APPENDIX A

LETTER FROM THE U.S. DEPARTMENT OF THE ARMY

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
FT. SHAFTER, HAWAII 96858-5440

REPLY TO ATTENTION OF

February 16, 2006

Regulatory Branch

File No. POH-2005-89

Naomi U. Kuwaye
Imanaka Kudo & Fujimoto
TOPA Financial Center
Fort Street Tower
745 Fort Street, 17th Floor
Honolulu, HI 96813

Subject: Request for review of Department of the Army (DA) jurisdictional determination for Kaloi Gulch, Ewa, Oahu, Hawaii

Dear Ms. Kuwaye:

This office has reviewed the materials you submitted on behalf of the University of Hawaii (UH), including a report by Wayne Wright of GeoEngineers dated November 7, 2005, in support of your request that the Corps re-evaluate its assertion of DA jurisdiction over the Kaloi Gulch in the vicinity of the proposed UH West Oahu Campus.

In support of your request, a file review was conducted by Ms. Stephanie Uechi of your staff on November 4, 2005, and, on November 8, 2005, the Corps provided copies of the documents she requested (copy of transmittal letter attached). The files presented to Ms. Uechi for her review were intended to provide a starting point and were not represented as or intended to be an exhaustive file review. Much of this material had already been reviewed by my staff in making our original determination of jurisdiction.

As part of its reevaluation of its jurisdictional determination (JD), this office reviewed your report, the files referenced in your letter as well as others pertaining to the Kaloi Gulch drainage basin, additional reports associated with the Haseko Ocean Pointe Marina development, aerial photographs, additional site inspections, and applicable case law.

While the Corps does not concur with the rationale behind your conclusion, we agree with your conclusion that the upper reaches of Kaloi Gulch do not have a regulated tributary connection to waters of the U.S. Therefore, a DA permit pursuant to Section 404 of the Clean Water Act (CWA) will not be required for the proposed fill associated with the UH West Campus or the North-South Road.

As a result of our re-examination of the facts associated with Kaloi Gulch, we have found that although an emergency overflow channel was constructed in 2000 to allow overflows from a very large, infrequent storm event to overtop the detention/retention basins of the Coral Creek golf course and proceed towards the Pacific Ocean in the vicinity of Oneula Beach Park (see details below), a site inspection revealed there are no physical indications that storm flows have

ever in fact overtopped the Coral Creek system and discharged to the Pacific Ocean. The storm water management systems associated with developments within the lower reaches of the Kaloi Gulch watershed have been engineered such that the upper reaches of the gulch have been, on a practical scale, effectively isolated from the Pacific Ocean.

For the record, we would like to clarify several misleading statements made in your November 28, 2005 letter and in Mr. Wright's report that we feel result from a misunderstanding of the Corps' regulatory program and a selective interpretation of the information in Corps files.

1. Absence of an historical, natural hydrological connection between Kaloi Gulch and Pacific

Under I(A)(1) of your letter you reference a 1997 report by PBR Hawaii and Tom Nance Water Resource Engineering and conclude that "research into the history of the Gulch reveals there has never been a natural outlet connecting the Gulch to the ocean." While the Corps does not dispute this conclusion, it should be noted that a man-made water conveyance can establish a tributary connection to a water of the U.S. This is supported by case law (United States v. Newdunn, 344 F.3d 407 (4th Cir. Sept. 10, 2003)). The report itself goes on to describe how the gulch had been modified by sugar plantations in the early to mid-twentieth century. According to the authors, the modifications consisted of constructing parallel levees to direct flows within the gulch onto makai lands, ending approximately one mile from shore at a sump for the shallow caprock well known as EP-27.

An earlier report, however, describes a continuation of the so-called Kaloi ditch from this sump to an ocean outlet. According to the "Drainage and Soil Erosion Control Report for Haseko (Ewa), Inc. Golf Course" by Wilson Okamoto & Associates, Inc., September 1994, P.10:

> The Kaloi irrigation ditch empties onto an existing sump area in a kiawe forest before it outlets to the Pacific Ocean via a very small drainage ditch near the City and County of Honolulu's Oneula Beach Park.
>
> The existing Kaloi Gulch irrigation ditch is used for delivery of irrigation water. It does not generally function as a drainage channel since the channel invert is higher than the adjoining topography.
>
> The irrigation ditch in the Haseko (Ewa), Inc. golf course site will remain as it exists until sugar cultivation in the region is terminated and the need of the irrigation facility ceases. The irrigation ditch will be removed eventually as properties upstream are developed.

Also, the "Final Report, Phase II – Data Recovery, Archaeological Mitigation Program, Ewa Marina Community Project, Volume I" by Paul H. Rosendahl, Ph.D., Inc., December 1995, P. 12, states that, "A drainage ditch runs from the cane fields through the project area terminating at the ocean within One'ula Park. This trench is lined with the terrigenuous soils from the sugar cane fields."

The existence of this small remnant drainage ditch was confirmed by Connie Ramsey and Farley Watanabe of my staff during a site inspection on November 1, 2005. Further, it is

depicted on a map in the "Final Report, Phase II – Data Recovery, Archaeological Mitigation Program, Ewa Marina Community Project, Volume III: Illustrations" by Paul H. Rosendahl, Ph.D., Inc., December 1995, Figure 3.4, "Historic Impacts to Project Area" (attached).

Therefore, the statement in the 1997 PBR Hawaii/Tom Nance report that "no channel, man-made or natural, has ever existed as a continuous conveyance all the way to the shoreline" appears to be incorrect. In his report, Mr. Wright states that "No evidence was found that Kalo'i Gulch is connected to the Pacific Ocean at any time." An Environmental Impact Statement Preparation Notice (EISPN) for the Kaloi Gulch Drainageway Improvement at Oneula Beach Park, prepared for Haseko (Ewa), Inc. by R.M. Towill Corporation, May 2004, (Corps. File No. 200400353) states that "the Kaloi Gulch drainage outlet is located at the easternmost portion of the existing Oneula Beach Park" (p.11). The EISPN further explains that "the portion of Kaloi Gulch which now connects to the project site, is the result of the construction of an emergency relief channel construction in June 2000" (p.23).

The stated purpose of the proposed drainageway improvements at Oneula Beach Park is to complete the interim measures of the initial emergency relief channel constructed to avoid recurrence of the flooding event that impacted Ewa Villages in November 1996, and, ultimately, to meet the City & County of Honolulu's drainage standard for a 100-year flow.

As further clarification, the "Kaloi Gulch Drainageway Improvements at Oneula Beach Park, Draft Environmental Impact Statement" by R.M. Towill, December 2004 (P. 4-7), states:

> As the Ewa Plan has undergone development over the past quarter century, conversion from agriculture to urban has both increased and concentrated stormwater runoff within the watershed. Developers in the Kaloi Gulch Watershed have installed basins for retention and detention to contain and store large amounts of storm water within their developments where it infiltrates into the ground.
>
> Runoff during periods of prolonged heavy rainfall, however, can exceed the retention capacity of these features and overflow onto makai lands, including Ocean Pointe and Oneula Beach Park. To accommodate this overflow and to provide flood relief for upland communities, HASEKO in June 2000 constructed an overflow emergency channel through the Ocean Pointe site.

This emergency channel can clearly be seen in the aerial photographs (Figure 2) in Mr. Wright's report. Thus, the Corps acknowledges that the downstream reaches of the Kaloi are usually dry, but the possibility remains for the upstream retention basins to be breached and for storm waters to move downstream within this wide, shallow drainageway to the Pacific Ocean.

As additional background, the 1997 PBR Hawaii/Tom Nance report also describes the separation of Kaloi's irrigation and drainage functions in the early 1990's as the City's re-development of Ewa Villages removed the levees in the project vicinity to direct stormwater into on-site retention-detention areas within what is now known as the Ewa Villages golf course. The irrigation function for plantation operations was maintained by a newly constructed

irrigation ditch that ended as described in Page 2 above. The stormwater flows were to be impounded within the Ewa Villages golf course with no outlet makai, which resulted in significant flooding of Ewa Villages from two major storms in November, 1996. As a result of these flooding events, the City and County of Honolulu initiated a task force to focus on the drainage issues within the Kaloi Gulch Watershed basin. As a result of regional planning, in the late 1990's, a bridge was constructed under the OR&L railroad right-of-way, which, until that point, had acted as a berm to concentrate floodwaters in the Ewa Villages. The bridge construction included the re-alignment of the Kaloi channel, connecting it downstream to Ewa by Gentry's Coral Creek golf course, which had incorporated retention basins within its design to accommodate storm flows.

It should be noted that since the date of the 1997 PBR Hawaii/Tom Nance report, further modifications to the Kaloi alignment have occurred (including those described above) as a result of continuing development of the Ewa plain as a major suburban region. This is also relevant to your discussion of the US Geological Survey topographic map "blue line" depiction of Kaloi Gulch, which indicates there is no surface connection to the Pacific Ocean. The USGS topographic map in Mr. Wright's report (Figure 1) is dated 1998, and since then changes have occurred within the watershed, which is why the USGS topographic maps are generally used by this District primarily as a guideline and not as conclusive records as to the extent of waters of the United States.

2. Corps jurisdictional determinations are inconsistent

Section III of your letter asserts that Corps' jurisdiction calls are inconsistent because we have allegedly not asserted jurisdiction over lower reaches and yet have asserted over upper reaches of the gulch. You support your point with a summary of jurisdictional determinations for areas downstream of the project location only. However, in reviewing these files, the situations vary and we believe it inappropriate to represent these as being inconsistent.

To further explain, I would like to note that there are essentially two aspects to Corps jurisdictional determinations: 1) the geographic determination of the presence and extent of waters of the United States; and 2) whether the proposed work involves the discharge of dredged or fill material below the Ordinary High Water Mark (OHWM). It would be easy to misconstrue a determination that no permit is required for a proposed project to mean the subject water body is not regulated, when, in fact, the waterbody is determined to be a "water of the U.S.," however, the actual project area would remain above the OHWM. The OHWM represents the lateral limit of Corps jurisdiction. Jurisdictional decisions are associated with the specific location and project scope and are necessarily case-by-case. Below are the cases you reference in your letter, with more specific information regarding each circumstance:

Corps File No. 990000285: The Corps letter dated May 10, 1999 addresses jurisdictional requirements for the construction of a channel for the relocated Kaloi Gulch to connect an existing retention pond (Ewa Villages Golf Course) to the Coral Creek Golf Course pond. The letter states that "connection to the jurisdictional portion of Kaloi Gulch will involve excavation

only. There will be no discharge of dredged or fill material to the existing gulch." A subsequent letter dated July 13, 1999 states that "all work will take place above the ordinary high water mark in Kaloi Gulch. Therefore a Department of the Army permit will not be required." Therefore, the Corps did not require a DA permit based on the nature and location of the work in relation to a water of the U.S., not because the discharge of fill material below the OHWM within Kaloi Gulch would not have been regulated.

Corps File No. 990000316 A Corps letter dated January 23, 1998 states that "the upper reaches of Kaloi Gulch are considered jurisdictional waters of the U.S. However, Kaloi Gulch in the vicinity of the Coral Creek Golf Course project site does not exhibit an ordinary high water mark, and therefore, is not considered a [jurisdictional] water of the United States at this location. We reaffirm our initial determination that a DA permit will not be required for this project."

Corps File No. 200400466 The Corps letter dated November 22, 2004 states that "The Corps considers Kaloi Gulch to be a water of the U.S. based on its tributary connection to the Pacific Ocean; however, a site inspection conducted by a member of my staff on November 19, 2004 revealed the absence of an Ordinary High Water Mark (OHWM) by which to establish a jurisdictional line for this section of the gulch. Any discharge of dredged material or fill into this portion of the gulch will not be subject to jurisdiction under Section 404 of the CWA, and no DA permit will be required."

Further, a particular aquatic feature may provide a tributary connection to a water of the U.S. without itself being regulated. An aquatic feature, such as downstream Kaloi Gulch, does not necessarily need to have a defined bed and bank or an OHWM to act as a hydrological connection. Therefore, what you interpret from our jurisdictional calls to indicate a severance in connection and represent inconsistencies is in fact neither. Your assertion that the Corps' declining jurisdiction over the downstream portions of Kaloi severs the tributary connection to upstream portions is erroneous.

In response to Mr. Wright's statement that, "A recent review of the Corps' files indicated that, in fact, this is the first instance where the Corps has asserted jurisdiction over Kalo'i Gulch despite an extensive history of various project that involved the Gulch," the Corps would like to refer you to the below Corps jurisdictional determinations for which the records were reviewed by your firm, but were not mentioned in your letter. The records do in fact show consistency over time in our jurisdictional determinations for Kaloi Gulch in the UH West Oahu campus project area:

Corps File No. 970000161 The August 12, 1997 Corps letter in this file addresses the East Kapolei Master Plan, which is where the proposed UH West Oahu campus is located, and states, "Kaloi Gulch at the subject area is considered a jurisdictional water of the U.S. This determination was based on the identification of Kaloi Gulch as an intermittent stream on the U.S. Geological Survey map and the presence of an ordinary high water mark. The determination was also based upon the condition of the gulch at the project site. Previous

determinations along other sections of the gulch have no bearing on this decision." Granted, this JD pre-dates the SWANCC decision, but that is irrelevant to the point of this discussion.

Corps File No. 990000173 Corps letter dated February 23, 1999 providing comments on a draft Environmental Assessment for the proposed North-South Road state "a DA permit will be required for work done in Kaloi Gulch at the road crossings."

Corps File No. 980000294 Corps letter dated September 2, 1998 providing comments on an EISPN for the UH West Oahu Campus state that "any impact to Kaloi or Honouliuli Gulches may require a DA permit."

I would like to note that all these files were reviewed by Ms. Uechi of your firm, with the exception of the Wilson Okamoto & Associates "Drainage and Soil Erosion Control Report for Haseko (Ewa), Inc. Golf Course," September 1994, and the two archaeological reports referenced in our letter, which are actually part of the Ocean Pointe/Ewa Marina administrative record and subsequently located during our effort to respond to your November 28th request.

We appreciate your patience during our re-examination of this jurisdictional determination. This revised determination is valid for a period of five (5) years from the date of this letter, unless new information warrants revision of the determination before the expiration date. This letter contains an approved jurisdictional determination for the UH West Oahu Campus project. If you object to this determination, you may request an administrative appeal under Corps regulations at 33 CFR Part 331. Enclosed you will find a Notification of Appeal Process (NAP) fact sheet and Request for Appeal (RFA) form. If you request to appeal this determination you must submit a completed RFA form to the Pacific Ocean Division Office at the following address:

Administrative Appeals Officer
c/o Michael T. Lee, Regulatory Program Manager
U.S. Army Corps of Engineers
Pacific Ocean Division
Building 525
Ft. Shafter, Hawaii 96858-5440

In order for an RFA to be accepted by the Corps, the Corps must determine that it is complete, that it meets the criteria for appeal under 33 CFR Part 331.5, and that it has been received by the Division Office within 60 days of the date of the NAP. Should you decide to submit an RFA form, it must be received at the above address by April 17, 2006.

If you do not object to this jurisdictional determination, there is no need to submit the RFA form to the Pacific Ocean Division.

For more information on our regulatory program, please visit our web site at http://www.poh.usace.army.mil/regulatory.asp. If you need further assistance, please contact Ms. Ramsey by phone at 438-2039, by facsimile at 438-4060, or by electronic mail at Connie.L.Ramsey@usace.army.mil . Please refer to file number above for further inquiries regarding this project. Thank you for your cooperation with our regulatory program.

Sincerely,

George P. Young, P.E.
Chief, Regulatory Branch

Attachments:
Transmittal letter from Corps dated November 8, 2005
Figure 3.4, Historic Impacts to Project Area, "Final Report, Phase II – Data Recovery, Archaeological Mitigation Program, Ewa Marina Community Project, Volume III: Illustrations" by Paul H. Rosendahl, Ph.D., Inc., December 1995
Notification of Administrative Appeals Options and Process and Request for Appeal Form

APPENDIX B

BOTANICAL SURVEY

BOTANICAL SURVEY
UNIVERSITY OF HAWAI'I WEST O'AHU
EAST KAPOLEI, 'EWA DISTRICT, O'AHU

by

CHAR & ASSOCIATES
Botanical Consulants
Honolulu, Hawai'i

Prepared for: PBR HAWAII

August 2003

BOTANICAL SURVEY
UNIVERSITY OF HAWAI'I WEST O'AHU
EAST KAPOLEI, 'EWA DISTRICT, O'AHU

INTRODUCTION

In mid-September 2002, the University of Hawai'i Board of Regents selected the 500-acre Kapolei Makai site as the permanent site for the University of Hawai'i West O'ahu campus. The 500-acre project site is bounded by Farrington Highway to the north; the proposed North-South Road to the east; overgrown, former sugar cane lands to the south; and the Kapolei residential area and Kapolei Golf Course to the west. A large portion of the 500-acre project site has recently been cleared for vegetatable crops or is already under cultivation by Aloun Farms. The Kalo'i and Hunehune Gulches cross the property. Scrub vegetation is found on the former cane fields on the lower southern portion of the site. A few plants of the endangered ko'oloa'ula (Abutilon menziesii) are associated with the scrub vegetation.

Field studies to assess the botanical resources on the proposed University of Hawai'i West O'ahu campus site were conducted from 17 to 20 June 2003. The primary objectives of the field studies were to:

1) prepare a general description of the vegetation on the site;
2) inventory the flora;
3) search for threatened and endangered species as well as species of concern; and
4) identify areas of potential environmental problems or concerns and propose appropriate mitigation measures.

SURVEY METHODS

Prior to undertaking the field studies, a search was made of the pertinent literature to familiarize the principal investigator with other botanical studies conducted in the general area. Topographic maps and a recent, colored aerial

photograph (1" = 200') were examined to determine vegetation cover patterns, terrain characteristics, access, boundaries, and reference points.

The areas with scrub and gulch vegetation were surveyed more intensively as they were more likely to harbor native plants. A few plants of the endangered ko'oloa'ula (Abutilon menziesii) occur on the project site; larger clusters of plants are found on the adjacent lands. All of the ko'oloa'ula plants, both on and off the project site, have been mapped and/or flagged during earlier studies. The plants are monitered periodically by staff from the State Division of Forestry and Wildlife (DOFAW). Actively cultivated farm lands were not surveyed in detail as rare plants were not likely to occur in such areas.

A walk-through survey method was used. Notes were made on plant associations and distribution, substrate types, disturbances, topography, exposure, drainage, etc. Plant identifications were made in the field; plants which could not be positively identified were collected for later determination in the herbarium, and for comparison with the most recent taxonomic literature.

The species recorded are indicative of the season ("dry" vs. "rainy") and the environmental conditions at the time of the survey. A survey taken at a different time of the year and under varying environmental conditions would no doubt yield slight differences in the species list, especially of the weedy, annual plants.

DESCRIPTION OF THE VEGETATION

Nagata (1996) conducted a biological survey (flora and fauna) for the approximately 1,300-acre East Kapolei Master Plan project site. This study covered the proposed 500-acre UH West O'ahu property. It was during the field survey in September and October 1996 that Nagata discovered the endangered ko'oloa'ula plants (see "Endangered Species" section in this report for discussion). In the 1996 study, large portions of the East Kapolei site supported abandoned sugar cane fields with sugar cane (Saccharum officinarum) making up 30 to 50% of the total

vegetation cover. In other places, sugar cane made up less than 5% of the cover with mixed herbs and grasses abundant. A botanical survey for the proposed North-South Road (Char 1997) recorded similar vegetation types.

Today, large areas with sugar cane are no longer present on the study site, having been replaced by a scrub vegetation composed primarily of swollen fingergrass (Chloris barbata), mixed herbaceous species, and small shrubs (subshrubs). The lands on the northern portion of the site, adjacent to Farrington Highway, are under cultivation by Aloun Farms.

Three vegetation types are recognized on the UH West O'ahu site in this report. An inventory of all the plant species observed during the field studies is presented at the end of the report.

Agricultural/Farm

Actively cultivated fields make up the agricultural farm lands vegetation type which covers the majority of the 500-acre project site. Most of the large fields bordering Farrington Highway have recently been bulldozed to clear them of woody growth and were being disked during our field survey in June. Short stumps of koa haole shrubs (Leucaena leucocephala) could be observed here and there in these fields. On the planted fields on the eastern portion of the site, hybrid sweet corn (Zea mays) covers large areas. Other crops observed include bell pepper (Capsicum annuum cv. "Grossum"); eggplant (Solanum melongena); a number of different melon cultivars such as watermelon and Thai watermelon (Citrullus lanatus), and canteloupe and honeydew (Cucumis melo); cultivars of Cucurbita pepo -- zucchini, pumpkin, kabocha; and yard-long bean (Vigna unguiculata).

A few weedy species such as swollen fingergrass, field bindweed (Ipomoea obscura), spiny amaranth (Amaranthus spinosus), and pigweed (Portulaca oleracea) can be found growing among the crop plants. Most of the weedy plants, however, occur along the uncultivated areas which border the fields; these weedy patches receive runoff from the cultivated fields so the weeds tend to

be lush and green, and 2 to 4 ft. tall in some places. Weedy species found here include clumps of Guinea grass (Panicum maximum), field bindweed, lion's ear (Leonotis nepetifolia), young koa haole shrubs, graceful spurge (Chamaesyce hypericifolia), Trianthema portulacastrum), milkweed (Sonchus oleraceus), cheese weed (Malva parviflora), etc. The native 'ilima (Sida fallax) is locally common in some places. One new species not recorded from the island of O'ahu, Russian thistle or tumbleweed (Salsola tragus), was collected and deposited at the Bishop Museum herbarium.

Scrub Vegetation

This vegetation type occupies the southern portion of the project site and is usually 1 to 3 ft. tall. Long dead stalks of sugar cane are scattered throughout this vegetation type. At the time of this survey, the project site was very dry with plant cover 50 to 60%. Bare soil areas with large, knee-deep cracks were prominent and made surveying difficult.

Swollen fingergrass is the most abundant species forming fairly large patches. In some places, buffelgrass (Cenchrus ciliaris) becomes locally abundant and forms a thick mat, 2 to 3 ft. tall. Four herbaceous species are abundant to common; these are false mallow (Malvastrum coromandelianum), coat buttons (Tridax procumbens), fuzzy rattlepod (Crotalaria incana), and golden crown-beard (Verbesina encelioides). Small shrubs of hoary abutilon (Abutilon incanum), 'uhaloa (Waltheria indica), and 'ilima are abundant; these small shrubs have fuzzy, gray to bluish-gray leaves, and give a grayish-blue cast to the vegetation where they form extensive patches, 1 to 3 ft. tall.

Scattered through this scrub cover are taller shrubs of koa haole and sourbush (Pluchea carolinensis), 3 to 10 ft. tall. Other woody components found here in small numbers are young kiawe (Prosopis pallida) and 'opiuma (Pithecellobium dulce) trees, 7 to 12 ft. tall. Interestingly, a few species usually used as landscaping material have established themselves within these former cane fields; these are the small crown flower (Calotropis procera), carrion flower (Stapelia

gigantea), and Sebesten plum (Cordia dichotoma).

On the old, crushed coral-covered cane haul roads and along irrigation ditches, the vegetation is somewhat denser. Koa haole shrubs and Guinea grass are common. Other species forming fairly large patches here include saltbush (Atriplex suberecta), 'uhaloa, slender mimosa (Desmanthus pernambucanus), Macroptilium atropurpureum, Natal redtop grass (Melinis repens), 'ilima, and swollen fingergrass.

Along the lower boundary (makai end), especially along the North-South Road corridor, there are a few plants of the endangered ko'oloa'ula within the project site. A more detailed discussion of the ko'oloa'ula plants on the project site is presented in the "Endangered Species" section of the report.

Gulch Vegetation

Kalo'i Gulch and Hunehune Gulch cross the project site. In most places, the gulches are shallow and narrow, however, Kalo'i Gulch becomes 25 to 45 ft. deep and wider along its eastern segment. A large plunge pool with standing water was found during the field studies. The intermittent streams along the bottom of each of the gulches have eroded down to the hardpan parent material.

The vegetation within the gulches (sides and bottom) is characterized by dense, robust clumps of Guinea grass, 5 to 10 ft. tall. The dense Guinea grass cover tends to exclude other species, but a few patches of California grass (Brachiaria mutica), sourbush, castor bean (Ricinus communis), wild bittermelon (Momordica charantia), comby hyptis (Hyptis pectinata), and cocklebur (Xanthium strumarium) are found where the Guinea grass cover is thin and the soil exposed.

Along the top banks of the gulches, buffelgrass forms a thick mat up to 3 ft. tall, but Guinea grass can also be abundant in places. Koa haole shrubs, 10 to 20 ft. high, occur as scattered stands or can sometimes become very dense and form small thickets, especially along the eastern section of Kalo'i Gulch.

Tangled mats of coccinia vine (Coccinia grandis) are frequently observed climbing up and over the koa haole shrubs. A few kiawe trees, 20 to 25 ft. tall, are also found along the top of the gulches.

ENDANGERED SPECIES

The ko'oloa'ula (Abutilon menziesii) is a member of the hibiscus or mallow family (Malvaceae). It is a much-branched shrub covered by velvety, silvery hairs. The heart-shaped leaves are silvery-green and the small 'ilima-like flowers range in color from pale peach to dark red. Abutilon is found in dry, lowland habitats on the islands of O'ahu, Maui, Lana'i, and Hawai'i (Wagner et al. 1990). In 1986, the species was federally listed as endangered and is protected under the provisions of the Endangered Species Act of 1973, as amended, and Chapter 195D, Hawaii Revised Statutes, as amended. In its natural habitat the plants are threatened by browsing animals, competition from weedy introduced species, fires, predation by insects, loss of native pollinators, and development (U.S. Fish and Wildlife Service 1994).

In September 1996, Nagata found 38 Abutilon menziesii plants on the East Kapolei project site; the reconnaissance survey covered roughly 80% of the property. After the unusually heavy rains in November 1996, Char (1997) conducted an intensive inventory of the plants in December and recorded a total of 88 plants. A year later, in December 1997, Nagata performed a detailed survey flagging and attaching numbered tags to the plants; survey engineers then mapped the plants. The 1997 survey recorded 87 plants, 86 from the East Kapolei site and North-South Road corridor and one plant within the fenceline of the adjacent City and County-owned golf course.

In 1998, a Habitat Conservation Plan (HCP) was prepared for the East Kapolei Master Plan; the HCP is an "umbrella plan" that includes the East Kapolei project as well as the North-South Road project. The HCP provides a description of the development actions which would impact the Abutilon plants and proposes a series of mitigative strategies to address the impacts (PBR 1998).

A few of the endangered Abutilon plants occur on the proposed UH West O'ahu site. These represent the most mauka extension of the Cluster C population. One plant remained at the Cluster D site in Nagata's 1997 study, but it has subsequently died (V. Caraway, DOFAW, pers. comm.); there may still be seeds of Abutilon present in the soil around Cluster D. The Abutilon population is periodically monited by the Division of Forestry and Wildlife (G. Mansker, pers. com.).

DISCUSSION AND RECOMMENDATIONS

The proposed 500-acre UH West O'ahu site was under sugar cane cultivation for nearly a century with the last harvest occurring in 1994, prior to permanent closure of Oahu Sugar Company in 1995 (PBR 1998). Today, only dead stalks of sugar cane and faint traces of planting furrows remain. Weedy scrub vegetation consisting of a mixture of swollen fingergrass and buffelgrass, herbaceous species, and small shrubs covers the former cane fields on the southern half of the property, while the northern portion is actively cultivated for various fruit and vegetable crops by Aloun Farms. The gulches which cross the site support dense Guinea grass and stands of koa haole shrubs.

The vegetation on the project site is dominated by introduced or alien species. A total of 95 plant species were observed during this study. Of these 89 (94%) are introduced; introduced species are all those plants which were brought to the Hawaiian Islands by humans, intentionally or accidentally, after Western contact, that is, Cook's arrival in the islands in 1778. Four species are indigenous or presumably indigenous, that is, they are native to the islands and elsewhere; these are the 'ilima (Sida fallax), hoary abutilon (Abutilon incanum), 'uhaloa (Waltheria indica), and popolo (Solanum americanum). Two species are endemic, that is, they are native only to the Hawaiian Islands; these are the endangered ko'oloa'ula (Abutilon menziesii) and pa'uohi'iaka (Jacquemontia ovalifolia subsp. sandwicensis).

None of the plants found on the project site, with the exception of the

ko'oloa'ula, is a threatened and endangered species or a species of concern (U.S. Fish and Wildlife Service 1999a, 1999b; Wagner et al. 1999). Almost all of the plants can be found in dry, lowland, disturbed habitats throughout the islands. Some of the natives such as the 'ilima, hoary abutilon, and 'uhaloa are common to abundant throughout the scrub vegetation on the project site and elsewhere.

A Habitat Conservation Plan for the endangered ko'oloa'ula plant on the 'Ewa site has already been prepared. Plant material from this population has been propagated and a few outplantings have been made at other locations. The University will need to work closely with the agencies involved in the Habitat Conservation Plan.

LITERATURE CITED

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APPENDIX A

PLANT SPECIES LIST -- U.H., West O'ahu

The following checklist is an inventory of all the plants observed on the project site during the field studies. The plants are arranged alphabetically by families into each of two groups: Dicots and Monocots. The taxonomy and nomenclature of the flowering plants, Dicots and Monocots, are in accordance with Wagner et al. (1990) and Wagner and Herbst (1999). The few recent name changes are those reported in the Hawaii Biological Survey series (Evenhuis and Eldredge, editors, 1999-2002).

For each species, the following information is provided:

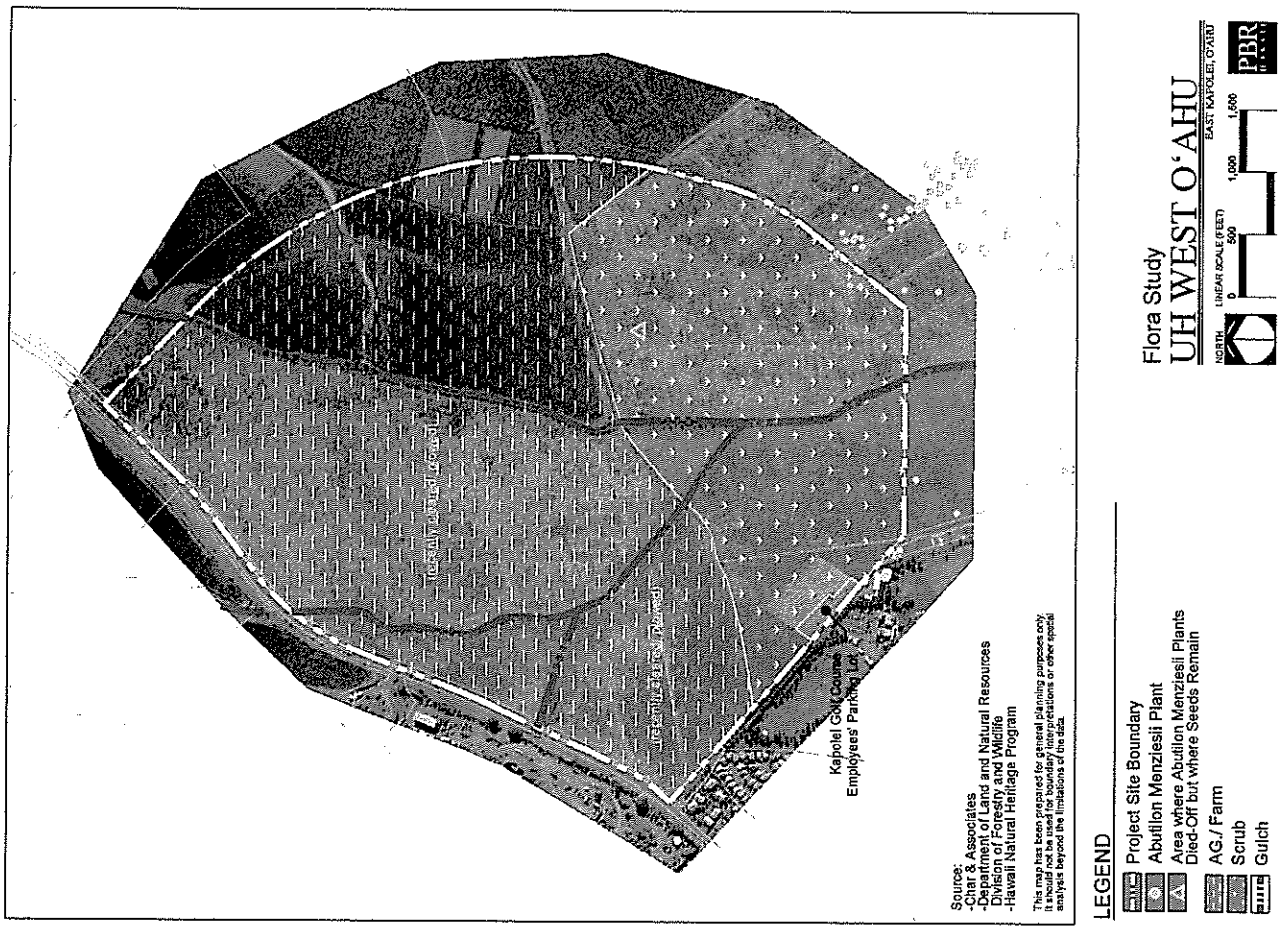
1. Scientific name with author citation.
2. Common English and/or Hawaiian name(s), when known.
3. Biogeographic status. The following symbols are used:
   - E = endemic = native only to the Hawaiian Islands;
   - I = indigenous = native to the Hawaiian Islands and elsewhere;
   - I? = questionably indigenous = data not clear if dispersal to the islands by natural or human-related mechanisms, but weight of evidence suggests probably natural;
   - X = introduced or alien = all those plants brought to the Hawaiian Islands by humans, intentionally or accidentally, after Western contact, that is Cook's arrival in the islands in 1778;
   - X? = questionably introduced = dates of introduction are very early/unclear; may be indigenous or of Polynesian introduction.
4. Presence (+) or absence (-) of a particular species within each of three vegetation types recognized on the project site (see text for discussion):
   - a = Agricultural/Farm Lands
   - s = Scrub Vegetation
   - g = Gulch Vegetation

Scientific name	Common name	Status	Vegetation type a	s	g
BORAGINACEAE (Borage family)					
Cordia dichotoma Forst. f.	Sebesten plum	X	-	+	-
CAPPARACEAE (Caper family)					
Cleome gynandra L.	wild spider flower, hohohina	X	+	-	-
CHENOPODIACEAE (Goosefoot family)					
Atriplex suberecta Verd.	saltbush	X	+	+	+
Chenopodium murale L.	'aheahea	X	+	+	-
Salsola tragus L.	Russian thistle, thumbleweed	X	+	+	-
CONVOLVULACEAE (Morning glory family)					
Ipomoea cairica (L.) Sweet	koali 'ai, koali	X?	-	-	+
Ipomoea obscura (L.) Ker-Gawl.	field bindweed	X	-	+	+
Ipomoea triloba L.	little bell, pink bindweed	X	+	+	-
Jacquemontia ovalifolia ssp. sandwicensis (A. Gray) K. Robertson	pa'uohi'iaka	E	-	+	-
Merremia aegyptia (L.) Urb.	hairy merremia, koali kua hulu	X?	+	+	-
CUCURBITACEAE (Gourd family)					
Citrullus lanatus (Thunb.) Matsum. & Nakai	watermelon	X	+	-	-
Coccinia grandis (L.) Voigt	coccinia, ivy gourd	X	+	-	+
Cucumis melo L. various cultivars	cantaloupe, honeydew	X	+	-	-
Cucurbita pepo L. various cultivars	zucchini, pumpkin, kabocha	X	+	-	-
Momordica charantia L.	wild bittermelon	X	+	-	+
EUPHORBIACEAE (Spurge family)					
Chamaesyce hirta (L.) Millsp.	hairy spurge, garden spurge	X	-	+	+
Chamaesyce hypericifolia (L.) Millsp.	graceful spurge	X	+	+	+
Chamaesyce hyssopifolia (L.) Sm.		X	+	-	+
Euphorbia heterophylla L.	Mexican fireweed	X	+	-	-
Ricinus communis L.	castor bean, koli	X	+	+	+

Scientific name	Common name	Status	Vegetation type a	s	g
FLOWERING PLANTS					
DICOTS					
AIZOACEAE (Fir-marigold family)					
Trianthema portulacastrum L.		X	+	+	+
AMARANTHACEAE (Amaranth family)					
Amaranthus spinosus L.	spiny amaranth, pakai kuku	X	+	+	-
Amaranthus viridis L.	slender amaranth, pakai	X	+	+	-
ANACARDIACEAE (Mango family)					
Schinus terebintifolius Raddi	Christmas berry	X	-	+	-
ASCLEPIADACEAE (Milkweed family)					
Calotropis procera (Aiton) W.T. Aiton	small crown flower	X	-	+	-
Stapelia gigantea N.E. Brown	carrion flower, Zulu-giant	X	-	-	+
ASTERACEAE (Daisy family)					
Bidens alba var. radiata (Schultz-Bip.) Ballard ex Melchert		X	+	-	-
Bidens pilosa L.	Spanish needle, ki, ki nehe	X	+	-	+
Emilia fosbergii Nicolson	flora's paintbrush, pualele	X	+	+	-
Pluchea carolinensis (Jacq.) G. Don	sourbush, pluchea	X	+	+	+
Pluchea indica (L.) Less.	Indian fleabane	X	+	+	-
Sonchus oleraceus L.	sowthistle	X	+	+	-
Tridax procumbens L.	coat buttons	X	-	+	+
Verbesina encelioides (Cav.) Benth. & Hook.	golden crown-beard	X	+	+	-
Xanthium strumarium var. canadense (Mill.) Torr. & A. Gray	cocklebur, kikania	X	-	-	+
BIGNONIACEAE (Bignonia family)					
Spathodea campanulata P. Beauv.	African tulip tree	X	-	+	-

Scientific name	Common name	Status	Vegetation type a	s	g
NYCTAGINACEAE (Four-o'clock family)					
Boerhavia coccinea Mill.		X	-	+	-
PASSIFLORACEAE (Passion flower family)					
Passiflora foetida L.	running pop, poha poha	X	-	+	-
PORTULACACEAE (Purslane family)					
Portulaca oleracea L.	common purslane, pigweed	X	+	-	-
SOLANACEAE (Nightshade family)					
Capsicum annuum L. cultivar "Grossum"	bell pepper	X	+	-	-
Datura stramonium L.	Jimson weed, la'au hano	X	-	+	-
Nicandra physalodes (L.) Gaertn.	apple of Peru	X	+	-	+
Nicotiana glauca R.C. Graham	tree tobacco	X	-	+	-
Solanum americanum Mill.	popolo, glossy nightshade	I?	+	+	-
Solanum lycopersicon var. cerasiforme (Dunal) Spooner, Anderson & Jansen	currant tomato, wild tomato	X	+	+	-
Solanum melongena L. various cultivars	eggplant, long eggplant	X	+	-	-
STERCULIACEAE (Cacao family)					
Waltheria indica L.	'uhaloa, hi'aloa, kanakaloa	I?	-	+	-
VERBENACEAE (Verbena family)					
Lantana camara L.	lantana, lakana	X	-	+	-
Stachytarpheta cayennensis (Rich.) Vahl	nettle-leaved vervain, owi, oi	X	-	+	-
MONOCOTS					
MUSACEAE (Banana family)					
Musa X paradisiaca L.	banana, mai'a	X	-	-	+
CYPERACEAE (Sedge family)					
Cyperus rotundus L.	nutgrass, nut sedge	X	+	-	-

Scientific name	Common name	Status	Vegetation type a	s	g
FABACEAE (Pea family)					
Acacia farnesiana (L.) Willd.	klu	X	+	+	-
Cassia sp.		X	-	+	-
Chamaecrista nictitans (L.) Moench	partridge pea, lauki	X	-	+	-
Crotalaria incana L.	fuzzy rattlepod, kukaehoki	X	+	+	-
Crotalaria pallida Aiton	smooth rattlepod, pikakani	X	+	-	-
Desmanthus pernambucanus (L.) Thellung	slender mimosa	X	+	+	+
Indigofera hendecaphylla Jacq.	creeping indigo	X	-	+	-
Indigofera suffruticosa Mill.	indigo, 'iniko	X	+	+	-
Leucaena leucocephala (Lam.) de Wit	koa haole, ekoa	X	+	+	+
Macroptilium atropurpureum (DC) Urb.		X	-	+	-
Macroptilium lathyroides (L.) Urb.	wild bean, cow pea	X	+	-	-
Pithecellobium dulce (Roxb.) Benth.	'opiuma	X	-	+	+
Prosopis pallida (Humb. & Bonpl. ex Willd.) Kunth	kiawe	X	+	+	+
Senna occidentalis (L.) Link	coffee senna, 'auko'i	X	+	-	-
Vigna unguiculata ssp. sesquipedalis (L.) Verdc.	yard-long bean	X	+	-	-
LAMIACEAE (Mint family)					
Hyptis pectinata (L.) Poit.	comb hyptis	X	+	-	+
Leonotis nepetifolia (L.) R. Br.	lion's ear	X	+	+	+
MALVACEAE (Mallow family)					
Abutilon grandifolium (Willd.) Sweet	hairy abutilon	X	+	-	-
Abutilon incanum (Link) Sweet	hoary abutilon, ma'o	I?	+	+	+
Abutilon menziesii Seem.	ko'oloa'ula	E	-	+	-
Malva parviflora L.	cheese weed	X	+	-	-
Malvastrum coromandelianum (L.) Garcke	false mallow, hauuoi	X	+	+	-
Sida ciliaris L.		X	+	+	-
Sida fallax Walp.	'ilima	I	+	+	+
Sida spinosa L.	prickly sida	X	+	+	-
MELIACEAE (Mahogany family)					
Melia azedarach L.	Chinaberry, pride of India	X	-	+	-



Scientific name	Common name	Status	Vegetation type a	s	g
POACEAE (Grass family)					
Bothriochloa pertusa (L.) A. Camus	pitted beardgrass	X	-	+	-
Brachiaria mutica (Forssk.) Stapf	California grass	X	-	-	+
Cenchrus ciliaris L.	buffelgrass	X	+	+	+
Cenchrus echinatus L.	common sandbur, 'ume'alu	X	+	-	-
Chloris barbata (L.) Sw.	swollen fingergrass, mau'ulei	X	+	+	+
Cynodon dactylon (L.) Pers.	Bermuda grass, manienie	X	-	+	-
Digitaria insularis (L.) Mez ex Ekman	sourgrass	X	+	-	+
Digitaria sp.	crabgrass	X	-	+	-
Eleusine indica (L.) Gaertn.	wiregrass, goosegrass	X	+	-	-
Eragrostis amabilis Wight & Arnott	lovegrass	X	-	+	-
Eragrostis cilianensis (All.) Link	stinkgrass	X	-	+	-
Melinis repens (Willd.) Zizka	Natal redtop, Natal grass	X	-	+	+
Panicum maximum Jacq.	Guinea grass	X	+	+	+
Panicum maximum var. trichoglume Eyles ex Robyns	green panicgrass	X	-	-	+
Saccharum officinarum L.	sugar cane, ko	X	-	+	-
Setaria verticillata (L.) P. Beauv.	bristly foxtail, mau'u pilipili	X	+	-	+
Sorghum bicolor (L.) Moench	sorghum	X	+	+	-
Zea mays L.	hybrid corn	X	+	-	-

APPENDIX C

HABITAT CONSERVATION PLAN FOR
ABUTILON MENZIESII AT KAPOLEI

Habitat Conservation Plan for Abutilon menziesii at Kapolei

State of Hawai'i
Department of Transportation

FINAL HCP
March 2004

Habitat Conservation Plan for Abutilon menziesii at Kapolei

State of Hawaii
Department of Transportation

Prepared by:

Yukie Ohashi
with
PBR HAWAII
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Parsons Brinckerhoff
and
State of Hawaii
Department of Transportation

FINAL HCP
March 2004

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PREFACE

The preparation of the *Habitat Conservation Plan for Abutilon menziesii at Kapolei* ("HCP") was initiated in 1996 with two State sponsored development proposals. The first proposal involved the 1,300-acre East Kapolei Master Plan project proposed by the Housing and Community Development Corporation of Hawaii ("HCDCH") under a right-of-entry agreement with the Department of Land and Natural Resources ("DLNR"). The second proposal by the Department of Transportation ("DOT") involved the North-South Road arterial highway which would bisect the 1,300-acre property. The earlier drafts of the HCP were therefore co-sponsored by DOT and HCDCH.

In actions by the Board of Land and Natural Resources in September 2002, the 1,300 acres of State land have been re-assigned to other State of Hawaii entities. The University of Hawaii has received 500 acres for the development of the University of Hawaii West Oahu campus ("UHWO") and the Department of Hawaiian Home Lands has acquired 200 acres for residential homestead development. The remaining 600 acres are again under the control of the DLNR. Thus, HCDCH no longer holds an interest to these Kapolei lands.

Abutilon menziesii has also been found on adjacent lands owned by the City and County of Honolulu. The City has therefore, requested that its land be included in the subject HCP to allow the construction of a proposed roadway segment and other potential future urban uses. Thus, the Final HCP incorporates an additional 81 acres for a total of 1,381 acres of land.

As described herein, DOT has assumed sole sponsorship of the HCP for the total population of *Abutilon menziesii* at the Kapolei property. DOT has also assumed mitigation responsibility as described in a Memorandum of Agreement ("MOA") with DLNR.

And finally, a request for an Incidental Take License for the Kapolei population will involve coordination and cooperation between DOT and other stakeholder parties through future agreements (i.e., MOA, Certificate of Inclusion) when other properties are ready to be developed.

EXECUTIVE SUMMARY

A population of *Abutilon menziesii* was discovered in late 1996 at Kapolei in the Ewa area, island of Oahu, State of Hawaii, on former sugarcane land. Hence, this population is referred to as the "Kapolei population". *A. menziesii* of the Mallow Family (Malvaceae) is also known by its Hawaiian name Kooloaula and its common name "red ilima". It has been a federally listed endangered species since 1986 and is protected under the provisions of the federal Endangered Species Act of 1973, as amended, and Chapter 195D, *Hawaii Revised Statutes*, as amended. *A. menziesii* is one of nine species included in the *Lanai Plant Cluster Recovery Plan* (US Fish and Wildlife Service, 1994).

This habitat conservation plan is prepared pursuant to Chapter 195D-21, HRS, as amended. Accordingly, the HCP provides a description of the development actions proposed on the 1,300-acre State-owned property and an adjacent 81-acre City and County of Honolulu ("City") property at Kapolei (referred herein as the "Kapolei property"). The HCP describes the impact of development actions on the Kapolei population and proposes a series of mitigative strategies that would provide a net gain of *A. menziesii* to further the recovery of the species.

The preparation of this HCP began in 1997, with drafts prepared in 1997, 1999, 2001, and 2003 and reviewed by the Department of Land and Natural Resources Division of Forestry and Wildlife ("DLNR DOFAW"), the Endangered Species Recovery Committee ("ESRC"), and the US Fish and Wildlife Service ("USFWS"). The present HCP incorporates the actions which have been undertaken as interim mitigation measures and describes the mitigation measures for the Kapolei population that are planned over a period of approximately 20 years.

The sponsor of this HCP is the State Department of Transportation ("DOT"), which will be acquiring a portion (approximately 24.6 acres) of the Kapolei property from DLNR for the proposed North-South Road. The Housing and Community Development Corporation of Hawaii ("HCDCH") had also previously contributed substantially to the development of the HCP and its Interim Management Plan.

The Presence of Abutilon menziesii on the Kapolei Property

For nearly a century, the Kapolei property was cultivated in sugarcane. According to the Oahu Sugar Company, sugarcane was last harvested on the property in 1994, prior to the permanent closure of the company in Spring 1995. Typical of sugarcane grown in Hawaii, the cane was a two-year crop and harvesting practices involved burning to reduce the leaf bulk before the cane stalks were mechanically harvested. Generally, the cane fire in each field lasted 20 to 30 minutes. The now abandoned fields at the Kapolei property were exposed to cane fires every two years during nearly ten decades of cane cultivation.

Botanical surveys of the Kapolei property have been conducted by Kenneth Nagata (1996) and Char & Associates (1996, 1997, 2003, 2004). The survey reports are attached as Appendices A, B, C, D, and E, respectively.

The property is described as a disturbed site characterized by the dominance of alien weed species interspersed with remnant sugar cane. Therefore, the discovery of *A. menziesii* in September 1996 by Nagata approximately two years after the last cane harvest is seen as an enigma (Nagata 1996). Nagata's 1996 reconnaissance survey covered 80 percent of the State property. A subsequent survey by Char in December 1996 following an unusually wet period in November and December 1996 recorded 88 plants. In December 1997 Nagata conducted a second comprehensive survey and recorded 86 plants on-site. One plant was observed off-site to the south of the project site at Renton Road. The December 1997 survey produced taxonomic data and a precise mapping of the plants. A subsequent GPS based map was produced by DLNR. In 2004, Char completed a survey of the City property and discovered an additional 7 plants.

The plants are spatially distributed in five clusters in the central and southern portions occupying approximately 25 percent of the Kapolei property and are described as Clusters A, B, C, D, and E. Through attrition the present number of plants has been reduced to between 30 and 50 (DLNR 2001) but new seedlings have recently been recorded (DLNR 2003); however, this HCP is generally based on the baseline number of 93 plants.

Landownership

The State-owned Kapolei property, consisting of approximately 1,300 acres, was previously leased to Oahu Sugar Company, Limited until 1995; upon its closure, the land was transferred back to the State of Hawaii under the jurisdiction of DLNR Land Division. Through a right-of-entry agreement with HCDCH the property was reclassified in 1998 for urban uses to further the development of Kapolei as the secondary urban center of the City and County of Honolulu and the State of Hawaii. The land tenure however, was changed in late 2002 and 500 acres were transferred to the University of Hawaii for a new West Oahu campus. In addition, 200 acres will be transferred to the Department of Hawaiian Home Lands ("DHHL") for residential development. Both the University of Hawaii and the DHHL have received right-of-entry to their properties and HCDCH's right-of-entry has been revoked. The remaining 600 acres have reverted to DLNR.

A portion of the proposed North-South Road property is owned by DLNR and a portion is owned by the Estate of James Campbell. *A. menziesii* is present only on the State-owned portion. The planned development of the North-South Road will require property conveyance from DLNR and the Estate of James Campbell to DOT. The land conveyance actions are anticipated to be accomplished in 2004 prior to the commencement of construction.

The 81-acre City and County of Honolulu property is comprised of portions of two larger parcels of land which include the adjacent existing Ewa Villages Golf Course to the north. The City's Kapolei Parkway roadway segment and future urban development are anticipated on this vacant land.

The Proposed Developments

Developments proposed by public agencies include the North-South Road, the Kapolei Parkway segment, and the University of Hawaii West Oahu campus. In addition, DHHL will develop residential homesteads for native Hawaiian beneficiaries. Collectively, the HCP refers to these

developments as the "Kapolei projects". The remaining DLNR land area has also been planned for urban uses, however, no specific development proposal is under consideration at this time.

North-South Road

The Department of Transportation is proposing to develop the North-South Road, a federal-aid highway, which would be a principal arterial roadway providing support to the regional network of roadways and to the Interstate Route H-1 ("H-1 Freeway"). The North-South Road would bisect and provide access to the land developments at the Kapolei property and also provide an alternate access roadway for other Kapolei and Ewa communities.

The North-South Road would traverse the Kapolei property between the H-1 Freeway (located to the north) and the City's segment of Kapolei Parkway (located to the south).

Kapolei Parkway Extension

The Kapolei Parkway segment is a 0.7 mile major collector roadway which will link the North-South Road and Renton Road and existing segments of the Kapolei Parkway. The subject roadway project will traverse the City's Ewa Villages property and will provide an alternative regional access to the H-1 Freeway. Regional access to Interstate H-1 is currently limited to Fort Weaver Road. The Kapolei Parkway segment is also a federal-aid highway project.

Department of Hawaiian Home Lands

DHHL is mandated to develop and deliver homesteads to qualified native Hawaiians. The development of 200 acres of DHHL lands would include approximately 1,000 residential homesteads and potentially some commercial and community facility uses to serve its new subdivisions. The first phase is planned for occupancy in 2006 and buildout expected in approximately 8 to 10 years. These uses have been described as part of the East Kapolei Master Plan. The DHHL parcels are to the west of North-South Road, with one parcel to the north of UHWO and the other to the south of UHWO.

A new segment of Kapolei Parkway will bisect the DHHL parcel. This segment will connect to the existing Kapolei Parkway to the west and to the City's proposed Kapolei Parkway segment (described above) and the North South-Road.

University of Hawaii West Oahu

The UH West Oahu campus will be a major educational facility in Kapolei, primarily serving the Leeward and Central Oahu region. The University is currently exploring options for the development of the campus and at present is planning an approximately 100-acre campus which will be developed in phases to an ultimate student population of 7,600. Additionally, about 150 acres of land will be allocated on the property for future campus expansion beyond the 7,600 student population. The University is also considering a number of land use options for the remaining 250 acres of land within the 500-acre property to serve the campus and surrounding region. Construction of the initial phase of the campus could begin in the latter part of 2005, with a completion date of

Fall 2007. The initial phase of campus development would be located in the northeastern portion of the property, in close proximity to Farrington Highway.

Department of Land and Natural Resources

The 600 acres of land under the authority of the DLNR Land Division have been previously planned for residential and school facilities as well as open space areas, which would serve as drainage detention basins as part of the East Kapolei Master Plan. The ultimate specific uses of these lands will be determined in the future.

Habitat Conservation Plan Goals and Objectives

Pursuant to Chapter 195D, the habitat conservation plan shall contain sufficient information for the Board of Land and Natural Resources ("BLNR") to ascertain with reasonable certainty the likely effect of the plan upon any endangered, threatened, proposed, or candidate species in the plan area and throughout its habitat range. Thus, the goal of this HCP is to initiate and sustain a program which would result in an overall net gain in the number of *Abutilon menziesii* on Oahu, thus, contributing towards the recovery of the species as required by HRS Chapter195D-30. HRS Chapter195D-2 defines "Recovery" or "recover" to mean that "the number of individuals of the protected species has increased to the point that the measures provided under this chapter (Chapter 195 HRS) or the Federal Endangered Species Act are no longer needed."

The objectives of the HCP are threefold: (1) describe the existing conditions of the Kapolei population; (2) describe the potential impacts of the Kapolei projects on *Abutilon menziesii*; and (3) describe the strategies and actions to mitigate the impacts. The major strategy designed to mitigate impacts and to benefit the species is the creation of three protected off-site wild populations on Oahu from the single degraded Kapolei population.

To test whether new populations could be established from Kapolei stock of *A. menziesii*, an Interim Management Program was initiated in 1998 and funded by HCDCH. This program has successfully been implemented by DLNR. A complete representation of 630 plant progeny were propagated from the Kapolei population and outplanted at Koko Crater Botanical Gardens, Kaena Point State Park, and Honouliuli Unit of the Pearl Harbor National Wildlife Refuge. The Interim Management Program is described in detail in Strategy (1) of Section 3 and in the DLNR Draft and Final Interim Management Report for *Abutilon menziesii* (2001, 2003), attached as Appendix F and Appendix G.

The HCP is formatted according to the guidelines set forth in HRS Chapter 195D-21. In addition, recommendations received from DLNR, the Endangered Species Recovery Committee, and the US Fish and Wildlife Service have been incorporated.

Impacts and Mitigative Measures

The development of the Kapolei projects is expected to result in incidental take of the entire Kapolei population during an approximately 20-year development period. Therefore, a series of actions are proposed that will produce three new offsite "wild" populations, protect the genetic diversity of the existing population, and protect existing individuals by relocating them to the new population

locations. This HCP also proposes long-term management that would occur concurrently with project development to ensure that benefits are realized for *A. menziesii*.

The duration of the HCP implementation and active management period is approximately 20 years and is tied to the accomplishment of the measurable goals that include the establishment of a minimum of three offsite self-sustaining populations. The successful implementation of the HCP would significantly increase the numbers of new plants on Oahu as well as improve their quality compared to the *in situ* disturbed canefield conditions at the Kapolei property.

Funding and Implementation

The primary funding mechanism is a trust fund for endangered species as promulgated in Chapter 195D-31, HRS. DOT will provide the funding to implement the HCP. The North-South Road, as planned, would affect approximately 25 percent of the population, and the other Kapolei projects would affect the remaining 75 percent. As agreed by DOT and DLNR in a Memorandum of Agreement, DOT on March 14, 2001 made available funds in the amount of $250,000 for the initial five years of HCP implementation. These initial funds are being utilized (since approximately August 2001) by DLNR to manage and implement the HCP strategies. The MOA also stipulates that the subsequent 15 years will also be funded by DOT. An additional $750,000 will also be delegated to DLNR upon the approval of the HCP by the Board of Land and Natural Resources (or the Hawaii Legislature, as appropriate) and the Governor's release of the funds for a total not to exceed $1 million over a maximum period of 20 years.

DOT will also establish a contingency fund and has developed a process for third party developers ("Cooperators") to utilize the Incidental Take License through a Certificate of Inclusion. The Cooperators would pay into a contingency fund for the following purposes: 1) to finance unanticipated costs incurred by DLNR in the implementation of the HCP measures; and 2) to fund the management and monitoring of three "wild" populations beyond 20 years. The total initial amount of the Contingency Fund is $200,000. To ensure this fund DOT will deposit the full $200,000 amount following the approval of the HCP.

SECTION 1

Identify the geographic area encompassed by the plan; the ecosystems, natural communities, or habitat types within the plan area that are the focus of the plan; and the endangered, threatened, proposed, and candidate species known or reasonably expected to be present in those ecosystems, natural communities, or habitat types in the plan area.

(1a) Geographic Area Encompassed by the Plan

The location of the existing plants is at Kapolei, Ewa District, Oahu, Hawaii (Figure 1). The property is bounded on the north by Farrington Highway and H-1 Freeway, to the west by the Villages of Kapolei and Kapolei Golf Course, to the south and southeast by Ewa Villages and Renton Road, and to the east by diversified agricultural fields and fallowed sugarcane land. It encompasses former sugar cane lands from approximately 60 feet above mean sea level ("AMSL") at Renton Road up to 200 feet MSL at the H-1 Freeway. The site also contains an existing Hawaiian Electric Company, Inc. ("HECO") powerline easement. Since 1999, BLNR has leased approximately 550 acres of the property to Aloun Farms, Inc. and A.M. Enterprise, LLC on a month-to-month basis for crop farming. The leased parcels are not known to have any *A. menziesii* on the premises. Kaloi Gulch and the Hunehune tributary, both intermittent ephemeral streams, traverse the property from the north to the southeast boundary. There are no known *A. menziesii* plants in the gulch and tributary.

New offsite populations of *Abutilon menziesii* have been initiated at the City and County of Honolulu Koko Crater Botanical Garden (Outplant Site #1), Kaena Point State Park (Outplant Site #2, Wild Site #1), and Honouliuli National Wildlife Refuge (Outplant Site #3, Wild Site #2). The Koko Crater site is not considered a "wild site"; however, its value is as a protected repository for the full genetic stock of the Kapolei population.

Additional outplant wild sites will be initiated within the region of the Kapolei population as well as other suitable areas on Oahu as described in Section 3, Strategy (4). Candidate sites include Diamond Head State Park, Lualualei Naval Reserve (at the Radio Transmission Facility), Kealia Trail, Kalaeloa Northern Trap and Skeet Range, Kalua Kauila (near Makua Valley), area mauka of Yokohama Beach and Makapuu Head. These sites are also described in Section 3, Strategy (4).

(1b) Ecosystems, Natural Communities, or Habitat Types within the Plan Area

The Ewa Plain experiences light rainfall with a mean annual rainfall of about 20 inches per year, most of which occurs between the months of November and April. Based on more than 50 years of data collected at Oahu Sugar Company (and its predecessor, Ewa Plantation), average annual daily minimum and maximum temperatures in the project area are 65 degrees F and 84 degrees F, respectively. On the arid Ewa plain, the fallow agricultural land and the low levels of evapo-transpiration which occurs from scrub vegetation produces little cooling effect.

The project area was formerly cultivated as sugarcane land and is now characterized as a disturbed coastal dry ecosystem. The vegetation of the region is generally lowland shrub with a coastal fringe of kiawe trees. In the past several years the Kapolei property and surrounding lands have been taken out of sugar cane cultivation and put to other uses (e.g. urbanization, diversified agriculture, fallowed fields).

The vegetation in the region is largely determined by the history of cultivation (or disturbance) on each parcel of land. Nagata (1996) has identified eight plant communities within the State's 1,300-acre project area: 1) Abandoned Cane Fields, 2) Fallowed Fields Mixed Herb Association, 3) Fallowed Fields Grassland Association, 4) Abandoned Fields, 5) Cultivated Fields, 6) Grasslands, 7) Gulch Association, and 8) Roadside Vegetation.

Within the Kapolei Parkway area, Char (2004, Appendix E), documents the dominant vegetation type as koa haole / buffel grass scrub.

Within the Kapolei property there are 80 to 100 plant species common to former sugar cane lands (Appendices A and B). Only two species are indigenous (*Sida fallax* or ilima and Jacquemontia *ovalifolia* or pauohiiaka), two are probably indigenous (*Waltheria indica* or uhaloa and *Abutilon incanum* or hoary abutilon), that is, they are native to the Hawaiian islands and elsewhere; and one, the subject plant, *Abutilon menziesii* or kooloaula is endemic, or native only to the Hawaiian Islands. The vast numbers of plants are non-native.

As previously mentioned, *Abutilon menziesii* is not known to be present on the areas which are in crop cultivation.

The Kaloi Gulch and Hunehune tributary gulch are intermittent and originate north, or mauka, of the H-1 Interstate Freeway. As stated above, past and recent surveys have found no *A. menziesii* within or directly adjacent to the gulches (Nagata 1996 and Char 1997, 1997, 2003, 2004).

(1c) The endangered, threatened, proposed, and candidate species known or reasonably expected to occur in the ecosystems, natural communities, or habitat types in the plan area.

Except as noted above, *A. menziesii* has been found throughout the natural communities and ecosystems of the Kapolei property.

Abutilon menziesii, also known by its Hawaiian name kooloaula, is a shrub in the Mallow Family (Malvaceae) with light green heart-shaped leaves and characteristic small dark red to maroon flowers; hence, the plant is also commonly referred to as the red ilima. Photographs in Figure 2 show *A. menziesii* in the Kapolei habitat.

Abutilon menziesii was federally listed as an endangered species in 1986 and is now protected under the provisions of the federal Endangered Species Act of 1973, as amended, and Chapter 195D, *Hawaii Revised Statutes* ("HRS"), as amended. It is one of nine endangered species included in the *Lanai Plant Cluster Recovery Plan* (US Fish and Wildlife Service, 1994).

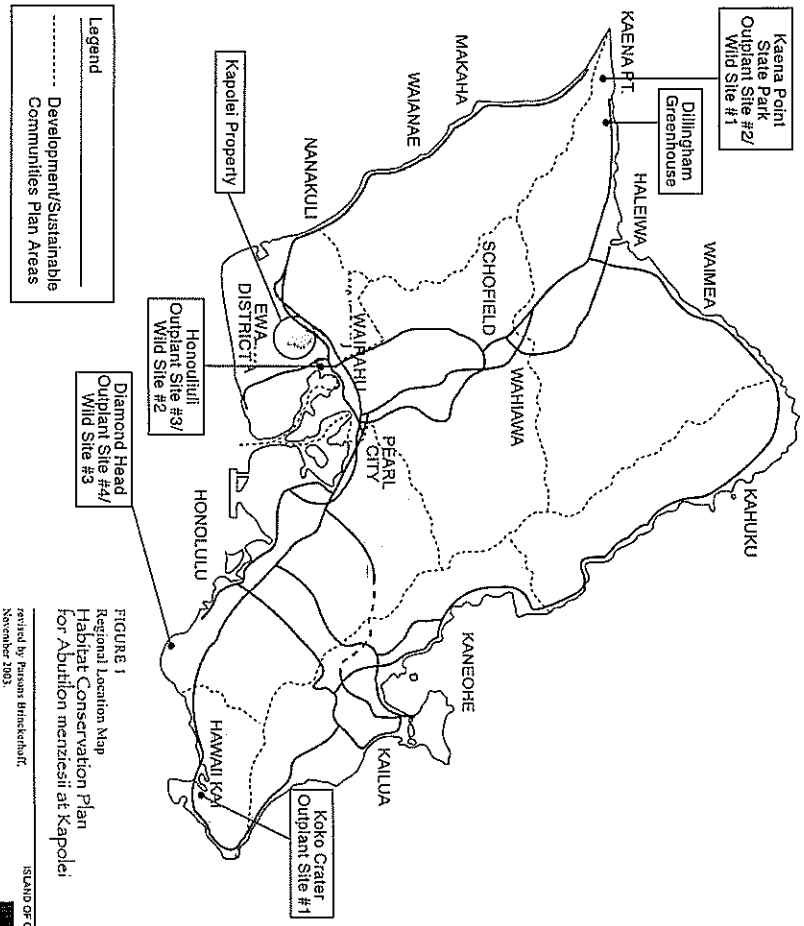


FIGURE 1
Regional Location Map
Habitat Conservation Plan
for Abutilon menziesii at Kapolei

revised by Parsons Brinckerhoff.
November 2003.

ISLAND OF OAHU

March 2004

Of the nine taxa described in the Lanai Recovery Plan, *A. menziesii* was assigned a high probability of recovery due to its larger population size, its resistance to some of the current threats, and the relative ease of propagation. The Lanai Recovery Plan does not describe the Kapolei population; the populations which are identified are on Lanai, Hawaii, and Maui.

At the time of the Nagata survey in September 1996, 38 individuals were recorded in a reconnaissance survey covering 80 percent of the State property. After the unusually heavy rains of November 1996, Char (1997) in a 100 percent survey of the areas described by Nagata recorded 86 plants at approximately the same locations as Nagata. In December 1997 Nagata performed a detailed survey and count which was followed by precise mapping. The survey and count resulted in 87 plants, 86 on the subject property and one (1) plant at an off-site location on City and County of Honolulu property at Renton Road adjacent to the southern boundary of the State property.[1] Additional plants were identified by Char in 2004 on the City property. The plants are in four clusters (Clusters A, B, C, and E) one additional plant (Cluster D) was also identified (Figure 3). In October 2003, DLNR DOFAW produced an updated map (Figure 3A) depicting the baseline and 16 new plant locations. The new plants occur in close proximity of a mature plant and fall within the known and mapped clusters.

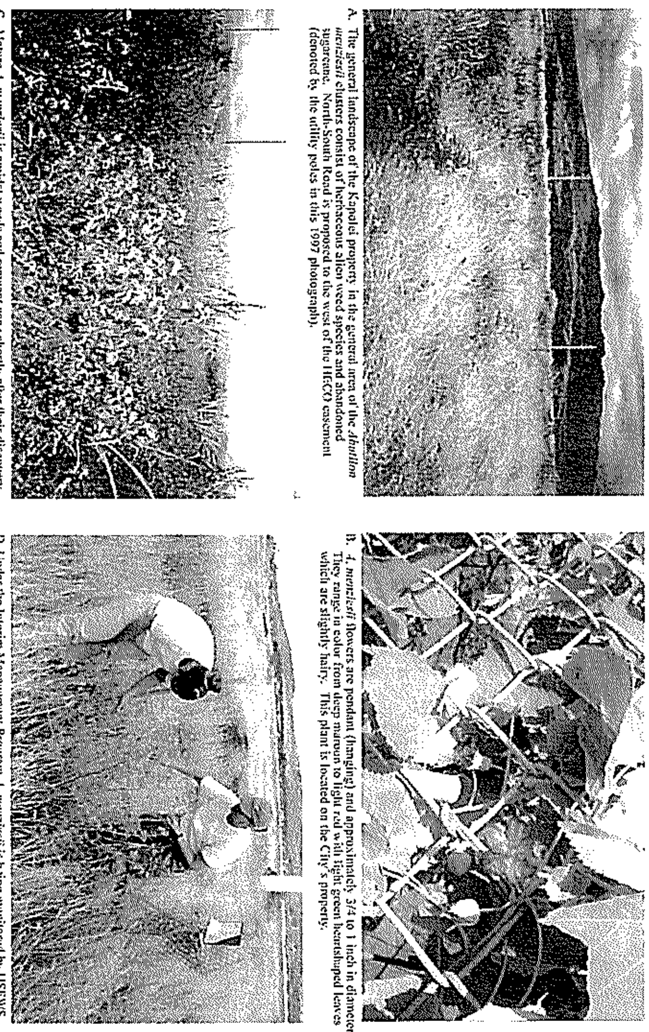
Since the previous baseline year of 1997 the numbers of individuals on the State-owned property have fluctuated with rainfall levels and it is anticipated that the number of individuals will continue to be dynamic. Therefore this HCP covers the entire population of *A. menziesii* within the State and City lands as depicted in Figure 5. To attempt to quantify the development impacts, a baseline population number of 93 (revised in 2004 to include City land) individuals has been assigned. This baseline of 93 individuals is differentiated from the approximate number of 50± currently existing plants. Table 1 describes the baseline distribution of *A. menziesii.*

Table 1. Baseline Population of *Abutilon menziesii* at Kapolei, 1997 (Revised to include Cluster E, 2004)

Cluster	No. of Plants
A	10
B	14
C	61
D	1
E	7
TOTAL	93

Cluster A consists of 10 individuals and is located at the southern end of the State project site. An existing dirt road situated in an east to west direction provides access to this cluster.

[1] The Kapolei population is distributed on State and City lands.



A. The general landscape of the Kapolei property in the general area of the *Abutilon menziesii* clusters consist of herbaceous alien weed species and abandoned sugarcane. North-South Road is proposed to the west of the HECO easement (denoted by the utility poles in this 1997 photograph).

B. *A. menziesii* flowers are pendant (hanging) and approximately 3/4 to 1 inch in diameter. They range in color from deep maroon to light red with light green heartshaped leaves which are slightly hairy. This plant is located on the City's property.

C. Mature *A. menziesii* is amidst weeds and remnant cane shortly after their discovery and prior to active management. (Photograph taken in 1997).

D. Under the Interim Management Program *A. menziesii* is being monitored by USFWS and DLNR staff. (Photograph taken in May 2003).

FIGURE 2
Photographs: *Abutilon menziesii* at Kapolei Property
Habitat Conservation Plan
for Abutilon menziesii at Kapolei
ISLAND OF OAHU
March 2004

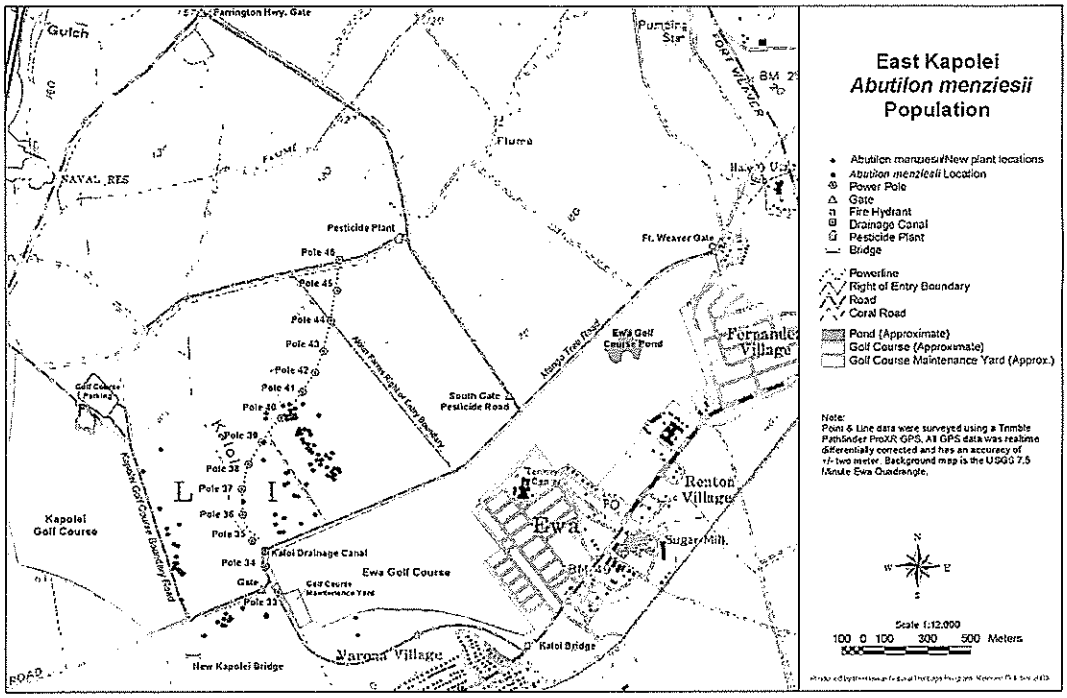


FIGURE 3A
Updated 2003 East Kapolei *Abutilon menziesii* Population
Habitat Conservation Plan
for Abutilon menziesii at Kapolei
revised by Parsons Brinckerhoff, November 2003.
ISLAND OF OAHU
November 2003

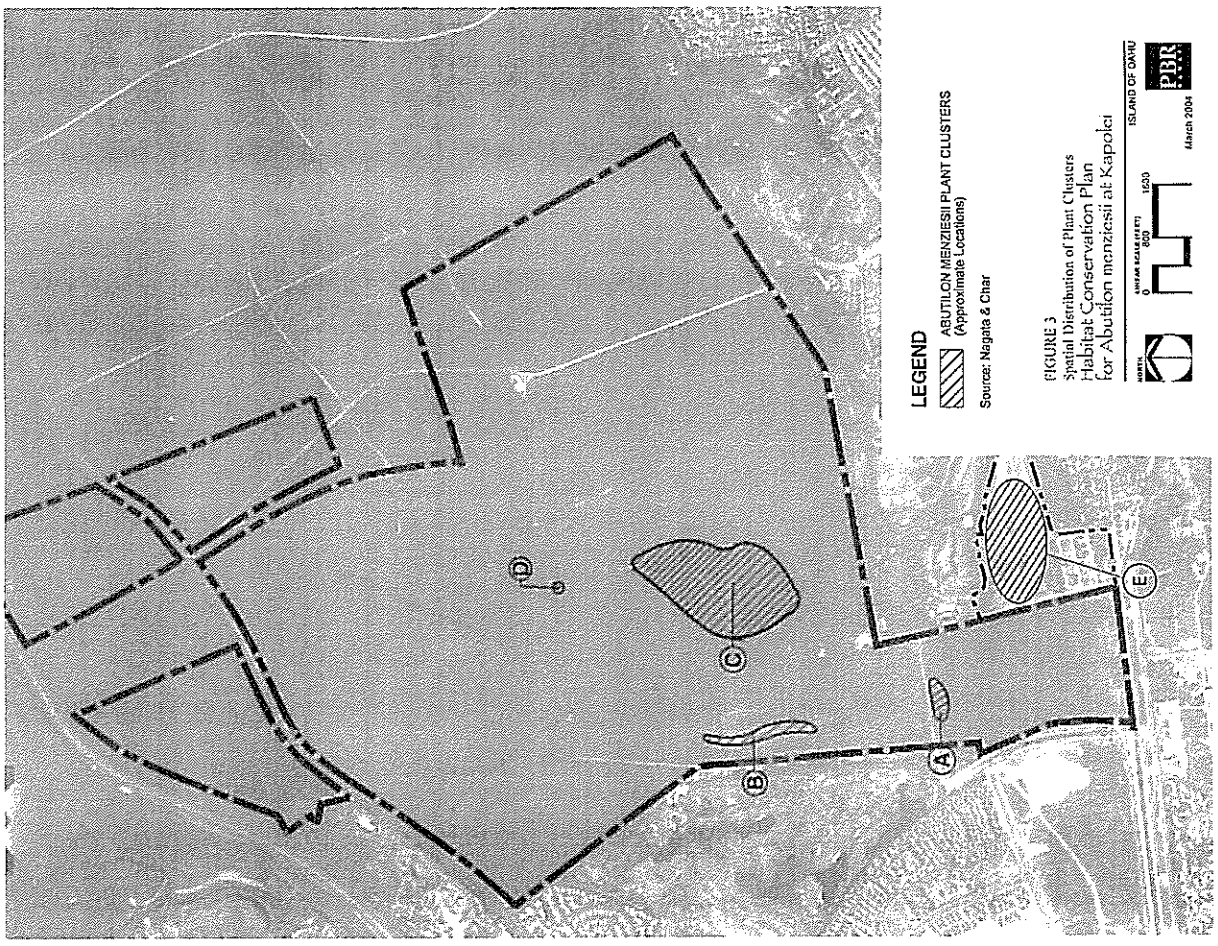


FIGURE 3
Spatial Distribution of Plant Clusters
Habitat Conservation Plan
for Abutilon menziesii at Kapolei

Cluster B consists of 14 individuals located along the western boundary of the State property which is marked by a chain-link fence. Individuals in this cluster are spread in a north-south direction and are accessed from the dirt road near Cluster A at the southern end of the property.

Cluster C, the largest cluster consisting of 61 plants occurs in the general area of the HECO powerline easement and primarily to the east of the powerline easement. The cluster is accessed from Mango Tree Road which is situated in an east-west direction. Several land uses would affect Cluster C, therefore three sub-areas identified as C-1, C-2 and C-3 have been designated.

Table 2. Cluster C (Sub-Areas)

Sub-Area	No. of Plants	Land Use
C-1	14	North-South Road
C-2	7	Drainage/Open Space Corridor
C-3	40	Residential, other urban uses
TOTAL	61	

Cluster D consisted of a single plant in the central area of the State site; however, this individual has not been seen since the initial recording.

The individuals in Cluster E are spread over an 81-acre area and occur as single plants, except at one location along a fence line at the property boundary and access roadway. At this location, there is a large, multi-stemmed plant, a young single-stemmed plant, and a seedling. Cluster E is accessed from the dirt road which leads to the Ewa Villages Golf Course Maintenance Facility. A segment of Kapolei Parkway and future urban uses are planned at this location.

At the time of the 1997 Nagata survey, plants in the population were 1 to 3.5 feet in height and included juveniles and mature individuals. Approximately 74% of the population were taller than 3 feet, 20% were between 2 to 3 feet, and only 6% were between 1 to 2 feet. No seedlings or small plants were identified. In December 1997, 37% of the plants were flowering and/or fruiting (Nagata 1997).

Present Status. Through natural senescence and accidental take (1997 to 2001), the number of plants has declined to 30 to 50 plants (DLNR 2001): however, in 2003, DLNR recorded 16 new plants in close proximity of existing mature plants (DLNR 2003). The actual number of plants is difficult to determine due to the dry conditions at Kapolei; plants which may appear to be dead may possibly revive during the wet season (DLNR 2001).

Contributing to the decline of the Kapolei population was a January 2000 incident in which approximately four plants were crushed/destroyed (by being plowed) and seedlings were killed (DLNR DOFAW/V. Caraway, personal communication).

SECTION 2

Describe the activities contemplated to be undertaken within the plan area with sufficient detail to allow the department to evaluate the impact of the activities on the particular ecosystems, natural communities, or habitat types within the plan area that are the focus of the plan habitat types in the plan area.

(2a) Description of the activities to be undertaken within the plan area in sufficient detail

The Kapolei projects include North-South Road, a segment of Kapolei Parkway, University of Hawaii West Oahu campus, Department of Hawaiian Home Lands residential homestead development, and unspecified urban uses on the DLNR lands. The projects are shown in a Conceptual Land Use Plan in Figure 4. Land ownership is shown in Figure 5 and described in Table 3.

Table 3. Landownership of the Parcels at the Kapolei Property

Project	TMK Number	Acres*
DOT / North-South Road**	9-1-16: 109 Campbell Estate portion	24.6 39.1
City & County of Honolulu Kapolei Parkway and Urban Uses	9-1-17: por. 069 9-1-17: por. 075	***41.0 / 6.3 ***40.0 / 2.7
DHHL	9-1-16: 108**** 9-1-18: 003	165.466 44.235
UHWO	9-1-16: por. 108 and 9-1-16: 120	500.327
DLNR	9-1-16: 008 9-1-17: 071 9-1-17: 088 9-1-17: 086 9-1-18: 005	31.915 204.254 200.000 40.619 65.999

* Approximate area. (NOTE: Information gathering is still in process due to recent changes in land disposition.)

** North-South Road alignment is under State DLNR and Campbell Estate ownership; to be transferred to DOT in 2004. Legal subdivision is still pending.

*** Approximately 81 acres of the vacant City property was surveyed by Char (2004); however, only approximately 9 acres comprise the Kapolei Parkway segment ROW. The remaining land is anticipated to be urbanized.

**** Parcel 108 includes another future segment of Kapolei Parkway; this roadway segment is to be sub-divided out of Parcel 108. The net area to DHHL will be approximately 200 acres.

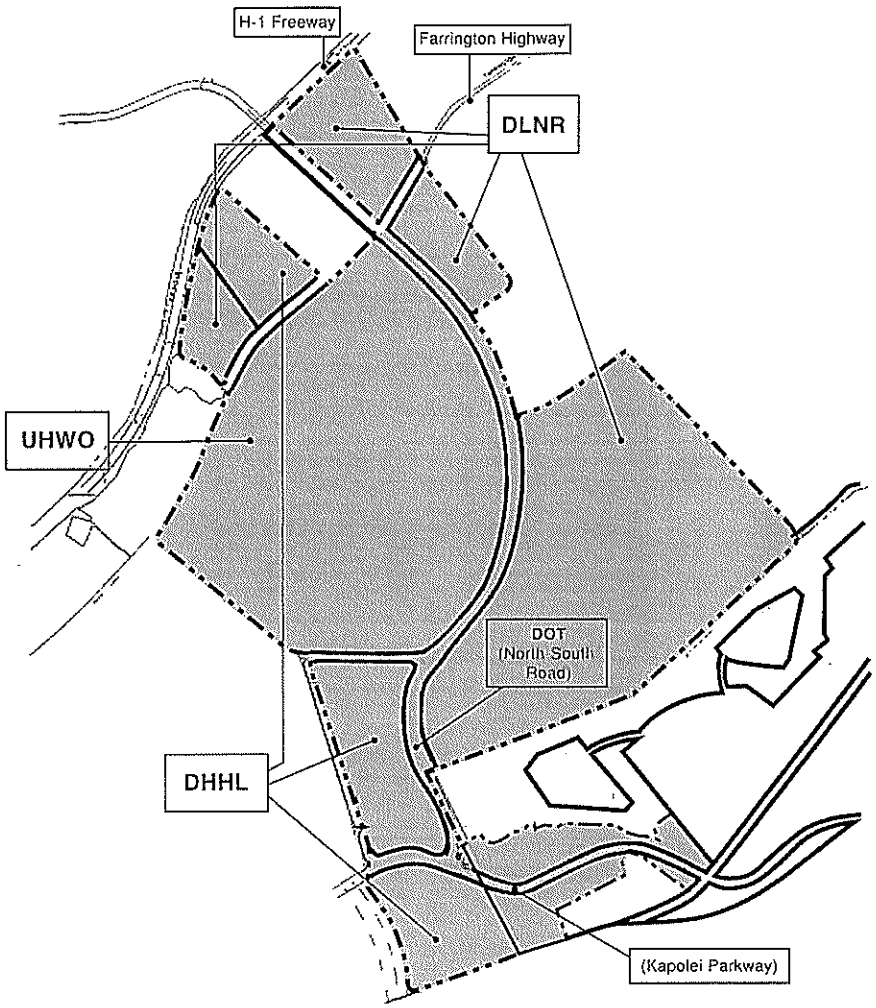
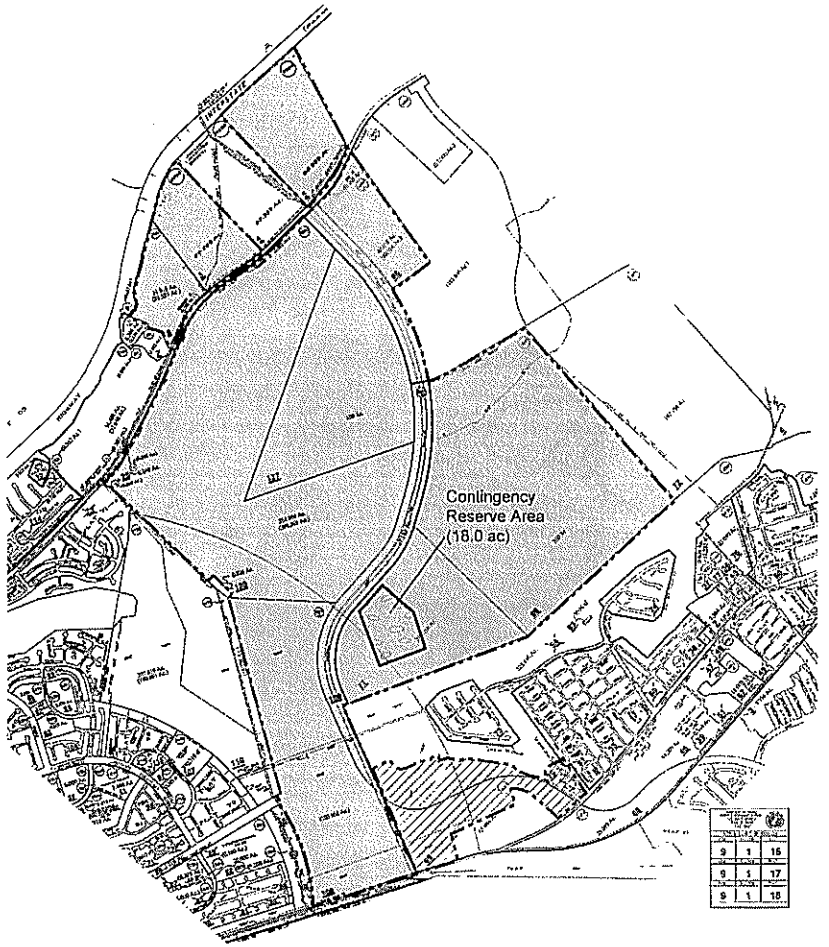


FIGURE 4
Conceptual Land Use Plan
Kapolei Property
Habitat Conservation Plan
for Abutilon menziesii at Kapolei

NORTH
LINEAR SCALE (FEET)
0 800 1600
ISLAND OF OAHU
MARCH 2004
PBR HAWAII



LEGEND
State Lands
City Lands
Contingency Reserve Area

FIGURE 5
Landownership Map
Habitat Conservation Plan
for Abutilon menziesii at Kapolei

NORTH
LINEAR SCALE (FEET)
0 800 1600
ISLAND OF OAHU
MARCH 2004
PBR HAWAII

The distribution of *A. menziesii* on the Kapolei property, and more specifically, within the development parcels, is shown in Figure 6. Surveys conducted since 1996 have not identified A. menziesii in Kaloi and Hunehune Gulches (Nagata 1996, 1997; Char 1997, 2003, 2004 and DLNR 2001, 2003); thus the HCP is not affected by activities proposed at either gulch location.[2] The approximate numbers of individuals are described in Table 4 following the descriptions of the proposed projects.

