Flt Protected	0.95	1.00		0.95	1.00	1.00			1.00	0.95	1.00	
Satd. Flow (prot)	1863	3689		1863	3725	1667			1611	3433	1583	
Flt Permitted	0.95	1.00		0.95	1.00	1.00			1.00	0.95	1.00	
Satd. Flow (perm)	1863	3689		1863	3725	1667			1611	3433	1583	
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	15	1046	73	90	780	289	0	0	32	445	0	23
RTOR Reduction (vph)	0	4	0	0	0	0	0	0	0	0	18	0
Lane Group Flow (vph)	15	1115	0	90	780	289	0	0	32	445	5	0
Turn Type	Prot			Prot		Free			Free	Prot		
Protected Phases	7	4		3	8					1	6	
Permitted Phases						Free			Free			
Actuated Green, G (s)	1.1	32.8		7.4	39.1	71.0			71.0	15.8	15.8	
Effective Green, g (s)	1.1	31.8		6.4	38.1	71.0			71.0	15.8	15.8	
Actuated g/C Ratio	0.02	0.45		0.09	0.54	1.00			1.00	0.22	0.22	
Clearance Time (s)	5.0	5.0		5.0	5.0					5.0	5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0					3.0	3.0	
Lane Grp Cap (vph)	29	1652		168	1999	1667			1611	764	352	
v/s Ratio Prot	0.01	c0.30		c0.05	0.21					c0.13	0.00	
v/s Ratio Perm						0.17			0.02			
v/c Ratio	0.52	0.67		0.54	0.39	0.17			0.02	0.58	0.01	
Uniform Delay, d1	34.7	15.5		30.9	9.6	0.0			0.0	24.7	21.5	
Progression Factor	1.00	1.00		1.00	1.00	1.00			1.00	1.00	1.00	
Incremental Delay, d2	14.7	1.1		3.3	0.1	0.2			0.0	1.1	0.0	
Delay (s)	49.4	16.6		34.1	9.8	0.2			0.0	25.8	21.5	
Level of Service	D	B		C	A	A			A	C	C	
Approach Delay (s)		17.0			9.3			0.0			25.6	
Approach LOS		B			A			A			C	

Intersection Summary			
HCM Average Control Delay	15.1	HCM Level of Service	B
HCM Volume to Capacity ratio	0.63		
Actuated Cycle Length (s)	71.0	Sum of lost time (s)	17.0
Intersection Capacity Utilization	61.3%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↰	↑↑↱		↰	↑↑	↱			↱	↰↰	↑↱	
Volume (vph)	28	901	140	107	1274	677	0	0	170	582	0	24
Ideal Flow (vphpl)	2000	2000	2000	2000	2000	2000	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	6.0		6.0	6.0	4.0			5.0	5.0	5.0	
Lane Util. Factor	1.00	0.95		1.00	0.95	1.00			1.00	0.97	1.00	
Frt	1.00	0.98		1.00	1.00	0.85			0.86	1.00	0.85	
Flt Protected	0.95	1.00		0.95	1.00	1.00			1.00	0.95	1.00	
Satd. Flow (prot)	1863	3650		1863	3725	1667			1611	3433	1583	
Flt Permitted	0.95	1.00		0.95	1.00	1.00			1.00	0.95	1.00	
Satd. Flow (perm)	1863	3650		1863	3725	1667			1611	3433	1583	
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	28	901	140	107	1274	677	0	0	170	582	0	24
RTOR Reduction (vph)	0	10	0	0	0	0	0	0	0	0	18	0
Lane Group Flow (vph)	28	1031	0	107	1274	677	0	0	170	582	6	0
Turn Type	Prot			Prot		Free			Free	Prot		
Protected Phases	7	4		3	8					1	6	
Permitted Phases						Free			Free			
Actuated Green, G (s)	2.2	33.3		8.3	39.4	76.4			76.4	19.8	19.8	
Effective Green, g (s)	2.2	32.3		7.3	38.4	76.4			76.4	19.8	19.8	
Actuated g/C Ratio	0.03	0.42		0.10	0.50	1.00			1.00	0.26	0.26	
Clearance Time (s)	5.0	5.0		5.0	5.0					5.0	5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0					3.0	3.0	
Lane Grp Cap (vph)	54	1543		178	1872	1667			1611	890	410	
v/s Ratio Prot	0.02	0.28		0.06	c0.34					c0.17	0.00	
v/s Ratio Perm						c0.41			0.11			
v/c Ratio	0.52	0.67		0.60	0.68	0.41			0.11	0.65	0.02	
Uniform Delay, d1	36.5	17.7		33.2	14.4	0.0			0.0	25.2	21.0	
Progression Factor	1.00	1.00		1.00	1.00	1.00			1.00	1.00	1.00	
Incremental Delay, d2	8.2	1.1		5.6	1.0	0.7			0.1	1.7	0.0	
Delay (s)	44.7	18.8		38.8	15.4	0.7			0.1	27.0	21.1	
Level of Service	D	B		D	B	A			A	C	C	
Approach Delay (s)		19.5			11.8			0.1			26.7	
Approach LOS		B			B			A			C	

Intersection Summary			
HCM Average Control Delay	15.7	HCM Level of Service	B
HCM Volume to Capacity ratio	0.59		
Actuated Cycle Length (s)	76.4	Sum of lost time (s)	5.0
Intersection Capacity Utilization	66.7%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↰↑↱			↰↑↱		↰	↑↑↱		↰	↑↑↱	
Volume (vph)	15	3	2	41	15	23	8	[illegible]	[illegible]	[illegible]	[illegible]	81
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	2000	2000	2000	2000	2000	2000
Total Lost time (s)		5.0			5.0		5.0	5.0		5.0	5.0	
Lane Util. Factor		1.00			1.00		1.00	0.95		1.00	0.95	
Frt		0.99			0.96		1.00	0.99		1.00	0.98	
Flt Protected		0.96			0.97		0.95	1.00		0.95	1.00	
Satd. Flow (prot)		1771			1744		1863	3692		1863	3661	
Flt Permitted		0.88			0.83		0.39	1.00		0.22	1.00	
Satd. Flow (perm)		1608			1479		757	3692		431	3661	
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	15	3	2	41	15	23	8	1099	69	90	618	81
RTOR Reduction (vph)	0	2	0	0	19	0	0	6	0	0	13	0
Lane Group Flow (vph)	0	18	0	0	60	0	8	1162	0	90	686	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4			8			2			6		
Actuated Green, G (s)		4.0			4.0		24.1	24.1		24.1	24.1	
Effective Green, g (s)		4.0			4.0		24.1	24.1		24.1	24.1	
Actuated g/C Ratio		0.10			0.10		0.63	0.63		0.63	0.63	
Clearance Time (s)		5.0			5.0		5.0	5.0		5.0	5.0	
Vehicle Extension (s)		3.0			3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)		169			155		479	2335		273	2316	
v/s Ratio Prot								c0.31			0.19	
v/s Ratio Perm		0.01			c0.04		0.01			0.21		
v/c Ratio		0.11			0.39		0.02	0.50		0.33	0.30	
Uniform Delay, d1		15.4			15.9		2.6	3.8		3.2	3.2	
Progression Factor		1.00			1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2		0.3			1.6		0.0	0.2		0.7	0.1	
Delay (s)		15.7			17.5		2.6	3.9		4.0	3.2	
Level of Service		B			B		A	A		A	A	
Approach Delay (s)		15.7			17.5			3.9			3.3	
Approach LOS		B			B			A			A	

Intersection Summary			
HCM Average Control Delay	4.3	HCM Level of Service	A
HCM Volume to Capacity ratio	0.48		
Actuated Cycle Length (s)	38.1	Sum of lost time (s)	10.0
Intersection Capacity Utilization	52.7%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	49	11	14	121	13	66	7	957	54	65	1150	73
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	2000	2000	2000	2000	2000	2000
Total Lost time (s)		5.0			5.0		5.0	5.0		5.0	5.0	
Lane Util. Factor		1.00			1.00		1.00	0.95		1.00	0.95	
Frt		0.97			0.96		1.00	0.99		1.00	0.99	
Flt Protected		0.97			0.97		0.95	1.00		0.95	1.00	
Satd. Flow (prot)		1757			1728		1863	3696		1863	3692	
Flt Permitted		0.77			0.77		0.17	1.00		0.24	1.00	
Satd. Flow (perm)		1394			1374		334	3696		470	3692	
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	49	11	14	121	13	66	7	957	54	65	1150	73
RTOR Reduction (vph)	0	10	0	0	21	0	0	5	0	0	5	0
Lane Group Flow (vph)	0	64	0	0	179	0	7	1006	0	65	1218	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4			8			2			6		
Actuated Green, G (s)		13.0			13.0		30.2	30.2		30.2	30.2	
Effective Green, g (s)		13.0			13.0		30.2	30.2		30.2	30.2	
Actuated g/C Ratio		0.24			0.24		0.57	0.57		0.57	0.57	
Clearance Time (s)		5.0			5.0		5.0	5.0		5.0	5.0	
Vehicle Extension (s)		3.0			3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)		341			336		190	2098		267	2096	
v/s Ratio Prot								0.27			c0.33	
v/s Ratio Perm		0.05			c0.13		0.02			0.14		
v/c Ratio		0.19			0.53		0.04	0.48		0.24	0.58	
Uniform Delay, d1		15.9			17.5		5.1	6.8		5.8	7.4	
Progression Factor		1.00			1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2		0.3			1.6		0.1	0.2		0.5	0.4	
Delay (s)		16.2			19.1		5.2	7.0		6.2	7.8	
Level of Service		B			B		A	A		A	A	
Approach Delay (s)		16.2			19.1			7.0			7.8	
Approach LOS		B			B			A			A	

Intersection Summary			
HCM Average Control Delay	8.6	HCM Level of Service	A
HCM Volume to Capacity ratio	0.57		
Actuated Cycle Length (s)	53.2	Sum of lost time (s)	10.0
Intersection Capacity Utilization	61.2%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		✥			✥		↰	↑↱		↰	↑↱	
Volume (vph)	41	12	23	91	19	96	58	1034	101	67	560	30
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	2000	2000	2000	2000	2000	2000
Total Lost time (s)		5.0			5.0		5.0	5.0		5.0	5.0	
Lane Util. Factor		1.00			1.00		1.00	0.95		1.00	0.95	
Frt		0.96			0.94		1.00	0.99		1.00	0.99	
Flt Protected		0.97			0.98		0.95	1.00		0.95	1.00	
Satd. Flow (prot)		1740			1708		1863	3676		1863	3697	
Flt Permitted		0.81			0.82		0.43	1.00		0.19	1.00	
Satd. Flow (perm)		1442			1434		842	3676		370	3697	
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	41	12	23	91	19	96	58	1034	101	67	560	30
RTOR Reduction (vph)	0	17	0	0	37	0	0	10	0	0	5	0
Lane Group Flow (vph)	0	59	0	0	169	0	58	1125	0	67	585	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4			8			2			6		
Actuated Green, G (s)		10.9			10.9		21.8	21.8		21.8	21.8	
Effective Green, g (s)		10.9			10.9		21.8	21.8		21.8	21.8	
Actuated g/C Ratio		0.26			0.26		0.51	0.51		0.51	0.51	
Clearance Time (s)		5.0			5.0		5.0	5.0		5.0	5.0	
Vehicle Extension (s)		3.0			3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)		368			366		430	1877		189	1887	
v/s Ratio Prot								c0.31			0.16	
v/s Ratio Perm		0.04			c0.12		0.07			0.18		
v/c Ratio		0.16			0.46		0.13	0.60		0.35	0.31	
Uniform Delay, d1		12.3			13.4		5.5	7.4		6.2	6.1	
Progression Factor		1.00			1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2		0.2			0.9		0.1	0.5		1.1	0.1	
Delay (s)		12.6			14.3		5.6	7.9		7.4	6.2	
Level of Service		B			B		A	A		A	A	
Approach Delay (s)		12.6			14.3			7.8			6.3	
Approach LOS		B			B			A			A	

Intersection Summary			
HCM Average Control Delay	8.1	HCM Level of Service	A
HCM Volume to Capacity ratio	0.55		
Actuated Cycle Length (s)	42.7	Sum of lost time (s)	10.0
Intersection Capacity Utilization	60.0%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		✣			✣		↰	↑↱		↰	↑↱	
Volume (vph)	97	38	34	138	26	43	41	872	92	117	1125	42
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	2000	2000	2000	2000	2000	2000
Total Lost time (s)		5.0			5.0		5.0	5.0		5.0	5.0	
Lane Util. Factor		1.00			1.00		1.00	0.95		1.00	0.95	
Frt		0.97			0.97		1.00	0.99		1.00	0.99	
Flt Protected		0.97			0.97		0.95	1.00		0.95	1.00	
Satd. Flow (prot)		1762			1752		1863	3672		1863	3705	
Flt Permitted		0.75			0.75		0.17	1.00		0.25	1.00	
Satd. Flow (perm)		1359			1349		340	3672		484	3705	
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	97	38	34	138	26	43	41	872	92	117	1125	42
RTOR Reduction (vph)	0	11	0	0	11	0	0	10	0	0	3	0
Lane Group Flow (vph)	0	158	0	0	196	0	41	954	0	117	1164	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4			8			2			6		
Actuated Green, G (s)		13.9			13.9		25.9	25.9		25.9	25.9	
Effective Green, g (s)		13.9			13.9		25.9	25.9		25.9	25.9	
Actuated g/C Ratio		0.28			0.28		0.52	0.52		0.52	0.52	
Clearance Time (s)		5.0			5.0		5.0	5.0		5.0	5.0	
Vehicle Extension (s)		3.0			3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)		379			377		177	1910		252	1927	
v/s Ratio Prot								0.26			c0.31	
v/s Ratio Perm		0.12			c0.15		0.12			0.24		
v/c Ratio		0.42			0.52		0.23	0.50		0.46	0.60	
Uniform Delay, d1		14.6			15.1		6.5	7.7		7.6	8.4	
Progression Factor		1.00			1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2		0.7			1.3		0.7	0.2		1.4	0.5	
Delay (s)		15.4			16.4		7.2	8.0		8.9	8.9	
Level of Service		B			B		A	A		A	A	
Approach Delay (s)		15.4			16.4			7.9			8.9	
Approach LOS		B			B			A			A	

Intersection Summary			
HCM Average Control Delay	9.5	HCM Level of Service	A
HCM Volume to Capacity ratio	0.57		
Actuated Cycle Length (s)	49.8	Sum of lost time (s)	10.0
Intersection Capacity Utilization	61.6%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	58	853	85	144	520	8	83	12	324	3	7	7
Ideal Flow (vphpl)	2000	2000	2000	2000	2000	2000	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0		5.0	5.0			5.0			5.0	
Lane Util. Factor	1.00	0.95		1.00	0.95			1.00			1.00	
Frt	1.00	0.99		1.00	1.00			0.90			0.94	
Flt Protected	0.95	1.00		0.95	1.00			0.99			0.99	
Satd. Flow (prot)	1863	3675		1863	3717			1652			1744	
Flt Permitted	0.95	1.00		0.95	1.00			0.93			0.95	
Satd. Flow (perm)	1863	3675		1863	3717			1549			1668	
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	58	853	85	144	520	8	83	12	324	3	7	7
RTOR Reduction (vph)	0	7	0	0	1	0	0	155	0	0	5	0
Lane Group Flow (vph)	58	931	0	144	527	0	0	264	0	0	12	0
Turn Type	Prot			Prot			Perm			Perm		
Protected Phases	7	4		3	8			2			6	
Permitted Phases							2			6		
Actuated Green, G (s)	3.5	26.4		8.3	31.2			16.9			16.9	
Effective Green, g (s)	3.5	26.4		8.3	31.2			16.9			16.9	
Actuated g/C Ratio	0.05	0.40		0.12	0.47			0.25			0.25	
Clearance Time (s)	5.0	5.0		5.0	5.0			5.0			5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0			3.0			3.0	
Lane Grp Cap (vph)	98	1457		232	1741			393			423	
v/s Ratio Prot	0.03	c0.25		c0.08	c0.14							
v/s Ratio Perm								c0.17			0.01	
v/c Ratio	0.59	0.64		0.62	0.30			0.67			0.03	
Uniform Delay, d1	30.9	16.2		27.7	11.0			22.4			18.7	
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Incremental Delay, d2	9.2	0.9		5.1	0.1			4.5			0.0	
Delay (s)	40.1	17.2		32.7	11.1			26.8			18.7	
Level of Service	D	B		C	B			C			B	
Approach Delay (s)		18.5			15.7			26.8			18.7	
Approach LOS		B			B			C			B	

Intersection Summary			
HCM Average Control Delay	19.3	HCM Level of Service	B
HCM Volume to Capacity ratio	0.70		
Actuated Cycle Length (s)	66.6	Sum of lost time (s)	20.0
Intersection Capacity Utilization	76.9%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↰	↑↑↱		↰	↑↑↱			✥			✥	
Volume (vph)	53	804	99	195	1093	7	149	19	184	13	22	108
Ideal Flow (vphpl)	2000	2000	2000	2000	2000	2000	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0		5.0	5.0			5.0			5.0	
Lane Util. Factor	1.00	0.95		1.00	0.95			1.00			1.00	
Frt	1.00	0.98		1.00	1.00			0.93			0.90	
Flt Protected	0.95	1.00		0.95	1.00			0.98			1.00	
Satd. Flow (prot)	1863	3664		1863	3722			1695			1665	
Flt Permitted	0.95	1.00		0.95	1.00			0.80			0.96	
Satd. Flow (perm)	1863	3664		1863	3722			1390			1609	
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	53	804	99	195	1093	7	149	19	184	13	22	108
RTOR Reduction (vph)	0	10	0	0	1	0	0	50	0	0	78	0
Lane Group Flow (vph)	53	893	0	195	1099	0	0	302	0	0	65	0
Turn Type	Prot			Prot			Perm			Perm		
Protected Phases	7	4		3	8			2			6	
Permitted Phases							2			6		
Actuated Green, G (s)	3.2	26.5		12.3	35.6			21.1			21.1	
Effective Green, g (s)	3.2	26.5		12.3	35.6			21.1			21.1	
Actuated g/C Ratio	0.04	0.35		0.16	0.48			0.28			0.28	
Clearance Time (s)	5.0	5.0		5.0	5.0			5.0			5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0			3.0			3.0	
Lane Grp Cap (vph)	80	1296		306	1769			392			453	
v/s Ratio Prot	0.03	c0.24		c0.10	0.30							
v/s Ratio Perm								c0.22			0.04	
v/c Ratio	0.66	0.69		0.64	0.62			0.77			0.14	
Uniform Delay, d1	35.3	20.7		29.2	14.6			24.7			20.1	
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Incremental Delay, d2	18.7	1.5		4.3	0.7			9.1			0.1	
Delay (s)	54.0	22.2		33.5	15.3			33.8			20.3	
Level of Service	D	C		C	B			C			C	
Approach Delay (s)		24.0			18.1			33.8			20.3	
Approach LOS		C			B			C			C	

Intersection Summary			
HCM Average Control Delay	22.3	HCM Level of Service	C
HCM Volume to Capacity ratio	0.71		
Actuated Cycle Length (s)	74.9	Sum of lost time (s)	15.0
Intersection Capacity Utilization	80.1%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	16	25	4	269	27	321	8	538	259	722	1049	17
Ideal Flow (vphpl)	1900	1900	1900	2000	2000	2000	2000	2000	2000	2000	2000	2000
Total Lost time (s)	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	6.0
Lane Util. Factor	1.00	0.95	1.00	0.95	0.95	0.88	1.00	0.95	1.00	0.97	0.95	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	0.96	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1770	3539	1583	1770	1790	2933	1863	3725	1667	3614	3725	1667
Flt Permitted	0.95	1.00	1.00	0.95	0.96	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	1770	3539	1583	1770	1790	2933	1863	3725	1667	3614	3725	1667
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	16	25	4	269	27	321	8	538	259	722	1049	17
RTOR Reduction (vph)	0	0	0	0	0	160	0	0	186	0	0	8
Lane Group Flow (vph)	16	25	4	148	148	161	8	538	73	722	1049	9
Turn Type	Split		Free	Split		pt+ov	Prot		Perm	Prot		Perm
Protected Phases	4	4		8	8	8 1	5	2		1	6	
Permitted Phases			Free						2			6
Actuated Green, G (s)	3.5	3.5	85.5	13.5	13.5	42.9	0.9	24.1	24.1	24.4	47.6	47.6
Effective Green, g (s)	3.5	3.5	85.5	13.5	13.5	42.9	0.9	24.1	24.1	24.4	47.6	46.6
Actuated g/C Ratio	0.04	0.04	1.00	0.16	0.16	0.50	0.01	0.28	0.28	0.29	0.56	0.55
Clearance Time (s)	5.0	5.0		5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	72	145	1583	279	283	1472	20	1050	470	1031	2074	909
v/s Ratio Prot	c0.01	0.01		c0.08	0.08	0.05	0.00	0.14		c0.20	c0.28	
v/s Ratio Perm			0.00						0.04			0.01
v/c Ratio	0.22	0.17	0.00	0.53	0.52	0.11	0.40	0.51	0.16	0.70	0.51	0.01
Uniform Delay, d1	39.7	39.6	0.0	33.1	33.0	11.2	42.0	25.8	23.1	27.3	11.7	8.9
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	1.6	0.6	0.0	1.9	1.7	0.0	12.6	0.4	0.2	2.2	0.2	0.0
Delay (s)	41.2	40.2	0.0	35.0	34.8	11.3	54.6	26.2	23.2	29.5	11.9	8.9
Level of Service	D	D	A	D	C	B	D	C	C	C	B	A
Approach Delay (s)		37.0			22.6			25.5			19.0	
Approach LOS		D			C			C			B	

Intersection Summary			
HCM Average Control Delay	21.5	HCM Level of Service	C
HCM Volume to Capacity ratio	0.55		
Actuated Cycle Length (s)	85.5	Sum of lost time (s)	15.0
Intersection Capacity Utilization	60.6%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↰	↑↑	↱	↰	↰↑	↱↱	↰	↑↑	↱	↰↰	↑↑	↱
Volume (vph)	32	53	36	394	86	885	35	996	482	431	742	51
Ideal Flow (vphpl)	1900	1900	1900	2000	2000	2000	2000	2000	2000	2000	2000	2000
Total Lost time (s)	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	6.0
Lane Util. Factor	1.00	0.95	1.00	0.95	0.95	0.88	1.00	0.95	1.00	0.97	0.95	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	0.97	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1770	3539	1583	1770	1804	2933	1863	3725	1667	3614	3725	1667
Flt Permitted	0.95	1.00	1.00	0.95	0.97	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	1770	3539	1583	1770	1804	2933	1863	3725	1667	3614	3725	1667
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	32	53	36	394	86	885	35	996	482	431	742	51
RTOR Reduction (vph)	0	0	0	0	0	240	0	0	294	0	0	26
Lane Group Flow (vph)	32	53	36	236	244	645	35	996	188	431	742	25
Turn Type	Split		Free	Split		pt+ov	Prot		Perm	Prot		Perm
Protected Phases	4	4		8	8	8 1	5	2		1	6	
Permitted Phases			Free						2			6
Actuated Green, G (s)	5.9	5.9	102.0	20.8	20.8	44.1	3.7	37.0	37.0	18.3	51.6	50.6
Effective Green, g (s)	5.9	5.9	102.0	20.8	20.8	44.1	3.7	37.0	37.0	18.3	51.6	50.6
Actuated g/C Ratio	0.06	0.06	1.00	0.20	0.20	0.43	0.04	0.36	0.36	0.18	0.51	0.50
Clearance Time (s)	5.0	5.0		5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	102	205	1583	361	368	1268	68	1351	605	648	1884	827
v/s Ratio Prot	c0.02	0.01		0.13	c0.14	c0.22	0.02	c0.27		c0.12	0.20	
v/s Ratio Perm			0.02						0.11			0.02
v/c Ratio	0.31	0.26	0.02	0.65	0.66	0.51	0.51	0.74	0.31	0.67	0.39	0.03
Uniform Delay, d1	46.1	46.0	0.0	37.3	37.4	21.1	48.3	28.3	23.3	39.0	15.5	13.2
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	1.8	0.7	0.0	4.2	4.5	0.3	6.4	2.1	0.3	2.6	0.1	0.0
Delay (s)	47.9	46.6	0.0	41.5	41.8	21.4	54.7	30.4	23.6	41.6	15.7	13.2
Level of Service	D	D	A	D	D	C	D	C	C	D	B	B
Approach Delay (s)		33.1			28.5			28.8			24.7	
Approach LOS		C			C			C			C	

Intersection Summary			
HCM Average Control Delay	27.6	HCM Level of Service	C
HCM Volume to Capacity ratio	0.64		
Actuated Cycle Length (s)	102.0	Sum of lost time (s)	15.0
Intersection Capacity Utilization	71.4%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↰	↑	↱	↰↰	↑↱		↰	↑↑	↱	↰	↑↑	↱
Volume (vph)	1	4	9	578	2	42	16	760	567	34	1284	1
Ideal Flow (vphpl)	1900	1900	1900	2000	2000	2000	2000	2000	2000	2000	2000	2000
Total Lost time (s)	5.0	5.0	4.0	5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0
Lane Util. Factor	1.00	1.00	1.00	0.97	1.00		1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	1.00	0.85	1.00	0.86		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1770	1863	1583	3614	1680		1863	3725	1667	1863	3725	1667
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	1770	1863	1583	3614	1680		1863	3725	1667	1863	3725	1667
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	1	4	9	578	2	42	16	760	567	34	1284	1
RTOR Reduction (vph)	0	0	0	0	31	0	0	0	325	0	0	1
Lane Group Flow (vph)	1	4	9	578	13	0	16	760	242	34	1284	0
Turn Type	Split		Free	Split			Prot		Perm	Prot		Perm
Protected Phases	4	4		8	8		5	2		1	6	
Permitted Phases			Free						2			6
Actuated Green, G (s)	0.8	0.8	74.9	19.0	19.0		1.4	32.0	32.0	3.1	33.7	33.7
Effective Green, g (s)	0.8	0.8	74.9	19.0	19.0		1.4	32.0	32.0	3.1	33.7	33.7
Actuated g/C Ratio	0.01	0.01	1.00	0.25	0.25		0.02	0.43	0.43	0.04	0.45	0.45
Clearance Time (s)	5.0	5.0		5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	19	20	1583	917	426		35	1591	712	77	1676	750
v/s Ratio Prot	0.00	c0.00		c0.16	0.01		0.01	0.20		c0.02	c0.34	
v/s Ratio Perm			c0.01						0.15			0.00
v/c Ratio	0.05	0.20	0.01	0.63	0.03		0.46	0.48	0.34	0.44	0.77	0.00
Uniform Delay, d1	36.7	36.7	0.0	24.8	21.0		36.4	15.4	14.4	35.1	17.3	11.3
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	1.2	4.9	0.0	1.4	0.0		9.2	0.2	0.3	4.0	2.2	0.0
Delay (s)	37.8	41.6	0.0	26.3	21.0		45.6	15.7	14.7	39.1	19.4	11.3
Level of Service	D	D	A	C	C		D	B	B	D	B	B
Approach Delay (s)		14.6			25.9			15.6			19.9	
Approach LOS		B			C			B			B	

Intersection Summary			
HCM Average Control Delay	19.3	HCM Level of Service	B
HCM Volume to Capacity ratio	0.66		
Actuated Cycle Length (s)	74.9	Sum of lost time (s)	15.0
Intersection Capacity Utilization	64.4%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lane Configurations	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ideal Flow (vphpl)	1900	1900	1900	2000	2000	2000	2000	2000	2000	2000	2000	2000
Total Lost time (s)	5.0	5.0	4.0	5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0
Lane Util. Factor	1.00	1.00	1.00	0.97	1.00		1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	1.00	0.85	1.00	0.88		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	7	16	41	618	17	57	84	1447	833	50	1107	14
RTOR Reduction (vph)	0	0	0	0	44	0	0	0	325	0	0	7
Lane Group Flow (vph)	7	16	41	618	30	0	84	1447	508	50	1107	7
Turn Type	Split		Free	Split			Prot		Perm	Prot		Perm
Protected Phases	4	4		8	8		5	2		1	6	
Permitted Phases			Free						2			6
Actuated Green, G (s)	2.5	2.5	96.8	21.8	21.8		7.3	47.4	47.4	5.1	45.2	45.2
Effective Green, g (s)	2.5	2.5	96.8	21.8	21.8		7.3	47.4	47.4	5.1	45.2	45.2
Actuated g/C Ratio	0.03	0.03	1.00	0.23	0.23		0.08	0.49	0.49	0.05	0.47	0.47
Clearance Time (s)	5.0	5.0		5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	46	48	1583	814	391		140	1824	816	98	1739	778
v/s Ratio Prot	0.00	c0.01		c0.17	0.02		c0.05	c0.39		0.03	0.30	
v/s Ratio Perm			c0.03						0.30			0.00
v/c Ratio	0.15	0.33	0.03	0.76	0.08		0.60	0.79	0.62	0.51	0.64	0.01
Uniform Delay, d1	46.1	46.3	0.0	35.0	29.6		43.3	20.6	18.1	44.6	19.6	13.8
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	1.5	4.1	0.0	4.1	0.1		7.1	2.5	1.5	4.4	0.8	0.0
Delay (s)	47.7	50.4	0.0	39.1	29.6		50.4	23.1	19.6	49.1	20.3	13.8
Level of Service	D	D	A	D	C		D	C	B	D	C	B
Approach Delay (s)		17.8			38.1			22.8			21.5	
Approach LOS		B			D			C			C	

[illegible]			
HCM Average Control Delay	24.9	HCM Level of Service	C
HCM Volume to Capacity ratio	0.73		
Actuated Cycle Length (s)	96.8	Sum of lost time (s)	15.0
Intersection Capacity Utilization	77.2%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lane Configurations												
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ideal Flow (vphpl)	2000	2000	2000	1900	1900	1900	2000	2000	2000	2000	2000	2000
Total Lost time (s)	5.0	5.0	4.0	5.0	5.0		5.0	5.0	5.0	5.0	5.0	4.0
Lane Util. Factor	0.95	0.95	1.00	1.00	1.00		1.00	0.95	1.00	1.00	0.95	1.00
Frpb, ped/bikes	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	1.00	0.85	1.00	0.95		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	0.96	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1770	1780	1667	1770	1765		1863	3725	1667	1863	3725	1667
Flt Permitted	0.95	0.96	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	1770	1780	1667	1770	1765		1863	3725	1667	1863	3725	1667
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	492	17	93	64	73	39	46	818	39	17	1262	594
RTOR Reduction (vph)	0	0	0	0	16	0	0	0	22	0	0	0
Lane Group Flow (vph)	256	253	93	64	96	0	46	818	17	17	1262	594
Confl. Peds. (#/hr)							39					
Turn Type	Split		Free	Split			Prot		Perm	Prot		Free
Protected Phases	4	4		8	8		5	2		1	6	
Permitted Phases			Free						2			Free
Actuated Green, G (s)	19.8	19.8	95.6	11.1	11.1		4.3	42.5	42.5	2.2	40.4	95.6
Effective Green, g (s)	19.8	19.8	95.6	11.1	11.1		4.3	42.5	42.5	2.2	40.4	95.6
Actuated g/C Ratio	0.21	0.21	1.00	0.12	0.12		0.04	0.44	0.44	0.02	0.42	1.00
Clearance Time (s)	5.0	5.0		5.0	5.0		5.0	5.0	5.0	5.0	5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	367	369	1667	206	205		84	1656	741	43	1574	1667
v/s Ratio Prot	c0.14	0.14		0.04	0.05		0.02	0.22		0.01	c0.34	
v/s Ratio Perm			0.06						0.01			c0.36
v/c Ratio	0.70	0.69	0.06	0.31	0.47		0.55	0.49	0.02	0.40	0.80	0.36
Uniform Delay, d1	35.1	35.0	0.0	38.7	39.5		44.7	18.9	14.9	46.0	24.1	0.0
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	5.7	5.2	0.1	0.9	1.7		7.1	0.2	0.0	5.9	3.0	0.6
Delay (s)	40.8	40.2	0.1	39.6	41.2		51.8	19.1	14.9	51.9	27.1	0.6
Level of Service	D	D	A	D	D		D	B	B	D	C	A
Approach Delay (s)		34.3			40.6			20.6			19.0	
Approach LOS		C			D			C			B	

Intersection Summary			
HCM Average Control Delay	23.0	HCM Level of Service	C
HCM Volume to Capacity ratio	0.65		
Actuated Cycle Length (s)	95.6	Sum of lost time (s)	10.0
Intersection Capacity Utilization	64.7%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	532	31	134	24	31	51	176	1814	105	27	1036	702
Ideal Flow (vphpl)	2000	2000	2000	1900	1900	1900	2000	2000	2000	2000	2000	2000
Total Lost time (s)	5.0	5.0	4.0	5.0	5.0		5.0	5.0	5.0	5.0	5.0	4.0
Lane Util. Factor	0.95	0.95	1.00	1.00	1.00		1.00	0.95	1.00	1.00	0.95	1.00
Frpb, ped/bikes	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	1.00	0.85	1.00	0.91		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	0.96	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1770	1783	1667	1770	1689		1863	3725	1667	1863	3725	1667
Flt Permitted	0.95	0.96	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	1770	1783	1667	1770	1689		1863	3725	1667	1863	3725	1667
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	532	31	134	24	31	51	176	1814	105	27	1036	702
RTOR Reduction (vph)	0	0	0	0	48	0	0	0	31	0	0	0
Lane Group Flow (vph)	282	281	134	24	34	0	176	1814	74	27	1036	702
Confl. Peds. (#/hr)							39					
Turn Type	Split		Free	Split			Prot		Perm	Prot		Free
Protected Phases	4	4		8	8		5	2		1	6	
Permitted Phases			Free						2			Free
Actuated Green, G (s)	20.2	20.2	104.3	6.5	6.5		14.5	53.5	53.5	4.1	43.1	104.3
Effective Green, g (s)	20.2	20.2	104.3	6.5	6.5		14.5	53.5	53.5	4.1	43.1	104.3
Actuated g/C Ratio	0.19	0.19	1.00	0.06	0.06		0.14	0.51	0.51	0.04	0.41	1.00
Clearance Time (s)	5.0	5.0		5.0	5.0		5.0	5.0	5.0	5.0	5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	343	345	1667	110	105		259	1911	855	73	1539	1667
v/s Ratio Prot	c0.16	0.16		0.01	0.02		c0.09	c0.49		0.01	0.28	
v/s Ratio Perm			0.08						0.04			c0.42
v/c Ratio	0.82	0.81	0.08	0.22	0.33		0.68	0.95	0.09	0.37	0.67	0.42
Uniform Delay, d1	40.3	40.3	0.0	46.5	46.8		42.7	24.1	12.9	48.8	24.9	0.0
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	14.6	13.7	0.1	1.0	1.8		6.9	10.8	0.0	3.1	1.2	0.8
Delay (s)	54.9	54.0	0.1	47.5	48.6		49.6	34.9	13.0	52.0	26.1	0.8
Level of Service	D	D	A	D	D		D	C	B	D	C	A
Approach Delay (s)		44.0			48.4			35.1			16.4	
Approach LOS		D			D			D			B	

Intersection Summary			
HCM Average Control Delay	[illegible]	HCM Level of Service	[illegible]
HCM Volume to Capacity ratio	[illegible]		
Actuated Cycle Length (s)	104.3	Sum of lost time (s)	[illegible]
Intersection Capacity Utilization	[illegible]	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	116	12	321	173	12	13	30	770	55	3	1417	11
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	2000	2000	2000	2000	2000	2000
Total Lost time (s)		5.0	5.0	5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0
Lane Util. Factor		1.00	1.00	1.00	1.00		1.00	0.95	1.00	1.00	0.95	1.00
Frt		1.00	0.85	1.00	0.92		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected		0.96	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)		1782	1583	1770	1717		1863	3725	1667	1863	3725	1667
Flt Permitted		0.73	1.00	0.67	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)		1356	1583	1257	1717		1863	3725	1667	1863	3725	1667
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	116	12	321	173	12	13	30	770	55	3	1417	11
RTOR Reduction (vph)	0	0	71	0	10	0	0	0	24	0	0	5
Lane Group Flow (vph)	0	128	250	173	15	0	30	770	31	3	1417	6
Turn Type	Perm		Perm	Perm			Prot		Perm	Prot		Perm
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4		4	8					2			6
Actuated Green, G (s)		19.4	19.4	19.4	19.4		2.9	45.7	45.7	0.5	43.3	43.3
Effective Green, g (s)		19.4	19.4	19.4	19.4		2.9	45.7	45.7	0.5	43.3	43.3
Actuated g/C Ratio		0.24	0.24	0.24	0.24		0.04	0.57	0.57	0.01	0.54	0.54
Clearance Time (s)		5.0	5.0	5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0
Vehicle Extension (s)		3.0	3.0	3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)		326	381	303	413		67	2112	945	12	2001	896
v/s Ratio Prot					0.01		c0.02	0.21		0.00	c0.38	
v/s Ratio Perm		0.09	c0.16	0.14					0.02			0.00
v/c Ratio		0.39	0.66	0.57	0.04		0.45	0.36	0.03	0.25	0.71	0.01
Uniform Delay, d1		25.7	27.6	26.9	23.4		38.1	9.5	7.7	39.9	13.9	8.7
Progression Factor		1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2		0.8	4.1	2.6	0.0		4.7	0.1	0.0	10.7	1.2	0.0
Delay (s)		26.4	31.7	29.5	23.5		42.8	9.6	7.7	50.5	15.1	8.7
Level of Service		C	C	C	C		D	A	A	D	B	A
Approach Delay (s)		30.2			28.8			10.7			15.1	
Approach LOS		C			C			B			B	

Intersection Summary			
HCM Average Control Delay	17.1	HCM Level of Service	B
HCM Volume to Capacity ratio	0.68		
Actuated Cycle Length (s)	80.6	Sum of lost time (s)	15.0
Intersection Capacity Utilization	79.2%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	22	6	69	63	8	10	158	2084	171	10	1166	28
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	2000	2000	2000	2000	2000	2000
Total Lost time (s)		5.0	5.0	5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0
Lane Util. Factor		1.00	1.00	1.00	1.00		1.00	0.95	1.00	1.00	0.95	1.00
Frt		1.00	0.85	1.00	0.92		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected		0.96	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)		1792	1583	1770	1708		1863	3725	1667	1863	3725	1667
Flt Permitted		0.76	1.00	0.74	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)		1416	1583	1377	1708		1863	3725	1667	1863	3725	1667
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	22	6	69	63	8	10	158	2084	171	10	1166	28
RTOR Reduction (vph)	0	0	63	0	9	0	0	0	46	0	0	12
Lane Group Flow (vph)	0	28	6	63	9	0	158	2084	125	10	1166	16
Turn Type	Perm		Perm	Perm			Prot		Perm	Prot		Perm
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4		4	8					2			6
Actuated Green, G (s)		7.7	7.7	7.7	7.7		13.7	62.0	62.0	1.1	49.4	49.4
Effective Green, g (s)		7.7	7.7	7.7	7.7		13.7	62.0	62.0	1.1	49.4	49.4
Actuated g/C Ratio		0.09	0.09	0.09	0.09		0.16	0.72	0.72	0.01	0.58	0.58
Clearance Time (s)		5.0	5.0	5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0
Vehicle Extension (s)		3.0	3.0	3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)		127	142	124	153		297	2692	1205	24	2145	960
v/s Ratio Prot					0.01		c0.08	c0.56		0.01	0.31	
v/s Ratio Perm		0.02	0.00	c0.05					0.07			0.01
v/c Ratio		0.22	0.04	0.51	0.06		0.53	0.77	0.10	0.42	0.54	0.02
Uniform Delay, d1		36.3	35.7	37.2	35.7		33.1	7.5	3.6	42.0	11.2	7.8
Progression Factor		1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2		0.9	0.1	3.3	0.2		1.8	1.4	0.0	11.3	0.3	0.0
Delay (s)		37.1	35.8	40.5	35.9		34.9	8.9	3.6	53.3	11.5	7.8
Level of Service		D	D	D	D		C	A	A	D	B	A
Approach Delay (s)		36.2			39.5			10.3			11.8	
Approach LOS		D			D			B			B	

Intersection Summary			
HCM Average Control Delay	12.0	HCM Level of Service	B
HCM Volume to Capacity ratio	0.76		
Actuated Cycle Length (s)	85.8	Sum of lost time (s)	15.0
Intersection Capacity Utilization	80.7%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations	↰	↱	↰	↑↑	↑↑	↱
Volume (vph)	119	618	139	734	1857	89
Ideal Flow (vphpl)	2000	2000	2000	2000	2000	2000
Total Lost time (s)	5.0	5.0	5.0	5.0	5.0	5.0
Lane Util. Factor	1.00	1.00	1.00	0.95	0.95	1.00
Frt	1.00	0.85	1.00	1.00	1.00	0.85
Flt Protected	0.95	1.00	0.95	1.00	1.00	1.00
Satd. Flow (prot)	1863	1667	1863	3725	3725	1667
Flt Permitted	0.95	1.00	0.95	1.00	1.00	1.00
Satd. Flow (perm)	1863	1667	1863	3725	3725	1667
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	119	618	139	734	1857	89
RTOR Reduction (vph)	0	4	0	0	0	35
Lane Group Flow (vph)	119	614	139	734	1857	54
Turn Type		pt+ov	Prot			Perm
Protected Phases	4	4 5	5	2	6	
Permitted Phases						6
Actuated Green, G (s)	28.0	47.9	14.9	81.0	61.1	61.1
Effective Green, g (s)	28.0	47.9	14.9	81.0	61.1	61.1
Actuated g/C Ratio	0.24	0.40	0.13	0.68	0.51	0.51
Clearance Time (s)	5.0		5.0	5.0	5.0	5.0
Vehicle Extension (s)	3.0		3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	438	671	233	2536	1913	856
v/s Ratio Prot	0.06	c0.37	0.07	0.20	c0.50	
v/s Ratio Perm						0.03
v/c Ratio	0.27	0.91	0.60	0.29	0.97	0.06
Uniform Delay, d1	37.2	33.6	49.2	7.6	28.1	14.6
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.3	17.1	4.1	0.1	14.3	0.0
Delay (s)	37.5	50.7	53.3	7.6	42.3	14.6
Level of Service	D	D	D	A	D	B
Approach Delay (s)	48.6			14.9	41.1	
Approach LOS	D			B	D	

Intersection Summary			
HCM Average Control Delay	36.2	HCM Level of Service	D
HCM Volume to Capacity ratio	0.95		
Actuated Cycle Length (s)	119.0	Sum of lost time (s)	10.0
Intersection Capacity Utilization	93.5%	ICU Level of Service	F
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ideal Flow (vphpl)	2000	2000	2000	2000	2000	2000
Total Lost time (s)	5.0	5.0	5.0	5.0	5.0	5.0
Lane Util. Factor	1.00	1.00	1.00	0.95	0.95	1.00
Frt	1.00	0.85	1.00	1.00	1.00	0.85
Flt Protected	0.95	1.00	0.95	1.00	1.00	1.00
Satd. Flow (prot)	1863	1667	1863	3725	3725	1667
Flt Permitted	0.95	1.00	0.95	1.00	1.00	1.00
Satd. Flow (perm)	1863	1667	1863	3725	3725	1667
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
RTOR Reduction (vph)	0	17	0	0	0	100
Lane Group Flow (vph)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Turn Type		pm+ov	Prot			Perm
Protected Phases	4	5	5	2	6	
Permitted Phases		4				6
Actuated Green, G (s)	19.4	41.2	21.8	71.5	44.7	44.7
Effective Green, g (s)	19.4	41.2	21.8	71.5	44.7	44.7
Actuated g/C Ratio	0.19	0.41	0.22	0.71	0.44	0.44
Clearance Time (s)	5.0	5.0	5.0	5.0	5.0	5.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	358	763	403	2640	1650	739
v/s Ratio Prot	c0.14	0.12	0.16	c0.58	0.30	
v/s Ratio Perm		0.14				0.05
v/c Ratio	0.72	0.58	0.72	0.82	0.68	0.11
Uniform Delay, d1	38.2	23.1	36.8	10.2	22.3	16.4
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	6.6	1.1	6.3	2.1	1.1	0.1
Delay (s)	44.8	24.1	43.1	12.3	23.4	16.5
Level of Service	D	C	D	B	C	B
Approach Delay (s)	31.6			16.0	22.5	
Approach LOS	C			B	C	

Intersection Summary			
HCM Average Control Delay	20.4	HCM Level of Service	C
HCM Volume to Capacity ratio	0.80		
Actuated Cycle Length (s)	100.9	Sum of lost time (s)	10.0
Intersection Capacity Utilization	78.6%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

HCS+: Ramps and Ramp Junctions Release 5.3

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:	
Agency/Co.:	
Date performed:	2/24/2009
Analysis time period:	AM Peak
Freeway/Dir of Travel:	H-2 Fwy NB Off-Ramp
Junction:	H-2 Fwy/Ka Uka Blvd
Jurisdiction:	
Analysis Year:	Year 2025 With Project
Description:	

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	4562	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	2	
Free-Flow speed on ramp	35.0	mph
Volume on ramp	1806	vph
Length of first accel/decel lane	800	ft
Length of second accel/decel lane	0	ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent ramp	377	vph
Position of adjacent ramp	Downstream	
Type of adjacent ramp	On	
Distance to adjacent ramp	1300	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	4562		1806		377	vph
Peak-hour factor, PHF	0.95		0.95		0.95	
Peak 15-min volume, v15	1201		475		99	v
Trucks and buses	2		2		2	%
Recreational vehicles	0		0		0	%
Terrain type:	Rolling		Level		Level	
Grade	0.00	%	0.00	%	0.00	%
Length	0.00	mi	0.00	mi	0.00	mi
Trucks and buses PCE, ET	2.5		1.5		1.5	
Recreational vehicle PCE, ER	2.0		1.2		1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	4946	1920	401	pcph

Estimation of V12 Diverge Areas

L_{EQ} = (Equation 25-8 or 25-9)

P_{FD} = 0.260 Using Equation 0

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 2707 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{Fi} = v_F$	4946	9400	No
$v_{FO} = v_F - v_R$	3026	9400	No
v_R	1920	3800	No
v_3 or v_{av34}	1119 pc/h	(Equation 25-15 or 25-16)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		No	
If yes, v_{12A} = 2707		(Equation 25-18)	

Flow Entering Diverge Influence Area

	Actual	Max Desirable	Violation?
v_{12}	2707	4400	No

Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\, v_{12} - 0.009\, L_D$ = 13.1 pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

Speed Estimation

Intermediate speed variable, D_S = 0.601

Space mean speed in ramp influence area, S_R = 51.2 mph

Space mean speed in outer lanes, S_0 = 70.8 mph

Space mean speed for all vehicles, S = 58.5 mph

HCS+: Ramps and Ramp Junctions Release 5.3

Phone:
Fax:
E-mail:

Diverge Analysis

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: PM Peak
Freeway/Dir of Travel: H-2 Fwy NB Off-Ramp
Junction: H-2 Fwy/Ka Uka Blvd
Jurisdiction:
Analysis Year: Year 2025 With Project
Description:

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	9193	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	2	
Free-Flow speed on ramp	35.0	mph
Volume on ramp	4843	vph
Length of first accel/decel lane	800	ft
Length of second accel/decel lane	0	ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent ramp	628	vph
Position of adjacent ramp	Downstream	
Type of adjacent ramp	On	
Distance to adjacent ramp	1300	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	9193		4843		628	vph
Peak-hour factor, PHF	0.95		0.95		0.95	
Peak 15-min volume, v15	2419		1274		165	v
Trucks and buses	2		2		2	%
Recreational vehicles	0		0		0	%
Terrain type:	Rolling		Level		Level	
Grade	0.00	%	0.00	%	0.00	%
Length	0.00	mi	0.00	mi	0.00	mi
Trucks and buses PCE, ET	2.5		1.5		1.5	
Recreational vehicle PCE, ER	2.0		1.2		1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	9967	5149	668	pcph

Estimation of V12 Diverge Areas

L_{EQ} = (Equation 25-8 or 25-9)

P_{FD} = 0.260 Using Equation 0

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 6402 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{Fi} = v_F$	9967	9400	Yes
$v_{FO} = v_F - v_R$	4818	9400	No
v_R	5149	3800	Yes
v_3 or v_{av34}	1782 pc/h	(Equation 25-15 or 25-16)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		No	
If yes, v_{12A} = 6402		(Equation 25-18)	

Flow Entering Diverge Influence Area

	Actual	Max Desirable	Violation?
v_{12}	6402	4400	Yes

Level of Service Determination (if not F)

Density, $D = 4.252 + 0.0086\, v_{12} - 0.009\, L_D$ = 44.9 pc/mi/ln

Level of service for ramp-freeway junction areas of influence F

Speed Estimation

Intermediate speed variable, D_S = 0.891

Space mean speed in ramp influence area, S_R = 44.5 mph

Space mean speed in outer lanes, S_0 = 68.3 mph

Space mean speed for all vehicles, S = 50.8 mph

HCS+: Ramps and Ramp Junctions Release 5.3

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: AM Peak
Freeway/Dir of Travel: H-2 Fwy NB On Ramp Loop
Junction: H-2 Fwy/Ka Uka Blvd
Jurisdiction:
Analysis Year: Year 2025 With Project
Description: (Analysis with NB Off Ramp)

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	2756	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	35.0	mph
Volume on ramp	377	vph
Length of first accel/decel lane	1500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	1806	vph
Position of adjacent Ramp	Upstream	
Type of adjacent Ramp	Off	
Distance to adjacent Ramp	1300	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	2756	377	1806	vph
Peak-hour factor, PHF	0.95	0.95	0.95	
Peak 15-min volume, v15	725	99	475	v
Trucks and buses	2	2	2	%
Recreational vehicles	0	0	0	%
Terrain type:	Rolling	Level	Level	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	2.5	1.5	1.5	
Recreational vehicle PCE, ER	2.0	1.2	1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	2988	401	1920	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 25-2 or 25-3)

P_{FM} = 0.168 Using Equation 4

$v_{12} = v_F (P_{FM})$ = 501 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	3389	9400	No
v_3 or v_{av34}	1243 pc/h	(Equation 25-4 or 25-5)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		Yes	
If yes, v_{12A} = 1195		(Equation 25-8)	

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	1195	4600	No

Level of Service Determination (if not F)

Density, $D = 5.475 + 0.00734\, v_R + 0.0078\, v_{12} - 0.00627\, L_A$ = 8.3 pc/mi/ln

Level of service for ramp-freeway junction areas of influence A

Speed Estimation

Intermediate speed variable,	M_S = 0.235	
Space mean speed in ramp influence area,	S_R = 59.6	mph
Space mean speed in outer lanes,	S_0 = 63.6	mph
Space mean speed for all vehicles,	S = 61.6	mph

HCS+: Ramps and Ramp Junctions Release 5.3

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: PM Peak
Freeway/Dir of Travel: H-2 Fwy NB On Ramp Loop
Junction: H-2 Fwy/Ka Uka Blvd
Jurisdiction:
Analysis Year: Year 2025 With Project
Description: (Analysis with NB Off-Ramp)

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	4350	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	35.0	mph
Volume on ramp	628	vph
Length of first accel/decel lane	1500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	4843	vph
Position of adjacent Ramp	Upstream	
Type of adjacent Ramp	Off	
Distance to adjacent Ramp	1300	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	4350		628		4843	vph
Peak-hour factor, PHF	0.95		0.95		0.95	
Peak 15-min volume, v15	1145		165		1274	v
Trucks and buses	2		2		2	%
Recreational vehicles	0		0		0	%
Terrain type:	Rolling		Level		Level	
Grade		%		%		%
Length		mi		mi		mi
Trucks and buses PCE, ET	2.5		1.5		1.5	
Recreational vehicle PCE, ER	2.0		1.2		1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	4716	668	5149	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 25-2 or 25-3)

P_{FM} = 0.134 Using Equation 4

$v_{12} = v_F (P_{FM})$ = 633 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	5384	9400	No
v_3 or v_{av34}	2041 pc/h	(Equation 25-4 or 25-5)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		Yes	
If yes, v_{12A} = 1886		(Equation 25-8)	

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	1886	4600	No

Level of Service Determination (if not F)

Density, $D = 5.475 + 0.00734\, v_R + 0.0078\, v_{12} - 0.00627\, L_A$ = 15.7 pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

Speed Estimation

Intermediate speed variable, M_S = 0.266

Space mean speed in ramp influence area, S_R = 58.9 mph

Space mean speed in outer lanes, S_0 = 61.7 mph

Space mean speed for all vehicles, S = 60.3 mph

HCS+: Ramps and Ramp Junctions Release 5.3

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: AM Peak
Freeway/Dir of Travel: H-2 Fwy NB On Ramp Loop
Junction: H-2 Fwy/Ka Uka Blvd
Jurisdiction:
Analysis Year: Year 2025 With Project
Description: (Analysis with NB On Ramp)

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	2756	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	35.0	mph
Volume on ramp	377	vph
Length of first accel/decel lane	1500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	344	vph
Position of adjacent Ramp	Downstream	
Type of adjacent Ramp	On	
Distance to adjacent Ramp	1700	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	2756		377		344	vph
Peak-hour factor, PHF	0.95		0.95		0.95	
Peak 15-min volume, v15	725		99		91	v
Trucks and buses	2		2		2	%
Recreational vehicles	0		0		0	%
Terrain type:	Rolling		Level		Level	
Grade		%		%		%
Length		mi		mi		mi
Trucks and buses PCE, ET	2.5		1.5		1.5	
Recreational vehicle PCE, ER	2.0		1.2		1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	2988	401	366	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 25-2 or 25-3)

P_{FM} = 0.168 Using Equation 4

$v_{12} = v_F (P_{FM})$ = 501 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	3389	9400	No
v_3 or v_{av34}	1243 pc/h	(Equation 25-4 or 25-5)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		Yes	
If yes, v_{12A} = 1195		(Equation 25-8)	

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	1195	4600	No

Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$ = 8.3 pc/mi/ln

Level of service for ramp-freeway junction areas of influence A

Speed Estimation

Intermediate speed variable, M_S = 0.235

Space mean speed in ramp influence area, S_R = 59.6 mph

Space mean speed in outer lanes, S_0 = 63.6 mph

Space mean speed for all vehicles, S = 61.6 mph

HCS+: Ramps and Ramp Junctions Release 5.3

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: PM Peak
Freeway/Dir of Travel: H-2 Fwy NB On Ramp Loop
Junction: H-2 Fwy/Ka Uka Blvd
Jurisdiction:
Analysis Year: Year 2025 With Project
Description: (Analysis with NB On-Ramp)

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	4350	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	35.0	mph
Volume on ramp	628	vph
Length of first accel/decel lane	1500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	551	vph
Position of adjacent Ramp	Downstream	
Type of adjacent Ramp	On	
Distance to adjacent Ramp	1700	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	4350		628		551	vph
Peak-hour factor, PHF	0.95		0.95		0.95	
Peak 15-min volume, v15	1145		165		145	v
Trucks and buses	2		2		2	%
Recreational vehicles	0		0		0	%
Terrain type:	Rolling		Level		Level	
Grade		%		%		%
Length		mi		mi		mi
Trucks and buses PCE, ET	2.5		1.5		1.5	
Recreational vehicle PCE, ER	2.0		1.2		1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	4716	668	586	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 25-2 or 25-3)

P_{FM} = 0.134 Using Equation 4

$v_{12} = v_F (P_{FM})$ = 633 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	5384	9400	No
v_3 or v_{av34}	2041 pc/h	(Equation 25-4 or 25-5)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		Yes	
If yes, v_{12A} = 1886		(Equation 25-8)	

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	1886	4600	No

Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\, v_R + 0.0078\, v_{12} - 0.00627\, L_A$ = 15.7 pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

Speed Estimation

Intermediate speed variable, M_S = 0.266

Space mean speed in ramp influence area, S_R = 58.9 mph

Space mean speed in outer lanes, S_0 = 61.7 mph

Space mean speed for all vehicles, S = 60.3 mph

HCS+: Ramps and Ramp Junctions Release 5.3

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: AM Peak
Freeway/Dir of Travel: H-2 Fwy NB On Ramp
Junction: H-2 Fwy/Ka Uka Blvd
Jurisdiction:
Analysis Year: Year 2025 With Project
Description:

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	3133	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	35.0	mph
Volume on ramp	344	vph
Length of first accel/decel lane	700	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	377	vph
Position of adjacent Ramp	Upstream	
Type of adjacent Ramp	On	
Distance to adjacent Ramp	1700	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	3133		344		377	vph
Peak-hour factor, PHF	0.95		0.95		0.95	
Peak 15-min volume, v15	824		91		99	v
Trucks and buses	2		2		2	%
Recreational vehicles	0		0		0	%
Terrain type:	Rolling		Level		Level	
Grade		%		%		%
Length		mi		mi		mi
Trucks and buses PCE, ET	2.5		1.5		1.5	
Recreational vehicle PCE, ER	2.0		1.2		1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	3397	366	401	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 25-2 or 25-3)

P_{FM} = 0.172 Using Equation 4

$v_{12} = v_F (P_{FM})$ = 584 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	3763	9400	No
v_3 or v_{av34}	1406 pc/h	(Equation 25-4 or 25-5)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		Yes	
If yes, v_{12A} = 1358		(Equation 25-8)	

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	1358	4600	No

Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\, v_R + 0.0078\, v_{12} - 0.00627\, L_A$ = 14.4 pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

Speed Estimation

Intermediate speed variable, M_S = 0.294

Space mean speed in ramp influence area, S_R = 58.2 mph

Space mean speed in outer lanes, S_0 = 63.1 mph

Space mean speed for all vehicles, S = 60.8 mph

HCS+: Ramps and Ramp Junctions Release 5.3

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: PM Peak
Freeway/Dir of Travel: H-2 Fwy NB On Ramp
Junction: H-2 Fwy/Ka Uka Blvd
Jurisdiction:
Analysis Year: Year 2025 With Project
Description:

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	4978	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	35.0	mph
Volume on ramp	551	vph
Length of first accel/decel lane	700	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	628	vph
Position of adjacent Ramp	Upstream	
Type of adjacent Ramp	On	
Distance to adjacent Ramp	1700	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	4978	551	628	vph
Peak-hour factor, PHF	0.95	0.95	0.95	
Peak 15-min volume, v15	1310	145	165	v
Trucks and buses	2	2	2	%
Recreational vehicles	0	0	0	%
Terrain type:	Rolling	Level	Level	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	2.5	1.5	1.5	
Recreational vehicle PCE, ER	2.0	1.2	1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	5397	586	668	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 25-2 or 25-3)

P_{FM} = 0.145 Using Equation 4

$v_{12} = v_F (P_{FM})$ = 780 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	5983	9400	No
v_3 or v_{av34}	2308 pc/h	(Equation 25-4 or 25-5)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		Yes	
If yes, v_{12A} = 2158		(Equation 25-8)	

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	2158	4600	No

Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\, v_R + 0.0078\, v_{12} - 0.00627\, L_A$ = 22.2 pc/mi/ln

Level of service for ramp-freeway junction areas of influence C

Speed Estimation

Intermediate speed variable,	M_S = 0.333	
Space mean speed in ramp influence area,	S_R = 57.3	mph
Space mean speed in outer lanes,	S_0 = 61.0	mph
Space mean speed for all vehicles,	S = 59.3	mph

HCS+: Ramps and Ramp Junctions Release 5.3

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: AM Peak
Freeway/Dir of Travel: H-2 Fwy SB Off-Ramp
Junction: H-2 Fwy/Ka Uka Blvd
Jurisdiction:
Analysis Year: Year 2025 With Project
Description:

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	4984	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	35.0	mph
Volume on ramp	550	vph
Length of first accel/decel lane	150	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent ramp	2262	vph
Position of adjacent ramp	Downstream	
Type of adjacent ramp	On	
Distance to adjacent ramp	1900	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	4984		550		2262	vph
Peak-hour factor, PHF	0.95		0.95		0.95	
Peak 15-min volume, v15	1312		145		595	v
Trucks and buses	2		2		2	%
Recreational vehicles	0		0		0	%
Terrain type:	Rolling		Level		Level	
Grade	0.00	%	0.00	%	0.00	%
Length	0.00	mi	0.00	mi	0.00	mi
Trucks and buses PCE, ET	2.5		1.5		1.5	
Recreational vehicle PCE, ER	2.0		1.2		1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	5404	585	2405	pcph

Estimation of V12 Diverge Areas

L_{EQ} = (Equation 25-8 or 25-9)

P_{FD} = 0.436 Using Equation 8

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 2686 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{Fi} = v_F$	5404	9400	No
$v_{FO} = v_F - v_R$	4819	9400	No
v_R	585	2000	No
v_3 or v_{av34}	1359 pc/h	(Equation 25-15 or 25-16)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		No	
If yes, v_{12A} = 2686		(Equation 25-18)	

Flow Entering Diverge Influence Area

	Actual	Max Desirable	Violation?
v_{12}	2686	4400	No

Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$ = 26.0 pc/mi/ln

Level of service for ramp-freeway junction areas of influence C

Speed Estimation

Intermediate speed variable, D_S = 0.481

Space mean speed in ramp influence area, S_R = 53.9 mph

Space mean speed in outer lanes, S_0 = 69.9 mph

Space mean speed for all vehicles, S = 60.9 mph

HCS+: Ramps and Ramp Junctions Release 5.3

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: PM Peak
Freeway/Dir of Travel: H-2 Fwy SB Off-Ramp
Junction: H-2 Fwy/Ka Uka Blvd
Jurisdiction:
Analysis Year: Year 2025 With Project
Description:

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	4060	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	35.0	mph
Volume on ramp	914	vph
Length of first accel/decel lane	150	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent ramp	1917	vph
Position of adjacent ramp	Downstream	
Type of adjacent ramp	On	
Distance to adjacent ramp	1900	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	4060		914		1917	vph
Peak-hour factor, PHF	0.95		0.95		0.95	
Peak 15-min volume, v15	1068		241		504	v
Trucks and buses	2		2		2	%
Recreational vehicles	0		0		0	%
Terrain type:	Rolling		Level		Level	
Grade	0.00	%	0.00	%	0.00	%
Length	0.00	mi	0.00	mi	0.00	mi
Trucks and buses PCE, ET	2.5		1.5		1.5	
Recreational vehicle PCE, ER	2.0		1.2		1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	4402	972	2038	pcph

Estimation of V12 Diverge Areas

L_{EQ} = (Equation 25-8 or 25-9)

P_{FD} = 0.436 Using Equation 8

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 2467 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{Fi} = v_F$	4402	9400	No
$v_{FO} = v_F - v_R$	3430	9400	No
v_R	972	2000	No
v_3 or v_{av34}	967 pc/h	(Equation 25-15 or 25-16)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		No	
If yes, v_{12A} = 2467		(Equation 25-18)	

Flow Entering Diverge Influence Area

	Actual	Max Desirable	Violation?
v_{12}	2467	4400	No

Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\, v_{12} - 0.009\, L_D$ = 24.1 pc/mi/ln

Level of service for ramp-freeway junction areas of influence C

Speed Estimation

Intermediate speed variable,	D_S = 0.515	
Space mean speed in ramp influence area,	S_R = 53.1	mph
Space mean speed in outer lanes,	S_0 = 71.3	mph
Space mean speed for all vehicles,	S = 59.8	mph

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Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: AM Peak
Freeway/Dir of Travel: H-2 Fwy SB On Ramp Loop
Junction: H-2 Fwy/Ka Uka Blvd
Jurisdiction:
Analysis Year: Year 2025 With Project
Description: (Analysis with SB Off-Ramp)

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	4434	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	35.0	mph
Volume on ramp	2262	vph
Length of first accel/decel lane	650	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	550	vph
Position of adjacent Ramp	Upstream	
Type of adjacent Ramp	Off	
Distance to adjacent Ramp	1900	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	4434		2262		550	vph
Peak-hour factor, PHF	0.95		0.95		0.95	
Peak 15-min volume, v15	1167		595		145	v
Trucks and buses	2		2		2	%
Recreational vehicles	0		0		0	%
Terrain type:	Rolling		Level		Level	
Grade		%		%		%
Length		mi		mi		mi
Trucks and buses PCE, ET	2.5		1.5		1.5	
Recreational vehicle PCE, ER	2.0		1.2		1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	4807	2405	585	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 25-2 or 25-3)

P_{FM} = -0.083 Using Equation 4

$v_{12} = v_F (P_{FM})$ = -397 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	7212	9400	No
v_3 or v_{av34}	2602 pc/h	(Equation 25-4 or 25-5)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12} /2		Yes	
If yes, v_{12A} = 1922		(Equation 25-8)	

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	1922	4600	No

Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\, v_R + 0.0078\, v_{12} - 0.00627\, L_A$ = 34.0 pc/mi/ln

Level of service for ramp-freeway junction areas of influence D

Speed Estimation

Intermediate speed variable,	M_S = 0.571	
Space mean speed in ramp influence area,	S_R = 51.9	mph
Space mean speed in outer lanes,	S_0 = 61.6	mph
Space mean speed for all vehicles,	S = 55.4	mph

HCS+: Ramps and Ramp Junctions Release 5.3

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: PM Peak
Freeway/Dir of Travel: H-2 Fwy SB On Ramp Loop
Junction: H-2 Fwy/Ka Uka Blvd
Jurisdiction:
Analysis Year: Year 2025 With Project
Description: (Analysis with SB Off-Ramp)

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	3146	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	35.0	mph
Volume on ramp	1917	vph
Length of first accel/decel lane	650	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	914	vph
Position of adjacent Ramp	Upstream	
Type of adjacent Ramp	Off	
Distance to adjacent Ramp	1900	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	3146		1917		914	vph
Peak-hour factor, PHF	0.95		0.95		0.95	
Peak 15-min volume, v15	828		504		241	v
Trucks and buses	2		2		2	%
Recreational vehicles	0		0		0	%
Terrain type:	Rolling		Level		Level	
Grade		%		%		%
Length		mi		mi		mi
Trucks and buses PCE, ET	2.5		1.5		1.5	
Recreational vehicle PCE, ER	2.0		1.2		1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	3411	2038	972	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 25-2 or 25-3)

P_{FM} = -0.037 Using Equation 4

$v_{12} = v_F (P_{FM})$ = -125 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	5449	9400	No
v_3 or v_{av34}	1768 pc/h	(Equation 25-4 or 25-5)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12} /2		Yes	
If yes, v_{12A} = 1364		(Equation 25-8)	

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	1364	4600	No

Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\, v_R + 0.0078\, v_{12} - 0.00627\, L_A$ = 27.0 pc/mi/ln

Level of service for ramp-freeway junction areas of influence C

Speed Estimation

Intermediate speed variable, M_S = 0.393

Space mean speed in ramp influence area, S_R = 56.0 mph

Space mean speed in outer lanes, S_0 = 63.1 mph

Space mean speed for all vehicles, S = 58.5 mph

HCS+: Ramps and Ramp Junctions Release 5.3

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: AM Peak
Freeway/Dir of Travel: H-2 Fwy SB On Ramp Loop
Junction: H-2 Fwy/Ka Uka Blvd
Jurisdiction:
Analysis Year: Year 2025 With Project
Description: (Analysis with SB On-Ramp)

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	4434	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	35.0	mph
Volume on ramp	2262	vph
Length of first accel/decel lane	650	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	1433	vph
Position of adjacent Ramp	Downstream	
Type of adjacent Ramp	On	
Distance to adjacent Ramp	1600	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	4434		2262		1433	vph
Peak-hour factor, PHF	0.95		0.95		0.95	
Peak 15-min volume, v15	1167		595		377	v
Trucks and buses	2		2		2	%
Recreational vehicles	0		0		0	%
Terrain type:	Rolling		Level		Level	
Grade		%		%		%
Length		mi		mi		mi
Trucks and buses PCE, ET	2.5		1.5		1.5	
Recreational vehicle PCE, ER	2.0		1.2		1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	4807	2405	1524	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 25-2 or 25-3)

P_{FM} = -0.083 Using Equation 4

$v_{12} = v_F (P_{FM})$ = -397 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	7212	9400	No
v_3 or v_{av34}	2602 pc/h	(Equation 25-4 or 25-5)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		Yes	
If yes, v_{12A} = 1922		(Equation 25-8)	

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	1922	4600	No

Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\, v_R + 0.0078\, v_{12} - 0.00627\, L_A$ = 34.0 pc/mi/ln

Level of service for ramp-freeway junction areas of influence D

Speed Estimation

Intermediate speed variable,	M_S = 0.571	
Space mean speed in ramp influence area,	S_R = 51.9	mph
Space mean speed in outer lanes,	S_0 = 61.6	mph
Space mean speed for all vehicles,	S = 55.4	mph

HCS+: Ramps and Ramp Junctions Release 5.3

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: PM Peak
Freeway/Dir of Travel: H-2 Fwy SB On Ramp Loop
Junction: H-2 Fwy/Ka Uka Blvd
Jurisdiction:
Analysis Year: Year 2025 With Project
Description: (Analysis with SB On-Ramp)

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	3146	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	35.0	mph
Volume on ramp	1917	vph
Length of first accel/decel lane	650	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	1333	vph
Position of adjacent Ramp	Downstream	
Type of adjacent Ramp	On	
Distance to adjacent Ramp	1600	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	3146		1917		1333	vph
Peak-hour factor, PHF	0.95		0.95		0.95	
Peak 15-min volume, v15	828		504		351	v
Trucks and buses	2		2		2	%
Recreational vehicles	0		0		0	%
Terrain type:	Rolling		Level		Level	
Grade		%		%		%
Length		mi		mi		mi
Trucks and buses PCE, ET	2.5		1.5		1.5	
Recreational vehicle PCE, ER	2.0		1.2		1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	3411	2038	1417	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 25-2 or 25-3)

P_{FM} = -0.037 Using Equation 4

$v_{12} = v_F (P_{FM})$ = -125 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	5449	9400	No
v_3 or v_{av34}	1768 pc/h	(Equation 25-4 or 25-5)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		Yes	
If yes, v_{12A} = 1364		(Equation 25-8)	

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	1364	4600	No

Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\, v_R + 0.0078\, v_{12} - 0.00627\, L_A$ = 27.0 pc/mi/ln

Level of service for ramp-freeway junction areas of influence C

Speed Estimation

Intermediate speed variable,	M_S = 0.393	
Space mean speed in ramp influence area,	S_R = 56.0	mph
Space mean speed in outer lanes,	S_0 = 63.1	mph
Space mean speed for all vehicles,	S = 58.5	mph

HCS+: Ramps and Ramp Junctions Release 5.3

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: AM Peak
Freeway/Dir of Travel: H-2 Fwy SB On Ramp
Junction: H-2 Fwy/Ka Uka Blvd
Jurisdiction:
Analysis Year: Year 2025 With Project
Description:

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	6696	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	35.0	mph
Volume on ramp	1433	vph
Length of first accel/decel lane	820	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	2262	vph
Position of adjacent Ramp	Upstream	
Type of adjacent Ramp	On	
Distance to adjacent Ramp	1600	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	6696		1433		2262	vph
Peak-hour factor, PHF	0.95		0.95		0.95	
Peak 15-min volume, v15	1762		377		595	v
Trucks and buses	2		2		2	%
Recreational vehicles	0		0		0	%
Terrain type:	Rolling		Level		Level	
Grade		%		%		%
Length		mi		mi		mi
Trucks and buses PCE, ET	2.5		1.5		1.5	
Recreational vehicle PCE, ER	2.0		1.2		1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	7260	1524	2405	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 25-2 or 25-3)

P_{FM} = 0.027 Using Equation 4

$v_{12} = v_F (P_{FM})$ = 198 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	8784	9400	No
v_3 or v_{av34}	3531 pc/h	(Equation 25-4 or 25-5)	
Is v_3 or v_{av34} > 2700 pc/h?		Yes	
Is v_3 or v_{av34} > 1.5 v_{12}/2		Yes	
If yes, v_{12A} = 2904		(Equation 25-8)	

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	2904	4600	No

Level of Service Determination (if not F)

Density, $D = 5.475 + 0.00734\, v_R + 0.0078\, v_{12} - 0.00627\, L_A$ = 34.2 pc/mi/ln

Level of service for ramp-freeway junction areas of influence D

Speed Estimation

Intermediate speed variable, M_S = 0.590

Space mean speed in ramp influence area, S_R = 51.4 mph

Space mean speed in outer lanes, S_0 = 59.0 mph

Space mean speed for all vehicles, S = 54.9 mph

HCS+: Ramps and Ramp Junctions Release 5.3

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 2/24/2009
Analysis time period: PM Peak
Freeway/Dir of Travel: H-2 Fwy SB On Ramp
Junction: H-2 Fwy/Ka Uka Blvd
Jurisdiction:
Analysis Year: Year 2025 With Project
Description:

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	4	
Free-flow speed on freeway	65.0	mph
Volume on freeway	5063	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	35.0	mph
Volume on ramp	1333	vph
Length of first accel/decel lane	820	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	Yes	
Volume on adjacent Ramp	1917	vph
Position of adjacent Ramp	Upstream	
Type of adjacent Ramp	On	
Distance to adjacent Ramp	1600	ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	5063	1333	1917	vph
Peak-hour factor, PHF	0.95	0.95	0.95	
Peak 15-min volume, v15	1332	351	504	v
Trucks and buses	2	2	2	%
Recreational vehicles	0	0	0	%
Terrain type:	Rolling	Level	Level	
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	2.5	1.5	1.5	
Recreational vehicle PCE, ER	2.0	1.2	1.2	

Heavy vehicle adjustment, fHV	0.971	0.990	0.990	
Driver population factor, fP	1.00	1.00	1.00	
Flow rate, vp	5489	1417	2038	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 25-2 or 25-3)

P_{FM} = 0.041 Using Equation 4

$v_{12} = v_F (P_{FM})$ = 223 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	6906	9400	No
v_3 or v_{av34}	2633 pc/h	(Equation 25-4 or 25-5)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		Yes	
If yes, v_{12A} = 2195		(Equation 25-8)	

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	2195	4600	No

Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734 v_R + 0.0078 v_{12} - 0.00627 L_A$ = 27.9 pc/mi/ln

Level of service for ramp-freeway junction areas of influence C

Speed Estimation

Intermediate speed variable, M_S = 0.408

Space mean speed in ramp influence area, S_R = 55.6 mph

Space mean speed in outer lanes, S_0 = 60.9 mph

Space mean speed for all vehicles, S = 58.0 mph

HCS+: Basic Freeway Segments Release 5.3

Phone: Fax:
E-mail:

Operational Analysis

Analyst:
Agency or Company:
Date Performed: 2/26/2009
Analysis Time Period: AM Peak
Freeway/Direction: H-2 Fwy NB
From/To:
Jurisdiction:
Analysis Year: Year 2025 With Project
Description: South of Ka Uka Blvd

Flow Inputs and Adjustments

Volume, V	4562	veh/h
Peak-hour factor, PHF	1.00	
Peak 15-min volume, v15	1141	v
Trucks and buses	2	%
Recreational vehicles	0	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.0	
Heavy vehicle adjustment, fHV	0.971	
Driver population factor, fp	1.00	
Flow rate, vp	1175	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	4	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	1.5	mi/h
Free-flow speed, FFS	68.5	mi/h
	Urban Freeway	

LOS and Performance Measures

Flow rate, vp	1175	pc/h/ln
Free-flow speed, FFS	68.5	mi/h
Average passenger-car speed, S	68.5	mi/h
Number of lanes, N	4	
Density, D	17.2	pc/mi/ln
Level of service, LOS	B	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Basic Freeway Segments Release 5.3

Phone: Fax:
E-mail:

Operational Analysis

Analyst:	
Agency or Company:	
Date Performed:	2/26/2009
Analysis Time Period:	PM Peak
Freeway/Direction:	H-2 Fwy NB
From/To:	
Jurisdiction:	
Analysis Year:	Year 2025 With Project
Description:	South of Ka Uka Blvd

Flow Inputs and Adjustments

Volume, V	9193	veh/h
Peak-hour factor, PHF	1.00	
Peak 15-min volume, v15	2299	v
Trucks and buses	2	%
Recreational vehicles	0	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.0	
Heavy vehicle adjustment, fHV	0.971	
Driver population factor, fp	1.00	
Flow rate, vp	2367	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	4	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	1.5	mi/h
Free-flow speed, FFS	68.5	mi/h
	Urban Freeway	

LOS and Performance Measures

Flow rate, vp	2367	pc/h/ln
Free-flow speed, FFS	68.5	mi/h
Average passenger-car speed, S	53.7	mi/h
Number of lanes, N	4	
Density, D	44.1	pc/mi/ln
Level of service, LOS	E	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Basic Freeway Segments Release 5.3

Phone: Fax:
E-mail:

Operational Analysis

Analyst:	
Agency or Company:	
Date Performed:	2/26/2009
Analysis Time Period:	AM Peak
Freeway/Direction:	H-2 Fwy NB
From/To:	
Jurisdiction:	
Analysis Year:	Year 2025 With Project
Description:	North of Ka Uka Blvd

Flow Inputs and Adjustments

Volume, V	3477	veh/h
Peak-hour factor, PHF	1.00	
Peak 15-min volume, v15	870	v
Trucks and buses	2	%
Recreational vehicles	0	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.0	
Heavy vehicle adjustment, fHV	0.971	
Driver population factor, fp	1.00	
Flow rate, vp	895	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	4	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	1.5	mi/h
Free-flow speed, FFS	68.5	mi/h
	Urban Freeway	

LOS and Performance Measures

Flow rate, vp	895	pc/h/ln
Free-flow speed, FFS	68.5	mi/h
Average passenger-car speed, S	68.5	mi/h
Number of lanes, N	4	
Density, D	13.1	pc/mi/ln
Level of service, LOS	B	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Basic Freeway Segments Release 5.3

Phone: Fax:
E-mail:

Operational Analysis

Analyst:	
Agency or Company:	
Date Performed:	2/26/2009
Analysis Time Period:	PM Peak
Freeway/Direction:	H-2 Fwy NB
From/To:	
Jurisdiction:	
Analysis Year:	Year 2025 With Project
Description:	North of Ka Uka Blvd

Flow Inputs and Adjustments

Volume, V	5529	veh/h
Peak-hour factor, PHF	1.00	
Peak 15-min volume, v15	1383	v
Trucks and buses	2	%
Recreational vehicles	0	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.0	
Heavy vehicle adjustment, fHV	0.971	
Driver population factor, fp	1.00	
Flow rate, vp	1424	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	4	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	1.5	mi/h
Free-flow speed, FFS	68.5	mi/h
	Urban Freeway	

LOS and Performance Measures

Flow rate, vp	1424	pc/h/ln
Free-flow speed, FFS	68.5	mi/h
Average passenger-car speed, S	68.5	mi/h
Number of lanes, N	4	
Density, D	20.8	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Basic Freeway Segments Release 5.3

Phone: Fax:
E-mail:

Operational Analysis

Analyst:
Agency or Company:
Date Performed: 2/26/2009
Analysis Time Period: AM Peak
Freeway/Direction: H-2 Fwy SB
From/To:
Jurisdiction:
Analysis Year: Year 2025 With Project
Description: North of Ka Uka Blvd

Flow Inputs and Adjustments

Volume, V	4984	veh/h
Peak-hour factor, PHF	1.00	
Peak 15-min volume, v15	1246	v
Trucks and buses	2	%
Recreational vehicles	0	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.0	
Heavy vehicle adjustment, fHV	0.971	
Driver population factor, fp	1.00	
Flow rate, vp	1283	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	4	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	1.5	mi/h
Free-flow speed, FFS	68.5	mi/h
	Urban Freeway	

LOS and Performance Measures

Flow rate, vp	1283	pc/h/ln
Free-flow speed, FFS	68.5	mi/h
Average passenger-car speed, S	68.5	mi/h
Number of lanes, N	4	
Density, D	18.7	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Basic Freeway Segments Release 5.3

Phone: Fax:
E-mail:

Operational Analysis

Analyst:
Agency or Company:
Date Performed: 2/26/2009
Analysis Time Period: PM Peak
Freeway/Direction: H-2 Fwy SB
From/To:
Jurisdiction:
Analysis Year: Year 2025 With Project
Description: North of Ka Uka Blvd

Flow Inputs and Adjustments

Volume, V	4060	veh/h
Peak-hour factor, PHF	1.00	
Peak 15-min volume, v15	1015	v
Trucks and buses	2	%
Recreational vehicles	0	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.0	
Heavy vehicle adjustment, fHV	0.971	
Driver population factor, fp	1.00	
Flow rate, vp	1045	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	4	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	1.5	mi/h
Free-flow speed, FFS	68.5	mi/h
	Urban Freeway	

LOS and Performance Measures

Flow rate, vp	1045	pc/h/ln
Free-flow speed, FFS	68.5	mi/h
Average passenger-car speed, S	68.5	mi/h
Number of lanes, N	4	
Density, D	15.3	pc/mi/ln
Level of service, LOS	B	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Basic Freeway Segments Release 5.3

Phone: Fax:
E-mail:

Operational Analysis

Analyst:
Agency or Company:
Date Performed: 2/26/2009
Analysis Time Period: AM Peak
Freeway/Direction: H-2 Fwy SB
From/To:
Jurisdiction:
Analysis Year: Year 2025 With Project
Description: South of Ka Uka Blvd

Flow Inputs and Adjustments

Volume, V	8129	veh/h
Peak-hour factor, PHF	1.00	
Peak 15-min volume, v15	2033	v
Trucks and buses	2	%
Recreational vehicles	0	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.0	
Heavy vehicle adjustment, fHV	0.971	
Driver population factor, fp	1.00	
Flow rate, vp	2093	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	4	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	1.5	mi/h
Free-flow speed, FFS	68.5	mi/h
	Urban Freeway	

LOS and Performance Measures

Flow rate, vp	2093	pc/h/ln
Free-flow speed, FFS	68.5	mi/h
Average passenger-car speed, S	61.9	mi/h
Number of lanes, N	4	
Density, D	33.8	pc/mi/ln
Level of service, LOS	D	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS+: Basic Freeway Segments Release 5.3

Phone: Fax:
E-mail:

Operational Analysis

Analyst:
Agency or Company:
Date Performed: 2/26/2009
Analysis Time Period: PM Peak
Freeway/Direction: H-2 Fwy SB
From/To:
Jurisdiction:
Analysis Year: Year 2025 With Project
Description: South of Ka Uka Blvd

Flow Inputs and Adjustments

Volume, V	6396	veh/h
Peak-hour factor, PHF	1.00	
Peak 15-min volume, v15	1599	v
Trucks and buses	2	%
Recreational vehicles	0	%
Terrain type:	Rolling	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	2.5	
Recreational vehicle PCE, ER	2.0	
Heavy vehicle adjustment, fHV	0.971	
Driver population factor, fp	1.00	
Flow rate, vp	1647	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	4	
Free-flow speed:	Base	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	1.5	mi/h
Free-flow speed, FFS	68.5	mi/h
	Urban Freeway	

LOS and Performance Measures

Flow rate, vp	1647	pc/h/ln
Free-flow speed, FFS	68.5	mi/h
Average passenger-car speed, S	67.9	mi/h
Number of lanes, N	4	
Density, D	24.3	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

J | Environmental Noise Assessment

D. L. ADAMS ASSOCIATES, LTD.
Consultants in Acoustics and Performing Arts Technologies

Environmental Noise Assessment Report
Koa Ridge Makai and Castle and Cooke Waiawa
Central Oahu, Hawaii

November 2008

DLAA Project No. 05-86A

Prepared for:
Helbert Hastert and Fee
Honolulu, Hawaii

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808/254-3318 • FAX 808/254-5295
www.dlaa.com • hawaii@dlaa.com

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1.0 EXECUTIVE SUMMARY

1.1 The proposed Koa Ridge communities consist of the Castle and Cooke Waiawa site and the Koa Ridge Makai site. The two sites combined are approximately 763 acres of currently undeveloped land in Central Oahu, Hawaii. The planned development would include the construction of approximately 5,000 new single- and multi-family residential units, schools, healthcare facilities, commercial and light industrial sites, recreational centers, and neighborhood parks. Full development of the project is anticipated in 2025.

1.2 Vehicular traffic noise from the nearby H-2 Freeway dominates the ambient noise environment near the eastern boundary of the Koa Ridge Makai project site and the western boundary of the Castle and Cooke Waiawa project site. Noise levels close to the freeway generally range from 53 dBA during the low traffic times to approximately 69 dBA during peak hour traffic times. At the north-eastern boundary of the Castle and Cooke Waiawa project site, noise levels are much quieter and generally range from 30 dBA at night to 57 dBA during the day. The average day-night level, $L_{dn,}$ varied from 57 dBA and 65 dBA depending on the proximity to the H-2 Freeway. The dominant noise sources include traffic, wind, birds, and farming equipment.

1.3 Development of project areas will involve excavation, grading, and other typical construction activities during construction. Construction noise from the Koa Ridge Makai and the Castle and Cooke Waiawa projects is not expected to impact adjacent properties, however, residences from initial phases may be impacted due to their proximity to the construction site. Noise from construction activities should be short term and must comply with State Department of Health noise regulations.

1.4 The proposed land uses may include noise generating activities which could impact adjacent residences. Noise mitigation measures should be incorporated into the project design to prevent such impacts. Consideration should also be given to the layout of the commercial and industrial areas to meet the State Department of Health noise regulations and reduce the noise impact. Restrictions may need to be placed on commercial uses allowed in the commercial and industrial areas in order to strictly control development of potential noise producing industries.

1.5 The traffic noise analysis was based on the year 2025 traffic volume projections with the project. Increases in peak hour traffic noise along the surrounding roadways are estimated to be less than 2 dBA. The change in traffic noise does not represent a significant increase for homes currently located along these roadways.

1.6 Vehicular traffic noise from the H-2 Freeway may significantly impact the proposed Koa Ridge Makai development. Traffic noise mitigation, such as a noise barrier wall or earthen berm, will be necessary to satisfy the FHWA noise limit of 67 dBA for parcels within 150 feet from the H-2 Freeway.

1.7 Vehicular traffic noise from Kamehameha Highway may significantly impact the proposed development. Any homes located within 100 feet of Kamehameha Highway will require traffic noise mitigation to meet the FHWA maximum L_{eq} noise limit of 67 dBA.

1.8 The schools within the proposed developments will not be exposed to noise levels in excess of the Board of Education (BOE) Policy 6700 design exterior noise guideline of L_{10} = 65 dBA as long as they are located a sufficient distance from the adjacent roadways. An appropriate setback could not be determined without traffic information for the internal roadways within the project site.

2.0 PROJECT DESCRIPTION

The proposed Koa Ridge Makai and Castle and Cooke Waiawa development sites combined are approximately 766 acres of undeveloped land in central Oahu, Hawaii, as shown in Figure 1. The Castle and Cooke Waiawa area is adjacent to the Mililani Memorial Park Cemetery, east of the H-2 freeway and north of the Waipio Interchange. The land is currently utilized for cattle grazing and was formerly utilized for pineapple cultivation. The Koa Ridge Makai area is located east of Kamehameha Highway and west of the H-2 Freeway. The land is also currently undeveloped and utilized for agricultural crops.

The planned development would include the construction of approximately 5,000 new single- and multi-family residential units, schools, healthcare facilities, commercial and light industrial sites, industrial site, recreational centers, and neighborhood parks. Full development of the project is anticipated in 2025.

3.0 NOISE STANDARDS

Various local and federal agencies have established guidelines and standards for assessing environmental noise impacts and set noise limits as a function of land use. A brief description of common acoustic terminology used in these guidelines and standards is presented in Appendix A.

3.1 State of Hawaii, Community Noise Control (DOH)

The State of Hawaii Community Noise Control Rule [Reference 1] defines three classes of zoning districts and specifies corresponding maximum permissible sound levels due to *stationary* noise sources such as air-conditioning units, exhaust systems, generators, compressors, pumps, etc. The Community Noise Control Rule does not address most *moving* sources, such as vehicular traffic noise, air traffic noise, or rail traffic noise. However, the Community Noise Control Rule does regulate noise related to agricultural, construction, and industrial activities, which may not be stationary.

The maximum permissible noise levels are enforced by the State Department of Health (DOH) for any location at or beyond the property line and shall not be exceeded for more than 10% of the time during any 20-minute period. The specified noise limits which apply are a function of the zoning and time of day as shown in Figure 2. With respect to mixed zoning districts, the rule specifies that the primary land use designation shall be used to determine the applicable zoning district class and the maximum permissible sound level. In determining the maximum permissible sound level, the background noise level is taken into account by the DOH.

3.2 U.S. Federal Highway Administration (FHWA)

The FHWA defines four land use categories and assigns corresponding maximum hourly equivalent sound levels, $L_{eq(h)}$, for traffic noise exposure [Reference 2], which are listed in Figure 3. For example, Category B, defined as picnic and recreation areas, parks, residences, motels, hotels, schools, churches, libraries, and hospitals, has a corresponding maximum exterior L_{eq} of 67dBA and a maximum interior L_{eq} of 52 dBA. These limits are viewed as design goals, and all projects meeting these limits are deemed in conformance with FHWA noise standards. Calculation of traffic noise levels should be conducted using a Federal Highway Administration traffic noise model [Reference 3].

3.3 Hawaii Department of Transportation (HDOT)

The HDOT has adopted FHWA's design goals for traffic noise exposure in its noise analysis and abatement policy [Reference 4]. According to the policy, a traffic noise impact occurs when the predicted traffic noise levels "approach" or exceed FHWA's design goals or when the predicted traffic noise levels "substantially exceed the existing noise levels." The policy also states that "approach" means at least 1 dB less than FHWA's design goals and "substantially exceed the existing noise levels" means an increase of at least 15 dB.

3.4 U.S. Environmental Protection Agency (EPA)

The U.S. EPA has identified a range of yearly day-night equivalent sound levels, L_{dn}, sufficient to protect public health and welfare from the effects of environmental noise [Reference 5]. The EPA has established a goal to reduce exterior environmental noise to an L_{dn} not exceeding 65 dBA and a future goal to further reduce exterior environmental noise to an L_{dn} not exceeding 55 dBA. Additionally, the EPA states that these goals are not intended as regulations as it has no authority to regulate noise levels, but rather they are intended to be viewed as levels below which the general population will not be at risk from any of the identified effects of noise.

3.5 U.S. Department of Housing and Urban Development (HUD)

HUD's environmental noise criteria and standards in 24 CFR 51 [Reference 6] were established for determining housing project site acceptability and must be satisfied for projects involving HUD or federal financing. These standards are based on day-night equivalent sound levels, L_{dn}, and are not limited to traffic noise exposure. However, for project sites in the vicinity of highways, the L_{dn} may be estimated to be equal to the design hour $L_{eq(h)}$, provided "heavy trucks (vehicles with three or more axles) do not exceed 10 percent of the total traffic flow in vehicles per 24 hours and the traffic flow between 10:00 p.m. and 7:00 a.m. does not exceed 15 percent of the average daily traffic flow in vehicles per 24 hours." For these same conditions, L_{dn}, may also be estimated as 3 dB less than the design hour L_{10}.

HUD site acceptability criteria rank sites as Acceptable, Normally Unacceptable, or Unacceptable. "Acceptable" sites are those where exterior noise levels do not exceed an L_{dn} of 65 dBA. Proposed housing projects on "Acceptable" sites do not require additional noise attenuation other than that provided by customary building techniques. "Normally Unacceptable" sites are those where the L_{dn} is above 65 dBA, but does not exceed 75 dBA. Housing on “Normally Unacceptable” sites requires some form of noise abatement, either at the property line or in the building construction, to ensure the interior noise levels are acceptable. “Unacceptable” sites are those where the L_{dn} is 75 dBA or higher. The term “Unacceptable” does not necessarily mean that housing cannot be built on those sites; however, more elaborate sound attenuation will likely be needed.

3.6 Board of Education (BOE)

BOE policy 6700 [Reference 7] sets four classroom noise level requirements:

1. Soundproofing design shall be used to reduce the noise level whenever the internal noise level exceeds 50 dBA.

2. Noise control shall be provided for all school facilities which generate exterior noise levels at the property line exceeding DOH standards.

3. Noise control measures shall be installed in classrooms and administration/staff facilities (excluding shop classrooms) whenever 50 percent of the intruding noise level measurements exceed 55 dBA when inside the classroom with windows and doors open and the room empty.

4. Air conditioning shall be provided to facilities exposed to exterior noise levels greater than L_{10} = 65dBA.

4.0 EXISTING ACOUSTICAL ENVIRONMENT

Two types of noise measurements were conducted to assess the existing acoustical environment in the vicinity of the project location. The first noise measurement type consisted of continuous long-term ambient noise level measurements (Locations L1, L2, L3, and L4). The second type of noise measurement was short-term and included traffic counts (Locations S1, S2, S3, and S4). The purpose of the short-term noise measurements and corresponding traffic counts were to validate a traffic noise prediction model. The long term measurement locations are shown in Figure 4.

4.1 Noise Measurement Procedure

Long-Term Noise Measurement Procedure

Continuous, hourly, statistical sound levels were recorded for at least 24 hours at each location. The measurements were taken using Larson-Davis Laboratories, Model 820, Type-1 Sound Level Meters together with Larson-Davis, Model 2560 Type-1 Microphones. Calibration was checked before and after the measurements with a Larson-Davis Model CAL200 calibrator. Both the sound level meter and the calibrator have been certified by the manufacturer within the recommended calibration period. The microphones were mounted on tripods, approximately 5 feet above grade. Windscreens covered the microphones during the entire measurement period. The sound level meters were secured in weather resistant cases.

Short-Term Noise Measurement Procedure

An approximate 30-minute equivalent sound level, L_{eq}, was measured at each measurement location. Vehicular traffic counts and traffic mix were documented during the measurement period. The noise measurement was taken using a Larson-Davis Laboratories, Model 824, Type-1 Sound Level Meter together with a Larson-Davis, Model 2541 Type-1 Microphone. Calibration was checked before and after the measurements with a Larson-Davis Model CAL200 calibrator. Both the sound level meter and the calibrator have been certified by the manufacturer within the recommended calibration period. The microphone and sound level meter were mounted on a tripod, approximately 5 feet above grade. A windscreen covered the microphone during the entire measurement period.

4.2 Noise Measurement Locations

Long-Term Noise Measurement Locations

Location L1: Adjacent to the Mililani Memorial/Prison Road fork, approximately 1000 feet east of the nearby H-2 Freeway. The dominant noise source was vehicular traffic from the freeway. Secondary noise sources included birds, wind, occasional aircraft flyovers, and occasional vehicles on the adjacent roadways.

Location L2: Adjacent to Prison Road in the northeast corner of the Castle and Cooke Waiawa project site. The dominant noise sources were wind and birds. Secondary noise sources included farm animals, farm equipment, and occasional aircraft flyovers.

Location L3: Adjacent to the H-2 Freeway on the northeast property line of the Koa Ridge Makai project site. The dominant noise source was vehicular traffic. Secondary noise sources included wind and occasional aircraft flyovers.

Location L4: Adjacent to the H2 freeway on the east side of the Koa Ridge Makai project site approximately 100 feet north of the Board of Water Supply water towers. The dominant noise source was vehicular traffic from the freeway. Secondary noise sources included wind, birds, and occasional aircraft flyovers.

Short-Term Noise Measurement Locations

Location S1: Positioned adjacent to Ka Uka Boulevard west of Moaniani Street, approximately 40 feet from the edge of pavement.

Location S2: Positioned adjacent to Kamehameha Highway south of Ka Uka Boulevard, approximately 50 feet from the edge of pavement.

Location S3: Positioned adjacent to Kamehameha Highway north of Ka Uka Boulevard, approximately 60 feet from the edge of pavement.

Location S4: Positioned adjacent to the H-2 freeway near the Pineapple Road Overpass, approximately 45 feet from the edge of pavement.

4.3 Long-Term Noise Measurement Results

The results from the long-term noise measurements are graphically presented in Figures 5, 6, 7, and 8, which show the measured equivalent sound levels, L_{eq}, in A-weighted decibels (dBA) as a function of the measurement date and time.

At location L1, the sound levels are relatively static, as shown in Figure 5. Traffic on the nearby H-2 Freeway dominates the ambient noise environment throughout the day and night, causing sound levels that are higher than a typical rural environment. The hourly L_{eq} noise levels generally range from 48 dBA during the low traffic times to approximately 61 dBA during peak hour traffic times. The average day-night level, $L_{dn,}$ was 60 dBA for the measurement period.

As shown in Figure 6, location L2 was very quiet during the nighttime hours where the ambient noise environment is dominated by natural sources such as wind. The hourly $L_{eq,}$ noise levels generally range from 30 dBA at night to 57 dBA during the day. The average day-night level, $L_{dn,}$ was 57 dBA for the measurement period.

Noise levels at location L3 were dominated by traffic on the H-2 Freeway throughout the day and night. The measurement period was cut short due to technical errors with the sound level meter. Figure 7 shows the hourly L_{eq} noise levels which generally range from 53 dBA at night to 69 dBA during the day. The average day-night level, L_{dn}, was 63 dBA for the measurement period.

The ambient noise environment at location L4 was also dominated by traffic along the H-2 Freeway. Excessive rain occurred during the measurement period, as indicated on Figure 8. The hourly L_{eq} noise levels generally range from 53 dBA at night to 66 dBA during the day. The average day-night level, L_{dn}, was 65 dBA for the measurement period.

5.0 POTENTIAL NOISE IMPACTS

5.1 Project Construction Noise

Development of project areas will involve excavation, grading, and other typical construction activities during construction. The various construction phases of the project will generate significant amounts of noise. The Koa Ridge Makai and Castle and Cooke Waiawa developments may impact existing adjacent properties, such as the Mililani Memorial Park, the commercial areas along Ka Uka Boulevard, as well as future adjacent properties such as the Waiawa Gentry development to the south. Similarly, residences from the initial phases may be impacted by construction noise from subsequent phases due to their proximity to the construction site. The actual noise levels produced during construction will be a function of the methods employed during each stage of the construction process. Typical ranges of construction equipment noise are shown in Figure 9. Pile driving and earthmoving equipment, e.g., bulldozers and diesel-powered trucks, will probably be the loudest equipment used during construction.

5.2 Project Generated Stationary Mechanical Noise and Compliance with State of Hawaii Community Noise Control Rule

The new land developments will incorporate stationary mechanical equipment that is typical for residential housing. Expected mechanical equipment may include air handling equipment, condensing units, etc. Noise from this mechanical equipment and other equipment must meet the State noise rules, which stipulate maximum permissible noise limits at the property line. For multi-family dwellings, the noise limits are 60 dBA during the day and 50 dBA during the night, as shown in Figure 2. For residential areas (i.e., single-family homes), noise limits are 55 dBA during the day and 45 during the night. For mixed zoning districts, the primary land use designation is used to determine the maximum permissible noise limits. Mitigation of mechanical noise to meet the State DOH noise rules should be incorporated into the project design.

5.3 Commercial and Industrial Mechanical Noise and Compliance with State of Hawaii Community Noise Control Rule

Noise emanating from the commercial and industrial developments could significantly impact the proposed noise sensitive residential areas. Mechanical equipment noise from commercial and industrial areas must meet the State DOH maximum permissible noise limits at the property line. For areas zoned industrial, the property line noise limit is 70 dBA during the day and night. For commercial areas, the noise limits are 60 dBA during the day and 50 dBA during the night. Intermittent commercial and industrial noises may be heard at the future healthcare facility and residential communities. Mitigation of mechanical and industrial noises should be incorporated into the design.

5.4 Compliance with FHWA/HDOT Noise Limits

A vehicular traffic noise analysis was completed for the existing conditions, and the future year 2025 projections with the “Build” condition using the FHWA Traffic Noise Model Look-up Tables Software Version 2.5 (2004) [Reference 8]. The traffic noise analysis is based on the traffic counts provided by the Traffic Consultant [Reference 9] and the Hawaii Department of Transportation (HDOT) [Reference 10]. Traffic volumes were not provided for the 2025 “No Build” condition. Traffic volumes were also not provided for the H-2 Freeway.

Vehicular traffic noise levels were calculated for 4 locations, Locations A, B, C, and D as shown in Figure 4. The short-term noise measurements and corresponding traffic counts were used to validate the software at the noise prediction locations. The results of the traffic noise analysis are described below and are summarized in Tables 1 and 2.

5.4.1 Vehicular Traffic Noise Impacts on the Surrounding Community

The Koa Ridge Makai development and the Castle and Cooke Waiawa land development project will provide housing for many residents, which will increase vehicular traffic in the surrounding communities. Year 2025 (with the project) projections of traffic volumes along Ka Uka Boulevard (Location A), and Kamehameha Highway (Locations B and C) indicate that an increase in traffic noise of less than 2 dB can be expected, which is not a significant increase.

The traffic noise projections listed in Table 1 for Locations A, B, and C assume a direct line-of-sight from the noise receiver to the roadway. Homes that are blocked by a barrier wall or earthen berm will experience significantly lower traffic noise levels than those listed in Table 1. The existing barrier wall located between the residences south of Ka Uka Boulevard (between Kamehameha Highway and Waipio Uka Street) and the roadway can effectively reduce traffic noise by approximately 5 to 10 dB. Similarly, the existing earthen berm located on both sides of Kamehameha Highway can reduce traffic noise levels by approximately 10 to 12 dB for the homes whose line-of-sight to the roadway has been blocked.

5.4.2 Vehicular Traffic Noise Impacts on the Project

Vehicular traffic is the primary noise source where the planned developments are adjacent to major roadways. However,vehicular traffic noise from roadways within the project sites was not assessed. The size and speed of the roadways should be considered when determining the appropriate setback distances for adjacent homes and schools. Year 2025 projections of traffic volumes along Kamehameha Highway (Location C) were used to estimate an appropriate setback distance such that the FHWA maximum noise limit of 67 dBA is satisfied at the new residences. Existing traffic volumes for the H-2 Freeway were used to estimate a minimum setback distance for residences built along the freeway. The estimated setback distances are described in the paragraphs below.

<u>Noise Prediction Location C – Kamehameha Highway</u>

Future year traffic projections show that homes built within 100 feet from the edge of pavement of Kamehameha Highway will experience noise levels that exceed the FHWA maximum noise limit of 67 dBA Homes that are located more than 100 feet from the roadway are expected to experience noise levels below the FHWA maximum noise and will not require mitigation.

Noise Prediction Location D – H2 Freeway

Future year projections along the H-2 Freeway were not provided. Therefore, the estimated distance required to meet the FHWA maximum exterior noise limit of 67 dBA should be considered a bare minimum. It is likely that a greater setback distance will be required for the project due to increased traffic volumes in the future. Existing traffic volumes provided by the HDOT show that homes built within 150 feet from the edge of pavement of the H-2 Freeway will experience noise levels that exceed the FHWA maximum noise limit of 67 dBA. Mitigation will be required in order to reduce traffic noise levels at these homes.

5.5 Compliance with EPA and HUD Noise Guidelines

The EPA has an existing design goal of $L_{dn} \leq 65$ dBA and a future design goal $L_{dn} \leq 55$ dBA for exterior noise levels. Exterior noise levels that do not exceed an L_{dn} of 65 dBA are considered acceptable, according to HUD noise guidelines. The results from the long-term noise measurements conducted at the proposed Koa Ridge Makai and Castle and Cooke Waiawa project sites were used to calculate the existing average day-night noise level, L_{dn}, shown in Figures 5, 6, 7 and 8. By 2025, traffic noise levels at the proposed project sites are predicted to increase depending on the proximity to the major roadways within the development. Parcels located adjacent to the H-2 Freeway and Kamehameha Highway are expected to experience an ambient noise environment greater than the HUD noise guidelines. Parcels that are located far from any major roadways are expected to experience an ambient noise environment that is between the existing and future EPA design goal.

It is important to note that the HUD and EPA noise guidelines are design goals and not enforceable regulations, although the HUD noise guidelines must be satisfied for projects involving HUD or federal financing. However, these guidelines and design goals are useful tools for assessing the noise environment.

5.6 Compliance with BOE Noise Guidelines

Board of Education (BOE) Policy 6700 [Reference 7] requires that air conditioning be installed for schools exposed to an exterior noise level of $L_{10} = 65$ dBA. The schools within the proposed Koa Ridge Makai or Castle and Cooke Waiawa project sites are not expected to experience an L_{10} greater than 65 dBA if they are located a significant distance from the adjacent roadways. Traffic data for roadways within the project site was not available to determine an appropriate setback distance.

5.7 Healthcare Facility Noise

A parcel has been designated for a future healthcare facility. Noise from ambulance or emergency vehicle sirens may impact the existing residential homes located along Ka Uka Boulevard and Kamehameha Highway. However, noise from emergency vehicles is exempt from the guidelines and standards for noise.

6.0 NOISE MITIGATION

6.1 Mitigation of Construction Noise

In cases where construction noise exceeds, or is expected to exceed the State’s "maximum permissible" property line noise levels [Reference 1], a permit must be obtained from the State DOH to allow the operation of vehicles, cranes, construction equipment, power tools, etc., which emit noise levels in excess of the "maximum permissible" levels.

In order for the State DOH to issue a construction noise permit, the Contractor must submit a noise permit application to the DOH, which describes the construction activities for the project. Prior to issuing the noise permit, the State DOH may require action by the Contractor to incorporate noise mitigation into the construction plan. The DOH may also require the Contractor to conduct noise monitoring or community meetings inviting the neighboring residents and business owners to discuss construction noise. The Contractor should use reasonable and standard practices to mitigate noise, such as using mufflers on diesel and gasoline engines, using properly tuned and balanced machines, etc. However, the State DOH may require additional noise mitigation, such as temporary noise barriers, or time of day usage limits for certain kinds of construction activities.

Specific permit restrictions for construction activities [Reference 1] are:

> "No permit shall allow any construction activities which emit noise in excess of the maximum permissible sound levels ... before 7:00 a.m. and after 6:00 p.m. of the same day, Monday through Friday."
> “No permit shall allow any construction activities which emit noise in excess of the maximum permissible sound levels... before 9:00 a.m. and after 6:00 p.m. on Saturday."
>
> “No permit shall allow any construction activities which emit noise in excess of the maximum permissible sound levels on Sundays and on holidays."

The use of hoe rams and jack hammers 25 lbs. or larger, high pressure sprayers, chain saws, and pile drivers are restricted to 9:00 a.m. to 5:30 p.m., Monday through Friday. In addition, construction equipment and on-site vehicles or devices whose operations involve the exhausting of gas or air, excluding pile hammers and pneumatic hand tools weighing less than 15 pounds, must be equipped with mufflers [Reference 1].

The DOH noise permit does not limit the noise level generated at the construction site, but rather the times at which noisy construction can take place. Therefore, noise mitigation for construction activities should be addressed using project management, such that the time restrictions within the DOH permit are followed.

6.2 Mitigation of the Koa Ridge Makai – Castle and Cooke Waiawa Community Development Noise

The design of the new residential development should give consideration to controlling the noise emanating from stationary mechanical equipment so as to comply with the State Department of Health *Community Noise Control* rules [Reference 1]. Noisy mechanical equipment should be located away from neighbors and the residential units, as much as is practical. Enclosed mechanical rooms may be required for some equipment. Typical noise mitigation for stationary equipment such as air-conditioning and ventilation equipment, refrigerators, compressors, etc, includes mufflers, silencers, acoustical enclosures, noise barrier walls, etc.

6.3 Mitigation of Commercial and Industrial Generated Noise

The design of new commercial and light industrial developments should give consideration to controlling noise emanating from mechanical equipment so as to comply with the State Department of Health Community Noise Control rules [Reference 1]. The most effective noise mitigation is to properly plan the project site by creating a buffer zone between noisy industrial activities and noise sensitive areas.

In order for the commercial areas to be compatible with the adjacent residential areas, noise mitigation measures should be implemented. Typical noise mitigation for stationary equipment such as air-conditioning and ventilation equipment, refrigerators, compressors, etc, includes mufflers, silencers, acoustical enclosures, noise barrier walls, etc. However, other noise sources may include non-stationary equipment such as trucks loading and unloading supplies. Additional industrial and commercial noise source may include ambulance sirens, backup alarms on trucks and forklifts, which are exempt from DOH noise regulations.

Consideration could also be given to the layout of the commercial areas to meet DOH noise regulations and reduce the noise impact. For example, noisier activities, such as traffic access and loading areas, should be located away from nearby residential areas. Low-noise commercial activities should border the adjacent future residential developments and should only occur during the day. Light industrial activities such as light manufacturing or processing should be located adjacent to the roadways in order to lessen the noise impact on residences.

Restrictions may need to be placed on all commercial uses allowed in the commercial areas in order to strictly control development of potential noise producing industries within the commercial areas. For example, sale and lease documents for the commercial property should disclose and emphasize the significance of the DOH noise regulations with respect to the abutting residential areas. With respect to mixed zoning districts, the DOH regulations specifies that the primary land use designation shall be used to determine the applicable zoning district class and the maximum permissible sound level. However, zoning district class B includes commercial, business, multi-family dwellings, and apartments with the corresponding maximum permissible sound level listed in Figure 2.

6.4 Mitigation of Traffic Noise

Vehicular traffic noise from the H-2 Freeway and Kamehameha Highway may significantly impact the proposed development. The calculated traffic noise levels show that residences located within 150 feet from the edge of pavement of the H-2 Freeway and 100 feet from Kamehameha Highway will require noise mitigation to meet the FHWA criteria. Any interior roadways that are similar in size, speed, and volume to that of Ka Uka Boulevard may also require noise mitigation.

A comprehensive traffic noise and barrier analysis using roadway coordinates and the FHWA Traffic Noise Model Software was not performed. The guidelines listed below are general in nature and should be applied where residential housing is constructed within the setback limits listed above and noise abatement becomes necessary. Effective noise mitigation measures might include:

- constructing barrier walls and/or earth berms along roadways;
- air-conditioning buildings instead of relying on natural ventilation;
- acoustically soften interior spaces by the addition of thick carpeting with a padding underlayment, an acoustical tile ceiling, louvered closet doors, etc.;
- using exterior wall constructions which exhibit high noise reductions; or
- reducing the elevation of the roadways relative to adjacent lands.

Typical exterior-to-interior noise reductions for naturally ventilated homes, i.e., with open windows, are approximately 9 dB. Adding absorption to interior spaces, (acoustically softening), can further reduce the noise levels 1 to 5 dB, depending upon the absorption initially present, and the amount of absorption added to the space. Air-conditioned or mechanically ventilated homes will also typically exhibit higher exterior-to-interior noise reductions achieved by several types of building constructions. Estimating the noise reduction provided by a barrier, however, is more difficult to generalize. Factors such as distances to roadways and setbacks, intervening ground conditions, barrier construction, barrier height, roadway elevations, etc., will determine the noise reduction afforded by a traffic noise barrier.

6.5 Mitigation of Noise at the Proposed Schools

Schools within the proposed Koa Ridge Makai and Castle and Cooke Waiawa sites are not expected to experience an L_{10} greater than 65 dBA if they are located a sufficient distance from the adjacent roadways. The setback could not be determined without traffic information for the roadways adjacent to the schools. Temporary noise mitigation measures will be required if construction activities occur in the vicinity of the elementary school. Construction and/or occupancy of the schools should occur after other construction activities near the school site are completed.

REFERENCES

1. Chapter 46, *Community Noise Control*, Department of Health, State of Hawaii, Administrative Rules, Title 11, September 23, 1996.

2. *Department of Transportation, Federal Highway Administration Procedures for Abatement of Highway Traffic Noise*, Title 23, CFR, Chapter 1, Subchapter J, Part 772, 38 FR 15953, June 19, 1973; Revised at 47 FR 29654, July 8, 1982.

3. *Federal Highway Administration's Traffic Noise Model*, FHWA-RD-77-108; U.S. Department of Transportation, December 1978.

4. *Noise Analysis and Abatement Policy*, Department of Transportation, Highways Division, State of Hawaii, June 1977.

5. *Toward a National Strategy for Noise Control*, U.S. Environmental Protection Agency, April 1977.

6. *Department of Housing and Urban Development Environmental Criteria and Standards*, Title 24, CFR, Part 51, 44 FR 40860, July 12, 1979; Amended by 49 FR 880, January 6, 1984.

7. *Policies and Standards for School Facilities Design*, Board of Education, Policy 6700, Appendix A, Acoustical and Environmental Control, March 1995.

8. *Federal Highway Administration's Traffic Noise Model Look-up Tables Software*, Ver. 2.5; U.S. Department of Transportation, December 17, 2004.

9. *Traffic Impact Analysis Report for Koa Ridge Makai and Waiawa Developments*, Wilson Okamoto Corporation., November, 2008.

10. *HDOT Traffic Station Maps 2006*, U.S Army Corps of Engineers, Honolulu District, July 10, 2007.

TABLE 1:
Predicted Traffic Noise Levels for the Surrounding Community+

Noise levels shown in the table are based on peak-hour traffic volumes, and are expressed in A-weighted decibels (dBA).

	Location A*		Location B*		Location C*	
	AM	**PM**	**AM**	**PM**	**AM**	**PM**
Existing (Calculated)	65.5	64.4	64.7	65.4	64.9	65.2
Future With Project (2025)	66.5	66.1	65.5	66.4	65.7	66.2
Future Increase With Project (2025)	1.0	1.7	0.8	1.0	0.8	1.0

\+ The noise level calculations were based on the traffic study provided by the Traffic Consultant [Reference 9].

* Location A - 25 feet south of Ka Uka Boulevard edge of pavement.
Location B - 110 feet east of Kamehameha Highway edge of pavement, south of Ka Uka Boulevard.
Location C - 100 feet north of the Kamehameha Highway edge of pavement, north of Ka Uka Boulevard.

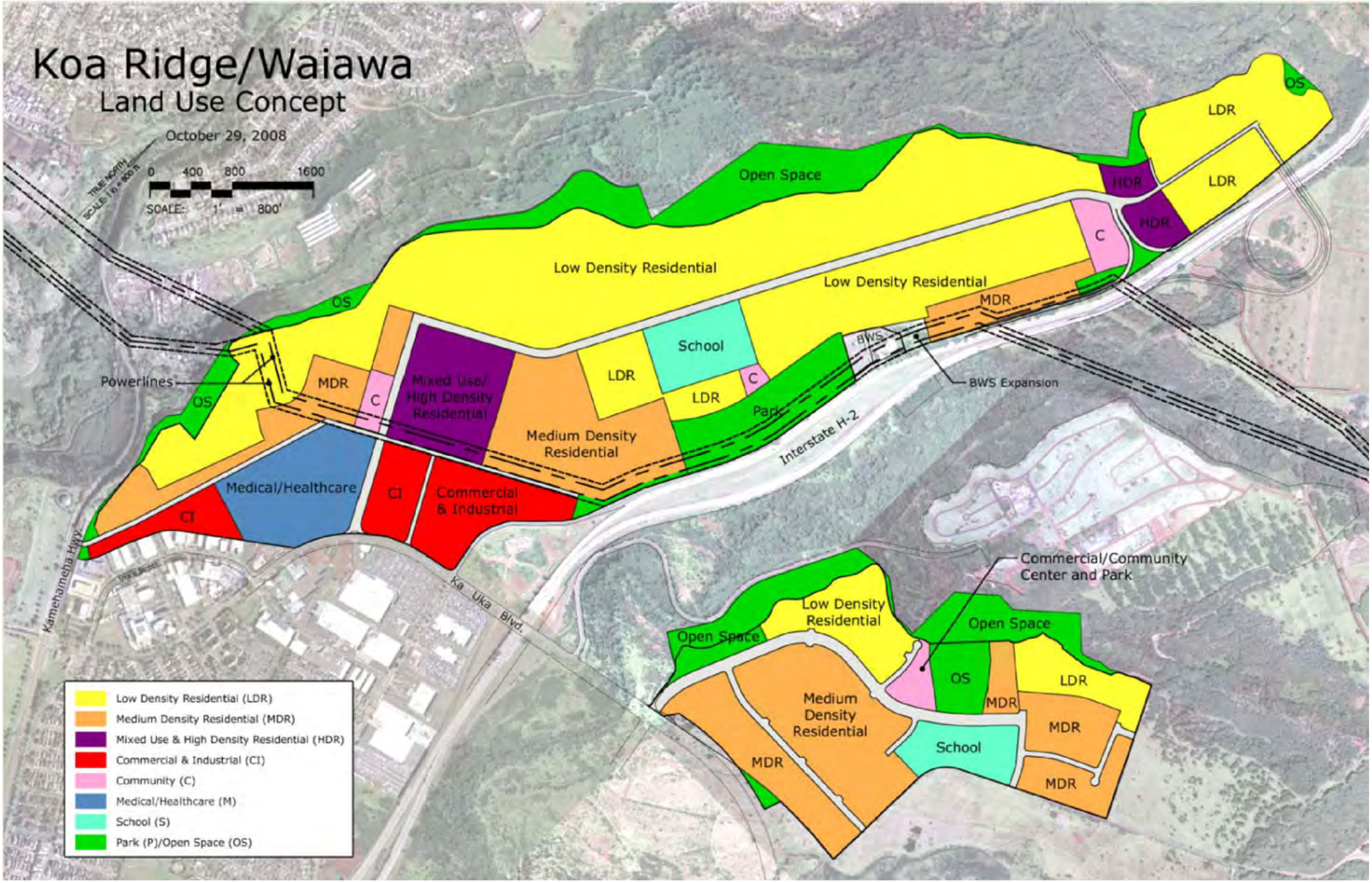
TABLE 2:
Predicted Traffic Noise Levels at the Project Site +

Noise levels shown in the table are based on peak-hour traffic volumes, and are expressed in A-weighted decibels (dBA).