North-South Road

The North-South Road, a new 6-lane major collector roadway, will traverse the Kapolei property and will provide regional access to the Interstate H-1 Freeway, connecting the Interstate Route H-1 ("H-1 Freeway") (at the north end) to a future segment of Kapolei Parkway (at the south end), a distance of approximately 3.6 km (2.2 miles). Its alignment is adjacent to and toward the west of the corridor delineated by the existing HECO power line electrical easement. The new roadway is designed with three vehicular lanes in each direction, a planting median, and sidewalks on both sides with an overall width of 116 feet.

The overall schedule for the North-South Road began with the initial planning in 1994 and an anticipated completion in 2008:

Planning:	June 1994 to September 2004
Design:	Aug 1997 to Sept 2004
Construction:	Dec 2004 to Dec 2008

The North-South Road construction is planned to be built in two phases:

- Phase 1 (late 2004 - 2007) - Mass grading for six (6) lanes and drainage improvements; construction of three (3) highway lanes from Kapolei Parkway to H-1 Freeway.
- Phase 2 (late 2005 - @2008) - Construction of additional three (3) lanes; construction of drainage detention basins, construction of intersections at Kapolei Parkway and Farrington Highway; construction of interchange at H-1 Freeway.

The Phase 1 component includes roadway and drainage grading and the construction of three (of the six) lanes on the Kapolei property. The impact to *A. menziesii* is anticipated in Phase 1.

The Phase 2 components include the construction of the additional three lanes and intersections on the Kapolei property. The off-site construction of the Interchange at the H-1 Freeway will also be completed in Phase 2. The Interchange would provide an access to the Kapolei downtown area and the Ewa plain. There are no known *A. menziesii* within the area of the Interchange, therefore,

[2] DOT will coordinate with the US Department of the Army Corps of Engineers on matters related to Kaloi and Hunehune gulches.

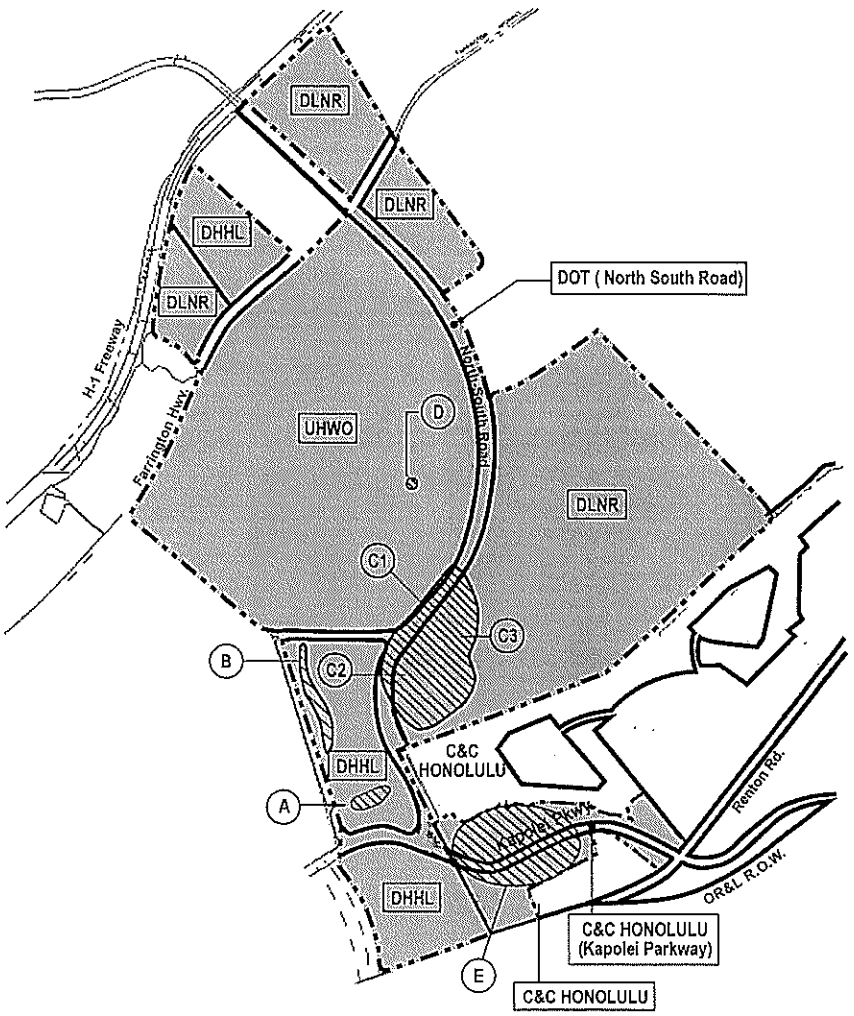


FIGURE 6
Overlay of Plant Clusters
On the Kapolei Projects
Habitat Conservation Plan
for Abutilon menziesii at Kapolei

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references to the North-South Road development is understood to be the segment through the Kapolei property.

A staging area and construction transit area approximately 50 feet to 75 feet wide along the west boundary of the North-South Road corridor is required; however, no known plants are present along this strip.

As a federal-aid highway, the North-South Road is undergoing a National Environmental Policy Act ("NEPA") review and Endangered Species Act, Section 7 consultation. The subject HCP will be submitted to USFWS as a component of the required biological assessment for the Section 7 process.

Kapolei Parkway Segment

The Kapolei Parkway, a new 6-lane major collector roadway, will traverse the City's Ewa Villages property and will provide alternate regional access to the H-1 Freeway, connecting the North-South Road at the north end to Renton Road at the south end; a distance of approximately 0.7 miles. The new roadway is designed with three vehicular lanes in each direction, a planting median, and sidewalk on one side and a multiuse (pedestrian and bicycle) pathway on the other side with an overall width of 116 feet. The project will include underground utilities (including water, sanitary sewer, electrical, and communication systems), storm drainage system, street lighting system, and landscape irrigation system.

The overall schedule for this segment of Kapolei Parkway began with initial planning in 1994, and the City anticipates completion in 2008:

Planning:	June 1994 to September 2004
Design:	December 2001 to December 2005
Construction:	June 2006 to December 2008

The Kapolei Parkway roadway is planned for construction in two phases:

- Phase 1 (mid 2006 - 2007) - Mass grading for six (6) lanes; construction of three (3) makai travel lanes from North-South Road to Renton Road.

- Phase 2 (late 2007 - 2008) - Construction of additional three (3) mauka lanes. The construction of these lanes is to be coordinated with completion of the North-South Road.

The Phase 1 components include roadway and drainage grading, the construction of three (of the six) lanes, and a portion of the underground utilities, storm drainage system, street lighting system, and landscape irrigation system on the Ewa Villages property. The impact to *A. menziesii* is anticipated in Phase 1.

The Phase 2 components include the construction of the additional three lanes and the balance of the underground utilities, storm drainage system, street lighting system, and landscape irrigation system on the Ewa Villages property.

A staging and construction transit area is required; it will be located where no known plants are present.

As a federal-aid highway, this segment of Kapolei Parkway is undergoing a NEPA review and Endangered Species Act, Section 7 consultation. The subject HCP will be submitted to USFWS as a component of the required biological assessment for the Section 7 process.

The City is planning to schedule construction of an additional three (3) lanes for the Kapolei Parkway segment from the Renton Road intersection (at the north end) to its connection to the existing Kapolei Parkway in the vicinity of the OR&L track right-of-way (at the south end) in coordination with the above Phase 2 segment and North-South Road completion. There are no known *A. menziesii* plants within this area (Char 2004). This latter construction activity will complete this 6-lane major collector roadway segment with the same typical roadway section with an overall width of 116 feet, matching the segment proposed above the Renton Road intersection.

University of Hawaii West Oahu

In September 2002, the BLNR conveyed in fee approximately 500 acres of land to the University of Hawaii for its West Oahu campus. The BLNR also issued to the University a right-of-entry to the property for planning purposes. The UH West Oahu property is bordered by the proposed North-South Road to the east, Farrington Highway to the north, the Kapolei Golf Course and Villages of Kapolei to the west, and DHHL lands to the south. The Kaloi Gulch and Hunehune Gulch traverse this parcel.

At the present time, portions of the UH West Oahu property are being leased for agricultural crop farming under revocable permits. A small portion of the 500-acre property (.826 acres) is also presently encumbered by revocable permit to Kapolei People's Inc. dba Kapolei Golf Course for their parking lot. Approximately two-thirds of the leased area has been cleared and plowed in preparation for planting.

The UH West Oahu will be a major educational facility in Kapolei, primarily serving the Leeward and Central Oahu region. The University is currently exploring options for the development of the campus and at present is planning for an approximately 100-acre campus which will be developed in phases to an ultimate student population of 7,600. Additionally, about 150 acres of land will be allocated on the property for future campus expansion beyond the 7,600 student population. Finally, the University is considering a number of land use options for the remaining 250 acres of lands within the 500-acre property to serve the campus and surrounding region. Construction of the campus could begin in the latter part of 2005, with a completion date of Fall 2007. The initial phase of campus development would be located in the northeastern portion of the property, in close proximity to the Farrington Highway.

There are very few *Abutilon menziesii* on this area of the Kapolei property. A recent survey in June 2003 by Char (Appendix D) confirms that there are two to three individuals from Cluster C at the south boundary and the one individual in Cluster D is no longer alive. However, Char (2003) notes that seeds may be present in the soil.

Department of Hawaiian Home Lands

In November 2002, BLNR granted DHHL a right-of-entry to approximately 200 acres at the Kapolei property and commenced the process to transfer those parcels to DHHL. The two parcels are to the west of the proposed North-South Road and at the northern and southern points of the Kapolei property. The northern property, Parcel 3, is approximately 49 acres and located between Farrington Highway and the H-1 Freeway. Directly to the south is the proposed UHWO property. The southern property, Parcel 108 (portion), is approximately 165 acres and directly adjacent to the UHWO southern boundary. Kapolei Golf Course and the Villages of Kapolei are to the west with the North-South Road to the east and DLNR lands beyond that. A portion of Parcel 108 will require future subdivision for the Kapolei Parkway extension in an east-west orientation. This latter subdivision will bisect the property into two non-contiguous parcels.

The mission of DHHL is to develop and deliver homesteads to qualified native Hawaiians pursuant to the Hawaiian Homes Commission Act. The acquisition of these parcels will allow DHHL to plan and develop approximately 1,000 residential homesteads and potentially some commercial and community facility uses to serve the new subdivision over a 8 to 10 year period from 2006-2016. Conceptually, the first increment is targeted to be completed in 2006. Ownership by DHHL and development of these uses have been described in the EIS for the East Kapolei Master Plan.

Abutilon menziesii is present on DHHL's Parcel 108 (portion) at Clusters A and B. Based on the baseline population, 10 individuals comprise Cluster A and 14 individuals comprise Cluster B. The development sequence will affect Cluster B initially followed by Cluster A.

Department of Land and Natural Resources

The remaining unassigned parcels (formerly part of the East Kapolei Master Plan) total approximately 600 acres in five parcels; the parcels are now under the authority of the DLNR Land Division and are to the east of the proposed North-South Road and the north of Farrington Highway.

The Environmental Impact Statement for the East Kapolei Master Plan designates urban uses including residential, public schools, parks, roadways as well as roadways and open space areas on these parcels which would serve as drainage detention basins. The ultimate uses of these lands will be determined in the future when a development proposal is again proposed by the State or other non-governmental entity.

More than half of the *A. menziesii* in Cluster C occur on the DLNR lands.

Kapolei Projects Conceptual Development Schedule

The commencement of construction for the North-South Road is planned for late 2004 with completion in 2008. The other Kapolei projects are in the early stages of planning and schedules have not yet been determined. Thus, Table 4 below is conceptual and may be changed. The impact to the full population of *A. menziesii* is assumed over 20 years as described in this HCP. However, even if development plans are delayed, the HCP strategies and mitigation measures will be

completed in its entirety. Moreover, in accordance with the expiration date of the incidental take license, any remaining in situ plants after July 31, 2021, will remain within the Kapolei property.

Table 4. Conceptual Development Phasing and Impacts to Plant Clusters

Development Phase* (Conceptual)	Plant Cluster	No. of Plants**	Land Use (Conceptual)
2004-2007 North South Road (Phase 1)	C	14+ 7 =21	Roadway (Initial Lanes 1-3, Drainage basins)
2005-2008 North-South Road (Phase 2)		0	Roadway (Lanes 4-6; intersections; interchange); phasing of drainage channel
2006 – 2007 Kapolei Parkway (Phase 1)	E	3	Roadway (Mass grading for 6 lanes; Lanes 1-3)
2007 – 2008 Kapolei Parkway (Phase 2)		0	Roadway (Lanes 4-6)
___ - __ City Land / Future Urban Uses***	E	4	Future Urban uses
2006-2016 DHHL (Parcel 108 por.)	A B	10 14	Residential Residential
2005 -2007 UHWO (Phase 1) ____ - ___ UHWO (Phase 2)*		0 0	University campus University campus extension
____ -____ UHWO (Future Phase)*	C, D	4	Other related uses (to be determined)
____ -____ DLNR lands*	C****	37	Ultimate Uses*****: Residential, Schools, Parks, Roadways

* Development phases are conceptual and development schedules have yet to be determined at this time.
** The number of plants is estimated and is based on the baseline population of 93 plants.
*** Future urban uses may include residential development by DHHL.
**** Sub-population includes plants within the 18-acre contingency reserve site.
***** Ultimate uses are as proposed by HCDCH for the East Kapolei Master Plan.

(2b) Evaluation of the impact of the activities on the particular ecosystems, natural communities, or habitat types within the plan area

The ultimate development of the Kapolei projects would result in incidental take of all *A. menziesii* plants and the plants are unlikely to survive in their current locations. Much of the non-native plant community on the proposed development sites will also be heavily impacted.

In anticipation of the impacts, an Interim Management Program has been implemented through an agreement between HCDCH and DLNR, and subsequently DOT, as described in Section 3, Strategy (1). Under Strategy (1), the following have been accomplished: 1) DOFAW successfully propagated the genetic representation of the Kapolei population[3], 2) DOFAW initiated outplanting at three sites:

[3] Propagules for genetic representation, including cuttings and seeds, of Kapolei population individuals, were collected from plants mature enough (multi-stemmed of fruiting) or alive at the commencement of collection. Immature individuals and the recently integrated City property individuals are yet to be genetically represented. The genetic resource of expired individuals not yet represented would attempt to be reclaimed through the soil seed bank.

Koko Crater (2000), Kaena Point (2002), and Honouliuli (2002), and 3) monitoring of those sites has been ongoing. The primary purpose of the HCP is the survival of East Kapolei's *Abutilon menziesii* and this will be accomplished through various identified measures including the "relocation" of the basic plan area of this species.

As the agency to implement the HCP, DLNR will pursue use of additional appropriate outplanting sites, and outplanting will occur after all required clearances have been obtained. The selection of appropriate outplanting sites is described in greater detail in Section 3 Strategy (4).

The HCP also establishes an 18-acre contingency reserve site (see Figures 5 and 11) which temporarily protects a colony of Cluster C from development until the short-term success criteria (as described in Section 7) are met at one wild site. Management of this area may include measures such as temporary fencing and firebreaks. If an outplanting site does not meet the short-term success criteria, this reserve site could be considered as a wild site.

SECTION 3

Identify the steps that will be taken to minimize and mitigate all negative impacts, including without limitation the impact of any authorized incidental take, with consideration of the full range of the species on the island so that cumulative impacts associated with the take can be adequately assessed; and the funding that will be available to implement those steps.

Described below are the details of the core elements of this HCP, including the mitigative steps and strategies for the impacts to *Abutilon menziesii* on the Kapolei property.

(3a) Full range of the species

Abutilon menziesii is uncommon and local in dry forests between elevations 200-520 meters on Lanai, East Maui, and Hawaii (Wagner 1999). On Oahu, a collection (Char 81.002, BISH) from an abandoned canefield at Barbers Point, Ewa, was made in 1981 and believed to represent an escapee from cultivation. At that time all cultivated plants on Oahu were descendent from plants derived from individuals propagated on the island of Hawaii. Differences in leaf morphology of progeny from this plant suggest that the Barbers Point plant may represent a distinct population (USFWS 1994). A single individual plant has recently been documented on Navy property at Lualualei (Moribe 1998 and Miyashiro 2001, personal communication). *A. menziesii* is also present in several botanical collections on Oahu including the Waimea Arboretum & Botanical Garden, the Honolulu Botanical Gardens, and Amy B. Greenwell Botanical Garden in Kealakekua in South Kona.

A database search by the Hawaii Natural Heritage Program for *A. menziesii* on Oahu resulted in the subject Kapolei population only.

The relationship of Kapolei plants and island of Hawaii plants is unknown at this time. Prior to the discovery of the Kapolei population, the area was not commonly known as a habitat for *A. menziesii*. Thus, DLNR botanists believe that the abundance and spatial distribution suggest that the Kapolei plants are probably natural remnants of a once more extensive Oahu population (Garnett 2001, personal communication) and not an escapee from cultivation as previously theorized. Moreover, the Kapolei population is the larger of the two known populations and accounts for approximately 99 percent of the known wild plants on Oahu (USFWS, L. Gibson).

(3b) Steps and strategies that will be taken to minimize and mitigate all negative impacts, including, without limitation, the impact of any authorized incidental take.

The strategies under consideration in this Habitat Conservation Plan include off-site and on-site measures which would be implemented, as listed in Table 5:

Table 5. Strategies to Assess and Mitigate the Development Impacts on *Abutilon menziesii* at Kapolei

Strategy	Mitigation Steps and Strategies
1	Interim Management Program (October 1998 to March 2000, extended to October 2001); Establish two test outplant wild population sites
2	Funding for the implementation of the HCP
3	Development schedule and mitigation phasing sequence
4	Establish new populations at three off-site locations
5	Long-term protection and maintenance of permanent *A. menziesii* populations
6	Appropriate research
7	Kapolei population strategies

Strategy (1) Interim Management Program (October 1998 to October 2001)

Through funding provided in 1998 by the Housing and Community Development Corporation of Hawaii ("HCDCH"), HCDCH and DLNR established an agreement to implement a pre-construction period Interim Management Program to test the viability of establishing *Abutilon menziesii* at two offsite locations on Oahu.

On March 14, 2001, DOT delegated the expenditure of $250,000 to DLNR for the implementation of the HCP strategies for Years 1 through 5. Funds became available in August 2001 and are subsequently being used by DLNR to complete Strategy (1) (Interim Management Program) of the HCP and to transition to HCP implementation to accomplish the overall HCP implementation strategies (described below).

The preliminary results of the Interim Program indicate that propagation of the species from cuttings and seed is highly successful in the nursery environment. Outplanting to offsite locations has also been successful in the first year. The *Interim Management Report for Abutilon menziesii* (DLNR 2001) and the *Final Interim Management Report for Abutilon menziesii* (DLNR 2003) are attached as Appendix F and Appendix G.

The Scope of Services of the Interim Management Program include the following tasks:

Task 1: Maintain in-situ population through monitoring, maintenance, and security (fire protection).

Known Kapolei plants have been marked with permanent stakes and mapped to a GIS layer. The existing plants are being maintained by weeding around them, and the application of herbicide, pesticide, and fertilizer, as necessary. A fire management strategy consisting for the following measures is being implemented to ensure that the plants are not accidentally destroyed.

- Identification of fire fighting resources available near the Kapolei population;
- Provide information to fire stations to assist them in protecting *A. menziesii* from fire;
- Identification of water resources near the Kapolei population.

The details of the fire management strategies are described in the Final Interim Management Report for *Abutilon menziesii* (DLNR DOFAW 2003, Appendix G).

Task 2: Propagate a total representation of plants through seeds and cuttings from the Kapolei Abutilon menziesii population. These plants will be used to maintain genetic representation of stock and provide stock for outplanting purposes. Work will be done at the existing State DLNR, Division of Forestry and Wildlife (DOFAW) nurseries.

All the known Kapolei population plants have been propagated through cuttings resulting in 630 first generation progeny from 62 in situ individuals.[4] In addition, 220 seedlings have been produced from seed collected from the first generation nursery plants (grown from cuttings). Additional seeds have been distributed to Lyon Aboretum, the National Seed Storage Laboratory in Fort Collins, Colorado, and the Pahole Rare Plant Facility.

Task 3: Establish two new populations of Abutilon menziesii in appropriate habitat to allow for natural establishment and long term viability. Each outplanting site was planted with a representative sub-sample of the Kapolei population and each individual plant has been tagged with a permanent metal tag.

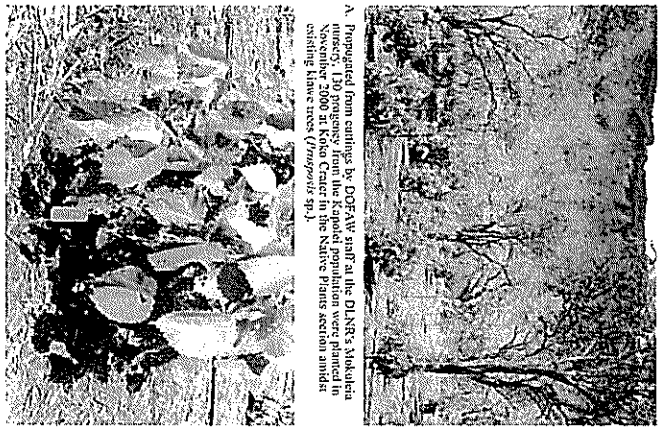
Three outplant populations of *Abutilon menziesii* have been initiated.

Outplant Site #1: Koko Crater Botanical Garden (Figure 7)

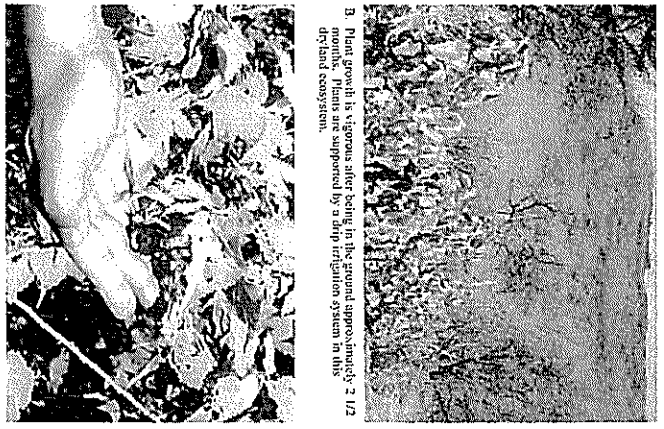
Through an agreement with DLNR DOFAW, the City and County of Honolulu Koko Crater Botanical Garden provided a 100 ft x 100 ft (10,000 sf) site for the initial planting. In November 2000, 140 *Abutilon menziesii* were planted in the 10,000 sf site, representing two complete sets of each of the original Kapolei plants. The *Abutilon* plot is in a public display area supported with drip irrigation. Hence, plants are lush and thriving. Koko Crater Botanical Garden staff will provide the long term care of these plants and will be propagating *Abutilon menziesii* from materials taken from these plants. Although this site is not being considered as a "wild site" its intent is as a living genetic repository of the full Kapolei population. DLNR will continue to coordinate the management regime (e.g. irrigation requirements, etc.) with Koko Crater Botanical Garden.

The outplant site is within a public garden setting and located in close proximity of one individual of another endangered *Abutilon* species (*A. eremitopetalum*) creating concerns about hybridization. Therefore, propagules from the Koko Crater outplanting will be limited to cuttings. Recent observations of this site indicate flowering, fruiting, and setting of seeds (personal communication, N. Sugii). The outplantings will be monitored for seedling recruitment, however due to the potential for hybridization with *A. eremitopetalum*, propagules for outplanting will be limited to cuttings.

[4] The baseline number of in situ plants at the Kapolei population numbered 93 individuals; however, through natural causes, the number had declined to 62 individuals at the time Task 2 was implemented, resulting in a genetic representation of only those existing at that time. Propagation of any subsequent "new" in situ plants (and including the plants on City property) which would constitute parental stock is also being undertaken by DLNR.



A. Propagated from cuttings by DOFAW staff at the DLNR's Makaleia nursery, 130 progeny from the Kapolei population were planted in November 2000 at Koko Crater in the Native Plants section amidst existing kiawe trees (*Prosopsis* sp.).



B. Plant growth is vigorous after being in the ground approximately 2 1/2 months. Plants are supported by a drip irrigation system in this dryland ecosystem.

C. Each plant is tagged and numbered for record keeping.

D. Kapolei progenies grown from seeds collected and planted in 1997 are flowering and fruiting a short distance from the main outplant site.

FIGURE 7
Photographs: Koko Crater Botanical Gardens (Outplant Site #1)
Habitat Conservation Plan
for Abutilon menziesii at Kapolei

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Outplant Site #2: Kaena Point State Park (Wild Site #1) (Figure 8)

The Kaena Point outplanting site was started in April 2001. The land is under the jurisdiction of the DLNR, Division of State Parks (TMK: 6-9-01: 4).

The approximately 3-acre outplanting site was established with two distinct planting areas separated by a four-wheel drive road. The site is completely protected from four-wheel drive vehicles by a rock barrier along the dirt road fronting the outplanting site. Site preparation included clearing the non-native brush and grass with weedeaters and with hand tools and treating the area with herbicide to prevent regrowth. A total of 142 *Abutilon menziesii* plants have been planted in the Kaena Point outplanting site. In addition, 20 other native species have been planted to create a coastal strand community.

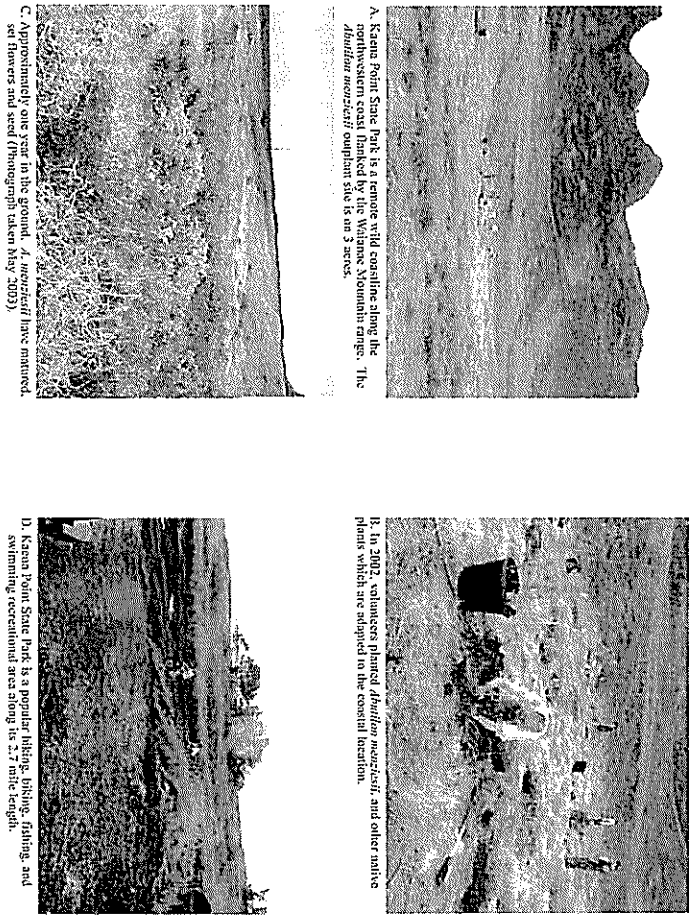
The plants were irrigated at the site to promote their establishment and to encourage the production of a maximum amount of seed to allow the build up of the seed bank and natural establishment of seedlings. The survival rate for plants at this site has been 98%. The 142 plants at this site represent a total of 44 of the original East Kapolei plants. Two *Abutilon* seedlings have grown naturally from seed produced by plants outplanted at this site. These seedlings have grown large enough to be considered part of this population.

The DLNR received permission from the U. S. Air Force to tap into the 4-inch water main that runs adjacent to the outplanting site allowing the construction of a complete irrigation system and including a galvanized steel water tank with a capacity of approximately 3,000 gallons to provide a water reserve for irrigating the plants. This tank is necessary because the 4-inch water main is pressurized only two days a week for 4 hours per day.

The threats to the Kaena Point outplanting site include the rapid growth of weeds and wild fires. This site was established in area with deep soil that was dominated by Guinea grass (*Panicum maximum*) and koa haole (*Leucaena leucocephala*). DLNR staff have had difficulty keeping up with the weed threat presented by these species and others at this outplanting site. To control weeds in the outplanting site, DLNR has used a variety of labor including regular Natural Area Reserves System employees, temporary workers such as the Emergency Environmental Workforce, and volunteers.

The other major threat to this outplanting site is fire. The fire strategy and fire fighting resources includes the installed water tank, the installed 2-inch outlet to allow fire engine hookup near the road, and the planting of native plants along the perimeter of the outplanting site to serve as a fuel break.

On August 20, 2003, a brush fire started by a vehicle about ¾ mile away burned a total of 160 acres along the coastal flats up to the nearby Kuaokala Game



A. Kaena Point State Park is a remote wild coastline along the northwestern coast flanked by the Waianae Mountain range. The *Abutilon menziesii* outplant site is on 3 acres.

B. In 2002, volunteers planted *Abutilon menziesii*, and other native plants which are adapted to the coastal location.

C. Approximately one year in the ground, *A. menziesii* have matured, set flowers and seed (Photograph taken May 2003).

D. Kaena Point State Park is a popular hiking, biking, fishing, and swimming recreational area along its 2.7 mile length.

FIGURE 8
Photographs: Kaena Point State Park
(Outplant Site #2/Wild Site #1)
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for Abutilon menziesii at Kapolei
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Management Area at about 1,100 feet elevation. This fire started late at night and was fanned by winds of 25 to 35 mph and burned to the edge of the outplanting site and around it. The fire moved so quickly that Honolulu Fire Department engine companies were unable to engage the fire near the ignition point or near the outplanting site resulting in a burn of approximately 30 percent of the 3-acre outplanting site. The effects of the fire on the *Abutilon menziesii* plants at the site are unknown at this time. An assessment will be made when the rainy season commences and there is sufficient moisture for growth.

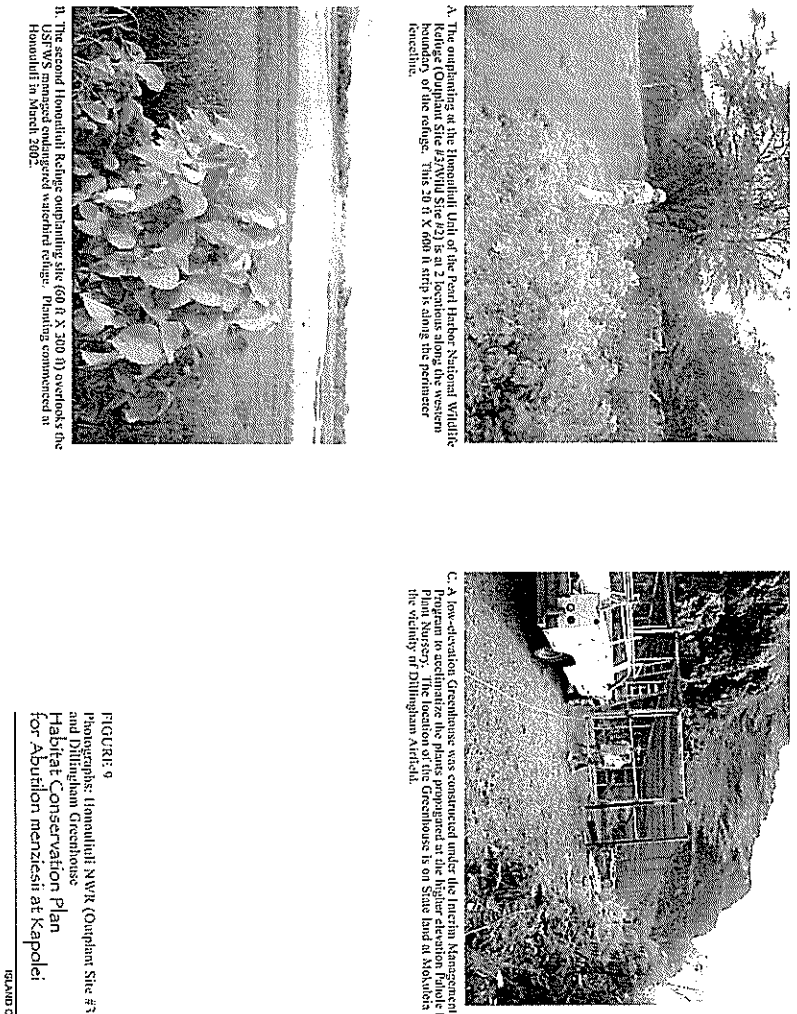
The plants along the edge were affected by the flames but not completely consumed. It is possible that many of these *Abutilon menziesii* plants will survive. The fire did burn many of the other native species planted in the area to serve as a fuel break along the front of the outplanting site. This fire would have been more damaging if these plants had not been in place. These fuel break plants will need to be replaced. The fire did destroy all irrigation pipes in the area and will need replacement. The lesson learned from this experience is that the fuel break plantings are perhaps, the most useful part of the fire strategy. The fuel break portion of this fire management strategy needs to be replaced and developed further with a wider buffer of fire resistant species established to encompass the entire outplanting site.

Outplant Site #3: Honouliuli Unit of the Pearl Harbor National Wildlife Refuge (Wild Site #2) (Figure 9)

A third outplanting site has been developed at the Honouliuli Unit of the US Fish and Wildlife Service Pearl Harbor National Wildlife Refuge which borders the West Loch of Pearl Harbor (TMK: 9-1-17). USFWS has a cooperative agreement with the Navy to manage the site as a refuge in perpetuity. This 37-acre unit is mostly a fresh water wetland managed for a variety of endangered water birds. The entire Honouliuli Unit is enclosed in an eight-foot chain link fence that provides predator control for the birds and security for the plants. DLNR DOFAW has selected and planted an upland area within this Unit and installed an irrigation system to assist with the initial establishment of plants.

There are two separate areas being used for outplanting within the refuge. The first consists of a narrow strip, approximately 20 by 600 feet, while the second site is approximately 60 by 300 feet. The first planting commenced on March 15, 2002 in the 20 by 600-foot site. Work at the second location began in January of 2003. Both locations are on an irrigation system and are managed entirely by DLNR DOFAW staff.

At this time the planting includes a total of 61 *Abutilon menziesii* plants at the Honouliuli Unit with a survival rate of 96 percent of the outplants. Plants from cuttings from 21 of the original East Kapolei plants are represented here. In addition, 21 seedlings of known parentage and 10 seedlings of unknown parentage that were removed from the East Kapolei population in the spring of 2002 have been planted here.



A. The outplanting at the Honouliuli Unit of the Pearl Harbor National Wildlife Refuge (Outplant Site #3/Wild Site #2) is at 2 locations along the western boundary of the refuge. This 20 ft X 600 ft strip is along the perimeter fenceline.

B. The second Honouliuli Refuge outplanting site (60 ft X 300 ft) overlooks the USFWS managed endangered waterbird refuge. Planting commenced at Honouliuli in March 2002.

C. A low-elevation Greenhouse was constructed under the Interim Management Program to acclimatize the plants propagated at the higher elevation Halawa Plant Nursery. The location of the Greenhouse is on State land at Makakilo in the vicinity of Dillingham Airfield.

FIGURE 9
Photographs: Honouliuli NWR (Outplant Site #3/Wild Site #2) and Dillingham Greenhouse

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A small number of the seedlings produced at the Kapolei population (approximately 10%) during the spring of 2002 were left there and subsequently perished. Three plants produced from seed were also planted at Honouliuli. The amount of area covered by this outplanting site is approximately ½ acre. There is sufficient area to add many more plants to this site.

The fire threat at this site is minimal. The eight-foot chain link fence provides a barrier to most of the possible ignition sources. A buffer of approximately 6 feet of bare ground is in place just inside most of the perimeter fence of this unit to serve as a barrier to predators of the endangered water birds. This buffer strip also serves as a firebreak to the outplanting site. The portion of the fence that doesn't have this buffer has fresh water marsh just inside the fence. The fire management strategy for this site is to ensure that this buffer strip remains in place.

Task 4: Research the biology of the species and determine seed storage requirements, salt and pathogen influence, and the best herbivore control methods.

Granular diazinon has been tested to determine success at controlling ants and azatin and dursban have been tested on a few plants to determine toxicity. Seed have been stored in an appropriate seed bank facility. Additional research is discussed under Strategy (6) below.

Task 5: Provide partial funding for the construction of a low-elevation greenhouse dedicated to growing A. menziesii and other threatened and endangered plant species on Oahu. This greenhouse would serve as a long-term greenhouse, to be owned and operated by the Division of Forestry and Wildlife, for low elevation threatened and endangered plant species on Oahu, including A. menziesii from the Kapolei population for the duration of HCP implementation.

The construction of the Dillingham Greenhouse by DLNR DOFAW has been completed (see Figure 9).

A 6,000 square foot nursery dedicated to the propagation of *Abutilon menziesii* and other threatened and endangered plant species on Oahu is located near the base of the Kealia Trail head, just behind the western end of Dillingham Airstrip in Mokuleia. The land falls under the control of the DLNR Land Division and is in the process of being transferred to DOFAW. The construction included the installation of the water and electrical systems. The greenhouse is 130 feet long by 40 feet wide by 12 feet tall. It is divided into an upper and a lower section along the entire length. All propagation of *A. menziesii* is now at this new facility.

Strategy (2) Funding for the Implementation of the HCP

The HCP's active mitigation effort will span a period of 20 years. The HCP is intended to provide adequate funding for the 20-year period beginning August 1, 2001 to July 31, 2021. Following the completion of 20 years of active mitigation, the HCP will provide additional funds for management of three wild outplanted sites.

The allotment for active mitigation over 20 years is valued at $1,000,000 averaging $250,000 over each five-year increment. This amount is pledged by DOT through funds which have already been delegated ($250,000) and funds which are to be released and delegated upon the approval of the HCP ($750,000).

Additional funds for the 20-year active mitigation period and for the post-Year 20 management period are from two sources: (1) Contingency Fund ($200,000) and (2) Interest earned on monies delegated (preliminary calculation of $440,000). Both of these fund sources are dynamic in nature and subject to change. The Contingency Fund of $200,000 would include an initial deposit of the full amount by DOT in 2005 and then be augmented by Cooperators. Cooperators are defined as other Kapolei property developers who would become sub-permittees of DOT's Incidental Take License through a Certificate of Inclusion. The Interest earned is subject to the prevailing interest rates and actual drawdown of the principle.

The funding sources for the HCP are summarized in Table 6.

Table 6. Funding Sources for the Habitat Conservation Plan (2001 to 2021+)

	HCP Phase / Time Period	Cost (in 2004 Dollars)	Source
(1)	Interim Management Program October 1998 – October 2001	$67,850 ($40,000 only has been remitted)	Special Funds by HCDCH
(2)	HCP Mitigation Period (2001 – 2021) Year 1 to Year 5 August 1, 2001 – July 31, 2006	$50,000/yr for five years. ($250,000 deposited March 14, 2001, with funds available August 1, 2001)	DOT funds
(3)	HCP Mitigation Period (2001 – 2021) Year 6 to Year 20 August 1, 2007 – July 31, 2021	$750,000 for 15 years. (Equivalent of $50,000 average per year for 15 years)	DOT funds (Funds appropriated by State Legislature, pending HCP approval & Governor's release of funds, about June 2004)
(4)	HCP Mitigation Period and Contingency Period (2005 – 2021+) Year 4 to Year 20+	$200,000 (Initial full deposit of $200,000 by DOT in 2005)	Contingency Fund (Fund to be augmented by Cooperators)
(5)	Post Year 20+ Management of Three (3) Wild Outplant Sites August 1, 2021 – Undetermined future	This amount is anticipated to be available from the remaining amount of the Contingency Fund and Interest income.	Remaining Contingency Fund and Interest earned on Items (3) and (4)

Funding for Years 1 – 20 of HCP Implementation

The provision for the establishment of the endangered species trust fund to be administered by DLNR is described in HRS Chapter195D-31. It states "the funds shall be held separate and apart from all other moneys, funds, and accounts in the state treasury, provided the moneys received as deposits or contributions from private sources shall be deposited and accounted for in accordance with the conditions established by the agencies or persons making the contribution. Earnings on the investment of the assets of the fund shall become part of the fund. Any balance in the fund at the end of a fiscal year shall be carried forward to the next fiscal year."

DOT intends to delegate a total of $1,000,000 for implementation of the HCP over a 20-year period from August 1, 2001 to July 31, 2021.

Contingency Fund - Funding After the 20th Year

Funding is provided for unanticipated events and for the management of three wild sites in the years following the 20-year HCP period.

DOT will establish a $200,000 contingency fund for the following purposes: 1) to finance unanticipated costs incurred by DLNR in the implementation of the HCP measures; and 2) to fund the management and monitoring of three "wild" populations beyond 20 years. The initial $200,000 deposit by DOT in 2005 will be augmented by Cooperators in the Incidental Take License, who have filed a certificate of inclusion with DOT.

Certificate of Inclusion

A Certificate of Inclusion would indicate the following:

a. DOT will be the holder of the Incidental Take License ("ITL").
b. Other agencies who propose to develop projects at the Kapolei property may have the protection of the ITL by obtaining a fully-executed Certificate of Inclusion and filing this document with DLNR.
c. The DOT, in consultation with DLNR, may require that other agencies contribute their various resources in order to sustain the mitigation effort of this HCP.

Memorandum of Agreement

DOT and DLNR have prepared a Memorandum of Agreement ("MOA") to implement the HCP. The MOA describes and states the following:

1. On August 1, 2001, DLNR shall implement the tasks set forth in "Exhibit A", attached hereto and incorporated herein. DLNR shall provide reasonable safeguards to secure the existence of at least three (3) "wild" *Abutilon menziesii* populations in appropriate protected habitats.

2. These populations will be maintained and managed beginning on the 1st day of August, 2001, and ending on the 31st day of July, 2021 or until all of the "success criteria" of the HCP has been accomplished.

3. DOT has delegated the expenditure of $250,000 from Act 328, SLH 1997, Item C0135, as amended by Act 116, SLH 1998, North-South Road, Kapolei Parkway to Interstate Route H-1, Oahu, to DLNR for the purpose of implementing mitigative strategies for the endangered *Abutilon menziesii*, thereby insuring funds to finance the HCP mitigative strategies costs for its first five years.

4. DOT shall also delegate to DLNR an additional lump sum amount of $750,000, which is intended to provide adequate funding for a period of fifteen (15) years from August 1, 2006. The precise amount needed to finance the mitigation effort will be estimated by DLNR and approved by DOT. The estimate shall not exceed $250,000 for 5 years, and funding will be used specifically to cover the expenses of DLNR, which relate to the mitigation of impacts to the Kapolei *Abutilon menziesii*. Interest earned on the funding, as delegated to DLNR, shall be retained by DLNR, be reserved to finance any additional mitigation beyond the term of the HCP, and be utilized in accordance with the purposes of the HCP. If a portion of the funding is unexpended due to an early termination of this MOA or the HCP, such funding shall be returned to DOT.

   DOT shall also delegate to DLNR an additional lump sum of $200,000 to serve as a "contingency fund", available over the term of the HCP. The contingency fund shall be used for emergency response, site development costs or other unanticipated expenditures required to fulfill the purposes of the HCP. The contingency fund is subject to legislative appropriation.

   All funding as directly or indirectly transferred by DOT to DLNR, shall be retained by DLNR, for the planned recovery of the *Abutilon menziesii*, until the "success criteria" is fully attained. If it is determined that all of the "success criteria" have been satisfactorily accomplished, the unexpended funds as of the date of the determination, shall be returned to DOT.

   In the event that additional funds for continued implementation of the HCP are needed, the DOT will seek alternative funding sources, including, but not limited to, transfers from the project's construction budget, participation by other State departments, and a separate legislative appropriation.

5. The MOA shall be null and void if the Board of Land and Natural Resources (or the State Legislature, as necessary) does not approve the HCP for the *Abutilon menziesii* in Kapolei.

6. The MOA may be terminated at any time by written consent of the parties of this agreement and any respective remaining funds shall be returned to DOT.

7. The MOA may be amended at any time by written consent of the parties of this agreement.

Strategy (3) Development schedule and mitigation phasing sequence

The period from 1997 to 2004 for the preparation of the HCP was unforseen at the start of the HCP planning period. The delay has been attributed to a number of factors including funding issues, real estate market conditions, analyses of regional drainage issues, and most recently, legislative amendments to the HCP law (Chapter 195D) to enable public agencies / landowners to participate in the HCP process.

This delay has provided an opportunity to test the HCP mitigation measures, specifically, the viability of propagating this species and to initiate outplant populations of *A. menziesii*. A further unanticipated consequence of the prolonged delay is the changes in land uses and ownership of parcels at the Kapolei property.

The decision of the Endangered Species Recovery Committee in the 2002 review established a review period of 15 years with a cap at 20 years for the subject HCP. However, presently, a 20-year implementation and active management time period is anticipated, followed by any necessary management at three wild sites after the conclusion of the 20th year.

A tentative conceptual schedule which represents the best information available at this time is provided in Table 7 to determine the order of impact of development on the Kapolei population. Once construction has commenced the impacts would occur incrementally over approximately 20 years during the Kapolei projects development period. The area of greatest impact is in the south of the property where *A. menziesii* are concentrated.

Table 7. Conceptual Development Phasing and Impacts to Plant Clusters

Development Phase* (Conceptual)	Cluster	No. of Plants	Land Use
2005 to 2008 (North-South Road)	C-1 C-2	14 7	Roadway Drainage basins
2006 to 2008 (Kapolei Parkway Segment) Future Urban Uses (undetermined schedule)	E E	3 4	Roadway Infill Residential Uses (Future)
2005 to 2014 (DHHL Homesteads)	A B	10 14	Residential
200_ to 20__ (UHWO)**	C C, D	0 3	Campus Campus related uses
20-- to 2020 (DLNR other lands)	C-3***	38	Residential, Parks, Schools, etc.,

* Development phases are conceptual and development schedules have yet to be determined at this time.
** UHWO development schedule has not yet been established.
*** Sub-cluster C-3 incorporates the 18-acre contingency reserve which will remain in place until the short-term success criteria are met at one outplant wild population.

The implementation of the mitigation measures described herein and a phasing sequence and conceptual schedule is shown in Table 8. The schedule assumes a favorable approval of the HCP.

Table 8. HCP Implementation Schedule (Conceptual)

Phases	Actions
Interim Management Program 1998 – 2001 (Extended to 2003)	HCDCH funds Interim Management Programs - Implemented by DLNR -Test Outplant Site #1 (Koko Crater) planted (130 plants / November 2000) -Test Outplant Site #2 / Wild Site #1 (Kaena State Park) planted (April 2001) -Test Outplant Site #3 / Wild Site #2 (Honouliuli National Wildlife Refuge) (2002-2003) -Dillingham Greenhouse under construction (2002-2003) DOT deposits initial $250,000 for Years 1-5 (2001 – 2006 – in part, to conclude the interim program and to initiate the first five-year increment of HCP implementation) to DLNR to implement the HCP. [NOTE: Funds were available in August 2001 for Year 1.] -DLNR hires staff to implement the HCP
HCP Review and Approval / Federal Section 7 Consultation 2003-2004	-BLNR review/approval of HCP -DOT/DLNR establish MOA -Approval of Incidental Take License -DOT delegates $750,000 to Years 6-20 funding -Section 7 consultation initiated and concluded with USFWS
HCP Implementation 2001 – 2021	- Establish the 18-acre contingency reserve at the in situ Kapolei population - Initiate and manage additional appropriate outplanting sites - Annual reporting - analyze success criteria, reporting of progress, and applying adaptive management strategies, as appropriate - Implement all other measures identified in the HCP - Annual fiscal reporting to DOT by DLNR - Development of Kapolei projects (Conceptually described in Table 7)
Long-term Management (After 2021)	- Appropriately manage 3 established outplant wild sites

The basis for this mitigation phasing sequence, although conceptual, is the result of the initial results of the Interim Program. This is based on the successful nursery propagation and initial outplanting to the three outplanting sites (Koko Crater, Kaena Point State Park, and Honouliuli National Wildlife Refuge).

Strategy (4) Establish new populations at three off-site locations

The HCP outlines a strategy to take cuttings and collect seeds from the existing *Abutilon menziesii* plants at the Kapolei property prior to their removal and to use these materials to: 1) maintain genetic representation of the original population by growing cuttings in nurseries and placing seeds in seed storage facilities; and 2) to establish three new wild populations in protected areas elsewhere on Oahu.

Described below are the following: 1) Criteria for wild site selection, and 2) Candidate sites for outplanting

(4) 1. Criteria for Wild Site Selection

Wild sites for *A. menziesii* re-introduction is generally considered to be an area where the species, after initial planting, with the support of temporary active management measures (e.g. irrigation, control of threats, etc.), will become self-sustaining and will naturally reproduce.

To establish criteria for site selection of appropriate candidate sites on Oahu for *A. menziesii* a brief summary description of the extant populations on Lanai and Maui was made. The physical characteristics, including vegetation type/plant communities, soils, elevation, rainfall, overall site characteristics, and identified threats were analyzed.

These sites are at Kaumalapau and Puu Mahanalua on Lanai and Kalialinui Gulch and Puu o Kali on Maui. Table 9 summarizes the findings and a preliminary analysis of the findings is summarized below.

Table 9. Summary description of extant Lanai and Maui populations of *Abutilon menziesii*

Site (Location)	Site Characteristics	Vegetation type/ Plant communities	Soil type	Elevation & Annual Rainfall	Threats
Kaumalapau (Lanai)	*Abutilon menziesii* occur in scattered colonies numbering approximately 400± in the area north of Kaumalapau Road to Paliamao Gulch. The area is formerly grazed by cattle and makai of overgrown abandoned pineapple fields.	Guinea grass (2 ft. to 3 ft. tall); scattered clumps of koa haole in swales	Molokai silty clay loam (MuC) Well-drained, deep soils on uplands	1,050 ft. to 1,150 ft. amsl 20 - 25 inches between Nov. and April; hot, dry summers	-Weeds -Fire
Puu Mahanalua "Twin Peaks" (Lanai)	*A. menziesii* is found at the base of the most mauka puu along abandoned pineapple field dirt roads. Mature colony of 35± plants (observed in 2001) with plant heights ranging from 4 ft. to 7 ft. Blossoms are unique in color (pale peach) and are upright (not pendant).	Guinea grass (6 ft. to 7 ft. tall)	Uwala silty clay loam (UwC) Well-drained soils on uplands, formed in material derived from basalt. Soil temperature of 70 degrees.	1,200 ft. amsl 15 - 25 inches between Nov. and April; very little rainfall in summer	-Weeds -Fire
Kalialinui	Plants occur along the top	Open scattered koa	Keahua silty clay	690 ft. to 750	-Weeds

Gulch (Central Maui)	banks of gulch adjacent to cane haul road. Fields are in active cultivation. Population in 3 colonies. 3 mature colonies *of A. menziesii* with plants reaching heights of 7 ft. to 8 ft. tall	haole/Guinea grass	loam (KnB) Well-drained reddish brown soils on uplands weathered from basic igneous rock; 20 to 40 inches deep	ft. amsl 15 to 25 inches	-Grazing -Fire
Puu o Kali (Kihei, Leeward Maui)	Plants occur on shallow pockets of soil on aa lava flow. Generally open with scattered stands of wiliwili (*Erythrina sandwicensis*).	Native Lowland dry shrubland	Very Stony Land (rVS). Young aa lava that has a thin covering of volcanic ash that extends deep into cracks and depressions.	500 ft. to 1,400 ft. amsl 30 to 40 inches	-Weeds -Grazing -Fire -Ungulates A fencing project is underway to control the deer grazing threat.

A preliminary analysis of the extant Lanai and Maui populations is summarized in Table 10.

Table 10. Preliminary analysis of physical characteristics of extant Lanai and Maui populations

Site Characteristics	Vegetation type/ Plant communities	Soil	Elevation & Rainfall
-Leeward or southern location -Located between actively or formerly cultivated fields and scrubland -Threats include weeds, fire, and ungulates. -At Puu o Kali, deer browsing threat to seedlings (being controlled through fencing) -Fire threats, species indicated to be somewhat fire tolerant (i.e. the Kapolei population)	-Presence of and abundance of alien grasses surround stands of *A. menziesii* -Natural recruitment of seedling establishment unknown over time due to alien grass cover	-Well drained deep soils	-Elevation ranges: 500 – 1,400 amsl -Annual rainfall range generally averages 20 inches; -USFWS (1995) notes that all known populations are frequently exposed to severe drought and flooding

In addition, the following set of guidelines for re-introduction is from the World Conservation Union[5]:

Choice of re-introduction site and type

- Site should be within the historic range of the species. For a re-introduction, there should be no remnant population to prevent disease spread, social disruption and introduction of alien genes. In some circumstances, a re-introduction may have to be made into an area which is

[5]Website: www.iucnssc rsg.org

fenced or otherwise delimited, but it should be within the species' former natural habitat and range.

- An introduction outside its historical range should be undertaken only as a last resort when no opportunities for re-introduction into the original site or range exist and only when a significant contribution to the conservation of the species will result.
- The re-introduction area should have assured their long-term protection (whether formal or otherwise).

Evaluation of re-introduction site

- Availability of suitable habitat: re-introductions should only take place where the habitat and landscape requirements of the species are satisfied, and likely to be sustained for the for-seeable future. The possibility of natural habitat change since extirpation must be considered. Likewise, a change in the legal/ political or cultural environment since species extirpation needs to be ascertained and evaluated as a possible constraint. The area should have sufficient carrying capacity to sustain growth of the re-introduced population and support a viable (self-sustaining) population in the long run.
- Identification and elimination, or reduction to a sufficient level, of previous causes of decline: could include disease; over-hunting; over-collection; pollution; poisoning; competition with or predation by introduced species; habitat loss; adverse effects of earlier research or management program; competition with domestic livestock, which may be seasonal. Where the release site has undergone substantial degradation caused by human activity, a habitat restoration program should be initiated before the re-introduction is carried out.

[End: World Conservation Union text]

(4) 2. Candidate Sites

Three new populations of *A. menziesii* have been initiated and are tentatively expected to persist. As evidenced by the successful propagation by DLNR in the Interim Management Program (Strategy (1), plants grown from cuttings and seed from the in situ Kapolei population thrive and produce fruit and viable seed under nursery conditions. The results of the Koko Crater Botanical Garden (Outplant Site #1), Kaena Point State Park (Outplant Site #2 / Wild Site #1), and Honouliuli National Wildlife Refuge (Outplant Site #3 / Wild Site #2) will provide critical information for the selection of additional candidate Wild Sites. It is anticipated a total of three viable wild sites will be determined from planting at several (e.g. more than three) outplant sites to achieve the long-term goal of this HCP, therefore, additional appropriate locations will be pursued and planted while monitoring the sites already planted.

DLNR DOFAW, ESRC, and DOT have had considerable discussion from 1997 to the present (2004) in evaluating potential outplant (or release) sites. Trials at several sites for wild site viability have been initiated and have resulted in outplanting at two sites, Kaena Point State Park and the Honouliuli Unit of the Pearl Harbor National Wildlife Refuge.

These and each future outplanting site will require active management over a 5-year period to before a determination is made on success or failure. Additional sites will continue to be pursued while existing sites are monitored, to yield three successful wild sites.

The discussions for the selection of additional wild sites include the following priority candidate site and other possible sites:

1. Priority Candidate Site
    - Diamond Head State Monument (Approved for outplanting by DLNR Division of State Parks)
2. Other Possible Sites
    - Honouliuli Kaluaa (The Nature Conservancy)
    - Kalaeloa (former Barber's Point Naval Air Station) Northern Trap and Skeet Range
    - Kalua Kauila (near Makua Valley)
    - Kealia Trail area (State DLNR) (Test planted by DOFAW)
    - Lualualei Naval Reserve
    - Makapuu Head
    - Yokohama Beach (mauka area)

The candidate site locations are shown in Figure 10 and Table 11 summarizes the sites which have been considered as candidate outplanting sites. The physical site characteristics, threats such as invasive weeds and the potential for fire, and land ownership and availability have been assessed to determine the suitability of each site as a permanent habitat for *A. menziesii.*

Table 11. Candidate sites for outplanting of *Abutilon menziesii*

Site Name/ Location	Ownership	Size (Outplant Site)	Site Characteristics	Threats / Other Relevant Comments
Diamond Head State Monument Waikiki, East Honolulu	State DLNR Division of State Parks	1 to 2 acres	-Within DLNR control -Convenient site accessibility -Controlled access -State parks master plan designates areas which are not within heavy "public transit areas" -Dry environment -Fairly deep soils -Waterline available in near proximity	-Fire -Weeds -Presently requires MOU between National Guard and DLNR; -National Guard to relocate from Diamond Head @ 2007-2010 -High Priority candidate site to be planted in 2004
Honouliuli Kaluaa Kunia, Waianae Mountains	Campbell Estate (The Nature Conservancy of Hawaii, Lc.)	@ 0.5 acre	-Site accessible by rough dirt road and on foot -Not a public access area; however, site is used by hunters, hikers -Dry mesic forest -No waterline available	-Fire -Weeds -Low Priority site due to uncertainty of lease renewal
Kalaeloa Northern Trap and Skeet Range Former Barbers Point Naval Air Station, Ewa	Federal Navy	---	-Convenient site accessibility -Controlled access (to some degree) -Site is scheduled for remediation to remove hazardous materials -Dry coastal lowlands -Presence of Ewa Plains 'Akoko (Chamaesyce skottsbergii, an endangered species -Shallow soil layer on karst substrate (to be exacerbated by remediation) -Unknown Waterline availability	-Fire -Weeds, Buffel grass -Site is planned to be remediated to remove lead shots; top layer of soil to be removed. -Low Priority site
Kalua Kauila Near Makua Valley	Federal Department of the Army	---	-Site access by foot -Controlled site access	-Fire -Weeds - Army is unwilling to allow more T&E species on its lands at this time
Kealia Trail Mokuleia (near Dillingham Nursery)	State DLNR	0.5 to 1.0 acre	-Convenient site accessibility -Public hunting and recreational area -Dry, forested environment -Moderate depth soils	-Fire -Invasive weeds -DOFAW's initial test planting at this site is not too positive;

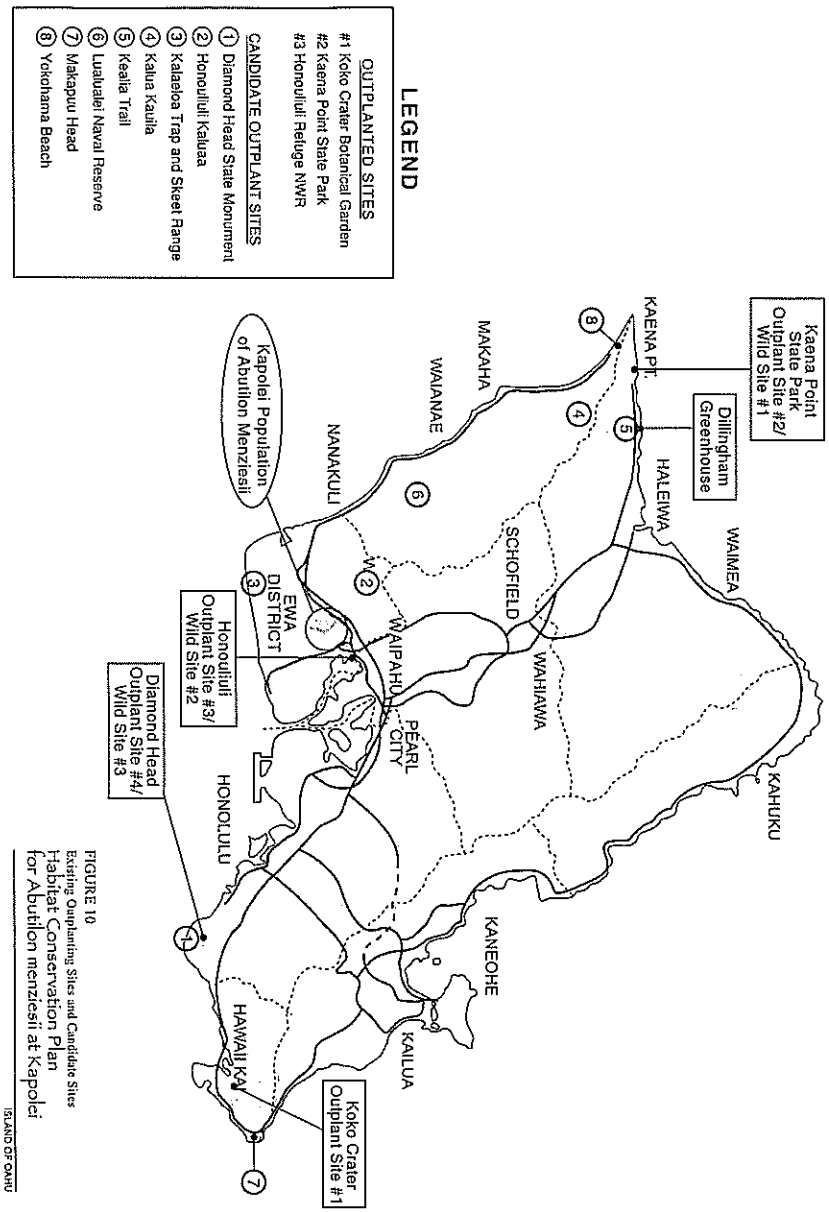

FIGURE 10
Existing Outplanting Sites and Candidate Sites
Habitat Conservation Plan
for Abutilon menziesii at Kapolei

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			-No Waterline available	-2nd site will be test planted in 2004
Lualualei Naval Reserve Waianae	Federal Navy	---	-Convenient site accessibility -Controlled access -Dry environment -Presence of *A. menziesii* (2 known) -Deep soils -Waterline available in proximity	-Fire -Weeds, Guinea grass -Navy is currently unwilling to collaborate and allow additional T&E species on its lands
Makapuu Head	State DLNR Division of State Parks	---	-Relative convenient site accessibility -Public recreational area -Dry coastal environment - Pockets of deep soils -Scattered pockets of native plant communities, including T&E species -Unknown Waterline availability	-Fire threat -Weeds, koa haole scrub, Guinea grass -Limited salt spray -Uncontrolled access (public recreational area)
Yokohama Beach (Within Kaena Point State Park) Leeward Coast (North of Makaha)	State DLNR Division of State Parks	0.5 to 1.0 acres	-Convenient site accessibility -Public recreational area -Dry coastal environment - Deep soils -Unknown Waterline availability	-High fire threat -Weeds, Guinea grass -Uncontrolled access (public recreational area) -Salt spray during kona weather

The priority candidate site, Diamond Head State Monument, is located at Waikiki in East Honolulu and is under DLNR Division of State Parks jurisdiction. The Diamond Head State Monument Master Plan includes areas which will remain as wildlands which may be appropriate for *A. menziesii* introduction. This site has been approved by the Division of State Parks.

From a biological perspective, the Lualualei Naval Reservation environment is a preferred site with appropriate microclimate, soil conditions, and protected status. Moreover, the site is believed to be an historic range of *Abutilon menziesii* with two individuals present at the NCTAMS PAC Radio Transmission Facility and is monitored by Navy staff (R. Miyashiro, personal communication). However, the current position of the Navy precludes the introduction of additional protected species at this location. Follow-up communication with the Navy will resume after the approval of the HCP.

Important considerations in the selection of each site include the following:

- Generally all sites may be exposed to fire threats, therefore, a site specific fire protection plan will be developed for each site – as part of the site assessment /selection process. The fire plan will include identification of the following: 1) fire fighting resources, 2) response responsibilities, 3) location of water resources, and 4) plans for fire breaks and fuel control.

- All sites that persist are to be considered permanent sites, therefore, future urbanization within and adjacent to the sites must be analyzed and landowner commitments for preservation must be secured.

Strategy (5) Long term protection and maintenance of permanent *Abutilon menziesii* populations

As described in this HCP and in the MOA between DOT and DLNR (Appendix H), the funds for a 20-year period for active management, protection, and maintenance of three permanent outplant sites have been partially delegated by DOT and will be supplemented after the approval of the HCP. Additionally, DOT agrees with the need for management of three wild sites beyond 20 years. Therefore, as described in Strategy (2), the funds for such management will be derived from two sources: 1) Interest earned (estimated at $440,000) on the delegated amounts of $950,000, and 2) Contingency Fund revenues (a portion of $200,000).

A further responsibility for long-term protection and maintenance of the permanent outplant sites after the HCP active management period of 20 years requires the commitment of Landowners of three outplant sites. The property owners will be required to commit to maintaining land uses that are compatible with the protection and management of the *Abutilon menziesii* populations on their property. Thus, the site selection process has analyzed criteria such as landownership status and potential future urbanization pressures on the candidate sites.

The MOA further states, "DLNR has the knowledge, expertise, and permanent presence needed to implement the mitigation of threatened and endangered species and agrees to implement the mitigation of threatened and endangered species and agrees to implement the management of the *A. menziesii* mitigation populations as outlined in the HCP".

Protection and Management of Wild Sites. The protection and management of the of the wild sites 3 will be funded through the monies contributed by DOT and earmarked for *A. menziesii* and as described in the MOA "Exhibit A - Scope of Services" includes the following:

A. Maintain three wild populations. The purpose of the populations is to allow for natural seedling recruitment and establish long-term viability of all three populations.

B. Propagation of a total representation of plants through cuttings from the Kapolei *Abutilon menziesii* population. These plants will be used to maintain genetic representation of stock and provide stock for outplanting purposes.

C. Administration: 1) Prepare biannual reports of progress and findings, and 2) Maintain adaptive management strategy as needed to improve plant recovery and success.

D. At the end of the contract period, DLNR shall prepare a summary final report, providing recommendations for future actions and possible alternatives, if any, based upon documented findings and results.

Strategy (6) Appropriate research

The research component would augment the research and testing measures described in Task 4 of Strategy (1): Interim Management Program which includes biological research, testing, and identification of testing parameters.

Research would focus on the "cultivation methods" of *A. menziesii* to attain the goal of establishing three viable new outplant sites. A review of past research studies would be made and appropriately applied to this project as situations arise at the various outplant site. The need would be determined by DLNR.

Research may include studies of various aspects of life history, habitat, pollinators, reproductive biology, optimum requirements for growth, requirements for population viability, and control of threats to better understand the requirements necessary for perpetuation of these plants. Such additional knowledge would allow more appropriate management and assessment techniques to be developed.

6.1 Collect diagnostic data on crucial associated ecosystem components.

1) Composition of flora and invertebrate, bird, and other fauna populations within the existing clusters to gain an understanding of any relationships between these organisms and *A. menziesii*.

2) Comparison of such information collected over time correlated with data from monitored populations of *A. menziesii* in known locations to provide insight into the required and/or preferred habitat for the species.

6.2 Study various aspects of growth of *A. menziesii*.

1) Growth and mortality of seedlings, cuttings, transplanted parent plants;

2) Growth of mature plants, including seasonal changes, optimum conditions and limiting factors;

3) Seasonal differences in temperature and light needs;

4) Water sources and requirements; and

5) Soil and nutrient requirements.

6.3 Study reproductive viability.

1) Breeding systems including self-compatibility;

2) Pollination vectors; and

3) Preferred conditions for flowering and seed set.

6.4 Determine the degree of threats posed by the nature of interactions with selected diseases/ introduced species.

Determine mechanisms of impact of diseases or pests. If diseases or introduced pests with negative impacts on *A.menziesii* are discovered, effects and mechanisms of each would be

determined. Research into mechanisms of impact of alien species, and any others that may be threats, would be performed as deemed necessary.

6.5 Determine effective control methods to combat insect pests that may adversely affect the species.

6.5.1 *Determine effective control methods for pests.* If the pests are determined to pose a threat to *A. menziesii*, research into effective control methods for these pests would be undertaken, ensuring that the control measures do not adversely affect this species.

6.5.2 *Determine effective control methods for hibiscus scale on Abutilon menziesii.* If the hibiscus scale is determined to pose a threat to *A. menziesii*, research into effective control methods for the hibiscus scale on the appropriate *A. menziesii* species would be undertaken, ensuring that the control measures do not adversely affect this species.

6.6 Other appropriate research to be considered.

Potential research would also be considered for the following:

1) Testing adult plants, seedlings, and seeds for salt tolerance via soil and salt spray; and

2) Conducting studies (or researching) off-island populations of *A. menziesii* to gain an understanding of how these populations function.

The decision to implement any additional research would be subject to other funding availability and a determination that these studies would directly significantly benefit the Kapolei population and the outplant sites as described in this HCP.

6.7 Currently ongoing research.

A research project by the University of Hawaii (Cliff Morden, principal investigator) is currently ongoing as a research component of the HCP. The research is to assess the extent of the genetic variation within the Ewa population of *Abutilon menziesii*. A genetic analysis of all plants from the Ewa population (at the Kapolei site or at outplanting/nursery sites) will be carried out. A limited number of individuals from other populations of *A. menziesii* (Lualualei, Oahu; Lanai, and Hawaii) will be sampled to determine affinities of the Ewa population. This research will address the extent of the genetic variation of the Ewa population, if this population is genetically distinct from other existing populations, and if genetic distance among plants correlate with the physical distance between plants. Random amplified polymorphic DNA (RAPD) markers will be used to assess the genetic diversity among individual plants. All population genetic distances will be statistically evaluated and will be compared to results from similar studies. Assessment of the genetic variation of the Kapolei population of *A. menziesii* will provide information allowing managers to make more informed management decisions concerning selection of source material for outplanting, collection, and storage of propagules to ensure representation of existing genetic material. The final report will include the following items:

1) Collection information for individuals
2) Description of methods
3) Results and discussion of genetic analyses

4) Statement regarding intra-population variation of *Abutilon menziesii* and its genetic relation to other populations

The requirements of soil collection and storage may not be practical or feasible and collection is unproven as a means to mitigate the seed bank when compared to the successful collection of seeds and vegetative cuttings from the Kapolei population. Therefore, soil collection and banking is left to be exercised at the discretion of DLNR.

SECTION 4

Identify those measures or actions to be undertaken to protect, maintain, restore, or enhance the ecosystems, natural communities, or habitat types within the plan area; a schedule for implementation of the actions or measures, including monitoring, that are to be undertaken in accordance with the schedule.

(4a) Measures or actions to be undertaken to protect, maintain, restore, or enhance the ecosystems, natural communities, or habitat types

Short-term and long-term measures and actions which would affect the existing *Abutilon menziesii* population have been described in detail in Section 3. The strategies outline the measures and actions of the HCP for the existing habitat, the interim management period, and the long-term period at the offsite outplant mitigation populations.

(4b) A schedule for implementation of the proposed measures and actions.

The schedule for implementation of the proposed measures and actions is described in detail in Section 3, Strategy (3).

All of the populations of *A. menziesii* have been and will be periodically monitored throughout each of the phases of the HCP Implementation Schedule. Monitoring of the *in situ* and reintroduction populations will be conducted to determine progress toward attaining taxon stability. Monitoring will also be conducted to assess the status of the management unit relative to control of alien taxa and to habitat restoration. In addition, monitoring is an essential and integral part of adaptive management, which will be undertaken and is more thoroughly described in Section 8.

Strategy (7) Kapolei Population strategies

An objective of the HCP over its 20-year program would allow the removal of the Kapolei population and relocating the full genetic resource to three offsite protected locations on Oahu. To assure that the short-term success criteria are met before the full population is removed (as described in Section 7 Table 13) an 18-acre area within the Kapolei population is established as a temporary contingency reserve. This area is shown in Figure 11, as well as on Figure 5.

An additional "Special Condition" to the State Incidental Take License to be issued to accompany the "Habitat Conservation Plan for Abutilon menziesii at Kapolei" would state, "No take or development can occur within the 18-acre area that surrounds the core *Abutilon menziesii* concentration within the area identified as Cluster C3 in the "Habitat Conservation Plan for *Abutilon menziesii* at Kapolei" until such time that one outplanting site has met short-term success criteria described in the HCP."

Management of the 18-acre reserve may include measures such as temporary fencing and firebreaks. If an outplanting site does not meet the short-term success criteria, this could be considered as a wild site.

Incidental Take

DLNR, as the property owner, will be responsible for the Kapolei population until the Kapolei projects are fully entitled and prior to the transfer of land to the Kapolei project developers. A stipulation of the transfer of the property would be the issuance of an Incidental Take Permit by DLNR to enable the removal of the Kapolei population plants to the outplant sites. The cost to remove and upkeep these "original plants" will be from the funds provided by DOT or from contributions to the Endangered Species Trust Fund. The costs associated with the transplanting of original plants would be from the allocations to each of the three wild sites.

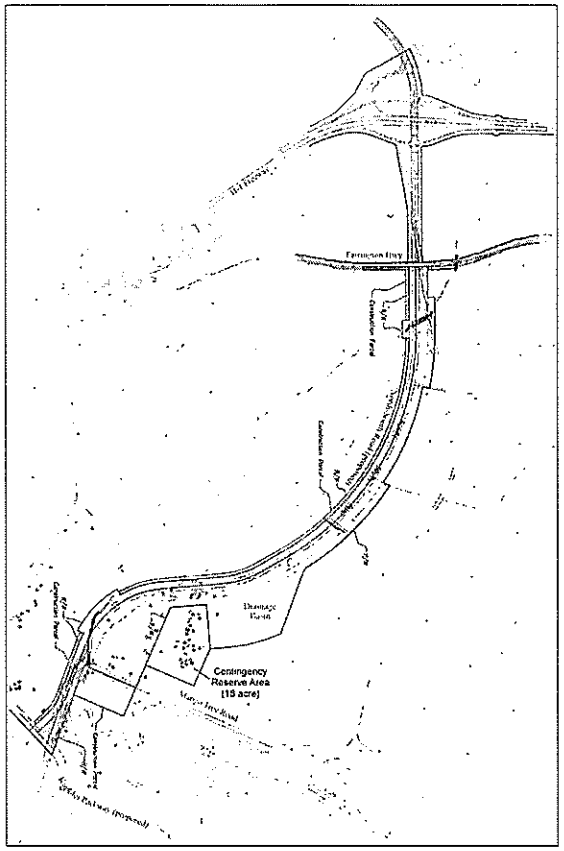
The City and County of Honolulu will issue a right-of-entry permit to DLNR DOFAW to collect propagules and conduct appropriate monitoring of the *A. menziesii* individuals (as described in this HCP) on the City property. However, the City will have overall responsibility for the plants on its property.

Prior to the construction of the North-South Road and removal of *A. menziesii*, DOT personnel will be consulting with DLNR regarding the location and treatment of the endangered plants along the project corridor.

Mitigation of the Seed Bank

To mitigate the seed bank at Kapolei, DOFAW has collected seeds and cuttings from approximately 75±% of all baseline plants. The uncollected 25±% is the due to plants lost through attrition, etc..

Mitigation of the seed bank will focus on seed storage at Lyon Arboretum, vegetative propagation at the new Dillingham Nursery, and the living genetic bank at Koko Crater Botanical Garden. The documentation of the Lyon Arboretum collection is accessed at the following website: http://www.hawaii.edu/scb/docs/science/seed/seedtabl.html



LEGEND

Abutilon menziesii

18-acre contingency reserve

Source: RM Towill Corporation

FIGURE 11
18-Acre Contingency Reserve Area
Habitat Conservation Plan
for Abutilon menziesii at Kapolei

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SECTION 5

Be consistent with the goals and objectives of any approved recovery plan for any endangered species or threatened species known or reasonably expected to occur in the ecosystems, natural communities, or habitat types in the plan area.

The preparation of the subject HCP involved the review of the *Lanai Plant Cluster Recovery Plan* (USFWS 1994) which includes *Abutilon menziesii* as one of nine endangered taxa. Appropriate guidelines are incorporated into the strategies contained herein.

Abutilon menziesii is considered to be a "long-lived" perennial and known or believed to have a life-span greater than 10 years (USFWS 1994, page 69). Conversely, "short-lived" perennials are those known or believed to have life spans greater than 1 year but less than 10 years. There are fewer than 700 *A. menziesii* individuals on Lanai, Maui and Hawaii; Oahu is listed as a possible location (USFWS 1994).

The Lanai Recovery Plan states the most serious threats as browsing and trampling by introduced ungulates, and competition from alien plants. Other threats include fire, seed predation, loss of pollinators and disease. Additional threats noted on Maui and Hawaii include agricultural and urban development.

The presence of the Kapolei population validates that the Leeward Oahu (and possibly Lualualei) and Ewa areas as historic ranges for the species. Threats to the subject population at Kapolei included agricultural cultivation until 1994 and impending urbanization as described herein.

The Lanai Recovery lists five necessary actions: 1) Protect habitat of current populations and manage threats, 2) Conduct research essential to conservation of the species, 3) Expand current populations, 4) Establish new populations as needed to reach recovery objectives, and 5) Validate and revise recovery objectives.

The total estimated cost of recovery for one (of nine) species in the Lanai Recovery Plan is estimated at $3,000,000 over a period of 20 years. The date of recovery (for all nine species) for downlisting to Threatened would be in 2015, if recovery criteria are met (USFWS 1994, page v.).

The Kapolei population is expected to be taken and relocated to the three new outplant sites where threats will be actively managed, research conducted, and populations expanded over the 20 year period. To implement the HCP measures, a funding commitment has been made, as described in the Memorandum of Agreement (Exhibit G) between DOT and DLNR for approximately $50,000 per year for a period of 20 years. Moreover, a commitment to implement the strategies of the HCP has been made by DLNR.

As indicated, there are no other endangered or threatened species in the East Kapolei area. However, remaining, in situ *Abutilon menziesii* will be maintained and protected onsite by DLNR until they are to be taken and relocated to the wild, outplanted sites, as described under Task 1 of Section 3, Strategy (1). In addition, an objective of this plan is the establishment of outplanting sites, which may become "plan areas" which may have other endangered species, and the coordination of these recovery efforts will also be performed by DLNR.

The mitigative measures of this HCP will contribute towards the USFWS Recovery Objective to delist this species. The criteria to meet the Recovery Objective of delisting are summarized below.

Table 12. Recovery Objectives of the Lanai Recovery Plan and HCP Objectives

Objectives	Lanai Recovery Plan	Associated HCP Actions
Interim Objectives	Stabilizing the existing populations: To be considered stable, each taxon must be managed to control threats (e.g. fenced) and be represented in an ex situ collection. In addition, a minimum total of three populations should be documented on Lanai and, if possible, at least one other island where they now occur or occurred historically. Each of these populations must be naturally reproducing and increasing in number, with a minimum of 25 mature individuals per population for long-lived perennials.	HCP goal is to establish 3 new ex situ wild populations on Oahu from the original degraded canefield population at Kapolei. At the new populations, threats from fire, vehicles, insect and weed pests, are to be controlled.
Downlisting	Taxon may be downlisted when a total of five to seven populations are documented on Lanai and at least one other island where it now occurs or occurred historically. Each of these populations must be naturally reproducing, stable or increasing in number, and secure from threats, with minimum of 100 mature individuals per population for long-lived perennials. Each of these populations must persist at this level for at least 5 consecutive years before downlisting is considered.	Presently, 830 progeny from cuttings and seeds, representing the full range at Kapolei have been propagated and planted at two outplant sites (Kaena Point and Honouliuli) and at Koko Crater Botanical Garden, which serves as a repository for the full genetic range of the Kapolei population. The next outplant site is anticipated to be on State land at Diamond Head Monument. Additional sites are being evaluated and will be selected for outplanting after all clearances are received. The goal is to achieve at least three sites which meet the success criteria described herein.
Delisting	Taxon may be delisted when a total of 8 to 10 populations are documented on Lanai and at least one other island where it now occurs or historically occurred. Each of these populations must be naturally reproducing, stable or increasing in number, and secure from threats, with a minimum of 100 mature individuals per population for long-lived perennials. Each population should persist at this level for at least five consecutive years before delisting is considered.	The funding for the HCP is provided by DOT and implementation of the HCP is by DLNR as described herein.

SECTION 6

Provide reasonable certainty that the ecosystems, natural communities, or habitat types will be maintained in the plan area, throughout the life of the plan, in sufficient quality, distribution, and extent to support within the plan area those species typically associated with the ecosystems, natural communities, or habitat types, including any endangered, threatened, proposed, and candidate species known or reasonably expected to be present in the ecosystems, natural communities, or habitat types within the plan area.

The ecosystems, natural communities or habitat types of the Kapolei property are described in Section 1(b). Studies by Nagata (1996) and Char (1997, 1997, 2003, 2004) indicate that, for the most part, the landscape and ecological conditions are typical of fallowed sugarcane fields at other Oahu locations. It should also be noted that other listed, endangered species have not been discovered in this area, and the interdependency of any organism with *A. menziesii* has not been established at this point.

As described in Section 3, Strategies (1) and (4), the establishment of three new outplant wild populations is a major goal of this HCP, as such, there will ultimately be three "plan areas". Several more potential outplant sites are planned, in order to achieve a minimum of three successful sites.

A primary purpose of the Interim Management Program was to preserve the genetic resource at the Kapolei population and to test the viability of outplanting at appropriate offsite locations. This represents the initial task towards providing a reasonable certainty that the natural Kapolei community of *A. menziesii* will be maintained. The initial results of the Interim Management Program are a positive indication that new plants can successfully be grown from seeds and cuttings and potentially, new populations can be established at appropriate offsite locations to maintain a habitat for this species. At the Kaena Point outplant site, a coastal strand community including approximately 20 native species has been initiated and seedling recruitment has been reported.

The initial results indicate that with continued management there is reasonable certainty that *A. menziesii* from the original Kapolei population could be established as a natural community. However, a final assessment will require continued management over time.

SECTION 7

Contain objective, measurable goals, the achievement of which will contribute significantly to the protection, maintenance, restoration, or enhancement of the ecosystems, natural communities, or habitat types; time frames within which the goals are to be achieved; and provisions for monitoring (such as field sampling techniques) and evaluating progress in achieving the goals quantitatively and qualitatively.

(7a) Objective, measurable goals, the achievement of which will contribute significantly to the protection, maintenance, restoration or enhancement of the ecosystems, natural communities, or habitat types

The primary objective of the HCP is the continued survival of the Kapolei genetic stock of *Abutilon menziesii* through the establishment of three offsite wild populations and one offsite repository site from the degraded canefield population at Kapolei. To achieve this goal, several sites will be outplanted, managed, and monitored for a period of five years before a determination is made whether a site has met the success criteria described herein. The short- and long-term goals are summarized in Table 13:

Table 13. HCP Short-term and Long-term Goals

	Goals
Short-Term Goals	1) Propagate the full complement of lineages of the in situ Kapolei population of *Abutilon menziesii*. 2) Establish a cultivated repository of the full complement of lineages of Kapolei *A. menziesii* at Koko Crater Botanical Garden. 3) Establish two test outplantings of *A. menziesii* at appropriate sites. 4) Represent the full complement of lineages of the in situ Kapolei population at all sites. 5) Establish and maintain an 18-acre contingency reserve area within the Kapolei population until the short-term success criteria are met at one wild outplant site.
Long-Term Goals	1) Maintain three new stable wild populations of *A. menziesii* by out-planting at several (more than three) appropriate sites. 2) For each wild population maintain an effective population of 120 flowering and seed producing plants (minimum of 100 mature individuals) over the term of the HCP. This number will assure an approximate 75 to 100 percent increase of the original population in each location and is five times that recommended by the Hawaii and Pacific Plants Recovery Coordinating Committee (as cited in USFWS 1998). 3) Monitoring of the outplanted populations will be conducted to determine progress toward attaining population stability. 4) The goal for seedling survival rate will be on average in the 10 - 25 percent range over a five year period taking into consideration the many variables related to achieving stability of reintroduced populations. "Survival rate" is defined as survival of individual plants for a minimum of one year. 5) Natural recruitment shall occur in all wild populations not dependent upon artificial management such as irrigation.

(7b) Time frame within which goals are to be achieved

At this time, the goals are anticipated to be achievable within the 20-year timeframe of the HCP. Following the 20-year period of active implementation and management, subsequent monitoring and any necessary management actions would be undertaken through a separate agreement with DLNR (or other qualified organization), for a period of time to be specified by DLNR and the Endangered Species Recovery Committee, until the final determination is made that the three outplant sites are firmly established.

(7c) Provisions for monitoring and evaluating progress in achieving the goals quantitatively and qualitatively

The criteria to measure success of the HCP actions include short-term, long-term, and overall criteria as described in Table 14.

Table 14. Measurable Criteria for Monitoring and Evaluating Progress of Goals

	Success criteria
Measurable Short-Term success criteria	1) At least 25% of the full complement of lineages outplanted in a population must survive for 2 years after irrigation is ceased. 2) During the first 5 years after each wild population is established there must be (a) recruitment of seedlings that survive through the dry season, and (b) seed production by at least 25 % of the full complement of outplanted lineages after irrigation is ceased.
Measurable Long-Term Success Criteria	1) At least 80 reproducing adult plants will be present in each population, averaged over a five-year period after irrigation is ceased. 2) The number of seedlings recruiting into the mature age class must be greater than the mortality rate of existing adult plants, averaged over a five-year period after irrigation is ceased.
Overall Success Criteria	If both Long-Term Success Criteria are met and there are more than 120 reproducing adult plants present at the end of a 5-year period at a site (including at least 40 plants recruited from the seed bank on site) then no additional management action will be required for that site as part of the HCP and only monitoring need continue over the following 5-year period.

Strategies which have been completed or are in progress - including Strategies (1) and (4) - have demonstrated promising initial results of the HCP actions. Approximately 850 plants have been propagated by DLNR and outplanted to three sites. At this time the 1,000 percent increase in total number of Kapolei-derived plants over the original baseline of 93 plants is a positive preliminary indicator of establishing three ex situ wild populations.

An annual reporting process is required by Chapter 195D-21(f), HRS, which states, "Participants in habitat conservation plan shall submit an annual report to the department within 90 days of each fiscal year ending June 30, that includes a description of activities and accomplishments, analysis of the problems and issues encountered in meeting or failing to meet the objectives set forth in the HCP, areas needing technical advice, status of funding, and plans and management objectives for the next fiscal year, including any proposed modifications thereto." In addition, monitoring will occur throughout the term of the HCP (as described in Section 8 below) and a report will be issued annually with a major assessment at each 5th year increment.

DOT intends to engage the services of DLNR to implement the strategies described in this HCP. DLNR, through the implementation of Strategy (1), has demonstrated the viability of propagating *Abutilon menziesii* and documented this in a progress report (Appendix F) and a final report (Appendix G).

SECTION 8

Provide for an adaptive management strategy that specifies the actions to be taken periodically if the plan is not achieving its goals.

Adaptive management is a strategy that allows for the change of management activities described in the HCP to ensure that the goals and accompanying success criteria of the HCP are achieved. Information from monitoring activities and other sources (e.g., research) will be used to evaluate whether the biological goals and success criteria of the HCP are being achieved and may be used to refine the design, scope, or implementation of the management actions described in the HCP.

Monitoring of the outplanting sites, which are intended to be self-sustaining, wild populations of *Abutilon menziesii*, as well as propagation and outplanting methods, and an examination of threats will be conducted to determine progress toward attaining the short-term and long-term goals and success criteria of the HCP. Monitoring will also be conducted of the Kapolei population of *A. menziesii* to track (e.g., survival, mortality, reproduction) live plants, including new recruits, remaining on site in order to maintain a complete representation of the genetic diversity of this population. Modifications to the management of the Kapolei population and outplanting sites will be made based on the results of the monitoring program and as research results in new information regarding *A. menziesii* (e.g., crucial ecosystem components, growth aspects, reproductive viability, outplanting methods, threat control methods, salt tolerance, genetics, seed bank dynamics).

The monitoring protocols are for various aspects of the HCP, as modified from the Makua Implementation Plan's Appendix E. Each monitoring protocol provides a description of the: 1) monitoring objectives; 2) monitoring methods and data analysis; 3) monitoring activity; and 4) potential management activities to be implemented in response to the information gathered.

Final decisions to change certain management actions will be approved by the DOT and DLNR DOFAW. DLNR DOFAW will determine which actions require additional recommendations by the ESRC.

There are five monitoring protocols which are described below:

- ***MONITORING PROTOCOL 1 – Monitor Individuals of Abutilon menziesii in the Kapolei Population***
- ***MONITORING PROTOCOL 2 – Conduct Phytosanitation Monitoring in Greenhouse Facilities***
- ***MONITORING PROTOCOL 3 – Assess Status and Stability of Outplanted Populations***
- ***MONITORING PROTOCOL 4 – Conduct Phytosanitation Monitoring at Outplanted Populations***
- ***MONITORING PROTOCOL 5 – Monitor Success of Outplanted Individuals***

The monitoring protocols are described in detail below.

MONITORING PROTOCOL 1 – Monitor Individuals of Abutilon menziesii in the Kapolei Population

Type of activity: Monitoring – As a goal of the Habitat Conservation Plan for *Abutilon menziesii* at Kapolei ("HCP") to provide a complete representation of the genetic diversity and survival of the Kapolei population of *A. menziesii*.

Description: Conduct monitoring of the survival of the Kapolei population; to determine phenology; and to collect propagules for storage, propagation, or experimentation.

Applicable for: *Abutilon menziesii* within the Kapolei population.

Management goals: Determine a window when collection of propagules is highly probable. Successfully collect an adequate number of propagules to achieve the goals for the HCP (e.g., complete representation of the genetic diversity of the Kapolei population). Manage to maintain the existence of the Kapolei population (i.e., survival of existing individuals and additional recruits until take occurs).

Preliminary sampling objectives: Be sure that the window for collection will ensure successful seed collection if plants reproduce.

Management response: Adjust schedule according to phenology patterns of *A. menziesii* for seed collection.

Area to monitor: The Kapolei population of *A. menziesii*, with the purpose of locating mature individuals from which propagules will be collected.

Monitoring framework: Conduct a complete survey of all individuals in the Kapolei population to determine if or when they would be flowering or fruiting.

Data to collect: Data will be collected following the Hawaii Rare Plant Restoration Group ("HRPRG") rare plant monitoring format. Record location information (map and/or GPS coordinates) as needed for any new mature individuals of *A. menziesii* found in the Kapolei population.

1. Record reproductive status of all individuals – record presence of fruit (mature or immature), and flower (buds or opened) and numbers of individuals with each.

2. Collection information – Record any collections made, assign numbers to plants sampled, designate purpose for collection before collecting. This information should follow all propagules throughout its life.

Data analysis methods: No statistical analyses are needed for this protocol. All data resulting from the field surveys should be entered into a database and GIS.
Data collection interval: Visit the Kapolei population quarterly to determine phenology or visit at

time of year when reproduction expected.

MONITORING PROTOCOL 2 – Conduct Phytosanitation Monitoring in Greenhouse Facilities

Type of activity: Monitoring - A component of the HCP to establish three wild, self-sustaining *A. menziesii* populations on Oahu.

Description: Maintain phytosanitation monitoring at the nursery designated for out-planting to ensure it is not contaminated with new pathogens or other pests of concern (Appendix 2.2 Phytosanitation Standards and Guidelines from the Makua Implementation Plan may be used as a reference).

Applicable for: Plants to be outplanted as part of establishing a wild, self-sustaining population of *A. menziesii* on Oahu.

Management goal: To prevent any introduction of pathogens or other pests of concern from the greenhouse (*ex situ*) environment into the out-planted site.

Preliminary sampling objectives: Be certain that pathogens or other pests of concern do not visibly contaminate the majority of the greenhouse plants proposed for outplanting.

Management response: If pathogens or pests are discovered within the lot of plants designated for outplanting, treat all of the plants with an appropriate pesticide and quarantine for longer period of time; reexamine the plants prior to any future outplanting.

Group to monitor: All of the individual plants proposed for outplanting.

Monitoring framework: Examine all individual plants proposed for outplanting.

Data to collect:

1. Presence or absence of pathogens or pests of concern – Record outbreaks of pathogens or pests of concern.

2. Identify type of pathogen present – Identify type of pathogen present. If pathogen is not controlled, then make a further identification by identifying pathogenic symptoms, document via photo and collect sample for analysis.

Data analysis methods: No statistical analyses are needed for this protocol. However, it is essential that a proper random sample be taken of all of the plants that are in the proposed outplanting lot unless all plants are to be examined.

Data collection interval: Data must be collected during the growing period and prior to outplanting. Monitoring should be conducted during the life of the plant in the propagation growing facility at least bi-weekly. The sampling must be done just before planned outplanting date because any lag between inspection and planting may allow for new pathogens to become established.

MONITORING PROTOCOL 3 – Assess Status and Stability of Outplanted Populations

Type of activity: Monitoring - A component of the HCP to establish three wild, self-sustaining *A. menziesii* populations on Oahu.

Description: Conduct initial baseline survey and continuing monitoring program for *A. menziesii* within each outplanted population to assess its status relative to the goals and success criteria identified in the HCP. Additionally, determine if the demographic structure of each outplanted population will be able to meet the overall goal and long-term success criteria of the HCP. Data will be collected on the distribution, abundance, status (vigor), population structure, and phenology of plants sampled, as well as evidence of damage by alien animal species (e.g., insects, rats, slugs) within an outplanted population.

Applicable for: Each outplanted population of *A. menziesii* on Oahu intended to be a wild, self-sustaining population.

Management goal: Manage each outplanted population to achieve the specified number of mature, reproducing individuals, and duration as specified in the HCP.

Preliminary sampling objectives:

1. Be certain that the number of mature plants capable of reproduction in each outplanted population is equal to or greater than the minimum number specified in the HCP to achieve the short-term success criteria.
2. Determine if demographic structure of outplanted population appears to be adequate to sustain a viable population of *A. menziesii* over time based on comparison of number of individuals in life-stage classes with predicted model of a stable population for *A. menziesii*.

Management response: If population stability is not achieved, one or more of the following responses are appropriate: 1) continue with the same management program for a longer time, 2) intensify threat control, 3) implement species augmentation, or 4) select another location to establish a wild, self-sustaining population.

Area to monitor: Systematic survey of all of the individuals in each outplanting population. Individuals must be within 500 meters of another plant of the same taxon to be considered to be part of that population.

Pilot studies: It is important to emphasize that the suggestions that follow regarding monitoring framework, data to collect, and data analysis methods are preliminary suggestions that need to be developed following completion of pilot studies in the outplanting populations. Pilot studies will be used to collect data that will be used to refine the protocol relative to variables which will be sampled, plot size and shape, sampling framework, number of samples to be taken, monitoring interval, and data analysis methods to be used.

Sample unit: Outplant population.

Monitoring framework: Either of several survey strategies may be used initially to establish the monitoring framework for this protocol. Continue to use that strategy for subsequent monitoring of the population.

1. Census of plants in the outplanted population. All individuals within an outplanted population will be located and data collected as specified below.

Data to collect: The fields described below are included in the HRPRG's Rare Plant Field Data Form, which may be used for data collection in this monitoring protocol.

1. Location of individuals – this would be quadrat number if sampling conducted along contiguous-plot belt transect, or GPS coordinates (UTM Zone 4, NAD 83 datum base) if using cluster sampling strategy. Some of the individuals in the population may be uniquely identified and tagged to help with collection of propagules or to allow for the collection of data on the progress of individuals through size or stage classes. Where GPS points cannot be used to locate individuals, the position of individuals will be hand-drawn in relationship to local landmarks and topography.

2. Number of individuals - use the following life-stage classes as defined for *A. menziesii*: *seedlings*; *immature individuals*; and *reproductively mature individuals*. Each of these classes must be determined for *A. menziesii*. For most outplanted populations, all of the mature plants will be located and counted.

3. Vigor of all individuals in the following classes: *healthy* – foliage appears green and vigorous, less than 10% dead leaves or defoliation; *moderate* – some chlorosis or deformity (e.g., curled, extremely small, insect damage) may be seen in the leaves, 10-50% dead leaves or defoliation; *poor* – most leaves may be dead or chlorotic or deformed, 50% dead leaves or defoliation; *dead* – no live foliage or woody tissue.

4. Evidence of damage from alien animals: data will also be recorded on the presence or sign of damage on the sampled plants from alien animals, particularly invertebrates, rats, or slugs.

5. Phenological stage: record data on the presence of *buds, flowers, immature fruits, mature fruits,* or *vegetative state* for each plant, or if the plant is *vegetative*, or *dormant*. This information will be summarized for the population as a whole.

Data analysis methods:

1. In many cases all of the individuals within an outplanted population will be enumerated so direct comparisons of the resulting numbers will be made with the specified short-term and long-term goals and success criteria of the HCP.

Data collection interval: Data should be collected on the status of each outplanted population annually. It would be ideal if data collection could coincide with time of fruiting by the plants to better evaluate seed set and to allow for collection of additional propagules, if needed, at the same

time. In any case data should always be collected at the same month of the year for a specific outplanted population.

MONITORING PROTOCOL 4 – Conduct Phytosanitation Monitoring at Outplanted Populations

Type of activity: Monitoring - A component of the HCP to establish three wild, self-sustaining *A. menziesii* populations on Oahu.

Description: Maintain baseline inventory for pathogens at outplanted populations and phytosanitation monitoring on outplanted individuals to determine if they are contaminated by new pathogens or other pest species of concern (Appendix 2.2 Phytosanitation Standards and Guidelines from the Makua Implementation Plan may be used as a reference).

Applicable for: All outplanting sites on Oahu and outplanted individuals of *A. menziesii*.

Management goal: To detect and control any introduction of a pathogen from the greenhouse (*ex situ*) environment into the outplanted site.

Preliminary sampling objectives: Be certain that all outplanted individuals are not visibly contaminated by pathogens or other pest species of concern, and other individuals within the vicinity of the outplanting site are not contaminated above the baseline as a result of the outplanting. Pathogens or pest species of concern must be identified by an expert.

Management response: If pathogens or other pest species of concern are discovered on outplanted individuals, there are options: 1) eliminate the problem with an appropriate control technique and continue to monitor in the field, or 2) remove contaminated plants from reintroduction site and treat the contaminated planting sites with an appropriate pesticide to eliminate the problem in the field. Additionally, if contaminated plants are found in the field, it is necessary to reevaluate the greenhouse phytosanitation monitoring protocol to determine why it failed and to make modifications to that protocol if needed.

Group to monitor: All of the individual plants that were outplanted, as well as a sample of other plant taxa within the outplanting area.

Monitoring framework: 1) Examine all individual plants that were outplanted. 2) Conduct a pilot study to determine the extent and number of plants to be examined for pathogens or other pest species of concern within the study area.

Data to collect:

1. Presence or absence of pathogens or pests of concern – Record outbreaks of pathogens or pests of concern.

2. Identify type of pathogen present – Identify type of pathogen present. If pathogen is not controlled, then make a further identification by identifying pathogenic symptoms, document via photo and collect sample for analysis.

Data analysis methods: No statistical analyses are needed for this protocol.

Data collection interval: Data should be collected on the status of plants at each outplanting site monthly for the first three months and then every three months to complete first year.

MONITORING PROTOCOL 5 – Monitor Success of Outplanted Individuals

Type of activity: Baseline survey and monitoring – A component of the HCP to achieve the short-term and long-term goals and success to achieve three wild, self-sustaining populations *A. menziesii* populations on Oahu.

Description: Monitor germination and/or survival, growth, reproduction, and phenology of all individual plants that have been outplanted or introduced as seeds for *A. menziesii* in an area. The results of this short-term monitoring will be used to develop or refine techniques that maximize the survival of individual plants that are outplanted into the wild. Additionally the information will be the basis for determining how many individuals need to be planted if augmentation of the outplanted population is needed.

Applicable for: Plants or seeds outplanted to sites intended to meet the goal of being a wild and self-sustaining population. Monitoring may be focused on determining germination or survival and growth of all individuals outplanted.

Management goals: 1) Determine germination and/or survival of plants, and 2) document horticultural methods used for propagation and outplanting (i.e., cuttings, mound layering, seeding, size of pot, etc.).

Preliminary sampling objectives: 1) Track lineages of outplanted individuals to aid in determining if complete genetic diversity of the Kapolei population is represented in the outplanted populations. 2) Track survival rate of outplanted individuals.

Management response: 1) The results of monitoring plant growth relative to the different horticultural treatments will be used to help predict or refine the results of the plant survival analysis. The results of the analysis of survival will also be used to determine or refine the projected number of individuals to outplant for *A. menziesii* to achieve a specified number of plants that will become part of the reproductive pool.

Area to monitor: Complete outplanted population.

Monitoring framework: All outplanted individuals will be maintained.

Data to collect:

1. Percent germination of planted seeds: When seeds are planted as a outplanting strategy, the number of individuals that germinate will be counted in a specific seed sowing block within the

outplanted site. Percent germination will be calculated by dividing the number of germinants by the total number of seeds planted.

2. Vigor will be recorded for all sampled individuals in the following classes: *healthy* – foliage appears green and vigorous, less than 10% dead leaves or defoliation; *moderate* – some chlorosis or deformity (e.g., curled, extremely small, or insect damage) may be seen in the leaves, 10-50% dead leaves or defoliation; *poor* – most leaves may be dead or chlorotic or deformed, 50% dead leaves or defoliation; *dead* – no live foliage or woody tissue.

3. Phenological stage: Record data if the plant is vegetative, reproductive, or dead.

4. Damage to Plants: Any obvious damage to the plants from ungulates, rodents, or insects will be identified and recorded when each of the sampled plants is examined and measured. This information may be useful in helping to understand reduced vigor or death of some of the plants that have been outplanted.

Data analysis methods:

1. Data collected in general will be used as a measure of the short- and long-term goals and the measurable short- and long-term success criteria, and vigor or survival of individual plants will be analyzed using a **contingency table design.**

Data collection interval: The first data collection time for this protocol will be just prior to moving plants out of the greenhouse and into the outplanting sites. During the first six months, data on germination (if seeds are used for outplanting) and/or survival of the plants will be assessed at least three times during this initial period. The next sampling time will be 12 months after seed sowing or planting, and thereafter the plants will be monitored annually.

Adaptive management options to consider include, but are not limited to:

- increasing or decreasing the number of plants outplanted into a site annually during the initial reintroduction phase
- (re)initiating reintroduction or augmentation efforts for a particular population unit;
- intensifying or changing post-planting care (*e.g.*, watering)
- increasing or decreasing the control of specific threats as indicated by threat monitoring

Final decisions to change management actions must be approved by the DOT and DLNR DOFAW. In addition, detailed adaptive management strategies will continue to be prepared in consultation with DLNR and USFWS.

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Appendix A
Biological Survey
K. Nagata
(September 1996)

EAST KAPOLEI MASTER PLAN

BIOLOGICAL SURVEY

Prepared by: Kenneth M. Nagata
For: PBR Hawaii
17 September 1996

INTRODUCTION

The project site occupies approximately 1300 acres in Honouliuli, Ewa District, Oahu. It encompasses the former sugar cane lands mauka of Varona Village from approximately 60' elevation, up to Farrington Highway. Two sections extend mauka to the H-1 Freeway. The west is bordered by the Kapolei development and the east boundary runs through abandoned sugar cane fields.

Ripperton and Hosaka (1942) classified the vegetation of the region as one of lowland shrub with a coastal fringe of kiawe trees (Prosopis pallida). Because of the arid conditions of the region the vegetation cover is generally sparse. Dominant shrubs include klu (Acacia farnesiana), koa-haole (Leucaena leucocephala) and 'ilima (Sida fallax) and the herb layer generally consists of annual grasses such as bristly foxtail (Setaria verticillata), swollen fingergrass (Chloris barbata) and feather fingergrass (Chloris virgata). In the foothills mauka of the flat lowlands where rainfall is more abundant the vegetation is denser and the herb layer includes Spanish needle (Bidens pilosa), false mallow (Malvastrum coromandelianum), cockelbur (Xanthium strumarium) and pili (Heteropogon contortus) in addition to the annual grasses of the lowlands.

Several recent surveys have been conducted in certain portions of the subject property and in the adjacent lands. In 1990 Funk completed a biological survey of the land immediately east and makai of the project site, including the village of Ewa (Funk 1990). Among the vegetation types recognized were Sugar Cane Fields, Ruderal Fields and Fallow Fields. These communities were characterized by actively cultivated sugar cane fields, abandoned cane fields, common "weedy" introduced plants and lowland wayside species including those mentioned by Ripperton and Hosaka (1942). Similar vegetation was found in the region immediately east of the subject property where common wayside species including koa-haole, Guinea grass (Panicum maximum) and cultivated and abandoned sugar cane fields were found to be prevalent (Funk 1994). Many of these same species were also present in the area between Varona Village and the golf course just makai of the project site (Nagata 1996) and in Kaloi Gulch (Nagata 1994).

METHODS AND MATERIAL

A walk-through survey was conducted in all plant communities between mid-September and early October, 1996 to determine the floristic compostition of the project site. Transects were established throughout the site and all plants observed were recorded and their relative abundance determined. In conjunction

with the plant survey a cursory inventory of animals was also made. All birds and mammals observed along the transects were recorded and listening posts were established at regular intervals. No quantitative analyses was attempted, however, and nests were not investigated.

RESULTS

FLORA

Virtually all of the lowlands and foothills in the Ewa-Honouliuli region has been altered by the cultivation of sugar cane. In the past several years certain lands have been taken out of sugar and put to other use, eg. diversified agriculture, urbanization, fallowing. Consequently, the vegetation of these lands are entirely secondary and the vegetation in the region is largely determined by the history of cultivation (or disturbance) on each individual parcel of land, ie. how long the cane field has been abandoned, whether the land was recently tilled, etc. Based mostly on these criteria, eight plant communities were recognized. Although these are drawn with discreet boundaries on the vegetation map it must be remembered that such finite boundaries do not exist in nature. Rather, each community exists as a continuum wth one blending into another. Furthermore, the survey was conducted during the dry season. Species composition and vegetational cover will differ somewhat during the rainy season.

Abandoned Cane Fields (ACF)

This is the largest vegetation type in the project site, representing the most recently abandoned sugar cane fields. Here, sugar cane generally accounts for about 50% of the total vegetational cover. In some areas the cane is 15' tall, robust and still very dense. In most areas, however, the cane is senile, less than 7' tall and accounts for as little as 30% of the total vegetational cover. In fields that have been abandoned for a longer period or where growing conditions were not optimal the clumps of cane are mostly dead or dying. Even in these fields these decrepit clumps are still in distinct rows. The vegetation between clumps usually consist of a mixed herb cover of 'ilima, Guinea grass, radiate fingergrass (Chloris radiata), 'uhaloa (Waltheria indica), hoary abutilon (Abutilon incanum), fuzzy rattlepod (Crotalaria incana), peria (Momordica charantia var. abbreviata) and nut grass (Cyperus rotundus). Total vegetational cover is generally about 75-90%; only where the cane is vigorous and dense is the cover up to 100%.

In some areas such as along the Ewa boundary fence the abundance of cane

is very low and the vegetation approaches that of the Fallow Fields. Here the vegetation is more open with more exposed ground. 'Ilima, 'uhaloa, peria, hoary abutilon and little bell (Ipomoea triloba) are abundant.

Fallowed Fields

The Fallowed Fields are those sugar cane fields which have been abandoned for such a long time that almost no living cane remain. Dead and dying clumps generally constitute less than 5% of the total cover. Dead cane stalks may litter the ground and planting furrows may still be evident but these fields are often difficult to recognize as sugar cane fields without close examination. Two Fallowed Fields subcommunities were recognized depending on the relative abundance of grasses.

(2) Fallowed Fields Mixed Herb Association (Fmh)

Typically the vegetation in this community is less than 4' tall and consists of a mixture of 'uhaloa, radiate fingergrass, 'ilima, hoary abutilon, false mallow, buffelgrass (Cenchrus ciliaris), golden crown-beard (Verbesina encelioides) and coat buttons (Tridax procumbens). Small isolated stands of dying cane occur in certain portions of this community. Small patches of Guinea grass and/or radiate fingergrass can also be found. These grasses along with swollen fingergrass (Chloris barbata), sourgrass (Digitaria insularis) and Natal redtop (Rhynchelytrum repens) are especially common in the mauka portions of this community. Along the road delineating the makai boundary the vegetational cover is only about 50%. Pa'uohi'iaka (Jacquemontia ovalifolia) is common in this open area. Several stands of dead or dying cane also occur here.

(3) Fallowed Fields Grassland Association (Fg)

In certain areas the fallowed cane fields are dominated by Guinea grass and/or radiate fingergrass. Almost no standing cane remain although the furrows are still more or less intact and fallen cane stalks are occasional throughout the community. In most areas the grass cover is 100% but small communities and individuals of 'ilima, hoary abutilon and false mallow are scattered through certain portions and swollen fingergrass and sourgrass are common in other areas.

(4) Abandoned Fields (A)

Several former cane fields in the mauka portion along Palehua Road and between Farrington Highway and the H-1 Freeway have been tilled or graded sometime in the past. The ground is quite level with few stones and although some sugar cane is resprouting the planting furrows are gone. These fields were probably planted in some crop in years past but are now overgrown with mostly 'uhaloa, fuzzy rattlepod,

nut grass and little bell. In one field mauka of Farrington Highway Guinea grass is abundant but in most of the Abandoned Fields this species is not quite so prevalent. Re-sprouting sugar cane is also common in the mauka portion of this field. Golden crown-beard, peria and hoary abutilon are common in some of the fields.

(5) Cultivated Fields (C)

Cultivated Fields are fields which have been recently plowed, actually planted in a crop (other than sugar cane), or which have been put to some urban use. Of the five fields designated as Cultivated Fields, three have been recently plowed. The vegetation in these consist mostly of seedling little bell, peria, fuzzy rattlepod, 'uhaloa, castor bean (Ricinus communis), graceful spurge (Chamaesyce hypericifolia) and re-sprouting nut grass. Vegetational cover is about 25-50%. In two fields watermelons (Citrellus lanatus) have been planted and along the Ewa boundary fence an approximately two-acre site has been graded and turned into a parking lot. Approximately half of this field has been paved with gravel. Most of the vegetation in this portion consist of Amaranthus viridis and nut grass. The vegetation in the ungravelled portion consist of peria, nut grass, 'uhaloa, radiate fingergrass, false mallow and re-sprouting sugar cane.

(6) Grasslands (GR)

Grasslands represent those lands which apparently have not been tilled, graded or planted in any crop including sugar cane. This community exists only on the steepest slopes just makai of the H-1 Freeway and is the smallest of all the vegetation types in the project site. The vegetation is one of Guinea grass 1-2' tall with emergent klu, koa-haole, and kiawe. On eroded slopes, 'ilima, false mallow, 'uhaloa, Beorhavia coccinea, garden spurge (Chamaesyce hirta) and virgate mimosa (Desmanthus virgatus) are found in small numbers.

(7) Gulch Association (GU)

Kaloi Gulch together with its tributary Hunehune Gulch represents the only natural drainage system in the project site. The vegetation in the gulches is characterized by extremely dense stands of Guinea grass 5-10' tall. So dense is this layer that very few other species are present. In the makai portion the predominant arborescent species is castor bean which grows to about 15' height. Koa-haole 20-30' tall replaces castor bean as the dominant overstory in the mauka sections of the gulch system. In the mauka portion of Hunehune Gulch ivy gourd (Coccinea grandis) is abundant, often completely enshrouding the Guinea grass and koa-haole. Paragrass (Brachiaria mutica), wood rose (Merremia tuberosa),

moon flower (Ipomoeaalba) and peria are also found but only in small to moderate numbers.

(4) Roadside Vegetation (R)

Numerous plant species are found along the paved and gravel roads. More species are found in this community than in any other in the project site. Guinea grass and radiate fingergrass are abundant. 'Uhaloa and nut grass are also found in large numbers and many other species including castor bean, fuzzy rattlepod, buffelgrass, graceful spurge, virgate mimosa, peria, lion's ear (Leonotis nepetifolia), Australian saltbush (Atriplex semibaccata), goosegrass (Eleusine indica), Natal redtop (Rhynchelytrum repens) and stinkgrass (Eragrostis cilianensis) are found in smaller numbers. This is not considered a significant plant community and its total area is very small.

Native Plant Communities

As a result of decades of sugar cultivation, virtually all of the vegetation in the project iste is secondary in nature. Of the 99 plant species recorded two are indigenous ('ilima, pa'uohi'iaka), two are probably indigenous ('uhaloa, hoary abutilon) and one is endemic (ko'oloa'ula; Abutilon menziesii). Of these, 'ilima, 'uhaloa and hoary abutilon are dominant or co-dominant in several plant communities and are significant elements in the vegetation in the site as a whole. Pa'uohi'iaka is found in small to moderate numbers in four vegetation types and is common in certain areas in the Fallowed Fields Mixed Herb community. It frequently grows in association with 'ilima, 'uhaloa and hoary abutilon. They do not, however, represent native plant communities. Rather, these native or possibly native species are well adapted to arid lowlands and are able to recolonize disturbed sites.

Except for ko'oloa'ula, all of the native species in the site are common lowland species in Hawaii. Ko'oloa'ula, on the other hand, is a rare and endangered species once endemic to Lanai, Maui, Oahu and Hawaii. It is now extinct on Hawaii.

Endangered Species

At least 38 individuals of the federally listed endangered species ko'oloa'ula were recorded from the site. Most of these (28) were in the Abandoned Cane Fields, six were in the Fallowed Fields Mixed Herb Association and four were in the Fallowed Fields Grassland Association. Approximate locations are indicated on Figure 2. All of these plants were healthy and most were flowering and/or fruiting.

Ko'oloa'ula was first submitted for listing as an endangered species in 1976 (Fed. Reg. 1976). The Endangered Species Act Amendments of 1978 required that the list of candidates for endangered status be withdrawn after two years and in 1979 ko'oloa'ula was withdrawn from consideration (Fed. Reg. 1979). In 1980 it was resubmitted as a top priority Category 1 Candidate (Fed. Reg. 1980) and in 1985 the U.S. Fish and Wildlife Service proposed to list it as an endangered species (Fed. Reg. 1985). On Sept. 26, 1986 it was formally listed (Fed. Reg. 1986) and is now protected under the provisions of the Endangered Species Act of 1973, as amended, and the Hawaii State Revised Statutes.

Significant wild populations of ko'oloa'ula are found on Lanai and Maui but its occurrence on Oahu is somewhat of an enigma. It was known from a single plant discovered in an abandoned sugar cane field mauka of Hawaii Raceway Track at Barbers Point in 1981 and more recently from another individual at the Lualualei Naval Magazine (D. Herbst, pers. comm.). Both of these occurrences as well as the current discovery are from highly disturbed environments. The Barbers Point location is approximately four miles from the project site and the Lualualei site is at least 15 miles away. Ko'oloa'ula was not found in any of the prior surveys in the immediate area (Funk 1990, 1994; Nagata 1994, 1996).

FAUNA

Mammals

No mammals were observed in the site. It is probable, however, that field mice (Mus musculus), mongoose (Herpestris auropunctatus) and one or more species of rats (Rattus spp.) are found in the property. In addition, pig trails were observed in several plant communities.

Birds

Seventeen species of birds were observed in the site. To be considered a sighting, the individual must be observed perched or on the ground and not merely flying overhead. In addition, owl pellets were found in the Fallowed Fields Grassland Association community. It is not known, however, whether these are from the barn owl (Tyto alba) or pueo (Asio flammeus). Fifteen species are introduced, one is a common migratory species (Pacific golden-plover) and one is indigenous (Black-crowned night heron).

ARDEIDAE

Cattle egret (Bubulcus ibid)

Eight individuals were observed in the Abandoned Fields mauka of Farrington

Highway. On 4 October the Abandoned Field community immediately makai of the Cultivated Field east of Palehua Road was being plowed. Nearly 100 cattle egrets were seen feeding in the freshly tilled ground.

Black-crowned night heron (Nycticorax nycticorax)

Two young birds were flushed out of Hunehune Gulch near Plantation Road. As there was no water in either Hunehune Gulch or Kaloi Gulch it is not known whether these individuals are residents of the area or whether they are transients. The black-crowned night heron is indigenous to Hawaii.

CHARADRIIDAE

Pacific golden-plover (Pluvialis dominica)

The Pacific golden-plover is a migratory species which commonly spends its winters in Hawaii. Many were observed in the site. Thirty-two were counted in exposed areas in the Abandoned Cane Fields. Most of these were in the open site near the Ewa boundary. Twenty-six were observed in various areas in the Fallowed Fields Mixed Herb Association - six of them from the exposed areas near the makai boundary road. Twenty-six were seen in the Cultivated Areas. Of these, 20 were in the "parking lot" at the Ewa boundary.

COLUMBIDAE

Rock dove (Columba livia)

Three were observed in the exposed sections of the Fallowed Field Mixed Herb Association in the makai portion of the site.

Barred dove (Geopelia striata)

Many were seen in all but two vegetation types. They were most abundant along the paved roads.

Lace-neck dove (Streptopelia chinensis)

This is the most widespread species in the property. It was found in moderate numbers in all vegetation types.

FRINGILLIDAE

Red-crested cardinal (Paroaria coronata)

Three individuals were seen in koa-haole shrubs along Plantation Road.

Kentucky cardinal (Richmondena cardinalis)

One individual was seen in the Fallowed Fields Mixed Herb Association.

PHASIANIDAE

Francolin (Francolinus sp.)

About a dozen were seen in the Abandoned Cane Fields near Kaloi Gulch in the makai portion of the property. These birds ran and hid too quickly for a positive identification to species.

Ring necked pheasant (Phasianus colchicus)

Three pairs were flushed from the Abandoned Cane Fields and one pair was flushed from the Abandoned Fields along Palehua Road.

PLOCEIDAE

House finch (Carpodacus mexicanus)

About 20 were seen in the property, mostly along the roadways.

Orange-cheeked waxbill (Estrilda melpoda)

These were seen in small numbers in the Fallowed Fields Mixed Herb Association, Abandoned Fields and along the roadways.

Black-headed mannikin (Lonchura malacca)

Black-headed mannikins were seen in moderate numbers in the Abandoned Cane Fields, Fallowed Fields communities and along the roadways.

Rice bird (Lonchura punctulata)

Rice birds were seen in moderate to small numbers in all but two plant communities. They were most common along the roadways and in the Fallowed Fields Grassland Association.

PYCNONOTIDAE

Red-vented bulbul (Pycnonotus cafer)

The red-vented bulbul was the second most widespread species in the site. It was found in small to moderate numbers in all vegetation types except the Cultivated Fields.

STURNIDAE

Common mynah (Acridotheres tristis)

Only three were seen in the Abandoned Cane Fields in the makai portion of the property.

ZOSTEROPIDAE

Japanese white-eye (Zosterops japonicus)

Japanese white-eyes were found in small numbers mostly along the roadways.

SUMMARY

The vegetation in the project site consists of sugar cane, lowland shrubs and herbs and grasses. The vast majority of the 99 species recorded from the property is non-native. Only three native species (one endemic, two indigenous) and two possibly indigenous species were encountered but with the exception of the endemic ko'oloa'ula these were present in moderate to large numbers. Native species constitute a rather significant element of the vegetation. However, no native plant communities are present. As a result of decades of sugar cultvation the vegetation is entirely secondary and the native ('ilima, pa'uohi'iaka) or possibly native (hoary abutilon, 'uhaloa) species which are so common in the site are merely recolonizing an already completely altered habitat. According the the U.S. Fish and Wildlife Service the endangered species ko'oloa'ula can also be included as secondary in origin.

The various plant communities in the site serve as an excellent refuge and feeding site for 17 bird species. Fifteen are introduced urban, field or game birds, one is indigenous (black-crowned night heron) and one is a common migratory species (Pacific golden-plover). Many of the birds including the plover are present in moderate to large numbers.

The proposed project will result in the loss of large numbers of 'ilima, pa'uohi'iaka, 'uhaloa and hoary abutilon. These are all common lowland species and theirs is not considered a significant loss to the native flora. The project will also result in the loss of habitat for a large number of Pacific golden-plovers and two black-crowned night herons. At least 38 individuals of the endangered ko'oloa'ula will be affected by the project. The disposition of these will be determined through consultation with the State of Hawaii Division of Forestry and Wildlife as prescribed by the Hawaii Endangered Species Law.

RECOMMENDATIONS

Because of the presence of the federally endangered ko'oloa'ula in the project site, consultation with the Hawaii State Department of Land and Natural Resources Division of Forestry and Wildlife is required under the provisions of the State Endangered Species Law before any grubbing can commence. Similar discussions with the U.S. Fish and Wildlife Service is also recommended. These consultations will essentially determine the fate of the proposed project and what mitigating measures will be required to preserve the ko'oloa'ula.

The plant survey was conducted at 80% coverage and although a more intensive search was conducted in the vicinity of each ko'oloa'ula there is a high probability that more individuals are present in the site. It is therefor recommended that a 100% survey be undertaken in selected areas as indicated in Figure 2.

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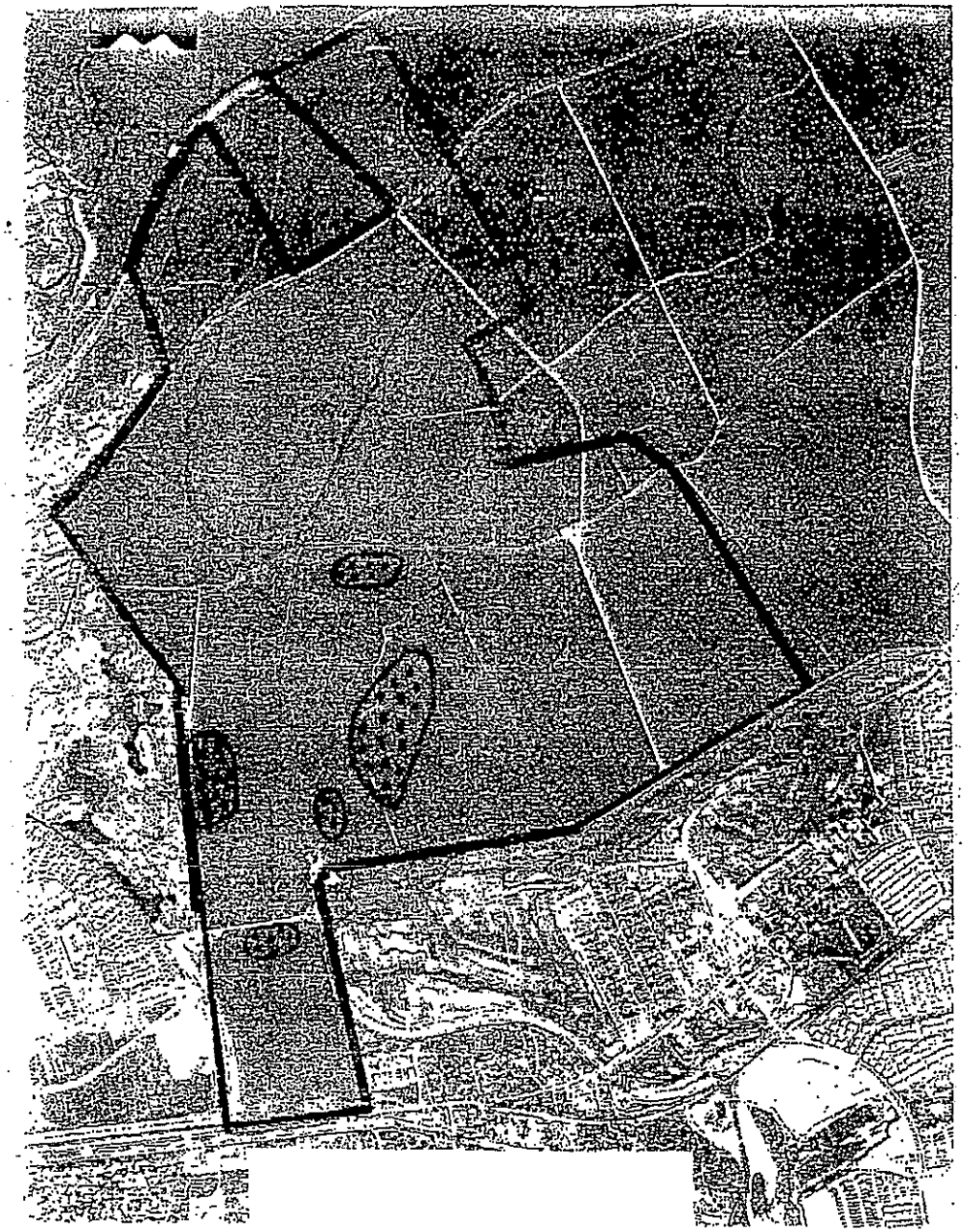

PLANT SPECIES CHECKLIST

Families are arranged alphabetically in two groups: Monocotyledons and Dicotyledons. Genera and species are arranged alphabetically within each family. Taxonomy, common names and status follow those of Neal (1965), St. John (1973) or Wagner et. al. (1990). The abundance determinations are relative and are subject to the judgement of the investigator.

EXPLANATION OF SYMBOLS

Species Status:

- E – Endemic to the Hawaiian Islands, ie. occurring naturally nowhere else in the world.
- I – Indigenous, ie. native to the Hawaiian Islands but also occurring naturally elsewhere.
- X – Exotic (alien), ie. plants introduced after the Western discovery of the islands.
- P – Polynesian introductions; ie. plants introduced before the Western discovery of the islands.

Relative Abundance Ratings:

- A – ABUNDANT, generally the major or dominant species in a given area.
- C – COMMON, generally distributed throughout a given area in large numbers.
- O – OCCASIONAL, generally distributed through a major portion of a given area, but in small numbers.
- U – UNCOMMON, observed uncommonly but more than 10 times in a given area.
- R – RARE, observed 2 to 10 times in a given area.

Vegetation Types:

- ACF – Abandoned Cane Fields
- Fmh – Fallowed Fields Mixed Herb Association
- Fg – Fallowed Fields Grassland Association
- A – Abandoned Fields
- C – Cultivated Fields
- GR – Grasslands
- GU – Gulch Association
- R – Roadside Vegetation

ANIMAL SPECIES CHECKLIST

Families are arranged alphabetically and genera and species are arranged alphabetically within each family. Taxonomy follows that of Berger (1981). Quantitative techniques were not employed and thus only presence is recorded in each vegetation type.

EXPLANATION OF SYMBOLS

Species Status:

- M – Migratory species.
- I – Indigenous, ie. native to the Hawaiian Islands but also occurring naturally elsewhere.
- X – Exotic (alien), ie. animals introduced after the Western discovery of the islands.

Vegetation Types:

- ACF – Abandoned Cane Fields
- Fmh – Fallowed Fields Mixed Herb Association
- Fg – Fallowed Fields Grassland Association
- A – Abandoned Fields
- C – Cultivated Fields
- GR – Grasslands
- GU – Gulch Association
- R – Roadside Vegetation

CHECK LIST OF PLANTS

SCIENTIFIC NAME	COMMON NAME	STATUS	RELATIVE ABUNDANCE							
			ACF	Fsh	Fg	A	C	GR	GU	R
CHECKLIST OF PLANTS										
MONOCOTYLEDONES										
CYPERACEAE										
Cyperus rotundus L.	Nut grass	X	C	C	G	C	C	–	–	C
POACEAE										
Bothriochloa pertusa (L.) A. Camus	Pitted beardgrass	X	U	U	U	–	–	–	–	U
Brachiaria mutica (Forssk.)Stapf	Paragrass	X	U	U	U	R	–	–	–	U
Cenchrus ciliaris L.	Buffelgrass	X	–	–	–	R	–	–	–	R
Chloris barbata (L.) Sw.	Swollen fingergrass	X	C	C	–	U	R	C	C	U
C. radiata (L.) Sw.	Radiate fingergrass	X	C	C	C	U	–	U	–	C
Cynodon dactylon (L.) Pers.	Bermuda grass	X	–	–	–	R	R	–	–	R
Digitaria insularis (L.) Mez ex Ekman	Sourgrass	X	U	U	U	U	–	–	U	U
Echinochloa crus-galli (L.) P. Beauv.	Barnyard grass	X	U	–	–	U	–	–	–	R
Eleusine indica (L.) Gaertn.	Goosegrass	X	U	–	–	–	–	–	–	U
Eragrostis ciliaensis (All.) Link	Stinkgrass	X	U	U	–	U	–	–	–	U
E. tenella (L.) P. Beauv. ex Roem. & Schult.	Japanese lovegrass	X	R	–	–	R	–	–	–	U
Leptochloa uninervia (K. Presl) Hitchc.		X	–	–	–	–	–	–	–	–
Panicum maximum Jacq.	Guinea grass	X	U	–	–	–	–	–	–	U
Rhynchelytrum repens (Willd.) Hubb.	Natal redtop	X	C	O	A	C	U	A	A	A
Saccharum officinarum L.	Sugar cane	X	O	O	R	R	R	–	R	O
Setaria verticillata (L.) P. Beauv.	Bristly foxtail	X	A	U	U	R	–	–	–	R
Sorghum halepense (L.) Pers.	Johnson grass	X	–	–	–	R	–	–	R	–
			–	–	U	U	–	–	–	U
DICOTYLEDONES										
AMARANTHACEAE										
Achyranthes aspera L.			U	U	–	–	–	–	–	–
Alternanthera caracasana Kunth	Mat chaff flower	X	–	R	–	–	–	–	–	R
Amaranthus spinosus L.	Spiny amaranth	X	U	U	–	U	C	–	–	C
A. viridis L.		X	U	U	–	U	C	–	–	C
ANACARDIACEAE										
Mangifera indica L.	Mango	X	–	–	–	–	–	–	–	R
Schinus terebinthifolius Raddi	Christmas berry	X	–	–	–	–	–	–	–	R
ASCLEPIADACEAE										
Calotropis gigantea (L.) W.T. Aiton	Crown flower	X	–	R	R	–	–	–	–	–
ASTERACEAE										
Bidens pilosa L.	Spanish needle	X	U	–	–	U	–	–	–	U
B. pilosa var. *minor* (Bl.) Sherff		X	U	–	–	–	–	–	–	U
Conyza bonariensis (L.) Cronq.	Hairy horseweed	X	U	–	–	–	–	–	–	U
Emilia fosbergii Nicolson	Flora's paintbrush	X	U	–	–	–	–	–	–	U
Flaveria trinervia (Spreng.) C. Mohr		X	O	–	–	–	–	–	–	R
Lactuca serriola L.	Prickly lettuce	X	–	–	–	–	–	–	–	R
Pluchea indica (L.) Less.	Indian fleabane	X	U	–	–	R	–	–	–	–
P. x fosbergii Cooperr. & Galang		X	U	U	U	–	–	–	–	U
P. symphytifolia (Mill.) Gillis		X	–	U	R	–	–	–	–	–
Sonchus asper (L.) J. Hill	Sourbush	X	U	U	U	–	–	–	–	U
	Prickly sow thistle	X	R	–	–	–	–	–	–	–

CHECK LIST OF PLANTS

SCIENTIFIC NAME	COMMON NAME	STATUS	RELATIVE ABUNDANCE							
			ACF	Fsh	Fg	A	C	GR	GU	R
ASTERACEAE										
Sonchus oleraceus L.	Sow thistle	X	R	–	–	U	–	–	–	–
Tridax procumbens L.	Coat buttons	X	U	U	U	U	U	–	–	U
Verbesina encelioides (Cav.) Benth. & Hook.	Golden crown-beard	X	U	U	–	U	R	–	–	U
Xanthium strumarium L.	Cocklebur	X	R	–	–	–	R	–	–	U
BIGNONIACEAE										
Spathodea campanulata Beauv.	African tulip	X	R	R	–	–	–	–	–	–
BORAGINACEAE										
Heliotropium procumbens var. *depressum* (Chan.) Fosb.		X	–	–	–	–	–	U	–	U
CAPPARACEAE										
Cleome gynandra L.	Wild spider flower	X	–	–	–	–	R	–	–	–
CHENOPODIACEAE										
Atriplex semibaccata R. Br.	Australian saltbush	X	–	–	–	R	–	–	–	U
A. suberecta Verd.		X	U	U	–	–	–	–	–	U
CONVOLVULACEAE										
Convolvulus arvensis L.	Field bindweed	X	U	U	–	–	U	–	–	U
Ipomoea alba L.	Moon flower	X	–	–	–	–	–	–	–	–
I. cairica (L.) Sweet	Asaji	X?	–	R	–	–	–	–	–	U
I. obscura (L.) Ker-Gawl.		X	U	U	–	–	–	–	–	–
I. triloba L.	Little bell	X	U	U	U	R	A	–	–	U
Jacquemontia ovalifolia (Choisy) H. Hallier	Pa'uohi'iaka	X	U	U	U	–	–	–	–	U
Merremia aegyptia (L.) Urb.	Hairy merremia	X?	U	U	–	U	U	–	–	–
M. tuberosa (L.) Rendle	Wood rose	X	–	–	–	–	–	–	R	–
CUCURBITACEAE										
Citrullus lanatus (Thunb.) Matsum. & Nakai	Watermelon	X	–	–	–	–	U	–	–	–
Coccinea grandis (L.) Voigt	Ivy gourd	X	O	U	U	U	U	R	A	U
Cucumis dipsaceus Ehrenb. ex Spach	Teasel gourd	X	–	R	–	–	–	–	–	–
Momordica charantia L. var. *abbreviata*	Paria	X	O	O	U	O	C	–	U	O
EUPHORBIACEAE										
Chamaesyce hirta (L.) Millsp.	Garden spurge	X	–	R	R	–	U	U	–	O
C. hyssopifolia (L.) Small	Graceful spurge	X	O	U	U	O	–	–	–	O
C. hypericifolia (L.) Millsp.		X	–	–	R	R	–	–	–	U
Euphorbia cyathophora J.A. Murray	Mexican fire plant	X	–	–	–	–	–	–	–	R
E. heterophylla L.	Kalike	X	–	–	–	U	U	–	–	–
Ricinus communis L.	Castor bean	X	U	–	U	U	O	–	C	O
FABACEAE										
Acacia farnesiana (L.) Willd.	Klu	X	–	–	R	R	–	U	R	X
Cassia sp.		X	–	U	–	–	–	–	–	–
Chamaecrista nictitans (L.) Moench	Japanese tea	X	–	–	–	–	R	–	–	R
Crotalaria incana L.	Fuzzy rattlepod	X	–	–	–	–	–	–	–	R
C. pallida Aiton	Smooth rattlepod	X	O	U	O	C	U	–	–	U
Desmanthus virgatus (L.) Willd.	Virgate mimosa	X	R	R	U	–	–	–	–	U
			U	O	U	U	–	U	–	O

CHECK LIST OF PLANTS

SCIENTIFIC NAME	COMMON NAME	STATUS			RELATIVE ABUNDANCE							
					ACE	Feb	Fe	A	C	GR	GU	R
FABACEAE												
Desmodium tortuosum (Sw.) DC.	Florida beggarweed	I			-	-	-	-	-	-	-	U
Erythrina sp.		X			-	-	-	-	-	-	R	R
Indigofera spicata Forssk.	Creeping indigo	X			-	-	-	-	-	-	-	U
I. suffruticosa Mill.	Indigo	I			U	U	U	R	-	-	-	U
Lablab purpureus (L.) Sweet	Hyacinth bean	X			R	R	-	-	-	-	-	U
Leucaena leucocephala (Lam.) de Wit	Koa-haole	X			U	U	U	U	-	O	A	U
Macroptilium lathyroides (L.) Urban	Cow pea	X			U	U	-	-	U	-	-	R
Pithecellobium dulce (Roxb.) Benth.	'Opiuma	X			R	R	-	-	-	-	-	R
Prosopis pallida (Humb. & Bonpl. ex Willd.) Kunth	Kiave	X			-	R	-	-	-	R	-	U
Senna occidentalis (L.) Link	Coffee senna	I			-	R	-	-	-	-	-	-
Vigna sesquipedalis Wight	Long bean	X			R	-	-	-	-	-	-	-
LAMIACEAE												
Leonotis nepetifolia (L.) R. Br.	Lion's ear	X			O	U	R	U	U	U	-	U
MALVACEAE												
Abutilon grandifolium (Willd.) Sweet	Hairy abutilon	X			-	-	-	-	-	U	-	U
A. incanum (Link) Sweet	Hairy abutilon	I?			C	C	C	O	R	U	-	-
A. menziesii Seem.	Ko'oloa'ula	E		ENDANGERED	U	R	-	-	-	-	-	-
Malvastrum coromandelianum (L.) Garcke	False mallow	X			O	C	O	O	C	U	-	O
Sida ciliaris L.		I			-	-	-	-	-	-	-	U
S. fallax Walp.	'Ilima	I			C	A	C	U	-	U	-	R
S. rhombifolia L.	Cuba jute	I			-	U	-	-	-	-	-	U
S. spinosa L.	Prickly sida	I			-	U	-	R	-	U	-	U
MORACEAE												
Morus sp.		X			R	-	-	-	-	-	-	-
NYCTAGINACEAE												
Boerhavia coccinea Mill.		X			O	O	R	U	U	U	-	U
PASSIFLORACEAE												
Passiflora foetida L.	Love-in-a-mist	X			U	-	U	O	R	U	-	U
PORTULACACEAE												
Portulaca oleracea L.	Pigweed	X			U	U	U	R	U	U	-	-
PRIMULACEAE												
Anagallis arvensis L.	Scarlet pimpernel	X			R	-	-	-	-	-	-	-
SOLANACEAE												
Datura stramonium L.	Jimson weed	I			-	-	-	-	-	-	R	-
Lycopersicon pimpinellifolium Mill.	Currant tomato	I			U	R	-	U	O	-	-	U
Nicotiana glauca R.C. Graham	Tree tobacco	X			U	R	R	-	-	-	-	U
STERCULIACEAE												
Waltheria indica L.	'Uhaloa	I?			C	I	O	C	O	U	-	C

CHECK LIST OF PLANTS

SCIENTIFIC NAME	COMMON NAME	STATUS			RELATIVE ABUNDANCE							
					ACE	Feb	Fe	A	C	GR	GU	R
TILIACEAE												
Triumfetta semitriloba Jacq.	Sacramento bur	X			-	-	-	-	-	-	-	R
ZYGOPHYLLACEAE												
TRIBULUS TERRESTRIS L.	Puncture vine	X			-	R	-	-	R	-	-	O

CHECK LIST OF PLANTS

SCIENTIFIC NAME	COMMON NAME	STATUS	RELATIVE ABUNDANCE							
CHECKLIST OF ANIMALS			ACF	Feh	Fg	A	C	GR	GU	R
ARDEIDAE										
Bubulcus ibis	Cattle egret	Y	–	–	–	X	X	–	–	–
Nycticorax nycticorax	Black-crowned night heron	I	–	–	–	–	–	–	–	X
CHARADRIIDAE										
Pluvialis dominica	Pacific golden-plover	M	X	X	–	–	X	–	–	–
COLUMBIDAE										
Columba livia	Rock dove	X	–	X	–	–	–	–	–	–
Geopelia striata	Barred dove	X	X	X	X	X	X	–	–	X
Streptopelia chinensis	Lace-neck dove	X	X	X	X	X	X	X	X	X
FRINGILLIDAE										
Paroaria coronata	Red-crested cardinal	X	–	–	–	–	–	–	–	X
Richmondena cardinalis	Kentucky cardinal	X	–	X	–	–	–	–	–	–
PHASIANIDAE										
Francolinus sp.	Francolin	Y	X	–	–	–	–	–	–	–
Phasianus colchicus	Ring-necked pheasant	X	X	–	–	X	–	–	–	–
PLOCEIDAE										
Carpodacus mexicanus	House finch	Y	Y	–	–	–	–	–	–	X
Estrilda melpoda	Orange-cheeked waxbill	X	–	X	–	X	–	–	–	X
Lonchura malacca	Black-headed munnibia	Y	X	X	X	–	–	–	–	X
L. punctulata	Rice bird	Y	X	X	X	X	–	X	–	X
PYCNONOTIDAE										
Pycnonotus cafer	Red-vented bulbul	X	Y	Y	Y	Y	–	X	X	X
STURNIDAE										
Acridotheres tristis	Common mynah	Y	X	–	–	–	–	–	–	–
ZOSTEROPIDAE										
Zosterops japonicus	Japanese white-eye	Y	Y	Y	–	–	–	–	–	X

Appendix B
Botanical Survey
W. Char
(January 1997)

CHAR & ASSOCIATES
Botanical/Environmental Consultants
4471 Puu Panini Ave.
Honolulu, Hawaii 96816
(808) 734-7828

January 1997

SUMMARY OF FINDINGS
KO'OLOA'ULA ON EAST KAPOLEI PROJECT SITE
'EWA DISTRICT, ISLAND OF O'AHU

INTRODUCTION

The ko'oloa'ula (Abutilon menziesii), a member of the hibiscus or mallow family (Malvaceae), is a much-branched shrub up to 6 to 9 ft. tall, which is covered by velvety, stellate pubescence. The heart-shaped leaves are silvery-green and the attractive flowers are maroon. It is uncommon and occurs in dryland habitats (Wagner et al. 1990). Today, the largest population is found on Lana'i (about 600 plants) in koa haole scrub. Five small populations occur on Maui on 'a'a lava and also on red soils in a large gulch adjacent to sugar cane fields. One population occurs at Puako on the island of Hawai'i. On O'ahu, a single plant was found in abandoned sugar cane fields near the Campbell Industrial Park. Recently, a single plant was found on the Navy's Lualualei facility in kiawe/Guinea grass scrub.

In 1986, the species was federally listed as endangered. All plants on the federal list are automatically added to the state endangered species list. In its natural habitat the ko'oloa'ula plants are threatened by browsing animals (cattle, goats, axis deer), competition from weedy introduced plants, fires, predation by introduced insects, loss of native pollinators, and development (U.S. Fish and Wildlife Service 1994).

Because the plant is attractive and is easy to cultivate (seeds and cuttings), it was once sold by several plant nurseries as "red 'ilima" prior to its listing.

A new populaion of the ko'oloa'ula was recently discovered by Nagata while conducting a survey of the HFDC's East Kapolei project site in September and October 1996. Nagata recorded at least 38 ko'oloa'ula plants from the southwest corner of the project site (Figure 1). Collections of the plants were deposited by Nagata at the Bishop Museum.

A survey to verify and to more accurately inventory and map the plants found by Nagata was conducted in December 1996. This survey followed an unusually heavy rainfall in November 1996 which lasted for about 10 days.

RESULTS

Three colonies of plants were identified in the field and mapped (Figure 2). We could not locate the northern-most colony mapped by Nagata.

Colony A: This colony consists of 6 large, mature (flowering/budding) plants, 2 to 6 ft. tall, and 2 juvenile (young, immature) plants, 1 to 1.5 ft. tall.

Colony B: This colony is found along the golf course fence. About half (11 plants) are composed of juvenile plants, most of which have probably sprouted and grown since the November rains. The remaining plants (10) are mature individuals.

Colony C: This is the largest colony and is found near the power

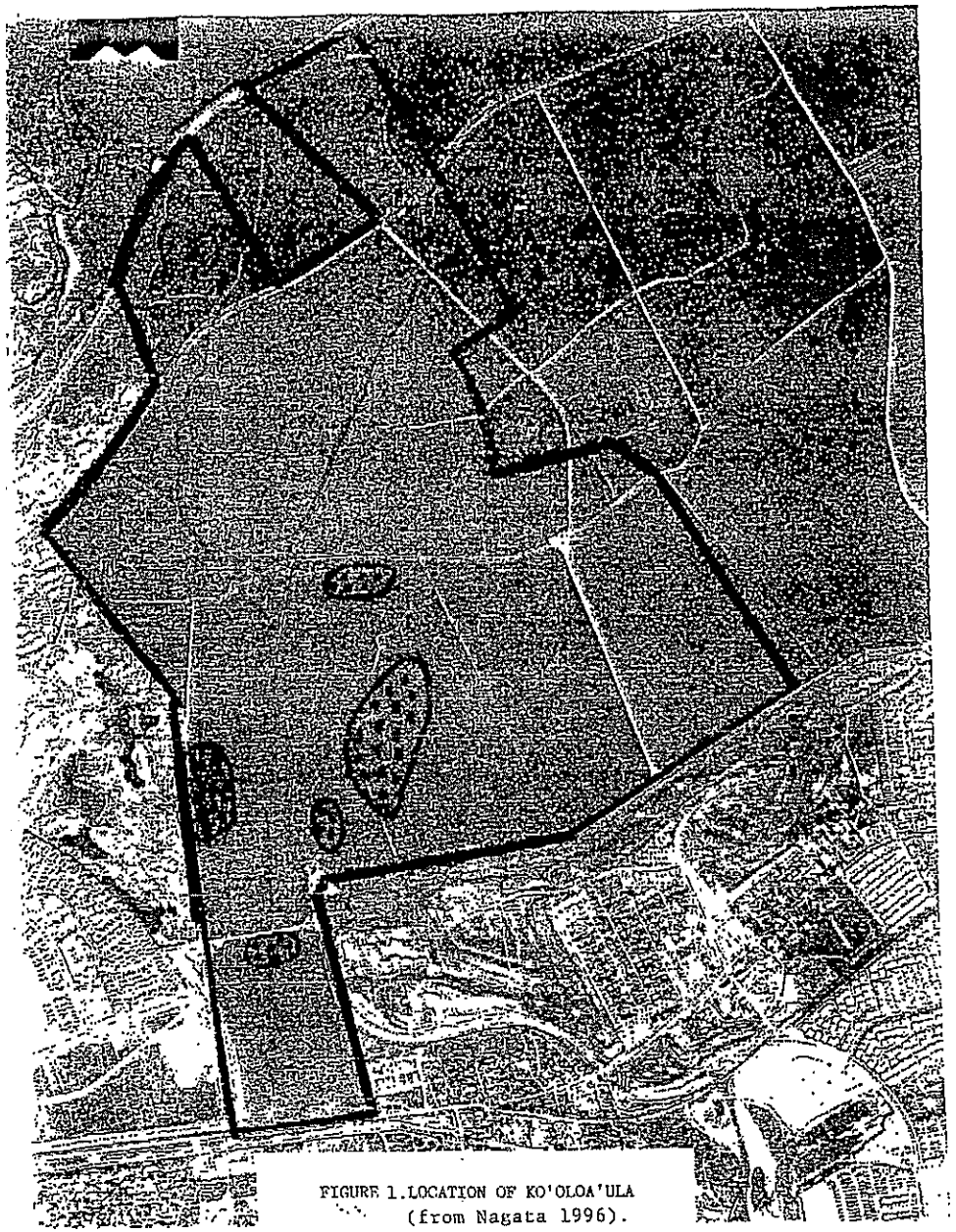

FIGURE 1.LOCATION OF KO'OLOA'ULA
(from Nagata 1996).

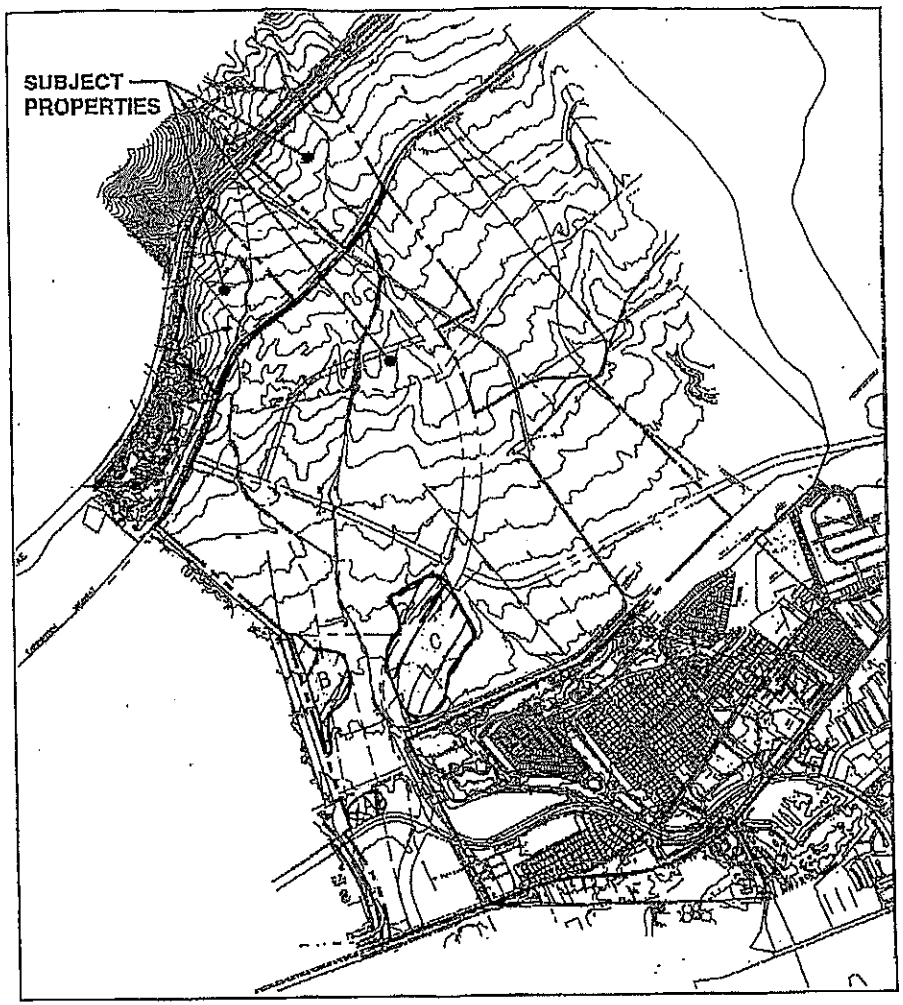

FIGURE 2

LOCATION OF KO'OLOA'ULA DURING
THIS SURVEY.

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FEET

February, 1997

PBR HAWAII

line. Nagata maps it as two separate colonies. But after the more intensive survey, we located plants between the two colonies and have thus lumped them into one larger colony. The majority of the plants are centered around an overgrown, coral-lined cane haul road. A few plants cross under the power line and extend north of the power line for a short distance. The colony consists of 55 large, mature plants (many of them 4 to 6 ft. tall), and 4 juvenile plants.

DISCUSSION AND RECOMMENDATIONS

A total of 88 ko'oloa'ula plants were found during the recent study to flag and inventory the plants on the East Kapolei site. There are a large number of juvenile plants, most of which sprouted and established themselves since the unusually heavy rainfall in November 1996. The number of plants will most likely increase during this rainy season (November 1996 to about February 1997).

It is recommended that a mitigation plan be initiated as soon as possible as the mature plants will continue to set seeds and the colonies will continue to expand in area.

The larger plants can be easily cultivated from seeds and cuttings while the smaller plants can be dug up and transplanted. It is recommended that an area be set aside for the conservation of these plants. An excellent location would be within the power line corridor. A greenway or belt of vegetation with the ko'oloa-'ula could be established here. A few plants already occur within this corridor.

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U.S. Fish and Wildlife Service. 1994. Lana'i plant cluster recovery plan: Abutilon eremitopetalum, Abutilon menziesii, Cyanea macrostegia ssp. gibsonii, Cyrtandra munroi, Gahnia lanaiensis, Phyllostegia glabra var. lanaiensis, Santalum freycinetianum var. lanaiensis, Tetramolopium remyii, and Viola lanaiensis. Portland, Or.

Wagner, W.L., D.R. Herbst, and S.H. Sohmer. 1990. Manual of the flowering plants of Hawai'i. 2 vols. University of Hawai'i Press and B.P. Bishop Museum Press, Honolulu. B.P. Bishop Museum Special Publication 83.

Appendix C
Botanical Survey
W. Char
(October 1997)

NORTH-SOUTH ROAD CORRIDOR STUDY

Ewa, Oahu, Hawaii
Project No. HWY-0-01-92

BOTANICAL SURVEY REPORT

October 1997

PB 100 YEARS
PARSONS BRINCKERHOFF
KAKU ASSOCIATES
R.M. TOWILL CORPORATION

NORTH-SOUTH ROAD CORRIDOR STUDY
Ewa, Oahu, Hawaii
Project No. HWY-0-01-92

Botanical Survey Report

Prepared for:

State of Hawaii
Department of Transportation
869 Punchbowl Street
Honolulu, Hawaii 96813

City and County of Honolulu
Department of Transportation Services
Pacific Park Plaza
711 Kapiolani Boulevard, Suite 1200
Honolulu, Hawaii 96813

Submitted by:

Parsons Brinckerhoff Quade & Douglas, Inc.
Pacific Tower, Suite 3000
1001 Bishop Street
Honolulu, Hawaii 96813

October 1997

PBQD Reference: 16218A - Product 8.6A

BOTANICAL RESOURCES STUDY
NORTH-SOUTH ROAD CORRIDOR
(H-1 FREEWAY TO KAPOLEI PARKWAY)
'EWA DISTRICT, ISLAND OF O'AHU

by

Winona P. Char
CHAR & ASSOCIATES
Botanical Consultants
Honolulu, Hawai'i

Prepared for:
PARSONS BRINCKERHOFF

October 1997

BOTANICAL RESOURCES STUDY
NORTH-SOUTH ROAD CORRIDOR
(H-1 FREEWAY TO KAPOLEI PARKWAY)
'EWA DISTRICT, ISLAND OF O'AHU

INTRODUCTION

The botanical resources found on the North-South road corridor from its proposed interchange with Interstate Route H-1 to its terminus at the proposed Kapolei Parkway is presented in this report. The majority of the alignment crosses sugar cane fields which are no longer in cultivation. Although sugar cane cultivation ceased two to three years ago, there are still a few remnant clumps of sugar cane in the area between Farrington Highway and Waimanalo Road. However, in most places the former fields are now overgrown with Guinea grass or mixed scrub vegetation. A narrow band of koa haole scrub can be found along old irrigation ditches, drainageways, and roadways.

A reconnaissance-level field study was conducted in June 1996, and later in December 1996 during the rainy season. The primary objectives of the field studies were to:

1) provide a description of the vegetation found on the undeveloped portions of the corridor;
2) inventory the flora;
3) search for threatened and endangered plants as well as species of concern; and
4) identify areas of potential environmental problems or concerns and propose appropriate mitigation measures.

One Federal and State listed endangered species, the ko'oloa'ula (Abutilon menziesii), was found during the field studies and is discussed in more detail in the "Endangered Plants" section of the report.

SURVEY METHODS

Prior to undertaking the field studies, a search was made of the pertinent literature to familiarize the principal investigator with other botanical studies conducted in the general area. The roadway alignment maps and a recent colored aerial photograph of the study area were examined to determine vegetation cover patterns, terrain characteristics, access, boundaries, and reference points.

A walk-through survey method was used. Notes were made on plant distributions and associations, substrate types, drainage, topography, exposure, etc. Plant identifications were made in the field; plants which could not be positively identified were collected for later determination in the herbarium (University of Hawai'i, Manoa - HAW), and for comparison with the recent taxonomic literature.

The species recorded during the field studies are indicative of the season ("rainy" vs. "dry") and the environmental conditions at the time of the studies. A survey taken at a different time of the year and under varying environmental conditions would no doubt yield slight variations in the species list, especially of the weedy, annual taxa.

DESCRIPTION OF THE VEGETATION

In the U.S. Fish and Wildlife Service sponsored 'Ewa Plains' Botanical Survey (Char and Balakrishnan 1979), the vegetation along the roadway corridor was mapped as "C", sugar cane fields.

On areas which were not actively cultivated, koa haole shrubland and mixed grass-shrubland were found. Since that survey, O'ahu Sugar Company, Ltd., has ceased cultivating the fields, and much of the 'Ewa Plains has been developed for the second city of Kapolei.

In the discussion below, the vegetation along the proposed North-South road corridor is described from mauka to makai, that is, from its proposed interchange with Interstate Route H-1 to its makai terminus at Kapolei Parkway. Locations are referenced to existing roads and landmarks as the corridor had not been flagged and staked at the time of the field studies. A checklist of all those plants inventoried during the field work is presented at the end of the report.

Vegetation along the corridor

At the interchange with H-1, dense koa haole shrubs (Leucaena leucocephala) border the highway and cover the southwest portion of the interchange. Clumps of Guinea grass (Panicum maximum), 3 to 5 ft. tall, form a thick cover between the shrubs. Scattered through this koa haole/Guinea grass scrub are trees of kiawe (Prosopis pallida) and 'opiuma (Pithecellobium dulce). Along Kalo'i Gulch, there are a few Java plum (Syzygium cumini) and kukui (Aleurites moluccana) trees among the koa haole thickets. Upslope of the highway are former sugar cane fields now overgrown with Guinea grass and buffel grass (Cenchrus ciliaris).

Between Interstate Route H-1 and Farrington Highway, the former sugar cane fields are now overgrown with buffel grass. A few clumps of the taller Guinea grass can be seen scattered here and there. Koa haole shrubs and a few kiawe trees line the edges of the grassy fields. A few of the fields had been planted earlier

with other crops such as watermelons, but in December these fields were overgrown with low mats of pink bindweed (Ipomoea triloba) and clumps of other weedy species such as cocklebur (Xanthium strumarium), apple of Peru (Nicandra physalodes), kaliko (Euphorbia heterophylla), etc.

On the State-owned lands between Farrington Highway and Waimanalo Road, the cane fields were the most recently fallowed and so there are still a few areas with remnant clumps of sugar cane plants (Saccharum officinarum), from 5 to 7 ft. tall. Where the plants collect runoff water in low lying areas, the sugar cane cover is somewhat dense. Where the soil is drier and cracked, there are only dead, dried out clumps of cane. The abandoned fields have been invaded by a mixed scrub composed of swollen fingergrass (Chloris barbata) and a number of other weedy species which include 'uhaloa (Waltheria indica), 'ilima (Sida fallax), hoary abutilon (Abutilon incanum), currant tomato (Lycopersicon pimpinellifolium), Guinea grass, lion's ear (Leonotis nepetifolia), coat buttons (Tridax procumbens), pink bindweed, castor bean (Ricinus communis), etc. In some places, Guinea grass has formed a dense cover, 3 to 6 ft. tall, with only a few other species present. Kalo'i and Makakilo Gulches, now reduced to somewhat narrow drainage channels, support koa haole shrubs and thick tangles of ivy gourd vine (Coccinia grandis).

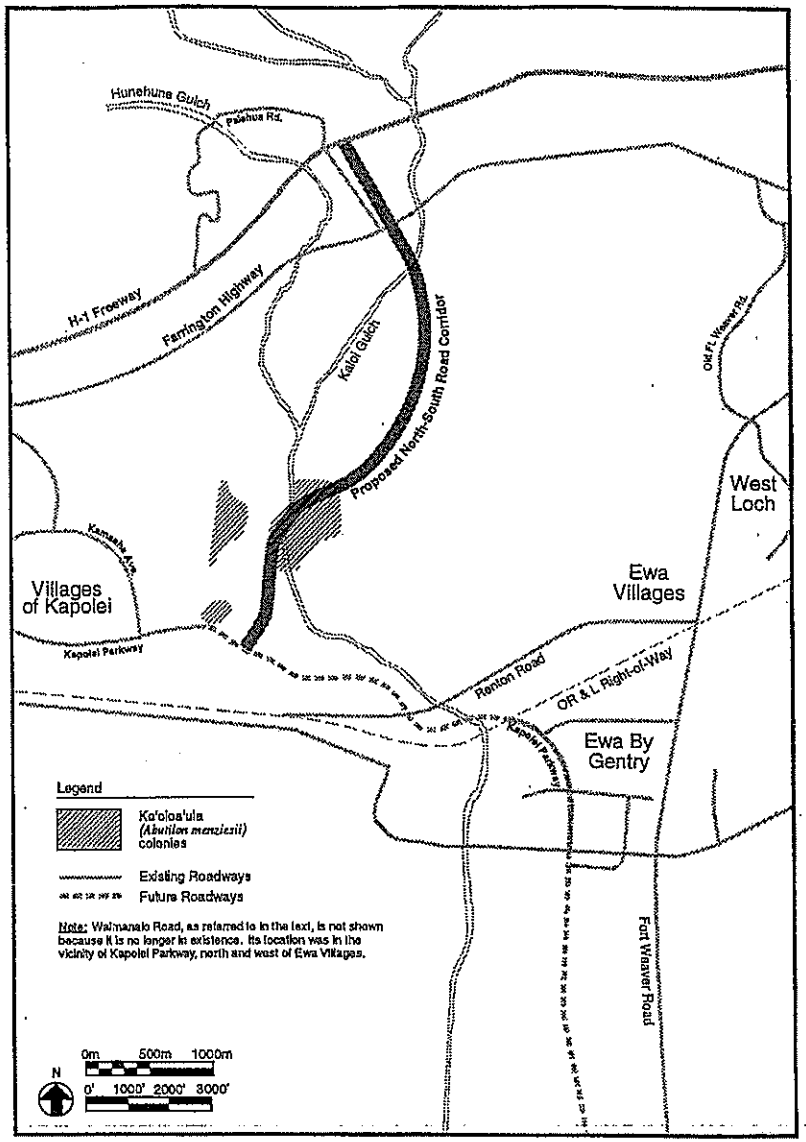
ENDANGERED PLANTS

Because the 'Ewa Plains have been extensively disturbed by agricultural activities for such a long period of time, there are few places which support native plant communities. The few places with native plants tend to be found on areas with karst or limestone topography; since these areas do not have soil they were unsuitable for agriculture. Two listed endangered species which occur today in such habitats are the 'Ewa Plains 'akoko (Chamaesyce

skottsbergii) and Achyranthes rotundata. Both are found only on limestone sites within Campbell Industrial Park and Barbers Point Naval Air Station (Char and Balakrishnan 1979; Traverse Group, Inc., 1988). One plant of the endangered ko'oloa'ula (Abutilon menziesii) was found in an overgrown sugar cane field near Kalaeloa Boulevard in the industrial park (Char and Balakrishnan 1979; Wagner et al. 1990; U.S. Fish and Wildlife Service 1994). There are historical records of two listed endangered species, the 'awiwi (Centaurium sebaeoides) and 'ihi'ihi (Marsilea villosa), and two species of concern, the 'ihi (Portulaca villosa) and pu'uka'a (Torulinium odoratum ssp. auriculatum), in the vicinity of the proposed corridor (B. Harper, USFWS, 01 February 1996 letter).

During the field studies for the State Housing Finance and Development Corporation's (HFDC) East Kapolei project, in September and October 1996, 38 plants of the endangered ko'oloa'ula were found by Ken Nagata, botanist, on the southwest corner of the HFDC project site. The plants occur primarily in mixed scrub and also in areas with remnant clumps of sugar cane. A survey to verify the findings and to more accurately inventory and map the plants was conducted in December 1996 (Char 1997). This December survey followed an unusually heavy period of rainfall in November 1996 in which the 'Ewa area received more than 20 inches of rainfall in about 10 days; average rainfall for the 'Ewa area is 20 inches per year.

A total of 88 ko'oloa'ula plants were flagged and inventoried; the plants occur in three colonies, located fairly close to each other. A large number of juvenile plants which had sprouted after the November rains were found. Some of the ko'oloa'ula plants lie within the proposed North-South road corridor where it follows near the existing HECO powerline (Figure 1).



Distribution of the Endangered Plant Ko'oloa'ula (Abutilon menziesii)
NORTH-SOUTH ROAD CORRIDOR STUDY
Botanical Survey Report
FIGURE 1

DISCUSSION AND RECOMMENDATIONS

The majority of the proposed North-South Road corridor will cross over former sugar cane fields now overgrown with weedy scrub and scattered koa haole thickets. These areas have little of botanical interest as they have been disturbed (under cultivation) for a long period of time and are dominated by introduced or alien plant species. The only area of concern is that portion of the corridor which will cross through the endangered ko'oloa'ula population.

A mitigation plan which would relocate the affected ko'oloa'ula plants is being prepared.

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SPECIES LIST -- North-South Road Corridor
(H-1 Freeway to Kapolei Parkway)

The following checklist is an inventory of the plants observed on the undeveloped lands within the proposed roadway corridor. The plants are arranged alphabetically by families within each of two groups: Dicots and Monocots. The taxonomy and nomenclature of the flowering plants follow the most recent treatment of the Hawaiian flora by Wagner et al. (1990) and new additions to the flora in Wagner and Herbst (1995).

The following information is provided for each species:

1. Scientific name with author citation.
2. Common English and/or Hawaiian name(s), when known.
3. Biogeographic status. The following symbols are used:
   - E = endemic = native only to the Hawaiian Islands.
   - I = indigenous = native to the Hawaiian Islands and also elsewhere throughout the Pacific and/or tropics.
   - I? = questionably indigenous = data not clear if introduced or if arrival here by natural means, but weight of evidence suggests probably indigenous.
   - P = Polynesian = plants originally of Polynesian introduction prior to Western contact (Cook's discovery of the islands in 1778).
   - X = introduced or alien = all those plants brought to the islands by humans, intentionally or accidentally, after Western contact (1778).
   - X? = questionably introduced = dates of introduction unclear or very early, may be indigenous or of Polynesian introduction.

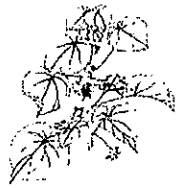
Scientific name	Common name	Status
DICOTS		
ACANTHACEAE (Acanthus family)		
Asystasia gangetica (L.) T. Anders.	Chinese violet	X
AIZOACEAE (Fir-marigold family)		
Trianthema portulacastrum L.		X
AMARANTHACEAE (Amaranthus family)		
Achyranthes aspera L.		X
Amaranthus spinosus L.	spiny amaranth, pakai kuku	X
Amaranthus viridis L.	slender amaranth, pakai	X
ANACARDIACEAE (Mango family)		
Schinus terebinthifolius Raddi	Christmas berry	X
ASCLEPIADACEAE (Milkweed family)		
Calotropis procera (Aiton) W.T. Aiton	blue crown flower	X
ASTERACEAE (Daisy family)		
Bidens pilosa L.	Spanish needle, beggars tick, ki	X
Conyza bonariensis (L.) Cronq.	hairy horseweed, 'ilioha	X
Emilia fosbergii Nicolson	Flora's paintbrush, red pualele	X
Pluchea indica (L.) Less.	Indian pluchea	X
Pluchea carolinensis (Jacq.) G. Don	pluchea, sourbush	X
Sonchus oleraceus L.	common sowthistle, pua-lele	X
Tridax procumbens L.	coat buttons	X
Verbesina encelioides (Cav.) Benth. & Hook.	golden crownbeard	X
Vernonia cinerea (L.) Less.	little ironweed	X
Xanthium strumarium var. canadense (Mill.) Torr. & A. Gray	cocklebur, kikania	X
BIGNONIACEAE (Bignonia family)		
Spathodea campanulata P. Beauv.	African tulip tree	X
CHENOPODIACEAE (Goosefoot family)		
Atriplex suberecta Verd.	saltbush	X
Chenopodium murale L.	'aheahea	X

Scientific name	Common name	Status
CONVOLVULACEAE (Morning-glory family)		
Ipomoea obscura (L.) Ker-Gawl.	field bindweed	X
Ipomoea triloba L.	pink bindweed, little bell	X
Merremia aegyptia (L.) Urb.	hairy merremia, koali kua hulu, kuahulu	X?
CUCURBITACEAE (Gourd family)		
Coccinia grandis (L.) Voigt	ivy gourd, scarlet-fruited gourd	X
Momordica charantia L.	wild bittermelon	X
EUPHORBIACEAE (Spurge family)		
Aleurites moluccana (L.) Willd.	kukui, tutui	P
Chamaesyce hirta (L.) Millsp.	hairy spurge	X
Chamaesyce hypericifolia (L.) Millsp.	graceful spurge	X
Chamaesyce prostrata (Ait.) Small	prostrate spurge	X
Euphorbia heterophylla L.	kaliko	X
Phyllanthus debilis Klein ex Willd.	niruri	X
Ricinus communis L.	castor bean, pa'aila, koli	X
FABACEAE (Pea family)		
Crotalaria incana L.	fuzzy rattlepod, kukae-hoki	X
Crotalaria pallida Aiton	smooth rattlepod, pika-kani	X
Desmanthus virgatus (L.) Willd.	slender mimosa	X
Indigofera suffruticosa Mill.	indigo, 'iniko	X
Indigofera spicata Forssk.	creeping indigo	X
Leucaena leucocephala (Lam.) de Wit	koa haole	X
Macroptilium lathyroides (L.) Urb.	wild bean, cow pea	X
Phaseolus sp.		X
Pithecellobium dulce (Roxb.) Benth.	'opiuma	X
Prosopis pallida (Humb. & Bonpl. ex Willd.) Kunth	kiawe	X
Senna pendula (Humb. & Bonpl. ex Willd.) H. Irwin & Barneby	senna	X
LAMIACEAE (Mint family)		
Leonotis nepetifolia (L.) R. Br.	lion's ear	X
MALVACEAE (Mallow family)		
Abutilon grandifolium (Willd.) Sweet	hairy abutilon, ma'o	X
Abutilon incanum (Link) Sweet	ma'o, hoary abutilon	I?

Scientific name	Common name	Status
Abutilon menziesii Seem.	ko'oloa'ula	E
Malvastrum coromandelianum (L.) Garcke	false mallow	X
Sida fallax Walp.	'ilima	I
Sida rhombifolia L.		X
MYRTACEAE (Myrtle family)		
Syzygium cumini (L.) Skeels	Java plum	X
NYCTAGINACEAE (Four-o'clock family)		
Boerhavia coccinea Mill.	red-flowered boerhavia	X
PASSIFLORACEAE (Passion flower family)		
Passiflora foetida L.	running pop, pohapoha	X
PORTULACACEAE (Purslane family)		
Portulaca oleracea L.	pigweed, 'akulikuli kula	X
SOLANACEAE (Nightshade family)		
Lycopersicon pimpinellifolium (Jusl.) Mill.	currant tomato	X
Nicandra physalodes (L.) Gaertn.	apple of Peru	X
Nicotiana glauca R.C. Graham	tree tobacco, paka	X
Solanum americanum Mill.	glossy nightshade, popolo, 'olohua	I?
STERCULIACEAE (Cacao family)		
Waltheria indica L.	'uhaloa, hi'aloa, kanakaloa	I?
ZYGOPHYLLACEAE (Creosote bush family)		
Tribulus terrestris L.	puncture vine, goat head	X
MONOCOTS		
COMMELINACEAE (Dayflower family)		
Commelina benghalensis L.	hairy honohono	X
CYPERACEAE (Sedge family)		
Cyperus rotundus L.	nut sedge, nutgrass	X
POACEAE (Grass family)		
Bothriochloa pertusa (L.) A. Camus	pitted beardgrass	X
Brachiaria mutica (Forssk.) Stapf	California grass	X

Scientific name	Common name	Status
Brachiaria subquadriparia (Trin.) Hitchc.		X
Cenchrus ciliaris L.	buffel grass	X
Cenchrus echinatus L.	common sandbur, 'ume'alu, mau'u kuku	X
Chloris barbata (L.) Sw.	swollen fingergrass, mau'u lei	X
Chloris radiata (L.) Sw.	plush grass	X
Cynodon dactylon (L.) Pers.	Bermuda grass, manienie	X
Dactyloctenium aegyptium (L.) Willd.	beach wiregrass	X
Digitaria insularis (L.) Mez. ex Ekman	sourgrass	X
Eleusine indica Gaertn.	goose grass, wire grass	X
Leptochloa uninervia (Presl.) Hitchc. & Chase	leptochloa	X
Melinis repens (Willd.) Zizka	Natal redtop, Natal grass	X
Panicum maximum Jacq.	Guinea grass	X
Panicum maximum var. trichoglume Eyles ex Robyns	green panicgrass	X
Saccharum officinarum L.	sugar cane, ko	X
Setaria verticillata (L.) Beauv.	bristly foxtail	X
Sorghum halepense (L.) Pers.	Johnson grass	X

Appendix D
Botanical Survey
W. Char
(August 2003)



BOTANICAL SURVEY
UNIVERSITY OF HAWAI'I WEST O'AHU
EAST KAPOLEI, 'EWA DISTRICT, O'AHU

by

CHAR & ASSOCIATES
Botanical Consulants
Honolulu, Hawai'i

Prepared for: PBR HAWAII

August 2003

BOTANICAL SURVEY
UNIVERSITY OF HAWAI'I WEST O'AHU
EAST KAPOLEI, 'EWA DISTRICT, O'AHU

INTRODUCTION

In mid-September 2002, the University of Hawai'i Board of Regents selected the 500-acre Kapolei Makai site as the permanent site for the University of Hawai'i West O'ahu campus. The 500-acre project site is bounded by Farrington Highway to the north; the proposed North-South Road to the east; overgrown, former sugar cane lands to the south; and the Kapolei residential area and Kapolei Golf Course to the west. A large portion of the 500-acre project site has recently been cleared for vegetatable crops or is already under cultivation by Aloun Farms. The Kalo'i and Hunehune Gulches cross the property. Scrub vegetation is found on the former cane fields on the lower southern portion of the site. A few plants of the endangered ko'oloa'ula (Abutilon menziesii) are associated with the scrub vegetation.