	Location C*		**Location D***	
	AM	**PM**	**AM**	**PM**
Existing (Calculated)	64.9	65.2	65.7	65.7
Future With Project (2025)	65.7	66.2	N/A	N/A

+ The noise level calculations were based on the traffic study provided by the Traffic Consultant [Reference 9] and traffic volumes from the HDOT Traffic Station Maps [Reference 10].

* Location C - 100 feet east of Kamehameha Highway edge of pavement, north of Ka Uka Boulevard.
Location D - 150 feet west of H2 Freeway edge of pavement.



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Project Location

Koa Ridge Makai and Castle and Cooke Waiawa

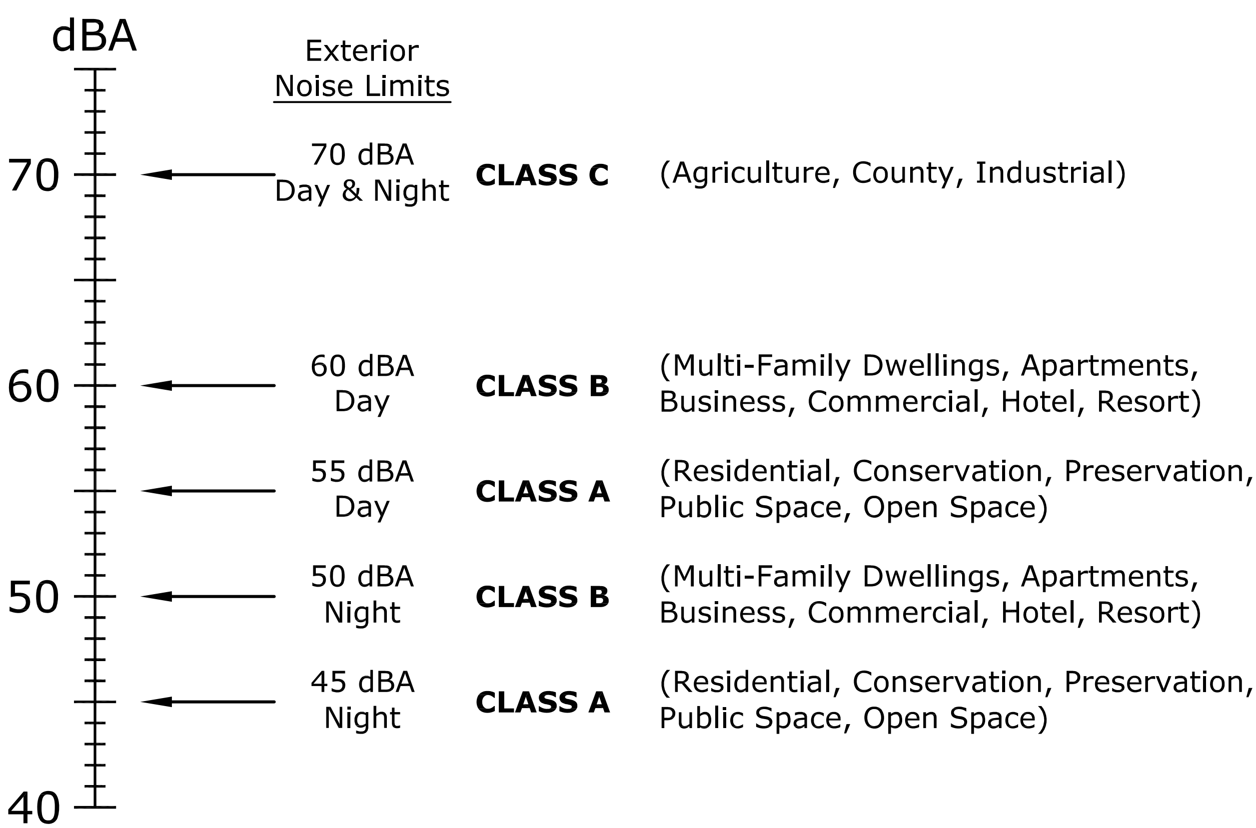
Not to Scale

Figure No

1

Date	Project No.	Drawn By
November 2008	05-86A	KMF

Zoning District	Day Hours (7 AM to 10 PM)	Night Hours (10 PM to 7 AM)
CLASS A Residential, Conservation, Preservation, Public Space, Open Space	55 dBA (Exterior)	45 dBA (Exterior)
CLASS B Multi-Family Dwellings, Apartments, Business, Commercial, Hotel, Resort	60 dBA (Exterior)	50 dBA (Exterior)
CLASS C Agriculture, Country, Industrial	70 dBA (Exterior)	70 dBA (Exterior)



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Hawaii Maximum Permissible Sound Levels for Various Zoning Districts

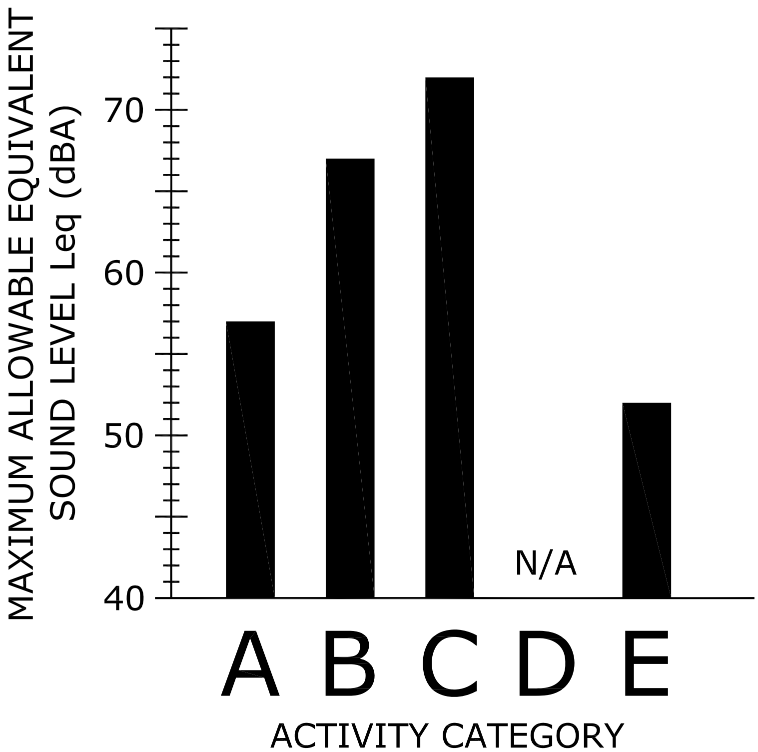
Koa Ridge Makai and Castle and Cooke Waiawa

Not to Scale

Date November 2008 | Project No. 05-86A | Drawn By TRB

Figure No 2

ACTIVITY CATEGORY	ACTIVITY CATEGORY DESCRIPTION	MAXIMUM EQUIVALENT SOUND LEVEL $L_{eq(h)}$
A	LANDS ON WHICH SERENITY AND QUIET ARE OF EXTRAORDINARY SIGNIFICANCE AND SERVE AN IMPORTANT PUBLIC NEED AND WHERE THE PRESERVATION OF THOSE QUALITIES IS ESSENTIAL IF THE AREA IS TO CONTINUE TO SERVE ITS INTENDED PURPOSE.	57 dBA (EXTERIOR)
B	PICNIC AREAS, RECREATION AREAS, PLAYGROUNDS, ACTIVE SPORT AREAS, PARKS, RESIDENCES, MOTELS, HOTELS, SCHOOLS, CHURCHES, LIBRARIES, AND HOSPITALS.	67 dBA (EXTERIOR)
C	DEVELOPED LANDS, PROPERTIES, OR ACTIVITIES NOT INCLUDED IN ACTIVITY CATEGORIES A OR B ABOVE.	72 dBA (EXTERIOR)
D	UNDEVELOPED LAND	N/A
E	RESIDENCES, MOTELS, HOTELS, PUBLIC MEETING ROOMS, SCHOOLS, CHURCHES, LIBRARIES, HOSPITALS, AND AUDITORIUMS.	52 dBA (INTERIOR)



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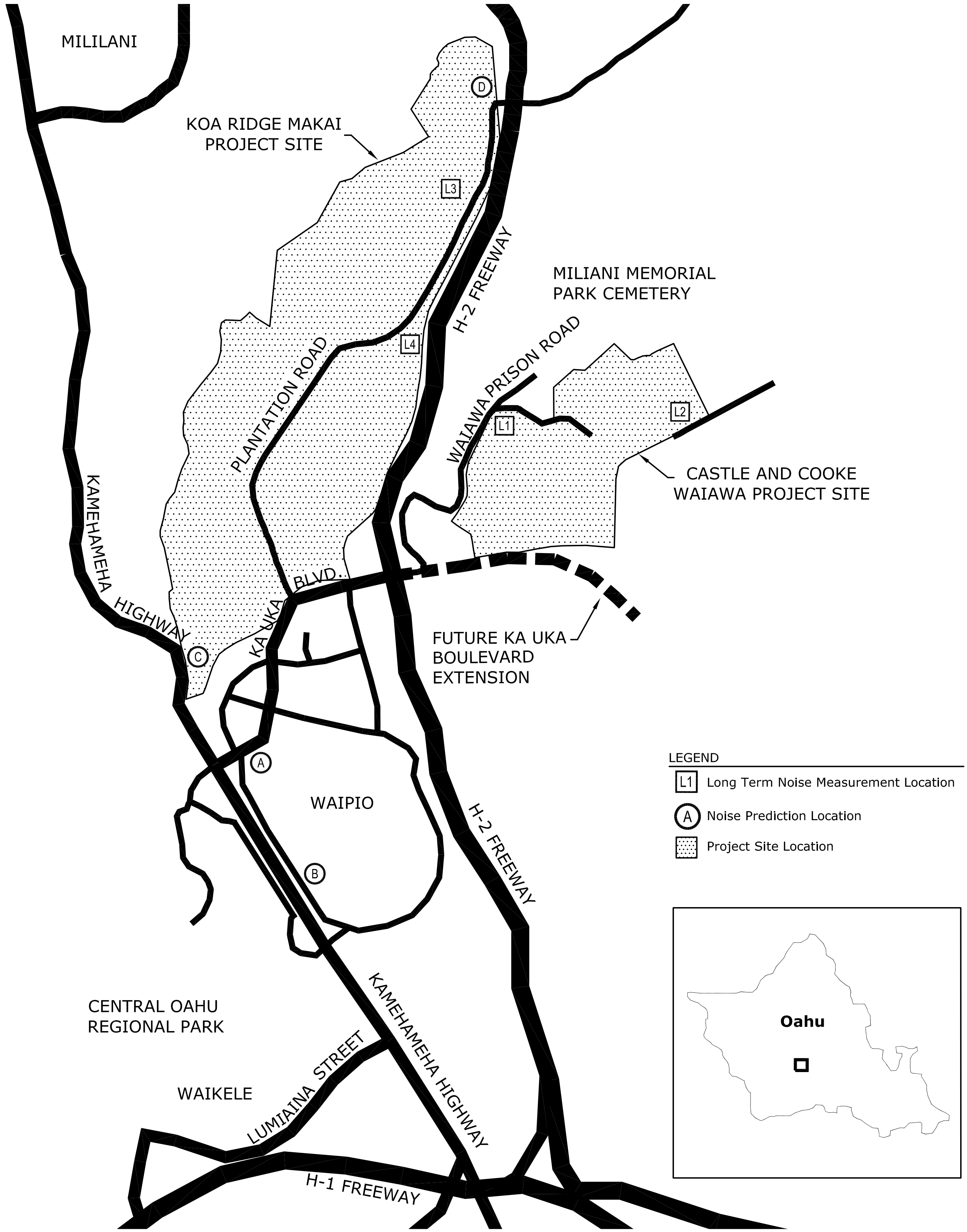
Federal Highways Administration Recommended Equivalent Hourly Sound Levels Based on Land Use

Koa Ridge Makai and Castle and Cooke Waiawa

Not to Scale

Date	Project No.	Drawn By	Figure No
November 2008	05-86A	TRB	3



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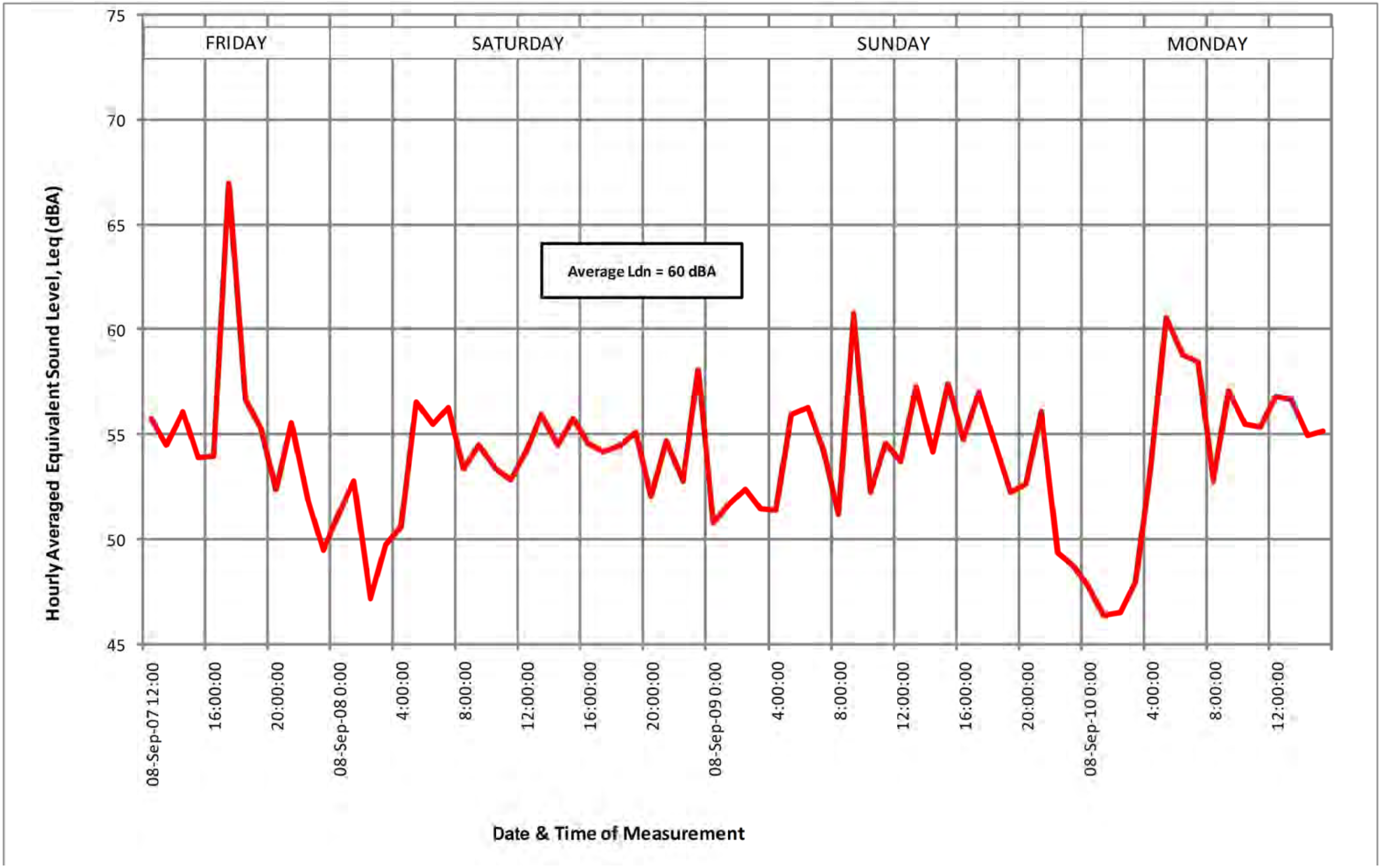
Noise Measurement and Prediction Locations

Koa Ridge Makai and Castle and Cooke Waiawa

Not to Scale

Date	Project No.	Drawn By	Figure No
November 2008	05-86A	KMF	4



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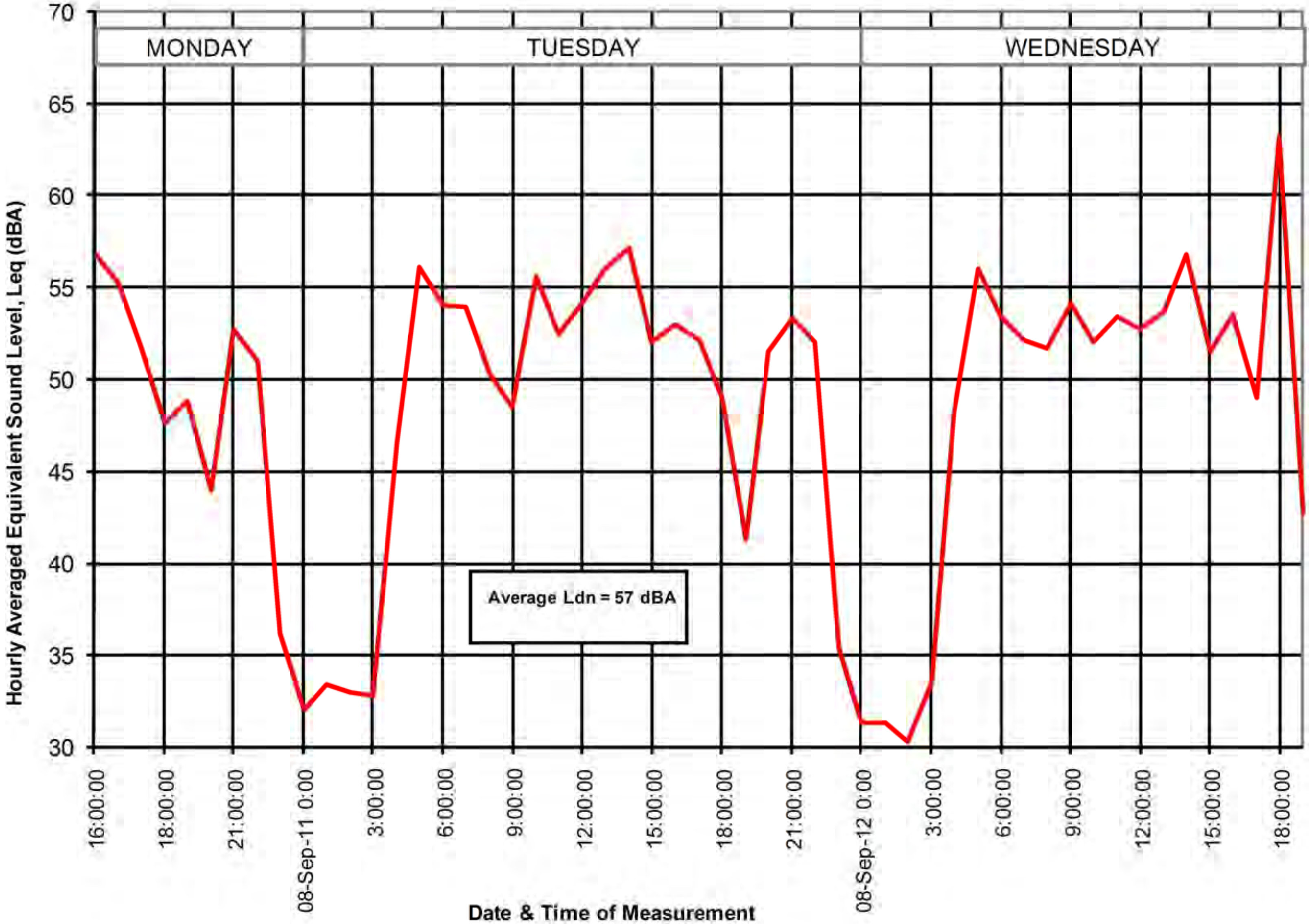
Graph of Long Term Noise Measurements (L1)

Koa Ridge Makai and Castle and Cooke Waiawa

Not to Scale

Date	Project No.	Drawn By	Figure No
November 2008	05-86A	KMF	5



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Graph of Long Term Noise Measurements (L2)

Koa Ridge Makai and Castle and Cooke Waiawa

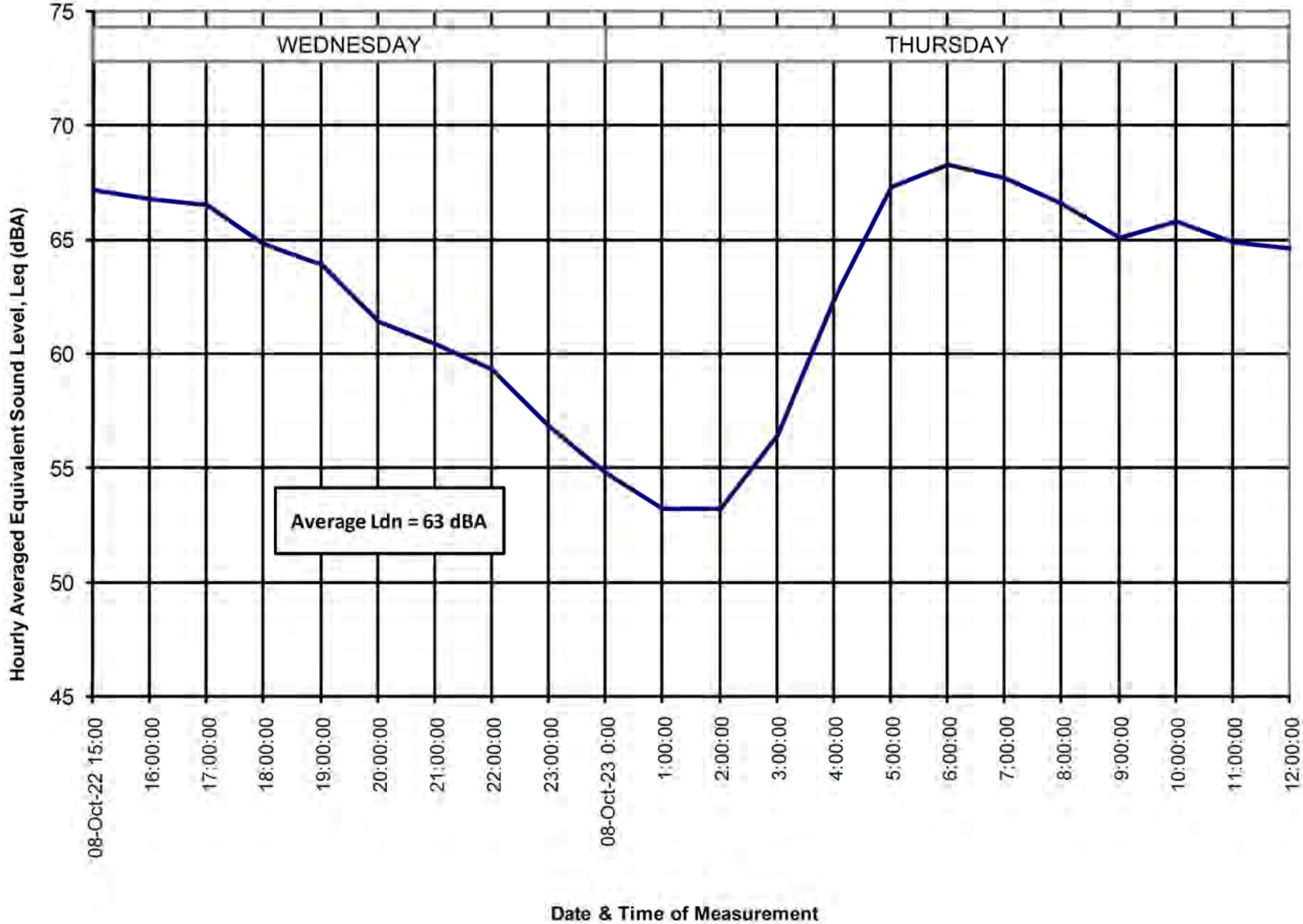
Not to Scale

Date
November 2008

Project No.
05-86A

Drawn By
KMF

Figure No
6



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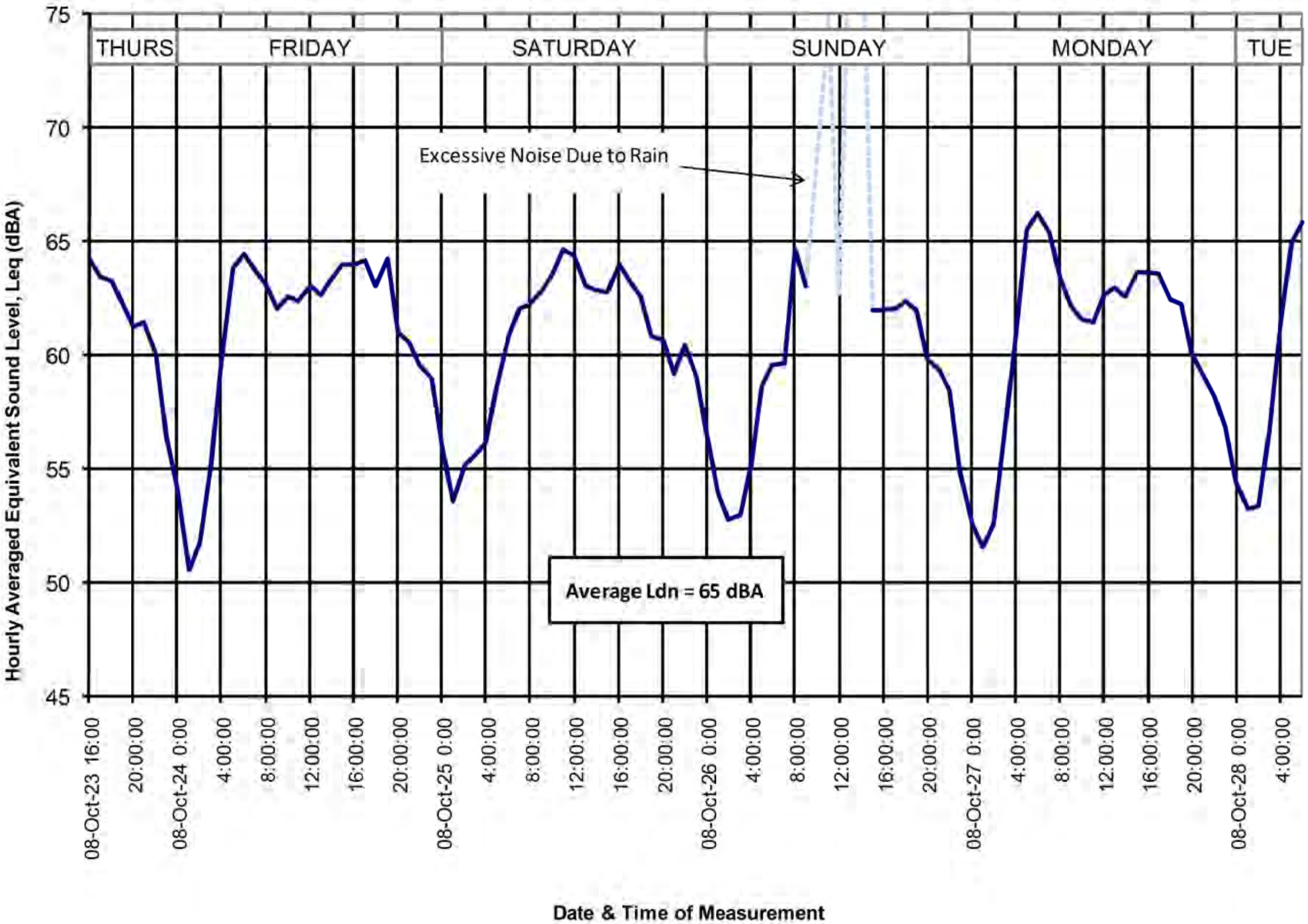
Graph of Long Term Noise Measurements (L3)

Koa Ridge Makai and Castle and Cooke Waiawa

Not to Scale

Date	Project No.	Drawn By
November 2008	05-86A	KMF

Figure No 7



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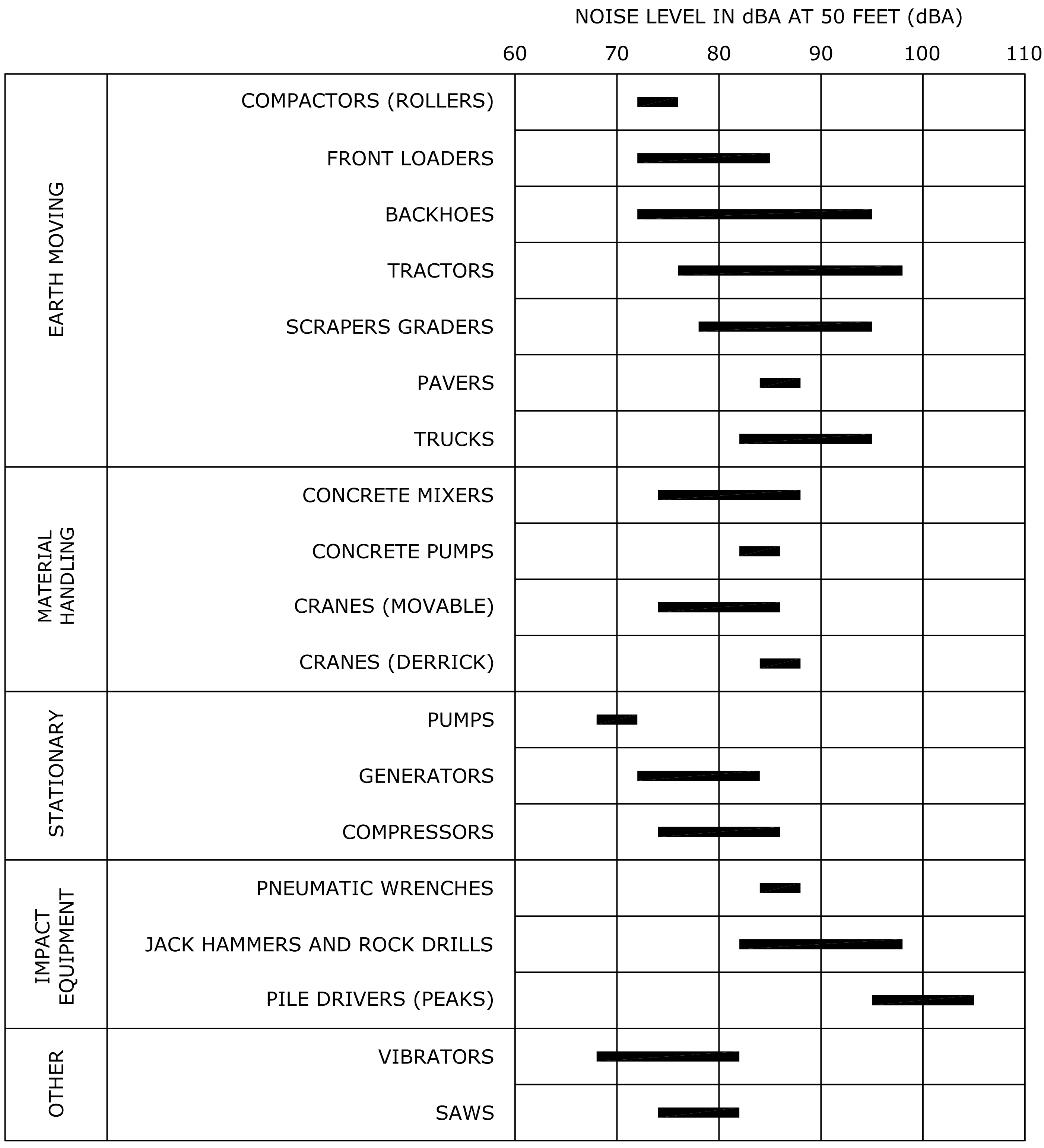
Graph of Long Term Noise Measurements (L4)

Koa Ridge Makai and Castle and Cooke Waiawa

Not to Scale

Date	Project No.	Drawn By	Figure No
November 2008	05-86A	KMF	8



NOTE: BASED ON LIMITED AVAILABLE DATA SAMPLES

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Typical Sound Levels from Construction Equipment

Koa Ridge Makai and Castle and Cooke Waiawa

Not to Scale

Figure No 9

Date	Project No.	Drawn By
November 2008	05-86A	TRB

APPENDIX A

Acoustic Terminology

Acoustic Terminology

Sound Pressure Level

Sound, or noise, is the term given to variations in air pressure that are capable of being detected by the human ear. Small fluctuations in atmospheric pressure (sound pressure) constitute the physical property measured with a sound pressure level meter. Because the human ear can detect variations in atmospheric pressure over such a large range of magnitudes, sound pressure is expressed on a logarithmic scale in units called decibels (dB). Noise is defined as “unwanted” sound.

Technically, sound pressure level (SPL) is defined as:

$$SPL = 20 \log (P/P_{ref}) \text{ dB}$$

where P is the sound pressure fluctuation (above or below atmospheric pressure) and P_{ref} is the reference pressure, 20 µPa, which is approximately the lowest sound pressure that can be detected by the human ear. For example:

If P = 20 µPa, then SPL = 0 dB
If P = 200 µPa, then SPL = 20 dB
If P = 2000 µPa, then SPL = 40 dB

The sound pressure level that results from a combination of noise sources is not the arithmetic sum of the individual sound sources, but rather the logarithmic sum. For example, two sound levels of 50 dB produce a combined sound level of 53 dB, not 100 dB. Two sound levels of 40 and 50 dB produce a combined level of 50.4 dB.

Human sensitivity to changes in sound pressure level is highly individualized. Sensitivity to sound depends on frequency content, time of occurrence, duration, and psychological factors such as emotions and expectations. However, in general, a change of 1 or 2 dB in the level of sound is difficult for most people to detect. A 3 dB change is commonly taken as the smallest perceptible change and a 6 dB change corresponds to a noticeable change in loudness. A 10 dB increase or decrease in sound level corresponds to an approximate doubling or halving of loudness, respectively.

A-Weighted Sound Level

Studies have shown conclusively that at equal sound pressure levels, people are generally more sensitive to certain higher frequency sounds (such as made by speech, horns, and whistles) than most lower frequency sounds (such as made by motors and engines)[1] at the same level. To address this preferential response to frequency, the A-weighted scale was developed. The A-weighted scale adjusts the sound level in each frequency band in much the same manner that the

[1] D.W. Robinson and R.S. Dadson, “A Re-Determination of the Equal-Loudness Relations for Pure Tones,” *British Journal of Applied Physics*, vol. 7, pp. 166 - 181, 1956. (Adopted by the International Standards Organization as Recommendation R-226.

human auditory system does. Thus the A-weighted sound level (read as "dBA") becomes a single number that defines the level of a sound and has some correlation with the sensitivity of the human ear to that sound. Different sounds with the same A-weighted sound level are perceived as being equally loud. The A-weighted noise level is commonly used today in environmental noise analysis and in noise regulations. Typical values of the A-weighted sound level of various noise sources are shown in Figure A-1.

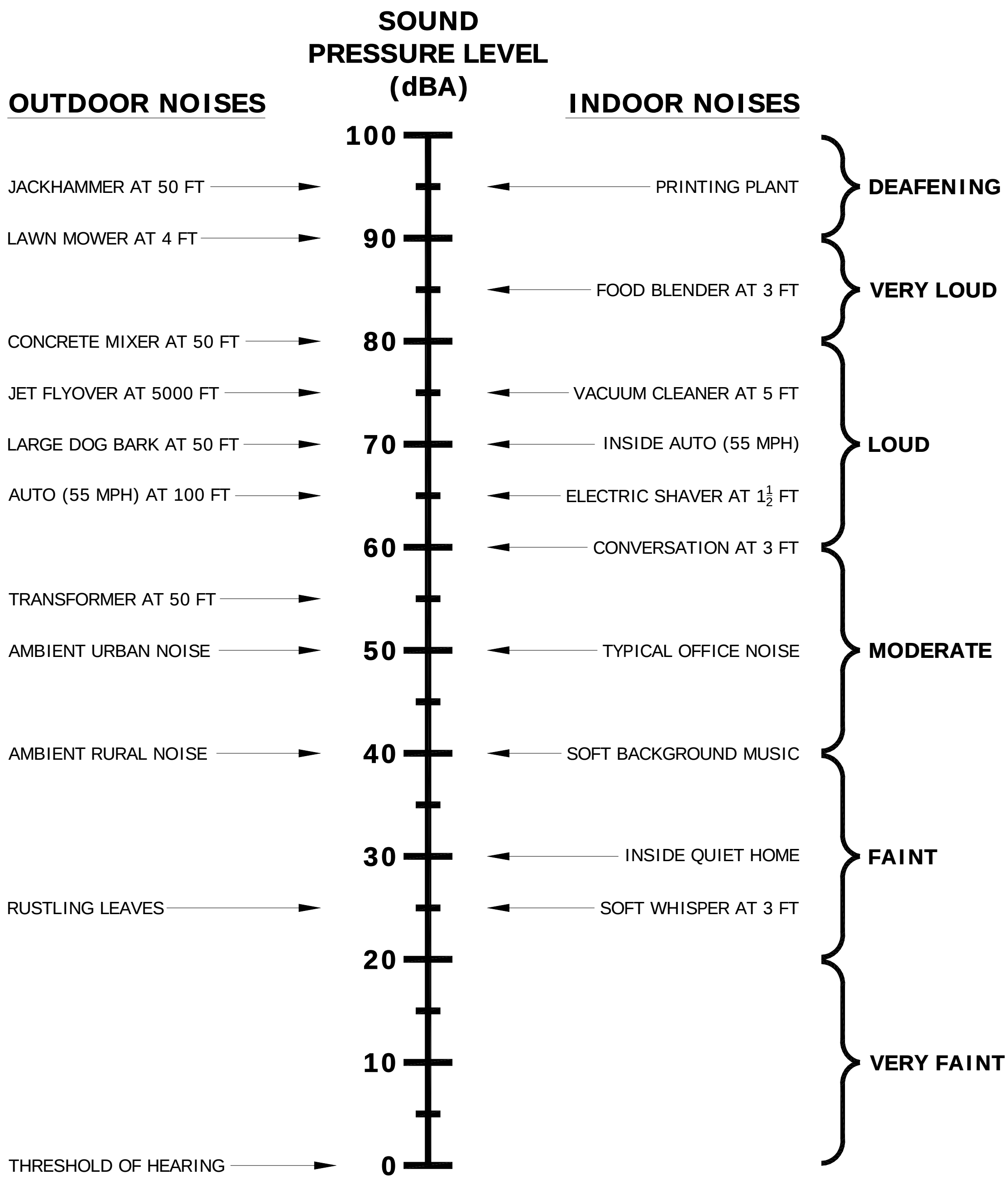

Figure A-1. Common Outdoor/Indoor Sound Levels

Equivalent Sound Level
The Equivalent Sound Level (L_{eq}) is a type of average which represents the steady level that, integrated over a time period, would produce the same energy as the actual signal. The actual *instantaneous* noise levels typically fluctuate above and below the measured L_{eq} during the measurement period. The A-weighted L_{eq} is a common index for measuring environmental noise. A graphical description of the equivalent sound level is shown in Figure A-2.

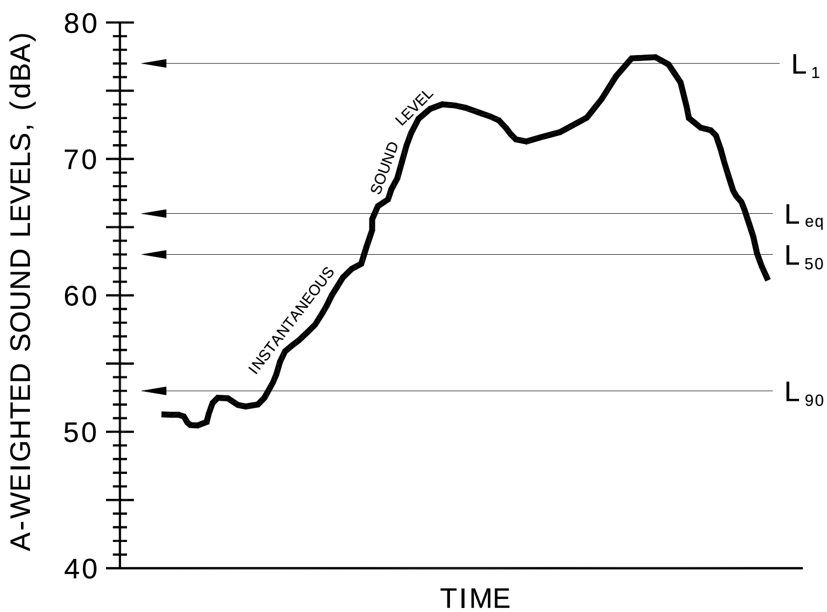

Figure A-2. Example Graph of Equivalent and Statistical Sound Levels

Statistical Sound Level
The sound levels of long-term noise producing activities such as traffic movement, aircraft operations, etc., can vary considerably with time. In order to obtain a single number rating of such a noise source, a statistically-based method of expressing sound or noise levels has been developed. It is known as the Exceedence Level, L_n. The L_n represents the sound level that is exceeded for n% of the measurement time period. For example, L_{10} = 60 dBA indicates that for the duration of the measurement period, the sound level exceeded 60 dBA 10% of the time. Typically, in noise regulations and standards, the specified time period is one hour. Commonly used Exceedence Levels include L_{01}, L_{10}, L_{50}, and L_{90}, which are widely used to assess community and environmental noise. A graphical description of the equivalent sound level is shown in Figure A-2.

Day-Night Equivalent Sound Level
The Day-Night Equivalent Sound Level, L_{dn}, is the Equivalent Sound Level, L_{eq}, measured over a 24-hour period. However, a 10 dB penalty is added to the noise levels recorded between 10 p.m. and 7 a.m. to account for people's higher sensitivity to noise at night when the background noise level is typically lower. The L_{dn} is a commonly used noise descriptor in assessing land use compatibility, and is widely used by federal and local agencies and standards organizations.

APPENDIX B

Photographs at Project Site

Location L3:
Approximately 135 feet west of the H-2 Freeway, adjacent to the Waiahole Ditch. (Photo faces east.)

Location L4
Approximately 135 feet west of the H-2 Freeway, in the vicinity of the Board of Water Supply Storage Tanks. (Photo faces east.)

K | Air Quality Study

AIR QUALITY STUDY

FOR THE PROPOSED

CASTLE & COOKE KOA RIDGE MAKAI AND

WAIAWA PROJECTS

CENTRAL OAHU, HAWAII

Prepared for:

Helber Hastert & Fee

January 2009

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Table

1.0 SUMMARY

Castle & Cooke is proposing to develop the Koa Ridge Makai and Waiawa Projects in the central Oahu area. The two proposed developments will include single- and multi-family homes, public and community facilities and commercial/retail/light industrial space. The projects are expected to be completed and fully occupied by 2025. This study examines the potential short- and long-term air quality impacts that could occur as a result of construction and use of the proposed projects and suggests mitigative measures to reduce any potential air quality impacts where possible and appropriate.

Both federal and state standards have been established to maintain ambient air quality. At the present time, seven parameters are regulated including: particulate matter, sulfur dioxide, hydrogen sulfide, nitrogen dioxide, carbon monoxide, ozone and lead. Hawaii air quality standards are comparable to the national standards except those for nitrogen dioxide and carbon monoxide which are more stringent than the national standards.

Regional and local climate together with the amount and type of human activity generally dictate the air quality of a given location. The climate of the central Oahu area is very much affected by its situation between the Koolau and Waianae Mountain Ranges. Winds are predominantly trade winds from the east northeast although probably deviated somewhat by the terrain. Occasional periods of kona storms may generate strong winds from the south. When the trade winds are weak, landbreeze-seabreeze circulations may develop. Wind speeds typically vary between about 5 and 15 miles per hour providing relatively good ventilation much of the time. Temperatures in the central Oahu area are generally very moderate with average daily temperatures ranging from about 65°F to 84°F. Rainfall in the central Oahu area is moderate with an average of about 40 to 50 inches per year.

The present air quality of the project area appears to be reasonably good based on nearby air quality monitoring data. Air quality data from the nearest monitoring stations operated by the Hawaii Department of Health suggest that all national air quality standards are currently being met, although occasional exceedances of the more stringent state standards for carbon monoxide may occur near congested roadway intersections.

If the proposed projects are given the necessary approvals to proceed, it may be inevitable that some short- and/or long-term impacts on air quality will occur either directly or indirectly as a consequence of project construction and use. Short-term impacts from fugitive dust will likely occur during the project construction phases. To a lesser extent, exhaust emissions from stationary and mobile construction equipment, from the disruption of traffic, and from workers' vehicles may also affect air quality during the period of construction. State air pollution control regulations require that there be no visible fugitive dust emissions at the property line. Hence, an effective dust control plan must be implemented to ensure compliance with state regulations. Fugitive dust emissions can be controlled to a large extent by watering of active work areas, using wind screens, keeping adjacent paved roads clean, and by covering of open-bodied trucks. Other dust control measures could include limiting the area that can be disturbed at any given time and/or mulching or chemically stabilizing inactive areas that have been worked. Paving and landscaping of project areas early in the construction schedule will also reduce dust emissions. Monitoring dust at the project boundary during the period of construction could be considered as a means to evaluate the effectiveness of the project dust control program. Exhaust emissions can be mitigated by moving construction equipment and workers to and from the project site during off-peak traffic hours.

After construction, motor vehicles coming to and from the proposed developments could potentially result in a long-term increase in air pollution emissions in the project area. To assess the impact of emissions from these vehicles, an air quality modeling study was undertaken to estimate current ambient concentrations of carbon monoxide at intersections in the project vicinity and to predict future levels with the proposed project. During worst-case conditions, model results indicated that present 1-hour and 8-hour carbon monoxide concentrations are within both the state and the national ambient air quality standards except possibly for the intersection of Kamehameha Highway and Waipahu Street. Analysis suggests that the more stringent state standards could potentially be exceeded during coincident worst-case traffic and worst-case atmospheric dispersion conditions at this location. With the project in the year 2025 and assuming that the roadway improvements identified in the project traffic study are implemented, carbon monoxide concentrations were estimated to decrease at most locations compared to the existing case except at the intersection of the H-2 northbound off ramp and Ka Uka Boulevard where a large increase was predicted. This indicates that at most locations the expected increase in traffic will be more than offset by the predicted decrease in average vehicle emissions over time. Even with the projected increased carbon monoxide concentrations at the intersection of the H-2 northbound off ramp and Ka Uka Boulevard, worst-case concentrations should remain within both national and state standards through the year 2025, and concentrations should comply with standards at all locations in the project area. Implementing mitigation measures for project traffic-related air quality impacts is probably unnecessary and unwarranted.

Depending on the demand levels, long-term impacts on air quality are also possible due to indirect emissions associated with a development's electrical power and solid waste disposal requirements. Quantitative estimates of these potential impacts were not made, but based on the estimated demand levels and emission rates involved, any impacts will likely be negligible. Nevertheless, incorporating energy conservation design features and promoting conservation and recycling programs within the proposed development could serve to further reduce any associated impacts.

2.0 INTRODUCTION

Castle & Cooke is proposing to develop the Koa Ridge Makai and Waiawa Projects on a total of approximately 766 acres of land in Central Oahu (see Figure 1 for project location). The sites for the projects straddle both sides of the H-2 Freeway near the Ka Uka Boulevard exit. The two developments will include a total of approximately 5,000 single- and multi-family homes, sites for parks, community centers, a church, schools, commercial/retail space, a medical complex, and light industrial space. Construction of the projects is expected to commence during 2010, and full development and occupancy is planned by 2025.

The purpose of this study is to describe existing air quality in the project area and to assess the potential short- and long-term direct and indirect air quality impacts that could result from construction and use of the proposed facilities as planned.

Measures to mitigate impacts by the projects are suggested where possible and appropriate.

3.0 AMBIENT AIR QUALITY STANDARDS

Ambient concentrations of air pollution are regulated by both national and state ambient air quality standards (AAQS). National AAQS are specified in Section 40, Part 50 of the Code of Federal Regulations (CFR), while State of Hawaii AAQS are defined in Chapter 11-59 of the Hawaii Administrative Rules. Table 1 summarizes both the national and the state AAQS that are specified in the cited documents. As indicated in the table, national and state AAQS have been established for particulate matter, sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone and lead. The state has also set a standard for hydrogen sulfide. National AAQS are stated in terms of both primary and secondary standards for most of the regulated air pollutants. National primary standards are designed to protect the public health with an "adequate margin of safety". National secondary standards, on the other hand, define levels of air quality necessary to protect the public welfare from "any known or anticipated adverse effects of a pollutant". Secondary public welfare impacts may include such effects as decreased visibility, diminished comfort levels, or other potential injury to the natural or man-made environment, e.g., soiling of materials, damage to vegetation or other economic damage. In contrast to the national AAQS, Hawaii State AAQS are given in terms of a single standard that is designed "to protect public health and welfare and to prevent the significant deterioration of air quality".

Each of the regulated air pollutants has the potential to create or exacerbate some form of adverse health effect or to produce environmental degradation when present in sufficiently high concentration for prolonged periods of time. The AAQS specify a maximum allowable concentration for a given air pollutant for one or more averaging times to prevent harmful effects. Averaging times vary from one hour to one year depending on the pollutant and type of exposure necessary to cause adverse effects. In the case of the short-term (i.e., 1- to 24-hour) AAQS, both national and state standards allow a specified number of exceedances each year.

The Hawaii AAQS are in some cases considerably more stringent than the comparable national AAQS. In particular, the Hawaii 1-hour AAQS for carbon monoxide is four times more stringent than the comparable national limit. The U.S. Environmental Protection Agency (EPA) is currently working on a plan to phase out the national 1-hour ozone standard in favor of the new (and more stringent) 8-hour standard.

The Hawaii AAQS for sulfur dioxide were relaxed in 1986 to make the state standards essentially the same as the national limits. In 1993, the state also revised its particulate standards to follow those set by the federal government. During 1997, the federal government again revised its standards for particulate, but the new standards were challenged in federal court. A Supreme Court ruling was issued during February 2001, and as a result, the new standards for particulate were finally implemented during 2005. To date, the Hawaii Department of Health has not updated the state particulate standards. In September 2001, the state vacated the state 1-hour standard for ozone and an 8-hour standard was adopted.

During the latter part of 2008, EPA revised the standard for lead making the standard more stringent. So far, the Hawaii

Department of Health has not revised the corresponding state standard for lead.

4.0 REGIONAL AND LOCAL CLIMATOLOGY

Regional and local climatology significantly affects the air quality of a given location. Wind, temperature, atmospheric turbulence, mixing height and rainfall all influence air quality. Although the climate of Hawaii is relatively moderate throughout most of the state, significant differences in these parameters may occur from one location to another. Most differences in regional and local climates within the state are caused by the mountainous topography.

Hawaii lies well within the belt of northeasterly trade winds generated by the semi-permanent Pacific high pressure cell to the north and east. On the island of Oahu, the Koolau and Waianae Mountain Ranges are oriented almost perpendicular to the trade winds, which accounts for much of the variation in the local climatology of the island. The site of the proposed project is located in central Oahu between the Koolau and Waianae Mountains at an elevation of about 500 ft.

Wind frequency data for Honolulu International Airport (HIA), which is located about 9 miles to the southeast of the project area, are given in Table 2. These data can be expected to be only semi-representative due to the differences in exposure and terrain effects. Wind frequency for HIA show that the annual prevailing wind direction for this area of Oahu is east northeast. On an annual basis, 34.7 percent of the time the wind is from this direction, and more than 70 percent of the time the wind is in the northeast quadrant. Winds from the south are infrequent occurring only a few days during the year and mostly in winter in association with kona storms. Wind speeds average about 10 knots (12 mph) and mostly vary between about 5 and 15 knots (6 and 17 mph).

Air pollution emissions from motor vehicles, the formation of photochemical smog and smoke plume rise all depend in part on air temperature. Colder temperatures tend to result in higher emissions of contaminants from automobiles but lower concentrations of photochemical smog and ground-level concentrations of air pollution from elevated plumes. In Hawaii, the annual and daily variation of temperature depend to a large degree on elevation above sea level, distance inland and exposure to the trade winds. Average temperatures at locations near sea level generally are warmer than those at higher elevations. Areas exposed to the trade winds tend to have the least temperature variation, while inland and leeward areas often have the most. The inland, higher-elevation location of the project sites results in a relatively moderate temperature profile compared to other coastal locations around Oahu and the state. Based on more than 50 years of data collected at the former Ewa Plantation a few miles away, average annual daily minimum and maximum temperatures in the Ewa Plain area are 65°F and 84°F, respectively [1]. The extreme minimum temperature on record is 47°F, and the extreme maximum is 93°F at this location. Temperatures at the project sites can be expected to be a few degrees cooler due to the higher elevation.

Small scale, random motions in the atmosphere (turbulence) cause air pollutants to be dispersed as a function of distance or time from the point of emission. Turbulence is caused by both mechanical and thermal forces in the atmosphere. It is oftentimes measured and described in terms of Pasquill-Gifford stability class. Stability class 1 is the most turbulent and class 6 the least. Thus, air pollution dissipates the best during stability class 1 conditions and the worst when stability class 6 prevails. In the project area, stability class 5 or 6 is generally the highest stability class that occurs, developing during clear, calm nighttime or early morning hours when temperature inversions form due to radiation cooling and mountain drainage flows. Stability classes 1 through 4 occur during the daytime, depending mainly on the amount of cloud cover and incoming solar radiation and the strength of the trade winds.

Mixing height is defined as the height above the surface through which relatively vigorous vertical mixing occurs. Low mixing heights can result in high ground-level air pollution concentrations because contaminants emitted from or near the surface can become trapped within the mixing layer. In Hawaii, minimum mixing heights tend to be high because of mechanical mixing caused by the trade winds and because of the temperature moderating effect of the surrounding ocean. Low mixing heights may sometimes occur, however, at inland locations and even at times along coastal areas early in the morning following a clear, cool, windless night. Coastal areas also may experience low mixing levels during sea breeze conditions when cooler ocean air rushes in over warmer land. Mixing heights in Hawaii typically are above 3000 feet (1000 meters).

Rainfall can have a beneficial affect on the air quality of an area in that it helps to suppress fugitive dust emissions, and it also may "washout" gaseous contaminants that are water soluble. Rainfall in Hawaii is highly variable depending on elevation and on location with respect to the trade wind. Rainfall is moderate in the central Oahu area averaging about 40 to 50 inches per year in the vicinity of the project sites.

5.0 PRESENT AIR QUALITY

Present air quality in the project area is mostly affected by air pollutants from motor vehicles, industrial sources, agricultural operations and to a lesser extent by natural sources. Table 3 presents an air pollutant emission summary for the island of Oahu for calendar year 1993. This has become somewhat dated but is the latest information available. The emission rates shown in the table pertain to manmade emissions only, i.e., emissions from natural sources are not included. As suggested in the table, much of the particulate emissions on Oahu originate from area sources, such as the mineral products industry and agriculture. Sulfur oxides are emitted almost exclusively by point sources, such as power plants and refineries. Nitrogen oxides emissions emanate predominantly from industrial point sources, although area sources (mostly motor vehicle traffic) also contribute a significant share. The majority of carbon monoxide emissions occur from area sources (motor vehicle traffic), while hydrocarbons are emitted mainly from point sources. Based on previous emission inventories that have been reported for Oahu, emissions of particulate and nitrogen oxides may have increased during the past several years, while emissions of sulfur oxides, carbon monoxide and hydrocarbons probably have declined.

The H-2 Freeway, which passes through the project area, is a major arterial roadway that presently carries moderate levels of vehicle traffic during peak traffic hours. Emissions from motor vehicles using this roadway, primarily nitrogen oxides and carbon monoxide, will tend to be carried over portions the project area by the prevailing winds.

Several sources of industrial air pollution are located in the Campbell Industrial Park, which is located at Barbers Point about 11 miles to the southwest of the project sites. Industries currently operating there include the Chevron and BHP refineries, H-Power, Kalaeloa Partners, Applied Energy Services, Hawaiian Cement and others. Hawaiian Electric Company’s Waiau Generating Station is located a few miles to the south at Pearl City. These industries emit large amounts of sulfur dioxide, nitrogen oxides, particulate matter, carbon monoxide and other air pollutants. Prevailing winds from the east or northeast will carry these emissions away from the project area most of the time.

Until recently, air pollution in the project area originating from agricultural sources could mainly be attributed to sugar cane operations in the Ewa area and to pineapple cultivation in the central Oaha area. Emissions from both the sugar mill and the canefield operations in the area have now been eliminated with the closure of the Oahu Sugar Company, and much of the former sugarcane lands are currently being used as pastureland or for diversified agriculture. Pineapple cultivation has been significantly reduced. Thus, air pollution from agricultural sources in the project area has been substantially reduced during the past several years.

Natural sources of air pollution emissions that also could affect the project area but cannot be quantified very accurately include the ocean (sea spray), plants (aero-allergens), wind-blown dust, and perhaps distant volcanoes on the island of Hawaii.

The State Department of Health operates a network of air quality monitoring stations at various locations on Oahu. Each station, however, typically does not monitor the full complement of air quality parameters. Table 4 shows annual summaries of air quality measurements that were made nearest to the project area for several of the regulated air pollutants for the period 2002 through 2006. These are the most recent data that are currently available.