Field studies to assess the botanical resources on the proposed University of Hawai'i West O'ahu campus site were conducted from 17 to 20 June 2003. The primary objectives of the field studies were to:

1) prepare a general description of the vegetation on the site;
2) inventory the flora;
3) search for threatened and endangered species as well as species of concern; and
4) identify areas of potential environmental problems or concerns and propose appropriate mitigation measures.

SURVEY METHODS

Prior to undertaking the field studies, a search was made of the pertinent literature to familiarize the principal investigator with other botanical studies conducted in the general area. Topographic maps and a recent, colored aerial

photograph (1" = 200') were examined to determine vegetation cover patterns, terrain characteristics, access, boundaries, and reference points.

The areas with scrub and gulch vegetation were surveyed more intensively as they were more likely to harbor native plants. A few plants of the endangered ko'oloa'ula (Abutilon menziesii) occur on the project site; larger clusters of plants are found on the adjacent lands. All of the ko'oloa'ula plants, both on and off the project site, have been mapped and/or flagged during earlier studies. The plants are monitered periodically by staff from the State Division of Forestry and Wildlife (DOFAW). Actively cultivated farm lands were not surveyed in detail as rare plants were not likely to occur in such areas.

A walk-through survey method was used. Notes were made on plant associations and distribution, substrate types, disturbances, topography, exposure, drainage, etc. Plant identifications were made in the field; plants which could not be positively identified were collected for later determination in the herbarium, and for comparison with the most recent taxonomic literature.

The species recorded are indicative of the season ("dry" vs. "rainy") and the environmental conditions at the time of the survey. A survey taken at a different time of the year and under varying environmental conditions would no doubt yield slight differences in the species list, especially of the weedy, annual plants.

DESCRIPTION OF THE VEGETATION

Nagata (1996) conducted a biological survey (flora and fauna) for the approximately 1,300-acre East Kapolei Master Plan project site. This study covered the proposed 500-acre UH West O'ahu property. It was during the field survey in September and October 1996 that Nagata discovered the endangered ko'oloa'ula plants (see "Endangered Species" section in this report for discussion). In the 1996 study, large portions of the East Kapolei site supported abandoned sugar cane fields with sugar cane (Saccharum officinarum) making up 30 to 50% of the total

vegetation cover. In other places, sugar cane made up less than 5% of the cover with mixed herbs and grasses abundant. A botanical survey for the proposed North-South Road (Char 1997) recorded similar vegetation types.

Today, large areas with sugar cane are no longer present on the study site, having been replaced by a scrub vegetation composed primarily of swollen fingergrass (Chloris barbata), mixed herbaceous species, and small shrubs (subshrubs). The lands on the northern portion of the site, adjacent to Farrington Highway, are under cultivation by Aloun Farms.

Three vegetation types are recognized on the UH West O'ahu site in this report. An inventory of all the plant species observed during the field studies is presented at the end of the report.

Agricultural/Farm

Actively cultivated fields make up the agricultural farm lands vegetation type which covers the majority of the 500-acre project site. Most of the large fields bordering Farrington Highway have recently been bulldozed to clear them of woody growth and were being disked during our field survey in June. Short stumps of koa haole shrubs (Leucaena leucocephala) could be observed here and there in these fields. On the planted fields on the eastern portion of the site, hybrid sweet corn (Zea mays) covers large areas. Other crops observed include bell pepper (Capsicum annuum cv. "Grossum"); eggplant (Solanum melongena); a number of different melon cultivars such as watermelon and Thai watermelon (Citrullus lanatus), and canteloupe and honeydew (Cucumis melo); cultivars of Cucurbita pepo -- zucchini, pumpkin, kabocha; and yard-long bean (Vigna unguiculata).

A few weedy species such as swollen fingergrass, field bindweed (Ipomoea obscura), spiny amaranth (Amaranthus spinosus), and pigweed (Portulaca oleracea) can be found growing among the crop plants. Most of the weedy plants, however, occur along the uncultivated areas which border the fields; these weedy patches receive runoff from the cultivated fields so the weeds tend to

be lush and green, and 2 to 4 ft. tall in some places. Weedy species found here include clumps of Guinea grass (Panicum maximum), field bindweed, lion's ear (Leonotis nepetifolia), young koa haole shrubs, graceful spurge (Chamaesyce hypericifolia), Trianthema portulacastrum), milkweed (Sonchus oleraceus), cheese weed (Malva parviflora), etc. The native 'ilima (Sida fallax) is locally common in some places. One new species not recorded from the island of O'ahu, Russian thistle or tumbleweed (Salsola tragus), was collected and deposited at the Bishop Museum herbarium.

Scrub Vegetation

This vegetation type occupies the southern portion of the project site and is usually 1 to 3 ft. tall. Long dead stalks of sugar cane are scattered throughout this vegetation type. At the time of this survey, the project site was very dry with plant cover 50 to 60%. Bare soil areas with large, knee-deep cracks were prominent and made surveying difficult.

Swollen fingergrass is the most abundant species forming fairly large patches. In some places, buffelgrass (Cenchrus ciliaris) becomes locally abundant and forms a thick mat, 2 to 3 ft. tall. Four herbaceous species are abundant to common; these are false mallow (Malvastrum coromandelianum), coat buttons (Tridax procumbens), fuzzy rattlepod (Crotalaria incana), and golden crown-beard (Verbesina encelioides). Small shrubs of hoary abutilon (Abutilon incanum), 'uhaloa (Waltheria indica), and 'ilima are abundant; these small shrubs have fuzzy, gray to bluish-gray leaves, and give a grayish-blue cast to the vegetation where they form extensive patches, 1 to 3 ft. tall.

Scattered through this scrub cover are taller shrubs of koa haole and sourbush (Pluchea carolinensis), 3 to 10 ft. tall. Other woody components found here in small numbers are young kiawe (Prosopis pallida) and 'opiuma (Pithecellobium dulce) trees, 7 to 12 ft. tall. Interestingly, a few species usually used as landscaping material have established themselves within these former cane fields; these are the small crown flower (Calotropis procera), carrion flower (Stapelia

gigantea), and Sebesten plum (Cordia dichotoma).

On the old, crushed coral-covered cane haul roads and along irrigation ditches, the vegetation is somewhat denser. Koa haole shrubs and Guinea grass are common. Other species forming fairly large patches here include saltbush (Atriplex suberecta), 'uhaloa, slender mimosa (Desmanthus pernambucanus), Macroptilium atropurpureum, Natal redtop grass (Melinis repens), 'ilima, and swollen fingergrass.

Along the lower boundary (makai end), especially along the North-South Road corridor, there are a few plants of the endangered ko'oloa'ula within the project site. A more detailed discussion of the ko'oloa'ula plants on the project site is presented in the "Endangered Species" section of the report.

Gulch Vegetation

Kalo'i Gulch and Hunehune Gulch cross the project site. In most places, the gulches are shallow and narrow, however, Kalo'i Gulch becomes 25 to 45 ft. deep and wider along its eastern segment. A large plunge pool with standing water was found during the field studies. The intermittent streams along the bottom of each of the gulches have eroded down to the hardpan parent material.

The vegetation within the gulches (sides and bottom) is characterized by dense, robust clumps of Guinea grass, 5 to 10 ft. tall. The dense Guinea grass cover tends to exclude other species, but a few patches of California grass (Brachiaria mutica), sourbush, castor bean (Ricinus communis), wild bittermelon (Momordica charantia), comby hyptis (Hyptis pectinata), and cocklebur (Xanthium strumarium) are found where the Guinea grass cover is thin and the soil exposed.

Along the top banks of the gulches, buffelgrass forms a thick mat up to 3 ft. tall, but Guinea grass can also be abundant in places. Koa haole shrubs, 10 to 20 ft. high, occur as scattered stands or can sometimes become very dense and form small thickets, especially along the eastern section of Kalo'i Gulch.

Tangled mats of coccinia vine (Coccinia grandis) are frequently observed climbing up and over the koa haole shrubs. A few kiawe trees, 20 to 25 ft. tall, are also found along the top of the gulches.

ENDANGERED SPECIES

The ko'oloa'ula (Abutilon menziesii) is a member of the hibiscus or mallow family (Malvaceae). It is a much-branched shrub covered by velvety, silvery hairs. The heart-shaped leaves are silvery-green and the small 'ilima-like flowers range in color from pale peach to dark red. Abutilon is found in dry, lowland habitats on the islands of O'ahu, Maui, Lana'i, and Hawai'i (Wagner et al. 1990). In 1986, the species was federally listed as endangered and is protected under the provisions of the Endangered Species Act of 1973, as amended, and Chapter 195D, Hawaii Revised Statutes, as amended. In its natural habitat the plants are threatened by browsing animals, competition from weedy introduced species, fires, predation by insects, loss of native pollinators, and development (U.S. Fish and Wildlife Service 1994).

In September 1996, Nagata found 38 Abutilon menziesii plants on the East Kapolei project site; the reconnaissance survey covered roughly 80% of the property. After the unusually heavy rains in November 1996, Char (1997) conducted an intensive inventory of the plants in December and recorded a total of 88 plants. A year later, in December 1997, Nagata performed a detailed survey flagging and attaching numbered tags to the plants; survey engineers then mapped the plants. The 1997 survey recorded 87 plants, 86 from the East Kapolei site and North-South Road corridor and one plant within the fenceline of the adjacent City and County-owned golf course.

In 1998, a Habitat Conservation Plan (HCP) was prepared for the East Kapolei Master Plan; the HCP is an "umbrella plan" that includes the East Kapolei project as well as the North-South Road project. The HCP provides a description of the development actions which would impact the Abutilon plants and proposes a series of mitigative strategies to address the impacts (PBR 1998).

A few of the endangered Abutilon plants occur on the proposed UH West O'ahu site. These represent the most mauka extension of the Cluster C population. One plant remained at the Cluster D site in Nagata's 1997 study, but it has subsequently died (V. Caraway, DOFAW, pers. comm.); there may still be seeds of Abutilon present in the soil around Cluster D. The Abutilon population is periodically monited by the Division of Forestry and Wildlife (G. Mansker, pers. com.).

DISCUSSION AND RECOMMENDATIONS

The proposed 500-acre UH West O'ahu site was under sugar cane cultivation for nearly a century with the last harvest occurring in 1994, prior to permanent closure of Oahu Sugar Company in 1995 (PBR 1998). Today, only dead stalks of sugar cane and faint traces of planting furrows remain. Weedy scrub vegetation consisting of a mixture of swollen fingergrass and buffelgrass, herbaceous species, and small shrubs covers the former cane fields on the southern half of the property, while the northern portion is actively cultivated for various fruit and vegetable crops by Aloun Farms. The gulches which cross the site support dense Guinea grass and stands of koa haole shrubs.

The vegetation on the project site is dominated by introduced or alien species. A total of 95 plant species were observed during this study. Of these 89 (94%) are introduced; introduced species are all those plants which were brought to the Hawaiian Islands by humans, intentionally or accidentally, after Western contact, that is, Cook's arrival in the islands in 1778. Four species are indigenous or presumably indigenous, that is, they are native to the islands and elsewhere; these are the 'ilima (Sida fallax), hoary abutilon (Abutilon incanum), 'uhaloa (Waltheria indica), and popolo (Solanum americanum). Two species are endemic, that is, they are native only to the Hawaiian Islands; these are the endangered ko'oloa'ula (Abutilon menziesii) and pa'uohi'iaka (Jacquemontia ovalifolia subsp. sandwicensis).

None of the plants found on the project site, with the exception of the

ko'oloa'ula, is a threatened and endangered species or a species of concern (U.S. Fish and Wildlife Service 1999a, 1999b; Wagner et al. 1999). Almost all of the plants can be found in dry, lowland, disturbed habitats throughout the islands. Some of the natives such as the 'ilima, hoary abutilon, and 'uhaloa are common to abundant throughout the scrub vegetation on the project site and elsewhere.

A Habitat Conservation Plan for the endangered ko'oloa'ula plant on the 'Ewa site has already been prepared. Plant material from this population has been propagated and a few outplantings have been made at other locations. The University will need to work closely with the agencies involved in the Habitat Conservation Plan.

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APPENDIX A

PLANT SPECIES LIST -- U.H., West O'ahu

The following checklist is an inventory of all the plants observed on the project site during the field studies. The plants are arranged alphabetically by families into each of two groups: Dicots and Monocots. The taxonomy and nomenclature of the flowering plants, Dicots and Monocots, are in accordance with Wagner et al. (1990) and Wagner and Herbst (1999). The few recent name changes are those reported in the Hawaii Biological Survey series (Evenhuis and Eldredge, editors, 1999-2002).

For each species, the following information is provided:

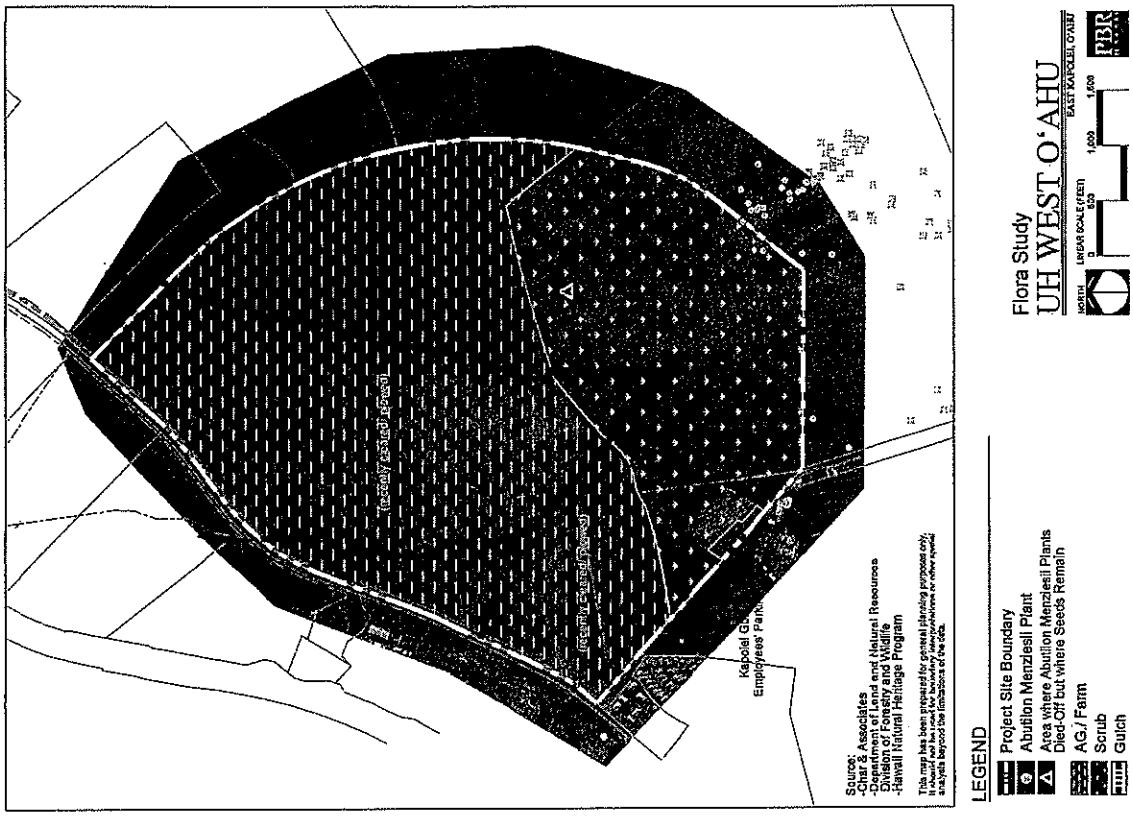
1. Scientific name with author citation.
2. Common English and/or Hawaiian name(s), when known.
3. Biogeographic status. The following symbols are used:
   - E = endemic = native only to the Hawaiian Islands;
   - I = indigenous = native to the Hawaiian Islands and elsewhere;
   - I? = questionably indigenous = data not clear if dispersal to the islands by natural or human-related mechanisms, but weight of evidence suggests probably natural;
   - X = introduced or alien = all those plants brought to the Hawaiian Islands by humans, intentionally or accidentally, after Western contact, that is Cook's arrival in the islands in 1778;
   - X? = questionably introduced = dates of introduction are very early/unclear; may be indigenous or of Polynesian introduction.
4. Presence (+) or absence (-) of a particular species within each of three vegetation types recognized on the project site (see text for discussion):
   - a = Agricultural/Farm Lands
   - s = Scrub Vegetation
   - g = Gulch Vegetation

Scientific name	Common name	Status	Vegetation type a	s	g
BORAGINACEAE (Borage family)					
Cordia dichotoma Forst. f.	Sebesten plum	X	-	+	-
CAPPARACEAE (Caper family)					
Cleome gynandra L.	wild spider flower, hchohina	X	+	-	-
CHENOPODIACEAE (Goosefoot family)					
Atriplex suberecta Verd.	saltbush	X	+	+	+
Chenopodium murale L.	'aheahea	X	+	+	-
Salsola tragus L.	Russian thistle, thumbleweed	X	+	+	-
CONVOLVULACEAE (Morning glory family)					
Ipomoea cairica (L.) Sweet	koali 'ai, koali	X?	-	-	+
Ipomoea obscura (L.) Ker-Gawl.	field bindweed	X	-	+	+
Ipomoea triloba L.	little bell, pink bindweed	X	+	+	-
Jacquemontia ovalifolia ssp. sandwicensis (A. Gray) K. Robertson	pa'uohi'iaka	E	-	+	-
Merremia aegyptia (L.) Urb.	hairy merremia, koali kua hulu	X?	+	+	-
CUCURBITACEAE (Gourd family)					
Citrullus lanatus (Thunb.) Matsum. & Nakai	watermelon	X	+	-	-
Coccinia grandis (L.) Voigt	coccinia, ivy gourd	X	+	-	+
Cucumis melo L. various cultivars	cantaloupe, honeydew	X	+	-	-
Cucurbita pepo L. various cultivars	zucchini, pumpkin, kabocha	X	+	-	-
Momordica charantia L.	wild bittermelon	X	+	-	+
EUPHORBIACEAE (Spurge family)					
Chamaesyce hirta (L.) Millsp.	hairy spurge, garden spurge	X	-	+	+
Chamaesyce hypericifolia (L.) Millsp.	graceful spurge	X	+	+	+
Chamaesyce hyssopifolia (L.) Sm.		X	+	-	+
Euphorbia heterophylla L.	Mexican fireweed	X	+	-	-
Ricinus communis L.	castor bean, koli	X	+	+	+

Scientific name	Common name	Status	Vegetation type a	s	g
FLOWERING PLANTS					
DICOTS					
AIZOACEAE (Fir-marigold family)					
Trianthema portulacastrum L.		X	+	+	+
AMARANTHACEAE (Amaranth family)					
Amaranthus spinosus L.	spiny amaranth, pakai kuku	X	+	+	-
Amaranthus viridis L.	slender amaranth, pakai	X	+	+	-
ANACARDIACEAE (Mango family)					
Schinus terebintifolius Raddi	Christmas berry	X	-	+	-
ASCLEPIADACEAE (Milkweed family)					
Calotropis procera (Aiton) W.T. Aiton	small crown flower	X	-	+	-
Stapelia gigantea N.E. Brown	carrion flower, Zulu-giant	X	-	-	+
ASTERACEAE (Daisy family)					
Bidens alba var. radiata (Schultz-Bip.) Ballard ex Melchert		X	+	-	-
Bidens pilosa L.	Spanish needle, ki, ki nehe	X	+	-	+
Emilia fosbergii Nicolson	flora's paintbrush, pualele	X	+	+	-
Pluchea carolinensis (Jacq.) G. Don	sourbush, pluchea	X	+	+	+
Pluchea indica (L.) Less.	Indian fleabane	X	+	+	-
Sonchus oleraceus L.	sowthistle	X	+	+	-
Tridax procumbens L.	coat buttons	X	-	+	+
Verbesina encelioides (Cav.) Benth. & Hook.	golden crown-beard	X	+	+	-
Xanthium strumarium var. canadense (Mill.) Torr. & A. Gray	cocklebur, kikania	X	-	-	+
BIGNONIACEAE (Bignonia family)					
Spathodea campanulata P. Beauv.	African tulip tree	X	-	+	-

Scientific name	Common name	Status	Vegetation type a	s	g
NYCTAGINACEAE (Four-o'clock family)					
Boerhavia coccinea Mill.		X	-	+	-
PASSIFLORACEAE (Passion flower family)					
Passiflora foetida L.	running pop, poha poha	X	-	+	-
PORTULACACEAE (Purslane family)					
Portulaca oleracea L.	common purslane, pigweed	X	+	-	-
SOLANACEAE (Nightshade family)					
Capsicum annuum L. cultivar "Grossum"	bell pepper	X	+	-	-
Datura stramonium L.	Jimson weed, la'au hano	X	-	+	-
Nicandra physalodes (L.) Gaertn.	apple of Peru	X	+	-	+
Nicotiana glauca R.C. Graham	tree tobacco	X	-	+	-
Solanum americanum Mill.	popolo, glossy nightshade	I?	+	+	-
Solanum lycopersicon var. cerasiforme (Dunal) Spooner, Anderson & Jansen	currant tomato, wild tomato	X	+	+	-
Solanum melongena L. various cultivars	eggplant, long eggplant	X	+	-	-
STERCULIACEAE (Cacao family)					
Waltheria indica L.	'uhaloa, hi'aloa, kanakaloa	I?	-	+	-
VERBENACEAE (Verbena family)					
Lantana camara L.	lantana, lakana	X	-	+	-
Stachytarpheta cayennensis (Rich.) Vahl	nettle-leaved vervain, owi, oi	X	-	+	-
MONOCOTS					
MUSACEAE (Banana family)					
Musa X paradisiaca L.	banana, mai'a	X	-	-	+
CYPERACEAE (Sedge family)					
Cyperus rotundus L.	nutgrass, nut sedge	X	+	-	-

Scientific name	Common name	Status	Vegetation type a	s	g
FABACEAE (Pea family)					
Acacia farnesiana (L.) Willd.	klu	X	+	+	-
Cassia sp.		X	-	+	-
Chamaecrista nictitans (L.) Moench	partridge pea, lauki	X	-	+	-
Crotalaria incana L.	fuzzy rattlepod, kukaehoki	X	+	+	-
Crotalaria pallida Aiton	smooth rattlepod, pikakani	X	+	-	-
Desmanthus pernambucanus (L.) Thellung	slender mimosa	X	+	+	+
Indigofera hendecaphylla Jacq.	creeping indigo	X	-	+	-
Indigofera suffruticosa Mill.	indigo, 'iniko	X	+	+	-
Leucaena leucocephala (Lam.) de Wit	koa haole, ekoa	X	+	+	+
Macroptilium atropurpureum (DC) Urb.		X	-	+	-
Macroptilium lathyroides (L.) Urb.	wild bean, cow pea	X	+	-	-
Pithecellobium dulce (Roxb.) Benth.	'opiuma	X	-	+	+
Prosopis pallida (Humb. & Bonpl. ex Willd.) Kunth	kiawe	X	+	+	+
Senna occidentalis (L.) Link	coffee senna, 'auko'i	X	+	-	-
Vigna unguiculata ssp. sesquipedalis (L.) Verdc.	yard-long bean	X	+	-	-
LAMIACEAE (Mint family)					
Hyptis pectinata (L.) Poit.	comb hyptis	X	+	-	+
Leonotis nepetifolia (L.) R. Br.	lion's ear	X	+	+	+
MALVACEAE (Mallow family)					
Abutilon grandifolium (Willd.) Sweet	hairy abutilon	X	+	-	-
Abutilon incanum (Link) Sweet	hoary abutilon, ma'o	I?	+	+	+
Abutilon menziesii Seem.	ko'oloa'ula	E	-	+	-
Malva parviflora L.	cheese weed	X	+	-	-
Malvastrum coromandelianum (L.) Garcke	false mallow, hauuoi	X	+	+	-
Sida ciliaris L.		X	+	+	-
Sida fallax Walp.	'ilima	I	+	+	+
Sida spinosa L.	prickly sida	X	+	+	-
MELIACEAE (Mahogany family)					
Melia azedarach L.	Chinaberry, pride of India	X	-	+	-



Scientific name	Common name	Status	Vegetation type a	s	g
POACEAE (Grass family)					
Bothriochloa pertusa (L.) A. Camus	pitted beardgrass	X	-	+	-
Brachiaria mutica (Forssk.) Stapf	California grass	X	-	-	+
Cenchrus ciliaris L.	buffelgrass	X	+	+	+
Cenchrus echinatus L.	common sandbur, 'ume'alu	X	+	-	-
Chloris barbata (L.) Sw.	swollen fingergrass, mau'ulei	X	+	+	+
Cynodon dactylon (L.) Pers.	Bermuda grass, manienie	X	-	+	-
Digitaria insularis (L.) Mez ex Ekman	sourgrass	X	+	-	+
Digitaria sp.	crabgrass	X	-	+	-
Eleusine indica (L.) Gaertn.	wiregrass, goosegrass	X	+	-	-
Eragrostis amabilis Wight & Arnott	lovegrass	X	-	+	-
Eragrostis cilianensis (All.) Link	stinkgrass	X	-	+	-
Melinis repens (Willd.) Zizka	Natal redtop, Natal grass	X	-	+	+
Panicum maximum Jacq.	Guinea grass	X	+	+	+
Panicum maximum var. trichoglume Eyles ex Robyns	green panicgrass	X	-	-	+
Saccharum officinarum L.	sugar cane, ko	X	-	+	-
Setaria verticillata (L.) P. Beauv.	bristly foxtail, mau'u pilipili	X	+	-	+
Sorghum bicolor (L.) Moench	sorghum	X	+	+	-
Zea mays L.	hybrid corn	X	+	-	-

Appendix E

Botanical Survey

W. Char

(March 2004)

BOTANICAL RESOURCES ASSESSMENT STUDY

KAPOLEI PARKWAY EXTENSION FROM NORTH-SOUTH ROAD TO OR&L RIGHT-OF-WAY

KAPOLEI, O'AHU

by

Winona P. Char

CHAR & ASSOCIATES
Botanical Consultants
Honolulu, Hawai'i

Prepared for: PARSONS BRINCKERHOFF

Revised March 2004

BOTANICAL RESOURCES ASSESSMENT STUDY
KAPOLEI PARKWAY EXTENSION FROM NORTH-SOUTH ROAD
TO OR&L RIGHT-OF-WAY
KAPOLEI, O'AHU

INTRODUCTION

The proposed Kapolei Parkway Extension will connect the proposed North-South Road with the OR&L right-of-way (ROW) where the existing Kapolei Parkway currently ends. A botanical survey for this extension of the Kapolei Parkway was conducted in two sections (Figure 1).

The first section of Kapolei Parkway is from the proposed intersection with North-South Road to the proposed intersection with Renton Road. The botanical survey area for this section consists of approximately 80 acres of City and County-owned lands located between Varona Village and Kalo'i Gulch/'Ewa Villages Golf Course (Figure 2). For the most part, the proposed parkway follows along or close to an existing paved road which accesses the golf course maintenance facility. In other places, it crosses koa haole/buffel grass scrub vegetation. The endangered Abutilon menziesii, common names ko'oloa'ula and red 'ilima, is known to occur on the adjacent State-owned lands; some Abutilon have also been recorded on the City and County-owned lands (Ohashi and PBR Hawaii 2003).

The second section of Kapolei Parkway is from the proposed intersection with Renton Road to the OR&L right-of-way (ROW). The botanical survey area for this section is an approximately 20-acre area bound by Renton Road to the west, the existing 'Ewa Mahiko Park to the north, the 'Ewa Gentry subdivision and a portion of the OR&L ROW to the east, and Kalo'i Gulch and the OR& L ROW to the south (Figure 3). This property is also owned by the City and County of Honolulu. The proposed parkway follows along an existing paved cane haul road. Except for Kalo'i Gulch, most of the site appears to have been graded in the past.

Field studies to assess the botanical resources on the ±80-acre study site including the proposed Kapolei Parkway corridor from North-South Road to Renton Road were conducted on 09 January 2004 by a team of two botanists. The Renton Road to OR&L ROW section was surveyed on 02 February 2004. The primary objectives of the field survey were to:

1) prepare a general description of the vegetation on the study sites; and
2) search for Abutilon menziesii as well as other threatened and endangered species and species of concern.

SURVEY METHODS

For the North-South Road to Renton Road section of Kapolei Parkway, a colored aerial photograph (roughly 1" = 250') was used, while the design and construction plans were

used for the Renton Road to OR&L ROW section. These were examined prior to the field studies to familiarize the botanists with vegetation cover patterns, terrain characteristics, access, boundaries, and reference points.

The proposed parkway corridor on the ±80-acre site was flagged and staked by the survey engineers before our field survey. Thirty (30)-foot wide transects were made through the koa haole/buffel grass scrub found between the existing paved road and the edge of the golf course. This is identified as "Area E" on Figure 1; plants of Abutilon are known from this portion of the study site. Less intensive transects were conducted for the more recently disturbed area makai of the existing paved road; this is identified as "Varona Village Extension" on Figure 1.

The survey for the proposed parkway corridor on the ±20-acre site between Renton Road to OR&L ROW focused on the less disturbed Kalo'i Gulch area. Notes were made on plant associations and distribution, disturbances, substrate types, topography, exposure, drainage, etc.

DESCRIPTION OF THE VEGETATION

The plant names used in this report follow Wagner et al. (1990) and Wagner and Herbst (1999). The few recent name changes are those reported in the Hawaii Biological Survey series (Evenhuis and Eldredge, eds., 1999-2002). The vegetation is described on each of the two areas within the ±80-acre site (Area E and Varona Village Extension), and on the ±20-acre Renton Road to OR&L ROW section.

Area E

Koa haole (Leucaena leucocephala)/buffel grass (Cenchrus ciliaris) scrub covers the portion of the study site located between the existing paved road and the golf course. Short-statured thickets of koa haole, 3 to 5 ft. tall, are scattered throughout this vegetation type. Buffel grass, 1 to 2 ft. tall, forms dense mats to loose tussocks between the thickets. Locally common are scattered patches of swollen fingergrass (Chloris barbata), stinkgrass (Eragrostis cilianensis), 'ilima (Sida fallax), Guinea grass (Panicum maximum), 'aheahea (Chenopodium murale), and hoary abutilon (Abutilon incanum). A few young trees of kiawe (Prosopis pallida), Chinaberry (Melia azedarch), and monkeypod (Samanea saman) can be observed here and there. Old bulldozer tracks and areas with coralline substrate are occasionally. encountered. Scattered patches of false mallow (Malvastrum coromandelianum), Trianthema portulacastrum, swollen fingergrass, little bell (Ipomoea triloba), spiny amaranth (Amaranthus spinosus), 'aheahea, Macroptilium atropurpureum, and castor bean (Ricinus communis) are common on these more recently disturbed areas.

Along the edge of the golf course (slopes of Kalo'i Gulch), the woody components become very dense. Koa haole thickets are 7 to 12 ft. tall and there are small, scattered stands of emergent kiawe, monkeypod, Eucalyptus, and 'opiuma (Pithecellobium dulce) trees. Shrubs of hairy abutilon (Abutilon grandifolium), kiu

(Acacia farnesiana), and sourbush (Pluchea carolinensis) are common. Robust clumps of Guinea grass, 5 to 6 ft. tall, and buffel grass, up to 3 ft. tall, form a dense cover between the woody components.

Four of the Abutilon menziesii locations occur on Area E in open koa haole/ buffel grass scrub (see Rare Plants section of this report).

Varona Village Extension

This portion of the study area located makai of the existing paved road has been bulldozed somewhat recently. Remnants of old house sites, old mango (Mangifera indica) and kalamungai (Moringa oleifera) trees, overgrown garden plots, and rusted parts of refrigerators, stoves, sheet metal, and a Suzuki Samurai vehicle can be found here. The vegetation is composed primarily of weedy, annual plants. Swollen fingergrass is the dominant component. Lion's ear (Leonotis nepetifolia), little bell, field bindweed (Ipomoea obscura), feather fingergrass (Chloris virgata), and saltbush (Atriplex suberecta) are locally abundant. Other weeds observed here include golden crown-beard (Verbesina encelioides), Spanish needle (Bidens pilosa), smooth rattlepod (Crotalaria pallida), 'uhaloa (Waltheria indica), castor bean, and wild tomato (Solanum lycopersicon).

Where the property borders the HECO easement, open, grassy fields of buffel grass are found. The woody components make up less than 5% of the cover; these include short-statured koa haole shrubs and young trees of kiawe and 'opiuma. Three medium-sized kiawe trees line the makai side of the existing paved road near the HECO easement. One plant of Abutilon is found associated with these trees. Also in this area are numerous clumps of Russian thistle or tumbleweed (Salsola tragus).

On the southwest corner of the property, there are large piles of coral rubble and boulders. This was the staging area for a sewer line at one time. The piles of excavated material are covered here and there with patches of tree tobacco shrubs (Nicotiana glauca), mats of Sida ciliaris and saltbush, and shrubs of 'ilima, 'uhaloa, and sourbush.

Renton Road to OR&L ROW Section

The proposed parkway alignment in this section follows along a former cane haul road. It consists of a thin layer of asphalt over crushed coral with patches of asphalt missing in many places. Along the open, grassy field of the park boundary is a narrow band of weedy vegetation with patches of reddish-colored soil. The weedy vegetation consists of a mixture of swollen fingergrass, buffel grass, green panicgrass (Panicum maximum var. trichoglume), and saltbush. A few scattered koa haole shrubs, 3 to 4 ft. tall, occur here. This area appears to have been graded when the parks playing field was installed.

On the makai side of the cane haul road, koa haole scrub borders the roadside and extends down the slopes into Kalo'i Gulch. Along the roadside, the shrubs are 6 to 10 ft. tall, but become somewhat taller, 10 to 15 ft. tall, within the gulch. Scattered through the koa haole scrub are emergent trees of kiawe and 'opiuma, 20 to 25 ft. tall. Other woody

components include sourbush and castor bean. Buffel grass and Guinea grass form dense clumps up to 3 ft. tall in most places.

On parts of the gulch slope, there are areas with exposed reddish-colored soil; a number of dirt bike trails also are found within the gulch. These open areas support a weedy mixture of plants which include castor bean, cocklebur (Xanthium strumarium), golden crown-beard, hairy merremia (Merremia aegyptia), spiny amaranth, false mallow, and Jimson weed (Datura strumonium). 'Uhaloa is locally abundant on these exposed areas. Other native species observed in the gulch area are 'ilima and hoary abutilon.

Along the gulch bottom, the vegetation is primarily Guinea grass and buffel grass with scattered koa haole shrubs and young kiawe and 'opiuma. In some places, there are small pools of standing muddy water; California grass (Brachiaria mutica) and primrose willow (Ludwigia octovalvis) are associated with these areas. Parts of the gulch adjacent to the bridge are concrete lined.

RARE PLANTS

The approximate locations of Abutilon menziesii are plotted on Figure 2. Only single plants are found at locations 2 to 5. At location 1, there is a large, multi-stemmed plant about 5 ft. tall; a young, single-stemmed plant about 2.5 ft. tall; and a seedling, 4 inches tall. No Abutilon menziesii was found in the Renton Road to OR&L ROW section.

The plants as well as the area around the plants have been flagged with blue and white stripped flagging. G. Mansker, Division of Forestry and Wildlife, will more accurately map the plants using a GPS unit later on.

No other threatened and endangered species or species of concern (U.S. Fish and Wildlife Service 1999; Wagner et al. 1999) were found during the field studies. The other native species which were observed on the study site are common species which can be found throughout the islands. These are the 'ilima (Sida fallax), 'uhaloa (Waltheria indica), hoary abutilon (Abutilon incanum), popolo (Solanum americanum), and pa'uohi'iaka (Jacquemontia ovalifolia ssp. sandwicensis).

DISCUSSION

The vegetation on the City and County-owned lands are dominated by introduced or alien species such as koa haole, buffel grass, kiawe, swollen fingergrass, etc. For the most part, the proposed Kapolei Parkway alignment follows along an existing paved road. None of the plants found on the property, with the exception of the Abutilon menziesii, is a threatened and endangered species or a species of concern.

The City and County will need to work closely with the other agencies involved in the Habitat Conservation Plan which has been prepared for the endangered Abutilon on the Kapolei site. Plant material from the five locations within the study site will need to be collected for propagation and included in future outplantings.

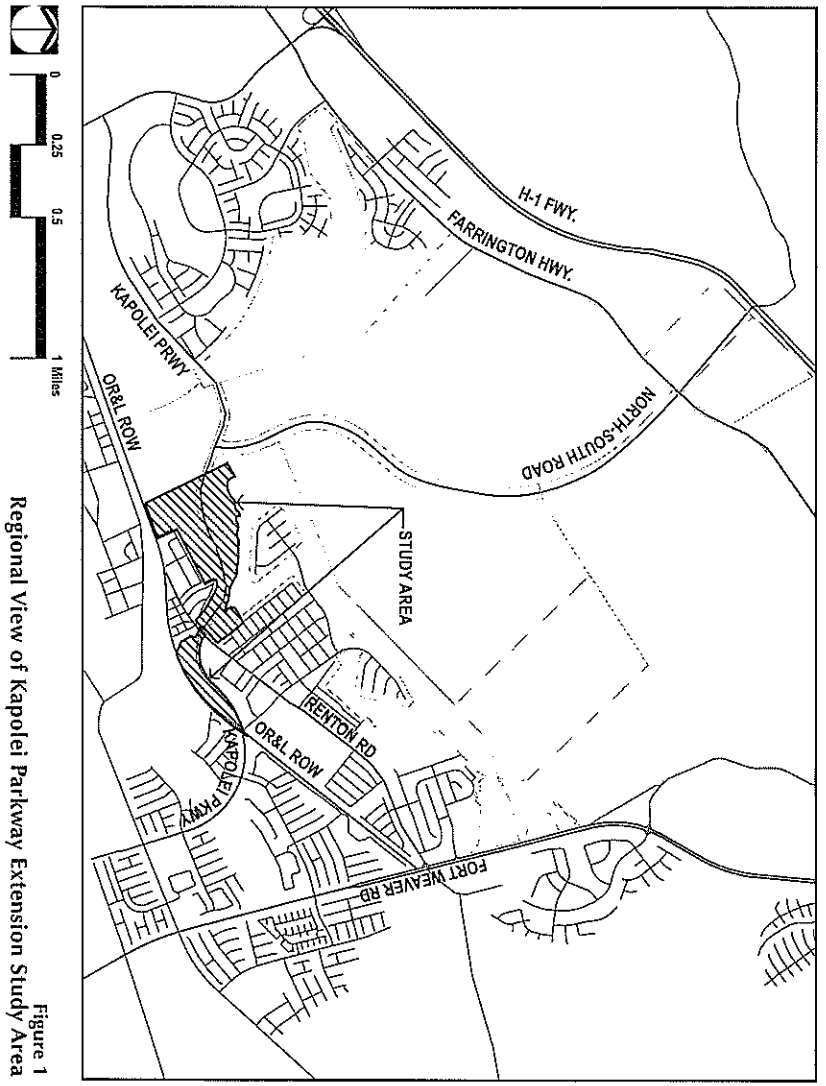


Figure 1
Regional View of Kapolei Parkway Extension Study Area

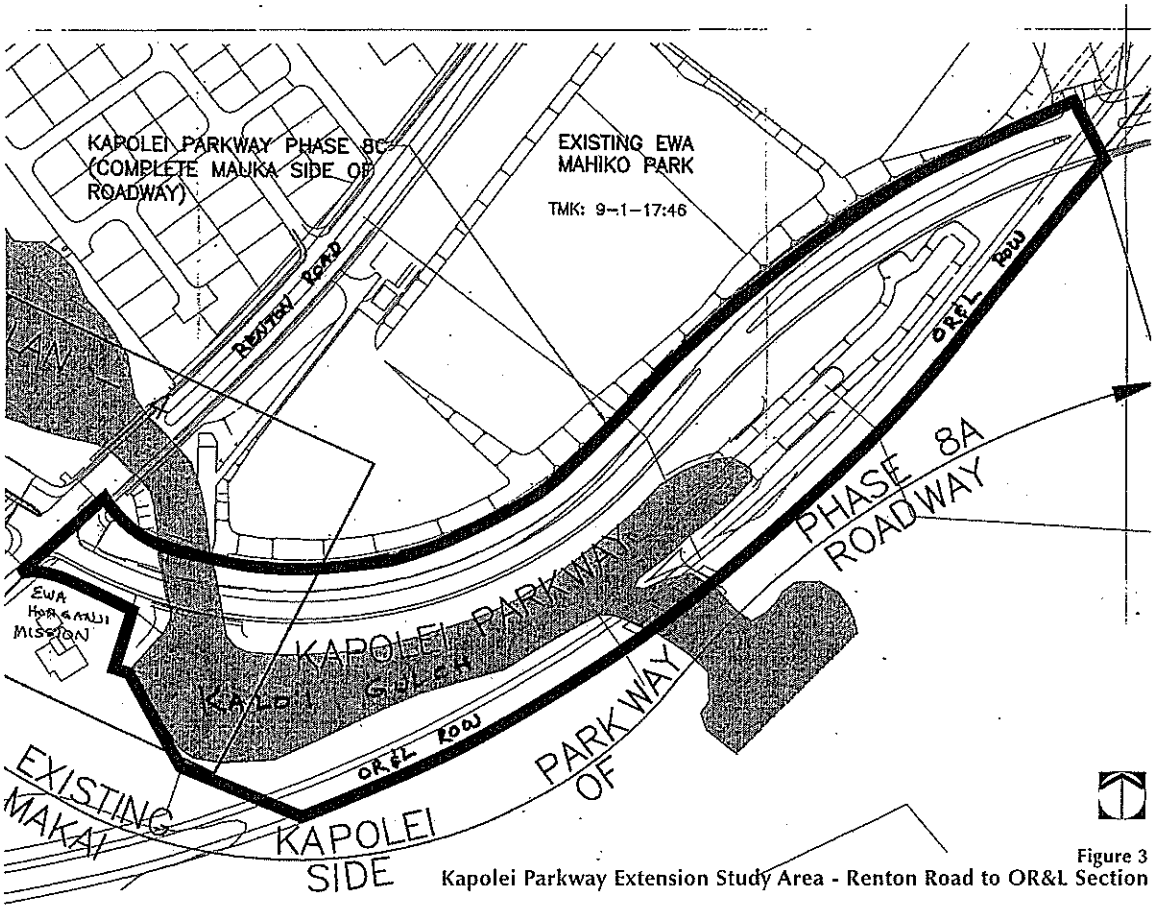


Figure 3
Kapolei Parkway Extension Study Area - Renton Road to OR&L Section

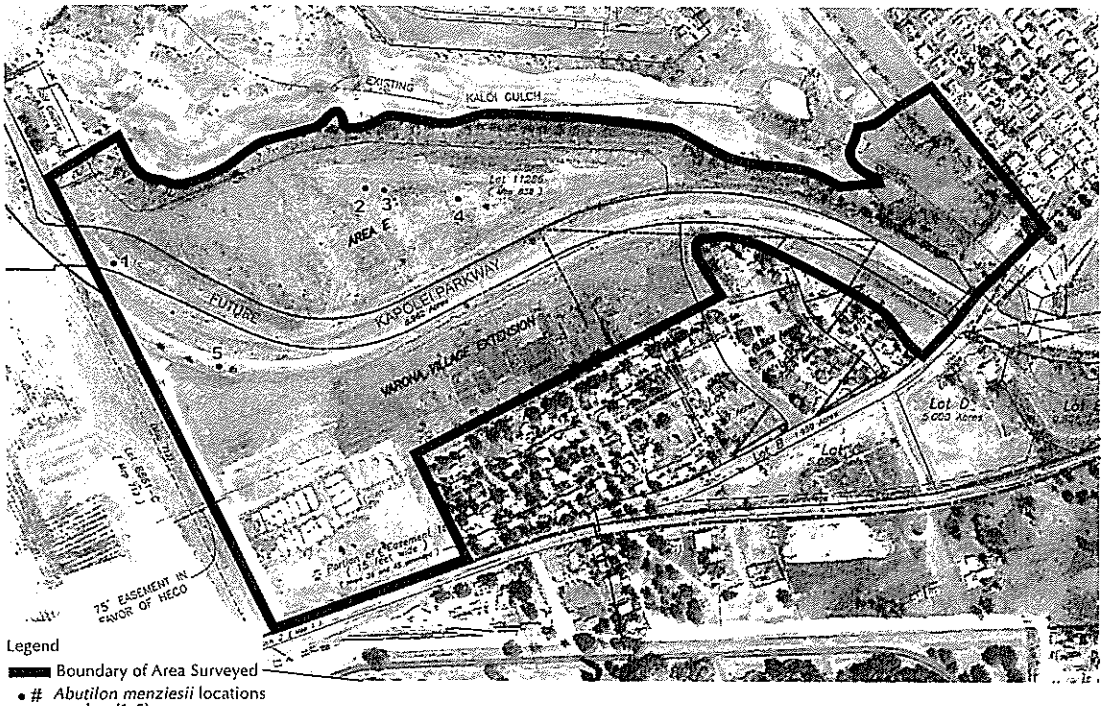


Figure 2
Kapolei Parkway Extension Study Area -
North-South Road to Renton Road Section

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Appendix F

Interim Management Report for Abutilon menziesii (April 24, 2001)

Department of Land and Natural Resources
Division of Forestry and Wildlife
Natural Area Reserve System

Interim Management Report for *Abutilon menziesii*
April 24, 2001

The following is a summary of activities implemented by the Department of Land and Natural Resources (DLNR) under the agreement, East Kapolei –Interim Mitigation Plan for the Endangered species, *Abutilon menziesii*, during the 31-month October 1, 1998 to April 24,2001. This report will summarize the activities completed during each of the 10 quarters during that period. We have not completed all activities set forth in the agreement. The only task that remains is the construction of a greenhouse (Task # 5). This is not a final report. A final report will be submitted when all tasks have been completed.

Task 1: Maintain existing population of Abutilon menziesii on State land at East Kapolei, Oahu, Hawaii. This work will include the following:

1. Monitoring

A total of 76 visits were made to the *Abutilon menziesii* plants at Kapolei between October 1998 and March 2000. Two DLNR staff conducted most of the site visits. The breakdown of the visits per quarter can be found in Table 1 below. Each plant was given a number and a permanent tag. The numbers given to plants followed those assigned during the survey done by Kenneth Nagata in December 1997, where appropriate. New numbers were assigned to plants not located during the Nagata surveys. As part of the monitoring process, four mature plants not found in the original survey were discovered; three are outside the project area near the Ewa golf course maintenance building and one adjacent to population C-1. Therefore the number of original plants in the East Kapolei population was the 86 found during the December 1997 survey by Kenneth Nagata, plus the 4 new plants discovered during the site visits made by DLNR staff during this project, for a grand total of 90 plants. We were successful in propagating clones from 62 of the 90 plants. In the Interim Report of 20 June 2000 we stated that there were 62 remaining plants. Several of these plants have since died due to natural senescence. The number of plants still alive is between 30 and 50. Determining whether an *Abutilon menziesii* is still alive is difficult. The plant may appear to be only dead sticks but a heavy rain will cause the plant to suddenly sprout green leaves. Therefore it is difficult to give a definitive total on the plants still alive in East Kapolei. We have contracted with Hawaii Natural Heritage Program to produce a detailed GIS map of all known *Abutilon menziesii* plants and plant locations. This map will be provided in the final report for this project.

Table 1. Site visits to East Kapolei *Abutilon menziesii* plants

Quarter	Number of Site Visits	Total Person Days
October 1998 - December 1998	13	26
January 1999 - March 1999	6	12
April 1999 - June 1999	7	16
July 1999 - September 1999	8	16
October 1999 – December 1999	7	14
January 2000 – March 2000	8	16
April 2000 – June 2000	8	8
July 2000 – September 2000	5	5
October 2000 – December 2000	6	6
January 2001 – March 2001	8	8

2. Maintenance

Plants were watered during each visit and treated six separate times with systemic insecticide to control hibiscus snow scale, ants, and mealy bugs. Vegetation immediately adjacent to each plant was removed during each visit to keep potential fire fuels away from the plant. Plants were not fertilized because of a concern of encouraging soft growth in the wild plants that could not be sustained without the installation of a permanent irrigation system.

3. Security

A fire plan has been implemented for the area that: creates a fire break around the *Abutilon menziesii* populations and individual plants; identifies the fire fighting resources available near the East Kapolei *Abutilon menziesii* population; and provides information to these resources to assist them with protecting these plants from fire. We have contracted the Hawaii Natural Heritage Program to produce a detailed GIS map of all the known *Abutilon menziesii* plants and the key fire resources in the area. This map will be provided to all the Fire Department Stations listed in this fire plan for their reference in case of a fire. This map will be a part of the final report. The TMK for the East Kapolei area where the plants are found is Oahu 9:1:6, parcel 109. The nearest Fire Station to the area is Kapolei Fire Station (Station 40). Station 40 is approximately 2.5 miles from the *Abutilon menziesii* populations.

The potential ignition sources for fires in the East Kapolei area are accidental ignitions from children playing with fire, careless smoking, vehicles in dry flashy fuels, misuse of fireworks, and intentionally set arson fires. Fireworks are prevalent during the New Years and Fourth of July holidays and illegal aerial fireworks are becoming more prevalent during these times. The potential of fireworks as an ignition source in Kapolei is quite high. Illegal motorcycle use of the parcel occurs and is another likely source for fires in the area. To mitigate for the potential for fire we have removed all fuel immediately adjacent to each plant. In late June 2000, we contracted an agricultural disc to create a 30-foot barrier of bare soil around each plant or each cluster of plants. This firebreak is still in place because we have not received any significant rainfall in the area since the establishment of this firebreak.

The fire fighting resources available at Station 40 in Kapolei are an Engine, a Ladder truck, and a Brush Fire truck. A Honolulu Fire Department Battalion Chief is stationed at Station 40. The next closest fire units are at Station 12 in Waipahu. Station 12 has an Engine, a Ladder truck, and a Water Tender. Station 35 in Makakilo is the third closest unit to the area and it has an Engine on site. Station 28 in Makakilo is the fourth closest unit with an Engine and a Water Tender on station. The GIS map we developed shows all the access routes to the main population clusters. This map will be provided the above Fire Stations.

Task 2: Propagate a total representation of plants through seeds and cuttings from the East Kapolei Abutilon menziesii population.

Task 2 of the agreement has been completed. All the known East Kapolei Abutilon menziesii plants have been propagated through cuttings. Figure 1 shows some of the 630 plants we have propagated from cuttings so far. The bullets below detail the propagation work we have done. Table 2 below details the cuttings taken from the East Kapolei *Abutilon menziesii* plants per quarter. Each cutting taken from an East Kapolei plant can be divided into up to six cuttings. We attempt to produce a plant from each cutting but not all are successful. Figure 2 is a photo of many *Abutilon menziesii* plants ready for outplanting.

- A total of 630 plants have been propagated from cuttings of 62 East Kapolei individuals.
- 220 seedlings have been produced from seed. This seed was collected from nursery plants grown from cuttings of the East Kapolei population.
- Research on optimum germination method is ongoing. We are using a heating mat under the seeding tray to speed germination rate. This method has been successful in speeding germination time from 3 to 4 months with regular germination technique to 2 to 3 weeks using this technique.
- We have sent over 800 seeds to Dr. Alvin Yoshinaga at Lyon Arboretum. A percentage of these are sent to the National Seed Storage Lab in Fort Collins, Colorado. These seeds are from nursery plants.
- We have seeds from 39 of the East Kapolei plants in storage at the Pahole Rare plant facility.

Table 2: Cuttings taken of East Kapolei Abutilon menziesii

Quarter	Number of Cuttings Taken
October 1998 - December 1998	120
January 1999 - March 1999	200
April 1999 - June 1999	70
July 1999 - September 1999	30
October 1999 – December 1999	36
January 2000 – March 2000	28
April 2000 – June 2000	40
July 2000 – September 2000	0
October 2000 – December 2000	0
January 2001 – March 2001	70

Figure 1: *Abutilon menziesii* cuttings

Figure 2: Plants grown from cuttings ready for outplanting

Task 3: Establish two wild populations of Abutilon menziesii in appropriate habitat

Two outplanting sites have been identified as the initial sites for the establishment of new wild populations of *Abutilon menziesii*. The first site is on unencumbered State land on the Mokulcia side of Kaena Point and the second is on City and County of Honolulu land in Koko Crater.

The first ouplanting site is located at the Koko Crater Botanical Garden. The Honolulu Botanical Gardens provided a 100 x 100 foot site set aside for the plant for the initial planting. On 16 November 2001, 140 *Abutilon menziesii* were planted at the site provided. These plants represent 2 complete sets of each of the original East Kapolei plants. The planting was accomplished with Honolulu Botanical gardens staff, DLNR staff, and several volunteers. The plants have been irrigated with a drip irrigation system and are thriving. Koko Crater Botanical Gardens staff will provide the long term care of these plants and will be propagating *Abutilon menziesii* from materials taken from these plants.

The Kaena Point outplanting site was initiated in April 2001. The outplanting area is about ¼ mile to the west of the site identified in the June 20, 2000 report. The approximately 3-acre outplanting site was established with two distinct planting areas separated by a four-wheel drive road. The site is completely protected from four-wheel drive vehicles by a rock barrier along the dirt road fronting the outplanting site. We prepared the site by clearing the non-native brush and grass with weedeaters and with hand tools. We treated the area with herbicide to prevent regrowth of these non-natives. A total of 61 *Abutilon menziesii* plants were planted by 6 April 2001. We will be planting more plants in the Kaena Point outplanting site by the end of May 2001. When planting is complete we will have two representatives of each of the 62 East Kapolei plants we have propagated. We also planted over 300 other native coastal plants of 20 different species in this site.

A complete irrigation system was constructed at the Kaena Point outplanting site to provide the initial irrigation for these plants. The DLNR received permission from the U. S. Air Force to tap into the 4-inch water main that runs adjacent to the outplanting site. We contracted a plumber to tap into the line and provide a pressure reducing valve, a backflow preventer, a water meter, and a 1-½ inch stub to attach our irrigation system to. We also installed a valve to supply water for fire suppression in the area. We constructed a corrugated galvanized steel water tank with a capacity of approximately 3,000 gallons to provide a water reserve for irrigating the plants. This tank is necessary because the 4-inch water main is pressurized only two days a week for 4 hours per day. The cost of the irrigation water will be an ongoing expense for this project. We consulted with DLNR Historic Preservation Division and they declared that the construction of the outplanting site would have no effect on significant historical sites. We checked with the City and County about the need for a Special Management Area permit. They confirmed that this site is within the Special Management Area. However, the work of developing the outplanting site did not require a permit because was not considered development.

Each outplanting site was planted with a representative sub-sample of the wild plants from East Kapolei and each individual plant will be tagged with permanent metal tags. Maintenance of these sites will be done during the establishment of these plants via weeding, application of herbicide, pesticide, and fertilizer.

As part of the national program to preserve rare species, replicates of all wild individuals will be planted in the living collections at Waimea Arboretum. It is hoped that this will provide seeds for further out plantings and for distribution. We have not done this yet because of the current staffing levels at the Waimea Arboretum

When the above sites are established we will consider other outplanting sites including:

- U. S. Navy land in Lualualei
- Barbers Point
- Kaena Iki/Yokohama Bay
- Diamond Head Crater
- Makapu'u/Queen's Beach
- A current outplanting site on State land near Kealia Trail

Task 4: Research into the biology of the Abutilon menziesii population.

1. *Document Past Research*
The University of Hawaii has not yet been contracted to document past research on the *Abutilon menziesii* population.

2. *Testing*

a) Test granular diazinon for use in controlling ants.
This was done on all plants and it is a very effective treatment in controlling ants.

b) Test Azatin and encapsulated Dursban on a few plants to determine toxicity.
These pesticides provide good control of scale and mealy bugs with no toxicity to *Abutilon*. The first trial was conducted on 6 plants in October 1998. The treatment was shown to be effective in this trial and about one month later the treatment was done on the remaining East Kapolei plants.

c) Test seed storage in appropriate facilities
Seeds have been collected from 39 individual East Kapolei plants and are being stored at the DLNR rare plant seed storage facility. Approximately 700 seeds have been collected from the East Kapolei plants. We have collected over 1,000 seeds from nursery plants grown from cuttings. We provided over 800 seeds to Dr. Alvin Yoshinaga at Lyon Arboretum for seed storage research. Some of these seeds have been sent to the National Seed Storage Lab in Fort Collins, Colorado for long term storage.

We will continue to work on finding the most effective germination technique for *Abutilon menziesii* seeds.

Task 5: Provide partial funding for the construction of a low-elevation greenhouse dedicated to growing A. menziesii and other threatened and endangered plant species on Oahu.

We have been working on getting a site for a nursery for *Abutilon menziesii* that is near the outplanting site and the DLNR rare plant nursery. The preferred site for the low-elevation nursery facility was identified behind Dillingham airfield. We had discussions with the Department of Transportation over a 6-month period and eventually were told that they were unable to lease any portion of the airfield for a use not associated with aviation.

The second site we identified for the nursery is on a portion of land owned by DLNR and leased by YMCA Camp Erdman. This six-acre site is immediately adjacent to the Camp on the Kaena Point side makai of Farrington Highway. YMCA Camp Erdman indicated keen interest in cooperating in the placement of this nursery here. This site is attractive because it is close to a

water and power source. Camp Erdman offers the benefits of 24-hour security and the potential as an educational outreach site for rare native plants. This site is considered a backup site because of the amount of work involved in removing the many iron wood trees on the site. The other negatives are that because the site is so close to the ocean the nursery would receive heavy salt spray and would be threatened by salt water during periods of high surf.

The primary site identified for the nursery is on land owned by the State of Hawaii, and leased to Mr. Ron Weidenbeck of Fish Farms Hawaii. The parcel is located in Lot 3 of TMK 6: 9: 01. Mr. Weidenbeck has approved DLNR removing a portion of Lot 3 to establish a nursery. The advantages of this site are: within a hundred yards of a water source; within a hundred yards of a power source; within a 8 foot high chain link perimeter fence; located away from the direct influence of the waves and salt spray; and above a planned caretakers cabin which will provide oversight of the area. We are currently working with Ms. Charlene Unoki of the Division of Land Management, DLNR to convert the lease of this parcel to the Division of Forestry and Wildlife from Mr. Weidenbeck. We expect to complete the transfer of this property and begin construction soon. We will submit the final report for the Housing and Community Development Corporation of Hawaii when we have completed the construction of this greenhouse.

Appendix G
Final Interim Management Report
for Abutilon menziesii
(October 31, 2003)

Department of Land and Natural Resources
Division of Forestry and Wildlife
Natural Area Reserves System

Final Interim Management Report
for
Abutilon menziesii
Actions completed by the Division of Forestry and Wildlife
October 31, 2003

The following is a summary of activities implemented by the Department of Land and Natural Resources (DLNR), Division of Forestry and Wildlife (DOFAW), for the Endangered species, *Abutilon menziesii,* during the 30-month period from April 24, 2001 to October 31, 2003. This is a final report on the interim management activities completed by DOFAW. The Habitat Conservation Plan (HCP) for *Abutilon menziesii* is nearly complete. The Board of Land and Natural Resources must approve the HCP before the plan is considered complete. All future reporting on the management of *Abutilon menziesii* will be done in relation to the HCP.

Project Background

The East Kapolei *Abutilon menziesii* population was discovered in 1996 by Kenneth Nagata during a biological survey conducted for PBR Hawaii, a consulting firm hired by the State of Hawaii agency then known as the Housing Finance and Development Corporation. This survey was done for the East Kapolei Master Plan project that proposed a mixture of residential and community development projects for the area. The East Kapolei area was in sugar cane cultivation for over a century when agricultural operations ceased in spring 1995. The State of Hawaii, Department of Transportation, and the City and County of Honolulu, Department of Transportation Services commissioned another botanical survey by Char and Associates, Botanical Associates, for a proposed highway. The corridor of this proposed highway, known as the North-South Road, passes directly through a significant portion of the East Kapolei Abutilon *menziesii* population. These surveys are documented in previous versions of the East Kapolei Master Plan Habitat Conservation Plan for *Abutilon menziesii.*

In 1999, the State of Hawaii, Housing Finance and Development Corporation, which had changed its' name to the Housing and Community Development Corporation of Hawaii (HCDCH), entered into an agreement with the DLNR/DOFAW for the interim mitigation of the East Kapolei *Abutilon menziesii* population. This agreement (found in Appendix A), which was signed September 15, 1999, was to cover tasks that DLNR/DOFAW completed from October 1, 1998 to March 31, 2000. This agreement was to provide $67,850.00 to complete 5 main tasks in relation to the protection of the East Kapolei *Abutilon menziesii* population and the conservation of the species. The main tasks were: 1) Maintain existing population of *Abutilon menziesii* on State land at East Kapolei, Oahu, Hawaii; 2) Propagate a total representation of plants through seeds and cuttings from the East Kapolei *Abutilon menziesii* population; 3) Establish two wild populations of *Abutilon menziesii* in appropriate habitat; 4) Research into the biology of the *Abutilon menziesii* population; 5) Provide partial funding for the construction of a low-elevation greenhouse dedicated to growing *Abutilon menziesii* and other threatened and endangered plant species on Oahu. A report entitled, Interim Management Report for *Abutilon menziesii,* dated April 24, 2001 documented the work done by DLNR/DOFAW from October 1, 1998 until the report date. DLNR/DOFAW was paid $40,125 for the work accomplishments documented in that

report. All phases of tasks 1, 2, and 4 were accomplished during that period. We were unable to complete all phases of tasks 3 and 5 of the original agreement. We were unable to complete task 3, the establishment of two wild populations of *Abutilon menziesii,* because we had difficulty finding landowners who had suitable habitat and were willing to allow a new population of endangered plant species to be established on their land. The difficulty we had in completing task 5, the establishment of a low-elevation greenhouse, was finding a suitable parcel of State owned land where building a nursery was feasible with a small budget.

A second agreement between HCDCH and DLNR/DOFAW was signed on January 30, 2001 (see Appendix B). This agreement was signed to complete the actions that were not fully completed in the first agreement. This agreement covered actions to complete the establishment of two wild populations, construction of a greenhouse, and the completion of a final report. In this agreement DLNR/DOFAW was to complete the remaining tasks during the period from November 1, 2000 to October 31, 2001. DLNR/DOFAW continued to work through the problems associated with completion of the tasks identified in the second agreement. However, we were not able to complete them all by October 31, 2001. In October 2001, HCDCH was no longer seeking to complete the East Kapolei Master Plan and the agreement was not extended. DLNR/DOFAW did not receive the $27,725.00 that was set aside to complete the tasks in this second agreement. This report will document the completion of all tasks completed by DLNR/DOFAW since April 24, 2001 that were identified in the original agreement. DLNR/DOFAW staff used a variety of funding sources to complete the second outplanting site and complete the nursery. The HCDCH only paid about 60% of the $67,850.00 they had originally pledged to complete the mitigation measures for the conservation of *Abutilon menziesii.*

The North/South Road project of the State of Hawaii, Department of Transportation (DOT), and the City and County of Honolulu, Department of Transportation Services, has become the lead project in the development of the HCP for the East Kapolei population of *Abutilon menziesii*. The DOT has set aside funds to continue work on the conservation of *Abutilon menziesii* until the HCP is finalized, and beyond. These funds have paid for part of the salary of a Horticulturist working for DLNR/DOFAW to work on the completion of the tasks mentioned above. That Horticulturist was hired in March 2001 and he continues to work on the conservation of *Abutilon menziesii*. The DOT funds have also been used to complete the nursery and support tasks related to the conservation of this species.

ACCOMPLISHMENT OF TASKS

Task 1: Maintain existing population of Abutilon menziesii on State land at East Kapolei, Oahu, Hawaii. This work will include the following:

1.Monitoring

A total of 30 visits were made to the *Abutilon menziesii* plants at Kapolei between April 2001 and October 2003. The Horticulturist DLNR/DOFAW hired to work on *Abutilon menziesii* did all the monitoring. The Horticulturist visited the East Kapolei population once a month, or three times per quarter. Each plant has been given a number and a permanent tag. The numbers given to plants followed those assigned during the survey done by Kenneth Nagata in December 1997, where appropriate. The total number of *Abutilon menziesii* at the time of the last report was 90. The DOFAW Horticulturist has found 16 new *Abutilon menziesii* plants in the East Kapolei area since the last report. New numbers were assigned to plants. We have not taken any cuttings from any of these plants. The plants are still too small to be able to withstand the stress of cuttings being

taken from them. One of the 16 new plants has produced seed. That seed has been collected and stored.

The East Kapolei area has been in drought conditions since April 2001. In the spring of 2002, the area did receive a few significant rains. In surveys done at East Kapolei by DLNR/DOFAW in March through May 2002 many *Abutilon* seedlings were found. The Horticulturist decided that the survival of these seedlings was more likely if they were transplanted when they were still small. A total of 31 seedlings from the East Kapolei population were dug up and transplanted in the nearby outplanting site at the Honouliuli Unit of the Pearl Harbor National Wildlife Refuge. 21 seedlings of known parentage and 10 seedlings of unknown parentage that were removed from the East Kapolei population have been planted there. A small portion of the seedlings produced at the East Kapolei population (approximately 10%) during the spring of 2002 were left at East Kapolei and subsequently perished.

In the time since April 24, 2001, several of the original 86 plants have died due to natural senescence. The number of plants still alive is between 25 and 40. Determining whether an *Abutilon menziesii* is still alive is difficult. The plant may appear to be only dead sticks but a heavy rain will cause the plant to suddenly sprout green leaves. Therefore it is difficult to give a definitive total on the plants still alive in East Kapolei. In Appendix C, we have a map with all the *Abutilon menziesii* plants and plant locations noted in relation to existing infrastructure and boundaries. In Appendix D, we provide a map with all known *Abutilon menziesii* plant locations, existing infrastructure, and boundaries overlaid on an aerial photo from PBR Hawaii that was in HCDCH HCP.

2. Maintenance
Irrigation was provided to the 16 new plants to enhance their establishment. A small amount of fertilizer was given to all the live plants. Weeding was done around the base of all plants, including the plants that have died, to discourage the deposition of weed seeds around the mother plant and to reduce competition from weedy species

3. Security
A fire plan has been implemented for the area that created a fire break around the *Abutilon menziesii* populations and individual plants; identifies the fire fighting resources available near the East Kapolei population; and provides information to these resources to assist them with protecting these plants from fire. We have contracted the Hawaii Natural Heritage Program to produce a detailed GIS map of all the known plants and the key fire resources in the area. This map (in Appendix C) will be provided to all the Fire Department Stations listed below for their reference in case of a fire. The TMK for the East Kapolei area where the plants are found is Oahu 9:1:6, parcel 109.

The potential ignition sources for fires in the East Kapolei area are accidental ignitions from children playing with fire, careless smoking, vehicles in dry flashy fuels, misuse of fireworks, and intentionally set arson fires. Fireworks are prevalent during the New Years and Fourth of July holidays and illegal aerial fireworks are becoming more prevalent during these times. The potential of fireworks as an ignition source in Kapolei is quite high. Illegal motorcycle use of the parcel occurs and is another likely source for fires in the area. In late June 2000, we contracted an agricultural disc to create a 30-foot barrier of bare soil around each plant or each cluster of plants. We have not had any significant heavy rains since then to increase the fuel near the plants. Currently this firebreak is still in place. This method of firebreak creation may be more detrimental

than beneficial to the East Kapolei population. The use of the agricultural disc can disturb seeds in the soil bank around the existing plants, which could be detrimental to their germination.

At this time (October 2003) the fuel in the entire project area is light and discontinuous. It is highly unlikely a brush fire could be sustained in the East Kapolei *Abutilon menziesii* population area at this time. The area should be monitored regularly because an extended period of above average rainfall could increase fuel levels sufficiently to present a fire threat.

The nearest Fire Station to the area is Kapolei Fire Station (Station 40). Station 40 is approximately 2.5 miles from the *Abutilon menziesii* populations. The fire fighting resources available at Station 40 in Kapolei are an Engine, a Ladder truck, and a Brush Fire truck. A Honolulu Fire Department Battalion Chief is stationed at Station 40. The next closest fire units are at Station 12 in Waipahu. Station 12 has an Engine, a Ladder truck, and a Water Tender. Station 35 in Makakilo is the third closest unit to the area and it has an Engine on site. Station 28 in Makakilo is the fourth closest unit with an Engine and a Water Tender on station. The GIS map shown in Appendix C shows all the access routes to the main population clusters. This map will be provided the above Fire Stations.

Task 2:Propagate a total representation of plants through seeds and cuttings from the East Kapolei Abutilon menziesii population.

Task 2 was completed before April 24, 2001. The 16 plants discovered since that time have not been propagated from cuttings. These plants are still to small to sustain cuttings being taken from them.

We have not propagated any new plants from seed since April 24, 2001. We have continued to collect seed from the East Kapolei population. There are 52 plants from the East Kapolei population represented in the seed collection at the Lyon arboretum seed storage facility. This total includes seeds from one of the 16 new plants discovered since April 24, 2003.

Task 3: Establish two wild populations of Abutilon menziesii in appropriate habitat

The Interim management report of April 24, 2001 identified two outplanting sites that were the initial sites for the establishment of new wild populations of *Abutilon menziesii*. The first site is on City and County of Honolulu land in Koko Crater and the second is on State land on the Mokuleia side of Kaena Point. Since that report we have completed a third ouplanting site at the Honoululi Unit of the U. S. Fish and Wildlife Service Pearl Harbor National Wildlife Refuge.

1. Koko Crater
The first ouplanting site is located at the Koko Crater Botanical Garden. The Honolulu Botanical Gardens provided a 100 x 100 foot site set aside for the plant for the initial planting. On 16 November 2001, 140 *Abutilon menziesii* were planted at the site provided. The planting was accomplished with Honolulu Botanical gardens staff, DLNR staff, and several volunteers. The plants have been irrigated with a drip irrigation system since then and are thriving. Koko Crater Botanical Gardens staff will provide the long term care of these plants and will be propagating *Abutilon menziesii* from materials taken from these plants. DLNR has provided support to weed the Koko Crater population on periodic visits to the site. This site met the criteria for the establishment of wild

populations under the first interim mitigation plan agreement between HCDCH and DLNR/DOFAW when it was initially established. However, since the establishment of this site, we have received comments from the Endangered Species Recovery Committee and others. These comments have caused DLNR/DOFAW to reconsider the appropriateness of this population to be considered a wild population. DLNR/DOFAW agrees that since this site is within a public display garden that it should not be considered as a wild population for the purposes of the Habitat Conservation Plan. In addition, the plants at Koko Crater have been on drip irrigation since they were planted. This has caused the plants to grow taller and have more luxuriant growth than they would in a truly wild population. DLNR/DOFAW views this population as a living collection representation of the genetic stock of the East Kapolei *Abutilon menziesii* population. DLNR/DOFAW will work with the staff at Koko Crater Botanical Gardens to coordinate the management of this population.

2. Kaena Point

The Kaena Point outplanting site was started in April 2001. The outplanting area is about ½ the distance between the end of the paved Farrington Highway and the vehicle barrier at the entrance to the Kaena Point Natural Area Reserve. The land is under the jurisdiction of the DLNR, Division of State Parks (TMK 6:9:01, Parcel 4). The DLNR Historic Preservation Division declared that the construction of the outplanting site would have no effect on significant historical sites. The City and County of Honolulu Planning Section confirmed that this site is within the Special Management Area. However, the work of developing the outplanting site did not require a permit because was not considered development.

The approximately 3-acre outplanting site was established with two distinct planting areas separated by a four-wheel drive road. The site is completely protected from four-wheel drive vehicles by a rock barrier along the dirt road fronting the outplanting site. The initial cost of installing this barrier was nearly $4,000. This barrier has been challenged by off-road vehicles occasionally and we have improved the barrier in areas where vehicles have attempted to breech the barrier. We prepared the site by clearing the non-native brush and grass with weedeaters and with hand tools. We treated the area with herbicide to prevent regrowth of these non-natives. A total of 61 *Abutilon menziesii* plants were planted by 6 April 2001. We have planted 81 additional plants since April 2001. A total of 142 *Abutilon menziesii* plants have been planted in the Kaena Point outplanting site. The plants were irrigated at the site to promote their establishment. The approach we plan to take at this site is to irrigate the plants to encourage the production of a maximum amount of seed to allow the build up of the seed bank and natural establishment of seedlings. The survival rate for plants at this site has been 98%. The 142 plants at this site represent a total of 44 of the original East Kapolei plants. Two *Abutilon* seedlings have grown naturally from seed produced by plants outplanted at this site. These seedlings have grown large enough to be considered part of this population.

A complete irrigation system was constructed at the Kaena Point outplanting site to provide the initial irrigation for these plants. The DLNR received permission from the U. S. Air Force to tap into the 4-inch water main that runs adjacent to the outplanting site. We contracted a plumber to tap into the line and provide a pressure reducing valve, a backflow preventer, a water meter, and a 1-½ inch stub to attach our irrigation system to. We also installed a valve to supply water for fire suppression in the area. We constructed a corrugated galvanized steel water tank with a capacity of approximately 3,000 gallons to provide a water reserve for irrigating the plants. This tank is necessary because the 4-

inch water main is pressurized only two days a week for 4 hours per day. The cost of the installation of this irrigation system was nearly $12,000 to complete these tasks.

The Kaena Point outplanting site has been a difficult one to maintain. This site was established in area with deep soil that was dominated by Guinea grass (*Panicum maximum*) and koa haole (*Leucaena leucocephala*). We have had difficulty keeping up with the weed threat presented by these species and others at this outplanting site. DLNR/DOFAW has used a variety of labor including regular Natural Area Reserves System employees; temporary workers such as the Emergency Environmental Workforce; and volunteers to control weeds in the outplanting site. This additional labor has barely allowed us to keep pace with the weed threat at this site. The money provided under the HCDCH agreement was used to establish the irrigation system at this site and pay a portion of the first year of the salary for the Horticulturist assigned to work on all the activities concerning the conservation and recovery of *Abutilon menziesii*. Money provided by the State of Hawaii DOT has continued to support this position since 2001. This Horticulturist position has spent the majority of his time working on construction of the nursery dedicated to growing *Abutilon menziesii*. We would not have been able to keep up with the weed threat at this site without the additional labor supplied by regular DLNR/DOFAW employees. We will not be able to continue to support the weed threat control at this site at this level. This is due to other important projects taking precedence and a hiring freeze that has left the Oahu Branch with three vacant positions. It will be very difficult for the Horticulturist to keep up with the weed threat at this outplanting site.

The other major threat to this outplanting site is fire. The fire plan that has been in place at this site is the installation of the water tank that serves as a resource for fire fighting in addition to being part of the irrigation system, installation of a 2 inch outlet to allow fire engine hookup near the road as another fire fighting resource, and the planting of native plants along the perimeter of the outplanting site to serve as a fuel break. These tasks were accomplished. However, the fuel break portion of this fire plan needs to be developed further with a wider buffer of fire resistant species established.

On August 20, a brush fire started by a vehicle about ¾ mile away burned a total of 160 acres along the coastal flats up to the nearby Kuaokala Game Management Area at about 1,100 feet elevation. This fire started late at night and was fanned by winds of 25 to 35 mph. The fire burned to the edge of the outplanting site and around it. The fire moved so quickly that Honolulu Fire Department engine companies were not able to engage the fire near the ignition point, or near the outplanting site. They did fight the fire to prevent its' spread in the Kuaokala GMA on August 21. The fire burned approximately 30 percent of the 3-acre outplanting site. The effects of the fire on the *Abutilon menziesii* plants at the site are unknown at this time. We will not know how many were killed by the fire until the rainy season commences and there is sufficient moisture for growth. The plants along the edge were affected by the flames but not completely consumed. It is possible that many of these *Abutilon menziesii* plants will survive. The fire did burn many of the other native species planted in the area to serve as a fuel break along the front of the outplanting site. This fire would of caused more damage if these plants had not been in place. These fuel break plants will need to be replaced. The fire did destroy all irrigation pipes in the area. The cost to replace this pipe will be about $3,000. The lesson that DLNR/DOFAW has learned from this experience is that the fuel break plantings are the most useful part of the fire plan. The fuel break at the Kaena Point outplanting site needs to be replaced and improved to encompass the entire outplanting site.

The HCP should set aside enough funds to cover the full costs of developing and maintaining an outplanting site. The money provided under the agreement with HCDCH provided funds to install the vehicle barrier and the irrigation system, and provided some funds towards the first year of the Horticulturists' salary. The total cost to establish this outplanting site was more than $20,000. This does not include the cost of staff time of DLNR/DOFAW employees. The cost would have been significantly higher if the site was further from a water source.

The initial establishment of outplanting sites will be the most expensive phase of the project. Future outplanting sites should be chosen with that in mind. Several important factors need to be considered when developing an outplanting site for wild *Abutilon menziesii* populations: 1) The site should have a water source or irrigation method identified and accounted for in the budget; 2) It is important that the weed threat at the site is manageable with limited staffing or, if that is not possible, the work force and the resources necessary to combat the weed threat should be identified up front; 3) The fire threat to the site should be addressed with fuel break plantings; 4) The site must not be too remote as to require significant travel time and effort to get personnel and tools and equipment there; 5) The protection of the site from human impact needs to be considered and addressed in the establishment of the site. The HCP should front load the first few years of the budget to address the costs associated with initial development of outplanting sites.

3. Honouliuli Unit of Pearl Harbor National Wildlife Refuge

A third outplanting site has been developed at the Honouliuli Unit of the U. S. Fish and Wildlife Service Pearl Harbor National Wildlife Refuge that borders the West Loch of Pearl Harbor (TMK 9:1:17). This 37-acre unit is mostly a fresh water wetland managed for a variety of endangered water birds. The entire Honouliuli Unit is enclosed in an eight-foot chain link fence that provides predator control for the birds and security for the plants. There is an upland area within this Unit that we felt was suitable for planting *Abutilon menziesii*. We installed an irrigation system at the site to assist with the initial establishment of plants there at a cost of approximately $2,500.

We have planted a total of 61 *Abutilon menziesii* plants at the Honouliuli Unit. The survival rate of the plants outplanted there is 96%. Plants from cuttings from 21 of the original East Kapolei plants are planted here. In addition, 21 seedlings of known parentage and 10 seedlings of unknown parentage that were removed from the East Kapolei population in the spring of 2002 have been planted here. A small portion of the seedlings produced at the East Kapolei population (approximately 10%) during the spring of 2002 were left at East Kapolei and subsequently perished. Three plants produced from seed were also planted at Honouliuli. The amount area covered by this outplanting site is approximately ½ an acre. There is sufficient area to add many more plants to this site.

The threat to this outplanting site from fire is minimal. The eight-foot chain link fence provides a barrier to most of the possible ignition sources. A buffer of approximately 6 feet of bare ground is in place just inside most of the perimeter fence of this unit to serve as a barrier to predators of the endangered water birds. This buffer strip also serves as a firebreak to the outplanting site. The portion of the fence that doesn't have this buffer has fresh water marsh just inside the fence. The only fire plan we have for this site is to make sure this buffer strip remains in place.

Task 4: Research into the biology of the Abutilon menziesii population.

No further research activities have been conducted on the biology of the *Abutilon menziesii* population. We have continued to collect seed produced by 52 of the original East Kapolei plants. Over 20,000 seeds have been collected.

Task 5: Provide partial funding for the construction of a low-elevation greenhouse dedicated to growing A. menziesii and other threatened and endangered plant species on Oahu.

We have completed the construction of a 6,000 square foot nursery dedicated to the propagation of *Abutilon menziesii* and other threatened and endangered plant species on Oahu. The nursery is located above the Kaena Point end of Dillingham Air Field on the North Shore of Oahu. The nursery is located is located in Parcel 3 of TMK 6: 9: 01. This parcel is owned by the State of Hawaii, managed by the Land Division of the DLNR, and was leased to Mr. Ron Weidenbeck of Fish Farms Hawaii. We are still in the process of getting the parcel under the jurisdiction of DLNR/DOFAW. There have been issues related to some of the other parcels leased to Mr. Weidenbeck in the area that have slowed this process.

This task has been the most difficult one to complete. The most difficult phase was locating suitable parcel of State owned land where building a nursery was feasible with a small budget. We looked at sites on DOT land closer to the Dillingham Airfield and a parcel near Camp Erdman in addition to others. The selection of a nursery site was not complete until October 2001. The site needed a significant amount of groundwork before it was usable as a nursery. The leveling of the site included hauling 300 tons of rock to the site. We finally completed the groundwork in March 2002. The next difficulty was developing construction specifications and getting bids for the construction of the main part of the nursery. This phase took from April 2002 until June 2002. We completed the construction of the main part of the nursery in the fall of 2002. Once the construction of the nursery was complete we installed the shade cloth with the help of DLNR/DOFAW staff and volunteers. The next to the last phase of the project was the completion of the electrical hook up which included the installation of a new power pole, electrical meter, and safety switch. We also had to wire the pumps for the water system, provide power in the nursery for lights, and outfit the storage containers we had moved to the site with lights and power outlets. The final phase of the nursery project was the installation of a water system. This phase required obtaining permission to tap into a line at a nearby concrete reservoir tank, the installation of a 10,000 gallon storage tank, installation of a 1,000 gallon booster tank, installation of pumps to lift water to the upper storage tank and pressurize the nursery supply lines, and installation of the irrigation system within the nursery. These final two phases were completed by the end of August 2003.

The original agreement with HCDCH set a budget of $10,000 to contribute towards the construction of a nursery dedicated to growing *Abutilon menziesii*. The total cost for completing all phases of this nursery was over $68,000.00. We utilized a variety of funding sources to complete the nursery. We utilized $13,189.53 of the funds set aside by DOT for *Abutilon menziesii* during the nursery construction phase of the project. The nursery alone cost more than the entire amount originally budgeted to complete all tasks in the first Interim Mitigation plan for the Endangered Species, *Abutilon menziesii*, between DLNR/DOFAW and HCDCH. The Horticulturist hired with a majority of his salary coming from DOT funds has spent 80% of his work time since October 2001 working on completion of this nursery. The monetary value of his time is not included in the total listed above.

APPENDIX A

BENJAMIN J. CAYETANO
GOVERNOR

DONALD K.W. LAU
EXECUTIVE DIRECTOR

SHARYN L. MIYASHIRO
EXECUTIVE ASSISTANT

FAX: (808) 587-0600

STATE OF HAWAII
DEPARTMENT OF BUSINESS, ECONOMIC DEVELOPMENT AND TOURISM
HOUSING AND COMMUNITY DEVELOPMENT CORPORATION OF HAWAII
677 QUEEN STREET, SUITE 300
Honolulu, Hawaii 96813

TO: Department of Land and Natural Resources
Division of Forestry and Wildlife
Oahu Branch

DATE: September 16, 1999
ATTENTION: Randy Kennedy

RE: East Kapolei – Interim Mitigation Plan for the Endangered Species, Abutilon Menziesii

WE ARE SENDING YOU X ATTACHED
___ UNDER SEPARATE COVER VIA _____ THE FOLLOWING ITEMS

COPIES	DATE	NO.	DESCRIPTION
1	9/15/99		Executed Agreement for the East Kapolei interim mitigation plan

THESE ARE TRANSMITTED as checked below:

___ For approval
X For your use
___ As requested/required
___ For review and comment
___ FOR BIDS DUE _____

___ Approved as submitted
___ Approved as noted
___ Returned for corrections

___ Resubmit
___ Submit
___ Return

___ copies for approval
___ copies for distribution
___ corrected prints

REMARKS: _____

IF THERE ARE ANY QUESTIONS, PLEASE CONTACT: Leo Domingo TELEPHONE NO. 587-3170

SIGNED: _____
Project Coordinator

COPY TO: _____

IF ENCLOSURES ARE NOT AS NOTED, KINDLY NOTIFY US AT ONCE.

DHS 4308/ (8/87)

AGREEMENT

THIS AGREEMENT is made this 15th day of September, 1999, by and between the HOUSING AND COMMUNITY DEVELOPMENT CORPORATION OF HAWAII ("HCDCH"), a public body and body corporate and politic of the State of Hawaii, whose post office address and principal place of business is 677 Queen Street, Suite 300, Honolulu, Hawaii 96813, and the DEPARTMENT OF LAND AND NATURAL RESOURCES ("DLNR"), State of Hawaii, whose address is 1151 Punchbowl Street, Honolulu, Hawaii 96813, and

WHEREAS, the Department of Land and Natural Resources (DLNR), has title to that certain real property situated at Honouliuli, Ewa, Oahu, Hawaii, containing an area of 1,300.000 acres, and identified as tax map keys: 9-1-016:008, 9-1-016:108, 9-1-016:109, 9-1-017:086, 9-1-017:071, 9-1-018:003, and 9-1-018:005 (collectively referred to as "East Kapolei State Land Bank,") and

WHEREAS, DLNR is in the process of transferring title of the East Kapolei State Land Bank to HCDCH for development purposes in order to satisfy legislative and administrative goals and objectives, specifically to generate funds for the University of Hawaii West Oahu Campus, to facilitate the development of private sector housing units, and to provide off-site infrastructure for the 200-acre site to be transferred to the Department of Hawaiian Home Lands, and

WHEREAS, HCDCH is the designated master plan developer for the East Kapolei Master Planned Development Project, which encompasses the East Kapolei State Land Bank, and

WHEREAS, HCDCH has filed a Final Environmental Impact Statement (FEIS) for the East Kapolei State Land Bank. The FEIS was accepted by the Governor of the State of Hawaii on September 23, 1998, conditioned upon satisfying the requirements of Chapter 343, Hawaii Revised Statutes, and specifically to implement the Habitat Conservation Plan for the endangered abutilon menziesii in accordance with the requirements of the U.S. Fish and Wildlife Service and the State Department of Land and Natural Resources;

WHEREAS, DLNR has the capability of performing the plant mitigation and has the knowledge and expertise to administer the mitigation of the endangered Abutilon Menziesii, and is willing to provide services for the interim mitigation of the endangered Abutilon Menziesii,

NOW THEREFORE, in consideration of the premises above, the parties mutually agree as follows:

1. DLNR shall perform the tasks set forth in "Exhibit A", attached hereto and incorporated herein. DLNR shall provide reasonable safeguards to secure the existence of the endangered Abutilon Menziesii, to maintain the existing plant population, to establish a new "wild" population, and to perform research into the biology of the endangered Abutilon Menziesii.

2. HCDCH will pay to DLNR the total sum of $67,860.00 as set forth in "Exhibit B", attached hereto and incorporated herein. Quarterly payments will be made upon submission of written quarterly reports of progress to HCDCH.

3. DLNR will perform the tasks during an 18-month period, beginning from October 1, 1998 and ending on March 31, 2000.

4. This Agreement shall be null and void if the Habitat Conservation Plan is not approved by DLNR.

5. This Agreement may be terminated at any time by written consent of both parties.

IN WITNESS WHEREOF, the undersigned have executed these presents as of the day and year first written above.

APPROVED AS TO FORM:

Deputy Attorney General

HOUSING AND COMMUNITY DEVELOPMENT CORPORATION OF HAWAII

Donald K. W. Lau
Its Executive Director

DEPARTMENT OF LAND AND NATURAL RESOURCES

Timothy E. Johns, Chairperson
Board of Land and Natural Resources

Exhibit "A"

SCOPE OF SERVICES

A. Task 1

Maintain existing population of Abutilon Menziesii on State lands at East Kapolei, Oahu, Hawaii. This work will include the following:

1. Monitoring

   a. Place permanent stakes for sequence shots.
   b. Record GPS data in notebook and on video soundtrack.
   c. Create a new map with GPS points using GIS.

2. Maintenance

   Maintain existing population by weeding, and applying herbicide, pesticide and fertilizer.

3. Security

   Develop and implement a fire protection plan for the population.

B. Task 2

Propagate a total representation of plants through seeds and cuttings from the Abutilon Menziesii population. These plants will be used to maintain genetic representation of stock and provide stock for outplanting purposes. Work will be done at the existing State DLNR, Division of Forestry and Wildlife (DOFAW) nurseries or at appropriate co-operating nurseries.

C. Task 3

Establish two wild populations of Abutilon Menziesii in appropriate habitat to allow for natural establishment and long term viability. Prepare and implement fire protection plan for the population. Secure wild population from off-road vehicles using boulder barriers.

D. Task 4

Research into the biology of the Abutilon Menziesii population.

1. Contract the University of Hawaii to document past research on the Abutilon Menziesii population.

2. Perform testing and identify testing parameters as follows:

   a. test granular diazinon for use in controlling ants;
   b. test Azatin and encapsulated Dursban on a few plants to determine toxicity;
   c. test seed storage in appropriate facilities in the event of problems with wild populations;
   d. establish testing parameters for outplanting site selection to include, but not limited to, salt influence, occasional storm wave wash influence, associated soil organisms, and accompanying pests.

E. Task 5

Construct a greenhouse dedicated to growing Abutilon Menziesii endangered plant species. The greenhouse would serve as a long-term greenhouse for threatened and endangered plant species on Oahu. Task 5 includes the following scope:

1. Site Preparation

   a. clear and grade the greenhouse site, having approximately 0.5 acres in size; and
   b. construct an eight-foot high chain link fence.

2. Water Supply

   a. develop a permanent water source for greenhouse irrigation;
   b. purchase and construct a 5,000 gallon tank for emergency backup water supply; and
   c. provide irrigation system for greenhouse.

3. Greenhouse Construction

   a. construct a greenhouse using a prefabricated greenhouse kit;
   b. construct two shade structures for preparing nursery stock for outplanting; and
   c. purchase benches, pots, and equipment necessary to operate the greenhouse.

F. Administration

Document findings and prepare quarterly reports of progress. At the end of the contract period, prepare a summary final report which provides a recommendation of action and possible alternatives, if any, based upon documented findings and results.

DEV 21000.19

Exhibit "B"

COMPENSATION

Payment will be made upon DLNR's submission of quarterly reports to HCDCH. Final payment will be made upon DLNR's submission of a final report to HCDCH. Compensation is based upon the following cost breakdown:

Task 1	in the amount of	$18,300.00
Task 2	in the amount of	$10,950.00
Task 3	in the amount of	$16,600.00
Task 4	in the amount of	$ 7,500.00
Task 5	in the amount of	$10,000.00
Administration	in the amount of	$ 4,500.00
	TOTAL COMPENSATION	$67,850.00

APPENDIX B

BENJAMIN J. CAYETANO
GOVERNOR

SHARYN L. MIYASHIRO
ACTING EXECUTIVE DIRECTOR

ROBERT J. HALL
ACTING EXECUTIVE ASSISTANT

FAX: (808) 587-0600

STATE OF HAWAII
DEPARTMENT OF BUSINESS, ECONOMIC DEVELOPMENT AND TOURISM
HOUSING AND COMMUNITY DEVELOPMENT CORPORATION OF HAWAII
677 QUEEN STREET, SUITE 300
Honolulu, Hawaii 96813

TO: DLNR – Division of Forestry and Wildlife
2135 Makiki Heights Drive
Honolulu, HI 96822

DATE: January 30, 2001
ATTENTION: Brent Liesemeyer

RE: East Kapolei – Interim Mitigation Plan for the Abutilon Menziesii

WE ARE SENDING YOU X ATTACHED
___ UNDER SEPARATE COVER VIA _____ THE FOLLOWING ITEMS

COPIES	DATE	NO.	DESCRIPTION
1			Inter-agency Agreement (Executed copy)

THESE ARE TRANSMITTED as checked below:

___ For approval
X For your use
___ As requested/required
___ For review and comment
___ FOR BIDS DUE _____

___ Approved as submitted
___ Approved as noted
___ Returned for corrections

___ Resubmit
___ Submit
___ Return

___ copies for approval
___ copies for distribution
___ corrected prints

REMARKS: _____

IF THERE ARE ANY QUESTIONS, PLEASE CONTACT: Leo Domingo TELEPHONE NO. 587-3170

SIGNED: _____
Project Coordinator

COPY TO: _____

IF ENCLOSURES ARE NOT AS NOTED, KINDLY NOTIFY US AT ONCE.

DHS 4308/ (8/87)

AGREEMENT

THIS AGREEMENT, made this 25th day of January, 2001, by and between the HOUSING AND COMMUNITY DEVELOPMENT CORPORATION OF HAWAII ("HCDCH"), a public body and body corporate and politic of the State of Hawaii, whose post office address and principal place of business is 677 Queen Street, Suite 300, Honolulu, Hawaii 96813, and the DEPARTMENT OF LAND AND NATURAL RESOURCES ("DLNR"), State of Hawaii, whose address is 1151 Punchbowl Street, Honolulu, Hawaii 96813.

WHEREAS, the DLNR has title to that certain real property situated at Honouliuli, Ewa, Oahu, Hawaii, containing an area of 1,300.000 acres, and identified as tax map keys: 9-1-016:008, 9-1-016:108, 9-1-016:109, 9-1-017:086, 9-1-017:071, 9-1-018:003, and 9-1-018:005 (collectively referred to as "East Kapolei State Land Bank"), and

WHEREAS, the DLNR is in the process of transferring title of the East Kapolei State Land Bank to HCDCH for development purposes in order to satisfy legislative and administrative goals and objectives, specifically to generate funds for the University of Hawaii West Oahu Campus, to facilitate the development of private sector housing units, and to provide off-site infrastructure for the 200-acre site to be transferred to the Department of Hawaiian Home Lands, and

WHEREAS, HCDCH is the designated master plan developer for the East Kapolei Master Planned Development Project, which encompasses the East Kapolei State Land Bank, and

WHEREAS, HCDCH has filed a Final Environmental Impact Statement (FEIS) for the East Kapolei State Land Bank. The FEIS was accepted by the Governor of the State of Hawaii on September 23, 1998, conditioned upon satisfying the requirements of Chapter 343, Hawaii Revised Statutes, and specifically to implement the Habitat Conservation Plan for the endangered Abutilon Menziesii in accordance with the requirements of the U. S. Fish and Wildlife Service and the State Department of Land and Natural Resources, and

WHEREAS, the DLNR has the capability to perform the plant mitigation, has the knowledge and expertise to administer the mitigation of the endangered Abutilon Menziesii, and is willing to provide services for the interim mitigation of the endangered Abutilon Menziesii, and

WHEREAS, HCDCH had previously entered into an agreement with the DLNR for similar services for the interim mitigation of the endangered Abutilon Menziesii, in an amount of $67,860.00.

This prior agreement expired on March 31, 2000, with a balance to complete interim mitigation in an amount of $27,725.00.

NOW THEREFORE, in consideration of the premises above, the parties mutually agree as follows:

1. DLNR shall perform the tasks set forth in "Exhibit A", attached hereto and incorporated herein. DLNR shall provide reasonable safeguards to secure the existence of the endangered Abutilon Menziesii, to maintain the existing plant population, to establish a new "wild" population, and to construct a greenhouse for the propagation of endangered plants.

2. HCDCH will pay to DLNR the total sum of $27,725.00 as set forth in "Exhibit B", attached hereto and incorporated herein. Quarterly payments will be made upon submission of written quarterly reports of progress to HCDCH.

3. DLNR will perform the tasks during a twelve-month period, starting from November 1, 2000 and ending on October 31, 2001.

4. This Agreement shall be null and void if the Habitat Conservation Plan is not approved by the DLNR.

5. This Agreement may be terminated at any time by written consent of both parties.

IN WITNESS WHEREOF, the undersigned have executed these presents as of the day and year first written above.

APPROVED AS TO FORM:

Deputy Attorney General

HOUSING AND COMMUNITY DEVELOPMENT CORPORATION OF HAWAII

Sharyn L. Miyashiro
Its Acting Executive Director

APPROVED AS TO FORM:

Deputy Attorney General

DEPARTMENT OF LAND AND NATURAL RESOURCES

Timothy E. Johns, Chairperson
Board of Land and Natural Resources

Exhibit "A"

SCOPE OF SERVICES

A. Task 1

Establish two wild populations of Abutilon Menziesii in appropriate habitat to allow for natural establishment and long term viability. Prepare and implement fire protection plan for the population. Secure wild population from off-road vehicles using boulder barriers.

B. Task 2

Construct a greenhouse dedicated to growing Abutilon Menziesii and endangered plant species. The greenhouse shall serve as a long-term greenhouse for threatened and endangered plant species on Oahu. Task 2 includes the following scope:

1. Site Preparation

   a. Clear and grade the greenhouse site, having approximately 0.5 acres in size; and
   b. construct an eight-foot high chain link fence.

2. Water Supply

   a. Develop a permanent water source for greenhouse irrigation;
   b. purchase and construct a 5,000 gallon tank for emergency backup water supply; and
   c. provide irrigation system for the greenhouse.

3. Greenhouse Construction

   a. Construct a greenhouse using a prefabricated greenhouse kit;
   b. construct two shade structures for preparing nursery stock for outplanting; and
   c. purchase benches, pots, and equipment necessary to operate the greenhouse.

C. Administration

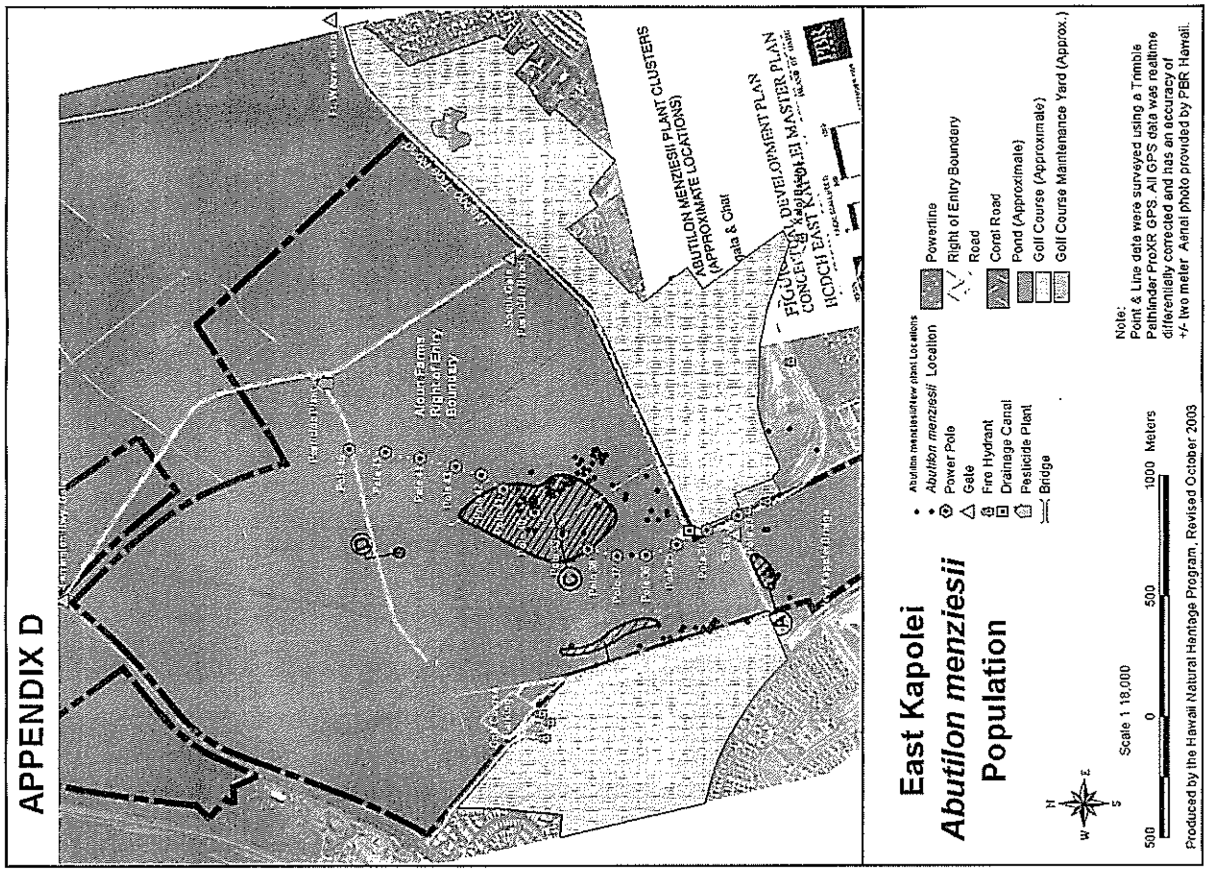
Document findings and prepare quarterly reports of progress. At the end of the contract period, prepare a summary final report which provides recommendation of action and possible alternatives, if any, based upon documented findings and results.

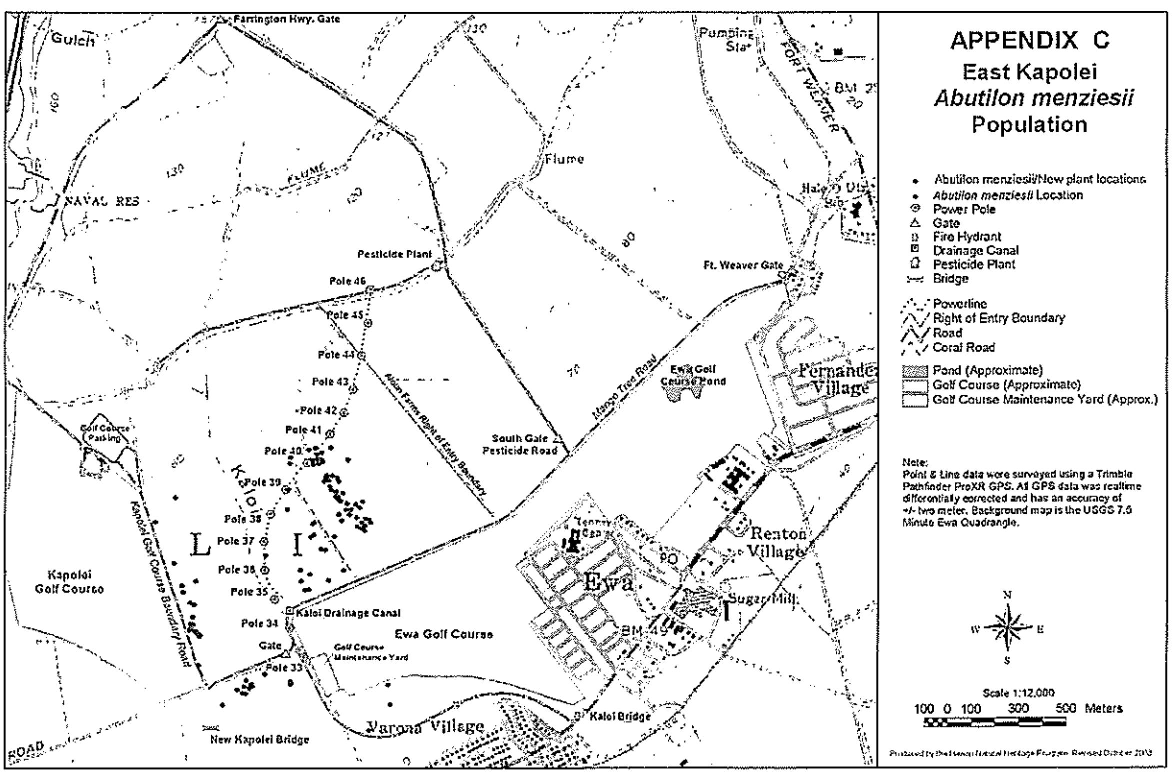
Exhibit "B"

COMPENSATION

Payment will be made upon DLNR's submission of quarterly reports to HCDCH. Final payment will be made upon DLNR's submission of a final report to HCDCH. Compensation is based upon the following cost breakdown:

Task 1	.....	$16,600.00
Task 2	.....	$10,000.00
Administration	.....	$ 1,125.00
	TOTAL COMPENSATION	$27,725.00


APPENDIX D
East Kapolei
Abutilon menziesii
Population
Abutilon menziesii/new plant Locations
Abutilon menziesii Location
Power Pole
Gate
Fire Hydrant
Drainage Canal
Pesticide Plant
Bridge
Powerline
Right of Entry Boundary
Road
Coral Road
Pond (Approximate)
Golf Course (Approximate)
Golf Course Maintenance Yard (Approx.)
Note:
Point & Line data were surveyed using a Trimble Pathfinder ProXR GPS. All GPS data was realtime differentially corrected and has an accuracy of +/- two meter. Aerial photo provided by PBR Hawaii.
Scale 1:18,000
500 0 500 1000 Meters
Produced by the Hawaii Natural Heritage Program, Revised October 2003
ABUTILON MENZIESII PLANT CLUSTERS
(APPROXIMATE LOCATIONS)
CONCEPTUAL DEVELOPMENT PLAN
HCDCH EAST KAPOLEI MASTER PLAN


APPENDIX C
East Kapolei
Abutilon menziesii
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Pond (Approximate)
Golf Course (Approximate)
Golf Course Maintenance Yard (Approx.)
Note:
Point & Line data were surveyed using a Trimble Pathfinder ProXR GPS. All GPS data was realtime differentially corrected and has an accuracy of +/- two meter. Background map is the USGS 7.5 Minute Ewa Quadrangle.
Scale 1:12,000
100 0 100 300 500 Meters
Farrington Hwy. Gate
Gulch
NAVAL RES
FLUME
Flume
Pumping Sta
Ft. Weaver Gate
Pesticide Plant
Pole 46
Pole 45
Pole 44
Pole 43
Pole 42
Pole 41
Pole 40
Pole 39
Pole 38
Pole 37
Pole 36
Pole 35
Pole 34
Pole 33
Gate
Kaloi Drainage Canal
Ewa Golf Course
Golf Course Maintenance Yard
South Gate Pesticide Road
Mango Tree Road
Ewa Golf Course Pond
Kapolei Golf Course
Golf Course Parking
Kapolei Golf Course Boundary Road
New Kapolei Bridge
Kaloi Bridge
Varona Village
Ewa
Renton Village
Sugar Mill
Fernandez Village
ROAD

APPENDIX D

AVIFAUNAL AND FERAL MAMMAL FIELD SURVEY

AVIFAUNAL AND FERAL MAMMAL FIELD SURVEY OF LANDS INVOLVED IN THE UNIVERSITY OF HAWAII – WEST O'AHU (UH WEST O'AHU) PROJECT, KAPOLEI, OAHU, HAWAII

Prepared for:

PBR-Hawaii

Prepared by:

Phillip L. Bruner
Environmental Consultant
Faunal (Bird & Mammal) Surveys
BYUH Box 1775
55-220 Kulanui Street
Laie, Hawaii 96762

21 April 2005

INTRODUCTION

This report presents the findings of a two day (15, 17 April 2005) field survey of lands involved in the University of Hawaii – West O'ahu project at Kapolei, Oahu (Fig. 1). References to pertinent published and unpublished source are also included to provide a broader perspective of the birds and mammals known from this region of Oahu. The goals of the field survey were:

1-Document the species of birds and mammals presently on the site.

2-Note any habitat features utilized by native and migratory birds.

SITE DESCRIPTION

The site contains 500.327 acres (Tmk: 9-1-016:120, 127, 129). The topography is flat and the majority of the plant cover is composed of alien (introduced) species. Portions of the site are under cultivation or recently plowed. Nearby lands contain residential landscaping. Drainage ditches in this area were dry and choked with brush and grass.

FIELD SURVEY PROTOCOLS

The site was surveyed by a combination of driving and walking. Nearby lands were also investigated. The survey was conducted during the morning hours when birds are active and more easily detected. All species of birds seen or heard were noted. Relative abundance data were taken using eight minute counts at scattered locations on and around the site. The number of migratory birds was also recorded. Data on the occurrence of mammals at this site were obtained by visual sightings. No trapping of mammals to determine their relative abundance was attempted.

The scientific names used in this report follow Pyle (2002) and Honacki et al. (1982). These two sources employ names used in the current scientific literature.

RESULT OF THE FIELD SURVEY

Native Land Birds:

No native land birds were recorded on the survey. The only species which occurs in this region is the Hawaiian Owl or Pueo (*Asio flammeus sandwichensis*). This bird is listed by the State of Hawaii as endangered on the island of Oahu. Pueo nest on the ground in tall grass habitats. They hunt over agricultural fields, open habitats and forests (Pratt et al. 1987, Hawaii Audubon Society 1997). I have seen Pueo on Barbers Point

property and at Ewa and Campbell Industrial Park on several occasions during the past ten years. My most recent sighting was at Barbers Point in October 2004.

Native Waterbirds:

No native waterbirds were seen on this survey. No suitable habitat for these birds occurs on this site.

Migratory Birds:

A total of 31 Pacific Golden-Plover or Kolea (*Pluvialis fulva*) were tallied on this survey. Kolea have been extensively studied in Hawaii and on their breeding grounds in Alaska (Johnson 1981, 1989, 1993, 2001a, 2001b, 2004). They are not listed as threatened or endangered. Plover prefer open habitats such as lawns, plowed fields as well as shorelines.

Seabirds:

No seabirds were recorded on the survey. None would be expected at this site.

Alien (Introduced) Birds:

Sixteen species of alien birds were tallied on this survey (Table One). These findings are consistent with the array of alien birds to be expected in this area (Hawaii Audubon Society 1997, Bruner 2000a, 2000b, 2002, 2003, 2004). None of this species are listed as threatened or endangered.

Feral Mammals:

The only feral mammals recorded on the survey were the Small Indian Mongoose (*Herpestes auropunctatus*) and feral cats (*Felis catus*). Rats (*Rattus spp.* and House Mouse (*Mus musculus*) likely occur in this area. The endangered Hawaiian Hoary Bat (*Lasiurus cinereus semotus*) is rarely recorded on Oahu (Tomich 1986, Kepler and Scott 1990). None were found on this survey. This species roosts solitarily in trees. They forage for flying insects at dusk and as well as after dark using echolocation (Tomich 1986). The chances of seeing a bat on Oahu are low due to their small numbers. It is therefore impossible to predict the chances of observing a bat at this location. They forage over native forest, disturbed habitats (fields and agricultural lands) and in urban settings (pers. observ.)

SUMMARY AND CONCLUSIONS

This survey searched the area of the proposed UH West O'ahu project. No native land birds, waterbirds or seabirds were found. The only migratory species detected was the Pacific Golden-Plover, a common migrant that is not threatened or endangered. Open fields and grassland habitat is suitable foraging grounds for migratory shorebirds such as the Pacific Golden-Plover and the native, endangered Pueo (Hawaiian Owl). The array and relatively abundance of alien birds tallied on the survey was typical of this region on Oahu. The landscape (habitat) changes resulting from this proposed

project will likely provoke an increase in the numbers of some alien birds such as Common Myna and Red-vented Bulbul as well as a decline in those alien species which prefer open grasslands and agricultural fields. The number of wintering migratory Pacific Golden-Plover may increase as the site is converted to lawns. Feral cats may increase in abundance, especially if they are being fed, as is often the case in public parks and around schools (pers. observ.)

Fig. 1. Location of faunal survey.

TABLE ONE

Alien (introduced) birds recorded on 15, 17 April 2005 at the UH West O'ahu proposed project site in Kapolei, O'ahu. Relative abundance estimates are based on an average of eight minute counts. Abundant (A)= 10+ per station, Common (C)=5-10 per station, Uncommon (U)=1-4 per station, Recorded (R)= not on a count station. Number which follows is total tallied over the two survey days.

Common Name	Scientific Name	Relative Abundance
Cattle Egret	*Bubulcus ibis*	R = 6
Ring-necked Pheasant	*Phasianus colchicus*	R = 3
Spotted Dove	*Streptopelia chinensis*	C
Zebra Dove	*Geopelia striata*	A
Sky Lark	*Alauda arvensis*	U
Red-vented Bulbul	*Pycnonotus cafer*	U
Northern Mockingbird	*Mimus polyglotos*	R = 2
Common Myna	*Acridotheres tristis*	C
Red-crested Cardinal	*Paroaria coronata*	U
Northern Cardinal	*Cardinalis cardinalis*	U
House Finch	*Carpodacus mexicanus*	C
Common Waxbill	*Estrilda astrild*	A
Red Avadavat	*Amandava amandava*	C
Nutmeg Mannikin	*Lonchura cantans*	C
Chestnut Munia	*Lonchura atricapilla*	U
Java Sparrow	*Padda oryzivora*	U

SOURCES CITED

Bruner, P. 2000a. Faunal (Bird & Mammal) survey of approximately 520 acres at NAVMAG Lualualei, Waikele branch, Oahu. Unpubl. ms. Prep. for Belt Collins & Associates.

_____ 2000b. Faunal (Bird & Mammal) field survey of the shoreline at Iroquois Points, Oahu. Unpubl. ms. Prep. For Belt Collins & Associates.

_____ 2002. Avifaunal and feral mammal survey of proposed BWA Kalaeloa Desalination facility, Kalaeloa, Ewa, Oahu, Hawaii. Unpubl ms. Prep. for Oceanit.

_____ 2003. Avifaunal and feral mammal field survey of the Barbers Point 215' Non Potable reservoir site at Makakilo, Oahu. Unpubl ms. Prep. for PBR-Hawaii and The Limtiaco Consulting Group.

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Hawaii Audubon Society. 1997. Hawaii's Birds. Fifth ed. Hawaii Audubon Society, Honolulu. 112pp.

Honacki, J.H., K.E. Kinman and J.W. Koeppl eds. 1982. Mammal species of the World: A taxonomic and geographic reference. Allen Press, Inc. and the Association of Systematic Collections. Lawrence, Kansas. 694pp.

Johnson, O.W., P.M. Johnson and P.L. Bruner. 1981. Wintering behavior and site-faithfulness of Golden-Plovers on Oahu. 'Elepaio 42(12): 123-130.

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Johnson, O.W., P.L. Bruner, J.J. Rotella, P.M. Johnson, and A.E. Bruner. 2001a. Long term study of apparent survival in Pacific Golden-Plovers at a wintering ground on Oahu, Hawaiian Islands. The Auk 118(2): 342-351.

Johnson, O.W., P.L. Bruner, A.E. Bruner, P.M. Johnson, R.J. Kienholz, and P.A. Brusseau. 2001b. Features of breeding biology in Pacific Golden-Plovers nesting on the Seward Peninsula, Alaska. Wader Study Group Bulletin 25:59-65.

Kepler, C.B. and J.M. Scott. 1990. Notes on the distribution and behavior of the endangered Hawaiian Hoary Bat (*Lasiurus cinereus semotus*). 'Elepaio 50(7): 59-64.

Pratt, H.D., P.L. Bruner, and D.G. Berrett. 1987. A field guide to the birds of Hawaii and the tropical Pacific. Princeton University Press. Princeton, New Jersey. 409pp.

Pyle, R.L. 2002. Checklist of the birds of Hawaii – 2002. 'Elepaio 62(6): 137-148.

Tomich, P.Q. 1986. Mammals in Hawaii. Bishop Museum Press. Honolulu. 375pp.

APPENDIX E

ARCHAEOLOGICAL RECONNAISSANCE
AND ASSESSMENT

SCIENTIFIC CONSULTANT SERVICES, Inc.
711 Kapiolani Blvd., Suite 777 Honolulu, Hawai'i 96813

Mr. David Hulse
PBR Hawaii
Pacific Tower, Suite 650
1100 Bishop Street
Honolulu, HI 96813

11-6-96

RE: Archaeological Reconnaissance and Assessment of the H.F.D.C- East Kapolei Development Project.

Dear Mr. Hulse;

At your request, Scientific Consultant Services, Inc. (SCS) has undertaken on behalf of PBR Hawaii, a cultural resources review of the subject properties being considered for development at Kapolei (TMK 9-1-16:17)(Figures 1 and 2).

The 1994 letter provided to us by your firm was generated by Don Hibbard of Historic Preservation Division (SHPD) and directed to Dean Uchida of Hawaii Agricultural and Rural Development Program (HARRP). This letter clearly indicates that most of the present project area has been declared to have "no effect" on historic sites due to the many years of commercial sugarcane production on these lands (Attachment A, Doc No. 9408TD01).

In order to be certain that sugarcane plantation operations covered the entire parcel indicated in Figure 2, SCS conducted an on-site inspection of the subject properties on October 23rd, 1996. Under the overall supervision of Robert L. Spear, Ph.D., Senior Archaeologist Jennifer Robins, B.A., and Field Assistant Amy Buffum accessed the northern section of the project area from Farrington Highway (Figures 3 and 4). The purpose of this visual inspection was to confirm that no cultural resources could be located in either the Hunehune and Kaloi Gulches or on the broad agricultural plains. These two gulches are approximately 4 meters wide and 4 meters deep. They appear to be natural gulches that have been modified for cane irrigation.

Given the lack of cultural resources found during the field inspection, and the State of Hawai'i letter referenced above, we concur with the Historic Preservation Division's assessment that future development on these land parcels will have "no effect" on historic sites, and that no further cultural resource work is required.

Sincerely,

Robert L. Spear, Ph.D.
President
Scientific Consultant Services, Inc.

cc. Dr. Tom Dye (SHPD)

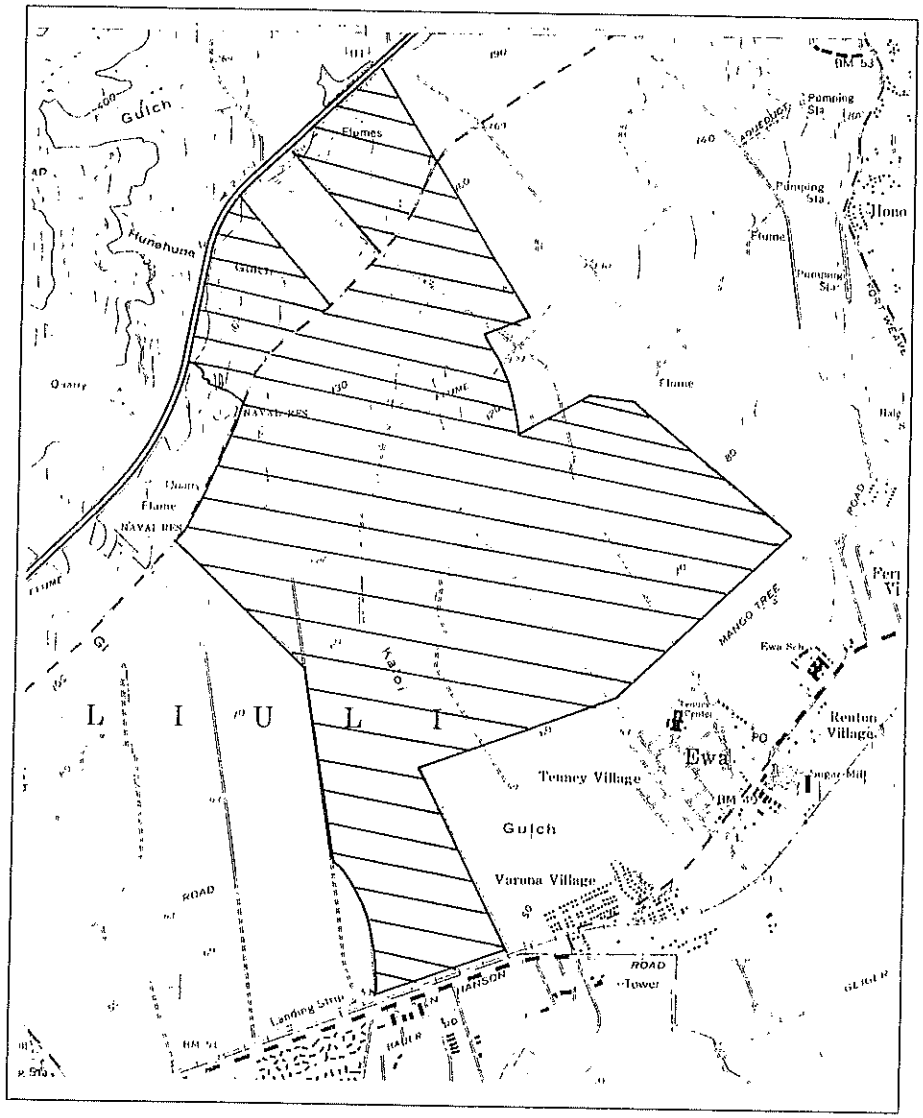

FIGURE 1: USGS EWA QUADRANGLE SHOWING PROJECT AREA.

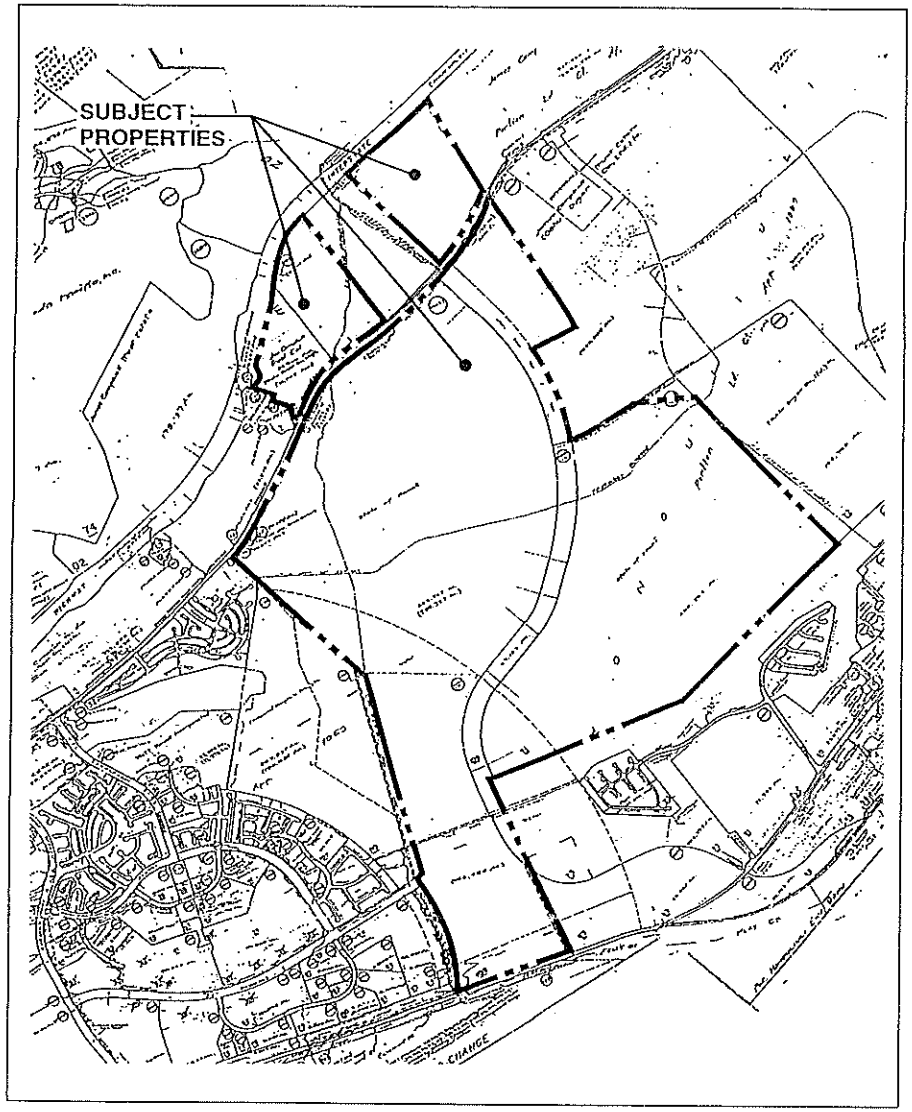

FIGURE 2: TAX MAP KEY 9-1-16: (VARIOUS) SHOWING PROJECT AREA (FROM PBR 1996).

FIGURE 3: GENERAL PROJECT AREA VIEW WITH HUNEHUNE GULCH IN THE DISTANCE. VIEW TO SOUTH.

FIGURE 4: GENERAL PROJECT AREA VIEW ALONG KALOI GULCH. VIEW TO SOUTHWEST.

ATTACHMENT A

JOHN WAIHEE
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
STATE HISTORIC PRESERVATION DIVISION
33 SOUTH KING STREET, 6TH FLOOR
HONOLULU, HAWAII 96813

41 712

KEITH AHUE, CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES
DEPUTIES
JOHN P. KEPPELER II
DONA L. HANAIKE
AQUACULTURE DEVELOPMENT PROGRAM
AQUATIC RESOURCES
CONSERVATION AND ENVIRONMENTAL AFFAIRS
CONSERVATION AND RESOURCES ENFORCEMENT
CONVEYANCES
FORESTRY AND WILDLIFE
HISTORIC PRESERVATION DIVISION
LAND MANAGEMENT
STATE PARKS
WATER AND LAND DEVELOPMENT

August 4, 1994

MEMORANDUM

LOG NO: 12362
DOC NO: 9408TD01

TO Dean Uchida
Hawaii Agricultural and Rural Development Program (HARRP)

FROM Don Hibbard, Administrator
Historic Preservation Division

SUBJECT State Lands at Kapolei, Reclassification from Agriculture to Urban
Honouliuli, 'Ewa, O'ahu
TMK: 9-1-16: por. 25; 9-1-17: por. 4

A review of our records shows that there are no known historic sites on these 1,300 acres of state lands. These lands were used for commercial sugar cane cultivation for many years and this would have destroyed any historic sites that might have been present. We believe that reclassification of these lands and their future development will have "no effect" on historic sites.

TD:jk

APPENDIX F

NOISE TECHNICAL REPORT

D. L. ADAMS ASSOCIATES, LTD.
Consultants in Acoustics and Performing Arts Technologies

Environmental Noise Assessment Report
University of Hawaii West Oahu Campus
Kapolei, Oahu, Hawaii

June 2006

DLAA Project No. 05-18

Prepared for:
University of Hawaii
Honolulu, Hawaii

970 N. KALAHEO AVE. • SUITE A311 • KAILUA, HAWAII 96734
808/254-3318 • FAX 808/254-5295
www.dlaa.com • hawaii@dlaa.com

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APPENDIX

1.0 EXECUTIVE SUMMARY

1.1 The project area is currently exposed to daytime ambient noise levels of 42 to 57 dBA, with the dominant noise sources being traffic, wind, and occasional distant aircraft fly overs. Along the northern edge of the site, the ambient noise levels range from 48 to 63 dBA due to the proximity of Farrington Highway.

1.2 Development of project areas will involve excavation, grading, and other typical construction activities during construction. The UH West Oahu project is not expected to impact adjacent properties, however, residences from the initial phases may be impacted by construction noise from subsequent phases 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.

1.3 The proposed mixed use areas may include activities which could impact adjacent residences. Noise mitigation measures should be incorporated into the project design to prevent such impacts, such as creating a buffer zone, installing mufflers and/or erecting barriers around noisy equipment, locating traffic access points away from residences, or including restrictions on excessive noise producing activities in sale and lease documents.

1.4 Increases in peak hour traffic noise along Farrington Highway due to the project are estimated to be less than 2 dB. This does not represent a significant increase for homes currently located along Farrington Highway.

1.5 Vehicular traffic noise from Farrington Highway may significantly impact the proposed development. Any homes within 225 feet of Farrington Highway will require some type of noise mitigation to meet the FHWA maximum exterior L_{eq} noise limit of 67 dBA. No homes should be built within 75 feet of Farrington Highway, even if noise mitigation treatments are planned.

1.6 Vehicular traffic noise from the proposed North-South Road may significantly impact the proposed development. Any homes within 100 feet of North-South Road will require some type of noise mitigation to meet the FHWA maximum exterior L_{eq} noise limit of 67 dBA.

1.7 Aircraft noise due to operations at nearby Kalaeloa Airport and the Honolulu International Airport may be audible at the project site. However, flights directly above the site are infrequent and the project site is outside of the L_{dn} 55 noise contour for both airports.

1.8 One of the proposed alignments of the future Honolulu rail transit system runs along North-South Road and includes two transit stations. Design of the UH West Oahu campus should include a minimum setback distance between the nearest residences and the transit guideway and stations to minimize the impact due to the transit system noise.

1.9 The elementary school within the UH West Oahu Campus development 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

2.0 PROJECT DESCRIPTION

The University of Hawaii West Oahu (UH West Oahu) property is a 500 acre site located in the 'Ewa Plain region of Oahu, adjacent to Kapolei and Makakilo (Figure 1). Farrington Highway borders the entire mauka portion of the property. A proposed North-South road would border the eastern side of the project site. Historically, the site was cultivated in sugarcane and is currently utilized for diversified agriculture.

The current master plan designates an area of approximately 103.5 acres for the development of the UH West Oahu campus which includes academic facilities, libraries, administration/student services buildings, campus center, parking areas and open spaces. The remaining land will be used for long-term campus expansion or non-campus development, including detention/basin, an elementary school, and other open spaces, as well as lands designated for a mixed-use village, commercial uses, and residential uses.

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. 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 Federal Aviation Administration (FAA)

The FAA addresses guidelines for compatible land use that surrounds airports [Reference 7]. Noise contour maps are expressed in terms of yearly day-night average sound levels, L_{dn}, due to aircraft operations. The FAA states that residences outside of the L_{dn} 65 noise contour are compatible without restrictions. Residences between the L_{dn} 65 and 75 contours are only compatible if noise mitigation measures are incorporated into the building structure. Residences inside of the L_{dn} 75 noise contour are generally not compatible. The compatibility of other land uses, such as commercial, manufacturing, public, and recreation, are shown in Table 1.

3.7 Hawaii Department of Transportation (HDOTA), Airports Division

The State of Hawaii, Department of Transportation, Airports Division has adopted noise restrictions that are similar to the FAA's, but more stringent [Reference 8]. Similar to the FAA, HDOTA expresses land use compatibility guidelines based on yearly day-night average sound levels, L_{dn}, due to aircraft operations. In most cases, the HDOTA states maximum noise limits that are 5 dB lower than the FAA. For example, the HDOTA states that residences outside of the 60 L_{dn} noise contour are compatible. Residences between 60 and 70 L_{dn} contours are only compatible if noise mitigation treatments are implemented. However, HDOTA states:

> "Where the community determines that these uses must be allowed, Noise Level Reduction (NLR) measures to achieve interior levels of 45 L_{dn}, or less should be incorporated into building codes and be considered in individual approvals. Normal local construction employing natural ventilation can be expected to provide an average NLR of approximately 9 dB. Total closure, plus air conditioning, may be required to provide additional outdoor to indoor NLR, and will not eliminate outdoor noise problems."

The HDOTA guidelines also specify 60 dBA as the maximum allowable L_{dn} level for school, day care center, and church uses without any mitigation measures. Commercial uses such as retail shops, restaurants, shopping centers, etc. are compatible with L_{dn} levels up to 65 dBA without any mitigation measures. With noise mitigation measures implemented, such commercial uses are allowed in areas exposed to an L_{dn} as high as 75 dBA. The compatibility of other land uses, such as manufacturing, public, and recreation, are shown in Table 2.

In addition to the HDOTA compatibility guidelines, The Hawaii Revised Statutes, Chapter 0508D, Section 15 states a notification is required to the buyer for real estate property that lies,

> "Within the boundaries of the noise exposure area shown on maps prepared by the department of transportation in accordance with Federal Aviation

Regulation Part 150-Airport Noise Compatibility Planning (14 Code of Federal Regulations Part 150) for any public airport;"

The FAR Part 150 noise exposure area boundary is defined as the 55 L_{dn} noise contour. Therefore, a notification to the buyer is required for all real estate transactions within the 55 L_{dn} noise contour.

3.8 Federal Transit Administration (FTA)

The FTA defines three land use categories and provides guidance in the assessment of noise and vibration due to transit systems based on an increase in cumulative noise. Methods for determining noise and vibration impacts and possible mitigation measures for typical transit projects are provided in the Transit Noise and Vibration Impact Assessment report [Reference 9]. One set of criteria defined in the report applies to all rail projects (including light rail transit, rapid rail transit, etc.) and their fixed facilities. The criteria, specified in maximum hourly equivalent sound levels, $L_{eq(h)}$, and day-night equivalent sound levels, L_{dn}, varies according to the existing noise levels, the predicted transit system project noise levels, and the land use category, as shown in Figure 4. The area between the two curves labeled as "Impact" is a transitional area where the change in cumulative noise level will be noticeable to most individuals, but may not be sufficient to cause adverse reactions from the community.

The FTA criteria were developed to recognize the heightened community annoyance caused by late night and early morning transit service and the varying sensitivity of communities to transit systems under different background noise conditions and is concurrent with various noise standards defined by other Federal agencies. It is important to note that the criteria are not enforceable regulations, but design goals that are useful tools for assessing the noise environment.

3.9 Board of Education (BOE)

BOE policy 6700 [Reference 10] 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 (Location L1 and L2), as shown in Figure 1. Long term measurements were conducted between March 7, 2005 and March 11, 2005. The second type of noise measurement was short-term and included traffic counts (Location S1). The purpose of the short-term noise measurements and corresponding traffic counts were to calibrate a traffic noise prediction model. Short term measurements were conducted between May 2, 2006 and May 3, 2006.

4.1 Noise Measurement Procedure

Long-Term Noise Measurement Procedure

Continuous, hourly, statistical sound levels were recorded for approximately 4 days at each location. The measurements were taken using a Larson-Davis Laboratories, Model 820, Type-1 Sound Level Meter together with a Larson-Davis, Model 2560 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 was mounted on a tripod, approximately 6 feet above grade. A windscreen covered the microphone during the entire measurement period. The sound level meter was secured in a weather resistant case.

Short-Term Noise Measurement Procedure

An approximate 30-minute equivalent sound level, L_{eq}, was measured. 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 6 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: Southern end (makai) of the project area, in a field near the proposed North-South Road, as indicated in Figure 1. Vehicles or farm equipment may have been operated in the vicinity of the sound meter.

Location L2: Approximately 100 ft from the edge of Farrington Highway on the northern (mauka) end of the project site, as indicated in Figure 1.

Short-Term Noise Measurement Location

Location S1: Positioned adjacent to Farrington Highway, approximately 45 feet makai of the edge-of-pavement.

4.3 Long-Term Noise Measurement Results

The 500-acre site, which is currently utilized for diversified agriculture or is undeveloped, currently experiences relatively low ambient noise levels except for some portions adjacent to Farrington Highway. The measured equivalent sound levels, L_{eq}, in A-weighted decibels (dBA) are graphically presented in Figure 5 for both locations.

Location L1 Noise Measurement Results

The sound levels at Location L1 are typical of a "rural" ambient environment. The daytime (7:00 AM to 10:00 PM) L_{eq} ranges from 42 dBA to 57 dBA. The average nighttime (10:00 PM to 7:00 AM) L_{eq} ranges from 34 dBA to 55 dBA. A meter overload occurred between 3:00 and 5:00 AM on March 9, 2005, possibly due to rain or excessive winds, therefore the average day-night level, L_{dn}, was estimated to be 55 dBA. The dominant and secondary noise sources at Location L1 are described below:

Dominant: Wind, birds, aircraft flyovers, possible operation of farming equipment and farm workers

Secondary: Vehicular traffic from Farrington Highway and H-1 Freeway

Location L2 Noise Measurement Results

The hourly equivalent sound levels, L_{eq}, at Location L2 range from 48 dBA to 63 dBA during the daytime hours and 39 dBA to 59 dBA during the nighttime hours. The average day-night level, L_{dn}, was calculated to be 59 dBA.

The dominant and secondary noise sources at Location L2 are described below:

Dominant: Vehicular traffic from Farrington Highway, wind.

Secondary: Birds, farming equipment, electrical lines, vehicular traffic from H-1 Freeway

4.4 Project Vicinity

The undeveloped lands west of the project site experience an acoustical environment similar to the project site with wind and occasional aircraft flyovers being dominant noise sources. Presently, the nearest developed land includes Kapolei and Makakilo to the west, the Villages of Kapolei to the south, and Ewa Villages to the east. Vehicular noise from Farrington Highway and the H-1 Freeway located mauka of the project site dominate the ambient environment in the vicinity of these roadways. In addition, a quarry and a recycling plant located close to the project site may contribute to some of the ambient noise. Heavy

trucks, which generate more noise than automobiles, travel to and from the quarry and recycling plant and constitute 20% of the AM peak hour traffic total on Farrington Highway.

4.5 Kalaeloa Airport and Honolulu International Airport Noise Contours

The project is several miles northeast of the Kalaeloa Airport and west of Honolulu International Airport. Therefore, the project site was assessed for aircraft noise using airport noise contour maps. The Kalaeloa Master Plan [Reference 11] includes year 2020 projections of airport operations and noise contour maps for airport alternates. Also included in the airport noise contour maps is the affect of the Honolulu International Airport operations [Reference 8]. A complete description of the Kalaeloa Airport alternates can be found in the Kalaeloa Master Plan. The UH West Oahu project site is outside of the L_{dn} 55 noise contours for both airports.

5.0 POTENTIAL NOISE IMPACTS AND NOISE MITIGATION

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 may generate significant amounts of noise. The UH West Oahu project is not expected to impact adjacent properties, since much of the land surrounding the project site is agricultural. Future developments on adjacent properties that are completed before the UH West Oahu development may be impacted by construction noise. 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 6. 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

A large portion of the project site is proposed for non-campus development, including residential and commercial use. Noise emanating from these commercial uses could significantly impact the proposed adjacent noise sensitive residential areas. The various phases in the long range development plan will incorporate stationary mechanical equipment that is typical for residential and commercial buildings. Expected mechanical equipment may include air handling equipment, condensing units, refrigeration 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, business, and commercial areas, 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 Compliance with FHWA/HDOT Noise Limits

A vehicular traffic noise analysis was completed for the existing conditions, future year 2015 projections with the "No Build" condition, and future year 2015 projections with the "Build" condition using the FHWA Traffic Noise Model Look-up Tables Software Version 2.5 (2004) [Reference 12]. The traffic noise analysis is based on the traffic counts provided by the Traffic Consultant [Reference 13]. Vehicular traffic noise levels were calculated for 4 locations, Locations A, B, C, and D as shown in Figure 7. The short-term noise measurement and corresponding traffic counts were used to calibrate the software at the noise prediction location along Farrington Highway (Location A). Only future noise level predictions were made for Locations B, C, and D because the corresponding roadways do not yet exist. The results of the traffic noise analysis for the existing (Farrington Highway only) and future year projections are described below and summarized in Table 3.

5.3.1 Vehicular Traffic Noise Impacts on the Project

Noise Prediction Location A

For the parcels adjacent to Farrington Highway, vehicular traffic noise levels are expected to increase by approximately 2 to 4 dB in the future under the "No Build" condition. The increase in traffic noise due to the UH West Oahu project is less than 2 dB. A 3 dB change or less in noise level is not considered to be significant. At noise prediction location A, 225' makai of Farrington Highway, existing noise levels were calculated to be slightly below the FHWA/HDOT maximum noise limit of 67 dBA during peak traffic hours. In the future, however, noise levels are expected to be at the FHWA/DOT limit.

Noise Prediction Location B

Future year traffic projections show that traffic noise levels at locations at least 100 feet from North-South Road (Location B) are expected to be slightly below the FHWA/HDOT maximum noise limit of 67 dBA under both "No Build" and "Build" conditions. The increase in traffic noise due to the UH West Oahu project is expected to be less than 2 dB.

Noise Prediction Locations C and D

The UH West Oahu Campus development project will provide campus facilities, housing, and some commercial business, which will create vehicular traffic in the campus area. Noise levels due to vehicular traffic were predicted for locations 25 feet from Roads B and F, noise prediction location C and D, respectively, and are well below the FHWA/HDOT maximum noise limit of 67 dBA.

5.3.2 Vehicular Traffic Noise Impacts on the Surrounding Community

Residences located adjacent to Farrington Highway southwest of the project site are beyond the route of the heavy trucks that dominate the noise environment at the UH West Oahu project site. The existing noise levels are estimated to be less than the FHWA/HDOT maximum noise limit of 67 dBA during the peak traffic hours. Vehicular traffic noise levels are expected to increase by 2 to 4 dB in the future (2015) without the UH West Oahu project. The increase in traffic noise due to the project is less than 2 dB. A 3 dB change or less in noise level is not considered to be significant.

5.4 Compliance with EPA and HUD Noise Guidelines

The results from the long-term noise measurements conducted at the proposed UH West Oahu site show a calculated day-night level, L_{dn}, of 59 dBA near Farrington Highway. As described above, traffic noise levels at the proposed project site are predicted to increase by approximately 3 to 5 dB due to the projected increase in vehicular traffic on Farrington Highway. Day-night noise levels are expected to be within the HUD noise guidelines, which state an exterior design goal of $L_{dn} \leq 65$ dBA, for residential units located at least 225 feet from the roadway. Similarly, the HUD "acceptable" maximum noise limit will be satisfied for all homes 100 feet, or more, from North-South Road.

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. Noise levels at homes 225 feet from Farrington Highway and 100 feet from North-South Road are expected to be below the existing EPA design goal but exceed the 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.

5.5 Compliance with FAA and HDOT Airports Division Guidelines

The UH West Oahu project site is outside of the 55 L_{dn} noise contour of both Honolulu International Airport and Kalaeloa Airport. Therefore, the project will not be impacted by aircraft noise. However, due to certain arrival and departure flight tracks associated with Kalaeloa Airport, aircraft flyovers may, at times, be audible at the project site. These flyovers should be infrequent, and therefore, should not significantly impact the proposed development.

5.6 Honolulu High Capacity Transit Project and Compliance with FTA Guidelines

The City and County of Honolulu Department of Transportation Services is currently evaluating alternatives for a high capacity transit service between Kapolei and Manoa. Two of the alignment alternatives run along the proposed North-South Road between Farrington Highway and Kapolei Parkway and will

include at least two stations in the vicinity of the UH West Oahu project site. A complete description of all alignment alternatives and current planning documents can be found on the Honolulu High Capacity Transit Project website [Reference 14]. Typical sound exposure levels of various transit systems are shown in Table 4.

The day-night level, L_{dn}, is estimated to be between 62-64 dBA at the project site due to increased traffic noise levels, not including rail transit noise. The FTA noise impact criteria shown in Figure 4 shows that an impact will occur if the rail transit project noise exceeds 58 dBA and a severe impact will occur if the transit project noise exceeds 64 dBA. This means the overall noise level increase of 2 to 4 dBA due to the transit line will become noticeable to residents closest to the transit line. Residents will likely complain if the overall noise levels increase by more than 4 dB.

5.7 Compliance with BOE Noise Guidelines

Board of Education (BOE) Policy 6700 [Reference 10] requires that air conditioning be installed for schools exposed to an exterior noise level of L_{10}=65dBA. An elementary school within the proposed UH West Oahu campus site is not likely to experience an L_{10} greater than 65dBA at its present proposed location at the intersection of Road "F" and Road "G".

6.0 POTENTIAL NOISE IMPACT ON THE PROJECT AND 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 UH West Oahu Development Noise

The design of the new 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 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.

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.

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.

6.3 Mitigation of Traffic Noise

Vehicular traffic noise from Farrington Highway may significantly impact the proposed development. The calculated traffic noise levels show that the residences constructed on parcels that border Farrington Highway should be at least 225 feet from the edge of pavement so as not to exceed the FHWA's maximum exterior L_{eq} noise limit of 67 dBA. Any homes within 225 feet of Farrington Highway will require some type of noise mitigation to meet the criteria. No homes should be built within 75 feet of Farrington Highway, even if noise mitigation treatments are planned.

Similarly, vehicular traffic noise from the proposed North-South Road may significantly impact the proposed development. The calculated traffic noise levels show that the residences constructed on parcels that border North-South Road should be at least 100 feet from the edge of pavement so as not to exceed the FHWA's maximum exterior L_{eq} noise limit of 67 dBA. Any homes within 100 feet of North-South Road will require some type of noise mitigation to meet the criteria.

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.

6.4 Mitigation of Aircraft Noise

The UH West Oahu project site is well outside the L_{dn} 55 dBA noise contour. Therefore, noise mitigation to attenuate aircraft noise is not necessary.

6.5 Mitigation of Rail Transit Noise

The FTAs impact assessment report has identified appropriate "screening" distances, i.e. minimum setback distances, within which a transit project has little possibility of creating a noise impact. The screening distances for various fixed guideway systems and facilities are listed in Table 5.

If a transit system noise impact has been determined, noise mitigation may be required. Noise can be effectively mitigated at the noise source (rail car) and along the noise path (tracks). Reducing rail noise may include the installation of:

- resilient rubber wheels,
- vehicle skirts,
- wheel truing,
- rail grinding, or
- undercar absorption.

Along the path of noise, sound barrier walls close to the guideway are very effective, often reducing noise 6 to 10 dB, and at the right-of-way line, less effective with typical reductions of 3 to 5 dB. Ballast laid to reduce noise can be expected to produce a 3-dB reduction at grade and a 5-dB reduction on aerial guideways.

6.6 Mitigation of Noise at the Proposed Elementary School

The elementary school within the proposed UH West Oahu campus site is not likely to experience an L_{10} greater than 65dBA at the intersection of Road "F" and Road "G", therefore noise mitigation is not required.

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. *FAA Regulations on Airport Noise Compatibility Planning Programs,* Code of Federal Regulations, Title 14, Chapter 1, Subchapter 1, Part 150; Issued by 49 FR 49269, December 18, 1984; corrected by 50 FR 5063, February 6, 1985; amended by 53 FR 8723, March 16, 1988; corrected by 53 FR 9726, March 24, 1988.

8. *Honolulu International Airport Master Plan Update and Noise Compatibility Program*, State of Hawaii Department of Transportation, Airports Division, Vol. 2, December 1989.

9. *Transit Noise and Vibration Impact Assessment*, Office of Planning, Federal Transit Administration, April 1995.

10. *Policies and Standards for School Facilities Design*, Board of Education, Policy 6700, Appendix A, Acoustical and Environmental Control, March 1995.

11. *Kalaeloa Airport Master Plan,* State of Hawaii Department of Transportation, Airports Division, November 1998.

12. *Federal Highway Administration's Traffic Noise Model Look-up Tables Software*, Ver. 2.5; U.S. Department of Transportation, December 17, 2004.

13. *Traffic Impact Analysis Report for the UH West Oahu Campus,* Parsons Brinckerhoff Quade & Douglas, Inc., May, 2006.

14. *Honolulu High Capacity Transit Corridor Project,* www.honolulutransit.org.

TABLE 1:
FAR Part 150 Recommendations for Land Use Compatibility in Yearly Day-Night Average Sound Levels

TYPE OF LAND USE	Yearly Day-Night Average Sound Level (L_{dn})					
	< 65	65-70	70-75	75-80	80-85	> 85
RESIDENTIAL:						
Residential (except mobile homes & transient lodgings)	Y	N(1)	N(1)	N	N	N
Mobile home parks	Y	N	N	N	N	N
Transient lodgings	Y	N(1)	N(1)	N(1)	N	N
PUBLIC USE:						
Schools	Y	N(1)	N(1)	N	N	N
Hospitals and nursing homes	Y	25	30	N	N	N
Churches, auditoriums, and concert halls	Y	25	30	N	N	N
Government services	Y	Y	25	30	N	N
Transportation	Y	Y	Y(2)	Y(3)	Y(4)	Y(4)
Parking	Y	Y	Y(2)	Y(3)	Y(4)	N
COMMERCIAL USE:						
Offices, business and professional	Y	Y	25	30	N	N
Wholesale/Retail:(bldg. Mater., hardware, & farm equip.)	Y	Y	Y(2)	Y(3)	Y(4)	N
Retail trade – general	Y	Y	25	30	N	N
Utilities	Y	Y	Y(2)	Y(3)	Y(4)	N
Communication	Y	Y	25	30	N	N
MANUFACTURING AND PRODUCTION:						
Manufacturing, general	Y	Y	Y(2)	Y(3)	Y(4)	N
Photographic and optical	Y	Y	25	30	N	N
Agriculture (except livestock) and forestry	Y	Y(6)	Y(7)	Y(8)	Y(8)	Y(8)
Livestock farming and breeding	Y	Y(6)	Y(7)	N	N	N
Mining and fishing, resource production and extraction	Y	Y	Y	Y	Y	Y
RECREATIONAL USE:						
Outdoor sports arenas and spectator sports	Y	Y(5)	Y(5)	N	N	N
Outdoor music shells, amphitheaters	Y	N	N	N	N	N
Nature exhibits and zoos	Y	Y	N	N	N	N
Amusements, parks, resorts and camps	Y	Y	Y	N	N	N
Golf courses, riding stables and water recreation	Y	Y	25	30	N	N

Note: Numbers in parentheses refer to the following notes.

(1) Where the community determines that residential or school uses must be allowed, measures to achieve outdoor-to-indoor Noise Level Reduction (NLR) of at least 25 dB and 30 dB should be incorporated into building codes and be considered in individual approvals. Normal residential construction can be expected to provide a NLR of 20 dB, thus, the reduction requirements are often stated as 5, 10, or 15 dB over standard construction and normally assume mechanical ventilation and closed windows year round. However, the use of NLR criteria will not eliminate outdoor noise problems.

(2) Measures to achieve NLR 25 must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise sensitive areas, or where the normal noise level is low.

(3) Measures to achieve NLR 30 must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise sensitive areas, or where the normal noise level is low.

(4) Measures to achieve NLR 35 must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise sensitive areas, or where the normal noise level is low.

(5) Land use compatible provided special sound reinforcement systems are installed.

(6) Residential buildings require a NLR of 25.

(7) Residential buildings require a NLR of 30.

(8) Residential buildings are not permitted.

Abbreviations:

Y(Yes) = Land Use and related structures compatible w/o restrictions.

N(No) = Land Use and related structures are not compatible and should be prohibited.

NLR = Noise Level Reduction (outdoor-to-indoor) to be achieved through incorporation of noise attenuation into the design and construction of the structure.

25, 30, or 35 = Land use and related structures general compatible; measures to achieve NLR of 25, 30, or 35 dB must be incorporated into design and construction of structures.

Regulatory Note.
The designations contained in this table do not constitute a Federal determination that any use of land covered by the program is acceptable or unacceptable under Federal, State, or local law. The responsibility for determining the acceptable and permissible land uses and the relationship between specific properties and specific noise contours rests with the local authorities. FAA determinations under Part 150 are not intended to substitute federally determined land uses for those determined to be appropriate by local authorities in response to locally determined needs and values in achieving noise compatible land uses.

Source: FAR Part 150, Appedix A, Table 1. "Land Use Compatibility with Yearly Day-Night Average Sound Levels."

TABLE 2:
State Department of Transportation Airports Division Recommendations for Local Land Use Compatibility in Yearly Day-Night Average Sound Levels (Ldn)

	Yearly Day-Night Average Sound Level (L_{dn})					
TYPE OF LAND USE	< 60	60-65	65-70	70-75	75-80	80-85
RESIDENTIAL:						
Low density residential, resorts, & hotels (w/ outdoor fac)	Y(a)	N(b)	N	N	N	N
Low density apartment w/ moderate outdoor use	Y	N(b)	N	N	N	N
High density apartment with limited outdoor use	Y	N(b)	N(b)	N	N	N
Transient lodgings (w/limited outdoor use)	Y	N(b)	N(b)	N	N	N
PUBLIC USE:						
Schools, day care centers, libraries, and churches	Y	N(c)	N(c)	N(c)	N	N
Hospitals, nursing homes, clinics, and health facilities	Y	Y(d)	Y(d)	Y(d)	N	N
Indoor auditoriums, and concert halls	Y(c)	Y(c)	N	N	N	N
Government services and offices serving the public	Y	Y	Y(d)	Y(d)	N	N
Transportation and parking	Y	Y	Y(d)	Y(d)	Y(d)	Y(d)
COMMERCIAL USE:						
Offices - government, business and professional	Y	Y	Y(d)	Y(d)	N	N
Wholesale/Retail: bldg. Mater., hardware, & heavy equip	Y	Y	Y(d)	Y(d)	Y(d)	Y(d)
Airport businesses - car rental, ticketing, lei stands, etc	Y	Y	Y(d)	Y(d)	N	N
Retail trade, restaurants, shp. Centers, financial inst., etc	Y	Y	Y(d)	Y(d)	N	N
Power plants, sweage treatment plants, & base yards	Y	Y	Y(d)	Y(d)	Y(d)	N
Studios w/o outdoor sets, broadcasting & Production fac	Y(c)	Y(c)	N	N	N	N
MANUFACTURING AND PRODUCTION:						
Manufacturing, general	Y	Y	Y(d)	Y(d)	Y(d)	N
Photographic and optical	Y	Y	Y(d)	Y(d)	N	N
Agriculture (except livestock) and forestry	Y	Y(e)	Y(e)	Y(e)	Y(e)	Y(e)
Livestock farming and breeding	Y	Y(e)	Y(e)	N	N	N
Mining and fishing, resource production and extraction	Y	Y	Y	Y	Y	Y
RECREATIONAL USE:						
Outdoor sports arenas and spectator sports	Y	Y(f)	Y(f)	N	N	N
Outdoor music shells, amphitheaters	Y(f)	N	N	N	N	N
Nature exhibits and zoos, neighborhood parks	Y	Y	Y	N	N	N
Amusements, beach parks, active playgrounds, etc	Y	Y	Y	Y	N	N
Public golf courses, riding stables, cemeteries, gardens, etc	Y	Y	N	N	N	N
Professional/resort sports facil., media event facil., etc	Y(f)	N	N	N	N	N
Extensive natural wildlife and recreation areas	Y(f)	N	N	N	N	N

Note: Letters in parentheses refer to the following notes.

(a) A noise level of 60 L_{dn} does not eliminate all risks of adverse noise impacts from aircraft noise. However, the 60 L_{dn} planning level has been selected by the State Airports Division as an appropriate compromise between the minimal risk of level of 55 L_{dn} and the significant risk level of 65 L_{dn}.

(b) Where the community determines that these uses should be allowed, Noise Level Reduction (NLR) measures to achieve interior levels of 45 L_{dn} or less should be incorporated into building codes and be considered in individual approvals. Normal local construction employing natural ventilation can be expected to provide an average NLR of approximately 9 dB. Total closure plus air conditioning may be required to provide additional outdoor-to-indoor NLR, but will not eliminate outdoor noise problems.

(c) Because the L_{dn} noise descriptor system represents a 24-hour average of individual aircraft noise events, each of which can be unique in respect to amplitude, duration, and tonal content, the NLR requirements should be evaluated for the specific land use, interior acoustical requirements, and properties of the aircraft noise events. NLR requirements should not be based solely upon the exterior L_{dn} exposure level.

(d) Measures to achieve required NLR must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise sensitive areas, or where the normal noise level is low.

(e) Residential buildings require NLR. Residential buildings should not be located where exterior noise is greater than 65 L_{dn}.

(f) Impact of amplitude, duration, frequency, and tonal content of aircraft noise events should be evaluated.

Abbreviations:
Y(Yes) = Land Use and related structures compatible without restrictions.
N(No) = Land Use and related structures are not compatible and should be prohibited.

Source: Airports Division, Department of Transportation, State of Hawaii

TABLE 3:
Predicted Traffic Noise Levels With and Without the Project and Resulting Increases Due to the Project[+]

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[*]		Location D[*]	
	AM	PM	AM	PM	AM	PM	AM	PM
Existing (Calculated)	64.7	57.6	N/A	N/A	N/A	N/A	N/A	N/A
Future Without Project (2015)	66.6	61.8	63.5	64.7	N/A	N/A	N/A	N/A
Future With Project (2015)	67.5	63.1	65.3	66.5	60.2	62.1	62.6	63.9
Future Increase Without Project (2015)	1.9	4.2	N/A	N/A	N/A	N/A	N/A	N/A
Future Increase With Project (2015)	2.8	5.5	N/A	N/A	N/A	N/A	N/A	N/A
Future Increase Due to Project (2015)	**0.9**	**1.3**	**1.8**	**1.8**	N/A	N/A	N/A	N/A

[+] The noise level calculations were based on the traffic study provided by the Traffic Consultant [Reference 12].
[*] Location A - 225 feet south of Farrington Highway edge of pavement
Location B - 100 feet west of the proposed North-South Road edge of pavement
Location C - 25 feet north of the proposed "Road B" edge of pavement
Location D - 25 feet south of the proposed "Road F" edge of pavement

TABLE 4:
Federal Transit Administration Transit System Source Reference Sound Exposure Level (SEL)

Source/Type		Reference Conditions	Reference SEL[*] (dBA)
Commuter Rail, At-Grade	Locomotives	Diesel-electric, 3000 hp, throttle 5	92
		Electric	90
	Cars	Ballast, welded rail	82
Rail Transit		At-grade, ballast, welded rail	82
AGT	Steel Wheel	Aerial, concrete, welded rail	80
	Rubber Tire	Aerial, concrete guideway	78
Monorail		Aerial, straddle beam	82
Maglev		Aerial, open guideway	72
Automobiles and Vans		Normal roadway surface conditions	73
City Buses		Normal roadway surface conditions	84
Commuter Buses		Normal roadway surface conditions	88
Rail System	Yards and Shops	20 train movements in peak activity hour	118
	Layover Tracks (commuter rail)	One train with diesel locomotive idling for one hour	116
Bus System	Storage Yard	100 buses accessing facility in peak activity hour	111
	Operating Facility	100 buses accessing facility, 30buses serviced and cleaned in peak activity hour	114
	Transit Center	20 buses in peak activity hour	101
Parking Garage		1000 cars in peak activity hour	92
Park and Ride Lot		12 buses, 1000 cars in peak activity hour	101

Note: Measured 50 feet from centerline of guideway/roadway for mobile sources at 50 mph; 50 feet from center of noise-generating activity for stationary sources..

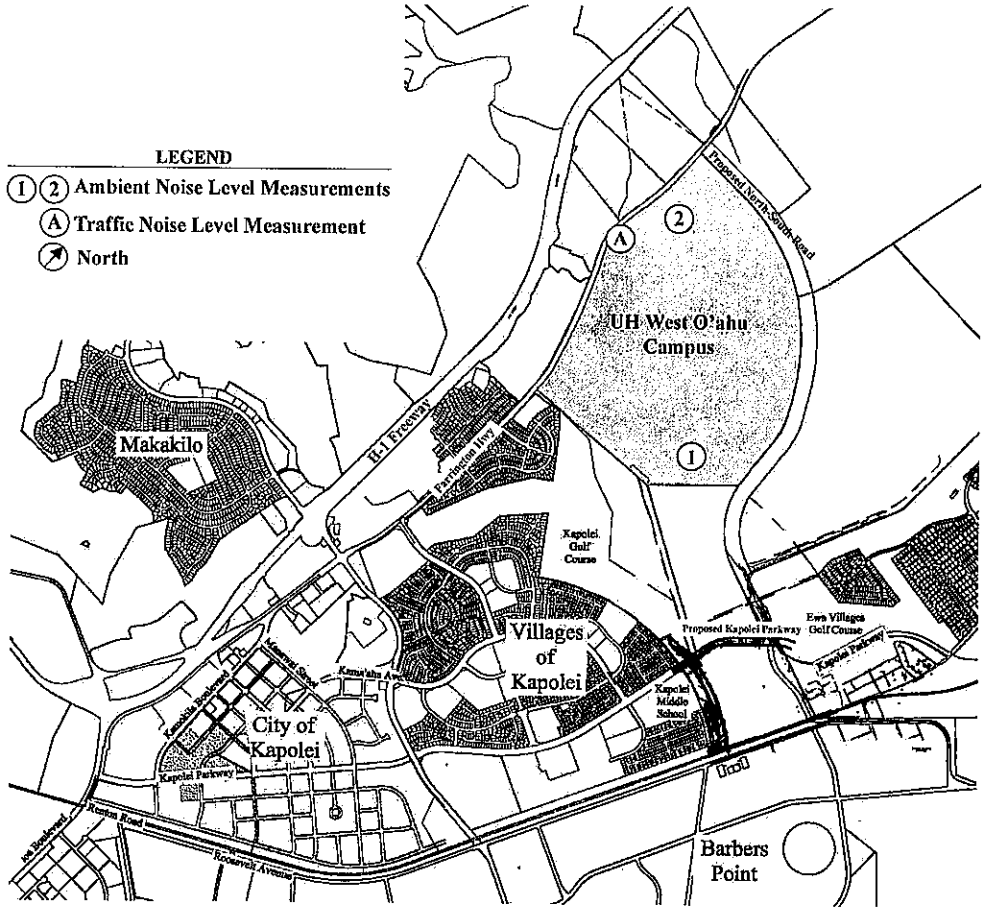
Source: Chapter 5: General Noise Assessment, Table 5-1, 5-3, 5-5. *Transit Noise and Vibration Impact Assessment*, Office of Planning, Federal Transit Administration, April 1995.

TABLE 5:
Federal Transit Administration Screening Distances for Noise Assessments

Type of Project		Screening Distance* (ft)	
		Unobstructed	Intervening Buildings
Fixed Guideway Systems:			
Commuter Rail Mainline		750	375
Commuter Rail Station		450	225
Rail Transit Guideway		700	350
Rail Transit Station		200	100
Access Roads		100	50
Low-and Intermediate-Capacity Transit	Steel Wheel	200	100
	Rubber Tire	125	75
	Monorail	300	150
Yards and Shops		2000	1000
Parking Facilities		150	75
Access Roads		100	50
Ancillary Facilities			
Ventilation Shafts		200	100
Power Substations		250	125

Note: Measured from centerline of guideway/roadway for mobile sources; from center of noise-generating activity for stationary sources.

Source: Chapter 4: Noise Screening Procedure, Table 4-1. *Transit Noise and Vibration Impact Assessment*, Office of Planning, Federal Transit Administration, April 1995.



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Noise Measurement Locations and Project Vicinity

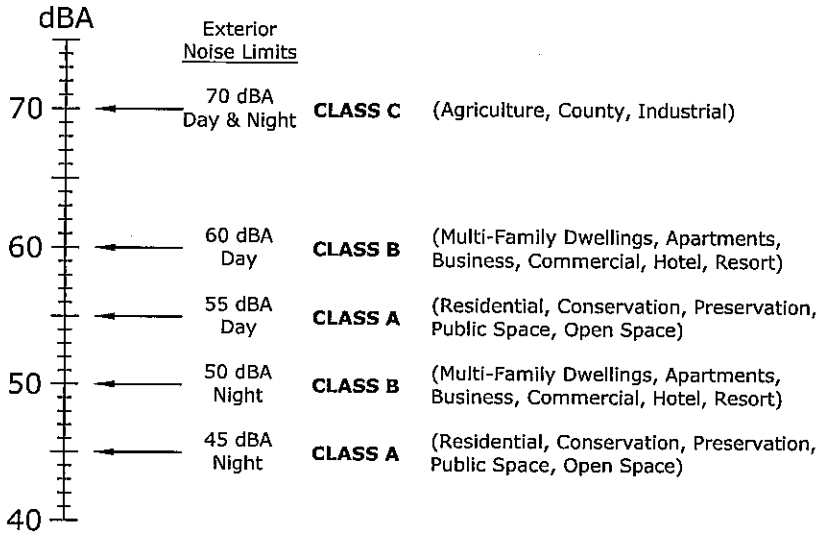
UH West Oahu

Not to Scale

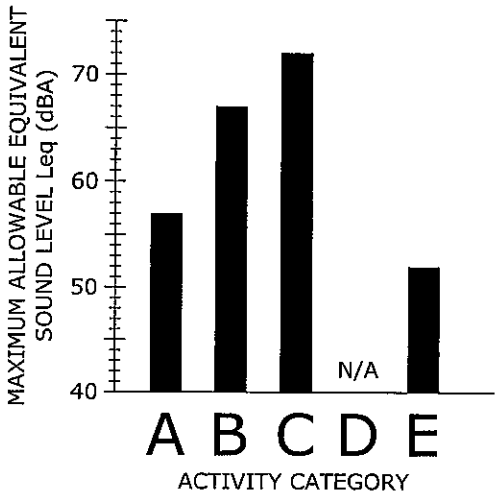
Date	Project No.	Drawn By
June 2006	05-18	DFD

Figure No 1

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)



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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Hawaii Maximum Permissible Sound Levels for Various Zoning Districts

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Not to Scale

Date: June 2006 | Project No.: 05-18 | Drawn By: TRB

Figure No 2

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Federal Highways Administration Recommended Equivalent Hourly Sound Levels Based on Land Use

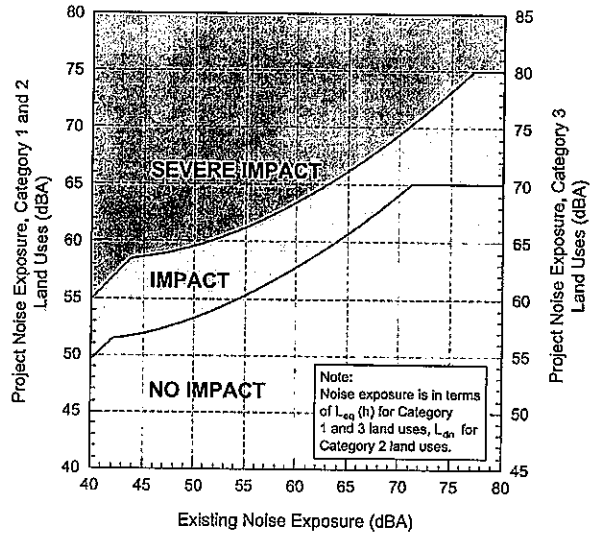
UH West Oahu

Not to Scale

Date: June 2006 | Project No.: 05-18 | Drawn By: TRB

Figure No 3

LAND USE CATEGORY	LAND USE CATEGORY DESCRIPTION	NOISE METRIC (dBA)
1	TRACTS OF LAND WHERE QUIET IS AN ESSENTIAL ELEMENT IN THEIR INTENDED PURPOSE. THIS CATEGORY INCLUDES LANDS SET ASIDE FOR SERENITY AND QUIET, AND SUCH LAND USES AS OUTDOOR AMPHITHEATERS AND CONCERT PAVILIONS, AS WELL AS NATIONAL HISTORIC LANDMARKS WITH SIGNIFICANT OUTDOOR USE.	OUTDOOR Leq(h)
2	RESIDENCES AND BUILDINGS WHERE PEOPLE NORMALLY SLEEP. THIS CATEGORY INCLUDES HOMES, HOSPITALS AND HOTELS WHERE A NIGHTTIME SENSITIVITY TO NOISE IS ASSUMED TO BE OF UTMOST IMPORTANCE.	OUTDOOR Ldn
3	INSTITUTIONAL LAND USES WITH PRIMARILY DAYTIME AND EVENING USE. THIS CATEGORY INCLUDES SCHOOLS, LIBRARIES, AND CHURCHES WHERE IT IS IMPORTANT TO AVOID INTERFERENCE WITH SUCH ACTIVITIES AS SPEECH, MEDITATION, AND CONCENTRATION ON READING MATERIAL. BUILDINGS WITH INTERIOR SPACES WHERE QUIET IS IMPORTANT, SUCH AS MEDICAL OFFICES, CONFERENCE ROOMS, RECORDING STUDIOS AND CONCERT HALLS FALL INTO THIS CATEGORY. PLACES FOR MEDITATION OR STUDY ASSOCIATED WITH CEMETERIES, MONUMENTS, MUSEUMS. CERTAIN HISTORICAL SITES, PARKS, AND RECREATIONAL FACILITIES ARE ALSO INCLUDED.	OUTDOOR Leq(h)



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Federal Transit Administration Noise Impact Criteria for Transit Projects

UH West Oahu | Not to Scale | Date June 2006 | Project No. 05-18 | Drawn By DFD | Figure No 4

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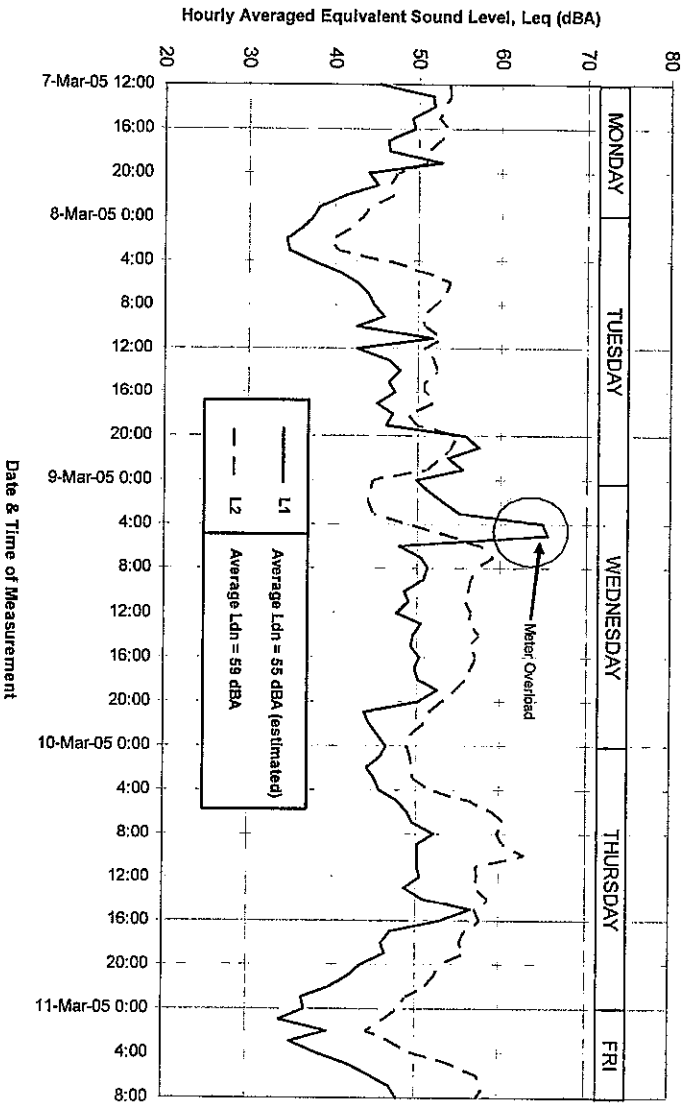
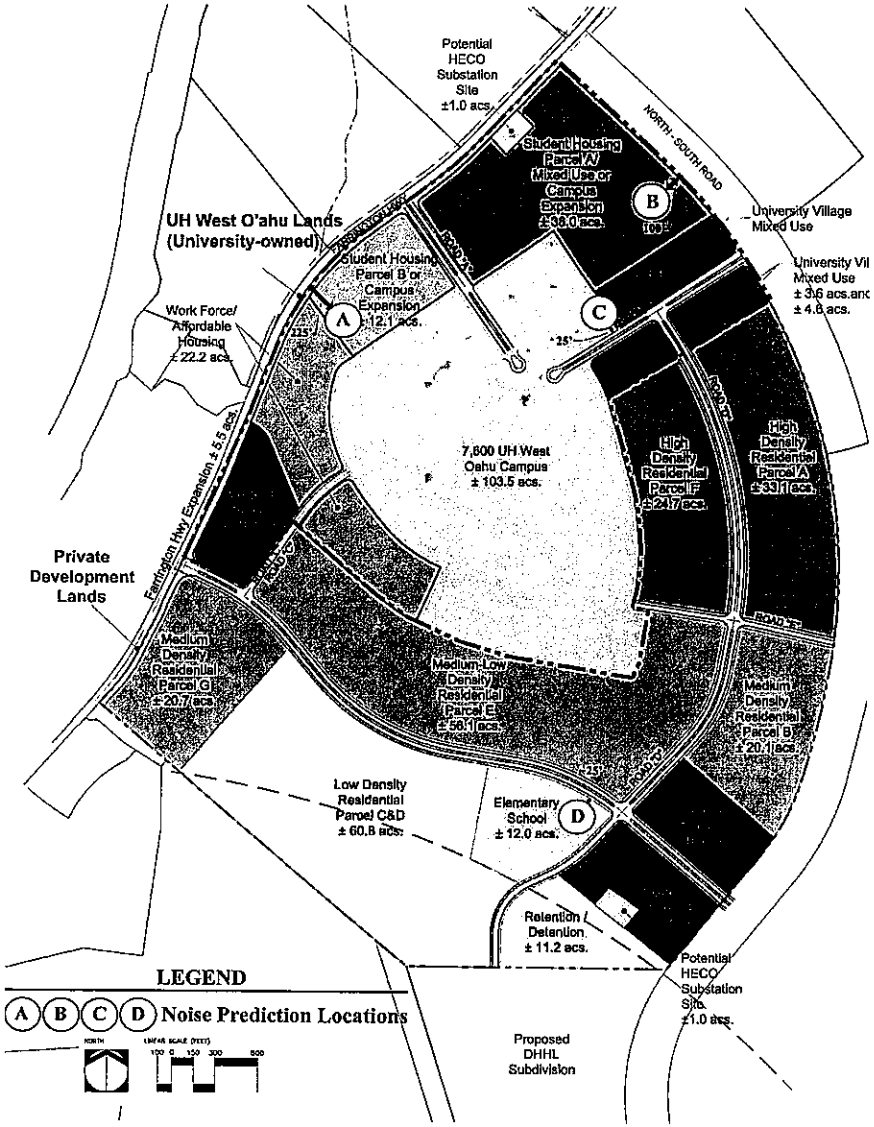
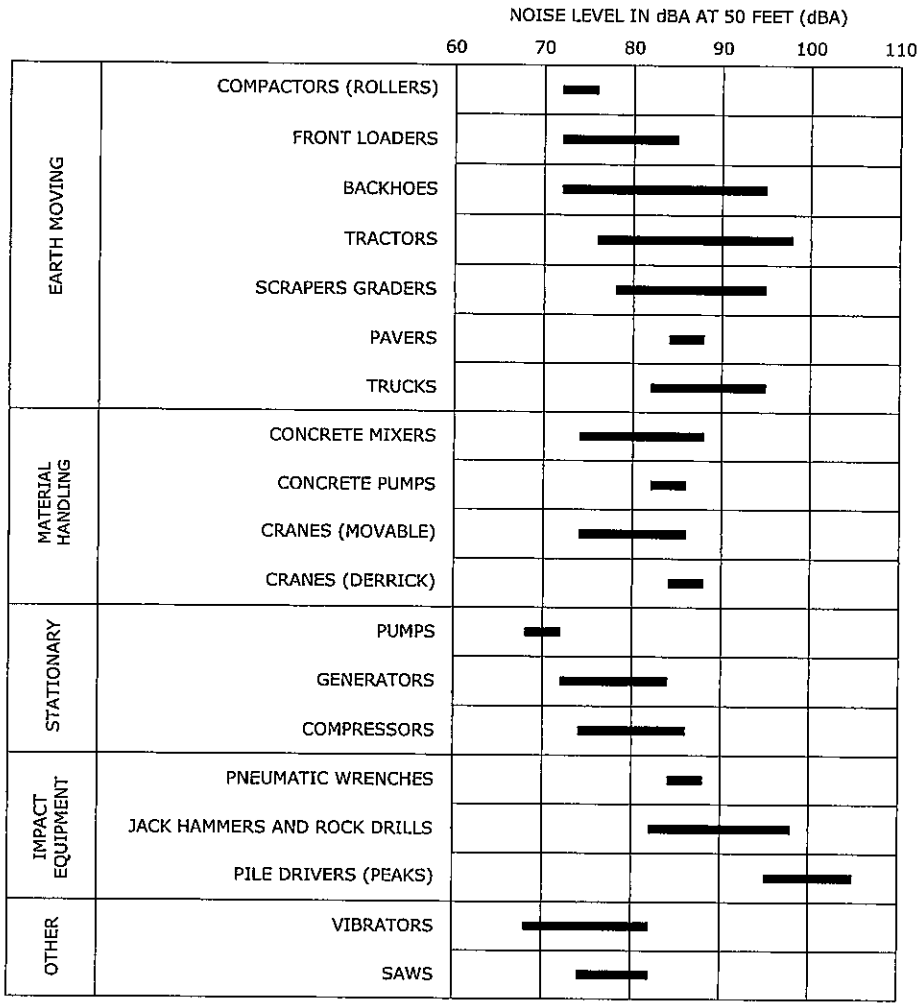
Graph of Long Term Noise Measurements

UH West Oahu | Not to Scale | Date June 2006 | Project No. 05-18 | Drawn By DFD | Figure No 5







NOTE: BASED ON LIMITED AVAILABLE DATA SAMPLES

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Noise Prediction Locations

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June 2006	05-18	DFD

Figure No 6

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Typical Sound Levels from Construction Equipment

UH West Oahu

Not to Scale

Date	Project No.	Drawn By
June 2006	05-18	TRB

Figure No 7

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.