During the 2002-2006 period, sulfur dioxide was monitored by the State Department of Health at an air quality station located at Kapolei, which is about 8 miles southwest of the project sites. Concentrations monitored were consistently low compared to the standards. Annual second-highest 3-hour concentrations (which are most relevant to the air quality standards) ranged from 12 to 28 $\mu g/m^3$, while the annual second-highest 24-hour concentrations ranged from 6 to 9 $\mu g/m^3$. Annual average concentrations were only about 1 to 5 $\mu g/m^3$. There were no exceedances of the state/national 3-hour or 24-hour AAQS for sulfur dioxide during the 5-year period.

Particulate matter less than 10 microns in diameter (PM-10) is measured at Pearl City, about 2 miles to the south of the project sites. Annual second-highest 24-hour PM-10 concentrations ranged from 27 to 99 $\mu g/m^3$ between 2002 and 2006. Average annual concentrations ranged from 15 to 16 $\mu g/m^3$. One exceedance of the 24-hour standard was reported in 2005. This exceedances was related to fireworks activity on New Years Day.

Carbon monoxide measurements were also made at the Kapolei monitoring station. The annual second-highest 1-hour concentrations ranged from 1.6 to 2.0 mg/m^3. The annual second-highest 8-hour concentrations ranged from 0.8 to 1.8 mg/m^3. No exceedances of the state or national 1-hour or 8-hour AAQS were reported.

Nitrogen dioxide is also monitored by the Department of Health at the Kapolei monitoring station. Annual average concentrations of this pollutant were consistently 9 $\mu g/m^3$, safely inside the state and national AAQS.

The nearest available ozone measurements were obtained at Sand Island (about 10 miles southeast of the project area). The second-highest 8-hour concentrations for the period 2002 through 2006 ranged between 77 and 108 $\mu g/m^3$, which is well inside the state and federal standards. The 8-hour standard for ozone did not exist prior to 2002. Prior to 2002, the now obsolete state 1-hour standard was typically exceeded several times each year.

Although not shown in the table, the nearest and most recent measurements of ambient lead concentrations that have been reported were made at the downtown Honolulu monitoring station between 1996 and 1997. Average quarterly concentrations were near or below the detection limit, and no exceedances of the state AAQS were recorded. Monitoring for this parameter was discontinued during 1997.

Based on the data and discussion presented above, it appears likely that the State of Hawaii AAQS for sulfur dioxide, nitrogen dioxide, ozone and lead are currently being met at the project sites. Concentrations of particulate matter normally comply with the standards except possibly during holiday fireworks activity. While carbon monoxide measurements at the Kapolei monitoring station suggest that concentrations are within the state and national standards, local “hot spots” may exist near traffic-congested intersections. The potential for this within the project area is examined later in this report.

6.0 SHORT-TERM IMPACTS OF PROJECT

Short-term direct and indirect impacts on air quality could potentially occur due to project construction. For a project of this nature, there are two potential types of air pollution emissions that could directly result in short-term air quality impacts during project construction: (1) fugitive dust from vehicle movement and soil excavation; and (2) exhaust emissions from on-site construction equipment. Indirectly, there also could be short-term impacts from slow-moving construction equipment traveling to and from the project site, from a temporary increase in local traffic caused by commuting construction workers, and from the disruption of normal traffic flow caused by lane closures of adjacent roadways.

Fugitive dust emissions may arise from the grading and dirt-moving activities associated with site clearing and preparation work. The emission rate for fugitive dust emissions from construction activities is difficult to estimate accurately. This is because of its elusive nature of emission and because the potential for its generation varies greatly depending upon the type of soil at the construction site, the amount and type of dirt-disturbing activity taking place, the moisture content of exposed soil in work areas, and the wind speed. The EPA [2] has provided a rough estimate for uncontrolled fugitive dust emissions from construction activity of 1.2 tons per acre per month under conditions of "medium" activity, moderate soil silt content (30%), and precipitation/evaporation (P/E) index of 50. Uncontrolled fugitive dust emissions at the project site would likely be somewhere near that level, depending on the amount of rainfall that occurs. In any case, State of Hawaii Air Pollution Control Regulations [3] prohibit visible emissions of fugitive dust from construction activities at the property line. Thus, an effective dust control plan for the project construction phase is essential.

Adequate fugitive dust control can usually be accomplished by the establishment of a frequent watering program to keep bare-dirt surfaces in construction areas from becoming significant sources of dust. In dust-prone or dust-sensitive areas, other control measures such as limiting the area that can be disturbed at any given time, applying chemical soil stabilizers, mulching and/or using wind screens may be necessary. Control regulations further stipulate that open-bodied trucks be covered at all times when in motion if they are transporting materials that could be blown away. Haul trucks tracking dirt onto paved streets from unpaved areas is often a significant source of dust in construction areas. Some means to alleviate this problem, such as road cleaning or tire washing, may be appropriate. Paving of parking areas and/or establishment of landscaping as early in the construction schedule as possible can also lower the potential for fugitive dust emissions. Monitoring dust at the project property line could be considered to quantify and document the effectiveness of dust control measures.

On-site mobile and stationary construction equipment also will emit air pollutants from engine exhausts. The largest of this equipment is usually diesel-powered. Nitrogen oxides emissions from diesel engines can be relatively high compared to gasoline-powered equipment, but the standard for nitrogen dioxide is set on an annual basis and is not likely to be violated by short-term construction equipment emissions. Carbon monoxide emissions from diesel engines, on the other hand, are low and should be relatively insignificant compared to vehicular emissions on nearby roadways.

Project construction activities will also likely obstruct the normal flow of traffic at times to such an extent that overall vehicular emissions in the project area will temporarily increase. The only means to alleviate this problem will be to attempt to keep roadways open during peak traffic hours and to move heavy construction equipment and workers to and from construction areas during periods of low traffic volume. Thus, most potential short-term air quality impacts from project construction can be mitigated.

7.0 LONG-TERM IMPACTS OF PROJECT

7.1 Roadway Traffic

After construction is completed, use of the proposed facilities will result in increased motor vehicle traffic in the project area, potentially causing long-term impacts on ambient air quality. Motor vehicles with gasoline-powered engines are significant sources of carbon monoxide. They also emit nitrogen oxides and other contaminates.

Federal air pollution control regulations require that new motor vehicles be equipped with emission control devices that reduce emissions significantly compared to a few years ago. In 1990, the President signed into law the Clean Air Act Amendments. This legislation requires further emission reductions, which have been phased in since 1994. More recently, additional restrictions were signed into law during the Clinton administration, which will begin to take effect during the next decade. The added restrictions on emissions from new motor vehicles will lower average emissions each year as more and more older vehicles leave the state's roadways. It is estimated that carbon monoxide emissions, for example, will go down by an average of about 30 to 40 percent per vehicle during the next 10 years due to the replacement of older vehicles with newer models.

To evaluate the potential long-term indirect ambient air quality impact of increased roadway traffic associated with a project such as this, computerized emission and atmospheric dispersion models can be used to estimate ambient carbon monoxide concentrations along roadways leading to and from the project. Carbon monoxide is selected for modeling because it is both the most stable and the most abundant of the pollutants generated by motor vehicles. Furthermore, carbon monoxide air pollution is generally considered to be a microscale problem that can be addressed locally to some extent, whereas nitrogen oxides air pollution most often is a regional issue that cannot be addressed by a single new development.

For this project, two scenarios were selected for the carbon monoxide modeling study: year 2008 with present conditions and year 2025 with the project. To begin the modeling study of the two scenarios, critical receptor areas in the vicinity of the project were identified for analysis. Generally speaking, roadway intersections are the primary concern because of traffic congestion and because of the increase in vehicular emissions associated with traffic queuing. For this study, several of the key intersections identified in the traffic study were also selected for air quality analysis. These included the following intersections:

- H-2 off ramp northbound at Ka Uka Boulevard
- Moaniani Street at Ka Uka Boulevard
- Ukee Street (west) at Ka Uka Boulevard
- Kamehameha Highway at Ka Uka Boulevard
- Kamehameha Highway at Waipio Uka Street
- Kamehameha Highway at Lumiaina Street
- Kamehameha Highway at Lumiauau Street
- Kamehameha Highway at Waipahu Street

The traffic impact report for the project [4] describes the projected future traffic conditions and laneage configurations of these intersections in detail. In performing the air quality impact analysis, it was assumed that all recommended traffic mitigation measures would be implemented.

The main objective of the modeling study was to estimate maximum 1-hour average carbon monoxide concentrations for each of the three scenarios studied. To evaluate the significance of the estimated concentrations, a comparison of the predicted values for each scenario can be made. Comparison of the estimated values to the national and state AAQS was also used to provide another measure of significance.

Maximum carbon monoxide concentrations typically coincide with peak traffic periods. The traffic impact assessment report evaluated morning and afternoon peak traffic periods. These same periods were evaluated in the air quality impact assessment.

The EPA computer model MOBILE6 [5] was used to calculate vehicular carbon monoxide emissions for each year studied. One of the key inputs to MOBILE6 is vehicle mix. Unless very detailed information is available, national average values are typically assumed, which is what was used for the present study. Based on national average vehicle mix figures, the present vehicle mix in the project area was estimated to be 38.0% light-duty gasoline-powered automobiles, 49.1% light-duty gasoline-powered trucks and vans, 3.6% heavy-duty gasoline-powered vehicles, 0.2% light-duty diesel-powered vehicles, 8.5% heavy-duty diesel-powered trucks and buses, and 0.6% motorcycles. For the future scenarios studied, the vehicle mix was estimated to change slightly with fewer light-duty gasoline-powered automobiles and more light-duty gasoline-powered trucks and vans.

Ambient temperatures of 59 and 68 degrees F were used for morning and afternoon peak-hour emission computations, respectively. These are conservative assumptions since morning/afternoon ambient temperatures will generally be warmer than this, and emission estimates given by MOBILE6 generally have an inverse relationship to the ambient temperature.

After computing vehicular carbon monoxide emissions through the use of MOBILE6, these data were then input to an atmospheric dispersion model. EPA air quality modeling guidelines [6] currently recommend that the computer model CAL3QHC [7] be used to assess carbon monoxide concentrations at roadway intersections, or in areas where its use has previously been established, CALINE4 [8] may be used. Until a few years ago, CALINE4 was used extensively in Hawaii to assess air quality impacts at roadway intersections. In December 1997, the California Department of Transportation recommended that the intersection mode of CALINE4 no longer be used because it was thought the model has become outdated. Studies have shown that CALINE4 may tend to over-predict maximum concentrations in some situations. Therefore, CAL3QHC was used for the subject analysis.

CAL3QHC was developed for the U.S. EPA to simulate vehicular movement, vehicle queuing and atmospheric dispersion of vehicular emissions near roadway intersections. It is designed to predict 1-hour average pollutant concentrations near roadway intersections based on input traffic and emission data, roadway/receptor geometry and meteorological conditions.

Input peak-hour traffic data were obtained from the traffic study cited previously. This included vehicle approach volumes, saturation capacity estimates, intersection laneage and signal timings. All emission factors that were input to CAL3QHC for free-flow traffic on roadways were obtained from MOBILE6 based on assumed free-flow vehicle speeds corresponding to the posted speed limits.

Model roadways were set up to reflect roadway geometry, physical dimensions and operating characteristics. Concentrations predicted by air quality models generally are not considered valid within the roadway-mixing zone. The roadway-mixing zone is usually taken to include 3 meters on either side of the traveled portion of the roadway and the turbulent area within 10 meters of a cross street. Model receptor sites were thus located at the edges of the mixing zones near all intersections that were studied for all three scenarios. This implies that pedestrian sidewalks either already exist or are assumed to exist in the future. All receptor heights were placed at 1.8 meters above ground to simulate levels within the normal human breathing zone.

Input meteorological conditions for this study were defined to provide "worst-case" results. One of the key meteorological inputs is atmospheric stability category. For these analyses, atmospheric stability category 6 was assumed for the morning cases, while atmospheric stability category 4 was assumed for the afternoon cases. These are the most conservative stability categories that are generally used for estimating worst-case pollutant dispersion within suburban areas for these periods. A surface roughness length of 100 cm and a mixing height of 1000 meters were used in all cases. Worst-case wind conditions were defined as a wind speed of 1 meter per second with a wind direction resulting in the highest predicted concentration. Concentration estimates were calculated at wind directions of every 5 degrees.

Existing background concentrations of carbon monoxide in the project vicinity are believed to be at low levels. Thus, background contributions of carbon monoxide from sources or roadways not directly considered in the analysis were accounted for by adding a background concentration of 1.0 ppm to all predicted concentrations for 2008. Although increased traffic is expected to occur within the project area during the next several years with or without the project, background carbon monoxide concentrations may not change significantly since individual emissions from motor vehicles are forecast to decrease with time. Hence, a background value of 1.0 ppm was assumed to persist for the future scenario studied.

Predicted Worst-Case 1-Hour Concentrations

Table 5 summarizes the final results of the modeling study in the form of the estimated worst-case 1-hour morning and afternoon ambient carbon monoxide concentrations. These results can be compared directly to the state and the national AAQS. Estimated worst-case carbon monoxide concentrations are presented in the table for two scenarios: year 2008 with existing traffic and year 2025 with the project. The locations of these estimated worst-case 1-hour concentrations all occurred at or very near the indicated intersections.

As indicated in the table, the highest estimated 1-hour concentration within the project vicinity for the present (2008) case was 9.9 mg/m^3. This was projected to occur during the morning peak traffic hour near the intersection of Kamehameha Highway and Waipahu Street. Concentrations at other locations and times studied were 7.1 mg/m^3 or lower. All predicted worst-case 1-hour concentrations for the 2008 scenario were within both the national AAQS of 40 mg/m^3 and the state standard of 10 mg/m^3, although the state standard was met by only a very small margin.

In the year 2025 with the proposed project, the predicted highest worst-case 1-hour concentration occurred during the afternoon at the intersection of the H-2 northbound ramp and Ka Uka Boulevard with a value of 6.8 mg/m^3, which is lower compared to the existing case. Other concentrations for this scenario ranged between 3.2 and 6.6 mg/m^3. With the project and assuming the roadway improvements identified in the project traffic study are implemented, carbon monoxide concentrations were predicted to decrease compared to the existing case at all locations studied except at the intersection of the H-2 northbound off ramp and Ka Uka Boulevard where an increase of about 50 to 75 percent would occur. Even with this relatively large increase, the predicted worst case carbon monoxide concentration at this location remained within the state and federal standards.

Predicted Worst-Case 8-Hour Concentrations

Worst-case 8-hour carbon monoxide concentrations were estimated by multiplying the worst-case 1-hour values by a persistence factor of 0.5. This accounts for two factors: (1) traffic volumes averaged over eight hours are lower than peak 1-hour values, and (2) meteorological conditions are more variable (and hence more favorable for dispersion) over an 8-hour period than they are for a single hour. Based on monitoring data, 1-hour to 8-hour persistence factors for most locations generally vary from 0.4 to 0.8 with 0.6 being the most typical. One study based on modeling [9] concluded that 1-hour to 8-hour persistence factors could typically be expected to range from 0.4 to 0.5. EPA guidelines [10] recommend using a value of 0.7 unless a locally derived persistence factor is available. Recent monitoring data for locations on Oahu reported by the Department of Health [11] suggest that this factor may range between about 0.2 and 0.6 depending on location and traffic variability. Considering the location of the project and the traffic pattern for the area, a 1-hour to 8-hour persistence factor of 0.5 will likely yield reasonable estimates of worst-case 8-hour concentrations.

The resulting estimated worst-case 8-hour concentrations are indicated in Table 6. For the 2008 scenario, the estimated worst-case 8-hour carbon monoxide concentrations for the eight locations studied ranged from 2.0 mg/m^3 at the H-2 northbound off ramp/Ka Uka Boulevard intersection to 5.0 mg/m^3 at the Kamehameha Highway/Waipahu Street intersection. The estimated worst-case concentrations for the existing case were within the national limit of 10 mg/m^3, but the concentration at the intersection of Kamehameha Highway and Waipahu Street equaled the state standard of 5 mg/m^3.

For the 2025 with project scenario, worst-case concentrations decreased at all locations compared to the existing case except at the intersection of the H-2 northbound off ramp and Ka Uka Boulevard where a significant increase was predicted. The worst-case concentrations ranged from 2.0 to 3.4 mg/m^3. All predicted 8-hour concentrations for this scenario were within both the national and the state AAQS.

Conservativeness of Estimates

The results of this study reflect several assumptions that were made concerning both traffic movement and worst-case meteorological conditions. One such assumption concerning worst-case meteorological conditions is that a wind speed of 1 meter per second with a steady direction for 1 hour will occur. A steady wind of 1 meter per second blowing from a single direction for an hour is extremely unlikely and may occur only once a year or less. With wind speeds of 2 meters per second, for example, computed carbon monoxide concentrations would be only about half the values given above. The 8-hour estimates are also conservative in that it is unlikely that anyone would occupy the assumed receptor sites (within 3 m of the roadways) for a period of 8 hours.

7.2 Electrical Demand

The proposed projects also will cause indirect air pollution emissions from power generating facilities as a consequence of electrical power usage. The peak electrical demand of the projects when fully developed is expected to reach about 50 megawatts [12]. Assuming the average demand is approximately one-half the peak demand, the annual electrical demand of the projects will reach approximately 220 million kilowatt-hours. Electrical power for the project will most probably be provided mainly by oil-fired generating facilities located on Oahu, but some of the project power could also come from sources burning other fuels, such as H-Power and the AES coal-fired power plant at Campbell Industrial Park. In order to meet the electrical power needs of the proposed project, power generating facilities will be required to burn more fuel and hence more air pollution will be emitted at these facilities. Given in Table 7 are estimates of the indirect air pollution emissions that would result from the project electrical demand assuming all power is provided by burning more fuel oil at Oahu's power plants. These values can be compared to the island-wide emission estimates for 1993 given in Table 3. The estimated indirect emissions from project electrical demand amount to less than 1 percent of the present air pollution emissions occurring on Oahu. If power is supplied instead or in part by coal or solid waste burning facilities, emissions will likely be higher than the values given in Table 7. Some of the emissions may be offset by the fact that some of the future residents will already be residents of Oahu.

7.3 Solid Waste Disposal

Solid waste generated by the proposed developments when fully completed and occupied is not expected to exceed about 26 tons per day [12]. Most project refuse will likely be hauled away and burned at the H-Power facility at Campbell Industrial Park to generate electricity. Burning of the waste to generate electricity will result in emissions of particulate, carbon monoxide and other contaminants, but these will be offset to some extent by reducing the amount of fuel oil that would be required to generate electricity for the project. Table 8 gives emission estimates assuming all project solid waste is burned at H-Power. These values can be compared to the island-wide emission estimates for 1993 given in Table 3. The estimated potential indirect emissions from project solid waste disposal demand amount to less than 0.1 percent of the present air pollution emissions occurring on Oahu.

8.0 CONCLUSIONS AND RECOMMENDATIONS

The major potential short-term air quality impact of the project will occur from the emission of fugitive dust during construction. Uncontrolled fugitive dust emissions from construction activities are estimated to amount to about 1.2 tons per acre per month, depending on rainfall. To control dust, active work areas and any temporary unpaved work roads should be watered at least twice daily on days without rainfall. Use of wind screens and/or limiting the area that is disturbed at any given time will also help to contain fugitive dust emissions. Wind erosion of inactive areas of the site that have been disturbed could be controlled by mulching or by the use of chemical soil stabilizers. Dirt-hauling trucks should be covered when traveling on roadways to prevent windage. A routine road cleaning and/or tire washing program will also help to reduce fugitive dust emissions that may occur as a result of trucks tracking dirt onto paved roadways in the project area. Paving of parking areas and establishment of landscaping early in the construction schedule will also help to control dust. Monitoring dust at the project boundary during the period of construction could be considered as a means to evaluate the effectiveness of the project dust control program and to adjust the program if necessary.

During construction phases, emissions from engine exhausts (primarily consisting of carbon monoxide and nitrogen oxides) will also occur both from on-site construction equipment and from vehicles used by construction workers and from trucks traveling to and from the project. Increased vehicular emissions due to disruption of traffic by construction equipment and/or commuting construction workers can be alleviated by moving equipment and personnel to the site during off-peak traffic hours.

By the year 2025, after construction of the proposed projects is completed and they are fully occupied, carbon monoxide concentrations in the project area will likely decrease at most locations compared to the existing case. This assumes that the roadway improvements identified in the project traffic study are implemented. The exception to this would be the intersection of the H-2 northbound off ramp and Ka Uka Boulevard. Although a relatively large increase in the carbon monoxide concentration is predicted at this location, worst-case concentrations should remain within both the state and the national ambient air quality standards. Implementing any air quality mitigation measures for long-term traffic-related impacts is probably unnecessary and unwarranted.

Any long-term impacts on air quality due to indirect emissions from supplying the project with electricity and from the disposal of waste materials generated by the project will likely be negligible based on the magnitudes of the estimated emissions compared to the current island-wide emissions. To further moderate any impacts, indirect emissions from project electrical demand could likely be reduced somewhat by incorporating energy-saving features into project design requirements. This might include the use of solar water heaters, water heater timers or possibly hot water on demand systems; designing building space so that window positions maximize indoor light without unduly increasing indoor heat; using landscaping where feasible to provide afternoon shade to cut down on the use of air conditioning; installation of insulation and double-glazed doors to reduce the effects of the sun and heat; movable, controlled openings for ventilation at opportune times; and possibly automated room occupancy sensors. Solid waste related air pollution could likely be reduced somewhat by the promotion of conservation and recycling programs within the proposed development.

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Figure 1 - Project Location

Table 1

SUMMARY OF STATE OF HAWAII AND NATIONAL AMBIENT AIR QUALITY STANDARDS

Pollutant	Units	Averaging Time	Maximum Allowable Concentration		
			National Primary	National Secondary	State of Hawaii
Particulate Matter (<10 microns)	$\mu g/m^3$	Annual 24 Hours	- 150[a]	- 150[a]	50 150[b]
Particulate Matter (<2.5 microns)	$\mu g/m^3$	Annual 24 Hours	15[c] 35[d]	15[c] 35[d]	- -
Sulfur Dioxide	$\mu g/m^3$	Annual 24 Hours 3 Hours	80 365[b] -	- - 1300[b]	80 365[b] 1300[b]
Nitrogen Dioxide	$\mu g/m^3$	Annual	100	100	70
Carbon Monoxide	mg/m^3	8 Hours 1 Hour	10[b] 40[b]	- -	5[b] 10[b]
Ozone	$\mu g/m^3$	8 Hours 1 Hour	157[e] 235[f]	157[e] 235[f]	157[e] -
Lead	$\mu g/m^3$	Calendar Quarter	0.15[g]	0.15[g]	1.5
Hydrogen Sulfide	$\mu g/m^3$	1 Hour	-	-	35[b]

[a] Not to be exceeded more than once per year on average over three years.
[b] Not to be exceeded more than once per year.
[c] Three-year average of the weighted annual arithmetic mean.
[d] 98th percentile value averaged over three years.
[e] Three-year average of fourth-highest daily 8-hour maximum.
[f] Standard is attained when the expected number of exceedances is less than or equal to 1.
[g] Rolling 3-month average.

Table 2

ANNUAL WIND FREQUENCY FOR HONOLULU INTERNATIONAL AIRPORT (%)

Wind Direction	Wind Speed (knots)									Total
	0-3	4-6	7-10	11-16	17-21	22-27	28-33	34-40	>40	
N	0.5	2.5	1.3	0.5	0.0	0.0	0.0	0.0	0.0	4.8
NNE	0.3	1.2	1.6	1.5	0.2	0.0	0.0	0.0	0.0	4.7
NE	0.3	2.1	6.1	11.0	3.2	0.3	0.0	0.0	0.0	23.0
ENE	0.2	2.5	10.9	16.6	4.1	0.3	0.0	0.0	0.0	34.7
E	0.1	1.0	2.5	2.8	0.5	0.0	0.0	0.0	0.0	7.0
ESE	0.0	0.3	0.4	0.3	0.0	0.0	0.0	0.0	0.0	1.1
SE	0.0	0.3	0.8	1.0	0.1	0.0	0.0	0.0	0.0	2.2
SSE	0.1	0.4	1.2	0.7	0.1	0.0	0.0	0.0	0.0	2.4
S	0.1	0.5	1.4	0.6	0.1	0.0	0.0	0.0	0.0	2.7
SSW	0.0	0.3	0.8	0.3	0.0	0.0	0.0	0.0	0.0	1.5
SW	0.0	0.2	0.8	0.4	0.0	0.0	0.0	0.0	0.0	1.5
WSW	0.0	0.3	0.5	0.4	0.0	0.0	0.0	0.0	0.0	1.2
W	0.1	0.5	0.2	0.0	0.0	0.0	0.0	0.0	0.0	1.1
WNW	0.2	1.4	0.3	0.1	0.0	0.0	0.0	0.0	0.0	2.0
NW	0.4	2.3	0.8	0.1	0.0	0.0	0.0	0.0	0.0	3.8
NNW	0.5	2.3	0.8	0.2	0.0	0.0	0.0	0.0	0.0	3.8
Calm	2.5									2.5
Total	5.4	18.3	30.6	36.5	8.5	0.7	0.0	0.0	0.0	100.0

Source: Climatography of the United States No. 90 (1965-1974), Airport Climatological Summary, Honolulu International Airport, Honolulu, Hawaii, U.S. Department of Commerce, National Climatic Center, Asheville, NC, August 1978.

Table 3

AIR POLLUTION EMISSIONS INVENTORY FOR ISLAND OF OAHU, 1993

Air Pollutant	Point Sources (tons/year)	Area Sources (tons/year)	Total (tons/year)
Particulate	25,891	49,374	75,265
Sulfur Oxides	39,230	nil	39,230
Nitrogen Oxides	92,436	31,141	123,577
Carbon Monoxide	28,757	121,802	150,559
Hydrocarbons	4,160	421	4,581

Source: Final Report, “Review, Revise and Update of the Hawaii Emissions Inventory Systems for the State of Hawaii”, prepared for Hawaii Department of Health by J.L. Shoemaker & Associates, Inc., 1996

Table 4

ANNUAL SUMMARIES OF AIR QUALITY MEASUREMENTS FOR MONITORING STATIONS NEAREST CASTLE & COOKE KOA RIDGE MAKAI AND WAIAWA PROJECTS

Parameter / Location	2002	2003	2004	2005	2006
Sulfur Dioxide / Kapolei					
3-Hour Averaging Period:					
No. of Samples	2420	2461	2504	2396	2526
Highest Concentration ($\mu g/m^3$)	47	26	17	64	12
2nd Highest Concentration ($\mu g/m^3$)	19	19	12	28	10
No. of State AAQS Exceedances	0	0	0	0	0
24-Hour Averaging Period:					
No. of Samples	344	351	355	333	363
Highest Concentration ($\mu g/m^3$)	9	9	7	21	8
2nd Highest Concentration ($\mu g/m^3$)	7	9	6	9	8
No. of State AAQS Exceedances	0	0	0	0	0
Annual Average Concentration ($\mu g/m^3$)	2	1	1	2	5
Particulate (PM-10) / Pearl City					
24-Hour Averaging Period:					
No. of Samples	243	329	335	336	325
Highest Concentration ($\mu g/m^3$)	66	30	32	195	87
2nd Highest Concentration ($\mu g/m^3$)	63	27	31	99	64
No. of State AAQS Exceedances	0	0	0	1	0
Annual Average Concentration ($\mu g/m^3$)	15	15	15	16	15
Carbon Monoxide / Kapolei					
1-Hour Averaging Period:					
No. of Samples	8354	8559	8507	8556	8615
Highest Concentration (mg/m^3)	2.2	2.2	2.4	1.7	1.6
2nd Highest Concentration (mg/m^3)	2.0	1.6	1.7	1.6	1.6
No. of State AAQS Exceedances	0	0	0	0	0
8-Hour Averaging Period:					
No. of Samples	1044	n/a	n/a	8551	8627
Highest Concentration (mg/m^3)	1.8	0.8	1.0	1.0	1.2
2nd Highest Concentration (mg/m^3)	1.8	0.8	1.0	1.0	1.2
No. of State AAQS Exceedances	0	0	0	0	0
Nitrogen Dioxide / Kapolei					
Annual Average Concentration ($\mu g/m^3$)	9	9	9	9	9
Ozone / Sand Island					
8-Hour Averaging Period:					
No. of Samples	8549	8641	8474	8670	8591
Highest Concentration (mg/m^3)	89	79	110	92	83
2nd Highest Concentration (mg/m^3)	88	77	108	92	83
No. of State AAQS Exceedances	0	0	0	0	0

Source: State of Hawaii Department of Health, “Annual Summaries, Hawaii Air Quality Data, 2002 - 2006”

Table 5

ESTIMATED WORST-CASE 1-HOUR CARBON MONOXIDE CONCENTRATIONS ALONG ROADWAYS NEAR CASTLE & COOKE KOA RIDGE MAKAI AND WAIAWA PROJECTS (milligrams per cubic meter)

Roadway Intersection	Year/Scenario			
	2008/Present		2025/With Project[a]	
	AM	PM	AM	PM
H-2 Off Ramp NB at Ka Uka Blvd	4.1	3.9	6.1	6.8
Moaniani Street at Ka Uka Blvd	6.9	5.1	5.2	4.4
Ukee Street (west) at Ka Uka Blvd	4.7	4.1	4.0	3.2
Kamehameha Highway at Ka Uka Blvd	5.5	4.7	4.7	4.1
Kamehameha Highway at Waipio Uka Street	7.1	5.3	6.1	4.3
Kamehameha Highway at Lumiaina Street	7.1	5.1	5.4	3.9
Kamehameha Highway at Lumiauau Street	5.3	4.4	4.5	3.6
Kamehameha Highway at Waipahu Street	9.9	5.9	6.6	3.9

Hawaii State AAQS: 10
National AAQS: 40

[a]Assumes roadway improvements shown in project traffic study

Table 6

ESTIMATED WORST-CASE 8-HOUR CARBON MONOXIDE CONCENTRATIONS ALONG ROADWAYS NEAR CASTLE & COOKE KOA RIDGE MAKAI AND WAIAWA PROJECTS (milligrams per cubic meter)

Roadway Intersection	Year/Scenario	
	2008/Present	2025/With Project[a]
H-2 Off Ramp NB at Ka Uka Blvd	2.0	3.4
Moaniani Street at Ka Uka Blvd	3.4	2.6
Ukee Street (west) at Ka Uka Blvd	2.4	2.0
Kamehameha Highway at Ka Uka Blvd	2.8	2.4
Kamehameha Highway at Waipio Uka Street	3.6	3.0
Kamehameha Highway at Lumiaina Street	3.6	2.7
Kamehameha Highway at Lumiauau Street	2.6	2.2
Kamehameha Highway at Waipahu Street	5.0	3.3

Hawaii State AAQS: 5
National AAQS: 10

[a]Assumes roadway improvements shown in traffic study

Table 7

ESTIMATED INDIRECT AIR POLLUTION EMISSIONS FROM CASTLE & COOKE KOA RIDGE MAKAI AND WAIAWA PROJECTS ELECTRICAL DEMAND[a]

Air Pollutant	Emission Rate (tons/year)
Particulate	6
Sulfur Dioxide	75
Carbon Monoxide	6
Volatile Organics	<1
Nitrogen Oxides	31

[a]Based on U.S. EPA emission factors for utility boilers [2]. Assumes electrical demand of 220 million kilowatt-hrs per year and low-sulfur oil used to generate power.

Table 8

**ESTIMATED INDIRECT AIR POLLUTION EMISSIONS FROM
CASTLE & COOKE KOA RIDGE MAKAI AND WAIAWA PROJECTS
SOLID WASTE DISPOSAL DEMAND[a]**

Air Pollutant	Emission Rate (tons/year)
Particulate	<1
Sulfur Dioxide	3
Carbon Monoxide	3
Volatile Organics	<1
Nitrogen Oxides	10
Lead	<1

[a]Based on U.S. EPA emission factors for municipal waste incinerators [2]. Assumes mass burn unit with 99 percent control of particulate emissions and solid waste disposal demand of 26 tons per day.

L | Phase I Environmental Site Assessment

PHASE I
ENVIRONMENTAL SITE ASSESSMENT

Koa Ridge Makai Development
Ka Uka Boulevard
Mililani, Hawaii 96789
TMK (1) 9-4-6: Parcels 1 (portion), 2 (portion), 38 and 39
TMK (1) 9-5-3: Parcels 1 (portion) and 4 (portion)

Prepared For:
CASTLE & COOKE HOMES HAWAII, INC.
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ETC Project No. 08-1014

October 2008

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APPENDICES

1.0 EXECUTIVE SUMMARY

This report presents the results of a Phase I Environmental Site Assessment (ESA) performed by EnviroServices & Training Center, LLC (ETC) in conformance with the scope and limitations of the American Society for Testing and Materials (ASTM) Practice E1527-05. This Phase I ESA was completed for Castle & Cooke Homes Hawaii, Inc. for the Subject Property located along Ka Uka Boulevard in Mililani, Hawaii and identified as Tax Map Key (TMK) identification numbers (1) 9-4-6: Parcels 1 (portion), 2 (portion), 38, and 39; and (1) 9-5-3: Parcels 1 (portion) and 4 (portion). Review of tax records revealed that the Subject Property is currently owned by Castle & Cooke Homes Hawaii, Inc.

ETC conducted a visual observation for the use and/or storage of hazardous materials and hazardous waste on September 10 and 12, 2008. During ETC's site reconnaissance activities, solid waste (i.e. construction and demolition debris and miscellaneous rubbish) was observed along the southwest portion of the Subject Property. In addition, batteries, automobile parts and an abandoned car were also observed. No releases were observed, however the quantities of solid waste and moderate vegetation made it infeasible to adequately and fully characterize the potential impact. In accordance with Hawaii Administrative Rules Title 11, Department of Health, Chapter 58.1 (HAR §11-58.1) property owners are responsible for "removing accumulated solid waste to an approved solid waste disposal facility." Although the waste did not appear to pose a material threat to human health or the environment, it may be the subject of an enforcement action if brought to the attention of appropriate government officials. Therefore, the presence of the solid waste and the potential impacts to underlying soil from the solid waste are considered a recognized environmental condition (REC).

The Subject Property was not listed in any of the government databases by the contracted database search. However, the contracted database search identified four (4) (4) SHWS sites, two (2) LUST sites, and twenty-eight (28) Orphan sites located within the specified radii. Based on these findings, ETC requested and reviewed select facility files from the Hawaii Department of Health (DOH) Solid and Hazardous Waste Branch (SHWB) and DOH Hazard Evaluation and Emergency Response (HEER) Office.

File review indicated that the *Waipio Heights Wells II* and *Mililani Wells I* facilities along with several other Central Oahu wells were found to be contaminated with various chemicals in the 1980s and 1990s. Specifically, trichloropropane (TCP), trichloroethylene (TCE), and dibromochloropropane (DBCP) were detected in drinking water samples collected from the *Waipio Heights Wells II* and/or *Mililani Wells I* were detected in drinking water samples collected from these wells. The source of the contamination was suspected to have originated from the agricultural usage of the central Oahu area, specifically pineapple cultivation. TCP and DBCP are either constituents or impurities of soil fumigants which were noted to have been used by Dole Company during the 1950s to 1977. The potential presence of residual contaminants associated with the former usage and/or application of fertilizers, pesticides, fumigants and/or herbicides on the Subject Property is considered a REC.

File review also indicated that the point source of the TCE contamination was suspected to have been the result of various releases from the Kipapa Petroleum, Oils, and Lubricants (POL) Storage area and/or the POL pipeline. A portion of the POL pipeline is located on the Subject Property which includes two valve pits (VP 18 and VP19). File review did not reveal any releases from the portion of the POL pipeline on the Subject Property. However, in the 1950s, several large fuel releases associated with the POL pipeline were noted. A Remedial Investigation and Feasibility Study (RI/FS) to assess potential releases from the POL pipeline is currently ongoing. The potential presence of residual contamination associated with the historic releases and presence of the POL pipeline on the Subject Property is considered a REC.

Based on ETC's database and file review, none of the remaining database identified facilities appeared to pose a reasonable risk of impacting the Subject Property.

Historical real property tax records, aerial photographs, file review and user provided documentation and references indicated past and prior use of the Subject Property for pineapple cultivation and possibly sugar cultivation. In addition, interview findings also confirmed that the Subject Property was formerly used for agricultural purposes. Activities commonly associated with commercial pineapple and/or sugar cultivation include the use and application of fertilizers, pesticides, fumigants and/or herbicides. This finding is considered a historical REC. Based on the past and prior use of the Subject Property, ETC cannot dismiss the potential presence of contamination for this historical REC and as such this past use is considered a REC for the Subject Property.

In summary, ETC performed a Phase I ESA in conformance with the scope and limitations of ASTM Practice E1527-05 on the Subject Property. This assessment has revealed no evidence of recognized environmental conditions in connection with the Subject Property except for the following:

- Potential presence of residual contaminants associated with the historic usage of the Subject Property for commercial pineapple and possible sugar cultivation.
- Presence of solid waste observed on the Subject Property (i.e. construction and demolition debris, tires, batteries, abandoned car, car parts/portions, etc.) and the potential impact to the underlying soil from the solid waste.
- Potential presence of residual contamination associated with historic releases and operation of the POL pipeline on the Subject Property and surrounding areas.

2.0 INTRODUCTION

EnviroServices & Training Center, LLC (ETC) was contracted by Castle & Cooke Homes Hawaii, Inc. (CCHHI) to complete a Phase I Environmental Site Assessment (ESA) for the Subject Property.

This Phase I ESA was performed in accordance with the ASTM International Standard E1527-05 entitled *Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process* (referred to herein as the ASTM Practice). The ASTM Practice is intended for use by parties who wish to assess the environmental condition of commercial real estate with respect to contaminants within the scope of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and petroleum products. As such, the ASTM Practice was designed to satisfy "all appropriate inquiry into the previous ownership and uses of the property consistent with good commercial or customary practice" as defined in 42 United States Code (U.S.C.) §9601(35)(B).

2.1 Background

Under CERCLA, persons may be held liable for cleaning up hazardous substances at properties that they either currently own or operate, or owned or operated at the time of disposal. Strict liability in the context of CERCLA means that a potentially responsible party may be liable for environmental contamination based solely on property ownership and without regard to fault or negligence.

In 1986, the Superfund Amendments and Reauthorization Act (SARA) amended CERCLA by creating an "innocent landowner" defense to CERCLA liability for those persons who could successfully demonstrate, among other requirements, that they "did not know and had no reason to know" prior to purchasing the property that any hazardous substance that is the subject of a release or threatened release was disposed of on, in, or at the property. Such persons, to demonstrate that they had "no reason to know" must have undertaken, prior to, or on the date of acquisition of the property, "all appropriate inquiries" into the previous ownership and uses of the property consistent with good commercial or customary standards and practices.

The Small Business Liability Relief and Brownfields Revitalization Act (referred to as "the Brownfields Amendments") were enacted in January 2002 to amend CERCLA. These amendments included providing funds to assess and clean up brownfields sites, clarifying CERCLA liability provisions for certain landowners, and providing funding to enhance state and tribal cleanup programs.

Subtitle B of Title II of the Brownfields Amendments revised CERCLA, clarifying the requirements necessary to establish the innocent landowner defense. The Brownfields Amendments also added protections from CERCLA liability for "bona fide prospective purchasers" and "contiguous property owners" who meet certain statutory requirements. Each of the CERCLA liability provisions for innocent landowners, bona fide prospective purchasers, and contiguous property owners (referred to collectively as "landowner liability protections," or LLPs) requires that, among other requirements, persons claiming the liability protections conduct all appropriate inquiries into prior ownership and use of a property prior to or on the date a person acquires a property.

A key provision of the Brownfields Amendments was to finalize regulations setting federal standards for the conduct of all appropriate inquiries. Such federal standards were promulgated in the *Standards and Practices for All Appropriate Inquiries, Final Rule, 40 CFR Part 312*, referred to as the AAI Final Rule.

Section 312.11 of the AAI Final Rule indicates that the ASTM International Standard E1527-05, entitled *Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process*, may be used to comply with the requirements set forth in Sections 312.23 through 312.31 of the AAI Final Rule. Therefore, this Phase I ESA was performed in conformance with the ASTM International Standard E1527-05.

2.2 Purpose

The purpose and goal of this Phase I ESA is to conduct an inquiry designed to identify recognized environmental conditions in connection with the Subject Property, to the extent feasible pursuant to the process described in the ASTM Practice. The term recognized environmental condition (REC) is defined as:

> "The presence or likely presence of any hazardous substances or petroleum products on a property under conditions that indicate an existing release, a past release, or a material threat of a release of any hazardous substances or petroleum products into structures on the property or into the ground, groundwater, or surface water of the property. The term includes hazardous substances or petroleum products even under conditions in compliance with laws. The term is not intended to include *de minimis* conditions that generally do not present a threat to human health or the environment and that generally would not be the subject of an enforcement action if brought to the attention of appropriate governmental agencies. Conditions determined to be *de minimis* are not recognized environmental conditions."

2.3 Scope of Services

The scope of work included the following:

- Development of a site description for the Subject Property including site background, physical characteristics and historical site conditions;
- Evaluation of user provided information including but not limited to environmental liens, activity and use limitations, specialized knowledge, valuation reduction of environmental issues, and other information pertaining to the property;
- Evaluation of information in programs such as NPL, CERCLIS, FINDS, ERNS, RCRA notifiers, and other governmental information systems within specific radii of the property to identify sites that would have the potential to impact the property;
- Visual evaluation of current site conditions (as applicable) including compliance with appropriate regulations as they pertain to the presence of facility storage tanks, drums, and containers; and transformers and other electrical equipment potentially containing PCBs;
- Visual evaluation of the adjacent properties to identify high-risk neighbors and the potential for a chemical to migrate onto the property; and
- Interviews with owner(s), site manager(s), occupant(s), local government official(s), and/or other individuals with past and prior use history of the property.

2.4 Significant Assumptions

This Phase I ESA is limited by the availability of information at the time of the assessment. Interviews were conducted and interviewee's responses were assumed to be answered in good faith, to the extent of his/her actual knowledge. In addition, since no hydrogeological data was available for the Subject Property, the groundwater was assumed to flow in the direction of the surface topography of the Subject Property and surrounding areas.

2.5 Conditions and Limitations

ETC has completed this Phase I ESA for the Subject Property in accordance with the scope and limitations of ASTM Practice E1527-05. ETC's findings and conclusions contained herein are professional opinions based solely upon visual observations, interviews, and interpretation of the historical information and documents available to ETC at the time this Phase I ESA was conducted. Opinions stated in this report do not apply to changes that may have occurred after the services were performed.

ETC has performed specified services for this project with the degree of care, skill and diligence ordinarily exercised by professional consultants performing the same or similar services. No other warranty, guarantee, or representation, expressed or implied, is included or intended; unless otherwise specifically agreed to in writing by both ETC and ETC's Client.

2.6 User Reliance

This report is intended for the sole use of ETC's Client, exclusively for the project site indicated. ETC's Client may use and release this report, including making and retaining copies, provided such use is limited to the particular site and project for which this report is provided. However, the services performed may not be appropriate for satisfying the needs of other users. Release of this report to third-parties will be at the sole risk of Client and/or said user, and ETC shall not be liable for any claims or damages resulting from or connected with such release or any third party's use or reuse of this report.

2.7 Environmental Professional Certification

We declare that, to the best of our professional knowledge and belief, we meet the definition of *Environmental Professional* as defined in §312.10 of 40 CFR 312. We have the specific qualifications based on education, training, and experience to assess a property of the nature, history, and setting of the Subject Property. We have developed and performed the all appropriate inquiries in conformance with the standards and practices set forth in 40 CFR Part 312.

Prepared by: ______________________________

Sharla Nakashima
Environmental Professional
EnviroServices & Training Center, LLC

3.0 SITE DESCRIPTION

3.1 Location and Description

The Subject Property, located along Ka Uka Boulevard consists of approximately 575 acres of land and is located in Mililani, Oahu, Hawaii (Appendix I, Figure 1). The Subject Property is identified as Tax Map Key (TMK) identification numbers (1) 9-4-6: Parcels 1 (portion), 2 (portion), 38, and 39; and (1) 9-5-3: Parcels 1 (portion) and 4 (portion). A site map is included in Appendix I, Figure 2. Photographic documentation is included in Appendix II.

3.2 Physical Setting

Groundcover at the Subject Property generally consists of moderate to dense vegetation. Asphalt and concrete paved areas were limited to the Waiawa Prison Road, which bisects the eastern parcels of the Subject Property. The Subject Property and surrounding areas exhibited a varying gradient with moderate to steep slopes along the border of the Kipapa Gulch.

3.2.1 Site Topography

Topographic map coverage of the Subject Property vicinity is provided by the United States Geological Survey, Island of Oahu, 7.5 minute Waipahu Quadrangle, 1998. The elevation of the Subject Property is between 300 and 750 feet above mean sea level (msl).

3.2.2 Regional Geology

Oahu is formed by the erosional remnants of two shield volcanoes. These are the Waianae range to the west and the Koolau range to the east. The Waianae volcano is estimated to have formed 2.4 to 3.6 million years before present. It consists of a tholeiitic lava shield with a thick cap of transitional to alkalic rock. Rejuvenation-stage volcanics of undifferentiated age occur in Kolekole Pass and on the south flank of the Waianae shield. Dike orientations define northwest and southwest rift zones (Macdonald, et al., 1983).

The Koolau volcano is estimated to have formed 1.8 to 2.6 million years before the present (Macdonald, et al., 1983). It consists of a tholeiitic lava shield and lacks an alkalic cap. It has well defined major dike complex trending northwest-southwest. A third, minor rift zone referred to as the Kaau rift trends southward from Kaau crater, near the upland crest of the Koolau Ridge. After a long dormant period and periods of deep erosion, the Koolau volcano developed abundant and scattered rejuvenation-stage vents, typically aligned on northeast-striking fissures (Macdonald, et al., 1983).

3.2.3 Site Geology

The soil at the Subject Property is mapped as a combination of Wahiawa silty clay, 0 to 3 percent slopes (WaA); Wahiawa silty clay, 3 to 8 percent slopes (WaB); Wahiawa silty clay, 8 to 15 percent slopes (WaC); Manana silty clay, 3 to 8 percent (MpB); Manana silty clay, 8 to 15 percent slopes (MpC); Lahaina silty clay, 3 to 7 percent slopes (LaB); Lahaina silty clay, 7 to 15 percent slopes, severely eroded (LaC3); Molokai silty clay loam, 3 to 7 percent slopes (MuB); and Helemano silty clay, 30 to 90 percent slopes (HLMG).

The majority of the Subject Property is mapped as part of the Wahiawa Series. Soil within the southern portion of the western parcels of the Subject Property are mapped a WaA, while soils within the northern portion of the western parcels and the southern portion of the eastern parcels are mapped as WaB. Soils within the eastern parcels are mapped as WaC. The Wahiawa series consists of well drained soils on the uplands of the island of Oahu developed in residuum and old alluvium from basic igneous rock. WaA, WaB, and WaC consist of a very dusky red silty clay surface layer approximately 12 inches thick. The subsoil, which is about 48 inches thick, consists of dark redish-brown silty clay that has a subangular blocky structure. This material is further underlain by weathered basic igneous rock. Acidity of the soil type ranges from medium acid to neutral, permeability is moderately rapid, runoff is slow and the erosion hazard is slight. In WaC soils, the runoff is mediume and the erosion hazard is moderate. Annual rainfall generally amounts to 40 to 60 inches. These soils are typically used for sugarcane, pineapple, pasture, and homesites. The natural vegetation consists of bermudagrass, guava, honohono, koa haole, and lantana.

Soils within the eastern portion of the eastern parcels of the Subject Property as well as soils within a portion of the center of the western parcels are characterized by the Manana Series, MpB and MpC. The series consists of well-drained soils on the uplands of the island of Oahu developed in material weathered from basic igneous rock. In a representative profile, MpC and MpD consist of an 8 inch thick surface layer of dark reddish-brown silty clay loam. The subsoil, which is about 42 inches thick, is dusky red, dark reddish-gray, and dark reddish-brown silty clay that has a subangular blocky structure. This subsoil also contains a nonporous, panlike sheet, measuring 1/8 inch to a 1/4 inch thick located at depths from 15 to 50 inches below ground surface. This material is further underlain by soft, weathered basic igneous rock which is extremely acid. Permeability is moderately rapid above the pan and moderate below, runoff is medium, and the erosion hazard is slight. Annual rainfall generally amounts to 40 to 60 inches. Manana soils are typically used for sugarcane, pineapple, and pasture. The natural vegetation consists of bermudagrass, Christmas berry, false staghornfern, glenwoodgrass, guava, koa, ohia, and sedges.

Soils within the western parcels of the Subject Property are defined on the southwestern corner by the Lahaina Series, LaB and LaC3. The series consists of well-drained soils on uplands of the islands of Lanai, Maui, Molokai, and Oahu. These soils developed in material weathered from basic igneous rock. In a representative profile, LaB soils have a surface layer about 15 inches thick of dark reddish-brown, silty clay. The subsoil, which is about 45 inches thick, is dusky-red and dark reddish-brown silty clay and silty clay loam in subangular blocky structure. The material is further underlain by soft, weathered basic igneous rock. The soils range from medium acid in the surface layer and slightly acid to medium acid in the subsoil. Permeability is moderate, runoff is slow, and the erosion hazard is slight. LaC3 soils have the same profile as the LaB soils except that the surface layer and part of the subsoil has been removed by erosion. The runoff is medium and the erosion hazard is severe. These soils are typically used for sugarcane and pineapple farming. The natural vegetation consists of bermudagrass, feather fingergrass, ilima, kiawe, lantana, oi, and uhaloa.

Soils within the western parcels of the Subject Property are further mapped in the south as MuB. MuB consists of well-drained soils on uplands on the islands of Maui, Lanai, Molokai, and Oahu. These soils formed in material weathered from basic igneous rock. The surface layer is dark reddish-brown silty clay loam about 15 inches thick. The subsoil, which is about 57 inches thick, is dark reddish-brown silty clay loam with a prismatic structure. Additionally, the material is moderately compact in place at depths between 35 and 64 inches. The material is further underlain by soft, weathered rock. The soil acidity ranges from slight to neutral, except in areas used for pineapple cultivation where the surface layer can be strongly to extremely acidic. The runoff is slow to medium and the erosion hazard is slight to moderate. These soils are typically used for sugarcane, pineapple, pasture, wildlife habitat, and homesites. The natural vegetation consists of kiawe, ilima, uhaloa, feather fingergrass, and buffelgrass.

Soils along the gulch areas (west and north borders) of the Subject Property are mapped as HLMG. HLMG consists of well-drained soils on alluvial fans and colluvial slopes on the sides of V-shaped gulches on the island of Oahu. HLMG formed in alluvium and colluvium derived from basic igneous rock. The surface layer is dark reddish-brown silty clay about 10 inches thick. The subsoil, which is about 50 inches thick, is dark reddish-brown and dark-red silty clay that has subangular blocky structure. This material is further underlain by soft, highly weathered basic igneous rock. Acidity of the soil ranges from slightly acid to neutral, permeability is moderate, runoff is medium to very rapid, and the erosion hazard is severe to very severe. The annual rainfall dominantly amounts to 30 to 60 inches but ranges to 75 inches at the highest vegetation. These soils are typically used for pasture, woodland, and wildlife habitat. The natural vegetation consists of bermudagrass, Christmas berry, eucalyptus, Formosa koa, guava, Japanese tea, Java plum, and koa haole. (USDA, 1972)

3.2.4 Regional Hydrogeology

The primary drinking water in the Hawaiian Islands is drawn from basal groundwater. Basal groundwater is formed by rainwater percolating down through the residual soils and permeable volcanic rock. All of the island situated below sea level, except within rift zones of the volcanoes, is saturated with ocean salt water and thus forms a basal lens called the "Ghyben-Herzberg" lens. A zone of transition between the fresh groundwater and the ocean salt water occurs due to the constant movement of the interface as a result of tidal fluctuations, seasonal fluctuations in recharge and discharge and aquifer development (Macdonald, et al., 1983).

Downward percolation of rainwater may be stopped by impermeable layers such as dense lava flows, alluvial clay layers and volcanic ash. The groundwater then forms a perched or high level aquifer, which is not in contact with salt water. Recharge of the aquifer occurs in areas of high rainfall, which are the interior mountainous areas. The groundwater flows from the recharge areas to the areas of discharge along the shoreline. Frictional resistance to groundwater flow causes it to pile up within the island until it attains sufficient hydraulic head to overcome friction. Thus, basal groundwater tends to slope toward the shoreline.

3.2.5 Site Hydrogeology

The majority of the Subject Property is underlain by the Waiawa Aquifer System, which is part of the Pearl Harbor Aquifer Sector on the island of Oahu. The aquifer is classified by Mink and Lau, 1990, with the system identification number 30202111 (11111). This system includes an unconfined, basal aquifer in flank, horizontally extensive lava. The groundwater in this aquifer is described as a currently used, fresh drinking water source with salinity less than 250 mg/l Cl^-. The groundwater is also described as irreplaceable with a high vulnerability to contamination (Mink and Lau, 1990). The southwestern portion of the parcels on the west side of the Subject Property are underlain by the Waipahu Aquifer System, which is part of the Pearl Harbor Aquifer Sector on the island of Oahu. The aquifer is classified by Mink and Lau, 1990, with the system identification number 30203111 (11111) and has the same characteristics as the Waiawa Aquifer System.

3.2.6 Nearest Surface Water Bodies

There are several surface water bodies adjacent to and within the Subject Property. The eastern parcels are traversed by an intermittent ditch/siphon which appears to be a tributary of the Panakauahi Gulch. The Panakauahi Gulch flows intermittently between the eastern and western portions of the Subject Property to the Waiawa Stream. The western parcels are also traversed by several separate intermittent ditches/siphons, which appear to be tributaries of the Kipapa Stream. The Kipapa Stream is located along the western boundary of the Subject Property.

3.3 Current Use of the Subject Property

The south portion of the Subject Property is currently used for diversified agriculture (i.e. taro, lettuce, basil, etc.) by Aloun Farms. The north portion of the Subject typically is currently unoccupied and consisted of moderate vegetation.

3.4 Current Uses of the Adjoining Properties

ETC visually inspected the neighboring properties and their operations from publicly accessible areas. The Subject Property is bordered by Ka Uka Boulevard to the south, commercial businesses and Kamehameha Highway to the southwest, Kipapa Gulch to the west and north, and the H-2 Interstate to the east. Photographic documentation of the Subject Property and adjoining properties is included in Appendix II.

4.0 USER PROVIDED INFORMATION

This section is intended to provide information obtained from the user of this Phase I ESA that will help identify RECs associated with the Subject Property. The information provided does not require the user to have the technical expertise of an environmental professional and are generally not provided by the environmental professional performing the Phase I ESA.

4.1 Required Information

In order to qualify for one of the LLPs offered by the Brownfields Amendments, the user must provide the following information (if available) to the environmental professional. Failure to provide this information could result in a determination that "all appropriate inquiry" is not complete. Mr. Ray Kunishige of CCHHI ("user") provided ETC with the following information.

4.1.1 Environmental Liens

The user had no knowledge of any environmental liens or governmental notifications relating to past or recurrent violations of environmental laws with respect to the Subject Property.

4.1.2 Activity and Use Limitations

The user had no knowledge of any other activity and land use limitations filed or recorded in a registry under federal, tribal, state or local law.

4.1.3 Specialized Knowledge

The user had no specialized knowledge or experience related to the Subject Property or nearby properties.

4.1.4 Valuation Reduction for Environmental Issues

The user indicated that the determination whether the purchase price being paid for the Subject Property reflects the fair market value of the Subject Property was not available.

4.1.5 Commonly Known or Reasonably Ascertainable Information

The user indicated that the Subject Property is currently used for diversified agriculture and was previously used for pineapple cultivation. Aloun Farms is the current tenant of the Subject Property and may use chemicals associated with diversified agriculture. Aloun Farms chemical usage information is discussed in Section 4.3.

The user indicated that computer equipment was illegally dumped at the site. These illegal dumping activities are discussed in Section 4.3.

4.1.6 Degree of Obviousness of Potential Contamination

The user indicated that past usage of the Subject Property include pineapple cultivation and diversified agriculture. The user also indicated that cleanup of fugitive dumping has occurred on the Subject Property. User provided documentation pertaining to the former fugitive dumping is further discussed in Section 4.3.

4.2 Other Information Pertaining to Subject Property

The user had no additional concerns regarding the Subject Property or any adjoining properties.

4.2.1 Reason for Performing Phase I ESA

This Phase I ESA was conducted as part of a concurrent Environmental Impact Statement (EIS) for the Subject Property.

4.2.2 Title Records

No title documents were provided by the user, however, ETC conducted a limited land title search which is documented in Section 5.3.3.

4.2.3 Owner, Property Manager, and Occupant Information

Subject Property Owner/Manager:

CCHHI, 100 Kahelu Avenue, 2nd floor, Mililani, HI 96789-8900

Contact: Ms. Beverly Kaku, Senior Land Agent, CCHHI

Tel: (808) 548-2945

Subject Property Occupant(s):

Aloun Farms

Contact: Mr. Alec Sou

Tel: (808) 389-7899

4.3 Other User Provided Information

ETC reviewed several Client provided environmental reports and correspondence pertaining to the Subject Property.

4.3.1 Letter Report, Solid and Hazardous Waste Management Services, Koa Ridge, EnviroServices & Training Center, LLC, May 3, 2005

Review of an ETC Letter Report, dated May 3, 2005 indicated that a report of fugitive dumping on the Subject Property was documented on February 18, 2005. Six 55-gallon drums were illegally disposed on the Subject Property. ETC personnel inspected the drums and determined that a limited release had occurred from one of the drums. Subsequently, ETC stabilized the leaking drum; absorbed the fluids; and removed the drums and any visually impacted soil. A total of four 55-gallon drums of flammable and oily waste were transported to Philip Services Hawaii for subsequent disposal at Burlington Environmental, Inc. in Kent, Washington. A total of 1.59 tons of soil impacted by a release of petroleum from the drums was excavated by ETC and transported to Waimanalo Gulch Sanitary Landfill (WGSL) for subsequent disposal. In addition, confirmation soil samples collected from the bottom of the excavation pit created during removal of the petroleum-impacted soil had constituent concentrations below method detection limits or below DOH Tier 1 Action Levels. As a result, ETC concluded that the illegally dumped waste had been sufficiently addressed through repackaging and disposal, and that soil impacted by a release of the waste stored in the drums has been sufficiently removed and disposed.

4.3.2 Site Assessment Report – Ka Uka Boulevard Abandoned Waste, EnviroServices & Training Center, LLC, January 2007

Review of the ETC Site Assessment Report, dated January 2007 indicated that abandoned waste was discovered on the Subject Property and reported to CCHHI by the Department of Health (DOH) Solid and Hazardous Waste Branch (SHWB) on September 19, 2006. The waste consisted of approximately 50 to 100 tires, 100 to 150 units of computers and computer monitors with Department of Defense markings from various military bases, two overturned 55-gallon drums containing unknown liquids, and stained soil directly beneath one of the drums. Subsequently, all abandoned waste and impacted soil were properly removed and disposed. In addition, confirmation soil samples indicated that with the exception of cadmium, all constituent concentrations were either below method detection limits or below their corresponding DOH Environmental Action Levels.

Cadmium concentrations exceeded the lowest DOH EAL of 12 mg/kg that pertains to potential terrestrial ecological impacts. ETC concluded that for this particular site, impacts to sensitive ecological receptors were unlikely for the following reasons:

- Surrounding areas are generally urban development, with adjacent agricultural use.
- The site is part of a property designated for future residential development.
- The nearest aquatic habitat is estimated to be approximately 2,500 to 3,000 feet away from the dump site.
- There are no known threatened or endangered fauna or flora habitats at or adjacent to the site based on data provided in the Hawaii Statewide GIS Program website, managed by the State of Hawaii Office of Planning.

Therefore, the DOH EAL which pertains to direct exposure for residential exposure scenarios was used. None of confirmed samples exceeded the direct exposure DOH EAL for cadmium. As a result, ETC concluded that the abandoned waste discovered at the Subject Property had been sufficiently addressed and no further investigative or remedial activities are recommended.

4.3.3 Other Provided References

CCHHI provided ETC with several references pertaining to the historic use of pesticides/herbicides in pineapple cultivation in Hawaii. As a result, ETC researched the following user provided references at the University of Hawaii:

- St. John, Harold and Edward Yataro Hosaka (1932). *Weeds of the pineapple fields of the Hawaiian islands* (p.10). Honolulu, University of Hawaii.
- Carter, Walter (1934). Unsaturated petroleum oils as insecticides. Reprinted from *Science*, 80 (2075), 315.
- Tam, Richard K. (1947). Comparative herbicidal value of 2,4-Dichlorophenoxyacetic acid and 2,4,5-Trichlorophenoxyacetic acid on some herbaceous weeds, shrubs, and trees under Hawaiian conditions. Reprinted from *The Botanical Gazette*, 109(2), 194-203.
- 1999 Pineapple Integrated Pest Management Guidelines and Elements. Retrieved March 18, 2008, from HAWAII IPM PROGRAM Integrated Pest Management. Website:http://www.extento.hawaii.edu/IPM/Certification/Pineapple/Guidelines1.asp.
- Cultivating Pineapple. A laboring report from Hawaii (1961). Honolulu. 1 video cassette (VHS) (9 minutes). [video recording]

Review of above referenced publications indicated that the following chemicals have been historically used in Hawaii's pineapple fields. Note that none of the references were specific to activities on the Subject Property.

- Sodium arsenite (applied as a spray for weed control);
- Diesel engine oil (applied as a spray for weed control);
- Sodium chlorate (applied as a spray for weed control);
- Carbon disulfide (injected into the soil for weed control);
- Chloropicrin (soil fumigant injected into the soil for weed control);
- Methyl bromide (soil fumigant for nematode control);
- Telone II (1,3-D) (soil fumigant for nematode control);

In addition, 2,4,5-T and 2,4-D (herbicides) were not likely used for weed control purposes due to their toxicity to the pineapple plant (Tam, 1947).

5.0 RECORDS REVIEW

5.1 Standard Environmental Record Sources

To obtain information concerning recognized environmental conditions at or near the Subject Property, ETC contracted Environmental Data Resources, Inc. (EDR) to conduct an environmental database search. EDR is a company that specializes in the review of public regulatory environmental databases. The regulatory agency report provided (Appendix IV) is based on an evaluation of the data collected and compiled by a contracted data research company. The report is a radius search report, which focuses on both the Subject Property and adjacent properties that may impact the Subject Property. Adjacent properties listed in governmental environmental records are identified within a specific search radius (Table 1). The search radius varies depending on the particular record being researched. The search is designed to meet the requirements of the current industry approach as described in ASTM Practice E1527-05. The information provided is assumed to be correct and complete, unless noted otherwise.

Table 1: ASTM Practice Environmental Record Sources and Recommended Search Distances

Environmental Database Sources	ASTM Practice Search Distances (miles)
Federal NPL Site List	1.0
Federal CERCLIS List	0.5
Federal CERCLIS NFRAP Site List	0.5
Federal RCRA CORRACTS Facilities List	1.0
Federal RCRA non-CORRACTS TSD Facilities List	0.5
Federal RCRA Generators List	Subject Property and adjoining properties
Federal Institutional Control/Engineering Control Registries	Subject Property only
Federal ERNS List	Subject Property only
State-Equivalent NPL	1.0
State-Equivalent CERCLIS	0.5
State Landfill and/or Solid Waste Disposal Site Lists	0.5
State Leaking UST List	0.5
State Registered UST List	Subject Property and adjoining properties
State Institutional Control Registry	Subject Property only
State Voluntary Cleanup/Response (VCP/VRP) Sites	0.5
State Brownfield Sites	0.5

5.1.1 Federal NPL

The National Priorities List (NPL) is the Environmental Protection Agency's (EPA) database of uncontrolled or abandoned hazardous waste properties, which are considered to pose an immediate threat to human health and the environment. These properties are identified for priority remedial response actions under the Superfund Program. The Subject Property was not identified as a NPL site. The database did not identify any NPL sites within a 1-mile radius of the Subject Property.

5.1.2 Federal CERCLIS and CERCLIS NFRAP

The Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) database contains information on various aspects of potentially uncontrolled or abandoned hazardous waste properties from initial screening and assessment phases to listing on the NPL. The Subject Property was not identified as an active CERCLIS site or a CERCLIS No Further Remedial Action Planned (NFRAP) site. The database did not identify any CERCLIS sites within a 0.5-mile radius of the Subject Property.

5.1.3 Federal RCRA CORRACTS

RCRA Corrective Action Sites (CORRACTS) database contains Resource Conservation Recovery Information System (RCRIS) sites with reported corrective action. The Subject Property was not identified as a CORRACTS facility. The database did not identify any RCRA CORRACTS sites within a 1-mile radius of the Subject Property.

5.1.4 Federal RCRA (non-CORRACTS) TSD Facilities

The EPA's RCRA program identifies and tracks hazardous waste from the point of generation to the point of final disposal. The RCRA Treatment, Storage or Disposal (TSD) facility database compiles those reporting facilities that treat, store, or dispose of hazardous waste. The Subject Property was not listed as a RCRA TSD facility. Additionally, the database did not identify any RCRA TSD facilities within a 0.5-mile radius of the Subject Property.

5.1.5 Federal RCRA Generator

The RCRA Generator database is a compilation by EPA's RCRIS of regulated facilities that generate hazardous waste. The Subject Property was not identified as a RCRA Generator. The database search did not identify any RCRA SQG or LQG sites adjacent to the Subject Property.

5.1.6 Federal Institutional Control/Engineering Control Registries

Engineering controls include various forms of caps, building foundations, liners, and treatment methods to create pathway elimination for regulated substances to enter environmental media or effect human health. Institutional Controls include administrative measures, such as groundwater use restrictions, construction restrictions, property use restrictions, and post remediation care requirements intended to prevent exposure to contaminants remaining on a site. The EPA Institutional Control and Engineering Control registry maintains a listing of sites with Institutional or Engineering Controls in place. The Subject Property was not identified to have institutional or engineering controls in place.

5.1.7 Federal ERNS

The Emergency Response Notification System (ERNS) tracks the initial notification of reported oil and hazardous material spills. The database contains information regarding the discharger, release date, material, amount released, incident location and release action taken. The Subject Property was not identified as an ERNS facility.

5.1.8 State Equivalent NPL and CERCLIS

The CERCLIS List is a compilation of known or suspected uncontrolled or abandoned hazardous waste sites. These sites either have been investigated or are currently under investigation by the EPA for the release, or threatened release, of hazardous substances. Once a site is placed in CERCLIS, it may be subjected to several levels of review and evaluation and ultimately placed on the National Priorities List. The State of Hawaii does not have a formal "State Superfund" program; therefore, the State Hazardous Waste Sites (SHWS) are the State of Hawaii's equivalent to the federal EPA's CERCLIS database. Additionally, because this information is acquired from the Hawaii Department of Health (DOH) Hazard Evaluation and Emergency Response (HEER) Office, these sites may or may not already be listed on the federal CERCLIS list. Priority sites planned for cleanup that use state funds (state equivalent superfund) are identified along with sites where cleanup is paid for by the potentially responsible parties. The Subject Property was not identified as a SHWS. The database search identified four (4) SHWS facilities within a 1-mile radius of the Subject Property.

5.1.9 State Landfill and/or Solid Waste Disposal

The State of Hawaii has records of all facilities that have received a solid waste management permit, including solid waste landfills, transfer stations, and incinerators. The Subject Property was not identified as a Solid Waste Facility/Landfill (SWF/LF) facility. The database search did not identify any SWF/LF facilities within a 0.5-mile radius of the Subject Property.

5.1.10 State Leaking Underground Storage Tanks

The DOH Underground Storage Tank (UST) Program maintains a listing of all reported leaks and releases from USTs. The Subject Property was not identified as a leaking underground storage tank (LUST) facility. The database identified two (2) LUST facilities within a 0.5-mile radius of the Subject Property.

5.1.11 State Registered Underground Storage Tanks

The DOH Underground Storage Tank (UST) Program registration system tracks known and registered UST systems. The Subject Property was not identified as a UST facility. The database search did not identify any UST facilities located adjacent to the Subject Property.

5.1.12 State Institutional Control Registry

Institutional Controls include administrative measures, such as groundwater use restrictions, construction restrictions, property use restrictions, and post remediation care requirements intended to prevent exposure to contaminants remaining on a site. The State Institutional Control listing includes Voluntary Response Program and Brownfields sites with institutional controls in place. The Subject Property was not identified as having institutional controls in place.

5.1.13 State Voluntary Cleanup/Response Sites

The Hawai'i Voluntary Response Program (VRP) was created on July 7, 1997 by amendments made to Hawaii's Environmental Response Law (ERL). The purpose of the VRP is to streamline the cleanup process in a way that will encourage prospective developers, lenders, and purchasers to voluntarily cleanup properties. The VRP facilitates the cleanup process and, in certain situations, provides relief from the strict liability provisions of the Federal CERCLA and Hawai'i ERL. The Subject Property was not identified as a VRP site. The database search did not identify any VRP sites located within a 0.5-mile radius of the Subject Property.

5.1.14 State Brownfields

A Brownfields site is land, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant. The Subject Property was not identified as a Brownfields site. The database search did not identify any Brownfields sites located within a 0.5-mile radius of the Subject Property.

5.1.15 Unmappable/Orphan Sites

Twenty-eight (28) unmappable sites were identified in the Orphan Summary of the EDR Report. Unmappable sites are not plotted due to poor or inadequate address information. Due to the inaccurate or incomplete information provided by the respective agency, these sites cannot be plotted with confidence. Review of the addresses and site names coupled with ETC site reconnaissance findings indicated that neither the Subject Property nor adjacent properties were identified in the Orphan Summary of the database report.

5.2 Additional Environmental Record Sources

The EDR database also included a number of other regulatory databases that are not specified by the ASTM Practice. In addition, the EDR database did not identify the Subject Property in any of the following databases.

Proposed NPL – Proposed National Priority List Sites

Delisted NPL – National Priority List Deletions

NPL RECOVERY – Federal Superfund Liens

HMIRS – Hazardous Materials Information Reporting System

DOD – Department of Defense Sites

FUDS – Formerly Used Defense Sites

US Brownfields – A Listing of Brownfields Sites

AIRS – A Listing of Permitted Facilities

CONSENT – Superfund (CERCLA) Consent Decrees

ROD – Records of Decision

UMTRA – Uranium Mill Tailings Sites

ODI – Open Dump Inventory

TRIS – Toxic Chemical Release Inventory System

TSCA – Toxic Substances Control Act

FTTS – FIFRA/TSCA Tracking System

SSTS – Section 7 Tracking Systems

ICIS – Integrated Compliance Information System

LUCIS – Land Use Control Information System

CDL – Clandestine Drug Labs

RADINFO – Radiation Information Database

PADS – PCB Activity Database System

MLTS – Material Licensing Tracking System

MINES – Mines Master Index File

RAATS – RCRA Administrative Action Tracking System

SPILLS – Release Notifications

DRYCLEANERS – Permitted Drycleaner Facility Listing

INDIAN RESERV – Indian Reservations

INDIAN LUST – Leaking Underground Storage Tanks on Indian Land

Manufactured Gas Plants – EDR Propriety Manufactured Gas Plants

5.3 Historical Use Information on the Subject and Adjoining Properties

Historical uses of the Subject Property and adjoining properties were investigated through the review of documentation available from public land records and State of Hawaii archived information. In addition, available aerial photographs, plat maps, Sanborn maps, and building permits were reviewed.

5.3.1 Aerial Photograph Review

Aerial photographs from the Map Collection of the University of Hawaii's Hamilton Library were reviewed. A total of six (6) aerial photographs were found that included the Subject Property. These photographs were dated 1952, 1959, 1962, 1968, 1977, and 2000.

The Subject Property and surrounding areas appeared to be used for agricultural purposes in the 1952 aerial photograph. However, apparent interior roads were visible and a large structure was noted on the southern portion of the western parcels. In addition, the Kipapa Gulch was noted along the west boundary of the Subject Property.

There were no changes to the Subject Property in the 1959 aerial photograph; however, Kamehameha Highway was visible to the west and a small area of residential housing was noted north of the southwest portion of the Subject Property. The 1962 aerial photograph appeared similar to the 1959 aerial photograph with no significant changes.

The Subject Property appeared the same in the 1968 aerial photograph as in the 1962 aerial photograph; however, the area to the west of the Subject Property appeared to be cleared for construction purposes.

The 1977 aerial photograph revealed significant residential development to the west of the Subject Property. Additionally, several more roads had been constructed including Ka Uka Boulevard and the H-2 Highway, which bisects the western and eastern parcels of the Subject Property. While the western parcels of the Subject Property remain in use for agriculture, the eastern parcels appear to have been lain fallow due to observed differences in vegetation.

Review of the 2000 aerial photograph indicated that water towers had been constructed adjacent to the eastern border of the western parcels. Review of the surrounding areas indicated that the residential area previously observed to the west had been further developed. Additionally, commercial type structures are apparent to the south of the Subject Property's western parcels.

5.3.2 Fire Insurance Maps

ETC contracted EDR to conduct a search for Sanborn fire insurance maps of the Subject Property. The search included an extensive review of the ERIIS Historical Map Collection, which is a private collection of prior-use maps in the United States. There were no Sanborn fire insurance maps available for the Subject Property.

5.3.3 Property Tax Files and Land Title Records

ETC conducted a limited chain of title search of the Subject Property at the City and County of Honolulu Tax Assessment office. ETC is not a professional title search company and does not warrant the completeness or accuracy of the information provided, but considers the data useful in screening the Subject Property for environmentally suspect owners or lessees.

The past and present owners of TMK (1) 9-4-6: Parcels 1 (portion), 2 (portion), 38, and 39; and TMK (1) 9-5-3: Parcels 1 (portion) and 4 (portion) are summarized in Table 2. The current owner of all the parcels on the Subject Property was listed as Castle & Cooke Homes Hawaii Inc.

Table 2: Chain of Title Review

Date	Description	Notes
TMK (1) 9-4-6: Parcels 1 (portion) and 2 (portion)		
Prior to 1952	Owner: John Ii Estate Ltd Lessee: Oahu Sugar Company	
1952 to 1960	Owner: Hawaiian Pineapple Company	
1960 to 1964	Owner: Dole Corporation	FKA Hawaiian Pineapple Co.
1964 to 1991	Owner: Castle & Cooke, Inc.	
1991 to 1993	Owner: Dole Food Company Inc.	FKA Castle & Cooke, Inc.
1993 to 1995	Owner: Castle & Cooke Homes Hawaii Inc.	FKA Dole Food Company Inc. and Castle & Cooke Residential, Inc.
1995 to 1996	Owner: Castle & Cooke Hawaii, Inc.	FKA Castle & Cooke Homes Hawaii Inc.
1996 to Present	Owner: Castle & Cooke Homes Hawaii Inc.	FKA Castle & Cooke Hawaii, Inc.
TMK (1) 9-4-6: Parcels 38 and 39		
Prior to 1952	Owner: John Ii Estate Ltd Lessee: Oahu Sugar Company	
1952 to 1960	Owner: Hawaiian Pineapple Company	
1960 to 1964	Owner: Dole Corporation	FKA Hawaiian Pineapple Co.
1964 to 1991	Owner: Castle & Cooke, Inc.	
1991 to 1993	Owner: Dole Food Company Inc.	FKA Castle & Cooke, Inc.

Date	Description	Notes
1993 to 1995	Owner: Castle & Cooke Homes Hawaii Inc.	FKA Dole Food Company Inc. and Castle & Cooke Residential, Inc.
1995 to 1996	Owner: Castle & Cooke Hawaii, Inc.	FKA Castle & Cooke Homes Hawaii Inc.
1996 to 2003	Owner: Castle & Cooke Homes Hawaii Inc.	FKA Castle & Cooke Hawaii, Inc.
2003 to Present	Owner: Castle & Cooke Homes Hawaii Inc.	New Parcel from 9-4-6: Parcel 1
TMK (1) 9-5-3: Parcel 1 (portion)		
Prior to 1952	Owner: John Ii Estate Ltd	
1952 to 1960	Owner: Hawaiian Pineapple Company Ltd.	
1960 to 1964	Owner: Dole Corporation	FKA Hawaiian Pineapple Co.
1964 to 1991	Owner: Castle & Cooke, Inc.	
1991 to 1993	Owner: Dole Food Company Inc.	FKA Castle & Cooke, Inc.
1993 to 1995	Owner: Castle & Cooke Homes Hawaii Inc.	FKA Dole Food Company Inc. and Castle & Cooke Residential, Inc.
1995 to 1996	Owner: Castle & Cooke Hawaii, Inc.	FKA Castle & Cooke Homes Hawaii Inc.
1996 to Present	Owner: Castle & Cooke Homes Hawaii Inc.	FKA Castle & Cooke Hawaii, Inc.
TMK (1) 9-5-3: Parcel 4 (portion)		
Prior to 1952	Owner: John Ii Estate Ltd Lessee: Libby McNeil & Libby	
1952 to 1960	Owner: Hawaiian Pineapple Company Ltd. Lessee: Libby McNeil & Libby	
1960 to 1964	Owner: Dole Corporation Lessee: Libby McNeil & Libby	FKA Hawaiian Pineapple Co.
1964 to 1991	Owner: Castle & Cooke, Inc.	
1991 to 1993	Owner: Dole Food Company Inc.	FKA Castle & Cooke, Inc.

Date	Description	Notes
1993 to 1995	Owner: Castle & Cooke Homes Hawaii Inc.	FKA Dole Food Company Inc. and Castle & Cooke Residential, Inc.
1995 to 1996	Owner: Castle & Cooke Hawaii, Inc.	FKA Castle & Cooke Homes Hawaii Inc.
1996 to Present	Owner: Castle & Cooke Homes Hawaii Inc.	FKA Castle & Cooke Hawaii, Inc.

5.3.4 Building Permits

A review of available building permits by the City and County of Honolulu indicated that the permits issued pertained to storage shed construction, fencing, retaining walls, and electrical work. In 1976, a building permit was issued to Dole Company for electrical service of floodlight poles with mercury lamps. Note that these lamps appeared to still be in service on the Subject Property at the loading and storage area.

6.0 SITE RECONNAISSANCE

ETC performed a site reconnaissance on September 10 and 12, 2008 in order to complete a visual survey to identify the use and/or storage of hazardous materials.

6.1 Methodology and Limiting Conditions

The west and north portions of the Subject Property encompassed the edge of the Kipapa Gulch, which included steep inaccessible inclines and dense vegetation. As such, these areas were not included in ETC's site reconnaissance activities. There were no other limiting conditions imposed by physical obstructions i.e. adjacent buildings, bodies of water, asphalt, and/or other paved areas.

6.2 General Site Setting

The Subject Property primarily consisted of undeveloped land. A loading and storage area was noted on the south portion of Subject Property near the entrance gate. A single story storage structure with an attached mobile trailer was observed within the loading and storage area.

The mobile trailer was inaccessible at the time of ETC's site reconnaissance activities however, Mr. Sou indicated that the trailer is used as a residence of an Aloun Farms employee. Mr. Sou indicated that the employee resides on the Subject Property for security purposes. In addition, several small sheds were noted throughout the south portion of the Subject Property. One or more of these structures were inaccessible at the time of ETC's site reconnaissance activities, however, Mr. Sou indicated that these sheds are rest/lunch areas for the Aloun Farms personnel. Based on the size and presumed usage of these shed structures and the mobile trailer, the contents of these structures were not anticipated to cause significant environmental impairment to the Subject Property.

In addition, several structures (i.e. sheds, canopy, animal pens, etc.) near the southwest border were observed. The structures appeared to be encroaching onto the Subject Property. The structures were locked and inaccessible at the time of ETC's site reconnaissance activities, therefore, ETC conducted a limited site reconnaissance of these structures.

ETC personnel also observed the Waiahole Ditch on the north portion of the Subject Property. A map of the Subject Property and the location of the Waiahole Ditch is included in Appendix I, Figure 2. Photographic documentation of ETC's site reconnaissance is included in Appendix II.

6.3 Exterior Observations

Visual inspection of the exterior areas of the Subject Property indicated the groundcover primarily consisted of bare soil, interior dirt and asphalt paved roads and vegetation. ETC observed several piles of the apparent solid waste along the southwest portion of the Subject Property. Observations included general construction and demolition debris (i.e. toilets, tiles, concrete, asphalt, etc.), tires, batteries, automobile parts, and miscellaneous municipal waste. In addition, ETC observed an apparent abandoned automobile along the west border of the Subject Property. No releases were observed in the vicinity of the abandoned automobile. All observed conditions on the Subject Property were documented and mapped out in Appendix I, Figure 2.

ETC observed two apparent water pumping stations on the central and north portions of the Subject Property. The northernmost water pump appeared to be defunct, however the southernmost water pump located on the central portion of the Subject Property appeared to be actively in-use. No apparent evidence of spills or releases of any oils were noted at these water pumps. Based on ETC's correspondence with Mr. Sou (Aloun Farms) and Mr. Nellis (Dole), these water pumps are likely connected to Waiahole Ditch for irrigation purposes on the Subject Property.

ETC observed an apparent valve pit (VP) associated with the Hickam Petroleum, Oils, and Lubricants (POL) pipeline, which reported traverses the southwest portion of the Subject Property. There are reportedly two VPs located on the Subject Property, however, ETC personnel only observed one VP during site reconnaissance activities. The approximate location of the POL and both VPs are mapped out in Appendix I, Figure 2.

6.3.1 USTs / ASTs

A visual inspection for the presence of USTs or aboveground storage tanks (ASTs) was also conducted. No visual evidence (i.e. vent or fill pipes, dispensers, etc.) of the presence of USTs were observed. One AST was observed in the loading and storage area of the Subject Property. Mr. Nellis indicated that the AST was formerly used to store liquid fertilizer. Mr. Sou indicated that Aloun Farms has not used the AST during their tenancy.

6.4 Interior Observations

Visual inspection of the interior areas of the loading and storage indicated that the storage structure is used to store equipment and various fertilizers (liquid and dry). Mr. Sou indicated that no pesticides, herbicides, and/or fungicides are stored on the Subject Property. Usage and storage of such chemicals are on an "as needed" basis to maintain the crops on the Subject Property.

ETC also conducted a visual inspection of the inaccessible interior areas of the southwest Subject Property structures. Several animals were observed in these areas. No chemical storage was evident during ETC's limited site reconnaissance in these areas.

6.5 Dielectric Fluid Containing Equipment

A visual inspection for hydraulic and electrical equipment or electrical components that use fluid that may contain PCBs was conducted. The following observations were noted:

- No hydraulic equipment was observed.
- Several pole mounted transformers were observed throughout the Subject Property. These pole mounted transformers were observed to be in good condition with no evidence of a release.
- Several high-voltage power lines were observed throughout the Subject Property. ETC also observed a black tar-like coating on the wood poles associated with the high-voltage power lines.

7.0 INTERVIEWS

The objective of the interviews is to obtain information from past and present owners, operators, and occupants of the Subject Property to identify potential RECs in connection with the Subject Property.

7.1 Interviews with Subject Property Owner

Mr. Ray Kunishige, Castle & Cooke Homes Hawaii, Inc., Site Construction Engineer, Subject Property Owner
Ms. Beverly Kaku, Castle & Cooke Homes Hawaii, Inc., Senior Land Agent, Subject Property Owner

- Mr. Kunishige's knowledge of the Subject Property and surrounding areas dates back approximately 4 years.
- Ms. Kaku's knowledge of the Subject Property and surrounding areas dates back approximately 39 years.
- The Subject Property has been owned by Dole Food Company and/or CCHHI since the early 1950s.
- The Subject Property was previously owned by the John Ii Estate Limited.
- The Subject Property has been used for agricultural purposes since the 1920s.
- There are no known permits from the County, State or Federal Government for the operation of the facility.
- The Waiahole Ditch is used as the primarily source of water for the Subject Property.
- There is no sewer system infrastructure on the Subject Property.
- There are HECO-owned pole-mounted transformers located on the Subject Property.
- There is an AST located on the Subject Property which was formerly used by Dole for the storage of liquid fertilizer (UAN). The AST is no longer in-use.
- Fertilizers were the only chemicals stored on the Subject Property.
- There is a fuel pipeline located on the Subject Property which is owned by the Air Force. The pipeline is anticipated to be removed in the near future.
- Past fugitive dumping of drums has occurred. The drums were removed by ETC.
- The Subject Property is bordered by the Ukee Industrial Park.
- There has been no known burying or burning of any waste or rubbish.
- Except for Pearl City Transmission, the Subject Property and/or adjoining properties are not used for dry cleaning operations, photo developing, junkyard, landfilling, waste TSDF, gasoline station, or recycling.

- There are no and have not been any pits, ponds, or lagoons located on the Subject Property in connection with treatment or waste disposal.
- There are no known environmental liens or governmental notifications relating to past or recurrent violations of environmental laws with respect to the Subject Property.
- The Subject Property does not discharge wastewater other than storm water.

7.2 Interviews with Subject Property Occupant

Mr. Mike Sou, Aloun Farms, Owner, Subject Property Occupant

- Mr. Sou's knowledge of the Subject Property and surrounding areas was limited to only current usage of the south portion of the Subject Property.
- Aloun Farms grows various vegetable and herbs on the Subject Property. Crops include corn, taro, lettuce, basil, etc.
- The loading and storage area is used to load and transfer harvested crops and store heavy equipment.
- The existing AST has never been used by Aloun Farms.
- An Aloun Farms employee lives at the loading and storage area in a trailer. The presence of a resident on the Subject Property is primarily for security purposes.
- Water is provided by the Waiahole Ditch. Aloun Farms uses the pre-existing irrigation piping to irrigate their crops. The irrigation lines are reportedly gravity fed from the ditch.

7.3 Interviews with Former Subject Property Owner/Occupant

Mr. Dan Nellis, Dole Food Company, Operations Director, Former Subject Property Owner/Occupant

- Mr. Nellis' knowledge of the Subject Property and surrounding areas dates back approximately 20 years.
- The Subject Property was previously used for pineapple cultivation. Sugarcane was not cultivated on the Subject Property.
- There is a staging loading area located on the Subject Property which consisted of a small office (radio dispatcher) and a concrete paved transfer station.
- There is an AST located within the former staging and loading area. The AST formerly stored liquid fertilizer (UAN), which was supplied by Dole, Brewer and/or United Ag Products.
- The water pumps on the Subject Property were used for irrigation purposes. The pumps supply water for the north and south field areas north and south of the Waihole Ditch.

- No pesticides, herbicides, fumigants, or fungicides were stored on the Subject Property. Telone was used on the Subject Property however, it was stored at Dole's storage facility in Wahiawa. Telone was transported to the Subject Property fields via "nurse truck."

7.4 Interviews with Subject Property Neighbor (Adjacent Property Owner)

Mr. Mike Dau, Subject Property Neighbor Owner

- Mr. Dau's knowledge of the Subject Property and surrounding areas dates back approximately 33 years.
- The Subject Property was previously used for pineapple cultivation until 1992-1993. The Subject Property remained vacant and unused from 1993 to 2003. Aloun Farms began farming on the Subject Property around 2003.
- During heavy rainfall, runoff from the Subject Property onto Mr. Dau's property occurs.
- The Steel Workers Union reportedly occupied the southwest border of the Subject Property.
- Limited fugitive dumping activities have occurred on the Subject Property. The limited dumping primarily consisted of household waste.

8.0 FINDINGS AND OPINIONS

8.1 Site Description

No significant findings to indicate suspect RECs, historical RECs, or *de minimis* conditions were identified.

8.2 User Provided Information

8.2.1 Required Information

The user indicated that Subject Property was formerly used for pineapple cultivation. The past and prior use history of the Subject Property is discussed further in Section 8.3.3.

8.2.2 Other Information Pertaining to the Subject Property

No significant findings to indicate suspect RECs, historical RECs, or *de minimis* conditions were identified.

8.2.3 Other User Provided Information

Letter Report, Solid and Hazardous Waste Management Services, Koa Ridge, ETC, May 3, 2005

Review of an ETC Letter Report indicated that six 55-gallon drums were illegally dumped on the Subject Property. The drums and associated contaminated soil were removed and properly disposed and confirmation soil sampling was conducted. Based on ETC's review, this finding is not considered a REC.

Site Assessment Report – Ka Uka Boulevard Abandoned Waste, ETC, January 2007

Review of the ETC Site Assessment Report indicated that abandoned waste was discovered on the Subject Property by the DOH SHWB in September 2006. The waste consisted of tires, computers and computer monitors, 55-gallon drums containing unknown liquids, and stained soil directly beneath one of the drums. Subsequently, all abandoned waste and impacted soil were properly removed and disposed. In addition, confirmation soil samples indicated that all constituent concentrations were either below method detection limits or below their appropriate DOH Environmental Action Levels. Based on ETC's review, this finding is not considered a REC.

Other Provided References

ETC researched several user provided references at the University of Hawaii. ETC review of these references indicated that various pesticides/herbicides and fumigants have historically been used in Hawaii's pineapple fields. These pesticides/herbicides and fumigants include sodium arsenite, diesel engine oil, carbon disulfide, chloropicrin, methyl bromide, and Telone II.

Additional References

In addition to the user provided references (discussed in Section 4.3.4), ETC also reviewed the following publications regarding the general usage of pesticides/herbicides in pineapple cultivation in Hawaii.

- Collins, J. L. 1968. *The Pineapple: Botany, Cultivation, and Utilization.* Word Crops Books.
- Collins, J. L. (1949). History, Taxonomy and Culture of the Pineapple. Reprinted from *Economic Botany*, 3 (4), 335-359.

Review of above reference publications indicated that the following chemicals have been historically used in Hawaii's pineapple fields. Note that none of the references were specific to activities on the Subject Property.

- D-D – 1,3-dichloropropane and 1,3-dichloropropene mixture applied as a soil fumigant for weed control. Usage of D-D began after World War I and was used almost universally in Hawaii (Collins, 1968).
- Pentachlorophenol and sodium pentachlorphenate (PCP) was used in a water or emulsified based form and sprayed as a pre-emergence herbicide (Collins, 1968).

8.2.4 Discussion

Review of the user provided information, documents and references indicated past and prior use of the Subject Property for pineapple cultivation. Based on user provided references coupled with ETC's additional research documentation, activities commonly associated with commercial pineapple cultivation include the use and application of fertilizers, pesticides, fumigants and/or herbicides. As such, this finding is considered a historical REC.

Based on the past and prior use of the Subject Property, ETC cannot dismiss the potential presence of residual contamination from this historical REC and as such the past use is considered a REC for the Subject Property.

8.3 Records Review

8.3.1 Standard Environmental Record Sources

Federal NPL

No significant findings to indicate suspect RECs, historical RECs, or *de minimis* conditions were identified.

Federal CERCLIS and CERCLIS NFRAP

No significant findings to indicate suspect RECs, historical RECs, or *de minimis* conditions were identified.

Federal RCRA CORRACTS

No significant findings to indicate suspect RECs, historical RECs, or *de minimis* conditions were identified.

Federal RCRA (non-CORRACTS) TSD Facilities

No significant findings to indicate suspect RECs, historical RECs, or *de minimis* conditions were identified.

Federal RCRA Generator

No significant findings to indicate suspect RECs, historical RECs, or *de minimis* conditions were identified.

Federal Institutional Control/Engineering Control Registries

No significant findings to indicate suspect RECs, historical RECs, or *de minimis* conditions were identified.

Federal ERNS

No significant findings to indicate suspect RECs, historical RECs, or *de minimis* conditions were identified.

State Equivalent NPL and CERCLIS

No significant findings to indicate suspect RECs, historical RECs, or *de minimis* conditions were identified.

ETC's database review indicated that two of the four identified SHWS sites were either classified as "no further action" sites, are situated topographically downgradient or crossgradient from the Subject Property, and/or were too distant to pose a reasonable risk of impacting the Subject Property. Therefore, ETC requested and reviewed two SHWS facility files.

ETC reviewed several environmental reports and various correspondence for the *Waipio Heights Wells II* and *Mililani Wells I* facility files, which were combined with other Central Oahu well sites as an area-wide site facility. These documents were either provided, released, and/or reviewed at the DOH HEER Office. Document review indicated that several Central Oahu wells were found to be contaminated with various agricultural-related chemicals and/or constituents in the 1980s and 1990s. Specifically, trichloropropane (TCP), trichloroethylene (TCE), and dibromochloropropane (DBCP) were detected in drinking water samples from the *Waipio Heights Wells II* and/or *Mililani Wells I*. Both well sites were not place on the NPL and are reportedly being treated. The source of the contamination was suspected to have originated from agricultural cultivation located throughout the Central Oahu area, specifically pineapple cultivation. TCP and DBCP are either constituents or impurities of soil fumigants which were noted to have been used by Dole Company during from the 1950s to 1977. The potential previous usage and/or application of fertilizers, pesticides, fumigants and/or herbicides on the Subject Property is considered a historical REC. Based on file review findings, ETC cannot dismiss the potential presence of residual contamination from this historical REC and as such the past use is considered a REC for the Subject Property.

File review also indicated that the source of the TCE contamination was suspected to have been the result of various releases from the Kipapa Petroleum, Oils, and Lubricants (POL) Storage area and/or the POL pipeline. As noted in Section 6.3, a portion of the POL pipeline is located on the Subject Property and includes two valve pits (VP 18 and VP19). File review did not reveal any releases from the portion of the POL pipeline located on the Subject Property, however, several large releases (>10,000-gallons fuel) were documented from the pipeline in the 1950s. A Remedial Investigation and Feasibility Study (RI/FS) of the POL pipeline is currently ongoing. The potential residual contamination associated with the historic releases and presence of the POL pipeline on the Subject Property is considered a historical REC. Based on file review findings, ETC cannot dismiss the potential presence of residual contamination from this historical REC and as such the POL is considered a REC for the Subject Property.

State Landfill and/or Solid Waste Disposal

No significant findings to indicate suspect RECs, historical RECs, or *de minimis* conditions were identified.

State Leaking Underground Storage Tanks

Database review indicated one of the two LUST sites was classified as a "no further action" site is situated topographically downgradient from the Subject Property; and is too distant to reasonably impact the Subject Property. Therefore, ETC reviewed the *Waipio Shell (9-202796)* facility file at the DOH SHWB. File review indicated that a release was observed during a subsurface investigation in March 2008. Release notification correspondence indicated that the impacted media was soil. No additional information was noted in the file. Although no release response activities were documented, the facility is located approximately 0.5-miles topographically downgradient from the Subject Property. Therefore, ETC believes that contaminant migration from this facility does not pose a reasonable risk of impacting the Subject Property

State Registered Underground Storage Tanks

No significant findings to indicate suspect RECs, historical RECs, or *de minimis* conditions were identified.

State Institutional Control Registry

No significant findings to indicate suspect RECs, historical RECs, or *de minimis* conditions were identified.

State Voluntary Cleanup/Response Sites

No significant findings to indicate suspect RECs, historical RECs, or *de minimis* conditions were identified.

State Brownfields

No significant findings to indicate suspect RECs, historical RECs, or *de minimis* conditions were identified.

Unmappable/Orphan Sites

No significant findings to indicate suspect RECs, historical RECs, or *de minimis* conditions were identified.

8.3.2 Additional Environmental Record Sources

No significant findings to indicate suspect RECs, historical RECs, or *de minimis* conditions were identified.

8.3.3 Historical Use Information on the Subject and Adjoining Properties

Review of user provided information, historical real property tax records and aerial photographs indicated past and prior use of the Subject Property for pineapple cultivation and/or possible sugar cultivation. Activities commonly associated with commercial pineapple and sugar cultivation include the use and application of fertilizers, pesticides, fumigants and/or herbicides. This finding is considered a historical REC.

Based on the past and prior use of the Subject Property, ETC cannot dismiss the potential presence of contamination for this historical REC and as such this past use is considered a REC for the Subject Property.

8.4 Site Reconnaissance

8.4.1 General Site Setting

No significant findings to indicate suspect RECs, historical RECs, or *de minimis* conditions were identified.

8.4.2 Exterior Observations

During ETC's site reconnaissance activities, solid waste (i.e. construction and demolition debris and miscellaneous rubbish) was observed along the southwest portion of the Subject Property. In addition, batteries, automobile parts and an abandoned car was also observed. No releases were observed, however the quantities of solid waste and moderate vegetation made it infeasible to adequately and fully characterize the potential impact. In accordance with Hawaii Administrative Rules Title 11, Department of Health, Chapter 58.1 (HAR §11-58.1) property owners are responsible for "removing accumulated solid waste to an approved solid waste disposal facility." Although the waste did not appear to pose a material threat to human health or the environment, it may be the subject of an enforcement action if brought to the attention of appropriate government officials. Therefore, the presence of the solid waste and the potential impacts to underlying soil from the solid waste are considered a REC.

ETC also observed an apparent valve pit associated with the POL pipeline, which reportedly traverses the southwest portion of the Subject Property. The POL was previously discussed in Section 8.3.1 and therefore will not be repeated here.

8.4.3 Interior Observations

No significant findings to indicate suspect RECs, historical RECs, or *de minimis* conditions were identified.

8.4.4 Dielectric Fluid Containing Equipment

ETC observed high-voltage power lines traversing the Subject Property. Extensive staining surrounding these poles was not observed and as such these poles are considered *de minimis* conditions.

8.5 Interviews

Interview findings also indicated past and prior use of the Subject Property and surrounding areas for pineapple cultivation. The historical usage of the Subject Property was discussed in Section 8.3.3 and therefore will not be repeated here.

9.0 DATA GAPS

Data gaps, which are defined as the lack of or inability to obtain information required for this Phase I ESA despite good faith efforts by the environmental professional to gather such information were identified during this Phase I ESA. ETC identified the following data gaps:

- ETC was unable to inspect all accessible areas of the Subject Property. Specifically, ETC was unable to inspect the interior areas of the several single story structures on the Subject Property. However, based on the usage of the Subject Property structures coupled with correspondence with Mr. Sou (Aloun Farms), the interiors were not expected to significantly impact the Subject Property. As such this data gap is not considered significant.
- ETC was unable to inspect limited areas of the west and north portions of the Subject Property due to safety concerns associated with the steep and inaccessible terrain along the edge of Kipapa Gulch. However, based on ETC's visual observations of the remaining areas of the Subject Property and those areas along the edge of the gulch, the steep inaccessible gulch areas were not anticipated to be significantly impacted by conditions other than limited fugitive dumping (i.e. solid waste) similar to that observed on other areas of the Subject Property.
- ETC was unable to confirm the PCB-status of the observed pole mounted transformers with HECO. However, since the transformers were observed to be intact with no evidence of a release, this data gap is not considered significant.

10.0 CONCLUSIONS

We have performed a Phase I ESA in conformance with the scope and limitations of ASTM Practice E1527-05 of Koa Ridge Makai Development on Ka Uka Road in Mililani, Hawaii the Subject Property. Any exceptions to, or deletions from, the ASTM Practice E1527-05 are described in Section 11.0 of this report. This assessment has revealed no evidence of recognized environmental conditions in connection with the Subject Property except for the following:

- Potential presence of residual contaminants associated with the historic usage of the Subject Property for commercial pineapple and possible sugar cultivation.
- Presence of solid waste observed on the Subject Property (i.e. construction and demolition debris, tires, batteries, abandoned car, car parts/portions, etc.) and the potential impact to the underlying soil from the solid waste.
- Potential presence of residual contamination associated with historic releases and operation of the POL pipeline on the Subject Property and surrounding areas.

11.0 DEVIATIONS AND ADDITIONAL SERVICES

No client imposed constraints or additions were requested. No additional services were requested by ETC's Client. As such, there were no deviations and/or deletions from the ASTM Practice E1527-05 upon completion of this Phase I ESA.

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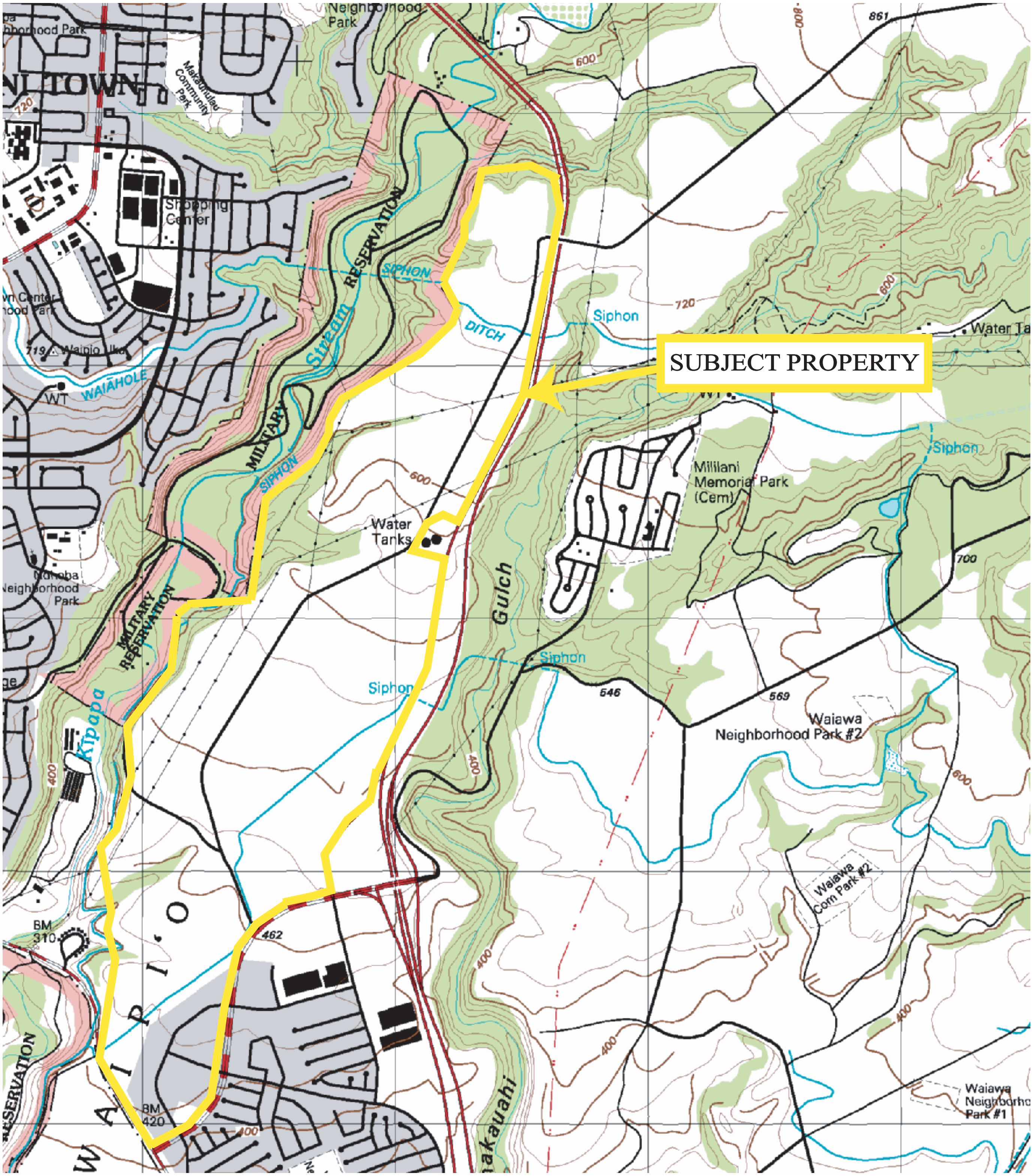
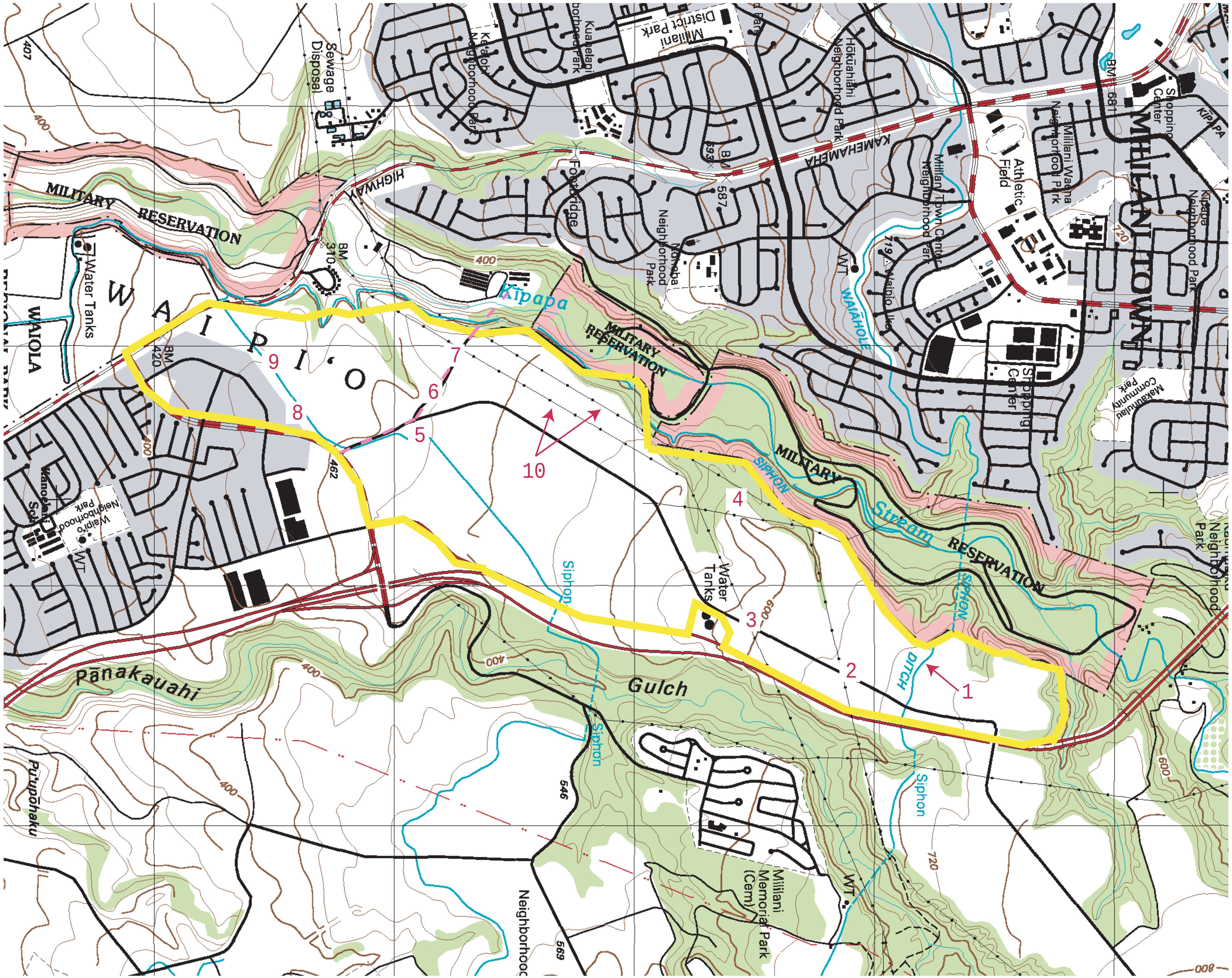
APPENDIX I
FIGURES



Source:
United States Geological Survey
Waipahu Quadrangle
Island of Oahu, 7.5 Minute Series, 1998

N	EnviroServices & Training Center, LLC	ETC Job: 08-1014	**Figure 1 - Site Location Map**
			Phase I Environmental Site Assessment
			Koa Ridge Makai Development
		October 2008	Ka Uka Boulevard
			Mililani, Oahu, Hawaii



LEGEND

1. Waihole Ditch
2. Water Pump
3. Water Pump
4. Abandoned Car
5. Inactive Fertilizer AST and Loading / Storage Area
6. Valve Pit (VP) 19
7. Valve Pit (VP) 18
8. Former Illegal Dumping
9. Solid Waste (i.e. Construction and Demolition debris, tires, car parts, etc.
10. High Voltage Power Lines

Hickam POL Pipeline

Source: United States Geological Survey, Waipahu Quadrangle, Island of Oahu, 7.5 Minute Series, 1998

EnviroServices & Training Center, LLC

ETC Job: 08-1014

October 2008

Figure 2 - Site Plan
Phase I Environmental Site Assessment
Koa Ridge Makai Development
Ka Uka Boulevard
Mililani, Oahu, Hawaii

APPENDIX II
PHOTOGRAPHIC DOCUMENTATION

Photograph 1: Loading and Storage area located on the south portion of the Subject Property near Ka Uka Boulevard.

Photograph 2: Inactive fertilizer AST located within the Loading and Storage area.

Photograph 3: Solid waste observed along the southwest border of the Subject Property.

EnviroServices & Training Center, LLC

ETC Job: 08-1014

October 2008

Photogrphaic Documentation
Phase I Environmental Site Assessment
Koa Ridge Makai Development
Ka Uka Boulevard
Mililani, Oahu, Hawaii

Photograph 4: Solid waste observed along the southwest border of the Subject Property .

Photograph 5: Suspect encroachments observed along the southwest border of the Subject Property.

Photograph 6: Shed structure located on the south portion of the Subject Property.

Photograph 7: Valve Pit (VP) 19 of the Hickam POL Pipeline.

Photograph 8: Water Pump structure located on the north portion of the Subject Property.

Photograph 9: Northernmost water pump structure located on the north portion of the Subject Property.

Photograph 10: Waihole Ditch located on the north portion of the Subject Property.

Photograph 11: Moderate-dense vegetation located on the north portion of the Subject Property which is currently vacant and unoccupied.

Photograph 12: South portion of the Subject Property currently occupied by Aloun Farms.

PHASE I
ENVIRONMENTAL SITE ASSESSMENT

Castle & Cooke Waiawa Development
Waiawa and Waipio
Oahu, Hawaii
TMK (1) 9-4-6: Parcel 29 (portion) and 31 (portion)
TMK (1) 9-6-4: Parcel 21

Prepared For:
CASTLE & COOKE HOMES HAWAII, INC.
P.O. Box 898900
Mililani, Hawaii 96789

Prepared By:
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ETC Project No. 08-1004

March 2008

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APPENDICES

1.0 EXECUTIVE SUMMARY

This report presents the results of a Phase I Environmental Site Assessment (ESA) performed by EnviroServices & Training Center, LLC (ETC) in conformance with the scope and limitations of the American Society for Testing and Materials (ASTM) Practice E1527-05. This Phase I ESA was completed for Castle & Cooke Homes Hawaii, Inc. for the Subject Property located along Waiawa Prison Road in Waipahu, Hawaii and identified as Tax Map Key (TMK) identification numbers (1) 9-4-6: Parcels 29 (portion) and 31 (portion); and (1) 9-6-4: Parcel 21. Review of tax records revealed that parcel 29 and 21 are currently owned by Castle & Cooke Homes Hawaii, Inc. Parcel 31 is currently owned by Waiawa Ridge Development, LLC.

ETC conducted a visual observation for the use and/or storage of hazardous materials and hazardous waste on March 7 and 14, 2008. During ETC's site reconnaissance activities, solid waste (i.e. construction and demolition debris and miscellaneous rubbish) and an abandoned car was observed near and/or along the borders and interior roads of the Subject Property. No releases were observed, however the quantities of solid waste made it infeasible to adequately and fully characterize the potential impact. Although the waste did not appear to pose a material threat to human health or the environment, it may be subject of enforcement action if brought to the attention of appropriate government officials. Therefore, ETC cannot dismiss the possibility that the underlying soil has been adversely impacted.

In addition to solid waste, ETC observed several auto parts/portions, batteries, an apparent photo developing machine, paint cans, and drums (5-gallon to 55-gallon capacity) on the Subject Property. In addition, the 55-gallon drums appeared to leaking a petroleum-based substance onto the soil ground surface and the batteries and apparent containers appeared to be in poor condition (i.e. missing lids, cracked containers, etc.). Given the poor container conditions coupled with the observed evidence of a release, ETC cannot dismiss the possibility that the underlying soil has been impacted.

ETC observed two apparent defunct transformers on the central portion of the Subject Property. Although the apparent transformers did not appear to contain any liquids or leakage, given the poor condition of the apparent transformers, ETC cannot dismiss the possibility that residual fluids may have impacted the ground beneath these transformers.

ETC's document review indicated that the various solid waste and an apparent "open" drum containing "old capacitors" was observed on the radio tower site area of the Subject Property. No evidence of a release was observed from the apparent capacitors or the circuitry fixtures, however, the drum was in poor condition (i.e. no lid) and exposed to inclement weather conditions. Therefore, ETC cannot dismiss the possibility that residual fluids may have impacted the ground beneath the drum.

The Subject Property was not listed in any of the government databases by the contracted database search. The contracted database search did identify thirty-three (33) Orphan sites within the specified radii. Based on ETC's database review, none of the facilities appeared to pose a reasonable risk of impacting the Subject Property.

Historical real property tax records, aerial photographs, and user provided documentation and references indicated past and prior use of the Subject Property for pineapple cultivation and possibly sugar cultivation. In addition, interview findings also confirmed that the Subject Property was formerly used for agricultural purposes. Activities commonly associated with commercial pineapple and/or sugar cultivation include the use and application of fertilizers, pesticides and/or herbicides. This finding is considered a historical recognized environmental condition (REC). Based on the past and prior use of the Subject Property, ETC cannot dismiss the potential presence of contamination for this historical REC and as such this past use is considered a REC for the Subject Property.

In summary, ETC performed a Phase I ESA in conformance with the scope and limitations of ASTM Practice E1527-05 on the Subject Property. This assessment has revealed no evidence of recognized environmental conditions in connection with the Subject Property except for the following.

- Potential presence of residual contaminants associated with the historic usage of the Subject Property for commercial pineapple and possible sugar cultivation.
- Presence of solid waste observed on the Subject Property (i.e. construction and demolition debris, batteries, car parts/portions, etc.) and the potential impact to the underlying soil from the solid waste.
- Presence of batteries, photo developing machine, paint cans, drums, leaking drums, etc. in poor condition.
- The presence of two apparent defunct transformers and “open” drum of capacitors observed in “poor” condition.

2.0 INTRODUCTION

EnviroServices & Training Center, LLC (ETC) was contracted by Castle & Cooke Homes Hawaii, Inc. (CCHHI) to complete a Phase I Environmental Site Assessment (ESA) for the Subject Property.

This Phase I ESA was performed in accordance with the ASTM International Standard E1527-05 entitled *Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process* (referred to herein as the ASTM Practice). The ASTM Practice is intended for use by parties who wish to assess the environmental condition of commercial real estate with respect to contaminants within the scope of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and petroleum products. As such, the ASTM Practice was designed to satisfy "all appropriate inquiry into the previous ownership and uses of the property consistent with good commercial or customary practice" as defined in 42 United States Code (U.S.C.) §9601(35)(B).

2.1 Background

Under CERCLA, persons may be held liable for cleaning up hazardous substances at properties that they either currently own or operate, or owned or operated at the time of disposal. Strict liability in the context of CERCLA means that a potentially responsible party may be liable for environmental contamination based solely on property ownership and without regard to fault or negligence.

In 1986, the Superfund Amendments and Reauthorization Act (SARA) amended CERCLA by creating an "innocent landowner" defense to CERCLA liability for those persons who could successfully demonstrate, among other requirements, that they "did not know and had no reason to know" prior to purchasing the property that any hazardous substance that is the subject of a release or threatened release was disposed of on, in, or at the property. Such persons, to demonstrate that they had "no reason to know" must have undertaken, prior to, or on the date of acquisition of the property, "all appropriate inquiries" into the previous ownership and uses of the property consistent with good commercial or customary standards and practices.

The Small Business Liability Relief and Brownfields Revitalization Act (referred to as "the Brownfields Amendments") was enacted in January 2002 to amend CERCLA. These amendments included providing funds to assess and clean up brownfields sites, clarifying CERCLA liability provisions for certain landowners, and providing funding to enhance state and tribal cleanup programs.