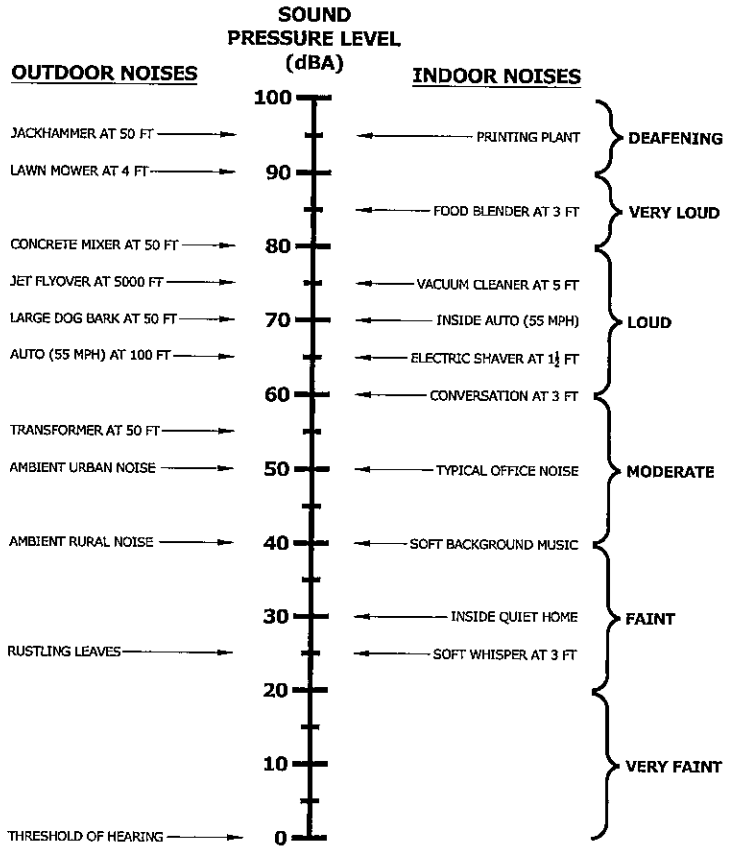

Figure A-1. Common Outdoor/Indoor Sound Levels

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.

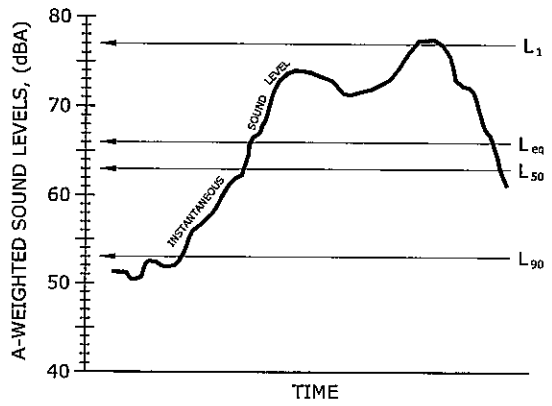

Figure A-2. Example Graph of Equivalent and Statistical Sound Levels

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.

Sound Exposure Level

The sound exposure level, SEL, is the total noise energy produced from a single noise event. The sound exposure level is used to describe the amount of noise from discrete moving sources such as an individual aircraft flyover or a single train passing by. The sound exposure level is the integration of all the acoustic energy contained within the event.

APPENDIX G

AIR QUALITY TECHNICAL REPORT

AIR QUALITY STUDY

FOR THE PROPOSED

UNIVERSITY OF HAWAII WEST OAHU PROJECT

EWA, OAHU, HAWAII

Prepared for:

PBR Hawaii

June 2006

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1.0 SUMMARY

The University of Hawaii and its private development partner are jointly proposing to develop the University of Hawaii West Oahu Project at Ewa, Oahu. The proposed project will include a mix of land uses including university classrooms and offices, student housing, single- and multi-family residential units, an elementary school, and retail/commercial space. Development of the project is expected to be completed in stages with full development by 2015. 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 facilities and suggests mitigative measures to reduce any potential air quality impacts where possible and appropriate. Potential impacts on the project from nearby industrial sources are also examined.

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 Kapolei area is very much affected by its leeward and coastal situation. Winds are predominantly trade winds from the east northeast except for occasional periods when kona storms may generate strong winds from the south or when the trade winds are weak and 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 leeward Oahu area are generally very moderate with average daily temperatures ranging from about 65°F to 84°F. The extreme minimum temperature recorded at the nearby (former) Ewa Plantation is 47°F, while the extreme maximum temperature is 93°F. This area of Oahu is one of the drier locations in the state with rainfall often highly variable from one year to the next. Monthly rainfall has been measured to vary from as little as a trace to as much as 15 inches. Average annual rainfall amounts to about 21 inches with summer months being the driest.

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 project is 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 phase. 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 active work areas, using wind screens, keeping adjacent paved roads clean, and covering 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 development will 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 both with and without the proposed project. During worst-case conditions, model results indicated that in the year 2015 without the project 1-hour and 8-hour carbon monoxide concentrations would comply with both the state and the national ambient air quality standards. With the project in the year 2015, carbon monoxide concentrations were estimated to increase at some locations in the project area by 20 percent or more. Even with these higher concentrations, worst-case concentrations should remain well within the national standards but may approach the more stringent state standards.

Options available to mitigate long-term, traffic-related air pollution are generally to further improve roadways, to reduce traffic or to reduce individual vehicular emissions. Aside from providing added roadway improvements, air pollution impacts from vehicular emissions could conceivably be mitigated by reducing traffic volumes through the promotion of bus service, rail transit and car pooling and/or by adjusting local school and business hours to begin and end during off-peak times. Reduction of emissions from individual vehicles is generally beyond the control of any single development and would have to be achieved through the promulgation of county, state or federal air pollution control regulations. Another potential mitigation measure might be to provide added buffer zones between walkways and roadways where space is available. Given that the more stringent state standards would likely be met during worst-case conditions, albeit by a small margin, implementing any air quality mitigation measures for long-term traffic-related 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. The UH West Oahu Campus portion of the project is striving for Leadership in Energy and Efficiency Design (LEED) Silver Certification, which is awarded by the U.S. Green Building

Council to projects that show a high level of commitment to sustainability through design and operation.

In evaluating the proposed project, it may be appropriate to consider not only impacts created by the project but also potential impacts on the project from nearby industrial sources. Due to the close proximity of industries located at Campbell Industrial Park, occasional impacts on the project from emissions emanating from these facilities may occur in conjunction with coincidental occurrences of industry malfunctions and southwesterly winds, both of which are relatively infrequent events. Increased scrutiny by the Department of Health, an air quality task force mandated by the state legislature, and the modernization by some industrial park tenants should help to mitigate future impacts on the proposed project.

2.0 INTRODUCTION

The University of Hawaii (UH) is proposing to relocate its existing West Oahu campus from its shared site with Leeward Community College to a site makai of Farrington Highway and adjacent to the future North-South Road in Ewa, Oahu, Hawaii (see Figure 1 for general project location). The project site is bordered by the North-South Road on its Koko Head side, the Villages of Kapolei and Golf Course on its Waianae side, Farrington Highway on the mauka side, and the Department of Hawaiian Home Lands (DHHL) East Kapolei I residential development on the makai side. In addition to the proposed UH-West Oahu campus, the development site would include a mix of land uses including residential and commercial uses, which would be developed by UH and its private development partner.

The student campus is planned to open in the fall of 2009 with an initial enrollment of about 1,520 students which would grow to an ultimate enrollment of 7,600 students by 2015. At build-out, the UH West Oahu Lands would include approximately 1,484 residential units (including affordable housing and student housing) and approximately 607,000 square feet of retail and office space. The Private Development Lands would include an additional 365 single-family residential units, 2,192 multi-family residential units, approximately 236,000 square feet of commercial space, and a 550-student elementary school.

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. Potential impacts on the project from nearby air pollution sources are also discussed. Measures to mitigate impacts either by the project or on the project 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 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.

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 on the broad Ewa Plain leeward of the Koolau Mountains.

Wind frequency data for Honolulu International Airport (HIA), which is located about 10 miles to the east of the project site, are given in Table 2. These data can be expected to be reasonably representative of the project area. 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 project's near coastal, leeward location results in a relatively moderate temperature profile compared to other locations around Oahu and the state. Based on more than 50 years of data collected at the former nearby Ewa Plantation, average annual daily minimum and maximum temperatures in the project 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.

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 Kapolei 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 radiational cooling. Stability classes 1 through 4 occur during the daytime, depending mainly on the amount of cloud cover and incoming solar radiation and the onset and extent of the sea breeze.

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 concentra-

tions 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 effect 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. The Ewa Plain is one of the driest areas on Oahu due to its leeward and near sea level location. Average annual rainfall amounts to about 21 inches but may vary from about 10 inches during a dry year to more than 40 inches during a wet year [1]. Most of the rainfall usually occurs during the winter months. Monthly rainfall may vary from as little as a trace to as much as 15 inches or more.

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. 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 ten years, while emissions of sulfur oxides, carbon monoxide and hydrocarbons probably have declined.

The H-1 Freeway, which passes through the project area to the north, is a major arterial roadway that presently carries moderate to heavy 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 away from the project site by the prevailing winds.

Several sources of industrial air pollution are located in the Campbell Industrial Park, which is located a few miles from the project site toward the southwest. 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 Kahe Generating Station is located a few miles to the northwest at Kahe Point. 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 site most of the time.

Until recently, air pollution in the project area originating from agricultural sources could mainly be attributed to sugar cane operations near the project site. Emissions from both the 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. Long-range uses for much of the land have not yet been determined.

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 2000 through 2004. These are the most recent data that are currently available.

During the 2000-2004 period, sulfur dioxide was monitored by the State Department of Health at an air quality station located at

Kapolei. 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 19 $\mu g/m^3$, while the annual second-highest 24-hour concentrations ranged from 5 to 9 $\mu g/m^3$. Annual average concentrations were only about 1 to 2 $\mu g/m^3$. 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 also measured at the Kapolei monitoring station. Annual second-highest 24-hour PM-10 concentrations ranged from 29 to 129 $\mu g/m^3$ between 2000 and 2004. Average annual concentrations ranged from 13 to 19 $\mu g/m^3$. All values reported were within the state and national AAQS.

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 ranged from 8 to 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 east of the project area). The second-highest 8-hour concentrations for the period 2002 through 2004 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, particulate matter, ozone and lead are currently being met at the project site. 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 2015 without the project and year 2015 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, the same key intersections identified in the traffic study were also selected for air quality analysis. These included the following intersections:

- North-South Road at Farrington Highway
- North-South Road at Road B
- North-South Road at Road F
- Farrington Highway at Road A
- Farrington Highway at Road F

None of these intersections presently exist, and the Farrington Highway intersections with Roads A and F would only exist in the with-project scenario. 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 two 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 study 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 40.9% light-duty gasoline-powered automobiles, 46.2% 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 Fahrenheit 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 had 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 (where applicable). 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 (35 to 45 mph depending on location).

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 1,000 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. 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. 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.

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 2015 without the project and year 2015 with the project. The locations of these estimated worst-case 1-hour concentrations all occurred at or very near the indicated intersections.

In the year 2015 without the proposed project, the highest worst-case 1-hour concentration was predicted to occur during the morning at the intersection of the North-South Road and Farrington Highway. A value of 7.9 mg/m^3 was predicted to occur at this location and time. Peak-hour worst-case values at the other locations and times studied for the 2015 without-project scenario ranged between 4.1 and 6.3 mg/m^3, with higher concentrations occurring during the morning at all three locations studied. All projected worst-case concentrations for this scenario remained within the state and national standards.

In the year 2015 with the proposed project, the predicted highest worst-case 1-hour concentration continued to occur during the morning at the intersection of the North-South Road and Farrington Highway with a value of 9.6 mg/m^3, which is about 22 percent higher compared to the without project case. Other concentrations for this scenario ranged between 3.8 and 7.9 mg/m^3. Although the predicted concentrations increased at all of the locations studied compared to the without project scenario, the values remained

within the state and federal standards, but the state standard was met by only a small margin.

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 2015 without-project scenario, the estimated worst-case 8-hour carbon monoxide concentrations for the three locations studied ranged from 2.8 mg/m^3 at the North-South Road/Road F intersection to 4.0 mg/m^3 at the North-South Road/Farrington Highway intersection. The estimated worst-case

concentrations for this scenario were within both the state standard of 5 mg/m^3 and the national limit of 10 mg/m^3.

For the 2015 with-project scenario, worst-case concentrations increased at all locations studied compared to the without project case. The worst-case concentrations ranged from 2.4 to 4.8 mg/m^3. All predicted 8-hour concentrations for this scenario were within both the national and the state AAQS, but the state standard was met with only a small margin.

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 project also will cause indirect air pollution emissions from power generating facilities as a consequence of electrical power usage. The peak electrical demand of the

project when fully developed (assuming conventional development) is expected to reach about 55 megawatts [12]. However, the UH West Oahu campus portion of the project is striving to achieve LEED Silver Certification which could help to reduce energy use on the campus. Assuming the average demand is approximately one-half the peak demand, the annual electrical demand of the project will amount to approximately 240 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.

7.3 Solid Waste Disposal

Solid waste generated by the proposed development when fully completed and occupied is not expected to exceed about 40 tons per day [13]. 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 IMPACTS ON PROJECT FROM CAMPBELL INDUSTRIAL PARK

In addition to assessing the air quality impacts of the project on the surrounding area, the reverse problem of impacts of air pollution sources located in the surrounding area on the project is also of concern. For this project, the issue of primary concern is the Campbell Industrial Park (CIP) located about 5 miles to the southwest of the project site. Several large industrial sources of air pollution are located at CIP including Applied Energy Systems (AES) Generating Station, Kalaeloa Partners Cogeneration Plant, the Chevron and BHP Refineries, H-Power and Hawaiian Cement. During the past few years, several incidents of acute air pollution levels have occurred in areas within and adjacent to CIP. Some of these incidents have been caused by upset conditions at the BHP and Chevron Refineries, while the source or sources of other incidents have never been identified.

As indicated in Section 4, the prevailing winds are in the northeast quadrant, which will carry emissions from CIP away from

the project site more than 70 percent of the time. Winds from the southwest, which could carry emissions toward the site, occur less than 5 percent of the time. While estimating specific air pollution levels at the project site is beyond the scope of the present study, it is unlikely that concentrations exceed air quality standards during normal operations. Emissions during normal operations are regulated by the Hawaii Department of Health, and industry operators are required to demonstrate compliance with state and national air quality standards in the surrounding public areas. Perhaps the greatest concern is the coincidence of industry malfunctions in conjunction with southwesterly-wind periods. Even if industry operators are very diligent in operating and maintaining their facilities, occasional malfunctions that result in air pollution incidents in nearby areas are probably unavoidable.

After several incidents over the past few years, the Department of Health has increased scrutiny of industries at CIP. Also, a task force mandated by the state legislature was formed to investigate recent air pollution incidents and to reduce future occurrences. In response to plant malfunctions that have caused the excessive release of air contaminants, several industries have begun modernization programs which are intended to improve operations.

9.0 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.

After construction of the proposed project is completed and it is fully occupied, carbon monoxide concentrations in the project area will likely increase at some locations by 20 percent or more due to emissions from project-related motor vehicle traffic. Worst-case concentrations should remain well within the national

ambient air quality standards but may approach the more stringent state standards.

Aside from further improving roadways, air pollution impacts from vehicular emissions could conceivably be mitigated by reducing traffic volumes through the promotion of bus service, rail transit and car pooling and/or by adjusting local school and business hours to begin and end during off-peak times. However, this mitigation measure is generally considered only partially successful. Reduction of emissions from individual vehicles is another potential mitigation measure, but this would have to be achieved through the promulgation of county, state or federal air pollution control regulations. For example, Hawaii currently does not require annual inspections of motor vehicle air pollution control equipment. At the present time, there is no indication that the state is contemplating adopting such rules.

An additional potential mitigation measure would be to provide added buffer zones between walkways and roadways in areas where space is available. Technically, however, the public would have to somehow be excluded from the buffer zones. The predicted worst-case concentrations in this report are based on a separation distance of 3 m (10 ft) between walkways and roadways. Doubling this distance to about 6 m (20 ft) would in many cases reduce maximum concentrations by about 10 to 15 percent.

Given that the more stringent state standards would be met during worst-case conditions, albeit by a small margin, 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 very small 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 (consistent with the efforts to achieve LEED Silver Certification). 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.

Due to the relatively close proximity of industries located at CIP, occasional impacts on the project from emissions emanating from these facilities will probably be unavoidable. Such impacts may occur in conjunction with the coincidental occurrence of industry malfunctions and southwesterly winds, both of which are relatively infrequent events. Increased scrutiny by the Department of Health, a special task force mandated by the state legislature to assess and monitor emissions in the area, and the

upgrade of some of the industries located at CIP, such as Chevron, should help to mitigate future impacts on areas adjacent to CIP.

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Figure 1 - Project Location Map

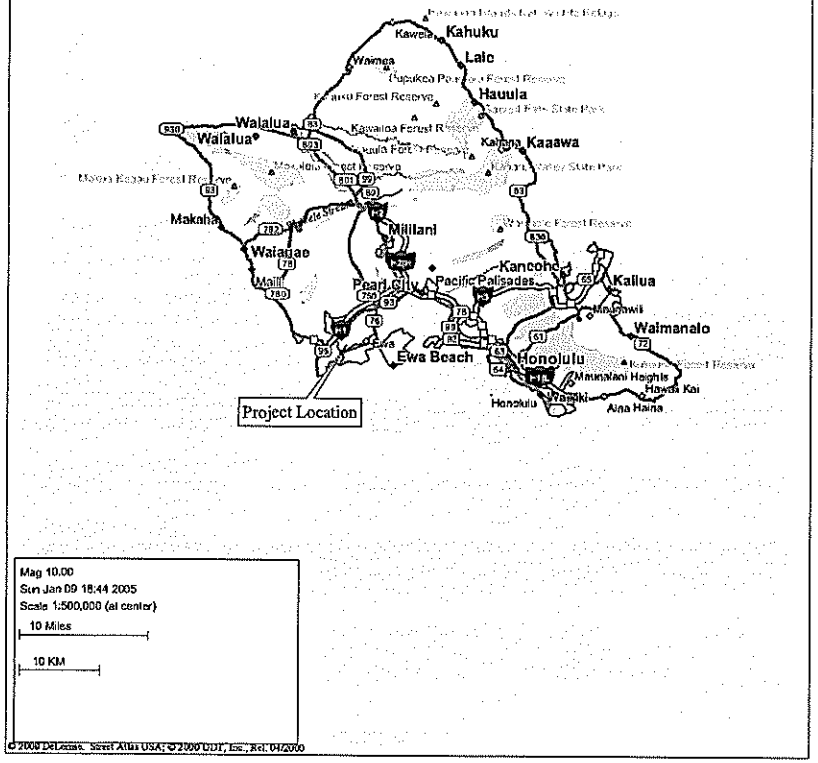

Table 1

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)	µg/m³	Annual 24 Hours	50[a] 150[b]	50[a] 150[b]	50 150[c]
Particulate Matter (<2.5 microns)	µg/m³	Annual 24 Hours	15[a] 65[d]	15[a] 65[d]	- -
Sulfur Dioxide	µg/m³	Annual 24 Hours 3 Hours	80 365[c] -	- - 1300[c]	80 365[c] 1300[c]
Nitrogen Dioxide	µg/m³	Annual	100	100	70
Carbon Monoxide	mg/m³	8 Hours 1 Hour	10[c] 40[c]	- -	5[c] 10[c]
Ozone	µg/m³	8 Hours 1 Hour	157[e] 235[f]	157[e] 235[f]	157[e] -
Lead	µg/m³	Calendar Quarter	1.5	1.5	1.5
Hydrogen Sulfide	µg/m³	1 Hour	-	-	35[c]

[a] Three-year average of annual arithmetic mean.

[b] 99th percentile value averaged over three years.

[c] Not to be exceeded more than once per year.

[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.

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 UNIVERSITY OF HAWAII WEST OAHU PROJECT

Parameter / Location	2000	2001	2002	2003	2004
Sulfur Dioxide / Kapolei					
3-Hour Averaging Period:					
No. of Samples	2505	2511	2420	2461	2504
Highest Concentration ($\mu g/m^3$)	23	24	47	26	17
2nd Highest Concentration ($\mu g/m^3$)	18	15	19	19	12
No. of State AAQS Exceedances	0	0	0	0	0
24-Hour Averaging Period:					
No. of Samples	362	359	344	351	355
Highest Concentration ($\mu g/m^3$)	6	7	9	9	7
2nd Highest Concentration ($\mu g/m^3$)	5	6	7	9	6
No. of State AAQS Exceedances	0	0	0	0	0
Annual Average Concentration ($\mu g/m^3$)	1	2	2	1	1
Particulate (PM-10) / Kapolei					
24-Hour Averaging Period:					
No. of Samples	356	352	351	343	339
Highest Concentration ($\mu g/m^3$)	148	121	55	72	53
2nd Highest Concentration ($\mu g/m^3$)	129	104	35	29	41
No. of State AAQS Exceedances	0	0	0	0	0
Annual Average Concentration ($\mu g/m^3$)	17	19	16	14	13
Carbon Monoxide / Kapolei					
1-Hour Averaging Period:					
No. of Samples	8595	8577	8354	8559	8507
Highest Concentration (mg/m^3)	2.5	2.3	2.2	2.2	2.4
2nd Highest Concentration (mg/m^3)	1.6	1.9	2.0	1.6	1.7
No. of State AAQS Exceedances	0	0	0	0	0
8-Hour Averaging Period:					
No. of Samples	1076	1073	1044	n/a	n/a
Highest Concentration (mg/m^3)	1.0	1.6	1.8	0.8	1.0
2nd Highest Concentration (mg/m^3)	0.8	1.3	1.8	0.8	1.0
No. of State AAQS Exceedances	0	0	0	0	0
Nitrogen Dioxide / Kapolei					
Annual Average Concentration ($\mu g/m^3$)	9	8	9	9	9
Ozone / Sand Island					
8-Hour Averaging Period:					
No. of Samples	-	-	8549	8641	8474
Highest Concentration (mg/m^3)	-	-	89	79	110
2nd Highest Concentration (mg/m^3)	-	-	88	77	108
No. of State AAQS Exceedances	-	-	0	0	0

Source: State of Hawaii Department of Health, "Annual Summaries, Hawaii Air Quality Data, 2000 - 2004"

Table 5

ESTIMATED WORST-CASE 1-HOUR CARBON MONOXIDE CONCENTRATIONS
ALONG ROADWAYS NEAR UNIVERSITY OF HAWAII WEST OAHU PROJECT
(milligrams per cubic meter)

Roadway Intersection	Year/Scenario			
	2015/Without Project		2015/With Project	
	AM	PM	AM	PM
North-South Road at Farrington Highway	7.9	5.8	9.6	6.8
North-South Road at Road B	6.3	4.3	7.9	6.3
North-South Road at Road F	5.6	4.1	7.7	6.0
Farrington Highway at Road A	-	-	4.7	3.6
Farrington Highway at Road F	-	-	5.2	3.8

Hawaii State AAQS: 10
National AAQS: 40

Table 6

ESTIMATED WORST-CASE 8-HOUR CARBON MONOXIDE CONCENTRATIONS ALONG ROADWAYS NEAR UNIVERSITY OF HAWAII WEST OAHU PROJECT (milligrams per cubic meter)

Roadway Intersection	Year/Scenario	
	2015/Without Project	2015/With Project
North-South Road at Farrington Highway	4.0	4.8
North-South Road at Road B	3.2	4.0
North-South Road at Road F	2.8	3.8
Farrington Highway at Road A	-	2.4
Farrington Highway at Road F	-	2.6

Hawaii State AAQS: 5
National AAQS: 10

Table 7

ESTIMATED INDIRECT AIR POLLUTION EMISSIONS FROM UNIVERSITY OF HAWAII WEST OAHU PROJECT ELECTRICAL DEMAND[a]

Air Pollutant	Emission Rate (tons/year)
Particulate	10
Sulfur Dioxide	80
Carbon Monoxide	6
Volatile Organics	<1
Nitrogen Oxides	35

[a]Based on U.S. EPA emission factors for utility boilers [2]. Assumes electrical demand of 240 million kilowatt-hrs per year and low-sulfur oil used to generate power.

Table 8

ESTIMATED INDIRECT AIR POLLUTION EMISSIONS FROM
UNIVERSITY OF HAWAII WEST OAHU PROJECT SOLID WASTE DISPOSAL DEMAND[a]

Air Pollutant	Emission Rate (tons/year)
Particulate	<1
Sulfur Dioxide	4
Carbon Monoxide	7
Volatile Organics	<1
Nitrogen Oxides	18
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 40 tons per day.

APPENDIX H

TRAFFIC STUDY

TRAFFIC STUDY

UNIVERSITY OF HAWAII

WEST OAHU

EWA, OAHU, HAWAII

June 2006

Revised October 2006

PARSONS BRINCKERHOFF

Over a Century of Engineering Excellence

TRAFFIC STUDY

UNIVERSITY OF HAWAII – WEST OAHU

Ewa, Oahu, Hawaii

June 2006

Revised October 2006

Prepared For:
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PBQD Reference Number:

16273B

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FIGURES

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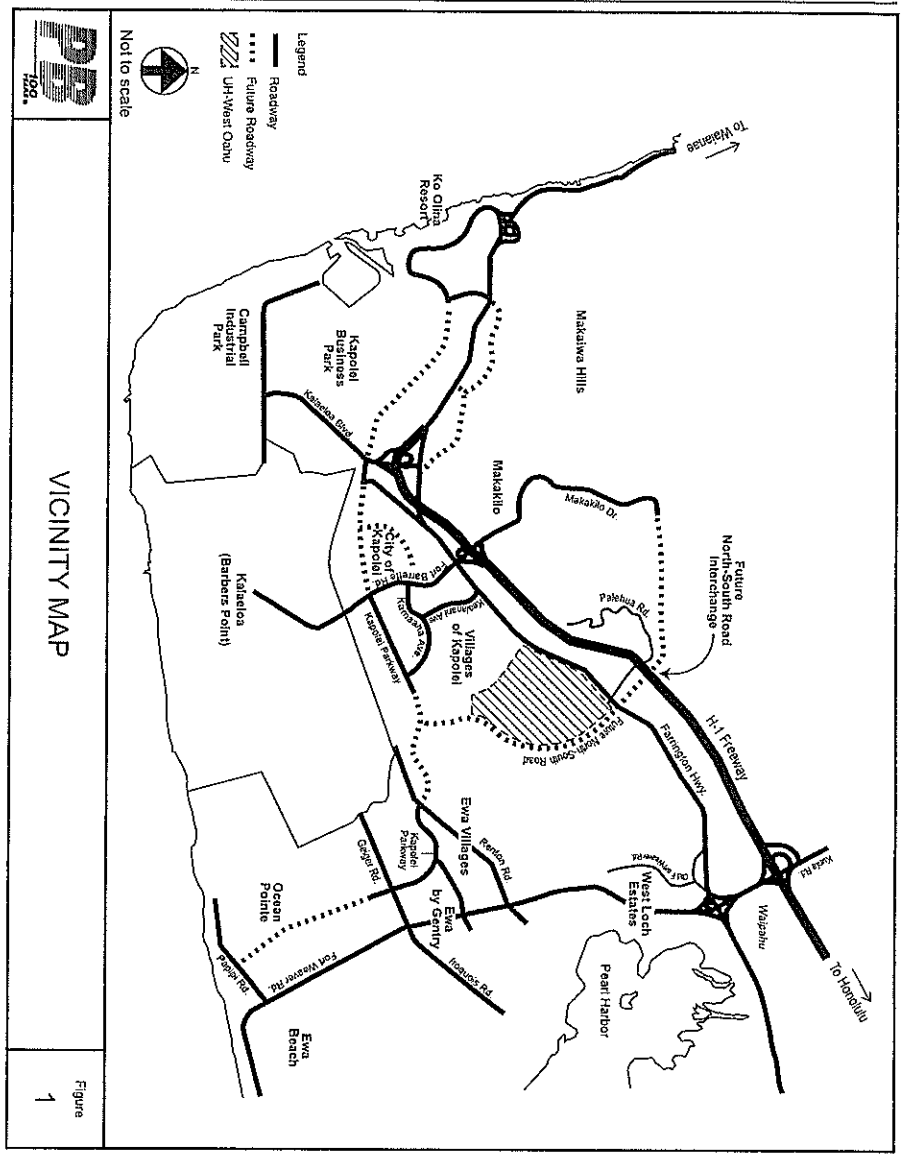
I. INTRODUCTION

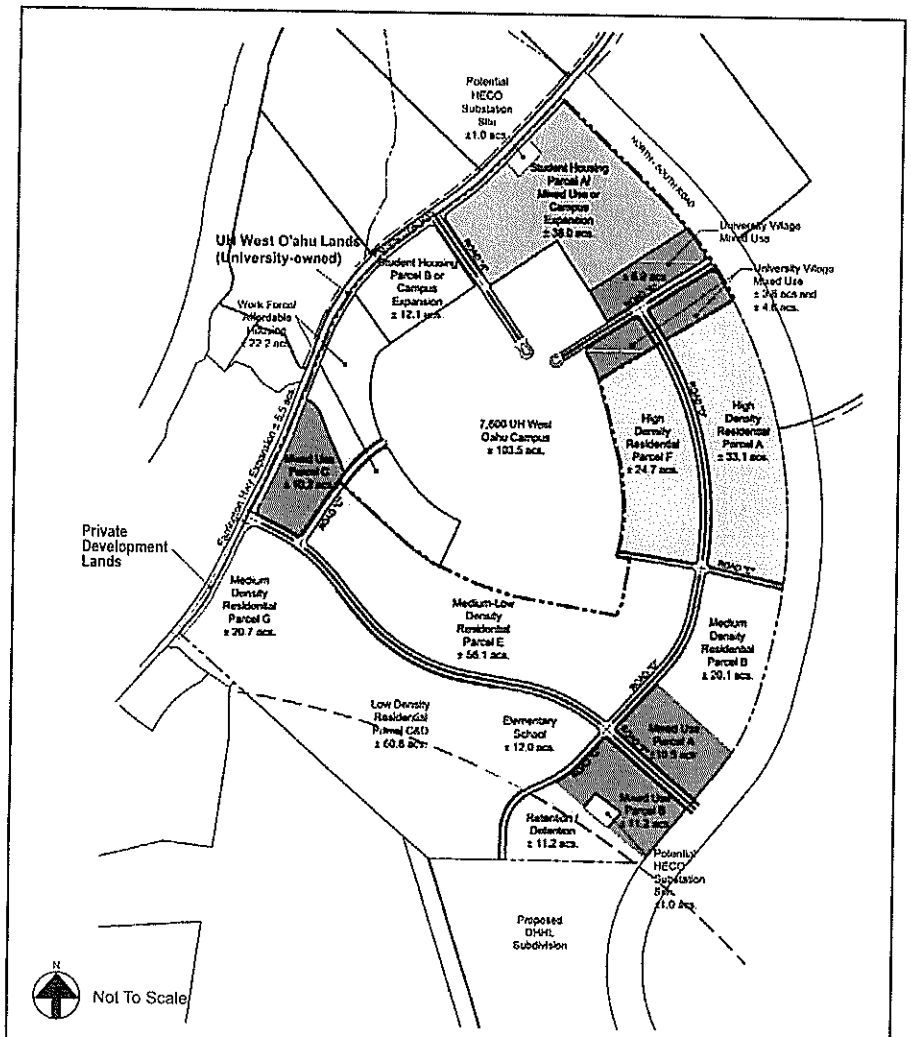
The University of Hawaii (UH) is planning to relocate its existing West Oahu campus from its shared site with Leeward Community College to a proposed site makai of Farrington Highway and adjacent to the future North-South Road in Ewa, Oahu, Hawaii. Figure 1 shows the general location of the proposed site. As shown in Figure 1, the proposed site is bordered by North-South Road on its Koko Head side, the Villages of Kapolei and Golf Course on its Waianae side, Farrington Highway on its mauka side and the Department of Hawaiian Home Lands (DHHL) East Kapolei I residential development on its makai side. In addition to the proposed UH-West Oahu campus, the development site would include a mix of land uses such as residential and commercial uses, and an elementary school. Part of the site would be developed by UH itself with the balance of the site being developed by a private development partner.

The initial student campus is planned to open Year 2008 consisting of 1,520 students and grow to an ultimate 7,600 student campus by Year 2015. Approximately 760 student housing units will be provided to accommodate approximately 30% of the ultimate student population. Along with the campus and student housing, the ultimate build out of the UH West Oahu development will add approximately 724 multi-family dwelling units and approximately 606,573 square feet of retail and office development in an integrated, mixed-use village setting.

The private development portion of the site is proposed to contain approximately 365 single-family residential units and 2,192 multi-family residential units, some of them located within a mixed use setting with approximately 236,313 square feet of commercial land use. Also included is a 550-student elementary school. Figure 2 shows the conceptual site plan for the UH West Oahu.

This report documents the assumptions and methodology used and summarizes the findings and recommendations of road configurations for the proposed UH West Oahu site. Analysis time frames of Year 2015 for build-out and Year 2008 for Phase 1 of the project are evaluated in this study.





CONCEPTUAL DEVELOPMENT PLAN

Figure 2

II. EXISTING CONDITIONS

A. Existing Roadway Network

Interstate H-1, Farrington Highway, Fort Weaver Road/Kunia Road, and Fort Barrette Road/Makakilo Drive provide regional and sub-regional access to the UH West Oahu study area. H-1 Freeway and Farrington Highway provide east – west regional circulation and Kunia Road/Fort Weaver Road and Makakilo Drive/Fort Barrette Road provide north – south circulation within the Ewa Plain. Figure 3 shows the existing roadway network and lane configurations.

H-1 Freeway

H-1 Freeway exists as a six-lane freeway in the vicinity of the proposed UH West Oahu site. The two closest H-1 Freeway interchanges are the Makakilo Interchange, located about 2 miles Waianae of the project site, and the Kunia Interchange, located about 2 miles Koko Head of the project site. The posted speed limit on this segment of H-1 Freeway is 60 miles per hour (mph).

Farrington Highway

Farrington Highway is a major arterial roadway providing east-west mobility in the Ewa plain. Adjacent to the project site, it is a 2-lane, undivided roadway. In the Waianae direction, Farrington Highway becomes a 4-lane, divided roadway from the Kapolei Golf Course Access Road to Kamokila Boulevard in the City of Kapolei. This portion of Farrington Highway is constructed to an urban cross-section with curb and gutter, and sidewalks. In the Koko Head direction, Farrington Highway becomes a four-lane, divided roadway as it approaches Fort Weaver Road. The posted speed limit of Farrington Highway is 35 mph in the study area.

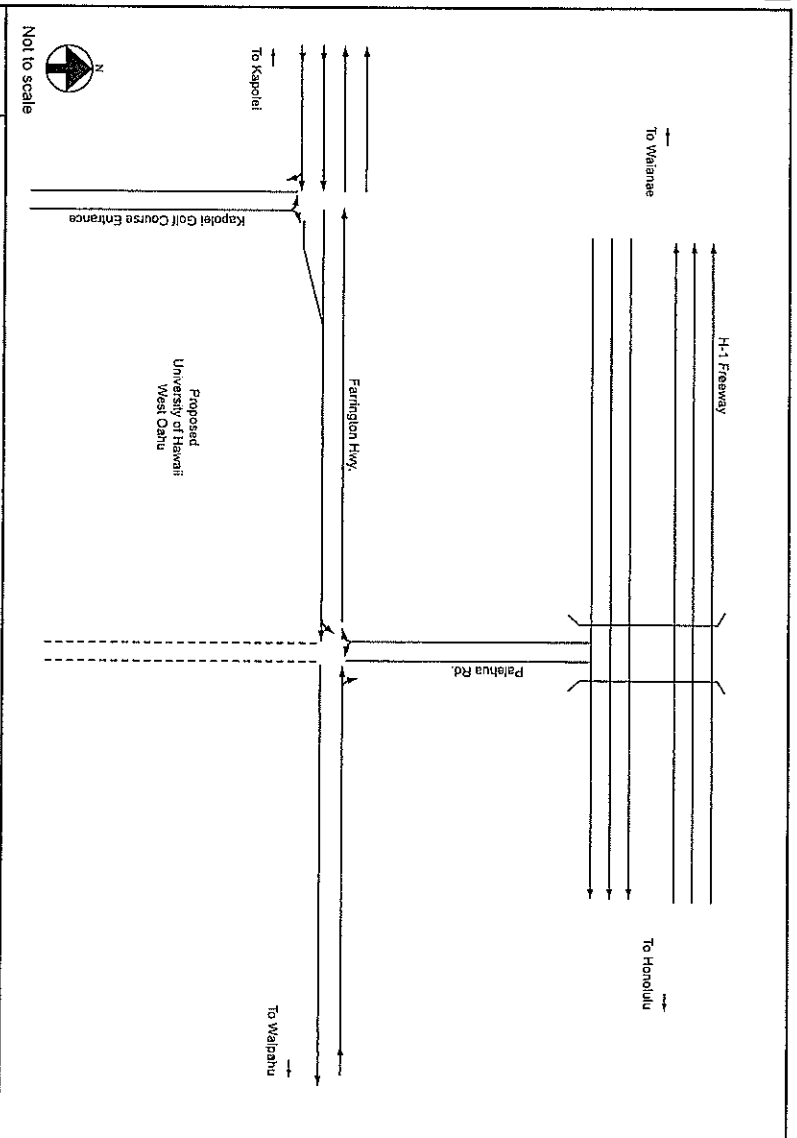


Figure 3
EXISTING ROADWAY NETWORK

Fort Weaver Road/Kunia Road

Fort Weaver Road is the principal north-south arterial roadway serving Ewa and Ewa Beach. It provides access from these areas to Farrington Highway. North of Farrington Highway it becomes Kunia Road, which provides access to H-1 Freeway and mauka areas up to central Oahu. The southern terminus is east of the Ewa Beach International Golf Club where it merges with Cormorant Avenue, leading into the Iroquois Point Naval Housing. Fort Weaver Road/Kunia Road is a six-lane expressway between H-1 Freeway and Laulaunui Street with interchanges at H-1 and Farrington Highway. It is a four-lane principal arterial from Farrington Highway to North Road and a two-lane minor arterial through the rest of Ewa Beach. The posted speed limit on Fort Weaver Road is 45 mph, transitioning to 35 mph makai of Geiger Road.

Makakilo Drive/Fort Barrette Road

Currently, Makakilo Drive/Fort Barrette Road is the north-south roadway serving Makakilo and Kapolei. It provides access to H-1 Freeway and Farrington Highway. Makai of Farrington Highway, Makakilo Drive becomes Fort Barrette Road. The makai terminus of Fort Barrette Road is at the entrance of Kalaeloa (formerly Barbers Point Naval Air Station) terminating at F.D. Roosevelt Avenue. Makakilo Drive is a four-lane roadway throughout most of the Makakilo development and is currently the only access for Makakilo to the H-1 Freeway. Fort Barrette Road is a two-lane major arterial road along its entirety but is planned to be widened to a four-lane roadway in the near future. The posted speed limit on Makakilo Drive and Fort Barrette Road varies between 25 mph and 40 mph.

B. Existing Transit Service

The City and County of Honolulu (C&C of Honolulu) Department of Transportation Services (DTS) - Public Transit Division currently provides an island-wide public bus transit system called TheBus. TheHandi-Van provides para-transit service for semi-ambulatory and non-ambulatory persons with disabilities. Both systems are operated by Oahu Transit Services (OTS). With a fleet of 525 buses, TheBus provides 86 numbered bus routes, over 120 sub-

routes and carries over 70 million passengers annually. Figure 4 shows the existing regional public transit routes within the Ewa Plain.

C. Existing Traffic Volumes

Automatic traffic recorders (ATRs) were placed along Farrington Highway on Thursday, April 15, 2004 in the vicinity of the future North-South Road. The AM and PM peak hours were found to occur from 7:00 AM to 8:00 AM and from 4:30 PM to 5:30 PM, respectively. Figure 5 shows the existing peak hour traffic volumes along Farrington Highway. Existing traffic count data can be found in Appendix A.

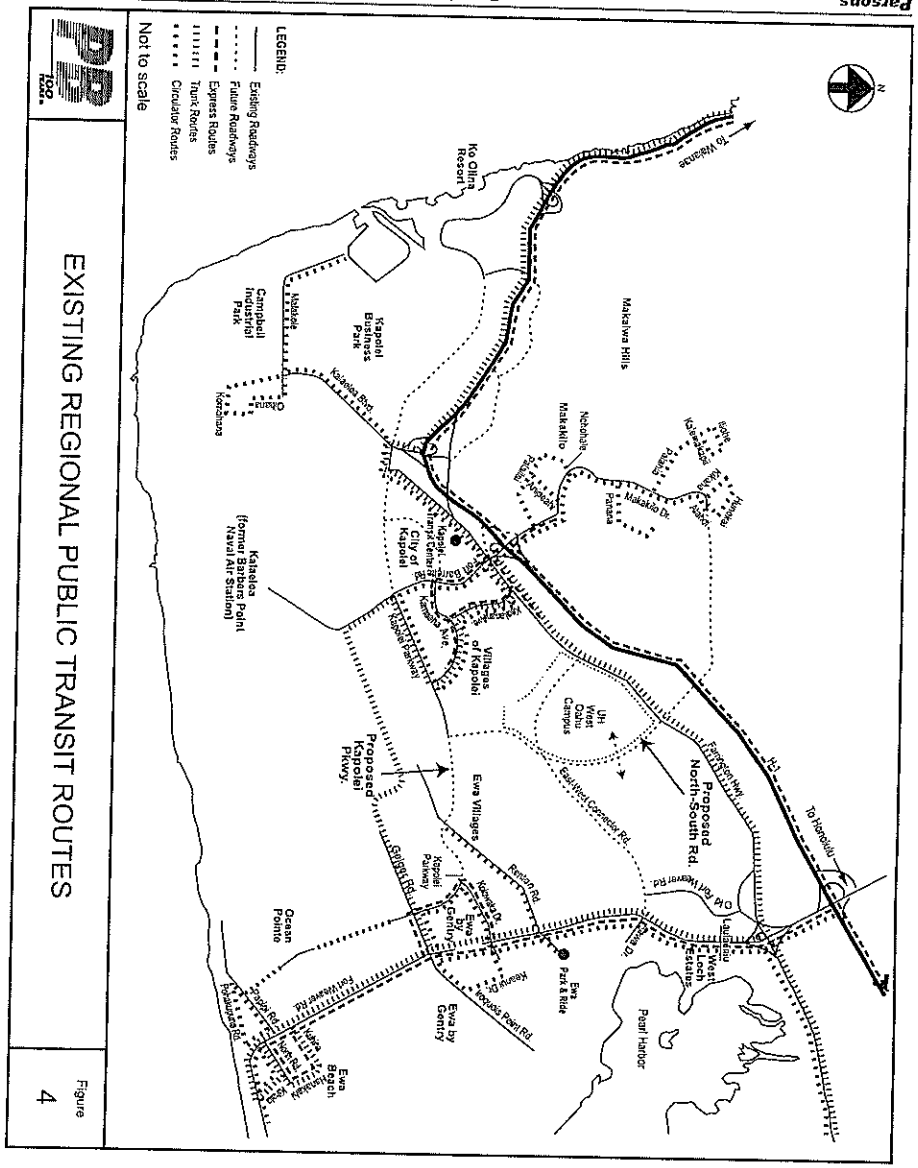
D. Existing Traffic Operations

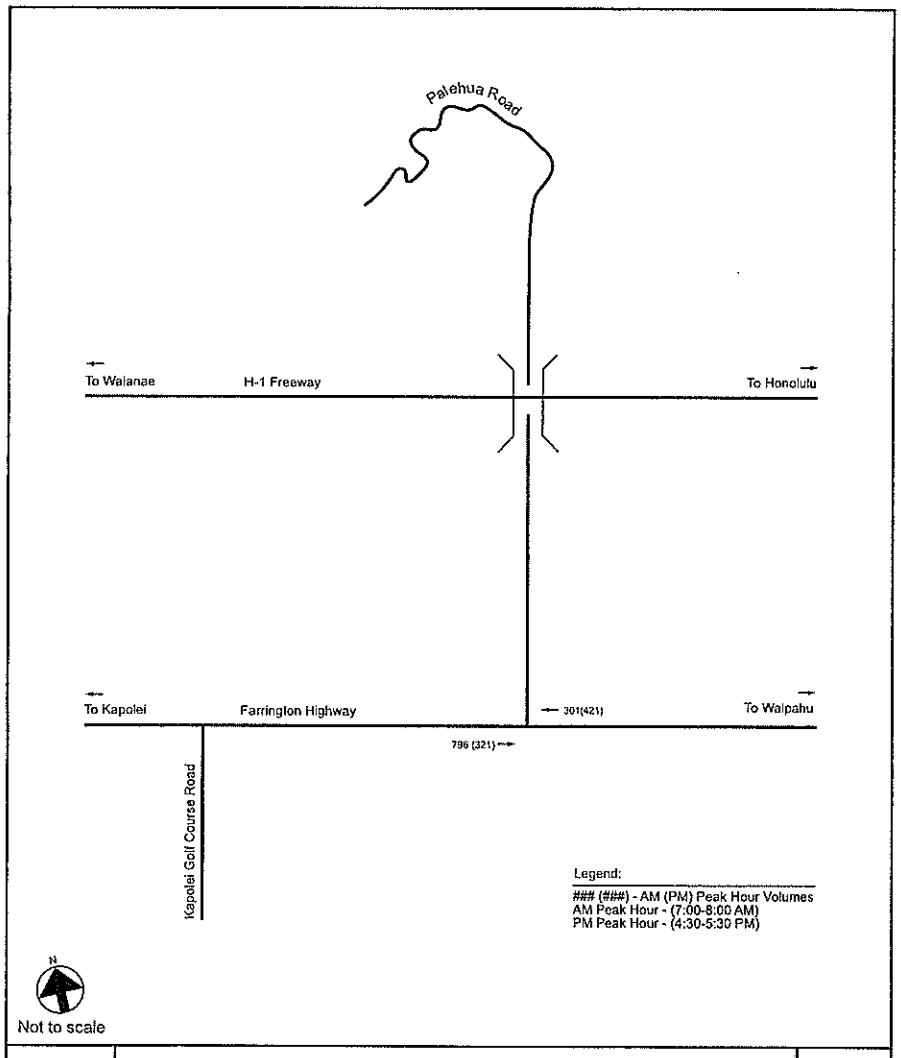
Currently, there are no public roadways in the vicinity of the proposed UH West Oahu site except for Farrington Highway. Farrington Highway was analyzed using the methodologies for two-lane, rural highways documented in the *2000 Highway Capacity Manual (HCM).*

Table 1 summarizes the existing conditions Level-of-Service (LOS) for Farrington Highway in the vicinity of the future North-South Road. Both segments operate at an acceptable LOS. For detailed analysis information, Appendix C includes two-lane highway analysis worksheets.

Table 1 Existing Two-Lane Highway LOS

Location	AM Peak		PM Peak	
	LOS	% Time Following	LOS	% Time Following
Farrington Highway	E	76.5%	E	66.1%





EXISTING PEAK HOUR TRAFFIC VOLUMES

Figure 5

Farrington Highway in the vicinity of the future University of Hawaii West Oahu operates acceptably during both AM and PM peak hours. Grace Pacific Corp. rock quarry is located just mauka of H-1 Freeway and is accessed via Farrington Highway and Palehua Road. A large portion of heavy trucks traveling on Farrington Highway is contributed to the rock quarry picking up and hauling excavated material. The majority of traffic traveling on Farrington Highway in the vicinity of the study area is traveling between Kapolei and Waipahu. Regional traffic headed to and from the Primary Urban Center generally travels on H-1 Freeway.

III. YEAR 2015 FUTURE TRAFFIC CONDITIONS

Year 2015 is the forecasted time frame for completion of the 7,600 student UH West Oahu campus, planned residential and commercial development, and proposed elementary school on site. Therefore Year 2015 forecasted traffic volumes were used for the "No Build" and "Build" traffic analysis for the UH West Oahu.

A. Year 2015 Roadways

Significant changes are expected for the roadway network in the vicinity of the proposed UH West Oahu site. H-1 Freeway and Farrington Highway are assumed to be widened and a new North-South Road and interchange constructed by Year 2015. Both the State of Hawaii Department of Transportation (HDOT) and the City and County of Honolulu were consulted on the potential timing of these projects.

H-1 Freeway

Based on the Oahu Regional Transportation Plan-TOP 2025 (ORTP), published by the Oahu Metropolitan Planning Organization, the high-occupancy vehicle (HOV) lanes on H-1 Freeway are planned to be extended from Waiawa Interchange (H-1/H-2 Merge) to the Makakilo Interchange.

North-South Road

Also included in the ORTP and currently under construction is a new north-south arterial roadway built by HDOT between H-1 Freeway and Kapolei Parkway. The new North-South Road will provide additional access to H-1 Freeway for the Ewa region and provide sub-regional accessibility for developments in the vicinity of the UH West Oahu site. The ultimate configuration of North-South Road includes three vehicular lanes with paved shoulders in each direction, a 28-foot median that could accommodate an exclusive rapid transit corridor, and sidewalks on both sides.

In conjunction with the North-South Road, a new diamond interchange connecting it to H-1 Freeway is planned to be completed by late Year 2008.

Farrington Highway

Based on the ORTP and other roadway plans for the Ewa area, Farrington Highway is assumed to be widened from a two-lane, undivided cross-section to a four-lane, divided cross-section between the Kapolei Golf Course Access Road and Fort Weaver Road. This would make Farrington Highway a continuous 4-lane, divided roadway between Kamokila Boulevard and the Waiawa Interchange.

Road "A"

Road "A" will be the first access to the UH West Oahu campus from Farrington Highway, Waianae of the North-South Road/Farrington Highway intersection. It will be one of the primary accesses to the UH West Oahu campus. Road "A" will be constructed as a four-lane urban cross-section with a raised median providing left-turn lanes at intersections. Road "A" will provide access to the campus, student housing, and the mixed use village planned as part of the UH West Oahu development.

Road "B"

Road "B" will be the first access to the UH West Oahu site from North-South Road, makai of the Farrington Highway/North-South Road intersection. It will be one of the primary accesses to the UH West Oahu campus and will be located opposite a major access for the proposed D.R. Horton development, located Koko Head of North-South Road. This intersection will be signalized when traffic signal warrants are satisfied. Road "B" is planned to be a four-lane divided roadway with a raised median providing left-turn lanes at intersections. Road "B" will provide access to the campus, student housing, and the UH mixed use village. It will also provide access to the high-density residential development areas planned adjacent to North-South Road by the University's private development partner.

Road "C"

Road "C" will be a two-lane roadway providing internal access to both UH West Oahu campus uses and to the private development mixed use and low-density residential uses.

It intersects Road "F", one of the major roadways that transect the UH West Oahu site, just makai of Farrington Highway.

Road "D"

Road "D" will be a four-lane, collector roadway that will provide an internal connection between Road "B" and Road "F" within the UH West Oahu site. Road "D" will have a raised median providing left-turn lanes at intersections. Road "D" will provide internal circulation within the UH West Oahu site and access to the high and medium density residential parcels proposed by the University's private development partner.

Road "E"

Road "E" will be a two-lane roadway providing access to North-South Road at a proposed right-in/right-out (RI/RO) driveway located between the planned Road "B" and Road "F" intersections along North-South Road.

Road "F"

Road "F" will be a four-lane, collector roadway that will transect the UH West Oahu site, providing access for the site to both Farrington Highway and North-South Road. Road "F" will intersect North-South Road directly opposite a major access for the Department of Hawaiian Homelands (DHHL) East Kapolei 2 residential and mixed-use development located Koko Head of North-South Road. This intersection is planned to be signalized when traffic signal warrants are satisfied. Road "F" will be a four-lane, divided roadway with a median providing left-turns at intersections. Internal to the UH West Oahu site, Road "F" will intersect Roads "D", "G", and "C" providing access to the adjacent residential private development and mixed use development as well as to internal areas of the UH West Oahu campus via other access roads.

Road "G"

Road "G" will be a two-lane undivided roadway providing access for the Department of Hawaiian Homelands (DHHL) East Kapolei I residential development located makai of the UH West Oahu campus. It will intersect Road "F" directly opposite Road "D"

Other Roads

Currently, the Department of Planning and Permitting is conducting the Ewa Connectivity Study which is intended to identify desirable regional roadways, a few of which may affect the UH West Oahu site directly or indirectly.

B. Year 2015 Transit Service

Future transit service in the vicinity of the proposed UH West Oahu site is expected to increase significantly within the future time frame of this project.

The City & County of Honolulu is currently conducting an Alternatives Analysis Study (AA) for the Honolulu High-Capacity Transit Project (HHCTP). This project explores the feasibility of several alternative ways to implement a high-capacity transit line within a 23-mile corridor that extends from Kapolei on the Waianae end to UH Manoa on the Koko Head end. One of the alternatives involves a fixed guideway system that could be aligned to service the UH West Oahu site with two transit stations.

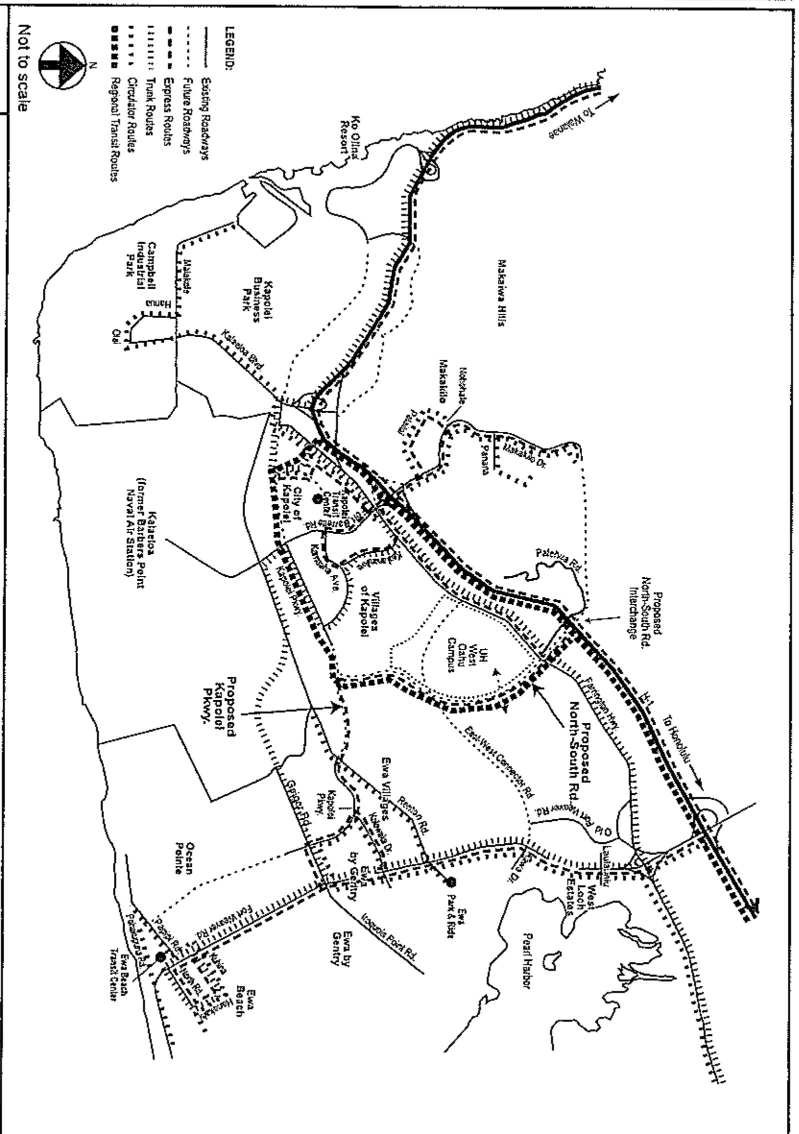
Even the "No Build" alternative being evaluated by the AA includes major upgrades in bus transit service within the area surrounding the proposed UH West Oahu site. Figure 6 illustrates a potential plan for public transit routes within the Ewa Plain. As shown in Figure 6, the UH West Oahu site would be well served by the public transit system.

C. Year 2015 Travel Demand

1. Trip Generation

The *Institute of Transportation Engineers (ITE), Trip Generation, 7th edition* (2003) was used to estimate the number of trips generated by the UH West Oahu development based on land uses identified in the conceptual development plan shown in Figure 2.

The ITE codes are shown for each parcel. Table 2 summarizes the total trips generated by UH West Oahu development. Traffic created along adjacent streets from the elementary school was assumed to be negligible during PM peak hour.



POTENTIAL YEAR 2015 PUBLIC TRANSIT ROUTES

Figure 6

Table 2
UH West Oahu Build Out Trip Generation Summary

Land Use	ITE Code	Intensity	Units	AM Peak Hour Trips		PM Peak Hour Trips	
				Enter	Exit	Enter	Exit
UH West Oahu Campus	550	7,600	Students	1,221	305	471	1,099
Student Housing Parcel B	230	230	DU	11	52	44	21
Mixed Use Village (Commercial)	820	164,439	SF	67	43	218	228
Mixed Use Village (Residential)	230	151	DU	7	34	29	14
Mixed Use Student Housing Parcel A (Commercial)	820	331,056	SF	135	86	439	460
Mixed Use Student Housing Parcel A (Residential)	230	646	DU	-311	-78	-120	-280
Work Force/Affordable Housing	230	355	DU	16	80	68	32
Residential Parcel A	230	530	DU	24	120	102	48
Residential Parcel B	210	241	DU	11	54	46	22
Residential Parcel C	210	183	DU	32	97	84	47
Residential Parcel D	210	182	DU	32	97	84	47
Residential Parcel E	210	561	DU	100	299	258	144
Residential Parcel F	230	395	DU	18	89	76	36
Residential Parcel G	230	248	DU	11	56	48	22
Mixed Use Parcel A (Commercial)	820	114,345	SF	47	30	151	159
Mixed Use Parcel A (Residential)	230	105	DU	5	24	20	9
Mixed Use Parcel B (Commercial)	820	121,968	SF	50	32	162	169
Mixed Use Parcel B (Residential)	230	112	DU	5	25	22	10
Mixed Use Parcel C (Commercial)	820	111,078	SF	45	29	147	154
Mixed Use Parcel C (Residential)	230	102	DU	5	23	20	9
Elementary School	520	550	Students	46	0	0	0
TOTAL				1,578	1,497	2,369	2,449

Note: SF= Leasable Square Feet, DU=Dwelling Unit, Ac=Acres
Trip Generation units are vehicles per hour. Trip generation equations documented in ITE Trip Generation, 7th Edition.

2. Trip Distribution and Assignment

The traffic generated by the proposed ultimate UH West Oahu Development was directionally distributed and assigned to the future roadway network.

A summary of regional travel patterns entering and exiting UH West Oahu was created from the Oahu Metropolitan Planning Organization (OMPO) travel demand model. Table 3 summarizes the distribution patterns of the generated volumes entering and exiting the UH West Oahu.

Table 3
UH West Oahu External Trip Distribution

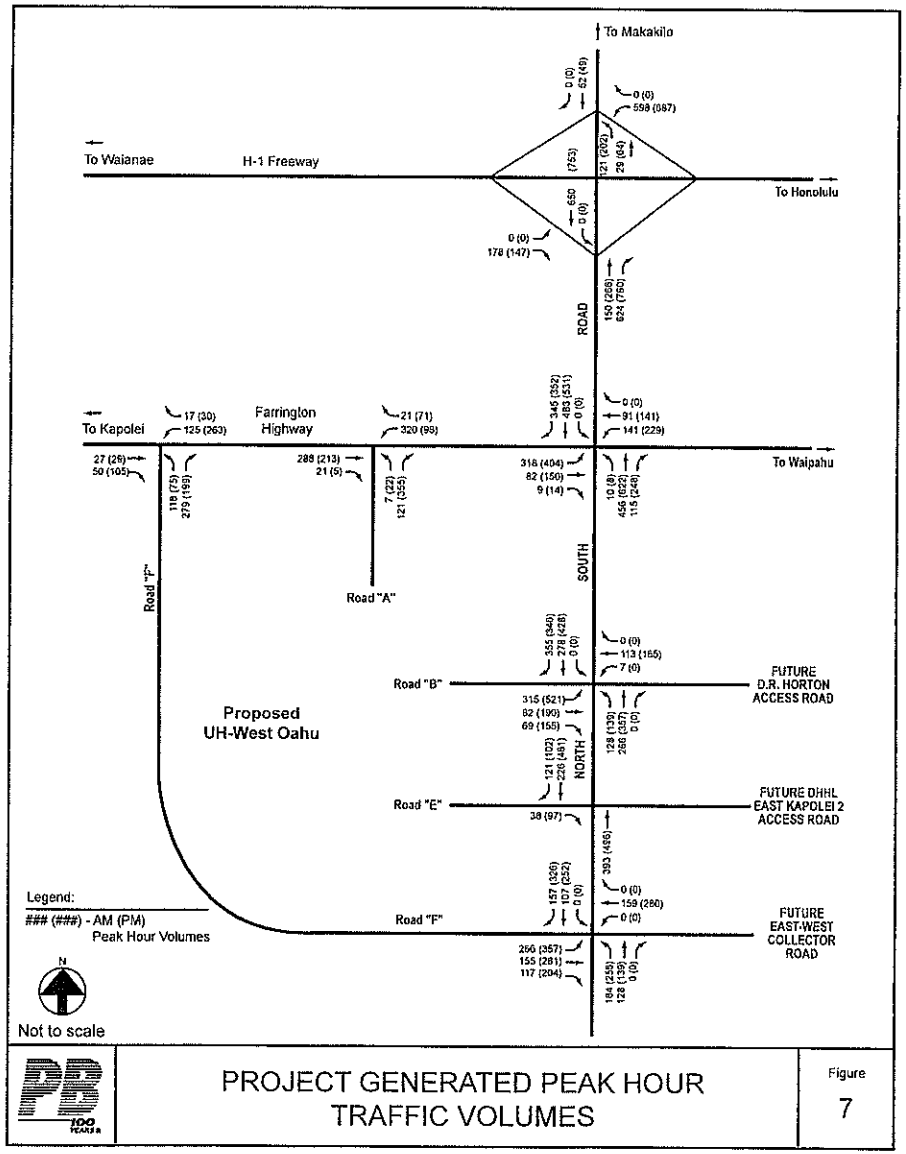
Area	Development Component		
	UH West Oahu	Commercial Development	Residential Development
Waianae Coast	18%	3%	14%
Kapolei/Kalaeloa	9%	4%	15%
East Kapolei/Waipahu	12%	45%	15%
Ewa Beach/Gentry	13%	23%	4%
Central Oahu	26%	19%	11%
Primary Urban Center	22%	6%	41%

Traffic generated from the UH West Oahu study area were distributed and assigned to the road network and are reflected in the project generated traffic turning volumes. Commercial retail trips were assumed to originate from Ewa, Villages of Kapolei, Royal Kunia, Kalaeloa, Makakilo and Waianae Coast. The trips associated with the elementary school were assumed to serve residential development within the UH West Oahu site and the DHHL East Kapolei I site.

These distributions were applied to the ultimate build out trips generated, and the resulting project-generated trip assignment is shown in Figure 7.

3. Year 2015 Background Traffic

Background traffic volumes are volumes not directly associated with development proposed for the UH West Oahu site. These volumes are comprised of sub-regional volumes using North-South Road and Farrington Highway, future trips associated with the DHHL East Kapolei I and 2 Residential Developments located makai and Koko Head of UH West Oahu site, respectively, and future trips associated with the D.R. Horton mixed use



PROJECT GENERATED PEAK HOUR TRAFFIC VOLUMES

Figure 7

development. These components were assigned to the future roadway system to estimate Year 2015 traffic volumes.

The projected Year 2015 background traffic volumes are shown in Figure 8 and represent the future traffic volumes without the proposed UH West Oahu development.

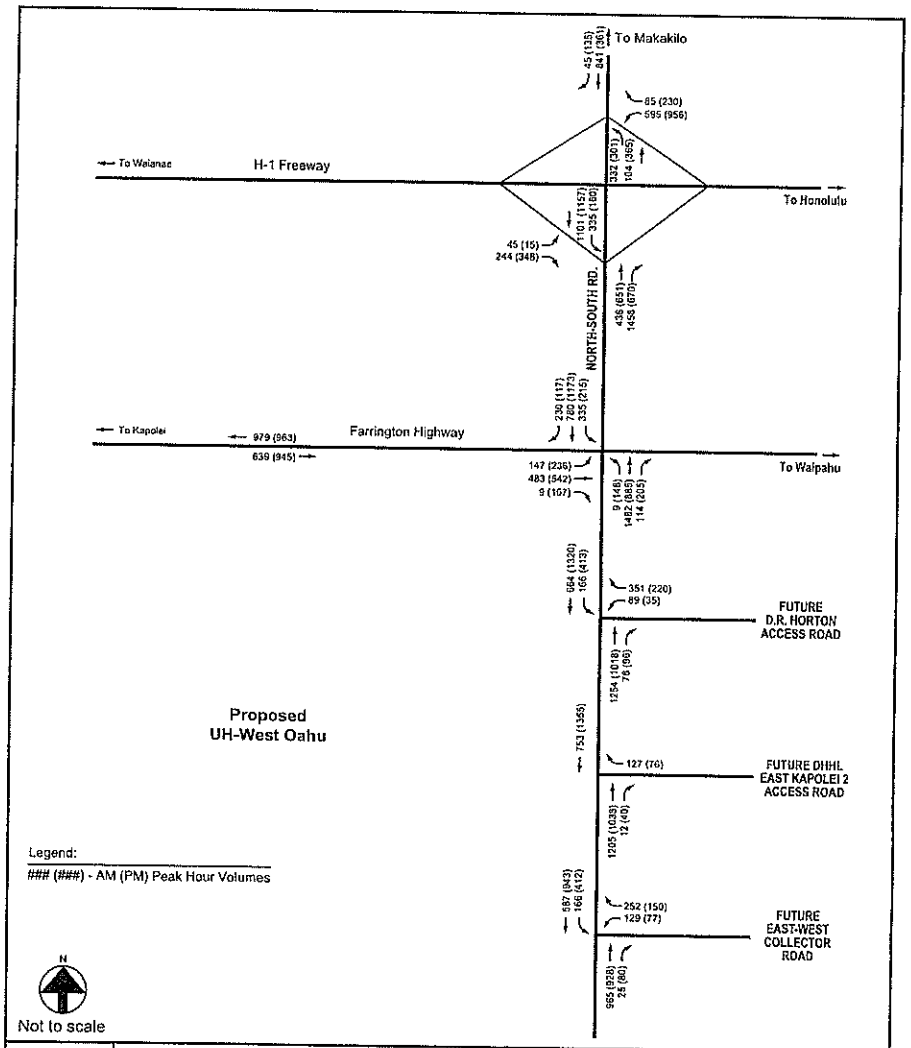
4. Total Traffic

The traffic generated by the ultimate UH West Oahu development shown in Figure 7 was combined with the background traffic shown in Figure 8. This sum represents the total Year 2015 total traffic volumes with the UH West Oahu development and is shown in Figure 9. As part of this summation, background traffic was re-assigned to take advantage of the new roadway network connections provided by Road "F" and Road "G" within the UH West Oahu site.

D. Year 2015 Traffic Operations

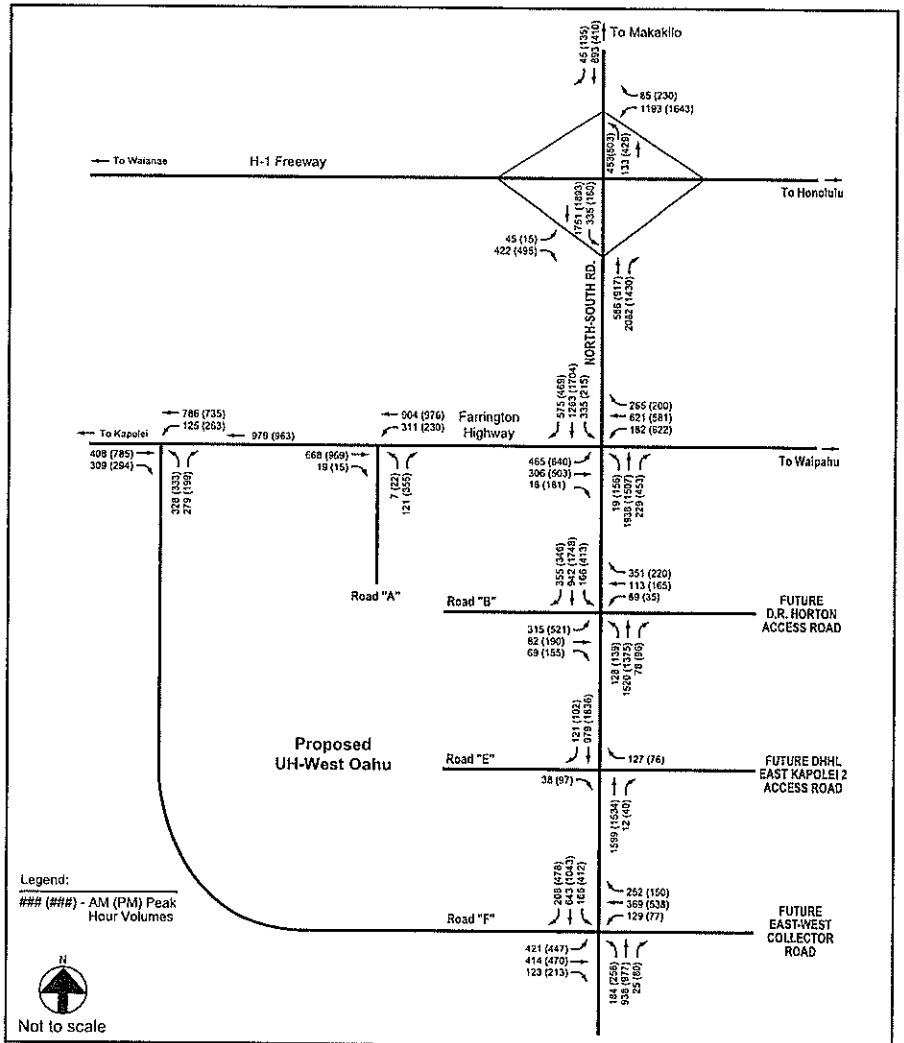
By the Year 2015 time frame, much of the future roadway network in the vicinity of the proposed UH West Oahu development is assumed to be in place. In that environment, traffic operations would be best described at key adjacent intersections. These intersections were analyzed using the methodologies for unsignalized and signalized intersections outlined in the *2000 Highway Capacity Manual (HCM)*. Operating conditions at an intersection are expressed as qualitative measures known as Level of Service (LOS) ranging from A to F. LOS A represents free-flow operations with low delay, while LOS F represents conditions with relatively high delay. The approach LOS is a weighted average of the LOS of individual traffic movement groups. Appendix B has more detailed definitions of intersection LOS.

Table 4 summarizes the projected Year 2015 peak hour intersection level-of-service without and with the UH-West Oahu development. As summarized in Table 4, all intersections analyzed are projected to operate acceptably (overall level-of-service E or better) during the peak hours. Appendix C includes intersection capacity worksheets. In these analyses, North-South Road was assumed to be built to its ultimate 6-lane cross-section with appropriate left-turn lanes at intersections. Based on the projected Year 2015



YEAR 2015 BACKGROUND PEAK HOUR TRAFFIC VOLUMES

Figure 8



YEAR 2015 TOTAL PEAK HOUR TRAFFIC VOLUMES

Figure 9

Table 4
Year 2015 Without and With
The University of Hawaii – West Oahu
Level-of-Service Summary

Intersection	Without UH West Oahu				With UH West Oahu			
	AM Peak		PM Peak		AM Peak		PM Peak	
	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay
North-South Rd/ H-1 WB Off Ramp Terminus	**D**	**36.9**	**C**	**31.0**	**D**	**42.5**	**D**	**41.3**
H-1 WB Off Ramp Left	D	39.7	D	36.0	D	44.4	D	47.4
H-1 WB Off Ramp Right	C	32.9	C	27.6	C	22.4	B	16.3
North-South NB Left	D	36.5	D	35.9	D	46.7	D	49.6
North-South NB Through	A	7.9	B	15.7	B	14.8	C	29.5
North-South SB Through	D	40.7	D	40.1	D	45.7	D	45.7
North-South SB Right	A	8.0	A	8.2	A	3.6	A	3.9
North-South Rd/ H-1 EB Off Ramp Terminus	**B**	**10.2**	**B**	**11.7**	**B**	**11.8**	**B**	**13.9**
H-1 EB Off Ramp Left	C	34.8	C	34.9	C	34.8	C	34.9
H-1 EB Off Ramp Right	A	0.0	A	0.1	A	0.1	A	0.1
North-South NB Through	C	31.0	C	28.9	C	31.3	C	33.8
North-South NB Right	A	0.3	A	0.0	A	1.8	A	0.2
North-South SB Left	C	33.4	C	32.2	D	35.5	C	32.2
North-South SB Through	A	9.2	A	9.0	B	14.8	B	16.4
North-South Rd/ Farrington Hwy	**D**	**40.6**	**D**	**41.3**	**D**	**47.1**	**D**	**45.9**
Farrington EB Left	D	50.8	D	43.7	E	64.0	E	65.2
Farrington EB Through	D	39.6	D	40.0	D	37.5	D	53.4
Farrington EB Right	B	18.3	C	22.0	B	14.2	C	33.3
Farrington WB Left	D	48.5	D	48.6	E	60.3	E	60.9
Farrington WB Through	D	52.4	D	46.1	E	70.0	E	67.2
Farrington WB Right	C	22.6	C	22.6	C	31.9	C	33.9
North-South NB Left	D	42.6	D	47.7	D	35.5	E	56.2
North-South NB Through	D	45.7	D	39.2	D	49.5	D	36.1
North-South NB Right	B	17.5	B	17.7	B	15.7	B	12.6
North-South SB Left	D	50.7	D	49.3	E	76.3	E	70.7
North-South SB Through	C	29..9	D	48.2	D	38.2	D	49.0
North-South SB Right	B	19.3	B	16.4	C	25.1	B	12.9

Note: NB=North Bound, SB=South Bound, EB=East Bound, WB=West Bound

Table 4 (Continued)

North-South Rd/ Road B	**C**	**28.5**	**B**	**19.0**	**D**	**38.9**	**D**	**54.9**
Road B EB Left	No	UHWO	Leg	--	D	53.6	D	63.7
Road B EB Through	No	UHWO	Leg	--	D	42.4	D	48.0
Road B EB Right	No	UHWO	Leg	--	D	42.5	D	47.7
Road B WB Left	C	32.8	D	35.4	D	47.7	D	49.3
Road B WB Through	No	UHWO	Leg	--	E	55.1	E	72.5
Road B WB Right	D	54.9	B	11.0				
North-South NB Left	No	UHWO	Leg	--	D	48.9	E	58.3
North-South NB Through/Right	C	32.3	C	31.5	D	35.7	D	48.5
North-South SB Left	D	39.1	D	41.5	D	55.0	E	65.7
North-South SB Through	A	3.8	A	2.4	C	29.8	D	52.9
North-South SB Right	No	UHWO	Leg	--				
North-South Rd/ Road E*	**Unsignalized RIRO****				**Unsignalized RIRO****			
Road E WB Right (East Kapolei 2)	C	18.8	B	14.8	D	28.9	C	21.8
Road E EB Right (UHWO)	No	UHWO	Leg	--	B	14.0	E	36.5
North-South Rd/ Road F	**C**	**28.0**	**C**	**26.8**	**D**	**47.0**	**D**	**48.4**
Road F EB Left	No	UHWO	Leg	--	D	50.3	E	60.1
Road F EB Through	No	UHWO	Leg	--	D	53.4	E	60.2
Road F EB Right	No	UHWO	Leg	--	C	34.0	C	22.2
Road F WB Left	C	33.8	D	35.6	D	44.4	D	53.0
Road F WB Through	No	UHWO	Leg	--	D	41.3	D	47.2
Road F WB Right	D	39.7	D	37.4				
North-South NB Left	No	UHWO	Leg	--	D	45.5	E	60.4
North-South NB Through/Right	C	34.7	C	34.1	D	49.8	D	35.8
North-South SB Left	C	34.8	D	48.1	D	45.2	D	54.9
North-South SB Through	A	8.4	A	7.6	D	46.0	D	50.2
North-South SB Right	No	UHWO	Leg	--				
Farrington Hwy/ Road A	**Intersection Does Not Exist in this Scenario**				**C**	**20.4**	**C**	**22.4**
Farrington EB Through/Right					C	34.0	D	36.0
Farrington WB Left					C	33.3	D	35.8
Farrington WB Through					A	6.8	A	7.4
Road A NB Left					D	37.0	D	36.6
Road A NB Right					B	11.0	B	16.4
Farrington Hwy/ Road F	**Intersection Does Not Exist in this Scenario**				**C**	**28.2**	**C**	**34.6**
Farrington EB Through/Right					D	36.9	D	46.7
Farrington WB Left					D	36.1	D	37.2
Farrington WB Through					B	11.2	A	8.7
Road F NB Left					D	38.7	D	48.0
Road F NB Right					D	37.9	D	38.4

* Highway Capacity Manual methodology does not allow for more than two through lanes on the major street.
** RIRO – Right-In/Right-Out + Defacto Left-turn during AM Peak.

peak hour traffic volumes, the Road "B" and Road "F" intersections on North-South Road and the Road "A" and Road "F" intersections on Farrington Highway are expected to operate as signalized intersections and are analyzed as such.

Queuing analyses were conducted using the Cumulative Poisson Distribution Method to determine storage lengths required for left-turn lanes at intersections. Table 5 summarizes the calculated left-turn lanes needed at the "Road A"/Farrington Highway, "Road F"/Farrington Highway, "Road B"/North South Road, and "Road F"/North South Road intersections.

Table 5 Left - Turn Storage Requirements

Direction	Analysis Year	Time Per.	No. of Lanes	Left-Turn Peak Hour Volume (vph)	Probable Vehicles Queued (vehicles)	Length of Left-Turn Bay Needed (feet)
Farrington Hwy EB to North South Road NB	2008	PM	2	357	18	250
Farrington Hwy WB to "Road A" SB		AM	1	80	6	150
"Road A" NB to Farrington Hwy WB		PM	1	5	1	25
Farrington Hwy WB to "Road F" SB		PM	1	220	12	300
"Road F" NB to Farrington Hwy WB		AM	1	37	3	75
"Road B" EB to North South Road NB		PM	2	156	9	125
North South Road NB to "Road B" WB		AM	1	56	4	100
Farrington Hwy EB to North South NB	2015	PM	2	640	29	400
Farrington Hwy WB to "Road A" SB		AM	1	311	16	400
"Road A" NB to Farrington Hwy WB		PM	1	22	2	50
Farrington Highway WB to "Road F" SB		PM	1	263	14	350
"Road F" NB to Farrington Hwy WB		PM	1	333	17	425
"Road B" EB to North South Road NB		PM	2	521	24	330
North South Road NB to "Road B" WB		PM	1	139	8	200
"Road F" EB to North South Road NB		PM	2	447	22	305
North South Road NB to "Road F" WB		PM	2	258	14	195

The time periods selected for this left-turn storage analysis were based on the larger of either AM or PM peak hour volumes for that specific left-turn movement.

E. Summary of Results

Intersections analyzed are projected to operate acceptably for peak hour conditions without or with the UH West Oahu. Implicit in these analysis results are specific roadway and intersection improvements and these are summarized in the following chapter of this report. In these analyses, North-South Road was assumed to be built to its ultimate 6-lane cross-section with appropriate left-turn lanes at intersections. Both Road "B" and "F" are expected to warrant signalization by ultimate build out.

IV. RECOMMENDATIONS AND CONCLUSIONS

A. Recommendations

This section of the report serves to verify that the assumed future roadway system will adequately handle the traffic demand placed on it at full buildout of the UH West Oahu development. The future roadway system is separated into regional and internal roadway components.

1. Regional Roadway Improvements

North-South Road

The new North-South Road and Kapolei Parkway have recently completed an environmental process in early 2005 and are currently in its design and construction phases. At buildout, North-South Road will be a six-lane, divided roadway from Kapolei Parkway to H-1 Freeway with a diamond interchange on H-1 Freeway. Southbound double left-turn bays on North-South Road will be needed at Road "F" to help accommodate both projected traffic demand from the DHHL East Kapolei 2 development on the KKHD side of North-South Road as well as from UH West Oahu. The North-South Road/Farrington Highway intersection will be channelized to provide exclusive right-turn lanes and double left-turn lanes on all approaches. This configuration is sufficient for the projected Year 2015 traffic demand with the proposed UH West Oahu development.

Farrington Highway

Farrington Highway will ultimately be a four-lane, divided roadway at buildout. It was found that this configuration is sufficient for the projected 2015 traffic demand with the proposed UH West Oahu development.

2. Internal Roadway Improvements

The internal roadways were evaluated with regard to amount of traffic carried. The roadway cross-sections as proposed were found to adequately handle the traffic demand projected at buildout of the UH West Oahu site.

These internal roadways would be constructed by UH as part of the development of the UH West Oahu site. Figures 10 through 15 summarize the improvements for the proposed internal roadways.

3. Parking

To supply adequate parking for students, UH West Oahu is providing 1 stall per 2 students (0.5 ratio) for the targeted student population in Phase 1 and a ratio of 0.37 for the build out phase based on average University rates from the *Institute of Transportation Engineers Parking Generation, 2nd Edition.* These ratios were also compared with the existing UH Manoa student parking ratio. Table 6 summarizes the proposed provided stalls for UH West Oahu, ITE suggested stalls and stalls provided if UH Manoa parking-to-student ratios were used.

Table 6 Proposed UH West Oahu Parking Stalls

Year	Student Population (Students)	UHWO Stalls Provided (Stalls)	ITE (Stalls)	UH Manoa based on Head Count (Stalls)
2008	1,520	760	562	464
2015	7,600	2,812	2,812	2,318

As shown in Table 6, the proposed UH West Oahu will provide more stalls than the recommended ITE suggested stalls during Phase 1, and have a better student-to-parking ratio than UH Manoa during Phase 1 and build out.

B. Conclusion

Based on the analysis of the proposed University of Hawaii West Oahu development, it is concluded that with roadway and traffic improvements recommended in this report, the roadway system can accommodate the traffic generated by the proposed land uses.

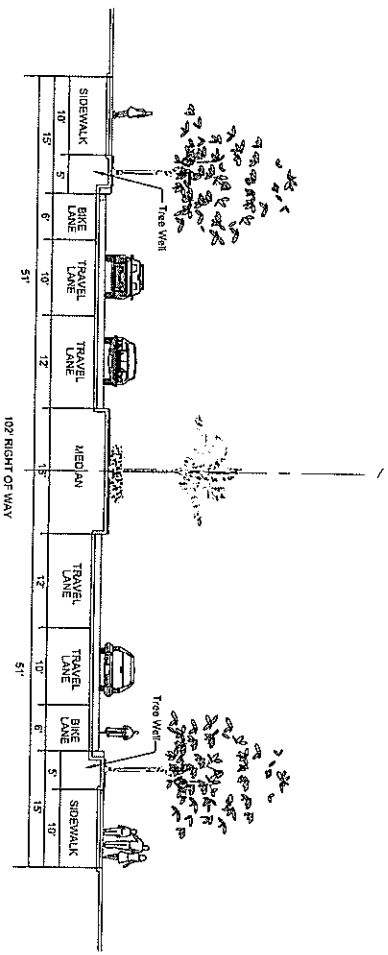
ROADS "A" and "B" (UP TO INTERSECTION WITH ROAD D)
TYPICAL CROSS-SECTIONS

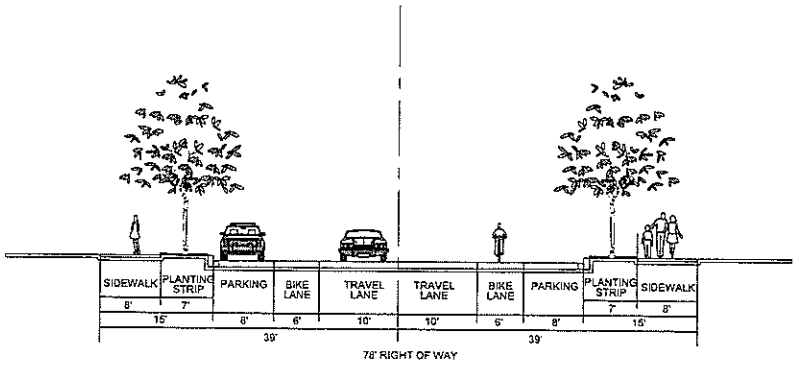
Figure 10

Not to scale

Note: Road B from North-South Road to Road D intersection will be 2-lane roadway with on-street parking (8' wide) till traffic demand warrants width

Modification to County Standard Arterial 2 Roadway, with wider sidewalks and tree wells instead of 10' planting strips





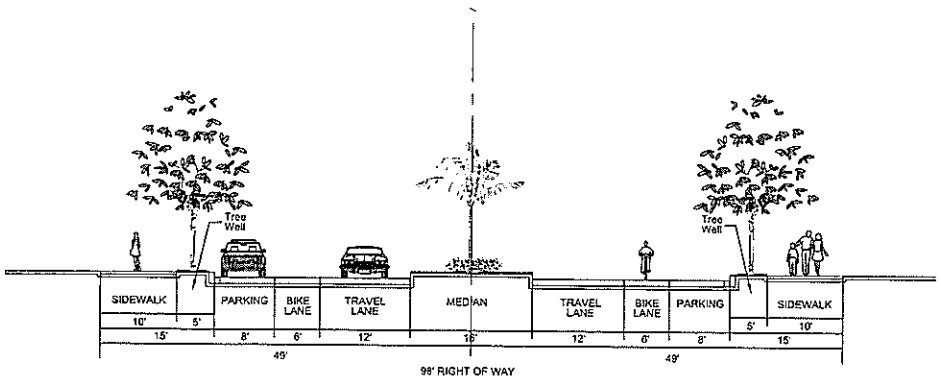
ROAD C

Note: Modification to County Standard Collector 1 Roadway, with wider sidewalks and narrower planting strips

Not to scale

ROAD "C" TYPICAL CROSS-SECTION

Figure 12



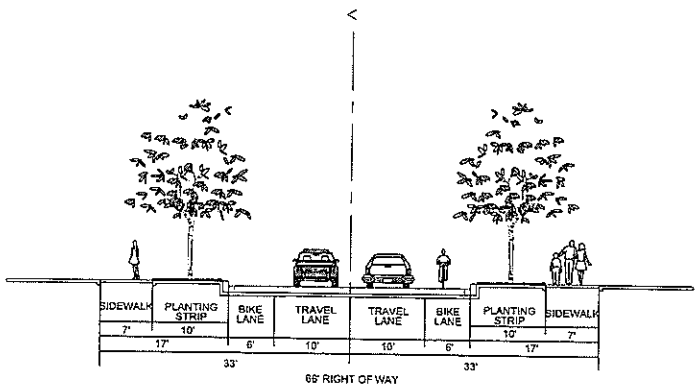
ROAD B
(From Road D to Campus Drop-Off)

Note: Modification to County Standard Collector 1 Roadway with wider sidewalks, tree wells (replacing planting strips), and a median

Not to scale

ROAD "B" TYPICAL CROSS-SECTION (FROM ROAD D TO CAMPUS DROP-OFF)

Figure 11



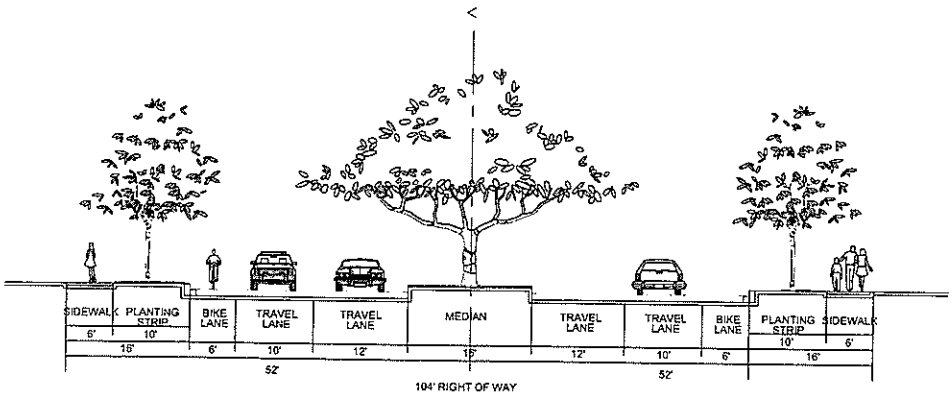
ROAD E

Note: Modification to County Standard Collector 3 Roadway with wider sidewalks and bike lanes instead of parking lanes

Not to scale

ROAD "E" TYPICAL CROSS-SECTION

Figure 14



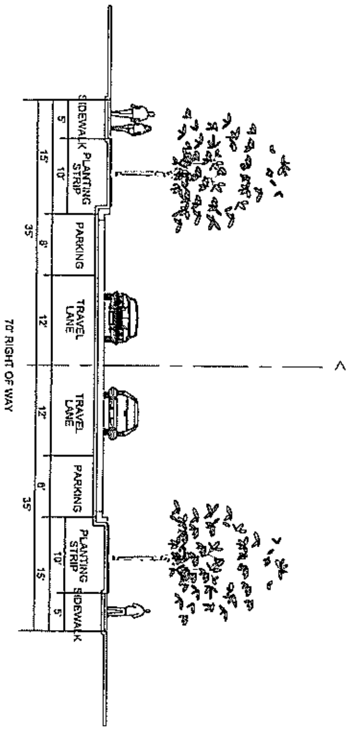
ROAD D and F

Note: Complies with County Standard Arterial 2 Roadway

Not to scale

ROADS "D" AND "F" TYPICAL CROSS-SECTIONS

Figure 13



ROAD G

Note: Complies with County Standard Collector 2 Roadway, coordinated to link to roadway accessing DHHL lands

Not to scale

ROAD "G" TYPICAL CROSS-SECTION

Figure 15

V. PHASE I TRAFFIC EVALUATION

Phase 1 of the UH West Oahu development is expected to be completed by the end of 2008. This phase will include the initial phase of the UH West Oahu campus, the University Village mixed use development, and residential and mixed use developments in the vicinity of Road "B" and Road "F" near Farrington Highway.

This section of the report contains a traffic evaluation of this Phase 1 condition to insure that the roadway elements that are assumed to be in place can accommodate the vehicular demand generated.

A. Phase 1 Development

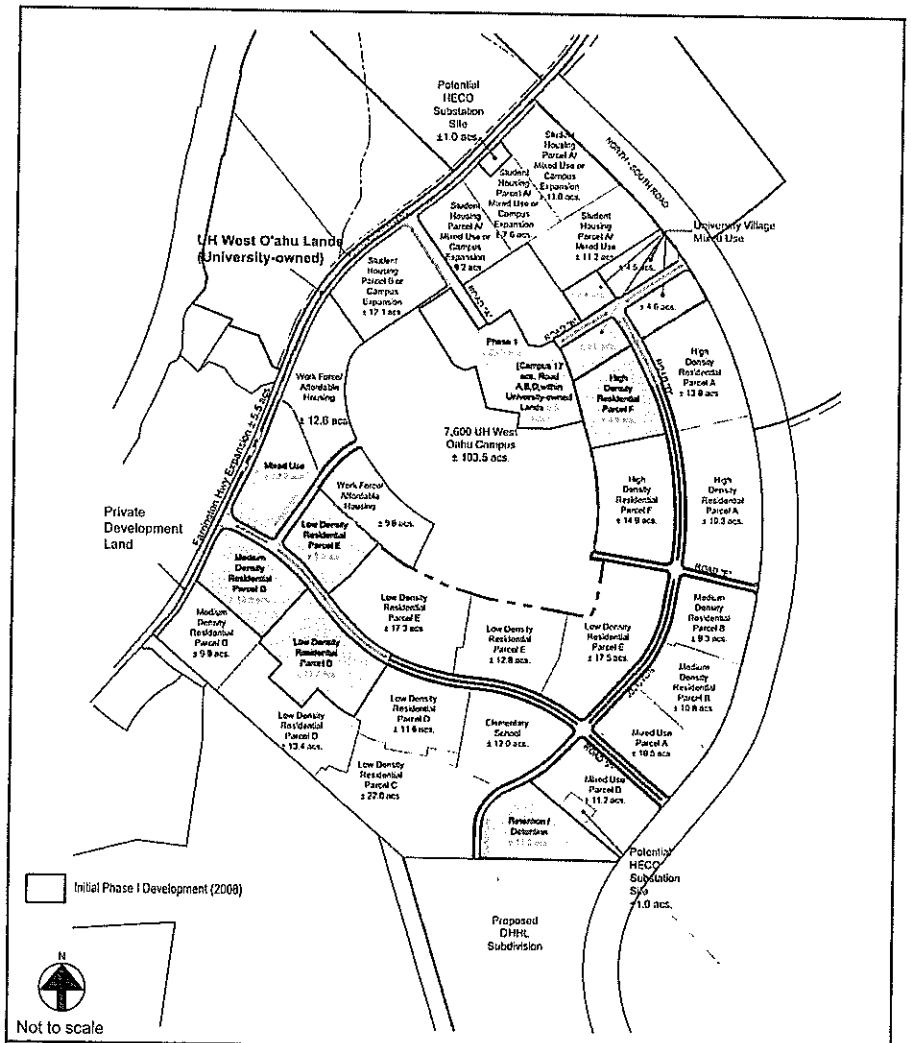
Phase 1 developments include portions of four residential parcels, a mixed-use parcel, a portion of University Village, part of the UH West Oahu campus, an electric substation, and a detention basin. A parcel map illustrating the Phase 1 developments in shown in Figure 16.

B. Phase 1 Roadway Network

The most significant change in the existing roadway network that is projected to be in place by the end of 2008 is the new North-South Road and interchange with H-1 Freeway. Parts of the internal roadway system are also assumed to be constructed. The following describes the future roadway network assumptions.

North-South Road

North-South Road is anticipated to be constructed to its ultimate 6-lane, divided configuration between the H-1 Freeway and Road "B", tapering to a four-lane undivided roadway makai of Road "B."



PHASE I CONCEPTUAL DEVELOPMENT PLAN

Figure 16

Farrington Highway

Farrington Highway was assumed to remain a two-lane, undivided roadway in the vicinity of UH West Oahu site. It is also assumed that at the North-South Road intersection, turn movements to and from Farrington Highway are channelized with exclusive turning lanes. Although North-South Road will have enough width in its medians to accommodate double left-turn lanes at Farrington Highway, it is assumed that only single left-turn lanes could be operated, since there would only be one receiving lane on Farrington Highway for this scenario.

Road "A"

Road "A" is planned to be constructed in its entirety with the initial UH West Oahu campus. During this time frame, it will primarily provide access to the campus.

Road "B"

Road "B" is planned to be constructed in its entirely with the initial UH West Oahu campus. During this time frame, it will provide access to the campus and two mixed-use parcels.

Road "D"

During Phase 1, Road "D" will only extend from Road "B" into a portion of the high-density Residential Parcel F.

Road "F"

During Phase 1, only the mauka half of Road "F" will be constructed between Farrington Highway and low-density Residential Parcels C and D.

C. Projected Phase 1 Travel Demand

1. Trip Generation

Phase 1 trips were generated based on the methodology of the *Institute of Transportation Engineers (ITE), Trip Generation, 7th edition (2003).* Table 7 summarizes the total trips generated by Phase 1 of the UH West Oahu development. Trips associated with the DHHL

East Kapolei 1 development makai of UH West Oahu were generated and assigned to the Phase 1 network.

Table 7
UH West Oahu Phase 1 Trip Generation Summary

Land Use	ITE Code	Intensity	Units	AM Peak Hour Trips		PM Peak Hour Trips	
				Enter	Exit	Enter	Exit
UH West Oahu Campus	550	1,520	Students	244	61	94	220
Mixed Use Village (Commercial)	820	65,340	SF	27	17	87	91
Mixed Use Village (Residential)	230	60	DU	3	14	12	6
Mixed Use Parcel C (Residential)	230	102	DU	5	23	20	9
Mixed Use Parcel C (Commercial)	820	111,078	SF	45	29	147	154
Residential Parcel D	210	83	DU	15	44	38	21
Residential Parcel E	210	85	DU	15	45	39	22
Residential Parcel F	230	157	DU	7	35	30	14
Residential Parcel G	230	130	DU	6	29	25	12
				367	298	492	548

SF=Leasable Square Feet, DU=Dwelling Unit, Ac=Acres

2. Trip Distribution and Assignment

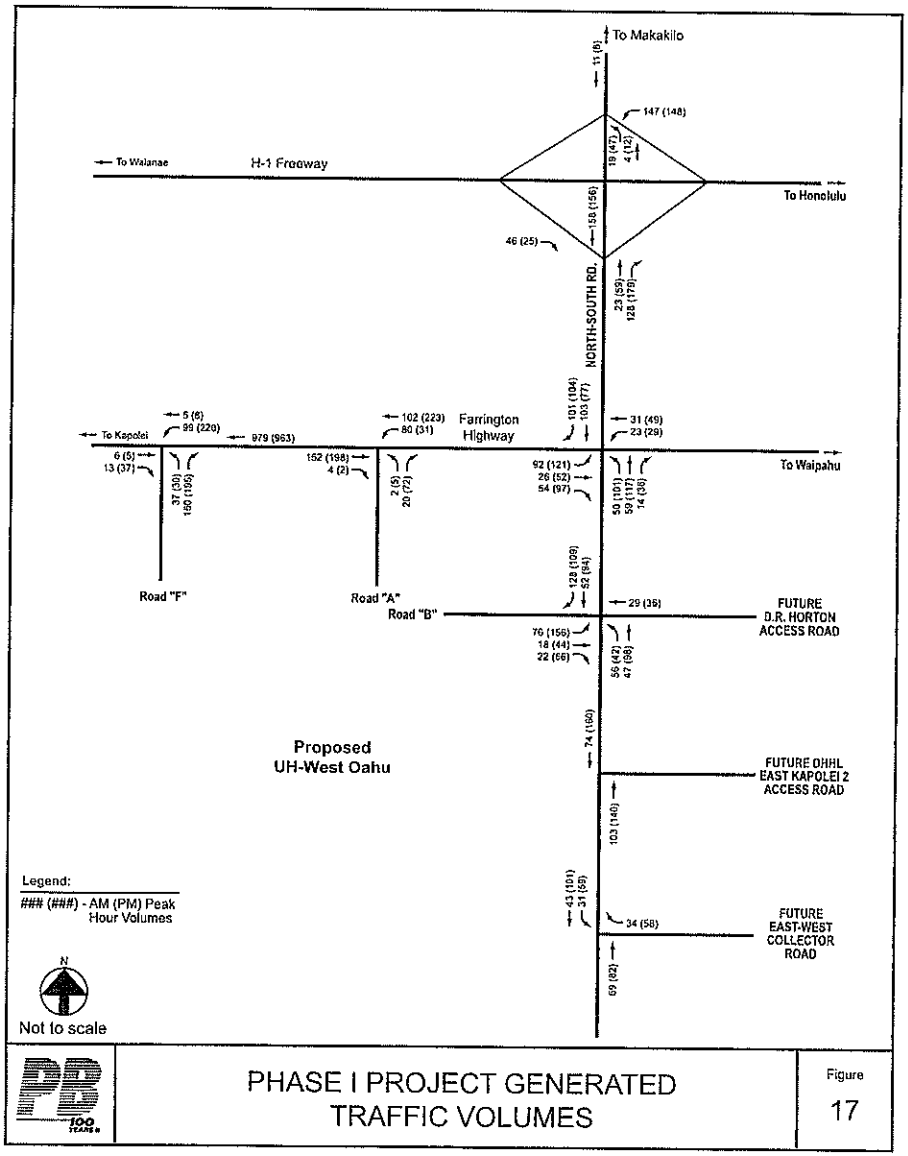
The traffic generated by Phase 1 of the UH West Oahu development was distributed and assigned to the network based on the regional travel patterns discussed in the ultimate build out trip distribution and assignment section. Phase 1 project generated volumes are summarized in Figure 17.

3. Background Traffic Volumes

Initial North-South Road traffic volume was based on the volume stated in the North-South Road & Kapolei Parkway Environmental Assessment (EA). The DHHL East Kapolei 1 site located makai of UH West Oahu is anticipated to be completed by late 2007 and was included in the background traffic volumes shown in Figure 18.

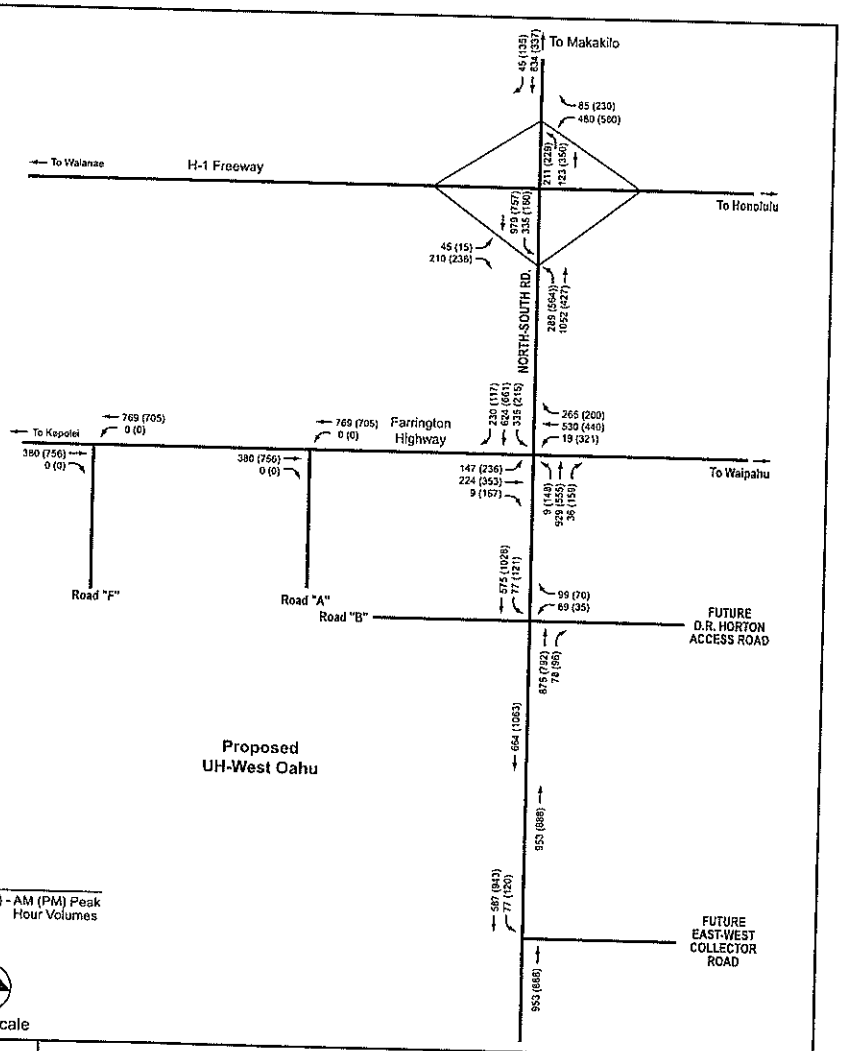
4. Total Traffic Volumes

Total Phase 1 traffic volumes were calculated from Year 2008 background volumes and Phase 1 project generated volumes, shown in Figure 19.



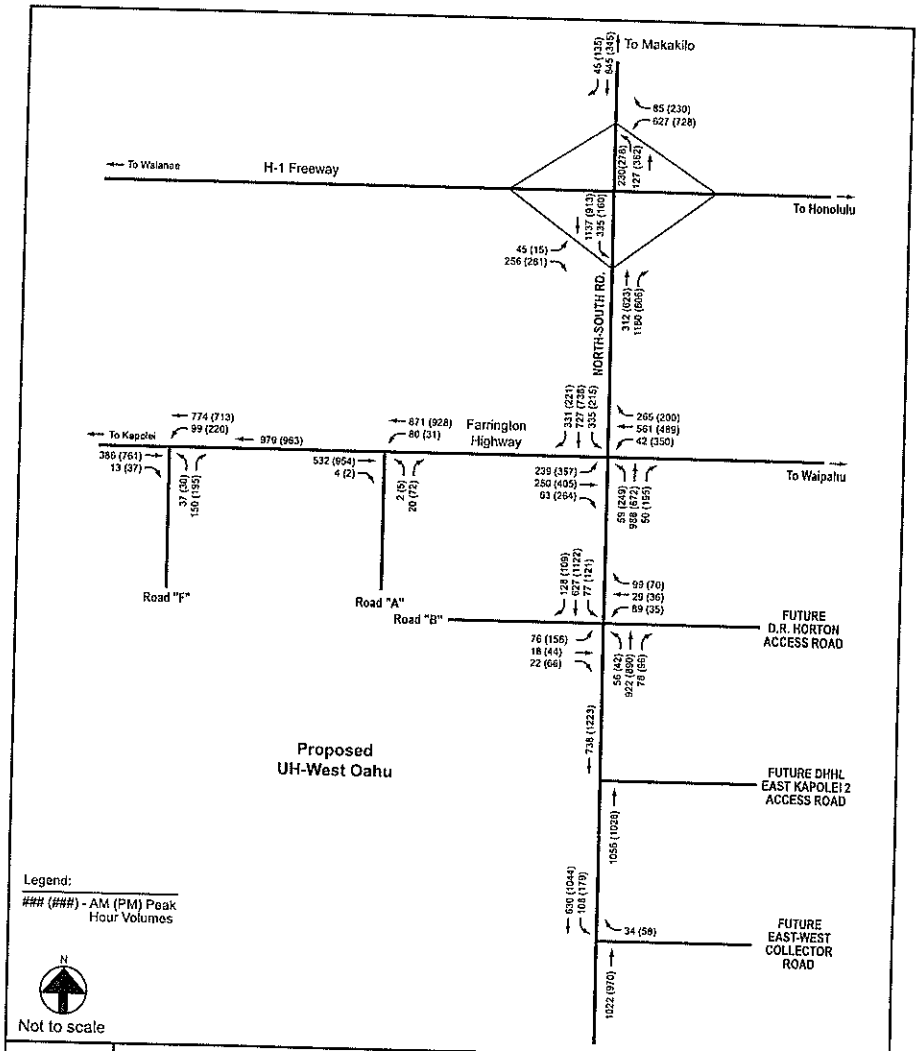
PHASE I PROJECT GENERATED TRAFFIC VOLUMES

Figure 17



PHASE I BACKGROUND TRAFFIC VOLUMES
WITHOUT UH WEST OAHU

Figure 18



PHASE I TOTAL TRAFFIC VOLUMES
WITH UH WEST OAHU

Figure 19

D. Projected Phase 1 Traffic Operations

The same methodologies used in the evaluation of Year 2015 traffic conditions were applied to the Phase 1 2008 traffic volumes and are summarized in Table 8.

Table 8
Year 2008 With University of Hawaii – West Oahu
Level-of-Service Summary

Intersection	2008 With Phase 1 of UHWO			
	AM Peak		PM Peak	
	LOS	Delay	LOS	Delay
North-South Rd/ H-1 WB Off Ramp Terminus	**C**	**34.4**	**D**	**40.1**
H-1 WB Off Ramp Left	D	36.1	D	48.1
H-1 WB Off Ramp Right	C	29.9	C	24.6
North-South NB Left	D	37.7	D	49.4
North-South NB Through	A	9.2	B	18.8
North-South SB Through	D	37.9	D	46.4
North-South SB Right	A	5.9	A	8.6
North-South Rd/ H-1 EB Off Ramp Terminus	**A**	**9.4**	**B**	**13.4**
H-1 EB Off Ramp Left	D	37.2	C	31.9
H-1 EB Off Ramp Right	A	0.1	A	0.1
North-South NB Through	C	27.4	C	31.8
North-South NB Right	A	0.1	A	0.0
North-South SB Left	C	33.4	C	32.2
North-South SB Through	A	8.0	A	9.9
North-South Rd/ Farrington Hwy	**D**	**43.8**	**D**	**48.7**
Farrington EB Left	D	54.3	E	64.7
Farrington EB Through	C	25.6	D	41.8
Farrington EB Right	B	13.7	B	16.2
Farrington WB Left	E	58.8	E	62.9
Farrington WB Through	D	53.8	E	56.1
Farrington WB Right	B	10.9	B	15.3
North-South NB Left	D	51.7	C	34.4
North-South NB Through	D	55.0	D	55.0
North-South NB Right	C	29.8	C	22.4
North-South SB Left	E	70.6	D	53.7
North-South SB Through	C	31.5	D	52.5
North-South SB Right	C	29.2	C	29.6

Table 8 (Continued)

North-South Rd/ Road B	**C**	**28.6**	**C**	**27.6**
Road B EB Left	D	45.5	D	41.4
Road B EB Through	D	42.1	D	48.0
Road B EB Right				
Road B WB Left	D	47.7	D	48.3
Road B WB Through	D	43.0	D	50.1
Road B WB Right				
North-South NB Left	D	45.3	D	47.6
North-South NB Through/Right	C	25.0	C	30.0
North-South SB Left	D	46.2	C	34.4
North-South SB Through	C	23.3	B	18.4
North-South SB Right				
North-South Rd/ Road E*				
Road E WB Right (East Kapolei 2)	No	UHWO	Leg	--
Road E EB Right (UHWO)	No	UHWO	Leg	--
North-South Rd/ Road F	**C**	**26.3**	**C**	**27.9**
Road F EB Left	No	UHWO	Leg	--
Road F EB Through	No	UHWO	Leg	--
Road F EB Right	No	UHWO	Leg	--
Road F WB Left	C	21.7	C	30.2
Road F WB Through	No	UHWO	Leg	--
Road F WB Right	B	15.9	B	15.1
North-South NB Left	No	UHWO	Leg	--
North-South NB Through/Right	C	28.9	C	29.8
North-South SB Left	C+	25.5+	C	27.0
North-South SB Through	C	22.7		
North-South SB Right	No	UHWO	Leg	--
Farrington Hwy/ Road A	**B**	**15.5**	**C**	**27.6**
Farrington EB Through/Right	C	22.3	D	39.3
Farrington WB Left	D	39.9	C	31.8
Farrington WB Through	A	9.0	B	14.7
Road A NB Left	D	40.1	C	33.8
Road A NB Right	C	20.1	B	11.0
Farrington Hwy/ Road F	**B**	**17.5**	**C**	**29.1**
Farrington EB Through/Right	C	24.3	D	41.5
Farrington WB Left	D	38.7	D	41.5
Farrington WB Through	B	10.4	A	6.9
Road F NB Left	D	37.0	D	41.2
Road F NB Right	B	18.0	D	47.1

* Right-In/Right-Out + Defacto left

E. Phase 1 Recommendations and Conclusions

This section of the report serves to verify that the assumed future roadway system will adequately handle the traffic demand placed on it at Phase 1 of the UH West Oahu development. The future roadway system is separated into regional and internal roadway components.

1. Regional Roadway Improvements

North-South Road

Phase I of the new North-South Road will be completed by late 2008. Phase I of North-South Road currently is proposed to include half of the ultimate roadway cross-section between Kapolei Parkway and Farrington Highway, the ultimate North-South Road/Farrington Highway intersection, the full six-lane cross section between Farrington Highway and H-1 Freeway and the ultimate diamond interchange connecting North-South Road to H-1 Freeway.

Based on evaluation of the Phase 1 traffic volumes and because of considerations of traffic safety, it is recommended that the ultimate cross-section of North-South Road be extended to Road "B" before tapering to the half cross-section width in the segment between Road "B" and Kapolei Parkway. This will allow an exclusive left-turn lane to be installed to service both mauka-bound and makai-bound left-turns into Road "B." Without the exclusive left-turn lane, through traffic would need to stop to wait for a left-turning vehicle to execute its left-turn before proceeding through the intersection. This situation would also increase exposure of left-turning vehicles to rear-end accidents.

Farrington Highway

Farrington Highway will ultimately be a four-lane, divided roadway at buildout. In the Phase 1 time frame, it was assumed to still have only two lanes (one in each direction). However, it also assumed that full channelization would be implemented at the Farrington Highway/North-South Road intersection to provide exclusive turn lanes on all approaches. It was determined that this configuration is sufficient for the projected Phase 1 traffic demand with the proposed UH West Oahu development.

2. Internal Roadway Improvements

The internal roadways were evaluated with regard to amount of traffic carried. The roadway cross-sections as proposed were found to adequately handle the traffic demand projected for Phase I of the UH West Oahu development.

Generated by MSC3000 Version 2.01 Copyright 1990-1992 Mitron Systems Corporation

Location ..... Farrington Hwy KKHD of Palehua RD EB
Location Code 31
County ..... HNL
Recorder Set 04/14/04 19:25
Recording Start ... 04/15/04 00:00
Recording End 04/16/04 07:30
Sample Time ..... 15 Minutes
Operator Number ... 84
Machine Number 3
Channel 1
Divide By 2
Summation ..... No
Two-Way ..... Yes

Thursday 04/15/04 Channel: 1 Direction: E

0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	Totals
23	18	11	9	38	183	664	796	466	311	283	312	236	224	319	320	284	267	186	139	86	65	69	30	5339
6	6	3	1	5	11	142	207	158	68	77	84	58	55	73	73	74	88	49	43	31	11	23	8	
6	3	4	2	9	39	188	235	122	84	62	82	48	59	74	69	60	74	39	38	21	18	20	9	
4	3	3	3	11	55	157	167	98	73	67	70	64	54	85	79	73	49	59	27	17	18	11	9	
7	6	1	3	13	78	177	187	88	86	77	76	66	56	87	99	77	56	39	31	17	18	15	4	

AM Peak Hour ..... 07:00 to 08:00 (796 vehicles)
AM Peak Hour Factor 84.7%
PM Peak Hour ..... 15:15 to 16:15 (321 vehicles)
PM Peak Hour Factor 81.1%

Appendix B Levels of Service Definitions

The *Highway Capacity Manual* defines six Levels of Service (LOS), labeled A through F, from best to worst conditions. Levels of Service for signalized and unsignalized intersections are defined in terms of average user delays. Delay is a measure of driver discomfort, frustration, fuel consumption, and lost travel time.

For unsignalized intersections, the *Highway Capacity Manual* evaluates gaps in the major street traffic flow and calculates available gaps for left-turns across oncoming traffic and for the left and right-turns onto the major roadway from the minor street.

LEVEL-OF-SERVICE A: Little or no delay.

LEVEL-OF-SERVICE B: Short traffic delays.

LEVEL-OF-SERVICE C: Average traffic delays.

LEVEL-OF-SERVICE D: Long traffic delays.

LEVEL-OF-SERVICE E: Very long traffic delays.

LEVEL-OF-SERVICE F: Demand volume exceeds capacity, resulting in extreme delays with queuing that may cause severe congestion and affect other movements at the intersection.

Volume Count Report
Generated by MSC3000 Version 2.01 Copyright 1990-1992 Mitron Systems Corporation

Location Code ..... Farrington Hwy KKHD of Palehua RD WB
Recorder Set 04/14/04 19:25
Recording Start ... 04/15/04 00:00
Recording End 04/16/04 07:30
Sample Time .... 15 Minutes
Operator Number ... 84
Machine Number 3
Channel 2
Divide By 2
Summation .... No
Two-Way .... Yes

Thursday 04/15/04 Channel: 2 Direction: W

0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	Totals
33	21	12	10	28	81	197	291	263	250	265	282	271	264	307	386	396	399	276	171	148	124	73	52	4600
12	7	5	2	6	9	37	55	65	58	55	80	57	63	80	93	94	109	82	53	49	36	19	25	
10	2	2	2	5	23	45	91	74	59	58	63	62	70	68	91	98	108	76	49	35	26	21	11	
7	7	4	3	8	23	61	81	59	67	61	65	73	59	83	111	107	100	54	35	39	26	20	9	
4	5	1	3	9	26	54	64	65	66	91	74	79	72	76	91	97	82	64	34	25	36	13	7	

AM Peak Hour .... 07:15 to 08:15 (301 vehicles)
AM Peak Hour Factor 82.7%
PM Peak Hour .... 16:30 to 17:30 (421 vehicles)
PM Peak Hour Factor 96.6%

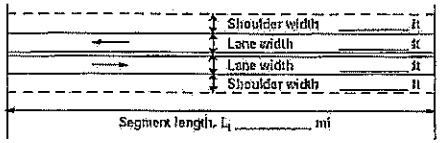
Appendix C Intersection Capacity Analysis Worksheets

TWO-WAY TWO-LANE HIGHWAY SEGMENT WORKSHEET

General Information		Site Information	
Analyst	C. Maruoka	Highway	Farrington Highway
Agency or Company	PBQD	From/To	Waipahu/Kapolei
Date Performed	9/29/04	Jurisdiction	Honolulu
Analysis Time Period	AM Peak Existing	Analysis Year	2004

Project Description: *UH West Oahu - Farrington Hwy - AM Existing*

Input Data



☒ Class I highway ☒ Class II highway

Terrain ☒ Level ☒ Rolling

Two-way hourly volume	1097 veh/h
Directional split	73 / 27
Peak-hour factor, PHF	0.90
No-passing zone	100
% Trucks and Buses , P_T	3 %
% Recreational vehicles, P_R	0%
Access points/ *mi*	0

Average Travel Speed

Grade adjustment factor, f_G (Exhibit 20-7)	1.00
Passenger-car equivalents for trucks, E_T (Exhibit 20-9)	1.2
Passenger-car equivalents for RVs, E_R (Exhibit 20-9)	1.0
Heavy-vehicle adjustment factor, f_{HV} $f_{HV}=1/(1+P_T(E_T-1)+P_R(E_R-1))$	0.994
Two-way flow rate[1], v_p (pc/h) $v_p=V/(PHF*f_G*f_{HV})$	1226
v_p * highest directional split proportion[2] (pc/h)	895

Free-Flow Speed from Field Measurement		Estimated Free-Flow Speed	
Field Measured speed, S_{FM}	*mi/h*	Base free-flow speed, $BFFS_{FM}$	45.0 *mi/h*
Observed volume, V_f	*veh/h*	Adj. for lane width and shoulder width[3], f_{LS} (Exhibit 20-6)	4.2 *mi/h*
Free-flow speed, FFS $FFS=S_{FM}+0.00776(V_f*f_{HV})$	*mi/h*	Adj. for access points, f_A (Exhibit 20-6)	0.0 *mi/h*
		Free-flow speed, FFS $(FSS=BFFS-f_{LS}-f_A)$	40.8 *mi/h*

Adj. for no-passing zones, f_{np} (*mi/h*) (Exhibit 20-11)	2.6
Average travel speed, ATS (*mi/h*) $ATS=FFS-0.00775v_p*f_{np}$	28.7

Percent Time-Spent-Following

Grade Adjustment factor, f_G (Exhibit 20-8)	1.00
Passenger-car equivalents for trucks, E_T (Exhibit 20-10)	1.1
Passenger-car equivalents for RVs, E_R (Exhibit 20-10)	1.0
Heavy-vehicle adjustment factor, f_{HV} $f_{HV}=1/(1+P_T(E_T-1)+P_R(E_R-1))$	0.997
Two-way flow rate[1], v_p (pc/h) $v_p=V/(PHF*f_G*f_{HV})$	1223
v_p * highest directional split proportion[2] (pc/h)	893
Base percent time-spent-following, BPTSF(%) $BPTSF=100(1-e^{-0.000879v_p})$	65.9
Adj. for directional distribution and no-passing zone, $f_{d/np}$(%)(Exh. 20-12)	10.6
Percent time-spent-following, PTSF(%) $PTSF=BPTSF+f_{d/np}$	76.5

Level of Service and Other Performance Measures

Level of service, LOS (Exhibit 20-3 for Class I or 20-4 for Class II)	E
Volume to capacity ratio v/c $v/c=V_p/3,200$	0.38
Peak 15-min veh-miles of travel, VMT_{15} (veh- *mi*) $VMT_{15}=0.25L_t(V/PHF)$	1371
Peak-hour vehicle-miles of travel, VMT_{60} (veh- *mi*) $VMT_{60}=V*L_t$	4937
Peak 15-min total travel time, TT_{15}(veh-h) $TT_{15}=VMT_{15}/ATS$	47.8

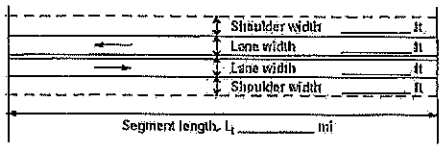
Notes

TWO-WAY TWO-LANE HIGHWAY SEGMENT WORKSHEET

General Information		Site Information	
Analyst	C. Maruoka	Highway	Farrington Highway
Agency or Company	PBQD	From/To	Waipahu/Kapolei
Date Performed	9/29/04	Jurisdiction	Honolulu
Analysis Time Period	PM Peak Existing	Analysis Year	2004

Project Description: UH West Oahu - Farrington Hwy - PM Existing

Input Data



☒ Class I highway ☐ Class II highway

Terrain ☒ Level ☐ Rolling

Two-way hourly volume	742 veh/h
Directional split	57 / 43
Peak-hour factor, PHF	0.90
No-passing zone	100
% Trucks and Buses , P_T	3 %
% Recreational vehicles, P_R	0%
Access points/ mi	0

Average Travel Speed

Grade adjustment factor, f_G (Exhibit 20-7)	1.00
Passenger-car equivalents for trucks, E_T (Exhibit 20-9)	1.2
Passenger-car equivalents for RVs, E_R (Exhibit 20-9)	1.0
Heavy-vehicle adjustment factor, f_{HV} f_{HV}=1/ (1+ $P_T(E_T-1)+P_R(E_R-1)$)	0.994
Two-way flow rate[1], v_p (pc/h) v_p=V/ (PHF * f_G * f_{HV})	829
v_p * highest directional split proportion[2] (pc/h)	473

Field Measured		Estimated Free-Flow Speed	
Field Measured speed, S_{FM}	mi/h	Base free-flow speed, $BFFS_{FM}$	45.0 mi/h
Observed volume, V_f	veh/h	Adj. for lane width and shoulder width[3], f_{LS} (Exhibit 20-5)	4.2 mi/h
Free-flow speed, FFS FFS=S_{FM}+0.00776(V_f / f_{HV})	mi/h	Adj. for access points, f_A (Exhibit 20-6)	0.0 mi/h
		Free-flow speed, FFS (FSS=BFFS-f_{LS}-f_A)	40.8 mi/h

Adj. for no-passing zones, f_{np} (mi/h) (Exhibit 20-11)	3.2
Average travel speed, ATS (mi/h) ATS=FFS-0.00776v_p-f_{np}	31.2

Percent Time-Spent-Following

Grade Adjustment factor, f_G (Exhibit 20-8)	1.00
Passenger-car equivalents for trucks, E_T (Exhibit 20-10)	1.1
Passenger-car equivalents for RVs, E_R (Exhibit 20-10)	1.0
Heavy-vehicle adjustment factor, f_{HV} f_{HV}=1/ (1+ $P_T(E_T-1)+P_R(E_R-1)$)	0.997
Two-way flow rate[1], v_p (pc/h) v_p=V/ (PHF * f_G * f_{HV})	827
v_p * highest directional split proportion[2] (pc/h)	471
Base percent time-spent-following, BPTSF(%) BPTSF=100(1-$e^{-0.000879v_p}$)	51.7
Adj. for directional distribution and no-passing zone, $f_{d/np}$(%)(Exh. 20-12)	14.4
Percent time-spent-following, PTSF(%) PTSF=BPTSF+$f_{d/np}$	66.1

Level of Service and Other Performance Measures

Level of service, LOS (Exhibit 20-3 for Class I or 20-4 for Class II)	E
Volume to capacity ratio v/c v/c=V_p/ 3,200	0.26
Peak 15-min veh-miles of travel,VMT_{15} (veh- mi) VMT_{15}= 0.25L_t(V/PHF)	928
Peak-hour vehicle-miles of travel, VMT_{60} (veh- mi) VMT_{60}=V*L_t	3339
Peak 15-min total travel time, TT_{15}(veh-h) TT_{15}= VMT_{15}/ATS	29.8

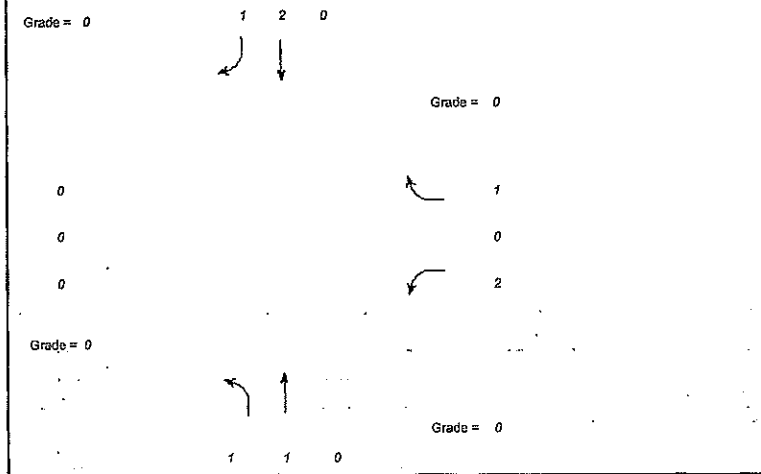
Notes

INPUT WORKSHEET

General Information		Site Information	
Analyst	JW	Intersection	N-S Rd/H-1 WB Off
Agency or Co.	PBQD	Area Type	All other areas
Date Performed	5/15/2006	Jurisdiction	Honolulu
Time Period	AM Peak (NB 2015)	Analysis Year	2015 NB

Project Description UH-West Oahu - 2015 AM NB North-South Rd H-1 WB Off Ramp

Intersection Geometry



Volume and Timing Input

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume (vph)				595		85	332	104			841	45
% Heavy veh	0	0	0	0	0	0	0	0	0	0	0	0
PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Actuated (P/A)				A		A	A	A			A	A
Startup lost time		2.0		2.0	2.0	2.0	2.0	2.0			2.0	2.0
Ext. eff. green		2.0		2.0	2.0	2.0	2.0	2.0			2.0	2.0
Arrival type		3		3	3	3	3	3			3	3
Unit Extension		3.0		3.0	3.0	3.0	3.0	3.0			3.0	3.0
Ped/Bike/RTOR Volume	0	0	0	0	0	0	0	0	0	0	0	0
Lane Width		12.0		12.0	12.0	12.0	12.0	12.0			12.0	12.0
Parking (Y or N)	N		N	N		N	N		N	N		N
Parking/hr												
Bus stops/hr		0		0	0	0	0	0			0	0

	WB Only	02	03	04	NB Only	Thru & RT	07	08
Timing	G = 34.0	G =	G =	G =	G = 39.0	G = 39.0	G =	G =
	Y = 4	Y =	Y =	Y =	Y = 0	Y = 4	Y =	Y =

Duration of Analysis (hrs) = 0.25 Cycle Length C = 120.0

CAPACITY AND LOS WORKSHEET

General Information

Project Description *UH-West Oahu - 2015 AM NB North-South Rd H-1 WB Off Ramp*

Capacity Analysis

	EB			WB			NB			SB		
Lane group				L		R	L	T		T	R	
Adj. flow rate		0		661	0	94	369	116		934	50	
Satflow rate				3505		1615	1805	1900		3618	1615	
Lost time		2.0		2.0	2.0	2.0	2.0	2.0		2.0	2.0	
Green ratio		0.00		0.28	0.00	0.28	0.32	0.65		0.32	0.64	
Lane group cap.				993		458	587	1235		1176	1036	
v/c ratio				0.67		0.21	0.63	0.09		0.79	0.05	
Flow ratio				0.19		0.06	0.20	0.06		0.26	0.03	
Crit. lane group		N		Y	N	N	Y	N		Y	N	
Sum flow ratios	0.65											
Lost time/cycle	8.00											
Critical v/c ratio	0.70											

Lane Group Capacity, Control Delay, and LOS Determination

	EB			WB			NB			SB		
Lane group				L		R	L	T		T	R	
Adj. flow rate		0		661	0	94	369	116		934	50	
Lane group cap.				993		458	587	1235		1176	1036	
v/c ratio				0.67		0.21	0.63	0.09		0.79	0.05	
Green ratio		0.00		0.28	0.00	0.28	0.32	0.65		0.32	0.64	
Unif. delay d_1				38.0		32.7	34.4	7.8		36.8	8.0	
Delay factor k				0.24		0.11	0.21	0.11		0.34	0.11	
Increm. delay d_2				1.7		0.2	2.2	0.0		3.9	0.0	
PF factor				1.000		1.000	1.000	1.000		1.000	1.000	
Control delay				39.7		32.9	36.5	7.9		40.7	8.0	
Lane group LOS				D		C	D	A		D	A	
Apprch. delay				38.8			29.7			39.0		
Approach LOS				D			C			D		
Intersec. delay	36.9			Intersection LOS						D		

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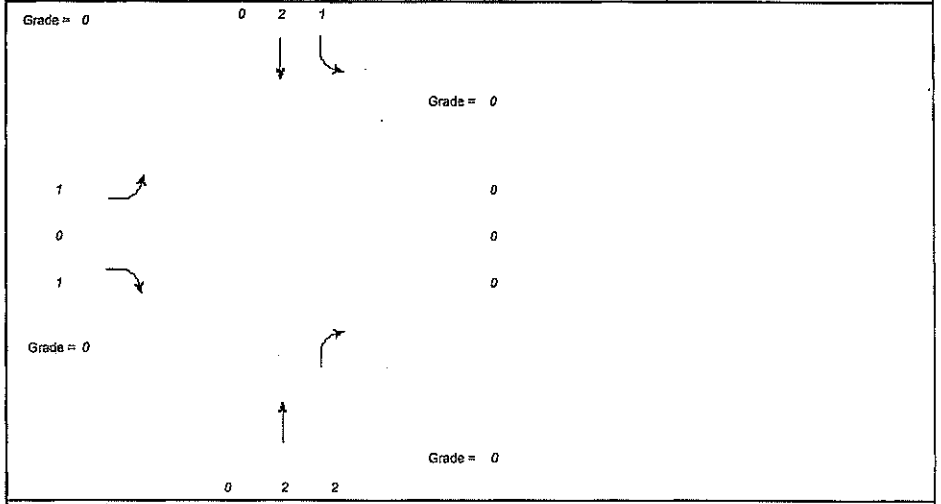
INPUT WORKSHEET

General Information		Site Information	
Analyst	JW	Intersection	N-S Rd/H-1 EB Off
Agency or Co.	PBQD	Area Type	All other areas
Date Performed	5/15/2006	Jurisdiction	Honolulu
Time Period	AM Peak (NB 2015)	Analysis Year	2015 NB

Project Description *UH-West Oahu - 2015 AM NB North-South Rd H-1 EB Off Ramp*

Intersection Geometry



Volume and Timing Input

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume (vph)	45		244					436	1458	335	1101	
% Heavy veh	0	0	0	0	0	0	0	0	0	0	0	0
PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Actuated (P/A)	A		A					A	A	A	A	
Startup lost time	2.0	2.0	2.0		2.0			2.0	2.0	2.0	2.0	
Ext. eff. green	2.0	2.0	2.0		2.0			2.0	2.0	2.0	2.0	
Arrival type	3	3	3		3			3	3	3	3	
Unit Extension	3.0	3.0	3.0		3.0			3.0	3.0	3.0	3.0	
Ped/Bike/RTOR Volume	0	0	0	0	0	0	0	0	0	0	0	0
Lane Width	12.0	12.0	12.0		12.0			12.0	12.0	12.0	12.0	
Parking (Y or N)	N		N	N		N	N		N	N		N
Parking/hr												
Bus stops/hr	0	0	0		0			0	0	0	0	

	EB Only	02	03	04	NS Perm	Thru & RT	07	08
Timing	G = 30.0	G =	G =	G =	G = 42.0	G = 40.0	G =	G =
	Y = 4	Y =	Y =	Y =	Y = 0	Y = 4	Y =	Y =
Duration of Analysis (hrs) = 0.25						Cycle Length C = 120.0		

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CAPACITY AND LOS WORKSHEET

General Information

Project Description *UH-West Oahu - 2015 AM NB North-South Rd H-1 EB Off Ramp*

Capacity Analysis

	EB			WB			NB		SB	
Lane group	L		R				T	R	L	T
Adj. flow rate	50	0	271		0		484	1620	372	1223
Satflow rate	1805		1615				3618	2859	1805	3618
Lost time	2.0	2.0	2.0		2.0		2.0	2.0	2.0	2.0
Green ratio	0.25	0.00	1.00		0.00		0.33	1.00	0.35	0.68
Lane group cap.	451		1615				1206	2859	632	2472
v/c ratio	0.11		0.17				0.40	0.57	0.59	0.49
Flow ratio	0.03		0.17				0.13	0.57	0.21	0.34
Crit. lane group		N	N		N		N	Y		N
Sum flow ratios	0.57									
Lost time/cycle	0.00									
Critical v/c ratio	0.57									

Lane Group Capacity, Control Delay, and LOS Determination

	EB			WB			NB		SB	
Lane group	L		R				T	R	L	T
Adj. flow rate	50	0	271		0		484	1620	372	1223
Lane group cap.	451		1615				1206	2859	632	2472
v/c ratio	0.11		0.17				0.40	0.57	0.59	0.49
Green ratio	0.25	0.00	1.00		0.00		0.33	1.00	0.35	0.68
Unif. delay d_1	34.7		0.0				30.8	0.0	31.9	9.1
Delay factor k	0.11		0.11				0.11	0.16	0.18	0.11
Increm. delay d_2	0.1		0.0				0.2	0.3	1.4	0.2
PF factor	1.000		0.950				1.000	0.950	1.000	1.000
Control delay	34.8		0.0				31.0	0.3	33.4	9.2
Lane group LOS	C		A				C	A	C	A
Apprch. delay	5.5						7.3		14.9	
Approach LOS	A						A		B	
Intersec. delay	10.2			Intersection LOS					B	

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INPUT WORKSHEET

General Information

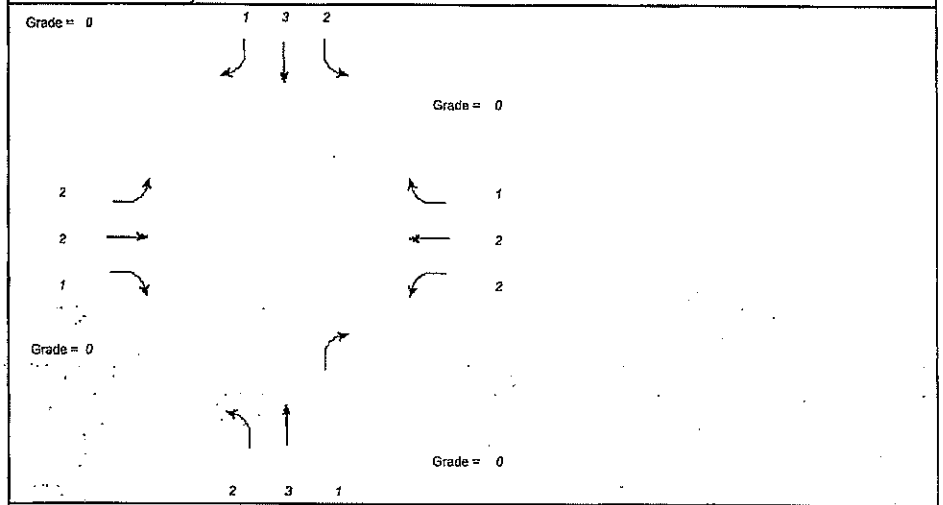
Analyst *JW*
Agency or Co. *PBQ&D*
Date Performed *5/15/2006*
Time Period *AM Peak (2015 NB)*

Site Information

Intersection *North-South Rd/Farrington Hwy*
Area Type *All other areas*
Jurisdiction *Honolulu*
Analysis Year *2015 (AM Pk NB)*

Project Description *UH West Oahu - NSR/Farrington AM Pk NB Yr 2015*

Intersection Geometry



Volume and Timing Input

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume (vph)	147	483	9	41	740	265	9	1482	114	335	780	230
% Heavy veh	0	0	0	0	0	0	0	0	0	0	0	0
PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Actuated (P/A)	A	A	A	A	A	A	A	A	A	A	A	A
Startup lost time	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Ext. eff. green	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Arrival type	3	3	3	3	3	3	3	4	3	3	4	3
Unit Extension	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Ped/Bike/RTOR Volume	0	0	0	0	0	0	0	0	0	0	0	0
Lane Width	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
Parking (Y or N)	N		N	N		N	N		N	N		N
Parking/hr												
Bus stops/hr	0	0	0	0	0	0	0	0	0	0	0	0

	Excl. Left	Thru & RT	03	04	Excl. Left	Thru & RT	07	08
Timing	G = 13.0	G = 31.0	G = 0.0	G = 0.0	G = 19.0	G = 41.0	G = 0.0	G = 0.0
	Y = 4	Y = 4	Y = 0	Y = 0	Y = 4	Y = 4	Y = 0	Y = 0

Duration of Analysis (hrs) = 0.25 Cycle Length C = 120.0

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CAPACITY AND LOS WORKSHEET

General Information

Project Description *UH West Oahu - NSR/Farrington AM Pk NB Yr 2015*

Capacity Analysis

	EB			WB			NB			SB		
Lane group	L	T	R	L	T	R	L	T	R	L	T	R
Adj. flow rate	163	537	10	46	822	294	10	1647	127	372	867	256
Satflow rate	3505	3618	1615	3505	3618	1615	3505	5176	1615	3505	5176	1615
Lost time	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Green ratio	0.11	0.26	0.45	0.11	0.26	0.45	0.16	0.34	0.48	0.16	0.34	0.48
Lane group cap.	380	935	727	380	935	727	555	1768	781	555	1768	781
v/c ratio	0.43	0.57	0.01	0.12	0.88	0.40	0.02	0.93	0.16	0.67	0.49	0.33
Flow ratio	0.05	0.15	0.01	0.01	0.23	0.18	0.00	0.32	0.08	0.11	0.17	0.16
Crit. lane group	Y	N	N		Y	N		Y	N	Y	N	N
Sum flow ratios	0.70											
Lost time/cycle	16.00											
Critical v/c ratio	0.81											

Lane Group Capacity, Control Delay, and LOS Determination

	EB			WB			NB			SB		
Lane group	L	T	R	L	T	R	L	T	R	L	T	R
Adj. flow rate	163	537	10	46	822	294	10	1647	127	372	867	256
Lane group cap.	380	935	727	380	935	727	555	1768	781	555	1768	781
v/c ratio	0.43	0.57	0.01	0.12	0.88	0.40	0.02	0.93	0.16	0.67	0.49	0.33
Green ratio	0.11	0.26	0.45	0.11	0.26	0.45	0.16	0.34	0.48	0.16	0.34	0.48
Unif. delay d_1	50.0	38.8	18.3	48.3	42.7	22.2	42.6	38.1	17.4	47.6	31.2	19.0
Delay factor k	0.11	0.17	0.11	0.11	0.41	0.11	0.11	0.45	0.11	0.24	0.11	0.11
Increm. delay d_2	0.8	0.9	0.0	0.1	9.7	0.4	0.0	9.5	0.1	3.1	0.2	0.2
PF factor	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.951	1.000	1.000	0.951	1.000
Control delay	50.8	39.6	18.3	48.5	52.4	22.6	42.6	45.7	17.5	50.7	29.9	19.3
Lane group LOS	D	D	B	D	D	C	D	D	B	D	C	B
Apprch. delay	41.9			44.7			43.7			33.3		
Approach LOS	D			D			D			C		
Intersec. delay	40.6			Intersection LOS						D		

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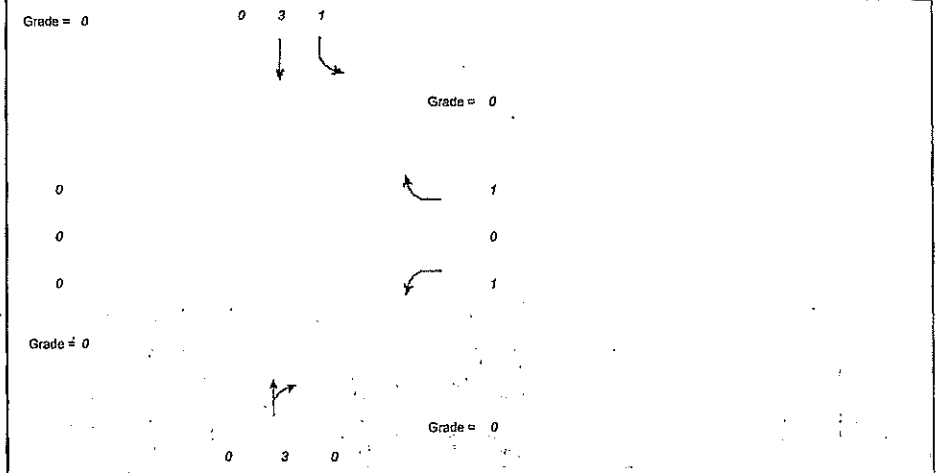
INPUT WORKSHEET

General Information		Site Information	
Analyst	JW	Intersection	North-South Rd/Road B
Agency or Co.	PBQ&D	Area Type	All other areas
Date Performed	5/15/2006	Jurisdiction	Honolulu
Time Period	AM Peak (2015 NB)	Analysis Year	2015 (AM Pk NB)

Project Description *UH West Oahu - NSR/Road B AM Pk NB Yr 2015*

Intersection Geometry



Volume and Timing Input

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume (vph)				89		351		1254	78	166	664	
% Heavy veh	0	0	0	0	0	0	0	0	0	0	0	0
PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Actuated (P/A)				A		A		A	A	A	A	
Startup lost time		2.0		2.0	2.0	2.0		2.0		2.0	2.0	
Ext. eff. green		2.0		2.0	2.0	2.0		2.0		2.0	2.0	
Arrival type		3		3	3	3		4		3	4	
Unit Extension		3.0		3.0	3.0	3.0		3.0		3.0	3.0	
Ped/Bike/RTOR Volume	0	0	0	0	0	0	0	0	0	0	0	0
Lane Width		12.0		12.0	12.0	12.0		12.0		12.0	12.0	
Parking (Y or N)	N		N	N		N	N		N	N		N
Parking/hr												
Bus stops/hr		0		0	0	0		0		0	0	

	WB Only	02	03	04	SB Only	Thru & RT	07	08
Timing	G = 34.0	G =	G =	G =	G = 29.0	G = 45.0	G =	G =
	Y = 4	Y =	Y =	Y =	Y = 4	Y = 4	Y =	Y =

Duration of Analysis (hrs) = 0.25 Cycle Length C = 120.0

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CAPACITY AND LOS WORKSHEET

General Information

Project Description *UH West Oahu - NSR/Road B AM Pk NB Yr 2015*

Capacity Analysis

	EB			WB			NB		SB	
Lane group			L		R		TR		L	T
Adj. flow rate		0	99	0	390		1480		184	738
Satflow rate			1805		1615		5130		1805	5176
Lost time		2.0	2.0	2.0	2.0		2.0		2.0	2.0
Green ratio		0.00	0.28	0.00	0.28		0.38		0.24	0.65
Lane group cap.			511		458		1924		436	3364
v/c ratio			0.19		0.85		0.77		0.42	0.22
Flow ratio			0.05		0.24		0.29		0.10	0.14
Crit. lane group		N		N	Y		Y		Y	N
Sum flow ratios	0.63									
Lost time/cycle	12.00									
Critical v/c ratio	0.70									

Lane Group Capacity, Control Delay, and LOS Determination

	EB			WB			NB		SB	
Lane group			L		R		TR		L	T
Adj. flow rate		0	99	0	390		1480		184	738
Lane group cap.			511		458		1924		436	3364
v/c ratio			0.19		0.85		0.77		0.42	0.22
Green ratio		0.00	0.28	0.00	0.28		0.38		0.24	0.65
Unif. delay d_1			32.6		40.6		32.9		38.4	8.6
Delay factor k			0.11		0.38		0.32		0.11	0.11
Increm. delay d_2			0.2		14.3		2.0		0.7	0.0
PF factor			1.000		1.000		0.920		1.000	0.438
Control delay			32.8		54.9		32.3		39.1	3.8
Lane group LOS			C		D		C		D	A
Apprch. delay			50.4				32.3		10.8	
Approach LOS			D				C		B	
Intersec. delay	28.5		Intersection LOS						C	

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TWO-WAY STOP CONTROL SUMMARY

General Information

Analyst	JW
Agency/Co.	PBQD
Date Performed	5/15/2006
Analysis Time Period	AM Peak (2015 NB)

Site Information

Intersection	North-South Road/Road E
Jurisdiction	Honolulu
Analysis Year	2015 NB (AM Pk)

Project Description *UH West Oahu - NSR/Road E AM Pk NB Yr 2015*

East/West Street: *Road E* North/South Street: *North-South Road*

Intersection Orientation: *North-South* Study Period (hrs): *0.25*

Vehicle Volumes and Adjustments

Major Street	Northbound			Southbound		
Movement	1	2	3	4	5	6
	L	T	R	L	T	R
Volume		1205	12		753	
Peak-Hour Factor, PHF	0.90	0.90	0.90	0.90	0.90	0.90
Hourly Flow Rate, HFR	0	1338	13	0	836	0
Percent Heavy Vehicles	0	--	--	0	--	--
Median Type	Raised curb					
RT Channelized			0			0
Lanes	0	2	0	0	2	0
Configuration		T	TR		T	
Upstream Signal		0			0	

Minor Street	Eastbound			Westbound		
Movement	7	8	9	10	11	12
	L	T	R	L	T	R
Volume						127
Peak-Hour Factor, PHF	0.90	0.90	0.90	0.90	0.90	0.90
Hourly Flow Rate, HFR	0	0	0	0	0	141
Percent Heavy Vehicles	0	0	0	0	0	0
Percent Grade (%)		0			0	
Flared Approach		N			N	
Storage		0			0	
RT Channelized			1			1
Lanes	0	0	0	0	0	1
Configuration						R

Delay, Queue Length, and Level of Service

Approach	Northbound	Southbound	Westbound			Eastbound		
Movement	1	4	7	8	9	10	11	12
Lane Configuration					R			
v (vph)					141			
C (m) (vph)					401			
v/c					0.35			
95% queue length					1.55			
Control Delay					18.8			
LOS					C			
Approach Delay	--	--	18.8					
Approach LOS	--	--	C					

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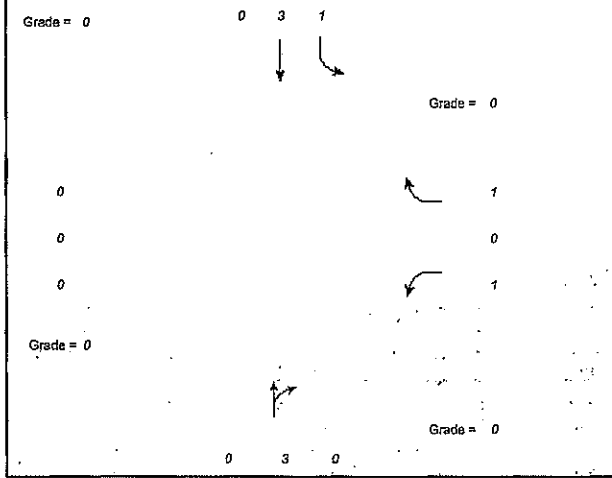
INPUT WORKSHEET

General Information		Site Information	
Analyst	JW	Intersection	North-South Rd/Road F
Agency or Co.	PBQ&D	Area Type	All other areas
Date Performed	5/15/2006	Jurisdiction	Honolulu
Time Period	AM Peak (2015 NB)	Analysis Year	2015 (AM Pk NB)

Project Description *UH West Oahu - NSR/Road F AM Pk NB Yr 2015*

Intersection Geometry



Volume and Timing Input

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume (vph)				129		252		965	25	166	587	
% Heavy veh	0	0	0	0	0	0	0	0	0	0	0	0
PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Actuated (P/A)				A		A		A	A	A	A	
Startup lost time		2.0		2.0	2.0	2.0		2.0		2.0	2.0	
Ext. eff. green		2.0		2.0	2.0	2.0		2.0		2.0	2.0	
Arrival type		3		3	3	3		3		3	3	
Unit Extension		3.0		3.0	3.0	3.0		3.0		3.0	3.0	
Ped/Bike/RTOR Volume	0	0	0	0	0	0	0	0	0	0	0	0
Lane Width		12.0		12.0	12.0	12.0		12.0		12.0	12.0	
Parking (Y or N)	N		N	N		N	N		N	N		N
Parking/hr												
Bus stops/hr		0		0	0	0		0		0	0	

	WB Only	02	03	04	SB Only	Thru & RT	07	08
Timing	G = 34.0	G =	G =	G =	G = 34.0	G = 40.0	G =	G =
	Y = 4	Y =	Y =	Y =	Y = 4	Y = 4	Y =	Y =

Duration of Analysis (hrs) = 0.25 — Cycle Length C = 120.0

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CAPACITY AND LOS WORKSHEET

General Information

Project Description *UH West Oahu - NSR/Road F AM Pk NB Yr 2015*

Capacity Analysis

	EB			WB			NB		SB	
Lane group			L		R		TR		L	T
Adj. flow rate		0	143	0	280		1100		184	652
Satflow rate			1805		1615		5156		1805	5176
Lost time		2.0	2.0	2.0	2.0		2.0		2.0	2.0
Green ratio		0.00	0.28	0.00	0.28		0.33		0.28	0.65
Lane group cap.			511		458		1719		511	3364
v/c ratio			0.28		0.61		0.64		0.36	0.19
Flow ratio			0.08		0.17		0.21		0.10	0.13
Crit. lane group		N		N	Y		Y		Y	N
Sum flow ratios	0.49									
Lost time/cycle	12.00									
Critical v/c ratio	0.54									

Lane Group Capacity, Control Delay, and LOS Determination

	EB		WB			NB		SB	
Lane group			L		R		TR	L	T
Adj. flow rate		0	143	0	280		1100	184	652
Lane group cap.			511		458		1719	511	3364
v/c ratio			0.28		0.61		0.64	0.36	0.19
Green ratio		0.00	0.28	0.00	0.28		0.33	0.28	0.65
Unif. delay d_1			33.5		37.3		33.9	34.3	8.4
Delay factor k			0.11		0.20		0.22	0.11	0.11
Increm. delay d_2			0.3		2.4		0.8	0.4	0.0
PF factor			1.000		1.000		1.000	1.000	1.000
Control delay			33.8		39.7		34.7	34.8	8.4
Lane group LOS			C		D		C	C	A
Apprch. delay			37.7			34.7		14.2	
Approach LOS			D			C		B	
Intersec. delay	28.0		Intersection LOS					C	

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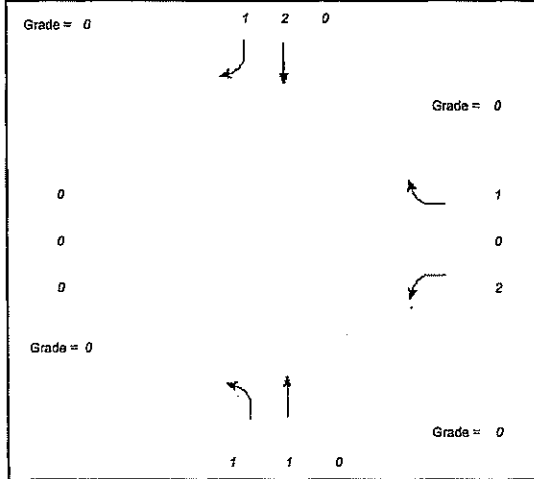
INPUT WORKSHEET

General Information		Site Information	
Analyst	JW	Intersection	N-S Rd/H-1 WB Off
Agency or Co.	PBQD	Area Type	All other areas
Date Performed	5/15/2006	Jurisdiction	Honolulu
Time Period	PM Peak (NB 2015)	Analysis Year	2015 NB

Project Description *UH-West Oahu - 2015 PM NB North-South Rd H-1 WB Off Ramp*

Intersection Geometry



Volume and Timing Input

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume (vph)				956		230	301	365			361	135
% Heavy veh	0	0	0	0	0	0	0	0	0	0	0	0
PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Actuated (P/A)				A		A	A	A			A	A
Startup lost time		2.0		2.0	2.0	2.0	2.0	2.0			2.0	2.0
Ext. eff. green		2.0		2.0	2.0	2.0	2.0	2.0			2.0	2.0
Arrival type		3		3	3	3	3	3			3	3
Unit Extension		3.0		3.0	3.0	3.0	3.0	3.0			3.0	3.0
Ped/Bike/RTOR Volume	0	0	0	0	0	0	0	0	0	0	0	0
Lane Width		12.0		12.0	12.0	12.0	12.0	12.0			12.0	12.0
Parking (Y or N)	N		N	N		N	N		N	N		N
Parking/hr												
Bus stops/hr		0		0	0	0	0	0			0	0

	WB Only	02	03	04	NB Only	Thru & RT	07	08
Timing	G = 46.0	G =	G =	G =	G = 38.0	G = 28.0	G =	G =
	Y = 4	Y =	Y =	Y =	Y = 0	Y = 4	Y =	Y =

Duration of Analysis (hrs) = 0.25 | Cycle Length C = 120.0

 HCS+™ Version 5.1 Generated: 5/18/2006 1:27 PM

CAPACITY AND LOS WORKSHEET

General Information

Project Description *UH-West Oahu - 2015 PM NB North-South Rd H-1 WB Off Ramp*

Capacity Analysis

	EB			WB			NB			SB		
Lane group				L		R	L	T		T	R	
Adj. flow rate		0		1062	0	256	334	406		401	150	
Satflow rate				3505		1615	1805	1900		3618	1615	
Lost time		2.0		2.0	2.0	2.0	2.0	2.0		2.0	2.0	
Green ratio		0.00		0.38	0.00	0.38	0.32	0.55		0.23	0.65	
Lane group cap.				1344		619	572	1045		844	1050	
v/c ratio				0.79		0.41	0.58	0.39		0.48	0.14	
Flow ratio				0.30		0.16	0.19	0.21		0.11	0.09	
Crit. lane group		N		Y	N	N	Y	N		Y	N	
Sum flow ratios	0.60											
Lost time/cycle	8.00											
Critical v/c ratio	0.64											

Lane Group Capacity, Control Delay, and LOS Determination

	EB			WB			NB			SB		
Lane group				L		R	L	T		T	R	
Adj. flow rate		0		1062	0	256	334	406		401	150	
Lane group cap.				1344		619	572	1045		844	1050	
v/c ratio				0.79		0.41	0.58	0.39		0.48	0.14	
Green ratio		0.00		0.38	0.00	0.38	0.32	0.55		0.23	0.65	
Unif. delay d_1				32.7		27.1	34.4	15.5		39.7	8.1	
Delay factor k				0.34		0.11	0.18	0.11		0.11	0.11	
Increm. delay d_2				3.3		0.5	1.5	0.2		0.4	0.1	
PF factor				1.000		1.000	1.000	1.000		1.000	1.000	
Control delay				36.0		27.6	35.9	15.7		40.1	8.2	
Lane group LOS				D		C	D	B		D	A	
Apprch. delay				34.4			24.8			31.4		
Approach LOS				C			C			C		
Intersec. delay	31.0			Intersection LOS						C		

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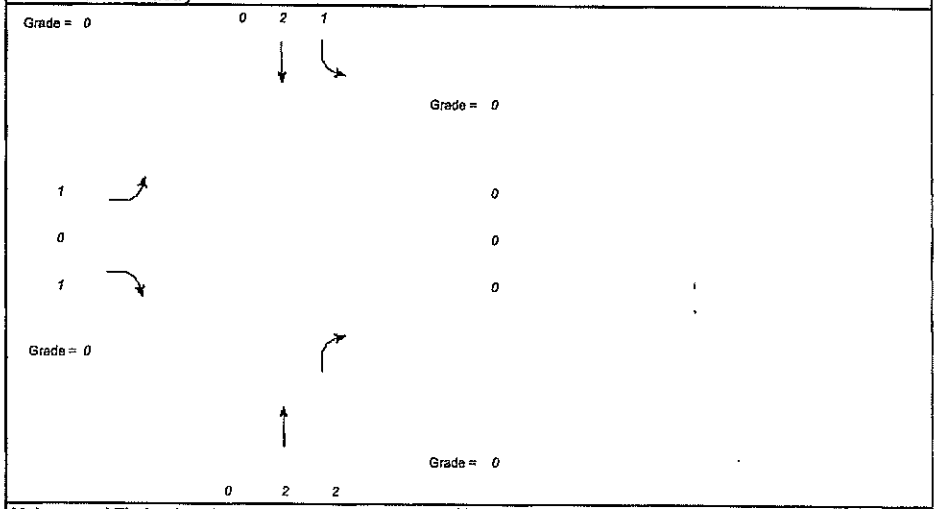
INPUT WORKSHEET

General Information		Site Information	
Analyst	JW	Intersection	N-S Rd/H-1 EB Off
Agency or Co.	PBQD	Area Type	All other areas
Date Performed	5/15/2006	Jurisdiction	Honolulu
Time Period	PM Peak (2015 NB)	Analysis Year	2015 NB

Project Description *UH-West Oahu - NS Rd/H-1 EB Off Ramp - PM Pk Hr 2015 NB*

Intersection Geometry



Volume and Timing Input

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume (vph)	15		348					651	670	160	1157	
% Heavy veh	0	0	0	0	0	0	0	0	0	0	0	0
PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Actuated (P/A)	A		A					A	A	A	A	
Startup lost time	2.0	2.0	2.0		2.0			2.0	2.0	2.0	2.0	
Ext. eff. green	2.0	2.0	2.0		2.0			2.0	2.0	2.0	2.0	
Arrival type	3	3	3		3			3	3	3	3	
Unit Extension	3.0	3.0	3.0		3.0			3.0	3.0	3.0	3.0	
Ped/Bike/RTOR Volume	0	0	0	0	0	0	0	0	0	0	0	0
Lane Width	12.0	12.0	12.0		12.0			12.0	12.0	12.0	12.0	
Parking (Y or N)	N		N	N		N	N		N	N		N
Parking/hr												
Bus stops/hr	0	0	0		0			0	0	0	0	

	EB Only	02	03	04	NS Perm	Thru & RT	07	08
Timing	G = 29.0	G =	G =	G =	G = 37.0	G = 46.0	G =	G =
	Y = 4	Y =	Y =	Y =	Y = 0	Y = 4	Y =	Y =

Duration of Analysis (hrs) = 0.25 — Cycle Length C = 120.0

 HCS+™ Version 5.1 Generated: 5/16/2006 1:26 PM

CAPACITY AND LOS WORKSHEET

General Information

Project Description *UH-West Oahu - NS Rd/H-1 EB Off Ramp - PM Pk Hr 2015 NB*

Capacity Analysis

	EB			WB			NB		SB	
Lane group	L		R				T	R	L	T
Adj. flow rate	17	0	387		0		723	744	178	1286
Satflow rate	1805		1615				3618	2859	1805	3618
Lost time	2.0	2.0	2.0		2.0		2.0	2.0	2.0	2.0
Green ratio	0.24	0.00	1.00		0.00		0.38	1.00	0.31	0.69
Lane group cap.	436		1615				1387	2859	557	2502
v/c ratio	0.04		0.24				0.52	0.26	0.32	0.51
Flow ratio	0.01		0.24				0.20	0.26	0.10	0.36
Crit. lane group	Y	N	N		N		N	N		Y
Sum flow ratios	0.36									
Lost time/cycle	8.00									
Critical v/c ratio	0.39									

Lane Group Capacity, Control Delay, and LOS Determination

	EB			WB			NB		SB	
Lane group	L		R				T	R	L	T
Adj. flow rate	17	0	387		0		723	744	178	1286
Lane group cap.	436		1615				1387	2859	557	2502
v/c ratio	0.04		0.24				0.52	0.26	0.32	0.51
Green ratio	0.24	0.00	1.00		0.00		0.38	1.00	0.31	0.69
Unif. delay d_1	34.8		0.0				28.5	0.0	31.8	8.9
Delay factor k	0.11		0.11				0.13	0.11	0.11	0.12
Increm. delay d_2	0.0		0.1				0.4	0.0	0.3	0.2
PF factor	1.000		0.950				1.000	0.950	1.000	1.000
Control delay	34.9		0.1				28.9	0.0	32.2	9.0
Lane group LOS	C		A				C	A	C	A
Apprch. delay	1.5						14.3		11.8	
Approach LOS	A						B		B	
Intersec. delay	11.7			Intersection LOS					B	

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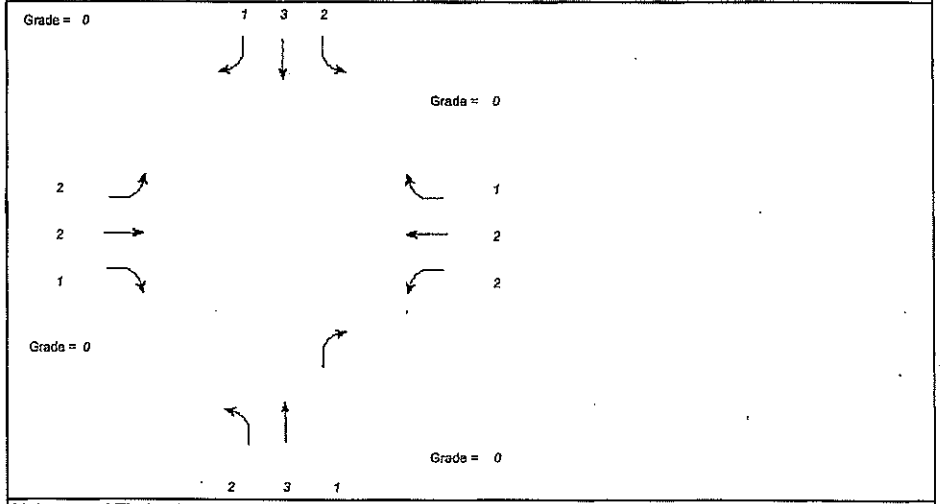
INPUT WORKSHEET

General Information		Site Information	
Analyst	JW	Intersection	North-South Rd/Farrington Hwy
Agency or Co.	PBQ&D	Area Type	All other areas
Date Performed	5/15/2006	Jurisdiction	Honolulu
Time Period	PM Peak (2015 NB)	Analysis Year	2015 (PM Pk NB)

Project Description *UH West Oahu - NSR/Farrington PM Pk NB Yr 2015*

Intersection Geometry



Volume and Timing Input

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume (vph)	236	542	167	393	698	200	148	885	205	215	1173	117
% Heavy veh	0	0	0	0	0	0	0	0	0	0	0	0
PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Actuated (P/A)	A	A	A	A	A	A	A	A	A	A	A	A
Startup lost time	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Ext. eff. green	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Arrival type	3	3	3	3	3	3	3	4	3	3	4	3
Unit Extension	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Ped/Bike/RTOR Volume	0	0	0	0	0	0	0	0	0	0	0	0
Lane Width	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
Parking (Y or N)	N		N	N		N	N		N	N		N
Parking/hr												
Bus stops/hr	0	0	0	0	0	0	0	0	0	0	0	0

	Excl. Left	Thru & RT	03	04	Excl. Left	Thru & RT	07	08
Timing	G = 22.0	G = 32.0	G = 0.0	G = 0.0	G = 16.0	G = 34.0	G = 0.0	G = 0.0
	Y = 4	Y = 4	Y = 0	Y = 0	Y = 4	Y = 4	Y = 0	Y = 0

Duration of Analysis (hrs) = 0.25 — Cycle Length C = 120.0

 HCS+™ Version 5.1 Generated: 5/18/2006 10:22 AM

CAPACITY AND LOS WORKSHEET

General Information

Project Description *UH West Oahu - NSR/Farrington PM Pk NB Yr 2015*

Capacity Analysis

	EB			WB			NB			SB		
Lane group	L	T	R	L	T	R	L	T	R	L	T	R
Adj. flow rate	262	602	186	437	776	222	164	983	228	239	1303	130
Satflow rate	3505	3618	1615	3505	3618	1615	3505	5176	1615	3505	5176	1615
Lost time	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Green ratio	0.18	0.27	0.43	0.18	0.27	0.43	0.13	0.28	0.50	0.13	0.28	0.50
Lane group cap.	643	965	700	643	965	700	467	1467	808	467	1467	808
v/c ratio	0.41	0.62	0.27	0.68	0.80	0.32	0.35	0.67	0.28	0.51	0.89	0.16
Flow ratio	0.07	0.17	0.12	0.12	0.21	0.14	0.05	0.19	0.14	0.07	0.25	0.08
Crit. lane group		N	N	Y	Y	N		N	N	Y	Y	N
Sum flow ratios	0.66											
Lost time/cycle	16.00											
Critical v/c ratio	0.76											

Lane Group Capacity, Control Delay, and LOS Determination

	EB			WB			NB			SB		
Lane group	L	T	R	L	T	R	L	T	R	L	T	R
Adj. flow rate	262	602	186	437	776	222	164	983	228	239	1303	130
Lane group cap.	643	965	700	643	965	700	467	1467	808	467	1467	808
v/c ratio	0.41	0.62	0.27	0.68	0.80	0.32	0.35	0.67	0.28	0.51	0.89	0.16
Green ratio	0.18	0.27	0.43	0.18	0.27	0.43	0.13	0.28	0.50	0.13	0.28	0.50
Unif. delay d_1	43.2	38.7	21.8	45.7	41.1	22.3	47.3	38.0	17.5	48.4	41.2	16.3
Delay factor k	0.11	0.21	0.11	0.25	0.35	0.11	0.11	0.24	0.11	0.12	0.41	0.11
Increm. delay d_2	0.4	1.3	0.2	2.9	5.0	0.3	0.5	1.2	0.2	1.0	7.1	0.1
PF factor	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.998	1.000	1.000	0.998	1.000
Control delay	43.7	40.0	22.0	48.6	46.1	22.6	47.7	39.2	17.7	49.3	48.2	16.4
Lane group LOS	D	D	C	D	D	C	D	D	B	D	D	B
Apprch. delay	37.7			43.2			36.6			45.9		
Approach LOS	D			D			D			D		
Intersec. delay	41.3			Intersection LOS						D		