Subtitle B of Title II of the Brownfields Amendments revised CERCLA, clarifying the requirements necessary to establish the innocent landowner defense. The Brownfields Amendments also added protections from CERCLA liability for "bona fide prospective purchasers" and "contiguous property owners" who meet certain statutory requirements. Each of the CERCLA liability provisions for innocent landowners, bona fide prospective purchasers, and contiguous property owners (referred to collectively as "landowner liability protections," or LLPs) requires that, among other requirements, persons claiming the liability protections conduct all appropriate inquiries into prior ownership and use of a property prior to or on the date a person acquires a property.

A key provision of the Brownfields Amendments was to finalize regulations setting federal standards for the conduct of all appropriate inquiries. Such federal standards were promulgated in the *Standards and Practices for All Appropriate Inquiries, Final Rule, 40 CFR Part 312*, referred to as the AAI Final Rule.

Section 312.11 of the AAI Final Rule indicates that the ASTM International Standard E1527-05, entitled *Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process*, may be used to comply with the requirements set forth in Sections 312.23 through 312.31 of the AAI Final Rule. Therefore, this Phase I ESA was performed in conformance with the ASTM International Standard E1527-05.

2.2 Purpose

The purpose and goal of this Phase I ESA is to conduct an inquiry designed to identify recognized environmental conditions in connection with the Subject Property, to the extent feasible pursuant to the process described in the ASTM Practice. The term recognized environmental condition (REC) is defined as:

> "The presence or likely presence of any hazardous substances or petroleum products on a property under conditions that indicate an existing release, a past release, or a material threat of a release of any hazardous substances or petroleum products into structures on the property or into the ground, groundwater, or surface water of the property. The term includes hazardous substances or petroleum products even under conditions in compliance with laws. The term is not intended to include *de minimis* conditions that generally do not present a threat to human health or the environment and that generally would not be the subject of an enforcement action if brought to the attention of appropriate governmental agencies. Conditions determined to be *de minimis* are not recognized environmental conditions."

2.3 Scope of Services

The scope of work included the following:

- Development of a site description for the Subject Property including site background, physical characteristics and historical site conditions;
- Evaluation of user provided information including but not limited to environmental liens, activity and use limitations, specialized knowledge, valuation reduction of environmental issues, and other information pertaining to the property;
- Evaluation of information in programs such as NPL, CERCLIS, FINDS, ERNS, RCRA notifiers, and other governmental information systems within specific radii of the property to identify sites that would have the potential to impact the property;
- Visual evaluation of current site conditions (as applicable) including compliance with appropriate regulations as they pertain to the presence of facility storage tanks, drums, and containers; and transformers and other electrical equipment potentially containing PCBs;
- Visual evaluation of the adjacent properties to identify high-risk neighbors and the potential for a chemical to migrate onto the property; and
- Interviews with owner(s), site manager(s), occupant(s), local government official(s), and/or other individuals with past and prior use history of the property.

2.4 Significant Assumptions

This Phase I ESA is limited by the availability of information at the time of the assessment. Interviews were conducted and interviewee's responses were assumed to be answered in good faith, to the extent of his/her actual knowledge. In addition, since no hydrogeological data was available for the Subject Property, the groundwater was assumed to flow in the direction of the surface topography of the Subject Property and surrounding areas.

2.5 Conditions and Limitations

ETC has completed this Phase I ESA for the Subject Property in accordance with the scope and limitations of ASTM Practice E1527-05. ETC's findings and conclusions contained herein are professional opinions based solely upon visual observations, interviews, and interpretation of the historical information and documents available to ETC at the time this Phase I ESA was conducted. Opinions stated in this report do not apply to changes that may have occurred after the services were performed.

ETC has performed specified services for this project with the degree of care, skill and diligence ordinarily exercised by professional consultants performing the same or similar services. No other warranty, guarantee, or representation, expressed or implied, is included or intended; unless otherwise specifically agreed to in writing by both ETC and ETC's Client.

2.6 User Reliance

This report is intended for the sole use of ETC's Client, exclusively for the project site indicated. ETC's Client may use and release this report, including making and retaining copies, provided such use is limited to the particular site and project for which this report is provided. However, the services performed may not be appropriate for satisfying the needs of other users. Release of this report to third-parties will be at the sole risk of Client and/or said user, and ETC shall not be liable for any claims or damages resulting from or connected with such release or any third party's use or reuse of this report.

2.7 Environmental Professional Certification

We declare that, to the best of our professional knowledge and belief, we meet the definition of *Environmental Professional* as defined in §312.10 of 40 CFR 312. We have the specific qualifications based on education, training, and experience to assess a property of the nature, history, and setting of the Subject Property. We have developed and performed the all appropriate inquiries in conformance with the standards and practices set forth in 40 CFR Part 312.

Prepared by: ______________________________

Sharla Horiuchi
Environmental Professional
EnviroServices & Training Center, LLC

3.0 SITE DESCRIPTION

3.1 Location and Description

The Subject Property, located along Mililani Cemetery Road consists of approximately 191 acres of land and is located in Waipio/Waiawa, Oahu, Hawaii (Appendix I, Figure 1). A site map is included in Appendix I, Figure 2. Photographic documentation is included in Appendix II.

3.2 Physical Setting

Groundcover at the Subject Property generally consists of moderate to dense vegetation. Asphalt and concrete paved areas were limited to the Waiawa Prison Road, which bisects the Subject Property. The Subject Property and surrounding areas exhibited a varying gradient, however the topographic grade of the Subject Property has an approximate 0 to 5 percent slope range to the southwest with moderate to steep slopes near the bordering Panakauahi Gulch.

3.2.1 Site Topography

Topographic map coverage of the Subject Property vicinity is provided by the United States Geological Survey, Island of Oahu, 7.5 minute Waipahu Quadrangle, 1998. The elevation of the Subject Property is between 400 and 600 feet above mean sea level (msl).

3.2.2 Regional Geology

Oahu is formed by the erosional remnants of two shield volcanoes. These are the Waianae range to the west and the Koolau range to the east. The Waianae volcano is estimated to have formed 2.4 to 3.6 million years before present. It consists of a tholeiitic lava shield with a thick cap of transitional to alkalic rock. Rejuvenation-stage volcanics of undifferentiated age occur in Kolekole Pass and on the south flank of the Waianae shield. Dike orientations define northwest and southwest rift zones (Macdonald, et al., 1983).

The Koolau volcano is estimated to have formed 1.8 to 2.6 million years before the present (Macdonald, et al., 1983). It consists of a tholeiitic lava shield and lacks an alkalic cap. It has well defined major dike complex trending northwest-southwest. A third, minor rift zone referred to as the Kaau rift trends southward from Kaau crater, near the upland crest of the Koolau Ridge. After a long dormant period and periods of deep erosion, the Koolau volcano developed abundant and scattered rejuvenation-stage vents, typically aligned on northeast-striking fissures (Macdonald, et al., 1983).

3.2.3 Site Geology

The soil at the Subject Property is mapped as a combination of Wahiawa silty clay, 0 to 3 percent slopes (WaA); Wahiawa silty clay, 3 to 8 percent slopes (WaB); Manana silty clay, 3 to 8 percent (MpB); Manana silty clay, 8 to 15 percent slopes (MpC); Manana silty clay, 15 to 25 percent slopes (MpD); and Helemano silty clay, 30 to 90 percent slopes (HLMG).

The majority of the Subject Property is characterized as part of the Wahiawa Series. The Subject Property consist of the Wahiawa silty clay, 0 to 3 percent slopes (WaA), while the western portion is Wahiawa silty clay, 3 to 8 percent slopes (WaB). The Wahiawa series consists of well drained soils on the uplands of the island of Oahu developed in residuum and old alluvium from basic igneous rock. WaA and WaB consists of a very dusky red silty clay surface layer approximately 12 inches thick. The subsoil, which is about 48 inches thick, consists of dark redish-brown silty clay that has a subangular blocky structure. This material is further underlain by weathered basic igneous rock. Acidity of the soil ranges from medium acid to neutral, permeability is moderately rapid, runoff is slow and the erosion hazard is slight. Annual rainfall amounts to 40 to 60 inches. These soils are used for sugarcane, pineapple, pasture, and homesites. The natural vegetation consists of bermudagrass, guava, honohono, koa haole, and lantana (USDA, 1972).

The Manana Series consists of well-drained soils on the uplands of the island of Oahu developed in material weathered from basic igneous rock. In a representative profile, MpB, MpC, and MpD consist of an 8 inch thick surface layer of dark reddish-brown silty clay loam. The subsoil, which is about 42 inches thick, is dusky red, dark reddish-gray, and dark reddish-brown silty clay that has a subangular blocky structure. This subsoil also contains a nonporous, panlike sheet, measuring 1/8 inch to a 1/4 inch thick located at depths from 15 to 50 inches below ground surface. This material is further underlain by soft, weathered basic igneous rock which is extremely acid. Permeability is moderately rapid above the pan and moderate below. MpB is classified as having slow runoff and a slight erosion hazard. MpC and MpD are described as having medium runoff and a moderate erosion hazard. Annual rainfall amounts to 40 to 60 inches. Manana soils are used for sugarcane, pineapple, and pasture. The natural vegetation consists of bermudagrass, Christmas berry, false staghornfern, glenwoodgrass, guava, koa, ohia, and sedges (USDA, 1972).

HLMG consists of well-drained soils on alluvial fans and colluvial slopes on the sides of V-shaped gulches. They are located on the island of Oahu and developed in alluvium and colluvium derived from basic igneous rock. The surface layer is dark reddish-brown silty clay about 10 inches thick. The subsoil, which is about 50 inches thick, is dark reddish-brown and dark-red silty clay that has subangular blocky structure. This material is further underlain by soft, highly weathered basic igneous rock. Acidity of the soil ranges from slightly acid to neutral, permeability is moderate, runoff is medium to very rapid, and the erosion hazard is severe to very severe. The annual rainfall dominantly amounts to 30 to 60 inches but ranges to 75 inches at the highest vegetation. These soils are used for pasture, woodland, and wildlife habitat. The natural vegetation consists of bermudagrass, Christmas berry, eucalyptus, Formosa koa, guava, Japanese tea, Java plum, and koa haole (USDA, 1972).

3.2.4 Regional Hydrogeology

The primary drinking water in the Hawaiian Islands is drawn from basal groundwater. Basal groundwater is formed by rainwater percolating down through the residual soils and permeable volcanic rock. All of the island situated below sea level, except within rift zones of the volcanoes, is saturated with ocean salt water and thus forms a basal lens called the "Ghyben-Herzberg" lens. A zone of transition between the fresh groundwater and the ocean salt water occurs due to the constant movement of the interface as a result of tidal fluctuations, seasonal fluctuations in recharge and discharge and aquifer development (Macdonald, et al., 1983).

Downward percolation of rainwater may be stopped by impermeable layers such as dense lava flows, alluvial clay layers and volcanic ash. The groundwater then forms a perched or high level aquifer, which is not in contact with salt water. Recharge of the aquifer occurs in areas of high rainfall, which are the interior mountainous areas. The groundwater flows from the recharge areas to the areas of discharge along the shoreline. Frictional resistance to groundwater flow causes it to pile up within the island until it attains sufficient hydraulic head to overcome friction. Thus, basal groundwater tends to slope toward the shoreline.

3.2.5 Site Hydrogeology

The Subject Property is underlain by the Waiawa Aquifer System, which is part of the Pearl Harbor Aquifer Sector on the island of Oahu. The aquifer is classified by Mink and Lau, 1990, with the system identification number 30202111 (11111). This system includes an unconfined, basal aquifer in flank, horizontally extensive lava. The groundwater in this aquifer is described as a currently used, fresh drinking water source with salinity less than 250 mg/l Cl^-. The groundwater is also described as irreplaceable with a high vulnerability to contamination (Mink and Lau, 1990).

3.2.6 Nearest Surface Water Bodies

The nearest surface water body is an intermittent ditch/siphon which traverses the southwest portion of the Subject Property. The ditch/siphon appeared to be a tributary to the intermittent water in the Panakauahi Gulch which eventually discharges to the Waiawa Stream.

3.3 Current Use of the Subject Property

The Subject Property is currently used a pasture land by Mr. Robert Cherry. Approximately 40 cattle graze on the Subject Property. An approximate 4 acre area of land located along the Waiawa Prison Road is occupied by a radio tower site.

3.4 Current Uses of the Adjoining Properties

ETC visually inspected the neighboring properties and their operations from publicly accessible areas. The Subject Property is bordered by the Panakauahi Gulch to the north, Mililani Cemetery Road and the Panakauahi Gulch to the west, pasture/vacant land to the northeast and south, and Waiawa Prison Road and pasture/vacant land to the east. Photographic documentation of the Subject Property and adjoining properties is included in Appendix II.

4.0 USER PROVIDED INFORMATION

This section is intended to provide information obtained from the user of this Phase I ESA that will help identify RECs associated with the Subject Property. The information provided does not require the user to have the technical expertise of an environmental professional and are generally not provided by the environmental professional performing the Phase I ESA.

4.1 Required Information

In order to qualify for one of the LLPs offered by the Brownfields Amendments, the user must provide the following information (if available) to the environmental professional. Failure to provide this information could result in a determination that "all appropriate inquiry" is not complete. Mr. Rodney Funakoshi of CCHHI ("user") provided ETC with the following information.

4.1.1 Environmental Liens

The user had no knowledge of any environmental liens or governmental notifications relating to past or recurrent violations of environmental laws with respect to the Subject Property.

4.1.2 Activity and Use Limitations

The user had no knowledge of any other activity and land use limitations filed or recorded in a registry under federal, tribal, state or local law.

4.1.3 Specialized Knowledge

The user had no specialized knowledge or experience related to the Subject Property or nearby properties.

4.1.4 Valuation Reduction for Environmental Issues

The user indicated that the determination whether the purchase price being paid for the Subject Property reflects the fair market value of the Subject Property was not available.

4.1.5 Commonly Known or Reasonably Ascertainable Information

The user was not aware of any commonly known or reasonably ascertainable information about the Subject Property that would help the environmental professional to identify conditions indicative of releases or threatened releases.

4.1.6 Degree of Obviousness of Potential Contamination

The user indicated that past usage of the Subject Property include pineapple cultivation, cattle ranching, and the presence of a radio tower. The user also indicated that cleanup of fugitive dumping of 18 drums occurred in 1997. User provided documentation pertaining to this cleanup is further discussed in Section 4.3.1.

4.2 Other Information Pertaining to Subject Property

The user had no additional concerns regarding the Subject Property or any adjoining properties.

4.2.1 Reason for Performing Phase I ESA

This Phase I ESA was conducted to identify potential development constraints associated with the Subject Property.

4.2.2 Title Records

Title records/documents for Parcels 21 and 29 were provided by the user. These documents are included in Appendix III. ETC also conducted a land title search which is documented in Section 5.3.3.

4.2.3 Owner, Property Manager, and Occupant Information

Subject Property Owner/Manager:

CCHHI, 100 Kahelu Avenue, 2nd floor, Mililani, HI 96789-8900

Contact: Ms. Beverly Kaku, Senior Land Agent, CCHHI

Tel: (808) 548-2945

Subject Property Occupant(s):

Flying R Livestock Ranch

Contact: Mr. Robert Cherry

Tel: (808) 864-9796

Hochman-McCann Hawaii, Inc. (Radio Tower Site)

Contact: Mr. George Hochman

Tel: (808) 342-0065

4.3 Other User Provided Information

ETC reviewed several Client provided environmental reports and correspondence pertaining to the Subject Property.

4.3.1 File Correspondence, March 6, 2000

Review of telephone correspondence and file notes, dated March 6, 2000 indicated that a report of fugitive dumping on the Subject Property was documented on April 16, 1997. Eighteen leaking metal drums were reportedly illegally disposed on the central portion of the Subject Property. The Hawaii Department of Health (DOH) Hazard Evaluation and Emergency Response (HEER) Office responded to the suspected release and stabilized the leaking drums; absorbed the fluids; and removed the drums and any visually impacted soil. DOH HEER Office personnel indicated that the drums contained type A and B roofing chemicals. Subsequently, DOH HEER Office personnel informed CCHHI that there would be no cost recovery for the cleanup and as a result the case was considered closed. In addition, the release notification form indicated that the incident was classified as a "no further action" required release.

4.3.2 Draft Environmental Impact Statement, Wilson Okamoto Corporation, October 2007

ETC's review of the *Draft Environmental Impact Statement (EIS)* performed by Wilson Okamoto Corporation (WOC) indicated that the EIS was performed for the Subject Property "to identify probable impacts and determine relevant mitigation measures resulting from the development of the" Castle & Cooke Waiawa project. The project consists of the development of the pasture and vacant lands of the Subject Property into a residential community. Review of the *Draft EIS* revealed historical usage of the Subject Property and surrounding areas. Specifically, the *Draft EIS* indicated that "for the greater part of a century, Dole Food Company Hawaii (Dole) grew pineapple on the" Subject Property. In 1993, "Dole ceased growing pineapple" on the Subject Property. Since 2000, the Subject Property and surrounding areas have been "leased to Flying R Livestock Co. for grazing cattle."

4.3.3 Phase I Environmental Site Assessment, EnviroQuest, Inc., February 2008

In February 2008, EnviroQuest, Inc. (EQI) conducted a Phase I Environmental Site Assessment for the radio tower site located on the Subject Property. EQI identified no evidence of recognized environmental conditions (RECs) for the radio tower site. EQI's Phase I ESA indicated that there was one "hollow tile single room structure," a 20 foot storage container, and antennae system located on the radio tower site. Although EQI did not identify any RECs for the radio tower site, review of EQI's photographic documentation indicated that various solid waste and an apparent "open" drum containing "old capacitors" was observed. In addition, "empty electronic circuitry" was observed on the site.

4.3.4 Other Provided References

CCHHI in cooperation with WOC provided ETC with several references pertaining to the historic use of pesticides/herbicides in pineapple cultivation in Hawaii. As a result, ETC researched the following user provided references at the University of Hawaii:

- St. John, Harold and Edward Yataro Hosaka (1932). *Weeds of the pineapple fields of the Hawaiian islands* (p.10). Honolulu, University of Hawaii.
- Carter, Walter (1934). Unsaturated petroleum oils as insecticides. Reprinted from *Science*, 80 (2075), 315.
- Tam, Richard K. (1947). Comparative herbicidal value of 2,4-Dichlorophenoxyacetic acid and 2,4,5-Trichlorophenoxyacetic acid on some herbaceous weeds, shrubs, and trees under Hawaiian conditions. Reprinted from *The Botanical Gazette*, 109(2), 194-203.
- 1999 Pineapple Integrated Pest Management Guidelines and Elements. Retrieved March 18, 2008, from HAWAII IPM PROGRAM Integrated Pest Management. Website:http://www.extento.hawaii.edu/IPM/Certification/Pineapple/Guidelines1.asp.
- Cultivating Pineapple. A laboring report from Hawaii (1961). Honolulu. 1 video cassette (VHS) (9 minutes). [video recording]

Review of above referenced publications indicated that the following chemicals have been historically used in Hawaii's pineapple fields. Note that none of the references were specific to activities on the Subject Property.

- Sodium arsenite (applied as a spray for weed control);
- Diesel engine oil (applied as a spray for weed control);
- Sodium chlorate (applied as a spray for weed control);
- Carbon disulfide (injected into the soil for weed control);
- Chloropicrin (soil fumigant injected into the soil for weed control);
- Methyl bromide (soil fumigant for nematode control);
- Telone II (1,3-D) (soil fumigant for nematode control);

In addition, 2,4,5-T and 2,4-D (herbicides) were not likely used for weed control purposes due to their toxicity to the pineapple plant (Tam, 1947).

5.0 RECORDS REVIEW

5.1 Standard Environmental Record Sources

To obtain information concerning recognized environmental conditions at or near the Subject Property, ETC contracted Environmental Data Resources, Inc. (EDR) to conduct an environmental database search. EDR is a company that specializes in the review of public regulatory environmental databases. The regulatory agency report provided (Appendix IV) is based on an evaluation of the data collected and compiled by a contracted data research company. The report is a radius search report, which focuses on both the Subject Property and adjacent properties that may impact the Subject Property. Adjacent properties listed in governmental environmental records are identified within a specific search radius (Table 1). The search radius varies depending on the particular record being researched. The search is designed to meet the requirements of the current industry approach as described in ASTM Practice E1527-05. The information provided is assumed to be correct and complete, unless noted otherwise.

Table 1: ASTM Practice Environmental Record Sources and Recommended Search Distances

Environmental Database Sources	ASTM Practice Search Distances (miles)
Federal NPL Site List	1.0
Federal CERCLIS List	0.5
Federal CERCLIS NFRAP Site List	0.5
Federal RCRA CORRACTS Facilities List	1.0
Federal RCRA non-CORRACTS TSD Facilities List	0.5
Federal RCRA Generators List	Subject Property and adjoining properties
Federal Institutional Control/Engineering Control Registries	Subject Property only
Federal ERNS List	Subject Property only
State-Equivalent NPL	1.0
State-Equivalent CERCLIS	0.5
State Landfill and/or Solid Waste Disposal Site Lists	0.5
State Leaking UST List	0.5
State Registered UST List	Subject Property and adjoining properties
State Institutional Control Registry	Subject Property only
State Voluntary Cleanup/Response (VCP/VRP) Sites	0.5
State Brownfield Sites	0.5

5.1.1 Federal NPL

The National Priorities List (NPL) is the Environmental Protection Agency's (EPA) database of uncontrolled or abandoned hazardous waste properties, which are considered to pose an immediate threat to human health and the environment. These properties are identified for priority remedial response actions under the Superfund Program. The Subject Property was not identified as a NPL site. The database did not identify any NPL sites within a 1-mile radius of the Subject Property.

5.1.2 Federal CERCLIS and CERCLIS NFRAP

The Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) database contains information on various aspects of potentially uncontrolled or abandoned hazardous waste properties from initial screening and assessment phases to listing on the NPL. The Subject Property was not identified as an active CERCLIS site or a CERCLIS No Further Remedial Action Planned (NFRAP) site. The database did not identify any CERCLIS sites within a 0.5-mile radius of the Subject Property.

5.1.3 Federal RCRA CORRACTS

RCRA Corrective Action Sites (CORRACTS) database contains Resource Conservation Recovery Information System (RCRIS) sites with reported corrective action. The Subject Property was not identified as a CORRACTS facility. The database did not identify any RCRA CORRACTS sites within approximately 1-mile of the Subject Property.

5.1.4 Federal RCRA (non-CORRACTS) TSD Facilities

The EPA's RCRA program identifies and tracks hazardous waste from the point of generation to the point of final disposal. The RCRA Treatment, Storage or Disposal (TSD) facility database compiles those reporting facilities that treat, store, or dispose of hazardous waste. The Subject Property was not listed as a RCRA TSD facility. Additionally, the database did not identify any RCRA TSD facilities within a 0.5-mile radius of the Subject Property.

5.1.5 Federal RCRA Generator

The RCRA Generator database is a compilation by EPA's RCRIS of regulated facilities that generate hazardous waste. The Subject Property was not identified as a RCRA Generator. The database search did not identify any RCRA SQG or LQG sites adjacent to the Subject Property.

5.1.6 Federal Institutional Control/Engineering Control Registries

Engineering controls include various forms of caps, building foundations, liners, and treatment methods to create pathway elimination for regulated substances to enter environmental media or effect human health. Institutional Controls include administrative measures, such as groundwater use restrictions, construction restrictions, property use restrictions, and post remediation care requirements intended to prevent exposure to contaminants remaining on a site. The EPA Institutional Control and Engineering Control registry maintains a listing of sites with Institutional or Engineering Controls in place. The Subject Property was not identified to have institutional or engineering controls in place.

5.1.7 Federal ERNS

The Emergency Response Notification System (ERNS) tracks the initial notification of reported oil and hazardous material spills. The database contains information regarding the discharger, release date, material, amount released, incident location and release action taken. The Subject Property was not identified as an ERNS facility.

5.1.8 State Equivalent NPL and CERCLIS

The CERCLIS List is a compilation of known or suspected uncontrolled or abandoned hazardous waste sites. These sites either have been investigated or are currently under investigation by the EPA for the release, or threatened release, of hazardous substances. Once a site is placed in CERCLIS, it may be subjected to several levels of review and evaluation and ultimately placed on the National Priorities List. The State of Hawaii does not have a formal "State Superfund" program; therefore, the State Hazardous Waste Sites (SHWS) are the State of Hawaii's equivalent to the federal EPA's CERCLIS database. Additionally, because this information is acquired from the Hawaii Department of Health (DOH) Hazard Evaluation and Emergency Response (HEER) Office, these sites may or may not already be listed on the federal CERCLIS list. Priority sites planned for cleanup that use state funds (state equivalent superfund) are identified along with sites where cleanup is paid for by the potentially responsible parties. The Subject Property was not identified as a SHWS. The database search did not identify any SHWS facilities within a 1-mile radius of the Subject Property.

5.1.9 State Landfill and/or Solid Waste Disposal

The State of Hawaii has records of all facilities that have received a solid waste management permit, including solid waste landfills, transfer stations, and incinerators. The Subject Property was not identified as a Solid Waste Facility/Landfill (SWF/LF) facility. The database search did not identify any SWF/LF facilities within a 0.5-mile radius of the Subject Property.

5.1.10 State Leaking Underground Storage Tanks

The DOH Underground Storage Tank (UST) Program maintains a listing of all reported leaks and releases from USTs. The Subject Property was not identified as a leaking underground storage tank (LUST) facility. The database did not identify any LUST facilities within a 0.5-mile radius of the Subject Property.

5.1.11 State Registered Underground Storage Tanks

The DOH Underground Storage Tank (UST) Program registration system tracks known and registered UST systems. The Subject Property was not identified as a UST facility. The database search did not identify any UST facilities located adjacent to the Subject Property.

5.1.12 State Institutional Control Registry

Institutional Controls include administrative measures, such as groundwater use restrictions, construction restrictions, property use restrictions, and post remediation care requirements intended to prevent exposure to contaminants remaining on a site. The State Institutional Control listing includes Voluntary Response Program and Brownfields sites with institutional controls in place. The Subject Property was not identified as having institutional controls in place.

5.1.13 State Voluntary Cleanup/Response Sites

The Hawaiʻi Voluntary Response Program (VRP) was created on July 7, 1997 by amendments made to Hawaii's Environmental Response Law (ERL). The purpose of the VRP is to streamline the cleanup process in a way that will encourage prospective developers, lenders, and purchasers to voluntarily cleanup properties. The VRP facilitates the cleanup process and, in certain situations, provides relief from the strict liability provisions of the Federal CERCLA and Hawaiʻi ERL. The Subject Property was not identified as a VRP site. The database search did not identify any VRP sites located within a 0.5-mile radius of the Subject Property.

5.1.14 State Brownfields

A Brownfields site is land, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant. The Subject Property was not identified as a Brownfields site. The database search did not identify any Brownfields sites located within a 0.5-mile radius of the Subject Property.

5.1.15 Unmappable/Orphan Sites

Thirty-three (33) unmappable sites were identified in the Orphan Summary of the EDR Report. Unmappable sites are not plotted due to poor or inadequate address information. Due to the inaccurate or incomplete information provided by the respective agency, these sites cannot be plotted with confidence. Review of the addresses and site names coupled with ETC site reconnaissance findings indicated that neither the Subject Property nor adjacent properties were identified in the Orphan Summary of the database report.

5.2 Additional Environmental Record Sources

The EDR database also included a number of other regulatory databases that are not specified by the ASTM Practice. In addition, the EDR database did not identify the Subject Property in any of the following databases.

Proposed NPL – Proposed National Priority List Sites

Delisted NPL – National Priority List Deletions

NPL RECOVERY – Federal Superfund Liens

HMIRS – Hazardous Materials Information Reporting System

DOD – Department of Defense Sites

FUDS – Formerly Used Defense Sites

US Brownfields – A Listing of Brownfields Sites

AIRS – A Listing of Permitted Facilities

CONSENT – Superfund (CERCLA) Consent Decrees

ROD – Records of Decision

UMTRA – Uranium Mill Tailings Sites

ODI – Open Dump Inventory

TRIS – Toxic Chemical Release Inventory System

TSCA – Toxic Substances Control Act

FTTS – FIFRA/TSCA Tracking System

SSTS – Section 7 Tracking Systems

ICIS – Integrated Compliance Information System

LUCIS – Land Use Control Information System

CDL – Clandestine Drug Labs

RADINFO – Radiation Information Database

PADS – PCB Activity Database System

MLTS – Material Licensing Tracking System

MINES – Mines Master Index File

RAATS – RCRA Administrative Action Tracking System

SPILLS – Release Notifications

DRYCLEANERS – Permitted Drycleaner Facility Listing

INDIAN RESERV – Indian Reservations

INDIAN LUST – Leaking Underground Storage Tanks on Indian Land

Manufactured Gas Plants – EDR Propriety Manufactured Gas Plants

5.3 Historical Use Information on the Subject and Adjoining Properties

Historical uses of the Subject Property and adjoining properties were investigated through the review of documentation available from public land records and State of Hawaii archived information. In addition, available aerial photographs, plat maps, Sanborn maps, and building permits were reviewed.

5.3.1 Aerial Photograph Review

Aerial photographs from the Map Collection of the University of Hawaii's Hamilton Library were reviewed. A total of six (6) aerial photographs were found that included the Subject Property. These photographs were dated 1952, 1959, 1962, 1968, 1977, and 2000. The Subject Property and surrounding areas appeared undeveloped with no visible structures in the 1951 aerial photograph. However, apparent interior roads were visible and the Subject Property appeared to be used for agricultural purposes. In addition, the Panakauahi Gulch was noted along the west boundary of the Subject Property. Due to cloud coverage, the Subject Property and surrounding areas were not clearly visible in the 1959 aerial photograph, however, no significant changes were observed. The 1962 aerial photograph appeared similar to the 1952 and 1959 aerial photographs with no significant changes. The 1968 aerial photograph appeared similar to the 1962 aerial photograph except the apparent Mililani Cemetery was noted north of the Subject Property. The 1977 aerial photograph appeared similar to the 1968 aerial photograph with no significant changes. However, the H2 highway was noted west of the Subject Property. Review of the 2000 aerial photograph indicated that a limited portion of the Subject Property along the apparent Waiawa Prison Road appeared developed with one or more structures (likely radio tower site). In addition, based on the observed differences in vegetation on the Subject Property, agricultural activities were suspected to have ceased. Review of the surrounding areas indicated that the areas west of the H2 highway appeared developed with commercial type structures and the previously observed Mililani Cemetery appeared further developed.

5.3.2 Fire Insurance Maps

ETC contracted EDR to conduct a search for Sanborn fire insurance maps of the Subject Property. The search included an extensive review of the ERIIS Historical Map Collection, which is a private collection of prior-use maps in the United States. There were no Sanborn fire insurance maps available for the Subject Property.

5.3.3 *Property Tax Files and Land Title Records*

ETC conducted a chain of title search of the Subject Property at the Hawaii County Real Property Tax office. The past and present owners of TMK (1) 9-6-4: Parcel 21 and TMK (1) 9-4-6: Parcels 29 (portion) and 31 are summarized in Table 2. The current owner of Parcel 21 and Parcel 29 was listed as Castle & Cooke Homes Hawaii Inc. The current owner of parcel 31 was listed as Waiawa Ridge Development, LLC.

Table 2: Chain of Title Review

Date	Description
TMK (1) 9-6-4: Parcel 21	
1996 to present	Owner: Castle & Cooke Homes Hawaii, Inc. FKA Castle & Cooke Hawaii, Inc. and Castle & Cooke Residential Inc.
1995 to 1996	Owner: Castle & Cooke Hawaii, Inc.
1987 to 1995	Owner: Castle & Cooke, Inc.
1987 to 1987	Owner: Castle & Cooke Inc. New parcel from TMK (1) 9-6-4: 1 and (1) 9-6-5: 1.
1946 to 1987	Owner: BP Bishop Estate Lessee: Oahu Sugar Co.
TMK (1) 9-4-6: Parcel 29 (Portion)	
1993 to present	Owner: Castle & Cooke Homes Hawaii, Inc. FKA Castle & Cooke Hawaii, Inc. and Castle & Cooke Residential Inc.
1991 to 1993	Owner: Dole Food Company, Inc. FKA Castle & Cooke, Inc.
1964 to 1993	Owner: Castle & Cooke, Inc.
1960 to 1964	Owner: Dole Corporation FKA Hawaiian Pineapple Co. Ltd.
1952 to 1960	Owner: Hawaiian Pineapple Co. Ltd.
Prior to 1952	Owner: John Ii Estate Ltd. Lessee: Oahu Sugar Co. (partial area lease)
TMK (1) 9-4-6: Parcel 31 (portion)	
2006 to present	Owner: Waiawa Ridge Development, LLC
2006 to 2006	Owner: Waiawa Development, LLC
1988 to 2006	Owner: Thomas H. Gentry Revocable Trust
1978 to 1988	Owner: Thomas H. Gentry (50%) Gentry Waipio (50%)
1972 to 1978	Owner: Thomas Henry Gentry
1964 to 1972	Owner: Castle & Cooke, Inc.
1960 to 1964	Owner: Dole Corporation FKA Hawaiian Pineapple Co. Ltd.
1952 to 1960	Owner: Hawaiian Pineapple Co.
Prior to 1952	Owner: John Ii Estate Lessee: Oahu Sugar Co. (partial area lease)

5.3.4 *Building Permits*

A review of available building permits issued by the City and County of Honolulu indicated that there were no permits available for the Subject Property.

6.0 SITE RECONNAISSANCE

ETC performed a site reconnaissance on March 7 and 14, 2008 in order to complete a visual survey to identify the use and/or storage of hazardous materials.

6.1 Methodology and Limiting Conditions

The west and central portions of the Subject Property encompassed the edge of the Panakauahi Gulch, which included steep inaccessible inclines. As such, these areas were not included in ETC's site reconnaissance activities. There were no other limiting conditions imposed by physical obstructions i.e. adjacent buildings, bodies of water, asphalt, and/or other paved areas.

6.2 General Site Setting

The Subject Property primarily consisted of undeveloped land. Two small single story structures were noted on the Waiawa Prison road and Mililani Cemetery road. Both structures were inaccessible at the time of ETC's site reconnaissance activities. One structure was part of the Radio Tower site and was inspected as part of the EQI's February 2008 Phase I ESA, which was discussed in Section 4.3.3. The second structure was located along the Mililani Cemetery Road and appeared to used for utility purposes. Based on the size and presumed usage of these structures, the contents of these structures were not anticipated to cause significant environmental impairment to the Subject Property.

ETC personnel also observed an apparent "dry" stone-lined irrigation/drainage ditch on the central portion of the Subject Property. A map of the Subject Property is included in Appendix I, Figure 2. Photographic documentation of ETC's site reconnaissance is included in Appendix II.

6.3 Exterior Observations

Visual inspection of the exterior areas of the Subject Property indicated the groundcover primarily consisted of bare soil, interior dirt and asphalt paved roads and various vegetation. ETC observed several piles of the apparent solid waste throughout the Subject Property. Observations included general construction and demolition debris (i.e. toilets, tiles, concrete, asphalt), and miscellaneous municipal waste. In addition, ETC observed an apparent abandoned automobile along the north border of the Subject Property. No releases were observed in the vicinity of the abandoned automobile.

ETC also observed several car parts/portions, car batteries, paint cans, and drums (5-gallon to 55-gallon capacity) on the Subject Property. Specifically, ETC observed two 55-gallon drums and an apparent defunct photo developing machine on the central portion of the Subject Property. The 55-gallon drums appeared to contain a petroleum-based substance and evidence of a release was observed. In addition, several of the batteries and containers appeared to be in poor condition (i.e. missing lids, cracked containers, etc.). All observed conditions on the Subject Property were documented and mapped out in Appendix I, Figure 2.

6.3.1 USTs / ASTs

A visual inspection for the presence of USTs or aboveground storage tanks (ASTs) was also conducted. No visual evidence (i.e. vent or fill pipes, dispensers, etc.) of the presence of USTs or ASTs were observed.

6.4 Interior Observations

The interior areas of the two observed building structures were not visually inspected, however these areas were not anticipated to significantly impact the Subject Property.

6.5 Dielectric Fluid Containing Equipment

A visual inspection for hydraulic and electrical equipment or electrical components that use fluid that may contain PCBs was conducted. The following observations were noted:

- No hydraulic equipment was observed.
- Several pole mounted transformers were observed along the Waiawa Prison Road and the Mililani Cemetery Road. These transformers were observed to be in good and condition with no evidence of a release.
- ETC observed two apparent defunct transformers on the central portion of the Subject Property in the vicinity of the radio tower site. ETC also observed a drum of apparent capacitors at the radio tower site. The apparent capacitors and the drum did not appear to be leaking. The transformers did not appear to contain any liquids and no evidence of a release was observed from the suspect transformers. However, the apparent transformers appeared to be in poor condition with evidence of exposed wiring. The locale of the apparent transformers was mapped out in Appendix I, figure 2.

7.0 INTERVIEWS

The objective of the interviews is to obtain information from past and present owners, operators, and occupants of the Subject Property to identify potential RECs in connection with the Subject Property.

7.1 Interviews with Subject Property Occupant

<u>Mr. Robert Cherry, Flying R Livestock Ranch, Subject Property Occupant</u>

- Mr. Cherry's knowledge of the Subject Property and surrounding areas dates back approximately 10 years. Mr. Cherry leased the majority of the Subject Property and much of the adjacent properties, which are owned by Gentry (aka Waiawa Ridge Development, LLC).
- The Subject Property was primarily used for pineapple cultivation. The upper adjacent area (north) may have been used for sugar cane cultivation.
- The Subject Property is currently used for cattle gazing. The cattle graze on the natural vegetation of the Subject Property. There are a total of 38 cows and 2 bulls on the Subject Property.
- The fences and water bins were installed throughout the Subject Property for the cattle.
- The cattle are not treated with any sprays, however, a pour on wormer called Ivomec is used on the cattle.
- No heavy equipment or machinery is stored or used on the Subject Property.
- Water is provided by irrigation water line(s) on the Subject Property, which are located throughout the Subject Property. The water originates from the Waiahole Ditch.
- There is no sewer system infrastructure on the Subject Property.
- There are no USTs, ASTs or mobile storage tanks on the Subject Property.
- There are not transformers or electricity on the Subject Property.
- There are no hazardous materials or wastes (PCBs, solvents, oils, etc.) on the Subject Property.
- There has been no burying or burning of any waste or rubbish.
- There is no known contamination on the Subject Property, however, there are piles of solid waste located on the Subject Property along the interior roads. Specifically, there are piles of concrete, tires, rocks, and various white goods, all of which was present prior to 1998.
- There are no and have not been any pits, ponds, or lagoons located on the Subject Property in connection with treatment or waste disposal
- There are no environmental liens or governmental notifications relating to past or recurrent violations of environmental laws with respect to the Subject Property.

8.0 FINDINGS AND OPINIONS

8.1 Site Description

No significant findings to indicate suspect RECs, historical RECs, or *de minimis* conditions were identified.

8.2 User Provided Information

8.2.1 Required Information

No significant findings to indicate suspect RECs, historical RECs, or *de minimis* conditions were identified.

8.2.2 Other Information Pertaining to the Subject Property

No significant findings to indicate suspect RECs, historical RECs, or *de minimis* conditions were identified.

8.2.3 Other User Provided Information

File Correspondence, March 6, 2000

No significant findings to indicate suspect RECs, historical RECs, or *de minimis* conditions were identified.

Draft EIS, WOC, October 2007

Review of WOC's Draft EIS indicated that Dole grew pineapple on the Subject Property for the "greater part of a century" until 1993. The past and prior use history of the Subject Property is discussed further in Section 8.3.3.

Phase I ESA, EQI, February 2008

ETC's review of EQI's February 2008 Phase I ESA for the 4-acre radio tower site located on the Subject Property indicated that the various solid waste and an apparent "open" drum containing "old capacitors" was observed on the radio tower site. In addition, "empty electronic circuitry" was observed on the site. These materials were also observed by ETC during site reconnaissance activities of the Subject Property (Section 6.3). No evidence of a release was observed from the apparent capacitors or the circuitry fixtures, however, the drum was in poor condition (i.e. no lid) and exposed to inclement weather conditions. Therefore, ETC cannot dismiss the possibility that residual fluids may impact the ground beneath the drum. As such, this finding is considered a REC.

Other Provided References

ETC researched several user provided references at the University of Hawaii. ETC review of these references indicated that various pesticides/herbicides and fumigants have historically been used in Hawaii's pineapple fields. These pesticides/herbicides and fumigants include sodium arsenite, diesel engine oil, carbon disulfide, chloropicrin, methyl bromide, and Telone II.

Additional References

In addition to the user provided references (discussed in Section 4.3.4), ETC also reviewed the following publications regarding the general usage of pesticides/herbicides in pineapple cultivation in Hawaii.

- Collins, J. L. 1968. *The Pineapple: Botany, Cultivation, and Utilization.* Word Crops Books.
- Collins, J. L. (1949). History, Taxonomy and Culture of the Pineapple. Reprinted from *Economic Botany*, 3 (4), 335-359.

Review of above reference publications indicated that the following chemicals have been historically used in Hawaii's pineapple fields. Note that none of the references were specific to activities on the Subject Property.

- D-D – 1,3-dichloropropane and 1,3-dichloropropene mixture applied as a soil fumigant for weed control. Usage of D-D began after World War I and was used almost universally in Hawaii (Collins, 1968).
- Pentachlorophenol and sodium pentachlorphenate (PCP) was used in a water or emulsified based form and sprayed as a pre-emergence herbicide (Collins, 1968).

8.2.4 Discussion

Review of the user provided information, documents and references indicated past and prior use of the Subject Property for pineapple cultivation. Based on user provided references coupled with ETC's additional research documentation, activities commonly associated with commercial pineapple cultivation include the use and application of fertilizers, pesticides and/or herbicides. As such, this finding is considered a historical REC.

Based on the past and prior use of the Subject Property, ETC cannot dismiss the potential presence of residual contamination from this historical REC and as such the past use is considered a REC for the Subject Property.

8.3 Records Review

8.3.1 Standard Environmental Record Sources

Federal NPL

No significant findings to indicate suspect RECs, historical RECs, or *de minimis* conditions were identified.

Federal CERCLIS and CERCLIS NFRAP

No significant findings to indicate suspect RECs, historical RECs, or *de minimis* conditions were identified.

Federal RCRA CORRACTS

No significant findings to indicate suspect RECs, historical RECs, or *de minimis* conditions were identified.

Federal RCRA (non-CORRACTS) TSD Facilities

No significant findings to indicate suspect RECs, historical RECs, or *de minimis* conditions were identified.

Federal RCRA Generator

No significant findings to indicate suspect RECs, historical RECs, or *de minimis* conditions were identified.

Federal Institutional Control/Engineering Control Registries

No significant findings to indicate suspect RECs, historical RECs, or *de minimis* conditions were identified.

Federal ERNS

No significant findings to indicate suspect RECs, historical RECs, or *de minimis* conditions were identified.

State Equivalent NPL and CERCLIS

No significant findings to indicate suspect RECs, historical RECs, or *de minimis* conditions were identified.

State Landfill and/or Solid Waste Disposal

No significant findings to indicate suspect RECs, historical RECs, or *de minimis* conditions were identified.

State Leaking Underground Storage Tanks

No significant findings to indicate suspect RECs, historical RECs, or *de minimis* conditions were identified.

State Registered Underground Storage Tanks

No significant findings to indicate suspect RECs, historical RECs, or *de minimis* conditions were identified.

State Institutional Control Registry

No significant findings to indicate suspect RECs, historical RECs, or *de minimis* conditions were identified.

State Voluntary Cleanup/Response Sites

No significant findings to indicate suspect RECs, historical RECs, or *de minimis* conditions were identified.

State Brownfields

No significant findings to indicate suspect RECs, historical RECs, or *de minimis* conditions were identified.

Unmappable/Orphan Sites

No significant findings to indicate suspect RECs, historical RECs, or *de minimis* conditions were identified.

8.3.2 Additional Environmental Record Sources

No significant findings to indicate suspect RECs, historical RECs, or *de minimis* conditions were identified.

8.3.3 Historical Use Information on the Subject and Adjoining Properties

Review of historical real property tax records and aerial photographs indicated past and prior use of the Subject Property for pineapple cultivation and or sugar cultivation. Activities commonly associated with commercial pineapple cultivation include the use and application of fertilizers, pesticides and/or herbicides. This finding is considered a historical REC.

Based on the past and prior use of the Subject Property, ETC cannot dismiss the potential presence of contamination for this historical REC and as such this past use is considered a REC for the Subject Property.

8.4 Site Reconnaissance

8.4.1 General Site Setting

No significant findings to indicate suspect RECs, historical RECs, or *de minimis* conditions were identified.

8.4.2 Exterior Observations

During ETC's site reconnaissance activities, solid waste (i.e. construction and demolition debris and miscellaneous rubbish) was observed near and/or along the borders and interior roads of the Subject Property. In addition, an abandoned car was also observed. No releases were observed, however the quantities of solid waste made it infeasible to adequately and fully characterize the potential impact. In accordance with Hawaii Administrative Rules Title 11, Department of Health, Chapter 58.1 (HAR §11-58.1) property owners are responsible for "removing accumulated solid waste to an approved solid waste disposal facility." Although the waste did not appear to pose a material threat to human health or the environment, it may be subject of enforcement action if brought to the attention of appropriate government officials. Therefore, the presence of the solid waste and the potential impacts to underlying soil from the solid waste are considered a REC.

ETC also observed several car parts/portions, car batteries, an apparent photo developing machine, paint cans, and drums (5-gallon to 55-gallon capacity) on the Subject Property. The 55-gallon drums appeared to leaking a petroleum-based substance onto the soil ground surface and the cars parts/portions, batteries and apparent containers appeared to be in poor condition (i.e. missing lids, cracked containers, etc.). Given the poor container conditions coupled with observed evidence of a release, this finding is considered a REC.

8.4.3 Interior Observations

No significant findings to indicate suspect RECs, historical RECs, or *de minimis* conditions were identified.

8.4.4 Dielectric Fluid Containing Equipment

ETC observed two apparent defunct transformers and a drum of apparent capacitors on the central portion of the Subject Property. The apparent capacitors were discussed in Section 8.2 and therefore will not be repeated here. Although the apparent transformers did not appear to contain any liquids or leakage, given the poor conditions of the apparent transformers, ETC cannot dismiss the possibility that residual fluids may have impacted the ground beneath these transformers. As such, this finding is considered a REC. Photographic documentation of these suspect transformers is included in Appendix II, photograph 13.

8.5 Interviews

Interview findings also indicated past and prior use of the Subject Property and surrounding areas for pineapple and sugar cultivation. The historical usage of the Subject Property was discussed in Section 8.3.3 and therefore will not be repeated here.

9.0 DATA GAPS

Data gaps, which are defined as the lack of or inability to obtain information required for this Phase I ESA despite good faith efforts by the environmental professional to gather such information were identified during this Phase I ESA. ETC identified the following data gaps:

- No Subject Property manager/owner was interviewed, however, based on the current and historical conditions of the Subject Property coupled with the information provided by the "user" and Mr. Robert Cherry, ETC does not believe this data gap was significant.
- ETC was unable to inspect all accessible areas of the Subject Property. Specifically, ETC was unable to inspect the interior areas of the two small single story structures on the Subject Property. One structure was part of the Radio Tower site and was inspected as part of the EQI's February 2008 Phase I ESA, which was discussed in Section 4.3.3. The second structure was located along the Mililani Cemetery Road and appeared to used for utility purposes. Based on the usage of the Subject Property structures, the interiors were not expected to significantly impact the Subject Property. As such this data gap is not considered significant.
- ETC was unable to inspect limited areas of the west and central portions of the Subject Property due to safety concerns associated with the steep and inaccessible terrain along the edge of the Panakauahi Gulch. However, based on ETC's visual observations of the remaining areas of the Subject Property and those areas along the edge of the gulch, the steep inaccessible gulch areas were not anticipated to be significantly impacted by any conditions other than limited fugitive dumping (i.e. solid waste) similar to that observed on other areas of the Subject Property.

10.0 CONCLUSIONS

We have performed a Phase I ESA in conformance with the scope and limitations of ASTM Practice E1527-05 of Waiawa Ridge Development on Waiawa Prison Road in Waipahu, Hawaii the Subject Property. Any exceptions to, or deletions from, the ASTM Practice E1527-05 are described in Section 11.0 of this report. This assessment has revealed no evidence of recognized environmental conditions in connection with the Subject Property except for the following:

- Potential presence of residual contaminants associated with the historic usage of the Subject Property for commercial pineapple and possible sugar cultivation.
- Presence of solid waste observed on the Subject Property (i.e. construction and demolition debris, batteries, car parts/portions, etc.) and the potential impact to the underlying soil from the solid waste.
- Presence of batteries, photo developing machine, paint cans, drums, leaking drums, etc. in poor condition.
- The presence of two apparent defunct transformers and “open” drum of capacitors observed in “poor” condition.

11.0 DEVIATIONS AND ADDITIONAL SERVICES

No client imposed constraints or additions were requested. No additional services were requested by ETC's Client. As such, there were no deviations and/or deletions from the ASTM Practice E1527-05 upon completion of this Phase I ESA.

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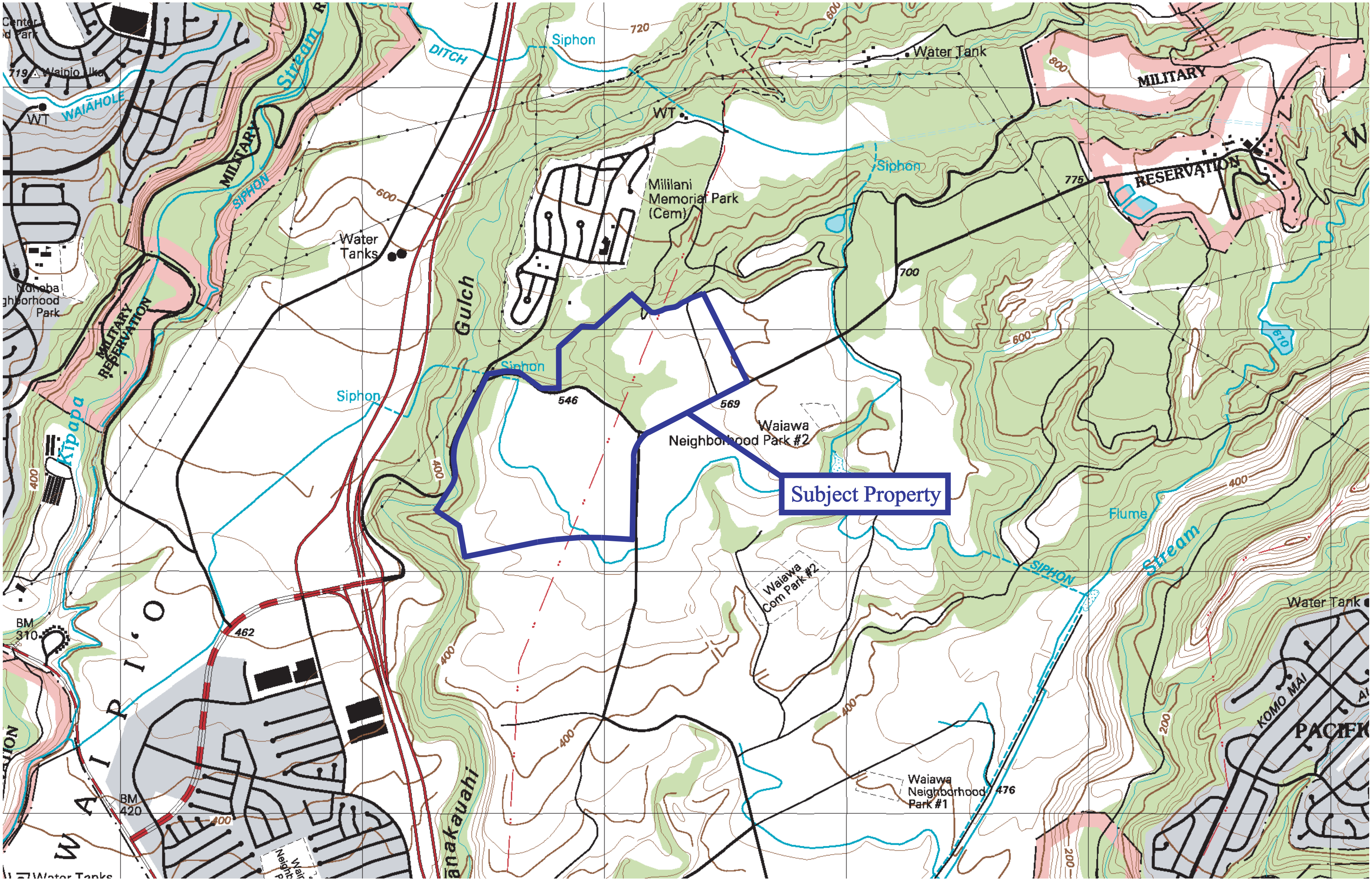
APPENDIX I
FIGURES



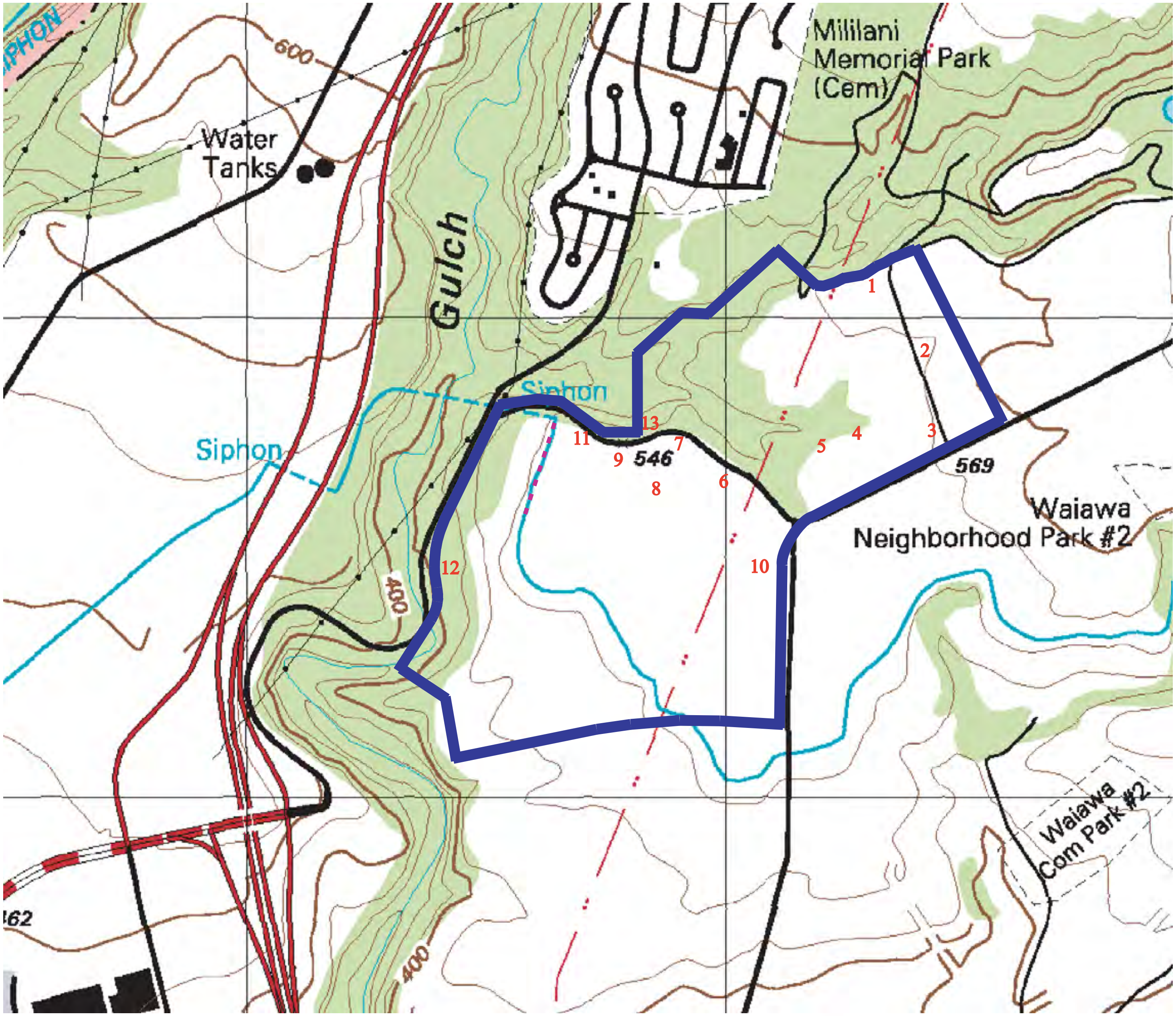
Source: University of Hawaii, USGS Waipahu Quadrangle, Island of Oahu, 7.5 Minute Series, 1998

EnviroServices & Training Center, LLC

Project: 08-1004

March 2008

Figure 1 - Site Location Map
Phase I Environmental Site Assessment
Castle & Cooke Waiawa Development
Waiawa / Waipio, Oahu, Hawaii
TMK (1) 9-4-6: 29 (parcel) & 31 (portion)
TMK (1) 9-6-4: 21



SITE RECONNAISSANCE OBSERVATIONS

1. Construction & demolition debris, car parts, tires, poles, etc. (Photo 1, 2 and 3)
2. Batteries (Photo 4)
3. Paint cans (Photo 5)
4. Construction & demolition debris (Photo 6)
5. Construction & demolition debris, tires, and miscellaneous solid waste (Photo 7 and 8)
6. Apparent photo developing machine and leaking 55-gallon drums (Photo 9 and 10)
7. Auto parts, tires, batteries, etc. (Photo 11 and 12)
8. Suspect transformers (Photo 13)
9. Radio Tower site location (Photo 14 and 15)
10. Auto parts, tires, batteries, etc. (Photo 16)
11. Batteries, metal drum and miscellaneous solid waste (Photo 17)
12. Tires and miscellaneous solid waste (Photo 18)
13. Abandoned automobile (Photo 19)

--- Observed portion of irrigation/ drainage ditch

Source: University of Hawaii, USGS Waipahu Quadrangle, Island of Oahu, 7.5 Minute Series, 1998

EnviroServices & Training Center, LLC

Project: 08-1004

March 2008

Figure 2 - Site Plan
Phase I Environmental Site Assessment
Castle & Cooke Waiawa Development
Waiawa / Waipio, Oahu, Hawaii
TMK (1) 9-4-6: 29 (parcel) & 31 (portion)
TMK (1) 9-6-4: 21

APPENDIX II
PHOTOGRAPHIC DOCUMENTATION

Photograph 1: Construction & demolition debris, car parts, tires, etc. located on the north portion of the Subject Property.

Photograph 2: Construction & demolition debris, car parts, tires, etc. located on the north portion of the Subject Property.

Photograph 2: Construction & demolition debris, car parts, tires, etc. located on the north portion of the Subject Property.

Photograph 4: Batteries located on the north portion of the Subject Property.

Photograph 5: Paint cans observed along interior road on the north portion of the Subject Property.

Photograph 6: Construction & demolition debris located on the central portion of the Subject Property.

EnviroServices & Training Center, LLC

Project: 08-1004

March 2008

Photographic Documentation
Phase I Environmental Site Assessment
Castle & Cooke Waiawa Development
Waiawa/Waipio, Oahu, Hawaii
TMK (1) 9-4-6: 29 (portion) & 31 (portion)
TMK (1) 9-6-4: 21

Photograph 7: Construction & demolition debris, tires, batteries, and miscellaneous solid waste located on the central portion of the Subject Property.

Photograph 8: Construction & demolition debris, tires, batteries, and miscellaneous solid waste located on the central portion of the Subject Property.

Photograph 9: Apparent photo developing machine located on the central portion of the Subject Property.

Photograph 10: Leaking 55-gallon drums located on the central portion of the Subject Property.

Photograph 11: Construction & demolition debris, tires, batteries, and miscellaneous solid waste located on the cnetral portion of the Subject Property.

Photograph 12: Construction & demolition debris, tires, batteries, and miscellaneous solid waste located on the central portion of the Subject Property.

Photograph 13: Suspect transformers located on the central portion of the Subject Property.

Photograph 14: Radio Tower site located on the central portion of the Subject Property.

Photograph 15: Radio Tower site located on the central portion of the Subject Property.

Photograph 16: Auto parts, tires, batteries, etc. located on the central portion of the Subject Property.

Photograph 17: Batteries, metal drum and miscellaneous solid waste located on the central portion of the Subject Property.

Photograph 18: Tires and miscellaneous solid waste located on the central portion of the Subject Property.

Photograph 19: Abandoned automobile located on the central portion of the Subject Property.

Photograph 20: Structure near the west border of the Subject Property along the Mililani Cemetery Road.

M | Preliminary Subsurface Investigation
Preliminary Rockfall Hazard Observations

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PRELIMINARY SUBSURFACE INVESTIGATION REPORT

KOA RIDGE MAKAI DEVELOPMENT
WAIPIO, EWA, OAHU, HAWAII

for

CASTLE & COOKE HOMES HAWAII, INC.

by

FEWELL GEOTECHNICAL ENGINEERING, LTD.

ALAN J. SHIMAMOTO
LICENSED
PROFESSIONAL
ENGINEER
No. 4393-C
HAWAII, U.S.A.

This report was prepared by
me or under my supervision.

By Alan J. Shimamoto

March 23, 2009

Important Information About Your

Geotechnical Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

The following information is provided to help you manage your risks.

Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical engineering study conducted for a civil engineer may not fulfill the needs of a construction contractor or even another civil engineer. Because each geotechnical engineering study is unique, each geotechnical engineering report is unique, prepared *solely* for the client. No one except you should rely on your geotechnical engineering report without first conferring with the geotechnical engineer who prepared it. *And no one — not even you* — should apply the report for any purpose or project except the one originally contemplated.

Read the Full Report

Serious problems have occurred because those relying on a geotechnical engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

A Geotechnical Engineering Report Is Based on A Unique Set of Project-Specific Factors

Geotechnical engineers consider a number of unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical engineering report that was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light industrial plant to a refrigerated warehouse,
- elevation, configuration, location, orientation, or weight of the proposed structure,
- composition of the design team, or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes—even minor ones—and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

Subsurface Conditions Can Change

A geotechnical engineering report is based on conditions that existed at the time the study was performed. *Do not rely on a geotechnical engineering report* whose adequacy may have been affected by: the passage of time; by man-made events, such as construction on or adjacent to the site; or by natural events, such as floods, earthquakes, or groundwater fluctuations. *Always* contact the geotechnical engineer before applying the report to determine if it is still reliable. A minor amount of additional testing or analysis could prevent major problems.

Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ—sometimes significantly—from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide construction observation is the most effective method of managing the risks associated with unanticipated conditions.

A Report's Recommendations Are *Not* Final

Do not overrely on the construction recommendations included in your report. *Those recommendations are not final,* because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations only by observing actual subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's recommendations if that engineer does not perform construction observation.*

A Geotechnical Engineering Report Is Subject to Misinterpretation

Other design team members' misinterpretation of geotechnical engineering reports has resulted in costly problems. Lower that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Contractors can also misinterpret a geotechnical engineering report. Reduce that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing construction observation.

Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical engineering report should *never* be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

Give Contractors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical engineering report, *but* preface it with a clearly written letter of transmittal. In that letter, advise contractors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. *Be sure contractors have sufficient time* to perform additional study. Only then might you be in a position to give contractors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

Read Responsibility Provisions Closely

Some clients, design professionals, and contractors do not recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of explanatory provisions in their reports. Sometimes labeled "limitations" many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform a *geoenvironmental* study differ significantly from those used to perform a *geotechnical* study. For that reason, a geotechnical engineering report does not usually relate any geoenvironmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures.* If you have not yet obtained your own geoenvironmental information, ask your geotechnical consultant for risk management guidance. *Do not rely on an environmental report prepared for someone else.*

Obtain Professional Assistance To Deal with Mold

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts of mold from growing on indoor surfaces. To be effective, all such strategies should be devised for the *express purpose* of mold prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional mold prevention consultant. Because just a small amount of water or moisture can lead to the development of severe mold infestations, a number of mold prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of the geotechnical engineering study whose findings are conveyed in this report, the geotechnical engineer in charge of this project is not a mold prevention consultant; ***none of the services performed in connection with the geotechnical engineer's study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not of itself be sufficient to prevent mold from growing in or on the structure involved.***

Rely, on Your ASFE-Member Geotechncial Engineer for Additional Assistance

Membership in ASFE/The Best People on Earth exposes geotechnical engineers to a wide array of risk management techniques that can be of genuine benefit for everyone involved with a construction project. Confer with you ASFE-member geotechnical engineer for more information.

ASFE
THE BEST PEOPLE ON EARTH

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Appendices

PRELIMINARY SUBSURFACE INVESTIGATION REPORT

Koa Ridge Makai Development

Waipio, Ewa, Oahu, Hawaii

INTRODUCTION

We have completed a preliminary subsurface investigation for the site of the Koa Ridge Makai Development in Waipio, Oahu, Hawaii. This report summarizes our findings and conclusions and presents general guidelines and preliminary recommendations regarding the geotechnical aspects of the site development. This work has been completed in general accordance with our November 20, 2008 Proposal and the December 9, 2008 Agreement for Services between Fewell Geotechnical Engineering, Ltd. and Castle & Cooke Homes Hawaii, Inc., Contract No. 8122133.

PURPOSE AND SCOPE

A preliminary subsurface investigation was undertaken at the request of Castle & Cooke Homes Hawaii, Inc. (CCHHI) to assist them with the geotechnical aspects of the development of the site of the Koa Ridge Makai Development. The investigation was performed mainly to aid CCHHI in preliminary project planning and cost-estimating. More comprehensive subsurface investigations with additional borings and/or test pits will be completed once more detailed information has been developed.

The scope of our geotechnical services included drilling a total of 12 test borings and excavating 8 test pits, and testing the recovered samples to determine their general geotechnical engineering characteristics. The information obtained was evaluated in conjunction with site conditions, including some of the perimeter gulch slopes. Our findings are presented in this report together with general guidelines and preliminary recommendations with regard to the soil conditions found.

The results of the field exploration, including a Site and boring Location Plan, and the Boring and Test Pit Logs are presented in Appendix A. The results of the laboratory tests are shown in Appendix B, and the Limitations of this investigation and report are included in Appendix C.

PROJECT CONSIDERATIONS

The general area of the site of the Koa Ridge Makai Development is shown on the Project Location Map, Figure 1, in Appendix A. The site is a relatively long parcel, which is generally aligned with its longitudinal axis in a general north-south direction. Most of the parcel occupies a plateau between the eastern slopes of Kipapa Gulch and the Interstate H-2. Ka Uka Boulevard and the existing Gentry-Waipio Industrial Subdivision border the eastern side of the southern section of the parcel, while the southwestern tip of the parcel borders an existing development and the portion of Kamehameha Highway entering Kipapa Gulch.

The parcel is about 13,000 feet long by up to about 3,000 feet wide and covers more than 600 acres. The land was previously used for the cultivation of pineapple but we understand that pineapple cultivation of the area ceased 15 to 20 years ago. The southern portion of the parcel is currently occupied by vegetable and fruit farms. The remaining northern section is vacant and undeveloped.

The parcel is currently accessed through a secured gate off of Ka Uka Boulevard and a wide dirt road which runs along the length of the parcel. The road enters the site from Ka Uka Boulevard in a general east to west direction, then turns in a northerly direction through the center of the site up to the area of a Board of Water Supply (BWS) facility. The dirt road then runs parallel to the Interstate H-2 up to the Pineapple Road Overpass which crosses the interstate at the northern end of the site. The remnants of another old road cross through the farmlands and provide access down into Kipapa Gulch.

Waiahole Ditch transects the northern section of the parcel, and passes through the site in a general east to west direction from the Interstate H-2 to the top of Kipapa Gulch. The ditch is estimated at 10 to 15 feet wide by about 5 feet deep and appears to be gunited. The water in the ditch appears to be 2 to 3 feet in depth. The northern end of the ditch connects to a large steel pipe, which drops down the slopes of Kipapa Gulch. A small concrete bridge provides access over the ditch along the dirt road through the site.

A BWS facility occupies about 3 acres on the southeastern border of the site adjacent to the Interstate H-2. The BWS facility includes 2 large water reservoirs, together with their related appurtenances, and is secured with chain-link fencing and locked gates. Each reservoir appears to be at least a 1 MG capacity tank. Water lines are suspected within the site due to the presence of the BWS facility.

At least 2 sets of high-voltage electrical lines cross through the site, mainly along the slopes of Kipapa Gulch. Two of the lines subsequently cross through the northeastern section of the parcel, from the area of Kipapa Gulch to the area of the Interstate H-2. The electrical lines are supported on both wood poles and steel poles. The steel poles are visually estimated at up to 125 feet high.

The southern area currently being farmed is relatively level with a gradual slope down toward the south and west. It generally consists of open areas, but also includes occasional undeveloped sections between the areas being farmed, mostly within small tributary gulches to Kipapa Gulch. Numerous dirt roads exist between the fields and along the slopes of the gulches, and irrigation pipes and lines are prevalent along the edges of the dirt roads. Buried water lines are also anticipated within this farming area.

The northeastern undeveloped portion of the site slopes up toward the northeast at an overall gradient estimated at about 10 percent. It is heavily vegetated with thick California grass up to 8 feet high, scattered large trees, and medium-sized to large bushes.

Numerous dirt roads once existed along the gulch and between the old pineapple fields, but most of these roads have been overgrown by vegetation and no longer appear to exist, except in a few isolated patches.

The site's northwestern site perimeter along Kipapa gulch meanders along the top of the gulch and along the tops of the numerous smaller side gullies, which extend into the parcel from the main gulch. This results in an irregular perimeter along the western side of the parcel with over 3½ miles of the parcel bordering the slopes of Kipapa Gulch or one of its smaller tributary gulches. The slopes along Kipapa Gulch and within the smaller tributary gulches are heavily forested with large trees and medium-sized to large brush, and thick California grasses.

The preliminary topographic plan provided by CCHHI in November 2008 and updated in January 2009 indicates that the slopes along some of its tributary gulches and at the southernmost tip of the parcel next to Kamehameha Highway are as little as 20 feet in height. However, most of the slopes along the edge of Kipapa Gulch are in the range of 200 to 300 feet high. The height of the gulch slopes is generally lowest along the southern end of the gulch and increase in height in the northerly direction.

Based on the preliminary topographic plan, the gulch slopes appear to generally be between 1 Horizontal to 1 Vertical (1H:1V) and 3H:1V, with most of the slopes at inclinations of between 1½H:1V and 2½H:1V. Most of the flatter slopes appear to be at the top of the slopes and the slopes become steeper toward the bottom of the slopes. Numerous small terraces or flatter areas interrupt the overall slopes in many areas.

The ground surface over the plateau area drops from about Elev. 730 in the northeastern corner next to the Interstate H-2, down to about Elev. 440 at the southwestern corner of the site next to Kamehameha Highway. The section of Kamehameha Highway next to the southwestern corner of the site varies in elevation from about Elev. 420 down to about Elev. 365, resulting in slopes of 20 to 75 feet in height.

The tops of the gulches along the western side of the plateau and adjacent to Kipapa Gulch ranges from about Elev. 450 at its southern end, up to about Elev. 730 at its northern limit. The bottom of the adjacent sections of Kipapa Gulch varies from about Elev. 250 at the southern end of the gulch, up to about Elev. 435 below its northern end. This results in total slope heights in the range of 200 to 300 feet.

The preliminary land use map provided by CCHHI on October 27, 2008 indicates that the development will generally be limited to the flatter plateau area of the parcel with no development on the slopes of Kipapa Gulch. It will be developed for residential and commercial purposes, together with their related infrastructure. Major collector roads totaling about 3½ miles will provide access to the various areas of the development. Nearly all of the perimeter areas along Kipapa Gulch will be designated as "green-belt" areas, which are left "as-is," or developed as parks.

Grading plans for the development of the parcel have not been developed at this time but we understand that it is anticipated that the overall grading of the parcel will likely follow the existing terrain. For the gently sloping plateau areas of the site, we have assumed that cuts and fills of up to 20 feet in depth and thickness will likely be necessary to maintain a relatively uniform gradient across the parcel.

We understand that the shallower upper portions of many of the smaller tributary gulches entering the parcel will be likely filled during the site development. Fills of up to 50 feet in height are anticipated to fill these gullies, based on the existing topography.

TRAFFIC CONSIDERATIONS

No information or traffic projections are available for the roads of the development at this time. However, we have assumed that both the interior residential streets and the collector roads for the development would be dedicated to the City and County of Honolulu. For the purposes of our preliminary evaluation, we have assumed that the collector roads will support no more than an Average Daily Traffic (ADT) of 15,000 vehicles per day (vpd) per lane of traffic. We have assumed that build-out for the roads and development would occur over a period of 10 years and that the ADT would remain constant over the remainder of the 40-year design life of the pavements.

The 24-hour truck traffic (T_{24}) has been assumed at 2 percent of the ADT. The truck traffic distribution has been assumed at 90 percent 2-axle trucks, 5 percent 3-axle trucks, 2 percent 4-axle trucks, 1 percent 5-axles trucks, and 1 percent 6-axle trucks or larger. FGE should be notified once traffic projections have been developed such that the preliminary pavement sections can be reviewed and revised, if necessary.

PRELIMINARY SUBSURFACE INVESTIGATION

A total of 12 test borings were drilled between December 22, 2008 and January 29, 2009 at the approximate locations shown on the Site and Boring Location Plan, Figure 2 in Appendix A. The borings were drilled to depths ranging from 20 feet to 80 feet below the existing ground surface with a Mobile B-53 or a Simco 2400 truck-mounted drilling rig, advancing 4-inch diameter continuous-flight augers. Where rock was encountered, the borings were advanced with coring and wash boring tools.

Relatively undisturbed samples of the subsurface soils were obtained at selected depths with a 3.0-inch O.D. split-spoon sampler, or a 2.0-inch O.D. Standard Penetration Sampler (SPT) driven by a 140-pound hammer falling 30 inches. The number of blows required to advance the samplers the final 12 inches into the soil mass was recorded and is shown on the borings logs. The blow counts shown on the logs are the actual blow counts obtained in the field; the blow counts for the 3.0-inch sampler have not been normalized to reflect their estimated SPT blow counts.

Where rock was encountered, samples of the rock were obtained with NX and PQ double-tube core barrels with a diamond-cutting bit. The degree of recovery (REC) and the Rock Quality Designation (RQD) for each core run are shown on the boring logs.

In addition to the test borings, 8 test pits were excavated within the interior areas of the site on January 24 and 25, 2009. Their approximate locations are shown on Figure 2. The test pits were excavated to a depth of 15 feet below the existing ground surface with a Caterpillar 125 track-mounted excavator. Bulk samples of the soils encountered were obtained at selected depths for laboratory testing.

The materials encountered in the borings and test pits are shown on the Boring Logs and Test Pit Logs, Figures 3 through 22 in Appendix A. A Boring and Test Pit Log Legend is included as Figure 23 for reference. Photographs of the recovered rock cores are illustrated as Figures 24 through 27 at the end of Appendix A.

LABORATORY TESTING

Selected samples of the subsurface soils recovered from the borings were tested in the laboratory to determine their general engineering characteristics, including in-situ density, moisture content, shear strength, consolidation, and swell under their in-situ conditions. Atterberg Limits tests were completed on visually representative samples to aid in the classification of the soils.

The bulk samples obtained from test pits were tested in general accordance with Laboratory Bearing Ratio (CBR) test ASTM D1883 to determine their CBR's and swells when compacted to at least 95 percent relative compaction at their optimum moisture contents. Where CBR swells in excess of 2 percent were obtained during the initial testing, additional tests were performed with the samples compacted at moisture contents wet of their optimum moisture contents.

The results of the laboratory tests are shown on the Boring and Test Pit Logs, where appropriate. The results of the Consolidation, CBR and Atterberg Limits tests are graphically illustrated in Figures 28 through 44 in Appendix B. Table I at the end of Appendix B presents a summary of the test results on the undisturbed samples, while Table II summarizes the results of the CBR tests on the bulk samples.

ANALYTICAL TESTING

In addition to the laboratory tests for the typical geotechnical engineering characteristics of the soils, pH and minimum resistivity tests were performed on 2 bulk samples obtained from the test pits to obtain a preliminary indication of the corrosivity of the near-surface and deeper soils. The samples showed pH values of 6.77 and 5.74, and minimum resistivities of 2,400 and 2,500 ohms-cm. The results of the pH and minimum resistivity tests are shown in Table III at the end of Appendix B.

GENERALIZED SUBSURFACE CONDITIONS

The test borings and test pits have revealed that the site for the Koa Ridge Makai Development is generally underlain by a thin surface layer of fill or disturbed soil followed by residual soils (soils weathered in-place from parent basalt rock). In the deeper borings along the tops of Kipapa Gulch and some of its tributary gulches, the residual soils are underlain by saprolites (residual soils still exhibiting a remnant rock structure) at greater depths, occasionally followed by intact basalt in varying stages of weathering.

The residual soils extend to the bottom of the test pits at a depth of 15 feet below the existing ground surface, and to the bottom of the shallower borings at a depth of 20 feet.

In the deeper borings along the edge of the gulches, the residual soils extend to varying depths ranging from 8½ to 61 feet, at which depths, saprolites were generally encountered. The layer of saprolite extends to the bottom of Borings 6, 8 and 9 at depths of 60 to 80 feet below the existing ground surface, and to depths of 22½ to 52½ feet in Borings 1, 7, 10, 11 and 12, where weathered basalt was found below the saprolites.

The weathered basalts extend to bottom of Borings 1, 7, 10, 11 and 12 at depths of 34½ to 74 feet below the existing ground surface. In general, the depths to both the saprolites and the basalts, where encountered, appear to increase along the edge of Kipapa Gulch in the northerly direction, i.e. toward the head of the gulch.

No weathered basalt was found in Borings 6 or 9, and saprolite was found below a layer of basalt in Boring 8. Borings 6, 8 and 9 were drilled along the edge of Kipapa Gulch along the western edge of the northern section of the site. In Boring 8, the saprolite below the basalt extends to the bottom of the boring at a depth of 60 feet.

Although fill was found at most of the boring and test pit locations, no fill was found in Test Pits 3 and 7, which were excavated at the bottom of two of the existing natural gullies transecting the site. Alluvial (water-deposited) soils were found down to depths of 6 and 5 feet at Test Pits 3 and 7, respectively, followed by residual soils below the alluvial soils. The alluvial soils consist of high-plasticity clayey silts which are designated as MH soils under the Unified Soil Classification system. They exhibit a blocky structure and appeared poorly compacted.

The predominant soils found throughout the site are the surface layers of fill and disturbed soils, the residual soils and saprolites, and the weathered basalt formations found below the natural residual soils and saprolites. Each of these materials is discussed in more detail below.

Fill, Disturbed Soils – The fill and disturbed soils found in the borings and test pits varied from 1 to 4½ feet in thickness at the boring and test pit locations. Except for the area of Borings 3 and 3a, the fill and disturbed soils generally appear to be in the range of ½ to 1½ feet along the perimeter of the site, and in the range of 1½ to 3 feet in the interior areas of the site. The thicker areas of fill and disturbed soils appear to occur where the land is being farmed and tilled.

The fills and disturbed soils generally consist of highly plastic clayey silts, which are designated as MH soils under the Unified Soil Classification system (USC). The upper ½ to 1 foot of fill and disturbed soils is loose and uncompacted, but, except in the area of Borings 3 and 3a, becomes stiff to very stiff below these depths and exhibit moderate to high densities. Root mats were observed to depths of 4 to 6 inches below the existing ground surface at most of the boring and test pit locations.

Borings 3 and 3a were drilled along the eastern perimeter of the site, adjacent to the southbound off-ramp from the Interstate H-2 to Ka Uka Boulevard. The fill found in Boring 3 extends down to a depth of 4½ feet at which depth the boring was terminated due to concerns that the fill may be backfill for a buried water line. Boring 3a was drilled 17 feet west of Boring 3, and a similar fill was found to a depth of 4 feet. The fills in both of these borings appear stiff but exhibit a blocky, uncompacted structure and high moisture contents.

Natural Residual Soils, Saprolites - The residual soils and saprolites below the surface fills and alluvial soils generally consist of highly plastic clayey silts which are classified as MH soils under the USC. Occasional layers of low-plasticity silt designated as ML, were found in Borings 3a, 8, 9 and 12, and highly plastic CH silty clays were found in Borings 1 and 2 along the southern and eastern sides of the site.

The residual soils and saprolites generally exhibit very stiff to hard consistencies, although seams with stiff to very stiff consistencies were occasionally found. They exhibit moderate to high moisture contents and low to moderate densities, moderate to high shear strengths, and low compressibility. A consolidation test on a sample of the residual soils indicate a preconsolidation pressure of 6,500 pounds per square foot (p.s.f.), which suggests that they should be only slightly compressible under moderate loads.

In general, the moisture contents of the residual soils and saprolites appear to be near or above their estimated optimum moisture contents within about 15 feet of the existing ground surface at the time of this investigation. Laboratory tests indicate that in-situ moisture contents of generally between about 25 and 40 percent for the soils above 15 feet, and higher moisture contents below this depth.

Laboratory compaction tests on the 8 of the 11 soil samples obtained within 15 feet of the existing ground surface indicate optimum moisture contents of 26.5 to 29.5 percent, with 3 samples exhibiting optimum moisture contents of 33.0 to 33.5 percent. Hence, the soils within 15 feet of the existing ground surface generally appear to range from slightly dry of optimum up to about 14 percent wet of their estimated optimum moisture contents.

Significantly wetter soils with moisture contents generally in the range of 40 to 60 percent were occasionally found in the borings, particularly below a depth of 15 feet. Although no bulk samples of these soils could be obtained due to their depths, it is anticipated that these moisture contents will be significantly wet of the optimum moisture contents for these soils.

The residual silts and saprolite generally exhibit low swells of less than 2 percent under their in-situ moisture conditions, particularly in the upper 10 feet of the soil profile. Moderate swells of 3.9 percent and 5.3 percent were exhibited by samples of the highly plastic CH clays found in Boring 1 at depths of 18½ and 28½ feet, and from a sample from Boring 9 at a depth of 23½ feet, where a swell of 7.3 percent was obtained on a sample of the MH-CH clays.

CBR tests performed on the bulk samples of the residual soils and saprolites recovered from the test pits similarly showed relatively low swells when they were compacted to at least 95 percent relative compaction at their optimum moisture contents as determined by Laboratory Compaction Test ASTM D1557, and saturated for at least 96 hours under a 51-p.s.f. surcharge. Ten of the 11 samples tested showed CBR swells of less than 2 percent and relatively high CBR's of 25.5 to 66.3.

One sample, which was obtained at a depth of 14 feet in Test Pit 8 on the eastern side of the site, exhibited a moderate CBR swell of 4 percent and a low CBR of 7.5 when compacted at its optimum moisture content. These results are typical of a soil with moderate shrink-swell characteristics. Re-compacting the same specimen at 3 percent above its optimum reduced the swell after 96 hours to 0.3 percent.

Weathered Basalt – Weathered basalt was found in 5 of the 7 deeper borings drilled adjacent to Kipapa Gulch on the western edge of the parcel. Basalt was found below the residual soils and saprolites in Borings 1, 7, 8, 10 and 11. The basalt varies from a completely weathered, or decomposed rock, to a moderately to slightly weathered intact basalt. The intact moderately to slightly weathered basalt varies from occasionally broken to massive and is medium hard to hard.

Except in Boring 8, the basalt found in these borings extends to the bottom of these borings at depths of 34½ to 74 feet below the existing ground surface, and was as thick as 15 feet in Boring 11. The basalt layer found in Boring 8 was 7 feet thick and was underlain by a layer of very hard saprolite with sections of completely weathered basalt which extends to a depth of 60 feet at which depth the boring was terminated.

Groundwater – Groundwater or subsurface seepage was not observed in any of the borings or test pits of this investigation, and are not anticipated to be factors in the planned construction. However, the relatively high in-situ moisture contents of the deeper soils can affect future earthwork construction. This is especially true for the deeper site excavations and deeper utility backfills in the cut areas of the site, particularly below depths of about 15 feet from the existing ground surface.

DISCUSSION AND CONCLUSIONS

The preliminary subsurface investigation has revealed that the site of CCHHI's Koa Ridge Makai Development is generally underlain by relatively competent residual soils and saprolites, although the residual soils are covered by relatively thin layer of surface materials of varying quality. We believe that the parcel can be developed for its intended use as a residential development provided the general guidelines and preliminary recommendations of this report are followed.

The residual soils and saprolites which predominate the site generally exhibit good engineering characteristics, with relatively low swells, low compressibility and good strength and pavement support capabilities. The most significant geotechnical concerns with the development of the site are the steep slopes along the portion of the site adjacent to Kipapa Gulch, the varying supportive capabilities of the surface fill and disturbed soils over the residual soil, and the potential of moderate shrink-swell potential of the deeper residual soils and saprolites. Each of these concerns and the more significant characteristics of the predominant soils at the site are discussed in more detail below.

Existing Slopes - The February 12, 2009 preliminary topographic plans provided by CCHHI indicate that the existing slopes along Kipapa Gulch on the western side of the development are relatively high and steep, with slopes generally in the range of 200 to 300 feet high, and at inclinations as steep as 1H:1V to as flat as 3H:1V. Where relatively uniform slopes occur their overall slopes do not appear to be steeper than 1½H:1V.

In general however, most of the slopes generally appear flatter toward the top of the slopes and steeper toward the bottom of the slopes, and include localized flatter and steeper areas throughout their profiles. Of significant concern are steeper slopes which occasionally occur at the tops of the existing slopes.

Our evaluation of the localized slopes of up to 60 feet high indicate that the slopes with inclinations of 1H:1V, and steeper, exhibit a safety factor of less than 1.5 under static conditions and less than 1.1 under the seismic conditions indicated by the 2003 International Building Code (IBC). These are the normally accepted minimum factors of safety for this type of geotechnical analysis.

For preliminary planning purposes, we believe that it would be prudent to laterally set-back the new construction at least 25 feet away from the tops of any slopes which are inclined at, or steeper than 1H:1V. Construction should be set back least 20 feet away from the tops of any slopes which are inclined at 1½H:1V or steeper. The setback may be decreased to 15 feet from the top of the slopes which are flatter than 1½H:1V.

The new construction, including any fill embankments up to 20 feet in height, should be setback from the existing slopes as recommended above. The above set-backs should be measured from the slope break at the top of the existing slopes to the new construction, or to the toe of the fill embankment supporting the new construction, whichever is nearest the slope. Any existing uncompacted fills and loose overcast materials near the tops of the slopes should be removed and/or reconstructed prior to the construction of the fill or the new structures.

Based on our preliminary reconnaissance of the slopes during our field investigation, it appears that the remnants of the dirt roads along the top of the gulch generally extend about 10 to 15 toward the interior of the property from the gulch slopes. The down slopes sides of the roads in many areas consist of either small berms of loose materials or overcast fills. We believe that in most of these areas, it would be prudent to set the construction back such that it does not encroach onto the remnants of the perimeter dirt roads along the tops of the gulches.

The construction setbacks depend on the actual construction planned at the top of the existing slopes, and the inclination and height of each slope. The above construction setbacks are given for preliminary planning purposes, and are likely conservative. The proposed construction should be evaluated on an individual basis once more design and topographic information is available to develop more detailed construction setback recommendations.

Surface Soils: Fills, Disturbed Soils – The upper ½ to 1 foot of the fills and disturbed soils exhibit poor engineering characteristics under their current conditions. Removal and recompaction of these materials should be anticipated. Additionally, for all of these materials, roots were observed down to depths of 4 to 6 inches below the existing ground surface in the test pits. Grubbing of the root mat to these depths should be anticipated to remove the organically contaminated soils during the clearing and grubbing operations.

Except for the area of Borings 3 and 3a, the fill and disturbed soils below a depth of 1 foot are generally very stiff to hard, but the upper ½ to 1 foot is loose and/or stiff. The upper foot of the agriculturally disturbed soils should be removed down to the deeper very stiff to hard soils or the natural residual soils prior to construction in these areas. The actual depth of their removal must be determined during construction. Once removed the exposed soils below the fills should be proof-rolled with a heavy compactor to detect any remaining soft spots or uncompacted fills.

The fill in the vicinity of Borings 3 and 3a appears wet and uncompacted down to depths of 4 to 4½ feet, but the actual lateral extent of the fill could not be determined within the scope of this preliminary investigation. Other uncompacted fills and possibly backfills for existing utilities within the site probably exist in scattered areas of the site due to its prior development and use. A review of any prior grading or development records of the site, if available, should be completed to determine the general areas of any prior fills and utilities within the site.

The uncompacted fills found in the area of Borings 3 and 3a, and other similar uncompacted fills should be removed in their entirety down to the very stiff to hard natural residual soils. Once removed, the fills should be reconstructed in accordance with currently accepted grading procedures prior to additional construction on or near these areas. The lateral extent of the existing fills should be better determined with additional test pits, probes or borings prior to additional development of these areas.

The excavated fills and disturbed soils may be re-used as fill provided they are selectively placed and compacted using the currently accepted typical grading procedures, i.e. they are moisture-conditioned to near their optimum moisture content, placed in loose level lifts of no more than 8 inches in thickness, and uniformly compacted to at least 90 percent relative compaction as determined by Laboratory Compaction Test ASTM D1557. Fills placed within 2 feet of pavement subgrades should be compacted to at least 95 percent relative compaction.

<u>Residual Silts and Saprolite Silts</u> – In general, the residual soils and saprolites should provide adequate support for the new residential development and it related roads and other improvements in either their natural state or when reconstructed properly as fill. This is particularly true of the upper 10 feet of the residual soils, which exhibit low swells, high strengths, low compressibility, and high pavement support characteristics.

The upper 10 feet of the residual soils should provide an excellent fill material with minimal special considerations. The very stiff to hard natural residual soils, or properly compacted fills constructed of these materials, should provide allowable bearing capacities in the range of 2,500 to 3,500 p.s.f. with minimal settlements. Pavements over these materials will likely consist of the minimal pavements necessary for the traffic using the pavements, and Select Borrow subbase would not be necessary beneath the concrete sidewalks, curbs and gutters.

Below a depth of 10 feet, the residual soils and saprolites appear to include occasional pockets of moderately expansive soils with increased plasticity, lower shear strengths and lower pavement support characteristics. This is particularly evident along the eastern and southern sides of the site near Borings 1 and 2, where highly plastic clays were found and in the area of Test Pit 8.

Although these deeper soils can support the new construction and be used as fill, the potential for pockets of moderately expansive soils should be anticipated, and additional testing of these soils should be completed to better determine their shrink-swell characteristics and the manner in which to reduce their impact on the planned construction.

Where encountered on the site, and depending on the grading in each area, we believe that it would be prudent to anticipate partial replacement methods to reduce the impact of the expansive soils on the new construction. For fills, this would entail selectively placing these soils at least 2 feet below the finish subgrades for the concrete slabs and pavements, and compacting them wet of their optimum moisture contents. The near-surface low-expansion materials should be used to cap the fills composed of the expansive soils such that the new construction bears on the low-expansion soils.

Where the grading exposes the expansive soils at the finish subgrade level, they should be over-excavated such that they can be capped with at least a 2-foot cap of the low-expansion near surface silts. Other alternative methods of minimizing the impact of the potentially moderately expansive soils are available and can be evaluated once more detailed design information has been developed.

The natural soils exhibit moisture contents which are generally near or above their estimated optimum moisture contents. Some drying of these soils should be anticipated to properly compact them as fill or backfill. Significantly higher moisture contents of 10 to 25 percent above the optimum moisture contents should be anticipated for the deeper soils below a depth of about 15 feet of the existing ground surface, and considerable drying should be anticipated to properly compact these soils as fill or backfill. Where practical, it will likely be beneficial to schedule the earthwork and site work construction for the drier periods of the year to minimize double-handling the soils and subsequent scheduling delays.

Cut slopes in the natural soils, and fill slopes comprised of the natural residual soils, alluvium and saprolites, which have been selectively placed and properly compacted, should be stable for inclinations of 2H:1V, or flatter, for heights of up to 20 feet without benches. Slopes exceeding these heights, including combined cut and fill slopes, should be provided with 8-foot wide benches at approximately 20-foot vertical increments up to heights of up to 40 feet. Slopes exceeding these heights are not anticipated and should be individually evaluated should they occur.

Intact basalt rock was found at depths no shallower than 22½ feet below the existing ground surface along the perimeter of the parcel adjacent to Kipapa Gulch. At this depth, significant excavations into the basalt are not anticipated. However, should the grading be designed such that excavation into the basalt is necessary within the excavated areas, the use of heavy rock excavating equipment should be anticipated to facilitate the removal of the basalt.

Gulch Fills – Although no plans have been developed for grading of the tributary gulches to Kipapa Gulch transecting the site, we understand that many of these gulches will likely be filled with up to 50 feet of fill during the site development. The alluvium found in the gulches exhibit a blocky structure and appears poorly consolidated. Where fill will be constructed over the alluvium in these gullies, the alluvium should be removed and replaced with compacted fill.

The removal of the alluvium should extend throughout the area encompassed by the fill and the area beneath its fill slope, plus at least 25 feet downslope of the toe of the fill embankment. The actual depth and lateral extent of its removal must be determined during construction but test pits excavated in 2 different gulches indicate that the alluvium was 5 to 6 feet thick at the test pit locations. The excavated alluvial soils may be re-used as fill provided it is properly placed and compacted.

Subdrains should be provided in a herringbone pattern down the gulches prior to fill placement to collect potential natural seepage within the gulch. The subdrains should consist of 4- to 6-inch diameter perforated pipes placed in a trench at least 18 inches in width to collect any subsurface seepage and dispose of it at least 20 feet outside the toe of the downstream fill slope. The subdrain trench should be lined with a non-woven filter fabric and the subdrain pipe should be surrounded by at least 4 inches of ASTM C33 No. 67 aggregate on all sides. The subdrains should be designed such that the subdrains (including their filter fabric) do not encroach within 5 feet vertically of the finish grades.

Settlements of up to 2 inches should be anticipated for 50-foot thick fills due to the large areal load on the natural ground and the compression of the fill under its own weight. Should settlements be a concern, compaction of the lower 30 feet of the fill to at least 95 percent relative compaction should reduce the settlements. Most of the settlements will occur during the fill construction with minimal post-construction settlements occurring once the grading has been completed.

Drainage provisions should be included in the design of the exposed fill slopes within the gulches, and care must be taken to minimize erosion due to the fine-grained nature of the on-site soils. Armoring or similar erosion-retardant provisions should be included in the design, particularly at the interfaces of the fill slopes with the natural soil abutments.

Preliminary Pavements – The preliminary subsurface investigation has revealed that most of the near-surface soils within about 10 feet of the existing ground surface should provide good pavement support characteristics. Hence, provided the near-surface soils are used to cap the developed areas, the design of the pavements will likely be influenced mainly by the traffic over the roads.

For interior residential streets subjected to low-volume traffic, it is anticipated that the minimum pavement thickness would be required under the pavement criteria of the City and County of Honolulu. The minimum pavement consists of 2 inches of Asphalt Concrete Paving (ACP), over 3 inches of Asphalt Treated Base Course (ATB), over 6 inches of Aggregate Base Course, placed on the compacted subgrade. This would result in a total pavement thickness of 11 inches.

The assumed traffic loading indicated in the "Traffic Considerations" section of this report results in a Traffic Index (TI) of 9.4 for the collector roads. Based on the traffic index and the CBR results, we believe that the low expansion near-surface soils would result in the pavement thicknesses of about 3 inches of ACP, over 4 inches of ATB, over 6 inches of Aggregate Base Course, placed on the compacted subgrade. This results in a total pavement thickness of 13 inches for the collector road pavements.

The above general guidelines and preliminary recommendations regarding the geotechnical aspects of the site are given to assist Castle & Cooke Homes Hawaii, Inc. with their preliminary planning and cost-estimating in the development of the site. Site-and project-specific, comprehensive subsurface investigations should be completed for the various parcels and infrastructure improvements of the development once more definitive design information has been developed.

Limitations – This report has been completed for the exclusive use of **Castle & Cooke Homes Hawaii, Inc.** for their **Koa Ridge Makai Development** in Waipio, Oahu, Hawaii. In the performance of this investigation and the preparation of this report, we have strived to perform our work in a manner consistent with that level of care and skill ordinarily exercised by members of the geotechnical profession practicing under similar conditions in Hawaii. No other warranty, either expressed or implied, is made. The limitations of this report and the investigation are included in Appendix C.

/ajs:sw:tjc:fse

APPENDIX A

Preliminary Subsurface Investigation Summary

Project Designation: Koa Ridge Makai Development **File:** 2914.01

Location: Waipio, Oahu, Hawaii

Project Location Map: Figure 1

Site and Boring Location Plan: Figure 2

Drilling Contractor: Hawaii Test Borings, Inc.

Drilling Equipment: Mobile B-53, Simco 2400

Drilling Method: /**x**/ 4-inch Auger // Wash
/**x**/ PQ Core /**x**/ NX Core

Boring Summary

Boring	Depth	Number of Samples	NX Core	Depth to Water Table*	Boring Log Figure No.
1	50.0'	12	0.0'	N.E.	3
2	20.0'	6	0.0'	N.E.	4
3	4.5	2	0.0	N.E.	5
3a	20.0'	6	0.0'	N.E.	5a
4	20.0'	6	0.0'	N.E.	6
5	20.0'	6	0.0'	N.E.	7
6	80.0'	20	0.0'	N.E.	8
7	74.0'	17	0.0'	N.E.	9
8	60.0	13	10.0'	N.E.	10
9	65.0	15	0.0'	N.E.	11
10	58.0	13	5.0'	N.E.	12
11	37.5	8	13.5'	N.E.	13
12	34.5'	7	6.0'	N.E.	14
Totals	543.5'	131	34.5'		

Date Started: 11-7-07 **Date Completed:** 11-29-07

*N.E.=None Encountered

APPENDIX A (Continued)

Preliminary Subsurface Investigation Summary

Project Designation: Koa Ridge Makai Development **File:** 2914.01

Location: Waipio, Oahu, Hawaii

Test Pit Summary:

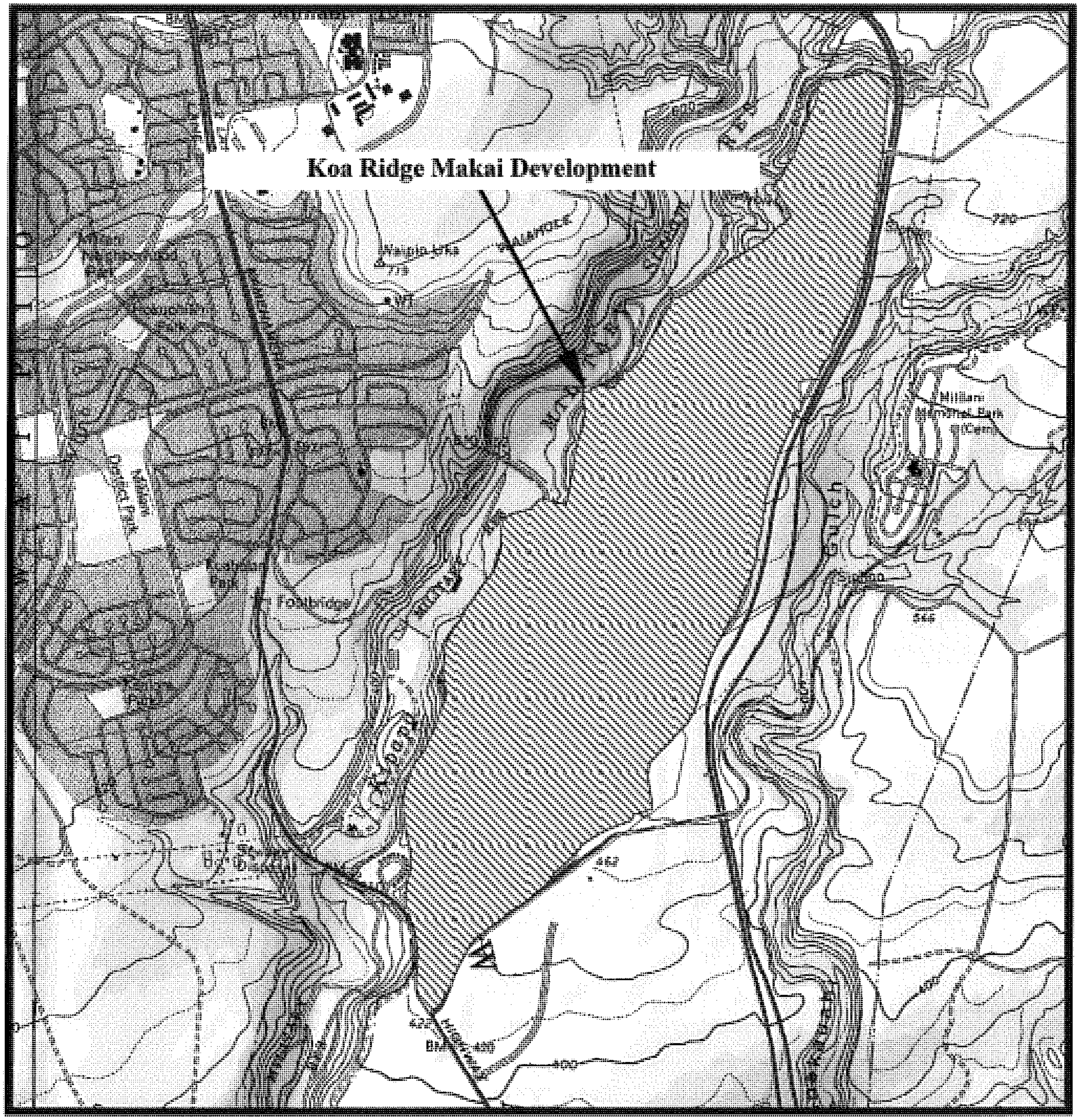
Test Pit	Depth	Number of Samples	Depth to Water Table*	Test Pit Log Figure No.
TP1	15.0’	2	N.E.	15
TP2	15.0'	3	N.E.	16
TP3	15.0'	2	N.E.	17
TP4	15.0’	2	N.E.	18
TP5	15.0’	2	N.E.	19
TP6	15.0’	2	N.E.	20
TP7	15.0’	2	N.E.	21
TP8	15.0’	3	N.E.	22
Totals	120.0’	18		

Date Started: 1-24-09 **Date Completed:** 1-25-09 *N.E.=None Encountered

Boring and Test Pit Log Legend: Figure 23

Rock Core Photographs

Boring 8	Figure 24
Boring 10	Figure 25
Boring 11	Figure 26
Boring 12	Figure 27



LEGEND:

PROJECT LOCATION

SCALE: 1:24000

GENERAL AREA:
WAIPIO, OAHU, HAWAII

REFERENCE:
WAIPAHU QUADRANGLE
U.S.G.S. TOPOGRAPHIC MAP

F.G.E. Ltd.

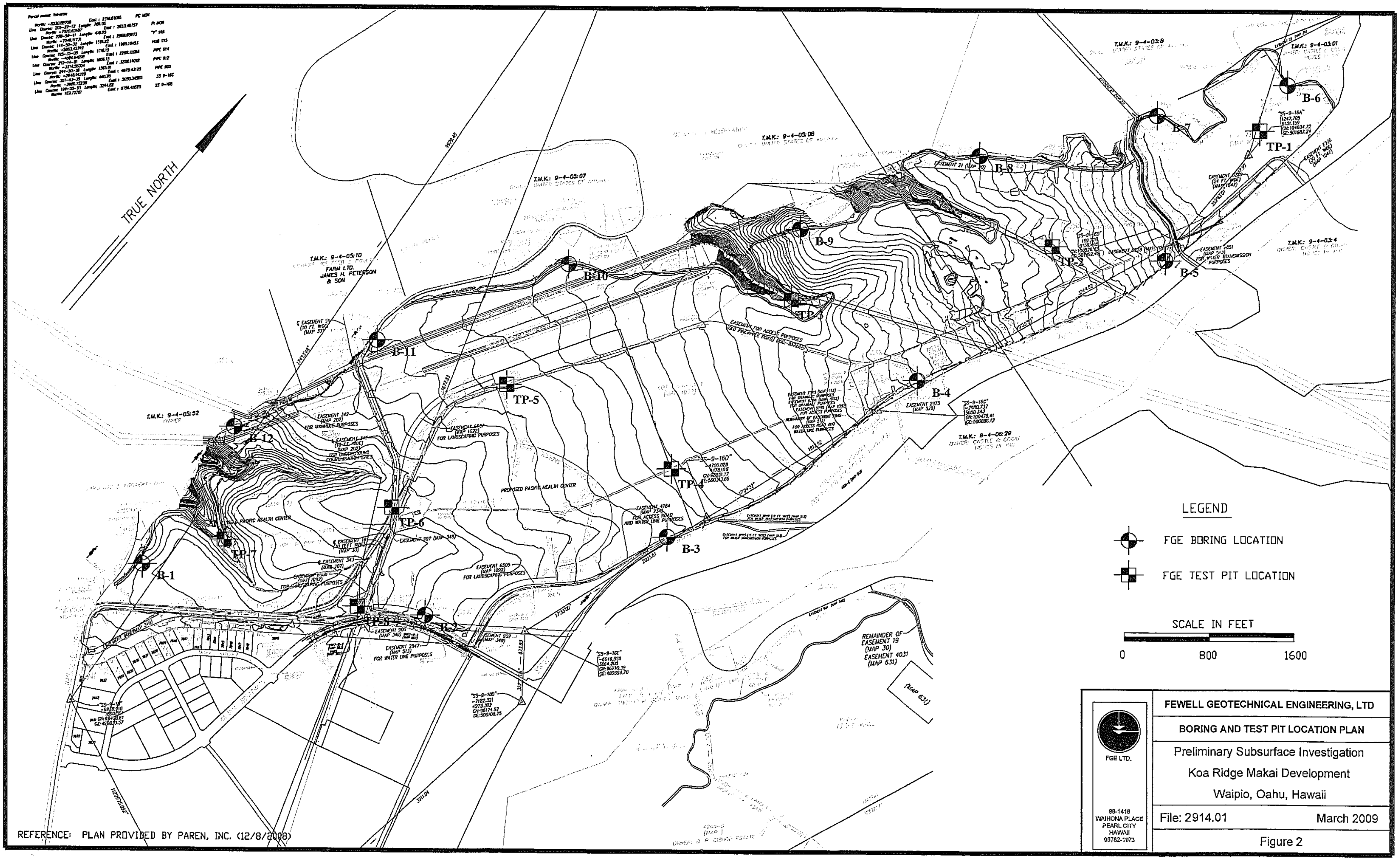
PROJECT LOCATION MAP

PRELIMINARY SUBSURFACE INVESTIGATION
KOA RIDGE MAKAI DEVELOPMENT
WAIPIO, OAHU, HAWAII

File: 2914.01

March 2009

Figure 1


TRUE NORTH
B-1
B-2
B-3
B-4
B-5
B-6
B-7
B-8
B-9
B-10
B-11
B-12
TP-1
TP-2
TP-3
TP-4
TP-5
TP-6
TP-7
TP-8
PROPOSED PACIFIC HEALTH CENTER
LEGEND
FGE BORING LOCATION
FGE TEST PIT LOCATION
SCALE IN FEET
0
800
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REFERENCE: PLAN PROVIDED BY PAREN, INC. (12/8/2008)
FGE LTD.
99-1418
WAIHONA PLACE
PEARL CITY
HAWAII
96782-1973
FEWELL GEOTECHNICAL ENGINEERING, LTD
BORING AND TEST PIT LOCATION PLAN
Preliminary Subsurface Investigation
Koa Ridge Makai Development
Waipio, Oahu, Hawaii
File: 2914.01
March 2009
Figure 2

FEWELL
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PRELIMINARY SUBSURFACE INVESTIGATION REPORT

INFRASTRUCTURE IMPROVEMENTS AND SLOPES WAIAWA MASTER PLAN WAIAWA, OAHU, HAWAII

for

CASTLE & COOKE HOMES HAWAII, INC.

by

FEWELL GEOTECHNICAL ENGINEERING, LTD.

ALAN J. SHIMAMOTO
LICENSED PROFESSIONAL ENGINEER
No. 4393-C
HAWAII, U.S.A.

ALAN J. SHIMAMOTO, P.E.

JUNE 2, 2008

Important Information About Your
Geotechnical Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

The following information is provided to help you manage your risks.

Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical engineering study conducted for a civil engineer may not fulfill the needs of a construction contractor or even another civil engineer. Because each geotechnical engineering study is unique, each geotechnical engineering report is unique, prepared *solely* for the client. No one except you should rely on your geotechnical engineering report without first conferring with the geotechnical engineer who prepared it. *And no one — not even you* — should apply the report for any purpose or project except the one originally contemplated.

Read the Full Report

Serious problems have occurred because those relying on a geotechnical engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

A Geotechnical Engineering Report Is Based on A Unique Set of Project-Specific Factors

Geotechnical engineers consider a number of unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical engineering report that was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light industrial plant to a refrigerated warehouse,
- elevation, configuration, location, orientation, or weight of the proposed structure,
- composition of the design team, or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes—even minor ones—and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

Subsurface Conditions Can Change

A geotechnical engineering report is based on conditions that existed at the time the study was performed. *Do not rely on a geotechnical engineering report* whose adequacy may have been affected by: the passage of time; by man-made events, such as construction on or adjacent to the site; or by natural events, such as floods, earthquakes, or groundwater fluctuations. *Always* contact the geotechnical engineer before applying the report to determine if it is still reliable. A minor amount of additional testing or analysis could prevent major problems.

Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ—sometimes significantly—from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide construction observation is the most effective method of managing the risks associated with unanticipated conditions.

A Report's Recommendations Are *Not* Final

Do not overrely on the construction recommendations included in your report. *Those recommendations are not final,* because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations only by observing actual subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's recommendations if that engineer does not perform construction observation.*

A Geotechnical Engineering Report Is Subject to Misinterpretation

Other design team members' misinterpretation of geotechnical engineering reports has resulted in costly problems. Lower that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Contractors can also misinterpret a geotechnical engineering report. Reduce that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing construction observation.

Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical engineering report should *never* be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

Give Contractors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical engineering report, *but* preface it with a clearly written letter of transmittal. In that letter, advise contractors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. *Be sure contractors have sufficient time* to perform additional study. Only then might you be in a position to give contractors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

Read Responsibility Provisions Closely

Some clients, design professionals, and contractors do not recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of explanatory provisions in their reports. Sometimes labeled "limitations" many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform a *geoenvironmental* study differ significantly from those used to perform a *geotechnical* study. For that reason, a geotechnical engineering report does not usually relate any geoenvironmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures.* If you have not yet obtained your own geoenvironmental information, ask your geotechnical consultant for risk management guidance. *Do not rely on an environmental report prepared for someone else.*

Obtain Professional Assistance To Deal with Mold

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts of mold from growing on indoor surfaces. To be effective, all such strategies should be devised for the *express purpose* of mold prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional mold prevention consultant. Because just a small amount of water or moisture can lead to the development of severe mold infestations, a number of mold prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of the geotechnical engineering study whose findings are conveyed in this report, the geotechnical engineer in charge of this project is not a mold prevention consultant; ***none of the services performed in connection with the geotechnical engineer's study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not of itself be sufficient to prevent mold from growing in or on the structure involved.***

Rely, on Your ASFE-Member Geotechncial Engineer for Additional Assistance

Membership in ASFE/The Best People on Earth exposes geotechnical engineers to a wide array of risk management techniques that can be of genuine benefit for everyone involved with a construction project. Confer with you ASFE-member geotechnical engineer for more information.

ASFE
The Best People on Earth

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PRELIMINARY SUBSURFACE INVESTIGATION REPORT

Infrastructure Improvements and Slopes
Waiawa Master Plan

Waiawa, Oahu, Hawaii

INTRODUCTION

A Preliminary Subsurface Investigation has been completed for the proposed layout of the significant infrastructure improvements and the existing slopes of the Waiawa Master Plan in Waiawa, Oahu, Hawaii. This report summarizes our findings and conclusions. This work was completed in general accordance with our June 26, 2007 Proposal and our July 25, 2007 Agreement for Services with Castle & Cooke Homes Hawaii, Inc., Contract No. 7122277.

PURPOSE AND SCOPE

The purpose of the preliminary subsurface investigation was to assist Castle & Cooke Homes Hawaii, Inc. (CCHHI) with the geotechnical aspects of the development of the site, mainly with respect to preliminary planning and cost estimating for the site infrastructure. Our scope of work included 1) drilling a total of 8 test borings and excavating 8 test pits, 2) testing the recovered samples to determine their general characteristics, 3) evaluating the site and soil information, including some of the perimeter gulch slopes, and 4) presenting our findings in this report.

This report presents general geotechnical guidelines and preliminary geotechnical recommendations for the development of the overall site for preliminary planning. It mainly addresses the main collector roads and natural perimeter slopes of the development. It does not include detailed recommendations for the development of the various parcels and the other facets of the future construction of the total site. Project-and site-specific, comprehensive subsurface investigations should be completed for each of these items once more detailed information has been developed.

The findings of the subsurface exploration, including a Site and Boring Location Plan, and the Boring and Test Pit Logs are included in Appendix A. The results of the laboratory tests are presented in Appendix B. The limitations of this investigation and report are included in Appendix C.

PROJECT CONSIDERATIONS

The preliminary information provided by CCHHI indicates that an approximately 200-acre parcel of land in Waiawa is being considered for development. The parcel is part of the future CCHHI's Koa Ridge Development, but is separated from the main Koa Ridge Development by Interstate H-2 and Panakauahi Gulch. We understand that this area is being referred to as "Waiawa" by CCHHI.

Waiawa is on a large plateau, which is surrounded by gulches on 3 of its sides and the foothills of the Koolau Mountain Range on its northern side. Panakauahi Gulch is on the northwestern and western sides of the plateau, while Waiawa Stream Gulch is on the eastern side of the plateau. The general area is shown on the Project Location Map, Figure 1, in Appendix A.

Much of the above-referenced Waiawa plateau will be developed as the Waiawa Ridge Development for residential and commercial uses. Future access to CCHHI's Waiawa development will be via the main collector entry road of the Waiawa Ridge Development crossing Panakauahi Gulch. Both the Waiawa Ridge Development and its main roads will be developed by developers other than CCHHI.

CCHHI's Waiawa development is an irregularly shaped parcel, which covers an estimated 200 acres on the northwestern side of the Waiawa plateau. The above-referenced Waiawa Ridge Development borders the southern and eastern sides of the

CCHHI parcel. The parcel includes parts of Panakauahi Gulch and some of its smaller tributary gulches on its northwestern and western sides. One of the smaller tributary gulches bisects the parcel near its midpoint, physically separating the parcel into eastern and western sections.

Mililani Cemetery Road, which passes through Panakauahi Gulch, generally forms the western edge of the western portion of the parcel. Currently, access to the CCHHI Waiawa parcel is limited to the Waiawa Correctional Facilities Road via Mililani Cemetery Road. The Waiawa Correctional Facilities Road is a narrow paved road, which starts at the Mililani Cemetery Road and progresses in a general west to east direction to the correctional facility at the foothills of the Koolau Range.

The road initially forms the northern border of the western part of the parcel, then crosses through the parcel at the above-referenced gulch, and passes along the parcel's southern border along the eastern part of the development. Locked gates and perimeter barbed wire fencing secure the Waiawa parcel from the road.

Panakauahi Gulch and its tributaries along the edge of the Waiawa development in this area range from 30 feet to about 140 feet in depth, with the higher slopes at the southwestern corner of the development. The gulch slopes gradually decrease in height as Panakauahi Gulch approaches its head past the eastern end of the development. The tributary gulch bisecting the Waiawa Development is estimated at between 20 feet and 60 feet deep. Intermittent streams apparently flow along the bottom of the gulches during periods of rainy weather, although they appeared dry at the time of our work.

The gulches, and the areas at the top of their slopes, are heavily vegetated with grasses, heavy brush, and medium to large sized trees. The gulch slopes are relatively steep, and based on the April 7, 2008 topographic plan provided by CCHHI, are between about 1 Horizontal to 1 Vertical (1H:1V) and 3H:1V, with most of the slopes estimated at between 1½H:1V and 2H:1V. Ground surface elevations at the bottom of the gulches range from about Elev. 305 below the southwestern corner of the parcel, up to about Elev. 500 below its northeastern corner.

The remainder of the parcel on the plateau portion of the ridge is generally clear of trees and consists of open pastures separated by barbed wire fencing and numerous gates. Vegetation in these areas generally consists of California grass and scattered small to medium sized trees. The terrain consists of gently rolling topography, which generally slopes down toward the west and south. Ground surface elevations vary from about Elev. 600 at the eastern limit of the parcel, down to about Elev. 450 at its southwestern corner above Panakauahi Gulch.

The preliminary schemes being considered by CCHHI indicate that the development of the Waiawa parcel will include subdividing the parcel for a number of multi-family and single-family residential subdivisions, plus appurtenant community structures such as community centers and their parks. Much of the perimeter areas along Panakauahi Gulch will be designed as "green-belt" areas, which are left "as-is," or developed as parks.

The various subdivisions and other aspects of the development will be accessed by approximately 12,500 feet of collector roads. Although detailed information has not been developed as yet for the new infrastructure, we have assumed that the new roads will be asphalt-paved roads with concrete curbs, gutters and sidewalks, typical of other residential developments.

The May 22, 2008 Preliminary Grading Plan provided by CCHHI for the development indicate that, in general, the site will be graded to slope down toward the south and west at overall gradients of between 2 and 4 percent. Except for some of the areas immediately adjacent to Panakauahi Gulch, most of the western section of the site will be excavated up to 20 feet below the existing grades, while fill will be placed within the tributary gulch bisecting the parcel, and on the eastern portion of the parcel.

The plans indicate that up to about 68 feet of fill will be necessary to establish the proposed grades within the area of the gulch bisecting the site, which results in a total slope height of about 68 feet from the toe of the fill slope to its top. Cuts of up to 25 feet in depth and fills of up to 15 feet in thickness will be necessary for the construction of the main collector road where it passes along the slope of Panakauahi Gulch. Some of these areas will be cut and filled resulting in total grade differences of up to 50 feet in height for the combined cut and fill slopes.

Some of the gulch slopes in the areas adjacent to the tributary gulch, immediately to its east and west, will also require sideslope fills on the slopes of the gulches. Although the fills will only be up to about 7 feet in thickness, the steep sloping terrain of the gulch slopes will result in fill slopes of up to 15 feet in height.

A large detention and water quality basin is planned within area of the tributary gulch for the collection of the on-site storm water runoff from the development. The preliminary plans indicate that the perimeter of the top of the basin will encompass approximately 8 acres, while the bottom of the basin will cover about an acre. The basin will be about 25 feet in depth, which would result in the impounding of up to about 48 acre-feet of water when filled.

Although detailed designs have not been developed at this time, we have assumed that the depth of the basin will not exceed 25 feet and will include an outlet pipe to release any impounded water within a relatively short period of time. Fewell Geotechnical Engineering, Ltd. (FGE) should be consulted once more detailed information has been developed for the basin, so that it can be reviewed and the appropriate geotechnical recommendations can be provided.

TRAFFIC CONSIDERATIONS

Traffic projections for the new collector roads are not available at this time. For the purposes of our preliminary evaluation, we have assumed that the residential collector roads will be dedicated to the City and County of Honolulu, and will support no more than an Average Daily Traffic (ADT) of 15,000 vehicles per day (vpd) per lane of traffic. We have assumed that build-out for the roads and development would occur over a period of 10 years and that the ADT would remain constant over the remainder of the 40-year design life of the pavements.

The 24-hour truck traffic (T_{24}) has been assumed at 2 percent of the ADT. The truck traffic distribution has been assumed at 90 percent 2-axle trucks, 5 percent 3-axle trucks, 2 percent 4-axle trucks, 1 percent 5-axles trucks, and 1 percent 6-axle trucks or larger. FGE should be notified once traffic projections have been developed such that the preliminary pavement sections can be reviewed and revised, if necessary.

PRELIMINARY SUBSURFACE INVESTIGATION

A total of 8 test borings were drilled and 8 test pits were excavated during the period of November 7, through November 29, 2007 at the approximate locations shown on the Site and Boring Location Plan, Figure 2, in Appendix A. The borings were drilled to depths ranging from 30 to 50 feet below the existing ground surface. Borings 1 through 4, 7 and 8 were drilled with a Mobile B-53 truck-mounted drilling rig. Borings 5 and 6 were drilled in the bottom of the gulch bisecting the site with a Simco 2400SK drilling rig, inserted via a helicopter. Both drilling rigs advanced the holes with 4-inch diameter continuous flight augers.

Relatively undisturbed samples of the subsurface soils were obtained with a 3.0-inch O.D. split-spoon sampler driven by a 140-pound hammer falling 30 inches. The number of blows required to advance the samplers the final 12 inches into the soil mass was recorded as the "blow counts" and are shown on the Boring Logs, Figures 3 through 10 in Appendix A, together with the materials found in each of the borings.

Where intact basalt rock was encountered, the borings were advanced, and samples of the basalt were obtained, with a double-tube NX core barrel with an industrial diamond-cutting bit and wash boring tools. The degree of recovery (REC) and the rock quality designations (RQD) are shown on the Boring Logs.

The test pits were excavated down to depths of 15 to 20 feet below the existing ground surface along the anticipated alignments of the future roads to observe the subsurface conditions and obtain large bulk samples of the subsurface soils down to the anticipated levels of the roads. The materials encountered in the test pits are shown on the Test Pit Logs, Figures 11 through 18, in Appendix A.

In addition to the borings and test pits, the near-vertical slope on the upslope side of the Waiawa Correctional Facilities Road, near Boring 3 was logged as SL-1. The log of this slope is shown in Figure 19. A Boring and Test Pit Log Legend has been included as Figure 20. Photographs of the rock cores are included as Figures 21 and 22 at the end of Appendix A.

LABORATORY TESTING

Selected samples of the subsurface soils were tested in our laboratory to determine their general engineering characteristics, including in-situ moisture content, unit weight, consolidation, shear strength and shrink-swell characteristics under their in-situ moisture conditions. Atterberg Limits tests were performed on visually representative soil samples to aid in the classification of the soils. In addition to the tests on the undisturbed soil samples, unconfined compressive strength tests were performed on selected rock cores of the underlying basalt.

Laboratory California Bearing Ratio (CBR) tests were performed on the bulk samples of the soils obtained from the test pits in general accordance with ASTM D1883 to determine their pavement support characteristics and swell when compacted. Additional CBR swell tests were performed on specimens prepared at different moisture contents when the initially tested specimens swelled over 2 percent when compacted at their optimum moisture contents.

The results of the laboratory tests are shown on the boring and test pit logs where appropriate. Additional test results are graphically exhibited in Figures 23 through 38 in Appendix B. Table I at the end of Appendix B summarizes the results of the tests on the relatively undisturbed samples, while Table II presents a summary of the CBR tests on the bulk samples. The compressive strength test results on the rock cores are summarized in Table III.

GENERALIZED SUBSURFACE CONDITIONS

The borings and test pits have revealed that the site of CCHHI's Waiawa development is generally underlain by relatively competent residual soils (soils weathered in-place from parent basalt) and saprolites (residual soils with a remnant rock structure). Varying types of surface materials cover the residual soils depending on the prior uses and geologic conditions of each area. In the borings along the southwestern edge of Panakauahi Gulch, basalt was found beneath the residual soils and saprolites.

The relatively flat area of the parcel, which comprises the vast majority of the site is generally underlain by a 1- to 2½-foot thick surface mantle of agriculturally disturbed soils, over the residual soils and saprolites. The residual soils and saprolites extend to the bottom of all of the test pits and most of the borings at depths of up to 45 feet below the existing ground surface.

Fill was encountered above the residual soils and saprolites in Borings 3 and 7, likely due to the prior grading of these areas. Boring 3 was drilled on the northern shoulder of the Waiawa Correctional Facilities Road, where 5 feet of loose uncompacted fill was found over the residual soils. A 1-foot thick layer of fill was found over the residual soils in Boring 7, which was drilled on the edge of an agricultural road along the top of Panakauahi Gulch near its eastern end. The residual soils and saprolites below the fill extend to the bottom of Borings 3 and 7 at depths of 30 and 45 feet.

Borings 5 and 6 were drilled within the tributary gulch for Panakauahi Gulch. Both Borings 5 and 6 revealed that the bottom of the gulch consist of recent alluvial (water-deposited) soils which extend down to depths of 8 and 8½ feet, at which depth residual soils were encountered. The residual soils and underlying saprolites in Borings 5 and 6 extend down to the bottom of the borings at depths of 30 and 40 feet.

Basalt was found below the residual soils and saprolites in Borings 1 and 2 at depths of 25½ and 32 feet respectively, but was not found in any of the other borings or test pits. Borings 1 and 2 were drilled along the edge of Panakauahi Gulch on the western side of the parcel. The basalt is generally slightly to moderately weathered and extended to the bottom of Borings 1 and 2 at depths of 40½ and 50 feet, respectively.

The fills, agriculturally disturbed soils, alluvium, residual soils, and saprolites generally consist of highly plastic clayey silts, which are designated as MH soils under the Unified Soil Classification system. A layer of low-plasticity silt designated as ML was found in Boring 2 between depths of 2 and 6½ feet, while a highly plastic clay designated as CH was found in Boring 6 between depths of 13 and 22 feet.

The fills, agriculturally disturbed soils and alluvium exhibit inconsistent and varying in-situ densities and consistencies, ranging from low densities and loose or stiff consistencies to relatively high densities with hard consistencies. In general, the fill found in Boring 3 appears to be loose and uncompacted, while the upper 1 to 1½ feet of the agriculturally disturbed soils also appear to be either loose, or stiff, and uncompacted. The deeper agriculturally disturbed soils exhibited consistencies of very stiff to hard.

The alluvium generally exhibits a hard consistency but relatively low densities, shear strengths and penetration resistances to sampling. A consolidation test performed on a sample of the alluvium indicates moderate compressibility under moderate loads.

The residual soils and saprolites below the surface materials generally exhibit very stiff to hard consistencies, moderate to high moisture contents and low to moderate densities. In general, the moisture contents appear to increase with increasing depth with a corresponding decrease in densities at greater depths. The in-situ moisture contents of the soils within approximately 15 feet of the existing ground surface generally appear to be within about 3 percent of their estimated optimum moisture contents, but significantly wetter soils were occasionally found in the borings, particularly at greater depths.

Although the residual silts and saprolite silts possess low to moderate densities, they exhibit very stiff to hard consistencies and moderate to high shear strengths. Consolidation tests on the residual soils indicate that they possess preconsolidation pressures in the range of 8,000 to 10,000 pounds per square foot (p.s.f.), which suggests that they should be only slightly compressible under even moderate loads.

The residual silt and saprolite generally exhibit low swells of less than 2 percent under their in-situ moisture conditions, particularly in the upper 10 feet of the soil profile. Moderate swells of 2.8 percent and 5.3 percent were exhibited by a sample from Boring 3 at a depth of 28½ feet and from a sample from Boring 6 at a depth of 13½ feet.

CBR tests performed on the bulk samples of the residual soils and saprolites recovered from the test pits similarly showed relatively low swells when they were compacted to at least 95 percent relative compaction at their optimum moisture contents as determined by Laboratory Compaction Test ASTM D1557, and saturated for at least 96 hours under a 51-p.s.f. surcharge. Nine of the 10 samples tested showed CBR swells of less than 2 percent and relatively high CBR's of 22 to 48.

One sample, which was obtained at a depth of 14.5 feet, exhibited a moderate CBR swell of 4.6 percent and a low CBR of 10 when compacted at its optimum moisture content. These results are typical of a soil with moderate shrink-swell characteristics. Re-compacting the same specimen at 3 and 6 percent above its optimum reduced the swell after 96 hours to 2.0 and 0.4 percent respectively.

The basalt found below the residual soils and saprolites in Borings 1 and 2 varies from highly to slightly weathered with most of the basalt being slightly weathered. The basalt varies from occasionally broke to massive and is medium hard to hard. Unconfined compressive strength tests on cores of the basalt indicate unconfined compressive strengths ranging from 4,249 pounds per square inch (p.s.i.) to 5,705 p.s.i.

<u>Groundwater</u> – Groundwater or subsurface seepage was not observed in any of the borings or test pits of this investigation, and are not anticipated to be factors in the planned construction. However, the relatively high in-situ moisture contents of the deeper soils can affect future earthwork construction. This is especially true for the deeper site excavations and deeper utility backfills in the cut areas of the site, particularly below depths of about 15 feet from the existing ground surface.

DISCUSSION AND CONCLUSIONS

The preliminary subsurface investigation has revealed that the site of CCHHI's Waiawa parcel is generally underlain by relatively competent residual soils and saprolites over basalt, although the residual soils are covered by relatively thin layer of surface materials of varying quality. We believe that the parcel can be developed for its intended use as a residential development provided the general guidelines and preliminary recommendations of this report are followed.

The residual soils and saprolites, which predominate the site generally, exhibit good engineering characteristics, with relatively low swells, low compressibility and good strength and pavement support capabilities. The most significant geotechnical concerns with the development of the site are the steep gulch slopes along the perimeter of the site, the varying supportive capabilities of the surface soils over the residual soil, and the moderate expansion of the deeper residual soils and saprolites. Each of these concerns and the more significant characteristics of the predominant soils at the site are discussed in more detail below, along with some of the currently known planned improvements.

Existing Slopes - The April 7, 2008 preliminary topographic plans provided by CCHHI indicate that the existing slopes along the western and northern sides of the Waiawa parcel are relatively high and steep, with slopes ranging from 30 to 140 feet in height, and at inclinations as steep as 1H:1V to as flat as 3H:1V. Our evaluation of the existing slopes indicate that the slopes with inclinations of 1H:1V, and steeper, exhibit a safety factor of less than 1.5 under static conditions and less than 1.1 under the seismic conditions indicated by the 2003 International Building Code (IBC). These are the normally accepted minimum factors of safety for this type of geotechnical analysis.

For preliminary planning purposes, we believe that it would be prudent to laterally set-back the new construction at least 25 feet away from the tops of any slopes which are inclined at, or steeper than 1H:1V. Construction should be set back least 20 feet away from the tops of any slopes which are inclined at 1½H:1V or steeper. The setback may be decreased to 10 feet from the top of the slopes, which are flatter than 1½H:1V.

The new construction, including any fill embankments up to 20 feet in height, should be setback from the existing slopes as recommended above. The above set-backs should be measured from the slope break at the top of the existing slopes to the new construction, or to the toe of the fill embankment supporting the new construction, whichever is nearest the slope. Any existing uncompacted fills and loose overcast materials near the tops of the slopes should be removed and/or reconstructed prior to the construction of the fill or the new structures.

Construction setbacks depend on the actual construction planned at the top of the existing slope, and the inclination and height of each slope. The above construction setbacks are given for preliminary planning purposes, and are likely conservative in some instances. The proposed construction should be evaluated on an individual basis once more design and topographic information is available to develop more detailed construction setback recommendations.

Surface Soils: Fills, Agriculturally Disturbed Soil, and Alluvium – The fill, alluvium and the upper 1½ feet of the agriculturally disturbed soils exhibit poor engineering characteristics under their current conditions. Removal and recompaction of these materials should be anticipated. Additionally, for all of these materials, roots were observed down to depths of 4 inches below the existing ground surface in the test pits and borings. Grubbing of the root mat to depths of 4 to 6 inches will likely be necessary to remove the organically contaminated soils during the clearing and grubbing operations.

The agriculturally disturbed soils below a depth of 1½ feet are generally very stiff to hard, but the upper 1½ feet is loose and/or stiff. The upper 1½ feet of the agriculturally disturbed soils should be removed down to the deeper very stiff to hard soils or the natural residual soils prior to construction in these areas.

The fill in the vicinity of Boring 3 is loose and uncompacted and has been placed on a sideslope condition. This fill, and other similar fills constructed during prior grading of the site, should be removed in their entirety down to the very stiff to hard natural residual soils and reconstructed in accordance with currently accepted grading procedures prior to additional construction on or near these areas. Alternatively the new construction should be setback at least 20 feet laterally away from these fills and the slopes, which they comprise, to minimize the impact of potential slope failures from these materials.

Reconstruction of the existing uncompacted fill on the existing gulch slopes, or construction of new fills on the gulch slopes, will be difficult and relatively expensive due to the severity of the existing slopes. Where this is necessary, the toe of the fills should be keyed into the residual soils to commence the fills, and benches should be cut into the residual soils to construct the fill as it proceeds upwards.

Both the keyways and benches should extend through the loose surface slope materials and extend at least 2 feet into the underlying very stiff to hard residual soils. Additionally, the keyways should extend a sufficient depth such that there is at least 6 feet of horizontal distance between the outer limit of the keyed fill and the slope face. Keys and benches should be at least the width of the construction equipment, but no less than 8 feet in width, to allow the equipment to place and compact the fill perpendicular to the fall line of the slope.

The alluvium found in the tributary gulch to Panakauahi Gulch exhibits low shear strengths and densities, and moderate compressibility, which can adversely affect the detention basin and the fill slope of the gulch fill. In the areas underlying the proposed detention basin and the slopes of the gulch fill, the alluvium should be removed down to the underlying hard residual soils prior to filling. The removal of the alluvium should extend throughout the area encompassed by the bottom of the basin and its fill slopes, and the area beneath the fill slope of the exterior gulch fill embankment, plus at least 25 feet downstream of the downstream toe of the exterior fill embankment.

The excavated fills, agriculturally disturbed soils and alluvium may be re-used as fill provided they are selectively placed and compacted using the currently accepted typical grading procedures, i.e. they are moisture-conditioned to near their optimum moisture content, placed in loose level lifts of no more than 8 inches in thickness, and uniformly compacted to at least 90 percent relative compaction as determined by Laboratory Compaction Test ASTM D1557. Fills placed within 2 feet of pavement subgrades should be compacted to at least 95 percent relative compaction.

Residual Silts and Saprolite Silts – In general, the residual soils and saprolites should provide adequate support for the new residential development and it related roads and other improvements in either their natural state or when reconstructed properly as fill. This is particularly true of the upper 10 feet of the residual soils, which exhibit low swells, high strengths, low compressibility, and high pavement support characteristics.

The upper 10 feet of the residual soils should provide an excellent fill material with minimal special considerations. The very stiff to hard natural residual soils, or properly compacted fills constructed of these materials, should provide allowable bearing capacities in the range of 2,500 to 3,500 p.s.f. with minimal settlements. Pavements over at least a 2-foot thickness of these materials will likely consist of the minimal pavements necessary for the traffic using the pavements, and Select Borrow subbase would not be necessary beneath the concrete sidewalks, curbs and gutters.

Below a depth of 10 feet, the residual soils and saprolites include pockets of moderately expansive soils with increased plasticity, lower shear strengths and lower pavement support characteristics. The occurrence of the pockets of the moderately expansive soils appears to increase with increasing depth.

Although these deeper soils can support the new construction and be used as fill, we believe that it would be prudent to selectively place these soils during the site grading to minimize the impact of their potential moderate shrink-swell characteristics on the new construction. This would entail placing these soils at least 2 feet below the finish subgrades for the concrete slabs and pavements, and compacting them wet of their optimum moisture contents.

Where the grading exposes them at the finish subgrade level, they should be over-excavated such that they can be capped with at least a 2-foot cap of the low-expansion near surface silts. Other alternative methods of minimizing the impact of the potentially moderately expansive soils are available and can be evaluated once more detailed design information has been developed.

The natural soils below a depth of about 15 feet of the existing ground surface exhibit moisture contents, which are above their estimated optimum moisture contents. Drying of these soils should be anticipated to properly compact them as fill or backfill. Where practical, it will likely be beneficial to schedule the earthwork and site work construction for the drier periods of the year to minimize double-handling the soils and subsequent scheduling delays.

Cut slopes in the natural soils, and fill slopes comprised of the natural residual soils, alluvium and saprolites, which have been selectively placed and properly compacted, should be stable for inclinations of 2H:1V, or flatter, for heights of up to 20 feet without benches. Slopes exceeding these heights, including combined cut and fill slopes, should be provided with 8-foot wide benches at approximately 20-foot vertical increments up to heights of up to 40 feet. Except for the gulch fill addressed below, slopes exceeding these heights are not anticipated and should be individually evaluated should they occur.

Intact basalt rock was found in the southwestern corner of the site along Panakauahi Gulch as shallow as 25½ feet below the existing ground surface. Although the planned cuts in this area should not encounter significant quantities of basalt, some rock excavation should be anticipated, during the grading and for the installation of the utilities within the excavated road areas. The use of heavy rock excavating equipment should be anticipated to facilitate the removal of the basalt.

Gulch Fill – The preliminary plans indicate that up to 68 feet of fill is planned for the tributary gulch, and that a portion of the fill and surrounding area will subsequently be excavated to construct a drainage basin. The sloping ground at the bottom of the gulch will result in a fill slope with a total height of about 68 feet. The slope may be designed at a slope of 2H:1V for this height provided 8-foot wide benches are provided at 20-foot vertical intervals.

Drainage provisions should be included in the design of the fill slope, but care must be taken to minimize erosion due to the fine-grained nature of the on-site soils. Armoring or similar erosion-retardant provisions should be included in the design, particularly at the interfaces of the fill slope with the natural soil abutments.

The recent alluvial soils within the gulch exhibit poor engineering characteristics. As indicated above, they should be selectively removed prior to the commencement of the fill construction in the gulch. The excavated alluvial soils may be used as fill provided they are used above the lower 10 feet of the fill, are laterally set back at least 30 feet from the face of the fill slope, and are properly compacted.

Subdrains should be provided in a herringbone pattern down the gulch prior to fill placement to collect potential natural seepage within the gulch. The subdrains should consist of 4- to 6-inch diameter perforated pipes placed in a trench at least 18 inches in width to collect any subsurface seepage and dispose of it at least 20 feet outside the toe of the downstream fill slope. The subdrain trench should be lined with a non-woven filter fabric and the subdrain pipe should be surrounded by at least 4 inches of ASTM C33 No.

67 aggregate on all sides. The subdrains should be designed such that the subdrains (including their filter fabric) do not encroach within 5 feet vertically of the finish grades.

The 68 feet of fill placed in the gulch will result in a surcharge of about 7,000 to 8,400 p.s.f. on the existing soils. Settlements should be anticipated due to the large areal load on the natural ground and the compression of the fill under its own weight. The lower 30 feet of the fill should be compacted to at least 95 percent relative compaction to reduce the settlements. However, up to 4 inches of settlements should be anticipated for the fill due to the large fill loads on the natural ground.

We believe that most of the settlements will occur during the fill construction with minimal post-construction settlements occurring once the grading has been completed. Shallow, monument-type settlement markers should be installed at the top of the fill once the grading has been completed to determine when the settlements have ceased.

Water Quality Basin – Little information has been developed for the design of the water quality basin, but we have assumed that it will be designed such that it is not considered a dam under the guidelines of the State of Hawaii Department of Land and Natural Resources (DLNR). However, the basin will impound a significant quantity of water upstream of the Mililani Cemetery Road and should include some special considerations in its design.

Since the basin is designed to hold 48 acre-feet of water, it is nearly a sufficient size to be considered a dam (50 acre-feet under the criteria of DLNR). Additionally, depending on the height of the maximum water level in the basin as measured from the downstream toe of the impounding embankment, a 25-foot deep water-quality basin may still be considered a dam, if this height exceeds 25 feet.

Classification of the structure as a dam would result in significant additional requirements to its design, including relatively flat slopes, continuous maintenance and inspections by

CCHHI, the development of Emergency Action Plan, and other requirements designed to safeguard the general public. The following conclusions and design guidelines assume that the water quality basin is not considered a dam. FGE, Ltd. should be consulted should the design of the basin result in its classification as a dam, such that the appropriate recommendations can be provided for its design.

The stability of the basin slopes is dependent upon the rapidity with which the basin is designed to drain once it fills with water, since the creation of a phreatic surface within the adjacent slopes directly affect their stability. Provided the basin is designed such that any water within the basin is drained within about 72 hours after filling, we believe that slopes of the basin may be constructed at 2H:1V for heights of 20 feet as recommended above with 8-foot wide benches provided at 20-foot vertical intervals. If water will be impounded in the basin for a longer period of time, 8-foot wide benches should be provided at vertical intervals of no more than 15 feet to flatten the overall slope.

The top of the embankment forming the dam of the basin should be at least 15 feet in width and should be a sufficient height to maintain at least 4 feet of freeboard over the maximum probable water level. The top of the embankment should be sloped slightly to drain toward interior of the basin. A camber of at least 6 inches in the design of the embankment should accommodate the anticipated settlements after construction.

The embankment should be protected from drying with evaporation retarding cover or vegetation. Drying can propagate drying and shrinkage cracks, which can result in conduits for water when the basin is filled, particularly should the cracks occur in the transverse direction across the embankment. Vegetation, if used, should consist of low grasses such as lawn cover to allow the occasional observation of the embankment slopes. Although it is not required by DLNR, we believe that occasional maintenance and observation of the embankment would be prudent to check for wear and tear of the embankment which could jeopardizes its integrity.

It is anticipated that the outlet works will consist of some type of outlet pipe to allow the water to drain from the basin relatively quickly after a significant storm event. The outlet pipe should not be constructed within the fill embankment for the basin since it can result in seepage along the pipe and potential subterranean erosion. The outlet pipe should be designed to exit the basin through one of its abutments in the natural residual soils, to minimize this potential.

The outlet pipe should be backfilled with the on-site, relatively impervious soils to minimize the potential for seepage along the outside of the pipes. Although we do not believe that collars are necessary, granular materials should not be used as bedding material or as backfill around the pipes. The bottom of the trench should be shaped to the curvature of the pipe and the backfills should consist of the relatively impervious on-site soils or similar impervious imported soils, which are properly placed and compacted.

Preliminary Pavements – The preliminary subsurface investigation has revealed that most of the near-surface soils within about 10 feet of the existing ground surface should provide good pavement support characteristics. Hence, provided the near-surface soils are used to cap the developed areas, the design of the pavements will likely be influenced mainly by the traffic, which the roads must support.

For interior residential streets subjected to low-volume traffic, it is anticipated that the minimum pavement thickness would be required under the pavement criteria of the City and County of Honolulu. The minimum pavement consists of 2 inches of Asphalt Concrete Paving (ACP), over 3 inches of Asphalt Treated Base Course (ATB), over 6 inches of Aggregate Base Course, placed on the compacted subgrade. This would result in a total pavement thickness of 11 inches.

The assumed traffic loading indicated in the "Traffic Considerations" section of this report results in a Traffic Index (TI) of 9.4 for the collector roads. Based on the traffic index and the CBR results, we believe that the low expansion near-surface soils would result in the pavement thicknesses of about 3 inches of ACP, over 4 inches of ATB, over 6 inches of Aggregate Base Course, placed on the compacted subgrade. This results in a total pavement thickness of 13 inches for the collector road pavements.

The above general guidelines and preliminary recommendations regarding the geotechnical aspects of the site are given to assist Castle & Cooke Homes Hawaii, Inc. with their preliminary planning and cost-estimating in the development of the site. Site- and project-specific, comprehensive subsurface investigations should be completed for the various parcels and infrastructure improvements of the development once more definitive design information has been developed.

Limitations – This report has been completed for the exclusive use of **Castle & Cooke Homes Hawaii, Inc.** for their **Waiawa Master Plan** in Ewa, Oahu, Hawaii. In the performance of this investigation and the preparation of this report, we have strived to perform our work in a manner consistent with that level of care and skill ordinarily exercised by members of the geotechnical profession practicing under similar conditions in Hawaii. No other warranty, either expressed or implied, is made. The limitations of this report and the investigation are included in Appendix C.

APPENDIX A

Preliminary Subsurface Investigation Summary

Infrastructure Improvements and Slopes
Waiawa Master Plan
Waiawa, Oahu, Hawaii

APPENDIX A

Preliminary Subsurface Investigation Summary

Project Designation: Infrastructure Improvements & Slopes Waiawa Master Plan **File:** 2785.01

Location: Waiawa, Oahu, Hawaii

Project Location Map: Figure 1

Site and Boring Location Plan: Figure 2

Drilling Contractor: Hawaii Test Borings, Inc.

Drilling Equipment: Mobile B-53

Drilling Method:
/**x**/ 4-inch Auger
/ / 4-inch Core
/ / Wash
/**x**/ NX Core

Boring Summary

Boring	Depth	Number of Samples	NX Core	Depth to Water Table*	Boring Log Figure No.
1	40.5'	7	14.5'	N.E.	3
2	50.0'	9	15.0'	N.E.	4
3	30.0'	8	0.0'	N.E.	5
4	30.0'	8	0.0'	N.E.	6
5	40.0'	10	0.0'	N.E.	7
6	30.0'	8	0.0'	N.E.	8
7	45.0'	11	0.0'	N.E.	9
8	45.0'	11	0.0'	N.E.	10
Totals	310.5'	72	29.5'		

Test Pit & Slope Log Summary:

Test Pit	Depth	Number of Samples	Depth to Water Table	Test Pit Log Figure No.
TP1	15.0'	2	N.E.	11
TP2	18.0'	3	N.E.	12
TP3	20.0'	3	N.E.	13

APPENDIX A (Continued)

Preliminary Subsurface Investigation Summary

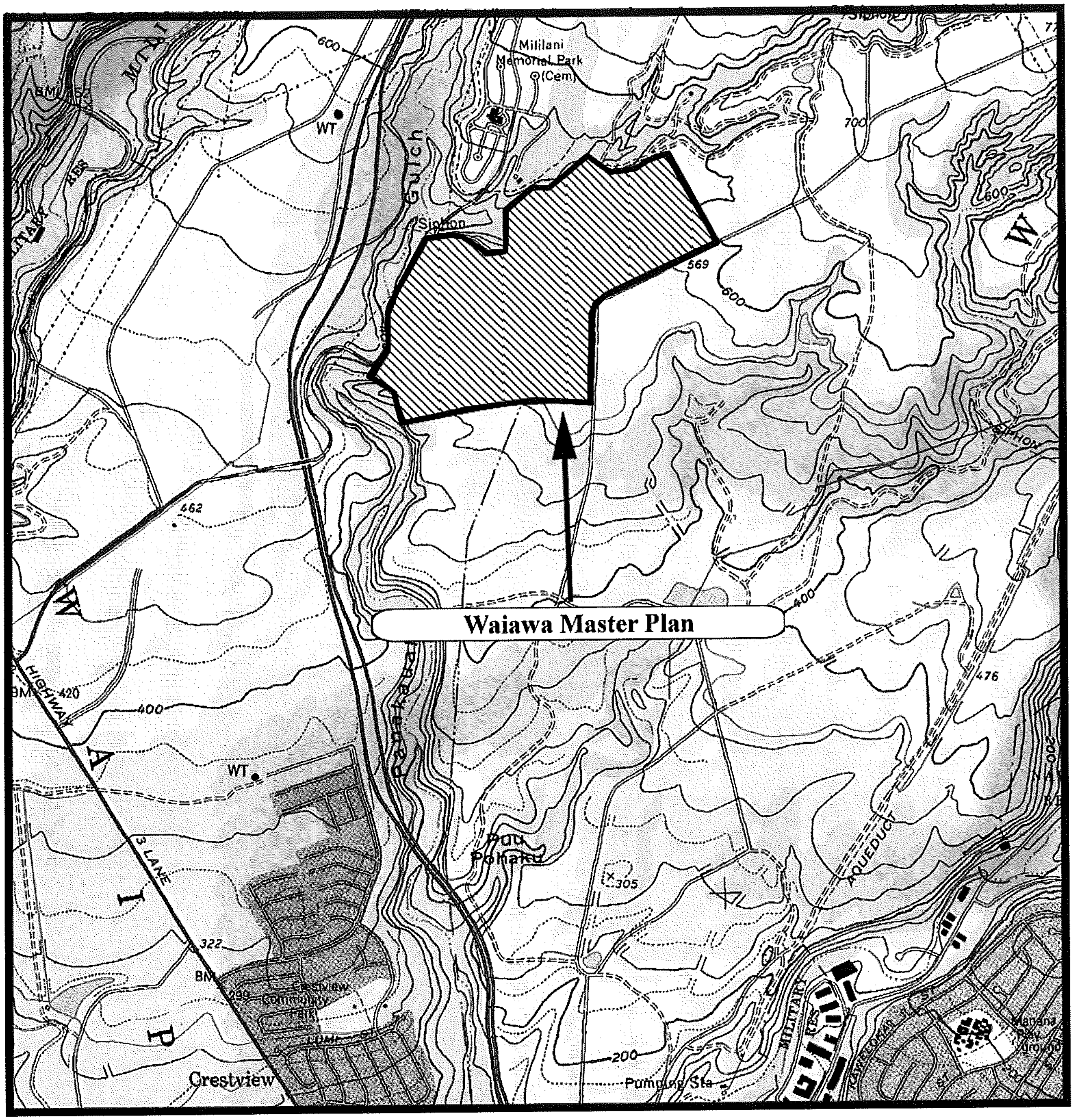
Test Pit & Slope Log Summary:

Test Pit	Depth	Number of Samples	Depth to Water Table	Test Pit Log Figure No.
TP4	20.0’	2	N.E.	14
TP5	15.0’	2	N.E.	15
TP6	15.0’	2	N.E.	16
TP7	15.0’	3	N.E.	17
TP8	16.0’	1	N.E.	18
SL1	8.5	2	N.E.	19
Totals	142.5’	20		

Date Started: 11-7-07 **Date Completed:** 11-29-07 N.E.=None Encountered

Boring and Test Pit Log Legend: Figure 20

Rock Core Photographs Figures 21 and 22



LEGEND:

PROJECT LOCATION

SCALE: 1:24000

GENERAL AREA:

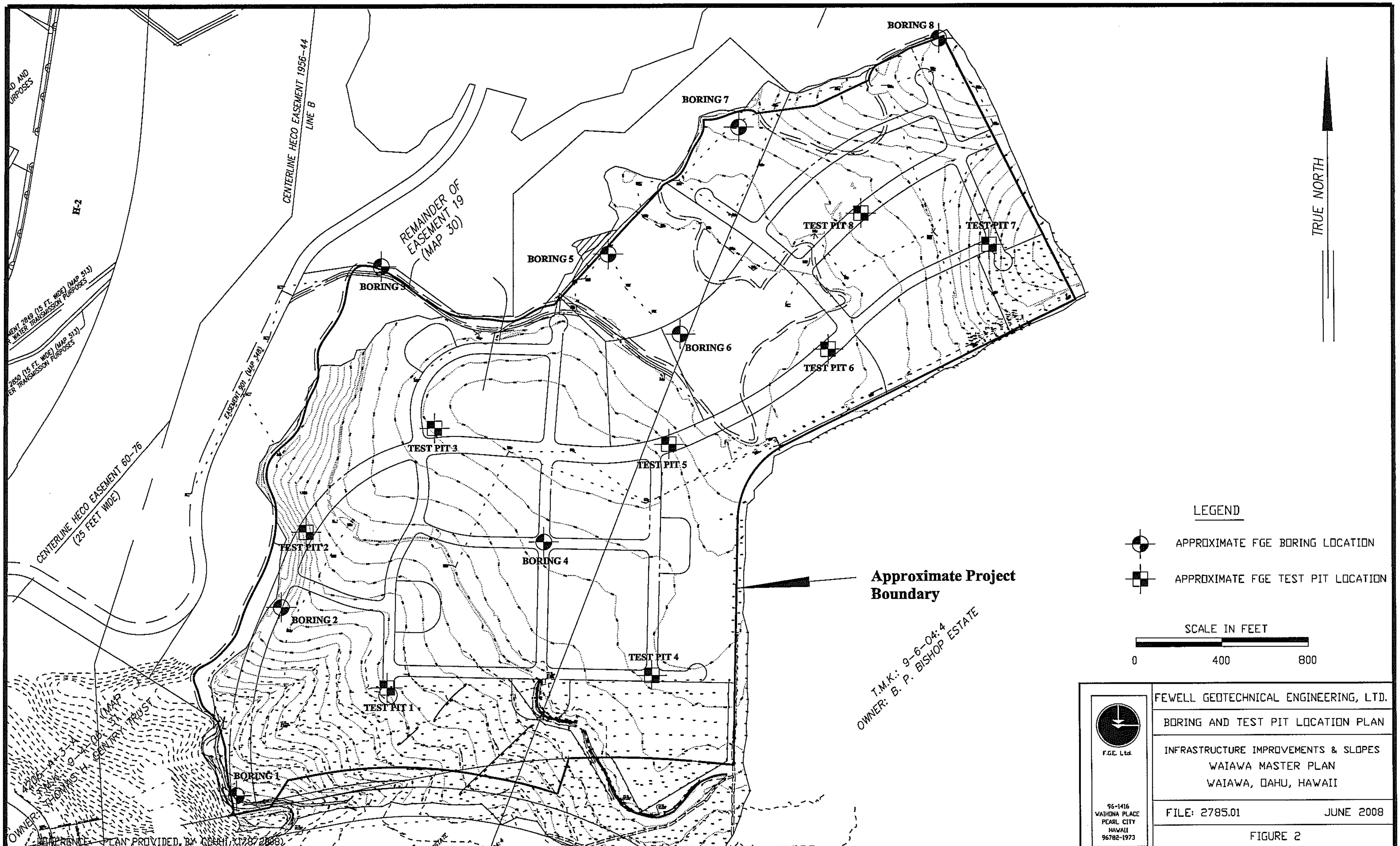
WAIAWA, OAHU, HAWAII

REFERENCE:

WAIPAHU QUADRANGLE
U.S.G.S. TOPOGRAPHIC MAP

	PROJECT LOCATION MAP Infrastructure Improvements & Slopes Waiawa Master Plan Waiawa, Oahu, Hawaii	File: 2785.01 June 2008

Figure 1


BORING 1
BORING 2
BORING 3
BORING 4
BORING 5
BORING 6
BORING 7
BORING 8
TEST PIT 1
TEST PIT 2
TEST PIT 3
TEST PIT 4
TEST PIT 5
TEST PIT 6
TEST PIT 7
TEST PIT 8
H-2
CENTERLINE HECO EASEMENT 1956-44 LINE B
REMAINDER OF EASEMENT 19 (MAP 30)
CENTERLINE HECO EASEMENT 60-76 (25 FEET WIDE)
EASEMENT 901 (MAP 348)
Approximate Project Boundary
T.M.K.: 9-6-04:4
OWNER: B. P. BISHOP ESTATE
TRUE NORTH
LEGEND
APPROXIMATE FGE BORING LOCATION
APPROXIMATE FGE TEST PIT LOCATION
SCALE IN FEET
0
400
800
FEWELL GEOTECHNICAL ENGINEERING, LTD.
BORING AND TEST PIT LOCATION PLAN
INFRASTRUCTURE IMPROVEMENTS & SLOPES
WAIAWA MASTER PLAN
WAIAWA, OAHU, HAWAII
FILE: 2785.01
JUNE 2008
FIGURE 2
F.G.E. Ltd.
96-1416
WAIHONA PLACE
PEARL CITY
HAWAII
96782-1973

FEWELL
GEOTECHNICAL
ENGINEERING, LTD.

Oahu Office
96-1416 Waihona Place
Pearl City, Hawaii 96782-1973
(808) 455-6569
FAX (808) 456-7062
E-mail: fge@fgeltd.com

Maui Office
360 Papa Place, Suite 103
Kahului, Hawaii 96732-2464
(808) 873-0110
FAX (808) 873-0906

File 2914.02
March 31, 2009

Castle & Cooke Homes Hawaii, Inc.
Mililani Field Office
95-1091 Ainamakua Drive
Mililani Town, Hawaii 96789

Attention: Mr. Ray Kunishige
Site Construction Engineer

Subject: **Preliminary Rockfall Assessment**
West-facing Slopes Above Existing Development
and Kamehameha Highway
Koa Ridge Development
Waipio, Oahu, Hawaii

In accordance with your request, we have completed a preliminary site reconnaissance of portions of the west-facing slopes on the southern end of the Koa Ridge Development in Waipio, Oahu, Hawaii. The reconnaissance was undertaken to obtain a preliminary indication of potential rockfall concerns along these slopes. This letter summarizes our observations and comments.

Background - The site of the Koa Ridge Development is a relatively level plateau on the eastern side of Kipapa Gulch in Waipio, Oahu, Hawaii. It covers about 600 acres and is a relatively long site with its longitudinal axis aligned in a general north to south direction. The parcel is bordered by the Interstate H-2, Ka Uka Boulevard, and the Gentry-Waipio Industrial Subdivision on its eastern side, and Kipapa Gulch along its western side. Kamehameha Highway and an existing development border the west-facing slopes on the southernmost section of the parcel.

A preliminary subsurface investigation was recently completed by Fewell Geotechnical Engineering, Ltd. (FGE) to evaluate the general subsurface conditions within the Koa Ridge Development. The preliminary investigation includes a preliminary analysis of some of the steeper slopes of the parcel to develop general guidelines and preliminary construction set-backs from the tops of the slopes for preliminary planning purposes. However, the investigation did not include an evaluation of rockfall conditions.

Rockfall Concerns - At the request of Castle & Cooke Homes Hawaii, Inc. (CCHHI), a preliminary reconnaissance of the west-facing slopes at the southern end of the Koa Ridge Development was completed by FGE due to potential rockfall concerns within the portions of these slopes which fall within CCHHI property. The tops of these west-facing slopes form the edge of the currently planned developable area on the southern end of the Koa Ridge Development. The area of the west-facing slopes is shown on the attached Figure 1 for reference.

The slopes drop down to Kipapa Stream on the northwestern side of the CCHHI area and down to Kamehameha Highway and an adjacent existing development on the western side of the Koa Ridge parcel. The property line between the CCHHI property and the adjacent Kamehameha Highway and/or the adjacent development falls part-way down the west-facing slopes.

The existing northwest-facing slopes in this area (See Figure 1) are visually estimated to extend up to about 200 feet above Kipapa Stream, and their inclinations vary from vertical to about 1½ Horizontal to 1 Vertical (1½H:1V). The slopes above Kamehameha Highway and the adjacent development are generally between 1½H:1V and 2H:1V within the CCHHI property. Where observed, the slopes in the adjacent properties to the west of the CCHHI property line appear to be much steeper, and in many areas near-vertical.

Two large natural gullies or swales start within the relatively level area of the CCHHI property and terminate in the adjacent existing development below the west-facing slopes. The gullies cut through the southern portion of the Koa Ridge property in a general northeast to southwest direction. The gullies slope down toward the existing adjacent development below and to the west of the southern section of the CCHHI property. The northern gully, which is nearest Kipapa Gulch, is about 1,600 feet long. The southern gully is closer to the southern end of the Koa Ridge Development and about 2,000 feet long. Both gullies are indicated in Figure 1.

Field Observations – A preliminary site reconnaissance was completed on February 24 and 25, 2009 to observe the general conditions along the above-referenced west-facing slopes at the southern end of the development and within the existing gullies. The slopes and gullies are heavily overgrown with tall grasses, shrubs and trees, such that close observations of the material comprising the slopes is not possible without some clearing and more extensive field work.

Due to the heavy overgrowth, the preliminary reconnaissance was limited to localized footpaths and existing ditches on the slopes and within the gullies. A more comprehensive field reconnaissance will be necessary to better evaluate the materials on the slopes with regard to rockfall concerns once more detailed topographical and development plans for the area are available.

Two drainage ditches were observed during the reconnaissance (See Figure 1). The ditches appear to intercept water along the west-facing slopes and within the 2 existing natural gullies. The upper ditch (See Upper Ditch in Figure 1) appears to be entirely within CCHHI property and collects water from the upper section of the southern gully. The ditch is an earth ditch with vertical sides, which appears to have been recently either excavated or cleaned. It is 3 to 5 feet deep, and about 8 feet wide with 3- to 5-foot high berms of the excavated soils stockpiled on top of its downslope sides.

The upper ditch starts near the top of the southern gully and within the CCHHI property. It follows the sideslope of the gully and slopes down slightly toward the northern gully. The ditch passes near the top of the slope of the adjacent ridge and then discharges into the northern gully via a near-vertical unlined discharge area. Most of its alignment exposes residual soils and saprolites with occasional areas of decomposed rock and spheroidally weathered boulders. The eroded discharge area appears to consist of highly weathered and fractured basalt with boulders of 1 to 3 feet in maximum dimension. A plunge pool located below contained boulders which appear to have fallen from the slopes above.

An earthen berm (See Figure 1), which appears to have recently been constructed or rebuilt, prevents the water from flowing down the fall-line of the northern gully and directs the water to another ditch which terminates off the cliffs overlooking Kipapa Stream. This second ditch is 5 to 6 feet deep and lined with CRM cut blocks. It is 3 to 4 feet wide at the bottom with near-vertical sides, such that top is about 6 to 7 feet wide. It appears to have recently been cleaned of debris and sediments and is relatively clear at this time. This ditch appears to be the northern leg of the lower ditch discussed in more detail below.

This second ditch wraps around the ridge in this area and discharges into Kipapa Stream on the northwestern side of the ridge. We understand that this discharge area (See Figure 1) is outside of the CCHHI property. The discharge has severely scoured the slope which appears to consist of highly fractured basalt in various stages of weathering. The drop into the stream is vertical and appears to be in the range of about 200 feet or more.

The discharge terminus also services another ditch which continues on in the northern direction along the eastern cliffs of Kipapa Gulch at this level. We understand that this ditch along Kipapa Gulch winds in and out of the CCHHI parcel. The ditch is full of sediments and boulders and does not appear to be maintained. The slopes above both ditches in this general area above Kipapa Stream appear to be highly fractured weathered basalt and it is evident that the unmaintained ditch is catching boulders and debris from the slopes above it.

Another ditch (See Lower Ditch in Figure 1) starts on the western side of the berm in the northern gully mentioned above, meanders in and out of CCHHI property, and terminates at a drainage structure above Kamehameha Highway. This lower ditch is below the upper ditch, and it appears that prior to the construction of the berm in the northern gully, this ditch connected to the CRM ditch mentioned above. This ditch is also lined with CRM cut blocks along its sides, but its designed depth cannot be determined due to the amount of sediments filling the ditch. The exposed sides of the ditch vary from 1 foot to about 3 feet in height and the bottom of the ditch appears to be 4 to 5 feet in width.

This lower ditch wraps around the center ridge overlooking the existing adjacent development, follows the sides of the southern gully into and out of the gully, and then again passes along the top of the slopes overlooking the existing development up to Kamehameha Highway. It then follows the top of the cut slopes above Kamehameha Highway up to its terminus at a drainage structure at its southern end. The intended direction of flow of the lower CRM lined ditch cannot be visually determined due to the sediments and debris filling the ditch, but it is likely that the flow is toward the drainage structure above Kamehameha Highway.

The lower ditch is currently acting to collect occasional boulders falling from above the ditch, and in some areas, many boulders have accumulated within the ditch (See Figure 1). Although the upslope areas are too overgrown to observe the ground surface, the presence of the boulders within the ditch indicates that some boulders are on the slopes above. Additionally, boulders up to 3 feet in maximum dimension were observed in the bottom of the gully below the lower ditch.

Water has jumped out of this lower ditch in 2 separate areas, which appear to be outside the CCHHI property and within the adjacent property of the existing development. Both of these areas occur where the ditch winds around the ridge between the northern and southern natural gullies. The downslope side of the ditch has failed along a section near the southern gully, and is severely undermined in an adjacent nearby area, although it is still intact.

In both areas the width of the accompanying eroded areas next to the ditch appear to be in the range of 10 to 20 feet wide. Severe erosion has occurred in both of these areas and scoured a near vertical slope exposing the subsurface materials. Visual observations of the exposed eroded area suggest that the slope consists of about 10 feet of uncompacted slope wash, residual soils, and saprolites, over highly fractured weathered basalts. Numerous boulders were observed within the soils over the fractured basalt.

The eroded slope is at least 50 feet high, and boulders appear to be falling down in both locations. Plunge pools at the bottom of the eroded slopes appear to be catching some of the boulders. Boulders may be traveling further than the plunge pool, but this could not be determined without observations within the adjacent property. However it appears that water jumping the channel in these 2 locations significantly impacts the development below.

There is also another smaller break in the ditch along the section above Kamehameha Highway, but there are insufficient field references to determine if this is within, or outside of, CCHHI property. This break is about 18 inches wide and appears to be the result of the loss of 1 or 2 of the top CRM cut blocks on the downhill side. Some minor erosion of the slope above Kamehameha Highway has started due to the break, and will likely become considerably worse if left as is, and result in rocks or boulders falling on the highway.

Discussion - Our preliminary reconnaissance indicates that there are rockfall concerns along the west-facing slopes of the southern portion of the Koa Ridge Development. However, most of the most significant concerns appear to occur within the adjacent properties rather than within the property of CCHHI.

These areas appear to be just outside the CCHHI property and below the lower drainage ditch. They appear to be immediately above a portion of Kamehameha Highway and above the adjacent existing development. Although these areas are outside of the CCHHI property, we believe that it would be prudent for CCHHI to notify their neighbors of the rockfall problems so that they can retain their own engineers to mitigate any rockfall concerns which can affect their health and safety.

Additionally, much of the observed erosion and rockfall concerns occur along the lower drainage ditch. Although the observed problems and potential problems appear to be outside of CCHHI property, the drainage ditch winds in and out of CCHHI property, and hence we believe that the degree of responsibility of CCHHI with regard to these occurrences will likely be questioned. We recommend that CCHHI consult with counsel regarding their liabilities with regard to these areas.

Within the CCHHI property, it appears that most of the rockfall concerns will likely be the result of localized boulders on the existing slopes and some areas of highly weathered fractured basalt. Although a comprehensive rockfall study will be necessary to better evaluate the slope conditions, based on our preliminary observations, we believe that these concerns can likely be satisfactorily addressed with selective removal of boulders from the slopes, the installation of boulder barriers along the slopes, localized stabilization of fractured basalts, or a combination of these methods.

The significant rockfall concerns within the CCHHI property are the highly weathered fractured basalts which were observed in 3 different areas immediately above the slopes along the existing drainage ditches. One of these areas is above the drainage ditch from the northern gully to its discharge area above Kipapa Stream, and above the existing unmaintained ditch trending northward from the discharge area. A similar face of highly weathered fractured basalt was observed at the discharge area of the upper ditch into the northern gully, and also on the upslope side of the lower ditch in the southern gully.

We understand that the discharge area into Kipapa Stream is outside CCHHI property but the unmaintained ditch is partially within and partially outside of the CCHHI property. However, although the topography and exposed rock conditions can result in significant rockfall from these cliffs, there does not appear to be any development in close proximity to this area, and falling rocks appear to be landing within Kipapa Stream below the cliffs.

The rocks currently falling from the scoured face of fractured basalt in the discharge area of the upper ditch is currently being collected in the plunge pool and an earthen berm across this area of the northern gully also act to retain boulders. Hence at the present time, some controls appear to be in place to minimize the potential for boulders traveling down the northern swale. However, periodic observation and maintenance of the collection area of the boulders will be necessary to contain future boulders resulting from the erosion of the discharge area and to maintain the drainage of water into the adjacent ditch to its discharge area above Kipapa Stream.

A similar face of fractured basalt was observed within the southern gully and portions of this face appear to be within CCHHI property. The existing sediment-filled drainage ditch below the rock face currently acts as a drop zone for the boulders and hinders them from traveling down the slopes. Cleaning off the loose boulders from this slope and installing a boulder barrier on the down slope side of the drainage ditch should act to minimize the potential of future boulders traveling down the slope and off the CCHHI property. Gunniting the rock face may be necessary should it be necessary to minimize the potential for boulders from falling into and blocking the existing ditch below the face.

The rockfall concerns within the remainder of the CCHHI property appear to mainly consist of occasional boulders which are likely the result of the natural weathering of the soil and rock formations. Although detailed observation of the existing slopes was not performed during this preliminary reconnaissance, the presence of boulders within the lower ditch and within the existing gullies suggest that at least some boulders are falling from the slopes above. A detailed reconnaissance will be necessary to locate the boulders such that precarious boulders can be selectively removed from the slope. Boulder barriers should also be anticipated in at least some areas to minimize boulders traveling outside the CCHHI property.

The methods employed to mitigate the rockfall concerns will be highly dependent on the future construction and hence would be construction- and site-specific. Many of the boulders within the existing swales will likely be removed during the filling of the swales such that the rockfall concerns are mitigated by the construction. In addition, the planned set-backs of the construction from the tops of the existing slopes should not result in an increase in the existing rockfall problems on the slopes below. Hence it is anticipated that future rockfall concerns will likely be reduced, rather than increased, by the future construction.

It should be realized that regardless of the methods employed to minimize the rockfall concerns, periodic observation and maintenance is an essential part of rockfall mitigation procedures. The conditions of the slopes inevitably change with the passage of time due to the on-going natural processes. The slopes and rockfall mitigation procedures must be observed to determine whether additional measures are necessary. In addition, the conditions of the existing drainage ditches can result in additional rockfall concerns and these must be observed and maintained to reduce future rockfall problems.

Preliminary Conclusions – Our preliminary reconnaissance indicates that there are rockfall concerns along the west-facing slopes of the southern portion of the Koa Ridge Development. However, most of the most significant concerns appear to occur within the adjacent properties rather than within the property of CCHHI.

We believe that the concerns within CCHHI property can likely be addressed with selective removal of boulders from the slopes, the installation of boulder barriers along the slopes, localized stabilization of fractured basalts, or a combination of these methods. The method of mitigation would be dependent on site-specific conditions and should be developed when more detailed topographic and development plans are available.

This preliminary rockfall evaluation has been completed for preliminary planning and cost-estimating purposes and is based on a limited reconnaissance of the west-facing slopes of the southern end of the Koa Ridge Development. A more comprehensive reconnaissance and study of the existing slopes should be completed once more detailed topographic and development plans are available.

Should you have any questions regarding this matter, or if we can be of additional assistance to you, please do not hesitate to contact us.

Respectfully submitted,

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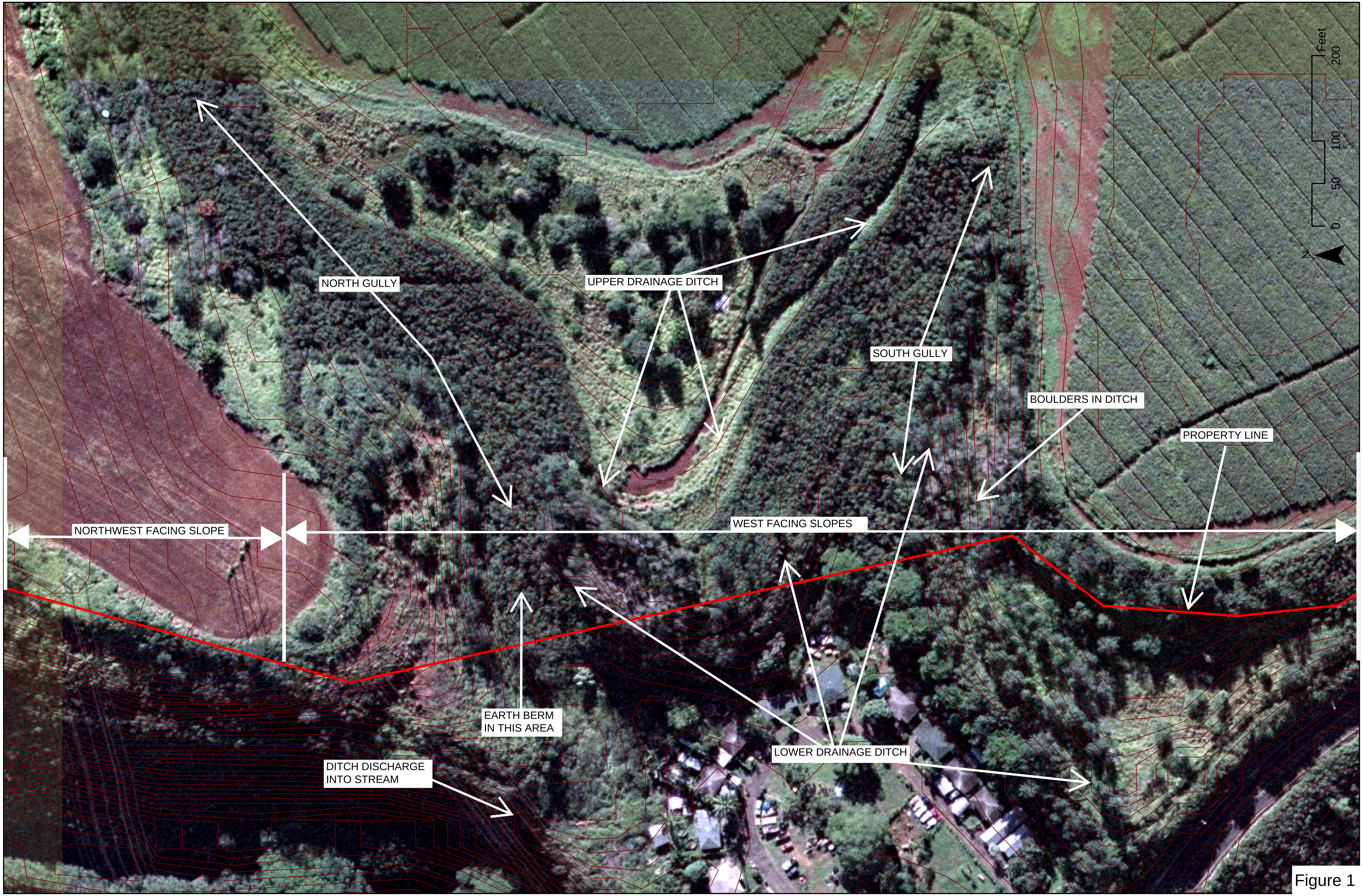
/ajs:tjc:fse

Attachment: Figure 1



Feet
200
100
50
0
N
NORTH GULLY
UPPER DRAINAGE DITCH
SOUTH GULLY
BOULDERS IN DITCH
PROPERTY LINE
NORTHWEST FACING SLOPE
WEST FACING SLOPES
EARTH BERM
IN THIS AREA
DITCH DISCHARGE
INTO STREAM
LOWER DRAINAGE DITCH

Figure 1