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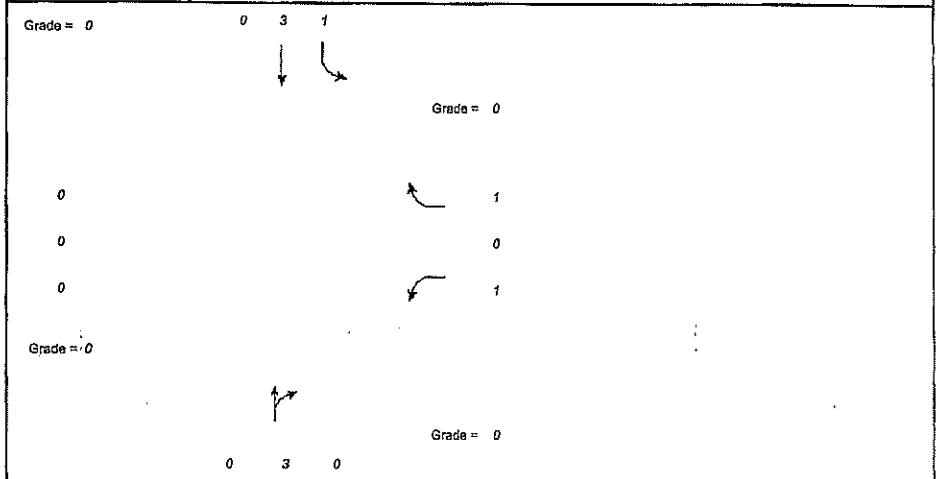
INPUT WORKSHEET

General Information		Site Information	
Analyst	JW	Intersection	North-South Rd/Road B
Agency or Co.	PBQ&D	Area Type	All other areas
Date Performed	5/15/2006	Jurisdiction	Honolulu
Time Period	PM Peak (2015 NB)	Analysis Year	2015 (PM Pk NB)

Project Description *UH West Oahu - NSR/Road B PM Pk NB Yr 2015*

Intersection Geometry



Volume and Timing Input

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume (vph)				35		220		1018	96	413	1320	
% Heavy veh	0	0	0	0	0	0	0	0	0	0	0	0
PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Actuated (P/A)				A		A		A	A	A	A	
Startup lost time		2.0		2.0	2.0	2.0		2.0		2.0	2.0	
Ext. eff. green		2.0		2.0	2.0	2.0		2.0		2.0	2.0	
Arrival type		3		3	3	3		4		3	4	
Unit Extension		3.0		3.0	3.0	3.0		3.0		3.0	3.0	
Ped/Bike/RTOR Volume	0	0	0	0	0	0	0	0	0	0	0	0
Lane Width		12.0		12.0	12.0	12.0		12.0		12.0	12.0	
Parking (Y or N)	N		N	N		N	N		N	N		N
Parking/hr												
Bus stops/hr		0		0	0	0		0		0	0	

	WB Only	02	03	04	SB Only	Thru & RT	07	08
Timing	G = 29.0	G =	G =	G =	G = 40.0	G = 43.0	G =	G =
	Y = 4	Y =	Y =	Y =	Y = 0	Y = 4	Y =	Y =

Duration of Analysis (hrs) = 0.25 | Cycle Length C = 120.0

 HCS+™ Version 5.1 Generated: 5/18/2006 10:22 AM

CAPACITY AND LOS WORKSHEET

General Information

Project Description *UH West Oahu - NSR/Road B PM Pk NB Yr 2015*

Capacity Analysis

	EB			WB			NB		SB	
Lane group			L		R		TR		L	T
Adj. flow rate		0	39	0	244		1238		459	1467
Satflow rate			1805		1615		5109		1805	5176
Lost time		2.0	2.0	2.0	2.0		2.0		2.0	2.0
Green ratio		0.00	0.24	0.00	0.61		0.36		0.33	0.69
Lane group cap.			436		982		1831		602	3580
v/c ratio			0.09		0.25		0.68		0.76	0.41
Flow ratio			0.02		0.15		0.24		0.25	0.28
Crit. lane group		N	Y	N	N		Y		Y	N
Sum flow ratios	0.52									
Lost time/cycle	8.00									
Critical v/c ratio	0.56									

Lane Group Capacity, Control Delay, and LOS Determination

	EB			WB			NB		SB	
Lane group			L		R		TR		L	T
Adj. flow rate		0	39	0	244		1238		459	1467
Lane group cap.			436		982		1831		602	3580
v/c ratio			0.09		0.25		0.68		0.76	0.41
Green ratio		0.00	0.24	0.00	0.61		0.36		0.33	0.69
Unif. delay d_1			35.3		10.8		32.6		35.8	8.0
Delay factor k			0.11		0.11		0.25		0.31	0.11
Increm. delay d_2			0.1		0.1		1.0		5.7	0.1
PF factor			1.000		1.000		0.936		1.000	0.290
Control delay			35.4		11.0		31.5		41.5	2.4
Lane group LOS			D		B		C		D	A
Apprch. delay			14.3				31.5		11.7	
Approach LOS			B				C		B	
Intersec. delay	19.0		Intersection LOS						B	

 HCS+™ Version 5.1 Generated: 5/18/2006 10:23 AM

TWO-WAY STOP CONTROL SUMMARY

General Information		Site Information	
Analyst	JW	Intersection	North-South Road/Road E
Agency/Co.	PBQD	Jurisdiction	Honolulu
Date Performed	5/15/2006	Analysis Year	2015 NB (PM Pk)
Analysis Time Period	PM Peak (2015 NB)		

Project Description: UH West Oahu - NSR/Road E PM Pk NB Yr 2015

East/West Street: Road E | North/South Street: North-South Road

Intersection Orientation: North-South | Study Period (hrs): 0.25

Vehicle Volumes and Adjustments

Major Street	Northbound			Southbound		
Movement	1	2	3	4	5	6
	L	T	R	L	T	R
Volume		1038	40		1355	
Peak-Hour Factor, PHF	0.90	0.90	0.90	0.90	0.90	0.90
Hourly Flow Rate, HFR	0	1153	44	0	1505	0
Percent Heavy Vehicles	0	--	--	0	--	--
Median Type	Raised curb					
RT Channelized			0			0
Lanes	0	2	0	0	2	0
Configuration		T	TR		T	
Upstream Signal		0			0	

Minor Street	Eastbound			Westbound		
Movement	7	8	9	10	11	12
	L	T	R	L	T	R
Volume						76
Peak-Hour Factor, PHF	0.90	0.90	0.90	0.90	0.90	0.90
Hourly Flow Rate, HFR	0	0	0	0	0	84
Percent Heavy Vehicles	0	0	0	0	0	0
Percent Grade (%)		0			0	
Flared Approach		N			N	
Storage		0			0	
RT Channelized			1			1
Lanes	0	0	0	0	0	1
Configuration						R

Delay, Queue Length, and Level of Service

Approach	Northbound	Southbound	Westbound			Eastbound		
Movement	1	4	7	8	9	10	11	12
Lane Configuration					R			
v (vph)					84			
C (m) (vph)					450			
v/c					0.19			
95% queue length					0.68			
Control Delay					14.8			
LOS					B			
Approach Delay	--	--	14.8					
Approach LOS	--	--	B					

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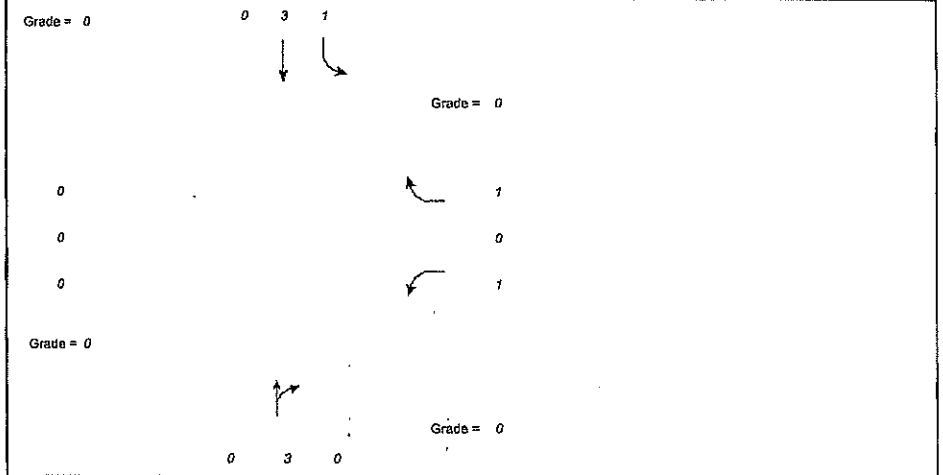
INPUT WORKSHEET

General Information		Site Information	
Analyst	JW	Intersection	North-South Rd/Road F
Agency or Co.	PBQ&D	Area Type	All other areas
Date Performed	5/15/2006	Jurisdiction	Honolulu
Time Period	PM Peak (2015 NB)	Analysis Year	2015 (PM Pk NB)

Project Description: UH West Oahu - NSR/Road F PM Pk NB Yr 2015

Intersection Geometry



Volume and Timing Input

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume (vph)				77		125		928	80	412	943	
% Heavy veh	0	0	0	0	0	0	0	0	0	0	0	0
PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Actuated (P/A)				A		A		A	A	A	A	
Startup lost time		2.0		2.0	2.0	2.0		2.0		2.0	2.0	
Ext. eff. green		2.0		2.0	2.0	2.0		2.0		2.0	2.0	
Arrival type		3		3	3	3		3		3	3	
Unit Extension		3.0		3.0	3.0	3.0		3.0		3.0	3.0	
Ped/Bike/RTOR Volume	0	0	0	0	0	0	0	0	0	0	0	0
Lane Width		12.0		12.0	12.0	12.0		12.0		12.0	12.0	
Parking (Y or N)	N		N	N		N	N		N	N		N
Parking/hr												
Bus stops/hr		0		0	0	0		0		0	0	

	WB Only	02	03	04	SB Only	Thru & RT	07	08
Timing	G = 30.0	G =	G =	G =	G = 37.0	G = 41.0	G =	G =
	Y = 4	Y =	Y =	Y =	Y = 4	Y = 4	Y =	Y =

Duration of Analysis (hrs) = 0.25 | Cycle Length C = 120.0

 HCS+™ Version 5.1 Generated: 5/18/2006 11:51 AM

CAPACITY AND LOS WORKSHEET

General Information

Project Description *UH West Oahu - NSR/Road F PM Pk NB Yr 2015*

Capacity Analysis

	EB			WB			NB		SB	
Lane group			L		R		TR		L	T
Adj. flow rate		0	86	0	139		1120		458	1048
Satflow rate			1805		1615		5114		1805	5176
Lost time		2.0	2.0	2.0	2.0		2.0		2.0	2.0
Green ratio		0.00	0.25	0.00	0.25		0.34		0.31	0.68
Lane group cap.			451		404		1747		557	3537
v/c ratio			0.19		0.34		0.64		0.82	0.30
Flow ratio			0.05		0.09		0.22		0.25	0.20
Crit. lane group		N		N	Y		Y		Y	N
Sum flow ratios	0.56									
Lost time/cycle	12.00									
Critical v/c ratio	0.62									

Lane Group Capacity, Control Delay, and LOS Determination

	EB			WB			NB		SB	
Lane group			L		R		TR		L	T
Adj. flow rate		0	86	0	139		1120		458	1048
Lane group cap.			451		404		1747		557	3537
v/c ratio			0.19		0.34		0.64		0.82	0.30
Green ratio		0.00	0.25	0.00	0.25		0.34		0.31	0.68
Unif. delay d_1			35.4		36.9		33.3		38.5	7.5
Delay factor k			0.11		0.11		0.22		0.36	0.11
Increm. delay d_2			0.2		0.5		0.8		9.6	0.0
PF factor			1.000		1.000		1.000		1.000	1.000
Control delay			35.6		37.4		34.1		48.1	7.6
Lane group LOS			D		D		C		D	A
Apprch. delay			36.8				34.1		19.9	
Approach LOS			D				C		B	
Intersec. delay	26.8		Intersection LOS						C	

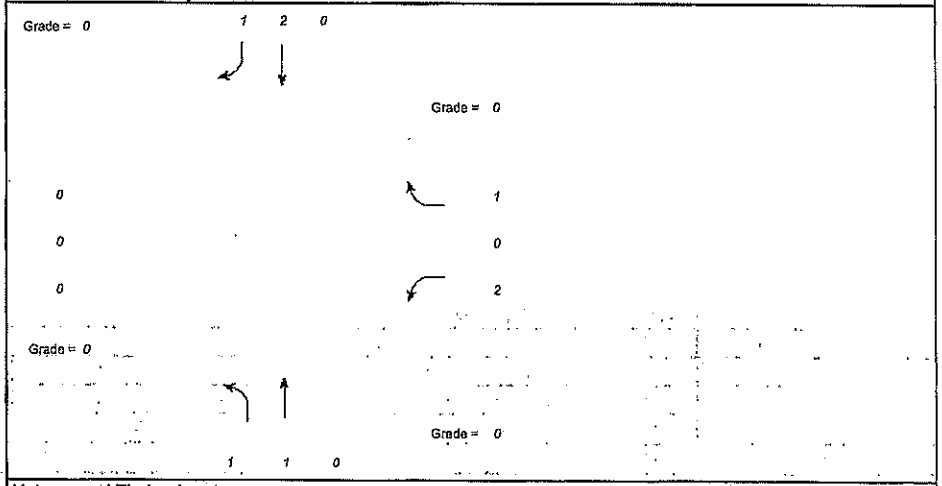
 HCS+™ Version 5.1 Generated: 5/18/2006 11:51 AM

INPUT WORKSHEET

General Information		Site Information	
Analyst	JW	Intersection	N-S Rd/H-1 WB Off
Agency or Co.	PBQD	Area Type	All other areas
Date Performed	5/15/2006	Jurisdiction	Honolulu
Time Period	~~AM Peak (Build 2035)~~	Analysis Year	2015 Build

Project Description *UH-West Oahu - 2015 AM Build North-South Rd H-1 WB Off Ramp*

Intersection Geometry



Volume and Timing Input

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume (vph)				1193		85	453	133			893	45
% Heavy veh	0	0	0	0	0	0	0	0	0	0	0	0
PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Actuated (P/A)				A		A	A	A			A	A
Startup lost time		2.0		2.0	2.0	2.0	2.0	2.0			2.0	2.0
Ext. eff. green		2.0		2.0	2.0	2.0	2.0	2.0			2.0	2.0
Arrival type		3		3	3	3	3	3			3	3
Unit Extension		3.0		3.0	3.0	3.0	3.0	3.0			3.0	3.0
Ped/Bike/RTOR Volume	0	0	0	0	0	0	0	0	0	0	0	0
Lane Width		12.0		12.0	12.0	12.0	12.0	12.0			12.0	12.0
Parking (Y or N)	N		N	N		N	N		N	N		N
Parking/hr												
Bus stops/hr		0		0	0	0	0	0			0	0

	WB Only	02	03	04	NB Only	Thru & RT	07	08
Timing	G = 44.0	G =	G =	G =	G = 35.0	G = 33.0	G =	G =
	Y = 4	Y =	Y =	Y =	Y = 0	Y = 4	Y =	Y =

Duration of Analysis (hrs) = 0.25 Cycle Length C = 120.0

 HCS+™ Version 5.1 Generated: 5/18/2006 9:15 AM

CAPACITY AND LOS WORKSHEET

General Information

Project Description *UH-West Oahu - 2015 AM Build North-South Rd H-1 WB Off Ramp*

Capacity Analysis

	EB			WB			NB			SB	
Lane group			L		R	L	T		T	R
Adj. flow rate	0		1326	0	94	503	148		992	50
Satflow rate			3505		1615	1805	1900		3618	1615
Lost time	2.0		2.0	2.0	2.0	2.0	2.0		2.0	2.0
Green ratio	0.00		0.37	0.00	0.37	0.29	0.57		0.28	0.68
Lane group cap.			1285		592	526	1077		995	1090
v/c ratio			1.03		0.16	0.96	0.14		1.00	0.05
Flow ratio			0.38		0.06	0.28	0.08		0.27	0.03
Crit. lane group	N		Y	N	N	Y	N		Y	N
Sum flow ratios	0.93									
Lost time/cycle	8.00									
Critical v/c ratio	1.00									

Lane Group Capacity, Control Delay, and LOS Determination

	EB			WB			NB			SB	
Lane group			L		R	L	T		T	R
Adj. flow rate	0		1326	0	94	503	148		992	50
Lane group cap.			1285		592	526	1077		995	1090
v/c ratio			1.03		0.16	0.96	0.14		1.00	0.05
Green ratio	0.00		0.37	0.00	0.37	0.29	0.57		0.28	0.68
Unif. delay d_1			36.0		25.6	41.7	12.2		43.5	6.5
Delay factor k			0.50		0.11	0.47	0.11		0.50	0.11
Increm. delay d_2			33.7		0.1	28.5	0.1		27.8	0.0
PF factor			1.000		1.000	1.000	1.000		1.000	1.000
Control delay			71.7		25.7	70.2	12.3		71.2	6.6
Lane group LOS			E		C	E	B		E	A
Apprch. delay			68.6			57.1			68.1	
Approach LOS			E			E			E	
Intersec. delay	66.0		Intersection LOS						E	

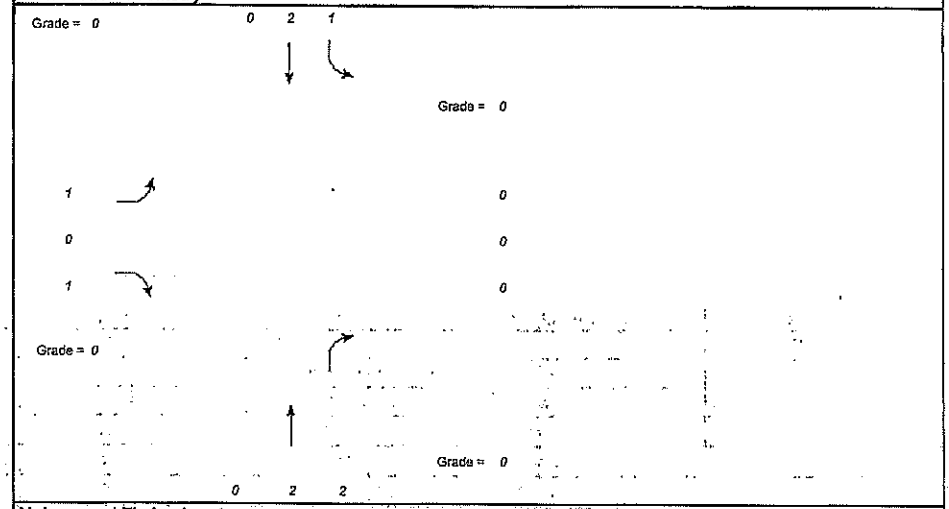
 HCS+™ Version 5.1 Generated: 5/18/2006 9:15 AM

INPUT WORKSHEET

General Information		Site Information	
Analyst	JW	Intersection	N-S Rd/H-1 EB Off
Agency or Co.	PBQD	Area Type	All other areas
Date Performed	5/15/2006	Jurisdiction	Honolulu
Time Period	AM Peak (Build 2015)	Analysis Year	2015 Build

Project Description *UH-West Oahu - 2015 AM Build North-South Rd H-1 EB Off Ramp*

Intersection Geometry



Volume and Timing Input

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume (vph)	45		422					586	2082	335	1751	
% Heavy veh	0	0	0	0	0	0	0	0	0	0	0	0
PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Actuated (P/A)	A		A					A	A	A	A	
Startup lost time	2.0	2.0	2.0		2.0			2.0	2.0	2.0	2.0	
Ext. eff. green	2.0	2.0	2.0		2.0			2.0	2.0	2.0	2.0	
Arrival type	3	3	3		3			3	3	3	3	
Unit Extension	3.0	3.0	3.0		3.0			3.0	3.0	3.0	3.0	
Ped/Bike/RTOR Volume	0	0	0	0	0	0	0	0	0	0	0	0
Lane Width	12.0	12.0	12.0		12.0			12.0	12.0	12.0	12.0	
Parking (Y or N)	N		N	N		N	N		N	N		N
Parking/hr												
Bus stops/hr	0	0	0		0			0	0	0	0	

	EB Only	02	03	04	NS Perm	Thru & RT	07	08
Timing	G = 30.0	G =	G =	G =	G = 40.0	G = 42.0	G =	G =
	Y = 4	Y =	Y =	Y =	Y = 0	Y = 4	Y =	Y =

Duration of Analysis (hrs) = 0.25 Cycle Length C = 120.0

 HCS+™ Version 5.1 Generated: 5/18/2006 9:15 AM

CAPACITY AND LOS WORKSHEET

General Information

Project Description *UH-West Oahu - 2015 AM Build North-South Rd H-1 EB Off Ramp*

Capacity Analysis

	EB			WB			NB		SB	
Lane group	L		R				T	R	L	T
Adj. flow rate	50	0	469		0		651	2313	372	1946
Satflow rate	1805		1615				3618	2859	1805	3618
Lost time	2.0	2.0	2.0		2.0		2.0	2.0	2.0	2.0
Green ratio	0.25	0.00	1.00		0.00		0.35	1.00	0.33	0.68
Lane group cap.	451		1615				1266	2859	602	2472
v/c ratio	0.11		0.29				0.51	0.81	0.62	0.79
Flow ratio	0.03		0.29				0.18	0.81	0.21	0.54
Crit. lane group		N	N		N		N	Y		N
Sum flow ratios	0.81									
Lost time/cycle	0.00									
Critical v/c ratio	0.81									

Lane Group Capacity, Control Delay, and LOS Determination

	EB			WB			NB		SB	
Lane group	L		R				T	R	L	T
Adj. flow rate	50	0	469		0		651	2313	372	1946
Lane group cap.	451		1615				1266	2859	602	2472
v/c ratio	0.11		0.29				0.51	0.81	0.62	0.79
Green ratio	0.25	0.00	1.00		0.00		0.35	1.00	0.33	0.68
Unif. delay d_1	34.7		0.0				30.9	0.0	33.6	13.0
Delay factor k	0.11		0.11				0.12	0.35	0.20	0.33
Increm. delay d_2	0.1		0.1				0.4	1.8	1.9	1.8
PF factor	1.000		0.950				1.000	0.950	1.000	1.000
Control delay	34.8		0.1				31.3	1.8	35.5	14.8
Lane group LOS	C		A				C	A	D	B
Apprch. delay	3.4						8.3		18.1	
Approach LOS	A						A		B	
Intersec. delay	11.8			Intersection LOS					B	

INPUT WORKSHEET

General Information

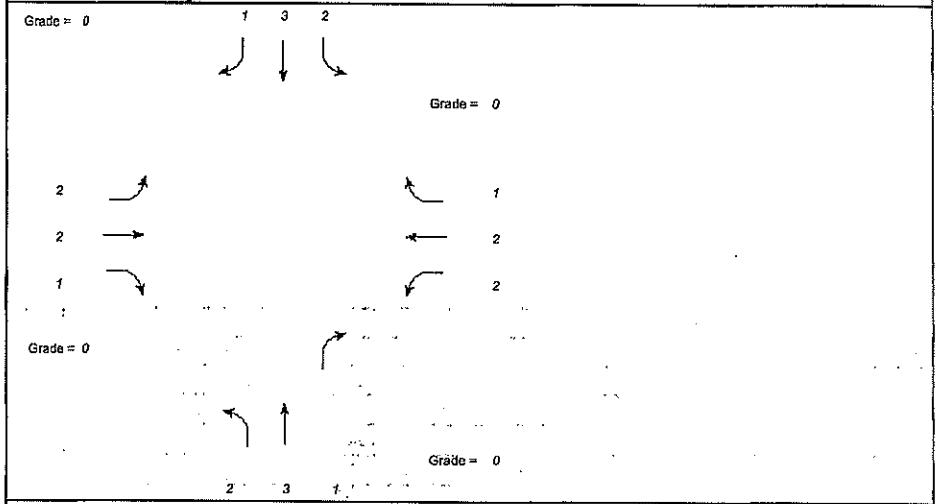
Analyst	JW
Agency or Co.	PBQ&D
Date Performed	5/15/2006
Time Period	AM Peak (2015 Build)

Site Information

Intersection	North-South Rd/Farrington Hwy
Area Type	All other areas
Jurisdiction	Honolulu
Analysis Year	2015 (AM Pk Build)

Project Description *UH West Oahu - NSR/Farrington AM Pk Build Yr 2015*

Intersection Geometry



Volume and Timing Input

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume (vph)	465	306	18	182	621	265	19	1938	229	335	1263	575
% Heavy veh	0	0	0	0	0	0	0	0	0	0	0	0
PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Actuated (P/A)	A	A	A	A	A	A	A	A	A	A	A	A
Startup lost time	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Ext. eff. green	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Arrival type	3	3	3	3	3	3	3	4	3	3	4	3
Unit Extension	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Ped/Bike/RTOR Volume	0	0	0	0	0	0	0	0	0	0	0	0
Lane Width	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
Parking (Y or N)	N		N	N		N	N		N	N		N
Parking/hr												
Bus stops/hr	0	0	0	0	0	0	0	0	0	0	0	0

	Excl. Left	EB Only	Thru & RT	04	Excl. Left	NB Only	Thru & RT	08
Timing	G = 10.0	G = 6.0	G = 24.0	G = 0.0	G = 14.0	G = 10.0	G = 40.0	G = 0.0
	Y = 4	Y = 0	Y = 4	Y = 0	Y = 4	Y = 0	Y = 4	Y = 0

Duration of Analysis (hrs) = 0.25 Cycle Length C = 120.0

CAPACITY AND LOS WORKSHEET

General Information

Project Description *UH West Oahu - NSR/Farrington AM Pk Build Yr 2015*

Capacity Analysis

	EB			WB			NB			SB		
Lane group	L	T	R	L	T	R	L	T	R	L	T	R
Adj. flow rate	517	340	20	202	690	294	21	2153	254	372	1403	639
Satflow rate	3505	3618	1615	3505	3618	1615	3505	5176	1615	3505	5176	1615
Lost time	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Green ratio	0.17	0.25	0.52	0.08	0.20	0.35	0.23	0.42	0.53	0.12	0.33	0.53
Lane group cap.	584	905	834	292	724	565	818	2157	861	409	1725	861
v/c ratio	0.89	0.38	0.02	0.69	0.95	0.52	0.03	1.00	0.30	0.91	0.81	0.74
Flow ratio	0.15	0.09	0.01	0.06	0.19	0.18	0.01	0.42	0.16	0.11	0.27	0.40
Crit. lane group	Y	N	N		Y	N		Y	N	Y	N	N
Sum flow ratios	0.86											
Lost time/cycle	12.00											
Critical v/c ratio	0.96											

Lane Group Capacity, Control Delay, and LOS Determination

	EB			WB			NB			SB		
Lane group	L	T	R	L	T	R	L	T	R	L	T	R
Adj. flow rate	517	340	20	202	690	294	21	2153	254	372	1403	639
Lane group cap.	584	905	834	292	724	565	818	2157	861	409	1725	861
v/c ratio	0.89	0.38	0.02	0.69	0.95	0.52	0.03	1.00	0.30	0.91	0.81	0.74
Green ratio	0.17	0.25	0.52	0.08	0.20	0.35	0.23	0.42	0.53	0.12	0.33	0.53
Unif. delay d_1	48.9	37.2	14.2	53.5	47.4	31.0	35.5	35.0	15.5	52.4	36.6	21.6
Delay factor k	0.41	0.11	0.11	0.26	0.46	0.13	0.11	0.50	0.11	0.43	0.35	0.30
Increm. delay d_2	15.1	0.3	0.0	6.8	22.6	0.9	0.0	18.9	0.2	23.9	3.1	3.5
PF factor	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.876	1.000	1.000	0.958	1.000
Control delay	64.0	37.5	14.2	60.3	70.0	31.9	35.5	49.5	15.7	76.3	38.2	25.1
Lane group LOS	E	D	B	E	E	C	D	D	B	E	D	C
Apprch. delay	52.6			58.9			45.9			40.6		
Approach LOS	D			E			D			D		
Intersec. delay	47.1			Intersection LOS						D		

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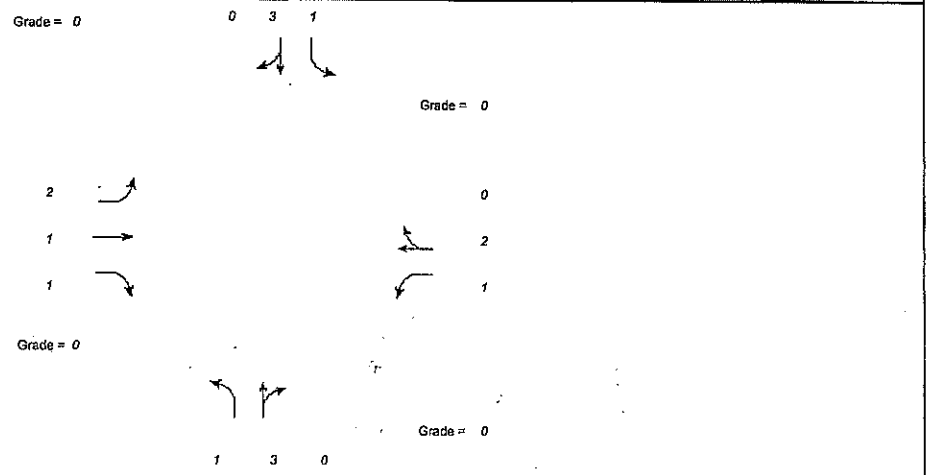
INPUT WORKSHEET

General Information		Site Information	
Analyst	JW	Intersection	North-South Rd/Road B
Agency or Co.	PBQ&D	Area Type	All other areas
Date Performed	5/15/2006	Jurisdiction	Honolulu
Time Period	AM Peak (2015 Build)	Analysis Year	2015 (AM Pk Build)

Project Description *UH West Oahu - NSR/Road B AM Pk Build Yr 2015*

Intersection Geometry



Volume and Timing Input

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume (vph)	315	82	69	89	113	315	128	1520	78	166	942	355
% Heavy veh	0	0	0	0	0	0	0	0	0	0	0	0
PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Actuated (P/A)	A	A	A	A	A	A	A	A	A	A	A	A
Startup lost time	2.0	2.0	2.0	2.0	2.0		2.0	2.0		2.0	2.0	
Ext. eff. green	2.0	2.0	2.0	2.0	2.0		2.0	2.0		2.0	2.0	
Arrival type	3	3	3	3	3		3	4		3	4	
Unit Extension	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Ped/Bike/RTOR Volume	0	0	0	0	0	0	0	0	0	0	0	0
Lane Width	12.0	12.0	12.0	12.0	12.0		12.0	12.0		12.0	12.0	
Parking (Y or N)	N		N	N		N	N		N	N		N
Parking/hr												
Bus stops/hr	0	0	0	0	0		0	0		0	0	

	Excl. Left	Thru & RT	03	04	Excl. Left	Thru & RT	07	08
Timing	G = 17.0	G = 22.0	G =	G =	G = 18.0	G = 47.0	G =	G =
	Y = 4	Y = 4	Y =	Y =	Y = 4	Y = 4	Y =	Y =

Duration of Analysis (hrs) = 0.25 Cycle Length C = 120.0

 HCS+™ Version 5.1 Generated: 5/19/2006 9:31 AM

CAPACITY AND LOS WORKSHEET

General Information

Project Description: *UH West Oahu - NSR/Road B AM Pk Build Yr 2015*

Capacity Analysis

	EB			WB			NB			SB	
Lane group	L	T	R	L	TR		L	TR		L	TR
Adj. flow rate	350	91	77	99	476		142	1776		184	1441
Satflow rate	3505	1900	1615	1805	3219		1805	5138		1805	4963
Lost time	2.0	2.0	2.0	2.0	2.0		2.0	2.0		2.0	2.0
Green ratio	0.14	0.18	0.18	0.14	0.18		0.15	0.39		0.15	0.39
Lane group cap.	497	348	296	256	590		271	2012		271	1944
v/c ratio	0.70	0.26	0.26	0.39	0.81		0.52	0.88		0.68	0.74
Flow ratio	0.10	0.05	0.05	0.05	0.15		0.08	0.35		0.10	0.29
Crit. lane group	Y	N	N		Y			Y		Y	N
Sum flow ratios	0.70										
Lost time/cycle	16.00										
Critical v/c ratio	0.80										

Lane Group Capacity, Control Delay, and LOS Determination

	EB			WB			NB			SB	
Lane group	L	T	R	L	TR		L	TR		L	TR
Adj. flow rate	350	91	77	99	476		142	1776		184	1441
Lane group cap.	497	348	296	256	590		271	2012		271	1944
v/c ratio	0.70	0.26	0.26	0.39	0.81		0.52	0.88		0.68	0.74
Green ratio	0.14	0.18	0.18	0.14	0.18		0.15	0.39		0.15	0.39
Unif. delay d_1	49.1	42.0	42.0	46.8	47.0		47.0	33.9		48.3	31.3
Delay factor k	0.27	0.11	0.11	0.11	0.35		0.13	0.41		0.25	0.30
Increm. delay d_2	4.5	0.4	0.5	1.0	8.1		1.9	5.0		6.7	1.6
PF factor	1.000	1.000	1.000	1.000	1.000		1.000	0.903		1.000	0.903
Control delay	53.6	42.4	42.5	47.7	55.1		48.9	35.7		55.0	29.8
Lane group LOS	D	D	D	D	E		D	D		D	C
Apprch. delay	50.0			53.8			36.7			32.7	
Approach LOS	D			D			D			C	
Intersec. delay	38.9			Intersection LOS						D	

TWO-WAY STOP CONTROL SUMMARY

General Information

Analyst	JW
Agency/Co.	PBQD
Date Performed	5/15/2006
Analysis Time Period	AM Peak (2015 Build)

Site Information

Intersection	North-South Road/Road E
Jurisdiction	Honolulu
Analysis Year	2015 Build (AM Pk)

Project Description: *UH West Oahu - NSR/Road E AM Pk Build Yr 2015*

East/West Street: *Road E* | North/South Street: *North-South Road*

Intersection Orientation: *North-South* | Study Period (hrs): *0.25*

Vehicle Volumes and Adjustments

Major Street	Northbound			Southbound		
Movement	1	2	3	4	5	6
	L	T	R	L	T	R
Volume		1599	12		979	121
Peak-Hour Factor, PHF	0.90	0.90	0.90	0.90	0.90	0.90
Hourly Flow Rate, HFR	0	1776	13	0	1087	134
Percent Heavy Vehicles	0	--	--	0	--	--
Median Type	Raised curb					
RT Channelized			0			0
Lanes	0	2	0	0	2	0
Configuration		T	TR		T	TR
Upstream Signal		0			0	

Minor Street	Eastbound			Westbound		
Movement	7	8	9	10	11	12
	L	T	R	L	T	R
Volume			38			127
Peak-Hour Factor, PHF	0.90	0.90	0.90	0.90	0.90	0.90
Hourly Flow Rate, HFR	0	0	42	0	0	141
Percent Heavy Vehicles	0	0	0	0	0	0
Percent Grade (%)	0			0		
Flared Approach		N			N	
Storage		0			0	
RT Channelized			1			1
Lanes	0	0	1	0	0	1
Configuration			R			R

Delay, Queue Length, and Level of Service

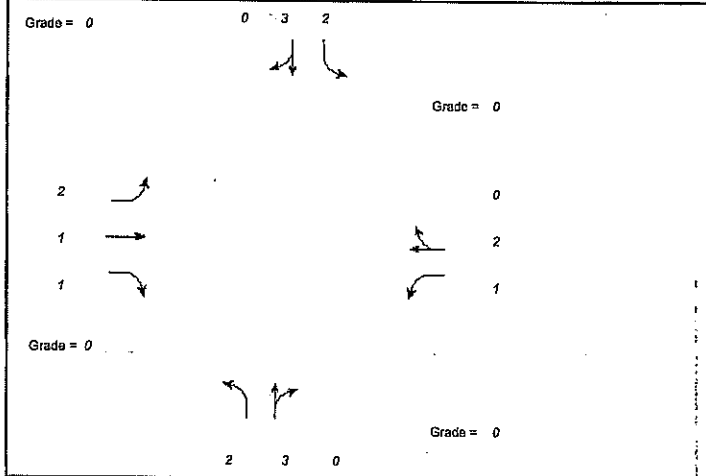
Approach	Northbound	Southbound	Westbound			Eastbound		
Movement	1	4	7	8	9	10	11	12
Lane Configuration					R			R
v (vph)					141			42
C (m) (vph)					288			442
v/c					0.49			0.10
95% queue length					2.53			0.31
Control Delay					28.9			14.0
LOS					D			B
Approach Delay	--	--	28.9			14.0		
Approach LOS	--	--	D			B		

INPUT WORKSHEET

General Information		Site Information	
Analyst	JW	Intersection	North-South Rd/Road F
Agency or Co.	PBQ&D	Area Type	All other areas
Date Performed	5/15/2006	Jurisdiction	Honolulu
Time Period	AM Peak (2015 Build)	Analysis Year	2015 (AM Pk Build)

Project Description *UH West Oahu - NSR/Road F AM Pk Build Yr 2015*

Intersection Geometry



Volume and Timing Input

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume (vph)	421	414	123	129	369	252	184	938	25	166	643	208
% Heavy veh	0	0	0	0	0	0	0	0	0	0	0	0
PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Actuated (P/A)	A	A	A	A	A	A	A	A	A	A	A	A
Startup lost time	2.0	2.0	2.0	2.0	2.0		2.0	2.0		2.0	2.0	
Ext. eff. green	2.0	2.0	2.0	2.0	2.0		2.0	2.0		2.0	2.0	
Arrival type	3	3	3	3	3		3	3		3	3	
Unit Extension	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Ped/Bike/RTOR Volume	0	0	0	0	0	0	0	0	0	0	0	0
Lane Width	12.0	12.0	12.0	12.0	12.0		12.0	12.0		12.0	12.0	
Parking (Y or N)	N		N	N		N	N		N	N		N
Parking/hr												
Bus stops/hr	0	0	0	0	0		0	0		0	0	

	Excl. Left	Thru & RT	03	04	Excl. Left	Thru & RT	07	08
Timing	G = 22.0	G = 34.0	G =	G =	G = 19.0	G = 29.0	G =	G =
	Y = 4	Y = 4	Y =	Y =	Y = 4	Y = 4	Y =	Y =

Duration of Analysis (hrs) = 0.25 | Cycle Length C = 120.0

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CAPACITY AND LOS WORKSHEET

General Information

Project Description *UH West Oahu - NSR/Road F AM Pk Build Yr 2015*

Capacity Analysis

	EB			WB		NB		SB	
Lane group	L	T	R	L	TR	L	TR	L	TR
Adj. flow rate	468	460	137	143	690	204	1070	184	945
Satflow rate	3505	1900	1615	1805	3397	3505	5155	3505	4986
Lost time	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Green ratio	0.18	0.28	0.28	0.18	0.28	0.16	0.24	0.16	0.24
Lane group cap.	643	538	458	331	962	555	1246	555	1205
v/c ratio	0.73	0.86	0.30	0.43	0.72	0.37	0.86	0.33	0.78
Flow ratio	0.13	0.24	0.08	0.08	0.20	0.06	0.21	0.05	0.19
Crit. lane group	Y	Y	N		N	Y	Y		N
Sum flow ratios	0.64								
Lost time/cycle	16.00								
Critical v/c ratio	0.74								

Lane Group Capacity, Control Delay, and LOS Determination

	EB			WB		NB		SB	
Lane group	L	T	R	L	TR	L	TR	L	TR
Adj. flow rate	468	460	137	143	690	204	1070	184	945
Lane group cap.	643	538	458	331	962	555	1246	555	1205
v/c ratio	0.73	0.86	0.30	0.43	0.72	0.37	0.86	0.33	0.78
Green ratio	0.18	0.28	0.28	0.18	0.28	0.16	0.24	0.16	0.24
Unif. delay d_1	46.2	40.7	33.7	43.5	38.7	45.1	43.5	44.9	42.6
Delay factor k	0.29	0.39	0.11	0.11	0.28	0.11	0.39	0.11	0.33
Increm. delay d_2	4.2	12.8	0.4	0.9	2.6	0.4	6.2	0.4	3.5
PF factor	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Control delay	50.3	53.4	34.0	44.4	41.3	45.5	49.8	45.2	46.0
Lane-group LOS	D	D	C	D	D	D	D	D	D
Apprch. delay	49.6			41.8		49.1		45.9	
Approach LOS	D			D		D		D	
Intersec. delay	47.0			Intersection LOS				D	

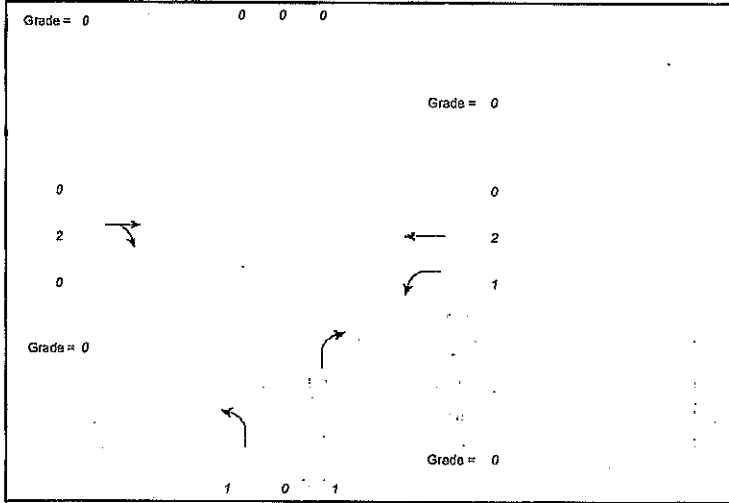
 HCS+™ Version 5.1 Generated: 5/19/2006 9:26 AM

INPUT WORKSHEET

General Information		Site Information	
Analyst	JW	Intersection	Farrington Hwy/Road A
Agency or Co.	PBQ&D	Area Type	All other areas
Date Performed	5/15/2006	Jurisdiction	Honolulu
Time Period	AM Peak (2015 Build)	Analysis Year	2015 (AM Pk Build)

Project Description *UH West Oahu - Farrington/Rd A AM Pk Build Yr 2015*

Intersection Geometry



Volume and Timing Input

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume (vph)		668	19	311	904		7		121			
% Heavy veh	0	0	0	0	0	0	0	0	0	0	0	0
PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Actuated (P/A)		A	A	A	A		A		A			
Startup lost time		2.0		2.0	2.0		2.0	2.0	2.0		2.0	
Ext. eff. green		2.0		2.0	2.0		2.0	2.0	2.0		2.0	
Arrival type		3		3	3		3	3	3		3	
Unit Extension		3.0		3.0	3.0		3.0	3.0	3.0		3.0	
Ped/Bike/RTOR Volume	0	0	0	0	0	0	0	0	0	0	0	0
Lane Width		12.0		12.0	12.0		12.0	12.0	12.0		12.0	
Parking (Y or N)	N		N	N		N	N		N	N		N
Parking/hr												
Bus stops/hr		0		0	0		0	0	0		0	

	WB Only	Thru & RT	03	04	NB Only	06	07	08
Timing	G = 41.0	G = 41.0	G =	G =	G = 26.0	G =	G =	G =
	Y = 4	Y = 4	Y =	Y =	Y = 4	Y =	Y =	Y =

Duration of Analysis (hrs) = 0.25 | Cycle Length C = 120.0

 HCS+™ Version 5.1 Generated: 5/18/2006 9:14 AM

CAPACITY AND LOS WORKSHEET

General Information

Project Description *UH West Oahu - Farrington/Rd A AM Pk Build Yr 2015*

Capacity Analysis

	EB		WB		NB			SB	
Lane group	TR		L	T	L		R		
Adj. flow rate	763		346	1004	8	0	134	0	
Satflow rate	3603		1805	3618	1805		1615		
Lost time	2.0		2.0	2.0	2.0	2.0	2.0	2.0	
Green ratio	0.34		0.34	0.72	0.22	0.00	0.59	0.00	
Lane group cap.	1231		617	2593	391		956		
v/c ratio	0.62		0.56	0.39	0.02		0.14		
Flow ratio	0.21		0.19	0.28	0.00		0.08		
Crit. lane group	Y		Y	N	Y	N	N	N	
Sum flow ratios	0.41								
Lost time/cycle	12.00								
Critical v/c ratio	0.45								

Lane Group Capacity, Control Delay, and LOS Determination

	EB		WB		NB			SB	
Lane group	TR		L	T	L		R		
Adj. flow rate	763		346	1004	8	0	134	0	
Lane group cap.	1231		617	2593	391		956		
v/c ratio	0.62		0.56	0.39	0.02		0.14		
Green ratio	0.34		0.34	0.72	0.22	0.00	0.59	0.00	
Unif. delay d_1	33.0		32.2	6.7	37.0		10.9		
Delay factor k	0.20		0.16	0.11	0.11		0.11		
Increm. delay d_2	1.0		1.2	0.1	0.0		0.1		
PF factor	1.000		1.000	1.000	1.000		1.000		
Control delay	34.0		33.3	6.8	37.0		11.0		
Lane group LOS	C		C	A	D		B		
Apprch. delay	34.0		13.6		12.4				
Approach LOS	C		B		B				
Intersec. delay	20.4		Intersection LOS					C	

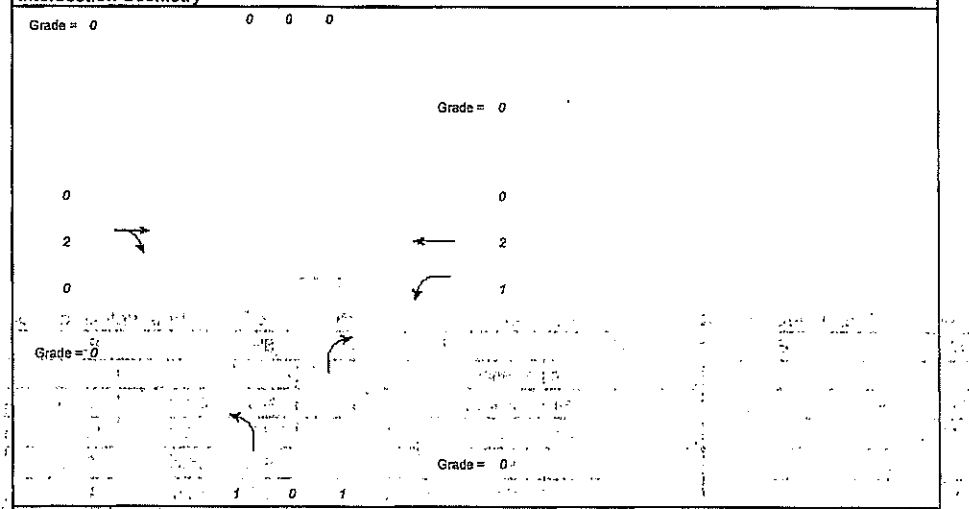
 HCS+™ Version 5.1 Generated: 5/18/2006 9:14 AM

INPUT WORKSHEET

General Information		Site Information	
Analyst	JW	Intersection	Farrington Hwy/ Road F
Agency or Co.	PBQ&D	Area Type	All other areas
Date Performed	5/15/2006	Jurisdiction	Honolulu
Time Period	AM Peak (2015 Build)	Analysis Year	2015 (AM Pk Build)

Project Description *UH West Oahu - Farrington/Rd F AM Pk Build Yr 2015*

Intersection Geometry



Volume and Timing Input

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume (vph)		408	309	125	786		328		279			
% Heavy veh	0	0	0	0	0	0	0	0	0	0	0	0
PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Actuated (P/A)		A	A	A	A		A		A			
Startup lost time		2.0		2.0	2.0		2.0	2.0	2.0		2.0	
Ext. eff. green		2.0		2.0	2.0		2.0	2.0	2.0		2.0	
Arrival type		3		3	3		3	3	3		3	
Unit Extension		3.0		3.0	3.0		3.0	3.0	3.0		3.0	
Ped/Bike/RTOR Volume	0	0	0	0	0	0	0	0	0	0	0	0
Lane Width		12.0		12.0	12.0		12.0	12.0	12.0		12.0	
Parking (Y or N)	N		N	N		N	N		N	N		N
Parking/hr												
Bus stops/hr		0		0	0		0	0	0		0	

	WB Only	Thru & RT	03	04	NB Only	06	07	08
Timing	G = 31.0	G = 40.0	G = 0.0	G = 0.0	G = 37.0	G = 0.0	G = 0.0	G = 0.0
	Y = 4	Y = 4	Y = 0	Y = 0	Y = 4	Y = 0	Y = 0	Y = 0

Duration of Analysis (hrs) = 0.25 | Cycle Length C = 120.0

 HCS+™ Version 5.1 Generated: 5/18/2006 9:14 AM

CAPACITY AND LOS WORKSHEET

General Information

Project Description *UH West Oahu - Farrington/Rd F AM Pk Build Yr 2015*

Capacity Analysis

	EB			WB			NB				SB			
Lane group		TR		L	T		L			R				
Adj. flow rate		796		139	873		364	0		310		0		
Satflow rate		3384		1805	3618		1805			1615				
Lost time		2.0		2.0	2.0		2.0	2.0		2.0		2.0		
Green ratio		0.33		0.26	0.63		0.31	0.00		0.31		0.00		
Lane group cap.		1128		466	2261		557			498				
v/c ratio		0.71		0.30	0.39		0.65			0.62				
Flow ratio		0.24		0.08	0.24		0.20			0.19				
Crit. lane group		Y		Y	N		Y	N		N		N		
Sum flow ratios	0.51													
Lost time/cycle	12.00													
Critical v/c ratio	0.57													

Lane Group Capacity, Control Delay, and LOS Determination

	EB			WB			NB				SB			
Lane group		TR		L	T		L			R				
Adj. flow rate		796		139	873		364	0		310		0		
Lane group cap.		1128		466	2261		557			498				
v/c ratio		0.71		0.30	0.39		0.65			0.62				
Green ratio		0.33		0.26	0.63		0.31	0.00		0.31		0.00		
Unif. delay d_1		34.9		35.8	11.1		35.9			35.5				
Delay factor k		0.27		0.11	0.11		0.23			0.21				
Increm. delay d_2		2.0		0.4	0.1		2.8			2.4				
PF factor		1.000		1.000	1.000		1.000			1.000				
Control delay		36.9		36.1	11.2		38.7			37.9				
Lane group LOS		D		D	B		D			D				
Apprch. delay	36.9			14.6			38.3							
Approach LOS	D			B			D							
Intersec. delay	28.2			Intersection LOS							C			

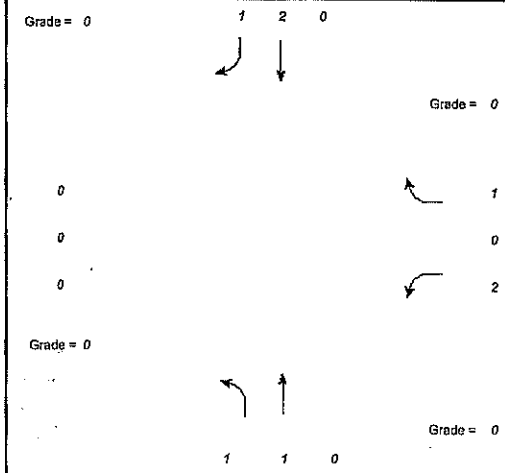
 HCS+™ Version 5.1 Generated: 5/18/2006 9:14 AM

INPUT WORKSHEET

General Information		Site Information	
Analyst	JW	Intersection	N-S Rd/H-1 WB Off
Agency or Co.	PBQD	Area Type	All other areas
Date Performed	5/15/2006	Jurisdiction	Honolulu
Time Period	PM Peak (Build 2015)	Analysis Year	2015 Build

Project Description *UH-West Oahu - 2015 PM Build North-South Rd H-1 WB Off Ramp*

Intersection Geometry



Volume and Timing Input

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume (vph)				1643		230	503	429			410	135
% Heavy veh	0	0	0	0	0	0	0	0	0	0	0	0
PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Actuated (P/A)				A		A	A	A			A	A
Startup lost time		2.0		2.0	2.0	2.0	2.0	2.0			2.0	2.0
Ext. eff. green		2.0		2.0	2.0	2.0	2.0	2.0			2.0	2.0
Arrival type		3		3	3	3	3	3			3	3
Unit Extension		3.0		3.0	3.0	3.0	3.0	3.0			3.0	3.0
Ped/Bike/RTOR Volume	0	0	0	0	0	0	0	0	0	0	0	0
Lane Width		12.0		12.0	12.0	12.0	12.0	12.0			12.0	12.0
Parking (Y or N)	N		N	N		N	N		N	N		N
Parking/hr												
Bus stops/hr		0		0	0	0	0	0			0	0

	WB Only	02	03	04	NB Only	Thru & RT	07	08
Timing	G = 58.0	G =	G =	G =	G = 38.0	G = 16.0	G =	G =
	Y = 4	Y =	Y =	Y =	Y = 0	Y = 4	Y =	Y =

Duration of Analysis (hrs) = 0.25 — Cycle Length C = 120.0

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CAPACITY AND LOS WORKSHEET

General Information

Project Description *UH-West Oahu - 2015 PM Build North-South Rd H-1 WB Off Ramp*

Capacity Analysis

	EB			WB			NB			SB		
Lane group				L		R	L	T			T	R
Adj. flow rate		0		1826	0	256	559	477			456	150
Satflow rate				3505		1615	1805	1900			3618	1615
Lost time		2.0		2.0	2.0	2.0	2.0	2.0			2.0	2.0
Green ratio		0.00		0.48	0.00	0.48	0.32	0.45			0.13	0.65
Lane group cap.				1694		781	572	855			482	1050
v/c ratio				1.08		0.33	0.98	0.56			0.95	0.14
Flow ratio				0.52		0.16	0.31	0.25			0.13	0.09
Crit. lane group		N		Y	N	N	Y	N			Y	N
Sum flow ratios	0.96											
Lost time/cycle	8.00											
Critical v/c ratio	1.03											

Lane Group Capacity, Control Delay, and LOS Determination

	EB			WB			NB			SB		
Lane group				L		R	L	T			T	R
Adj. flow rate		0		1826	0	256	559	477			456	150
Lane group cap.				1694		781	572	855			482	1050
v/c ratio				1.08		0.33	0.98	0.56			0.95	0.14
Green ratio		0.00		0.48	0.00	0.48	0.32	0.45			0.13	0.65
Unif. delay d_1				31.0		19.0	40.6	24.2			51.6	8.1
Delay factor k				0.50		0.11	0.48	0.16			0.46	0.11
Increm. delay d_2				46.2		0.2	31.8	0.8			27.9	0.1
PF factor				1.000		1.000	1.000	1.000			1.000	1.000
Control delay				77.2		19.3	72.4	25.1			79.5	8.2
Lane group LOS				E		B	E	C			E	A
Apprch. delay				70.1			50.6				61.8	
Approach LOS				E			D				E	
Intersec. delay	63.3			Intersection LOS							E	

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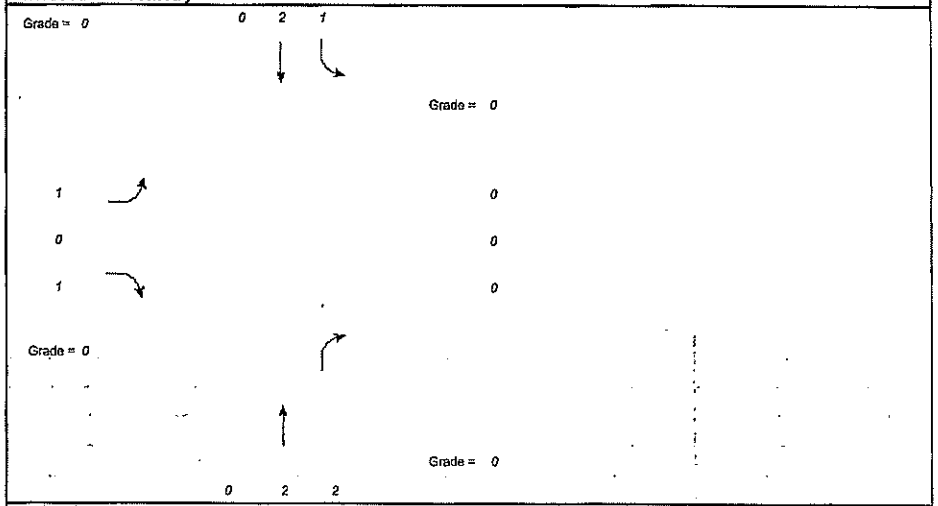
INPUT WORKSHEET

General Information		Site Information	
Analyst	JW	Intersection	N-S Rd/H-1 EB Off
Agency or Co.	PBQD	Area Type	All other areas.
Date Performed	5/15/2006	Jurisdiction	Honolulu
Time Period	PM Peak (2015 Build)	Analysis Year	2015 Build

Project Description *UH-West Oahu - NS Rd/H-1 EB Off Ramp - PM Pk Hr 2015 Build*

Intersection Geometry



Volume and Timing Input

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume (vph)	15		495					917	1430	160	1893	
% Heavy veh	0	0	0	0	0	0	0	0	0	0	0	0
PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Actuated (P/A)	A		A					A	A	A	A	
Startup lost time	2.0	2.0	2.0		2.0			2.0	2.0	2.0	2.0	
Ext. eff. green	2.0	2.0	2.0		2.0			2.0	2.0	2.0	2.0	
Arrival type	3	3	3		3			3	3	3	3	
Unit Extension	3.0	3.0	3.0		3.0			3.0	3.0	3.0	3.0	
Ped/Bike/RTOR Volume	0	0	0	0	0	0	0	0	0	0	0	0
Lane Width	12.0	12.0	12.0		12.0			12.0	12.0	12.0	12.0	
Parking (Y or N)	N		N	N		N	N		N	N		N
Parking/hr												
Bus stops/hr	0	0	0		0			0	0	0	0	

	EB Only	02	03	04	NS Perm	Thru & RT	07	08
Timing	G = 29.0	G =	G =	G =	G = 37.0	G = 46.0	G =	G =
	Y = 4	Y =	Y =	Y =	Y = 0	Y = 4	Y =	Y =

Duration of Analysis (hrs) = 0.25 — Cycle Length C = 120.0

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CAPACITY AND LOS WORKSHEET

General Information

Project Description *UH-West Oahu - NS Rd/H-1 EB Off Ramp - PM Pk Hr 2015 Build*

Capacity Analysis

	EB			WB			NB		SB		
Lane group	L		R				T	R	L	T	
Adj. flow rate	17	0	550		0		1019	1589	178	2103	
Satflow rate	1805		1615				3618	2859	1805	3618	
Lost time	2.0	2.0	2.0		2.0		2.0	2.0	2.0	2.0	
Green ratio	0.24	0.00	1.00		0.00		0.38	1.00	0.31	0.69	
Lane group cap.	436		1615				1387	2859	557	2502	
v/c ratio	0.04		0.34				0.73	0.56	0.32	0.84	
Flow ratio	0.01		0.34				0.28	0.56	0.10	0.58	
Crit. lane group	Y	N	N		N		N	N		Y	
Sum flow ratios	0.59										
Lost time/cycle	8.00										
Critical v/c ratio	0.63										

Lane Group Capacity, Control Delay, and LOS Determination

	EB			WB			NB		SB		
Lane group	L		R				T	R	L	T	
Adj. flow rate	17	0	550		0		1019	1589	178	2103	
Lane group cap.	436		1615				1387	2859	557	2502	
v/c ratio	0.04		0.34				0.73	0.56	0.32	0.84	
Green ratio	0.24	0.00	1.00		0.00		0.38	1.00	0.31	0.69	
Unif. delay d_1	34.8		0.0				31.8	0.0	31.8	13.6	
Delay factor k	0.11		0.11				0.29	0.15	0.11	0.38	
Increm. delay d_2	0.0		0.1				2.1	0.2	0.3	2.7	
PF factor	1.000		0.950				1.000	0.950	1.000	1.000	
Control delay	34.9		0.1				33.8	0.2	32.2	16.4	
Lane group LOS	C		A				C	A	C	B	
Apprch. delay	1.2						13.4		17.6		
Approach LOS	A						B		B		
Intersec. delay	13.9			Intersection LOS					B		

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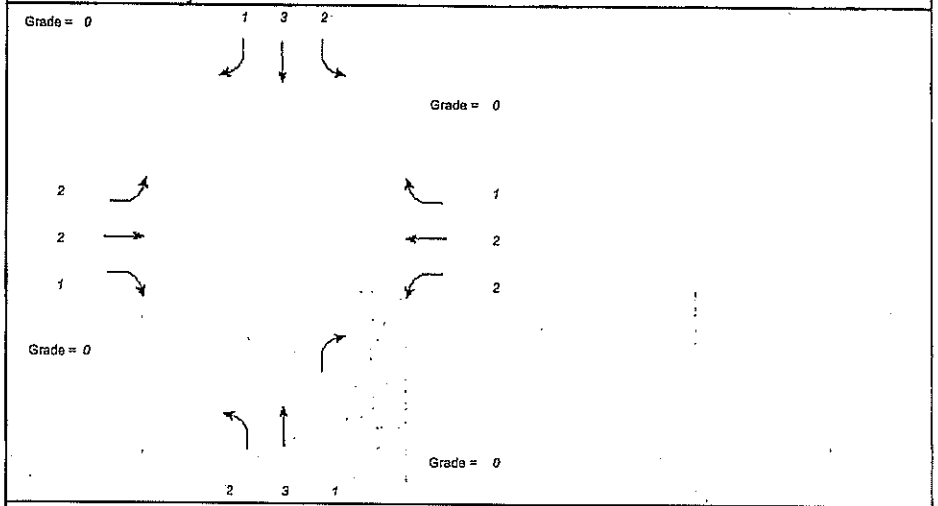
INPUT WORKSHEET

General Information		Site Information	
Analyst	JW	Intersection	North-South Rd/Farrington Hwy
Agency or Co.	PBQ&D	Area Type	All other areas
Date Performed	5/15/2006	Jurisdiction	Honolulu
Time Period	PM Peak (2015 Build)	Analysis Year	2015 (PM Pk Build)

Project Description *UH West Oahu - NSR/Farrington PM Pk Build Yr 2015*

Intersection Geometry



Volume and Timing Input

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume (vph)	640	503	181	622	581	200	156	1507	453	215	1704	469
% Heavy veh	0	0	0	0	0	0	0	0	0	0	0	0
PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Actuated (P/A)	A	A	A	A	A	A	A	A	A	A	A	A
Startup lost time	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Ext. eff. green	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Arrival type	3	3	3	3	3	3	3	4	3	3	4	3
Unit Extension	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Ped/Bike/RTOR Volume	0	0	0	0	0	0	0	0	0	0	0	0
Lane Width	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
Parking (Y or N)	N		N	N		N	N		N	N		N
Parking/hr												
Bus stops/hr	0	0	0	0	0	0	0	0	0	0	0	0

	Excl. Left	Thru & RT	03	04	Excl. Left	Thru & RT	07	08
Timing	G = 26.0	G = 23.0	G = 0.0	G = 0.0	G = 10.0	G = 45.0	G = 0.0	G = 0.0
	Y = 4	Y = 4	Y = 0	Y = 0	Y = 4	Y = 4	Y = 0	Y = 0
Duration of Analysis (hrs) = 0.25					Cycle Length C = 120.0			

CAPACITY AND LOS WORKSHEET

General Information

Project Description *UH West Oahu - NSR/Farrington PM Pk Build Yr 2015*

Capacity Analysis

	EB			WB			NB			SB		
Lane group	L	T	R	L	T	R	L	T	R	L	T	R
Adj. flow rate	711	559	201	691	646	222	173	1674	503	239	1893	521
Satflow rate	3505	3618	1615	3505	3618	1615	3505	5176	1615	3505	5176	1615
Lost time	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Green ratio	0.22	0.19	0.31	0.22	0.19	0.31	0.08	0.38	0.63	0.08	0.38	0.63
Lane group cap.	759	693	498	759	693	498	292	1941	1009	292	1941	1009
v/c ratio	0.94	0.81	0.40	0.91	0.93	0.45	0.59	0.86	0.50	0.82	0.98	0.52
Flow ratio	0.20	0.15	0.12	0.20	0.18	0.14	0.05	0.32	0.31	0.07	0.37	0.32
Crit. lane group	Y	N	N		Y	N		N	N	Y	Y	N
Sum flow ratios	0.82											
Lost time/cycle	16.00											
Critical v/c ratio	0.94											

Lane Group Capacity, Control Delay, and LOS Determination

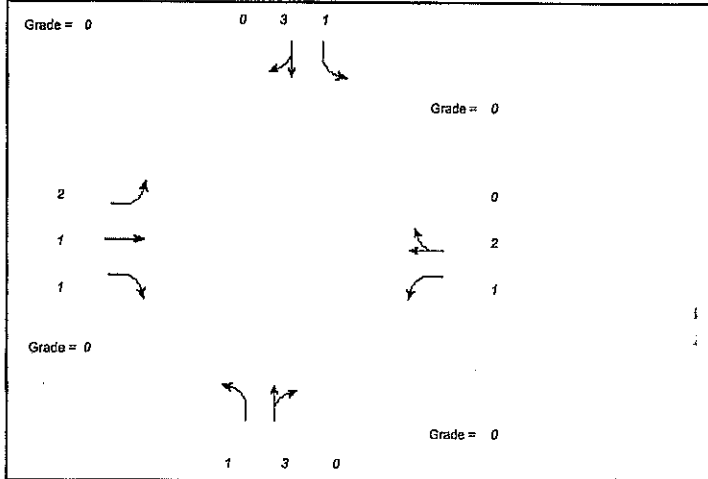
	EB			WB			NB			SB		
Lane group	L	T	R	L	T	R	L	T	R	L	T	R
Adj. flow rate	711	559	201	691	646	222	173	1674	503	239	1893	521
Lane group cap.	759	693	498	759	693	498	292	1941	1009	292	1941	1009
v/c ratio	0.94	0.81	0.40	0.91	0.93	0.45	0.59	0.86	0.50	0.82	0.98	0.52
Green ratio	0.22	0.19	0.31	0.22	0.19	0.31	0.08	0.38	0.63	0.08	0.38	0.63
Unif. delay d_1	46.2	46.4	32.8	45.9	47.7	33.3	53.0	34.6	12.3	54.1	37.0	12.5
Delay factor k	0.45	0.35	0.11	0.43	0.45	0.11	0.18	0.39	0.11	0.36	0.48	0.12
Increm. delay d_2	19.0	7.0	0.5	15.1	19.5	0.6	3.2	4.3	0.4	16.6	15.0	0.5
PF factor	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.920	1.000	1.000	0.920	1.000
Control delay	65.2	53.4	33.3	60.9	67.2	33.9	56.2	36.1	12.6	70.7	49.0	12.9
Lane group LOS	E	D	C	E	E	C	E	D	B	E	D	B
Apprch. delay	56.3			59.7			32.6			43.9		
Approach LOS	E			E			C			D		
Intersec. delay	45.9			Intersection LOS						D		

INPUT WORKSHEET

General Information		Site Information	
Analyst	JW	Intersection	North-South Rd/Road B
Agency or Co.	PBQ&D	Area Type	All other areas
Date Performed	5/15/2006	Jurisdiction	Honolulu
Time Period	PM Peak (2015 Build)	Analysis Year	2015 (PM Pk Build)

Project Description *UH West Oahu - NSR/Road B PM Pk Build Yr 2015*

Intersection Geometry



Volume and Timing Input

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume (vph)	521	190	155	35	165	220	139	1375	78	413	1748	346
% Heavy veh	0	0	0	0	0	0	0	0	0	0	0	0
PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Actuated (P/A)	A	A	A	A	A	A	A	A	A	A	A	A
Startup lost time	2.0	2.0	2.0	2.0	2.0		2.0	2.0		2.0	2.0	
Ext. eff. green	2.0	2.0	2.0	2.0	2.0		2.0	2.0		2.0	2.0	
Arrival type	3	3	3	3	3		3	4		3	4	
Unit Extension	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Ped/Bike/RTOR Volume	0	0	0	0	0	0	0	0	0	0	0	0
Lane Width	12.0	12.0	12.0	12.0	12.0		12.0	12.0		12.0	12.0	
Parking (Y or N)	N		N	N		N	N		N	N		N
Parking/hr												
Bus stops/hr	0	0	0	0	0		0	0		0	0	

	Excl. Left	EB Only	Thru & RT	04	Excl. Left	SB Only	Thru & RT	08
Timing	G = 13.0	G = 5.0	G = 17.0	G =	G = 15.0	G = 14.0	G = 40.0	G =
	Y = 4	Y = 0	Y = 4	Y =	Y = 4	Y = 0	Y = 4	Y =

Duration of Analysis (hrs) = 0.25 — Cycle Length C = 120.0

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CAPACITY AND LOS WORKSHEET

General Information

Project Description *UH West Oahu - NSR/Road B PM Pk Build Yr 2015*

Capacity Analysis

	EB			WB			NB			SB		
Lane group	L	T	R	L	TR		L	TR		L	TR	
Adj. flow rate	579	211	172	39	427		154	1615		459	2326	
Satflow rate	3505	1900	1615	1805	3308		1805	5134		1805	5047	
Lost time	2.0	2.0	2.0	2.0	2.0		2.0	2.0		2.0	2.0	
Green ratio	0.18	0.18	0.18	0.11	0.14		0.13	0.33		0.28	0.45	
Lane group cap.	643	348	296	196	469		226	1711		496	2271	
v/c ratio	0.90	0.61	0.58	0.20	0.91		0.68	0.94		0.93	1.02	
Flow ratio	0.17	0.11	0.11	0.02	0.13		0.09	0.31		0.25	0.46	
Crit. lane group	Y	N	N		Y			Y		Y	N	
Sum flow ratios	0.86											
Lost time/cycle	8.00											
Critical v/c ratio	0.92											

Lane Group Capacity, Control Delay, and LOS Determination

	EB			WB			NB			SB		
Lane group	L	T	R	L	TR		L	TR		L	TR	
Adj. flow rate	579	211	172	39	427		154	1615		459	2326	
Lane group cap.	643	348	296	196	469		226	1711		496	2271	
v/c ratio	0.90	0.61	0.58	0.20	0.91		0.68	0.94		0.93	1.02	
Green ratio	0.18	0.18	0.18	0.11	0.14		0.13	0.33		0.28	0.45	
Unif. delay d_1	47.9	45.0	44.8	48.8	50.7		50.2	38.9		42.3	33.0	
Delay factor k	0.42	0.19	0.17	0.11	0.43		0.25	0.46		0.44	0.50	
Increm. delay d_2	15.8	3.0	2.9	0.5	21.8		8.1	11.2		23.4	25.3	
PF factor	1.000	1.000	1.000	1.000	1.000		1.000	0.958		1.000	0.836	
Control delay	63.7	48.0	47.7	49.3	72.5		58.3	48.5		65.7	52.9	
Lane group LOS	E	D	D	D	E		E	D		E	D	
Apprch. delay	57.4			70.6			49.3			55.0		
Approach LOS	E			E			D			E		
Intersec. delay	54.9			Intersection LOS						D		

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TWO-WAY STOP CONTROL SUMMARY

General Information		Site Information	
Analyst	JW	Intersection	North-South Road/Road E
Agency/Co.	PBQD	Jurisdiction	Honolulu
Date Performed	5/15/2006	Analysis Year	2015 Build (PM Pk)
Analysis Time Period	PM Peak (2015 Build)		

Project Description: UH West Oahu - NSR/Road E PM Pk Build Yr 2015

East/West Street: Road E | North/South Street: North-South Road

Intersection Orientation: North-South | Study Period (hrs): 0.25

Vehicle Volumes and Adjustments

Major Street	Northbound			Southbound		
Movement	1	2	3	4	5	6
	L	T	R	L	T	R
Volume		1534	40		1836	102
Peak-Hour Factor, PHF	0.90	0.90	0.90	0.90	0.90	0.90
Hourly Flow Rate, HFR	0	1704	44	0	2040	113
Percent Heavy Vehicles	0	--	--	0	--	--
Median Type	Raised curb					
RT Channelized			0			0
Lanes	0	2	0	0	2	0
Configuration		T	TR		T	TR
Upstream Signal		0			0	

Minor Street	Eastbound			Westbound		
Movement	7	8	9	10	11	12
	L	T	R	L	T	R
Volume			97			76
Peak-Hour Factor, PHF	0.90	0.90	0.90	0.90	0.90	0.90
Hourly Flow Rate, HFR	0	0	107	0	0	84
Percent Heavy Vehicles	0	0	0	0	0	0
Percent Grade (%)		0			0	
Flared Approach		N			N	
Storage		0			0	
RT Channelized			1			1
Lanes	0	0	1	0	0	1
Configuration			R			R

Delay, Queue Length, and Level of Service

Approach	Northbound	Southbound	Westbound			Eastbound		
Movement	1	4	7	8	9	10	11	12
Lane Configuration					R			R
v (vph)					84			107
C (m) (vph)					297			218
v/c					0.28			0.49
95% queue length					1.13			2.46
Control Delay					21.8			36.5
LOS					C			E
Approach Delay	--	--	21.8			36.5		
Approach LOS	--	--	C			E		

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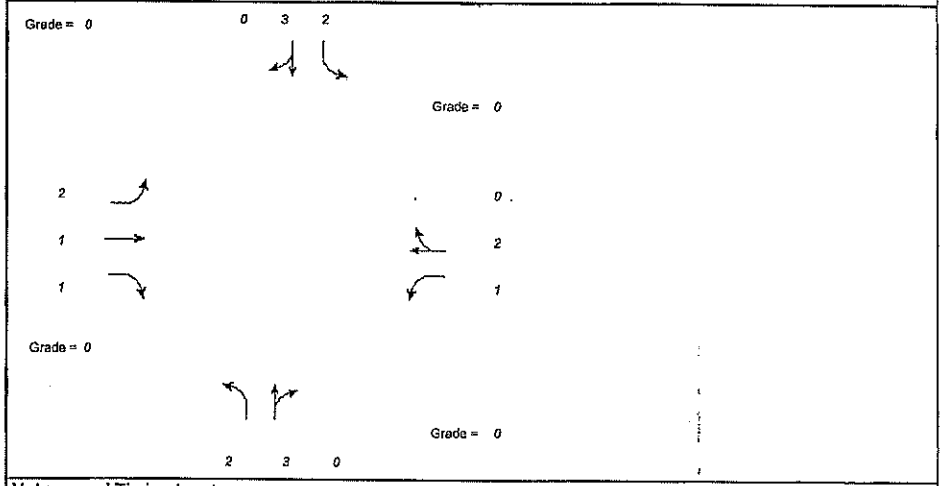
INPUT WORKSHEET

General Information		Site Information	
Analyst	JW	Intersection	North-South Rd/Road F
Agency or Co.	PBQ&D	Area Type	All other areas
Date Performed	5/15/2006	Jurisdiction	Honolulu
Time Period	PM Peak (2015 Build)	Analysis Year	2015 (PM Pk Build)

Project Description: UH West Oahu - NSR/Road F PM Pk Build Yr 2015

Intersection Geometry



Volume and Timing Input

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume (vph)	447	470	213	77	538	150	258	977	80	412	1043	478
% Heavy veh	0	0	0	0	0	0	0	0	0	0	0	0
PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Actuated (P/A)	A	A	A	A	A	A	A	A	A	A	A	A
Startup lost time	2.0	2.0	2.0	2.0	2.0		2.0	2.0		2.0	2.0	
Ext. eff. green	2.0	2.0	2.0	2.0	2.0		2.0	2.0		2.0	2.0	
Arrival type	3	3	3	3	3		3	3		3	3	
Unit Extension	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Ped/Bike/RTOR Volume	0	0	0	0	0	0	0	0	0	0	0	0
Lane Width	12.0	12.0	12.0	12.0	12.0		12.0	12.0		12.0	12.0	
Parking (Y or N)	N		N	N		N	N		N	N		N
Parking/hr												
Bus stops/hr	0	0	0	0	0		0	0		0	0	

	Excl. Left	EB Only	Thru & RT	04	Excl. Left	SB Only	Thru & RT	08
Timing	G = 12.0	G = 4.0	G = 32.0	G =	G = 13.0	G = 3.0	G = 40.0	G =
	Y = 4	Y = 0	Y = 4	Y =	Y = 4	Y = 0	Y = 4	Y =

Duration of Analysis (hrs) = 0.25 | Cycle Length C = 120.0

 HCS+™ Version 5.1 Generated: 5/19/2006 9:24 AM

CAPACITY AND LOS WORKSHEET

General Information

Project Description *UH West Oahu - NSR/Road F PM Pk Build Yr 2015*

Capacity Analysis

	EB			WB			NB			SB		
Lane group	L	T	R	L	TR		L	TR		L	TR	
Adj. flow rate	497	522	237	86	765		287	1175		458	1690	
Satflow rate	3505	1900	1615	1805	3499		3505	5117		3505	4932	
Lost time	2.0	2.0	2.0	2.0	2.0		2.0	2.0		2.0	2.0	
Green ratio	0.17	0.30	0.44	0.10	0.27		0.11	0.33		0.17	0.36	
Lane group cap.	584	570	713	181	933		380	1706		584	1767	
v/c ratio	0.85	0.92	0.33	0.48	0.82		0.76	0.69		0.78	0.96	
Flow ratio	0.14	0.27	0.15	0.05	0.22		0.08	0.23		0.13	0.34	
Crit. lane group	Y	N	N		Y		Y	N			Y	
Sum flow ratios	0.78											
Lost time/cycle	12.00											
Critical v/c ratio	0.87											

Lane Group Capacity, Control Delay, and LOS Determination

	EB			WB			NB			SB		
Lane group	L	T	R	L	TR		L	TR		L	TR	
Adj. flow rate	497	522	237	86	765		287	1175		458	1690	
Lane group cap.	584	570	713	181	933		380	1706		584	1767	
v/c ratio	0.85	0.92	0.33	0.48	0.82		0.76	0.69		0.78	0.96	
Green ratio	0.17	0.30	0.44	0.10	0.27		0.11	0.33		0.17	0.36	
Unif. delay d_1	48.6	40.5	21.9	51.0	41.3		52.0	34.6		47.9	37.6	
Delay factor k	0.38	0.43	0.11	0.11	0.36		0.31	0.26		0.33	0.47	
Increm. delay d_2	11.5	19.6	0.3	2.0	5.9		8.4	1.2		6.9	12.7	
PF factor	1.000	1.000	1.000	1.000	1.000		1.000	1.000		1.000	1.000	
Control delay	60.1	60.2	22.2	53.0	47.2		60.4	35.8		54.9	50.2	
Lane group LOS	E	E	C	D	D		E	D		D	D	
Apprch. delay	53.0			47.8			40.6			51.2		
Approach LOS	D			D			D			D		
Intersec. delay	48.4			Intersection LOS						D		

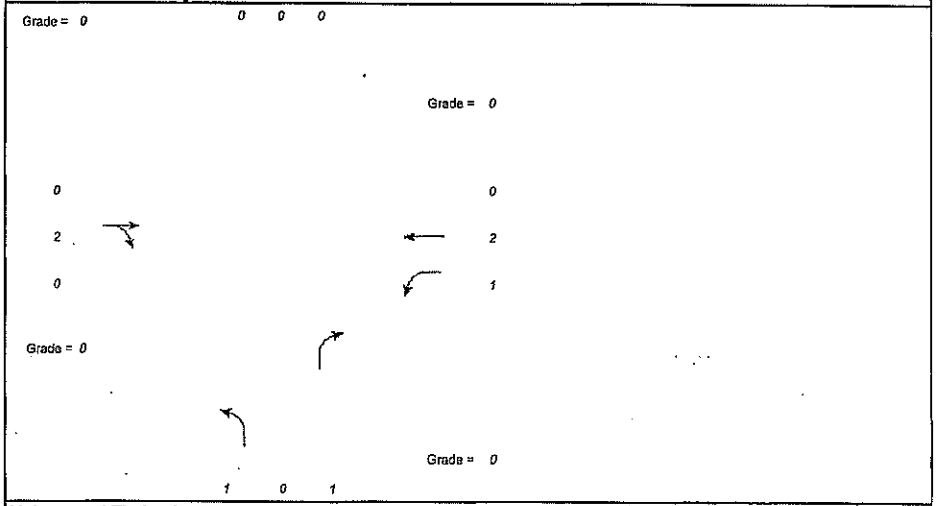
 HCS+™ Version 5.1 Generated: 5/19/2006 9:25 AM

INPUT WORKSHEET

General Information		Site Information	
Analyst	JW	Intersection	Farrington Hwy/ Road A
Agency or Co.	PBQ&D	Area Type	All other areas
Date Performed	5/15/2006	Jurisdiction	Honolulu
Time Period	PM Peak (2015 Build)	Analysis Year	2015 (PM Pk Build)

Project Description *UH West Oahu - Farrington/Rd A PM Pk Build Yr 2015*

Intersection Geometry



Volume and Timing Input

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume (vph)		969	15	230	976		22		355			
% Heavy veh	0	0	0	0	0	0	0	0	0	0	0	0
PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Actuated (P/A)		A	A	A	A		A		A			
Startup lost time		2.0		2.0	2.0		2.0	2.0	2.0		2.0	
Ext. eff. green		2.0		2.0	2.0		2.0	2.0	2.0		2.0	
Arrival type		3		3	3		3	3	3		3	
Unit Extension		3.0		3.0	3.0		3.0	3.0	3.0		3.0	
Ped/Bike/RTOR Volume	0	0	0	0	0	0	0	0	0	0	0	0
Lane Width		12.0		12.0	12.0		12.0	12.0	12.0		12.0	
Parking (Y or N)	N		N	N		N	N		N	N		N
Parking/hr												
Bus stops/hr		0		0	0		0	0	0		0	

	WB Only	Thru & RT	03	04	NB Only	06	07	08
Timing	G = 35.0	G = 46.0	G =	G =	G = 27.0	G =	G =	G =
	Y = 4	Y = 4	Y =	Y =	Y = 4	Y =	Y =	Y =

Duration of Analysis (hrs) = 0.25 Cycle Length C = 120.0

 HCS+™ Version 5.1 Generated: 5/18/2006 9:48 AM

CAPACITY AND LOS WORKSHEET

General Information

Project Description *UH West Oahu - Farrington/Rd A PM Pk Build Yr 2015*

Capacity Analysis

	EB	WB		NB			SB
Lane group	TR	L	T	L		R	
Adj. flow rate	1094	256	1084	24	0	394	0
Satflow rate	3609	1805	3618	1805		1615	
Lost time	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Green ratio	0.38	0.29	0.71	0.22	0.00	0.55	0.00
Lane group cap.	1383	526	2563	406		888	
v/c ratio	0.79	0.49	0.42	0.06		0.44	
Flow ratio	0.30	0.14	0.30	0.01		0.24	
Crit. lane group	Y		N		N	Y	N
Sum flow ratios	0.55						
Lost time/cycle	8.00						
Critical v/c ratio	0.59						

Lane Group Capacity, Control Delay, and LOS Determination

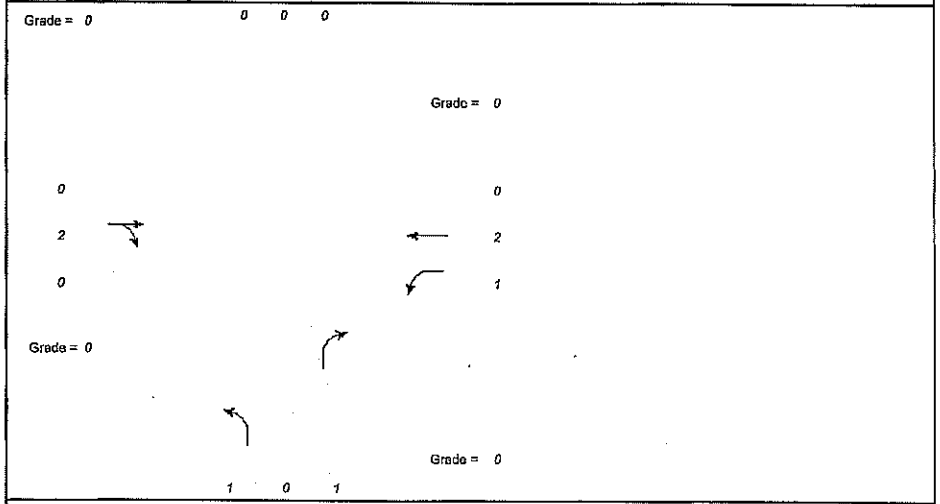
	EB	WB		NB			SB
Lane group	TR	L	T	L		R	
Adj. flow rate	1094	256	1084	24	0	394	0
Lane group cap.	1383	526	2563	406		888	
v/c ratio	0.79	0.49	0.42	0.06		0.44	
Green ratio	0.38	0.29	0.71	0.22	0.00	0.55	0.00
Unif. delay d_1	32.7	35.1	7.3	36.5		16.1	
Delay factor k	0.34	0.11	0.11	0.11		0.11	
Increm. delay d_2	3.2	0.7	0.1	0.1		0.4	
PF factor	1.000	1.000	1.000	1.000		1.000	
Control delay	36.0	35.8	7.4	36.6		16.4	
Lane group LOS	D	D	A	D		B	
Apprch. delay	36.0	12.8		17.6			
Approach LOS	D	B		B			
Intersec. delay	22.4	Intersection LOS					C

INPUT WORKSHEET

General Information		Site Information	
Analyst	JW	Intersection	Farrington Hwy/ Road F
Agency or Co.	PBQ&D	Area Type	All other areas
Date Performed	5/15/2006	Jurisdiction	Honolulu
Time Period	PM Peak (2015 Build)	Analysis Year	2015 (PM Pk Build)

Project Description *UH West Oahu - Farrington/Rd F PM Pk Build Yr 2015*

Intersection Geometry



Volume and Timing Input

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume (vph)		785	294	263	735		333		199			
% Heavy veh	0	0	0	0	0	0	0	0	0	0	0	0
PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Actuated (P/A)		A	A	A	A		A		A			
Startup lost time		2.0		2.0	2.0		2.0	2.0	2.0		2.0	
Ext. eff. green		2.0		2.0	2.0		2.0	2.0	2.0		2.0	
Arrival type		3		3	3		3	3	3		3	
Unit Extension		3.0		3.0	3.0		3.0	3.0	3.0		3.0	
Ped/Bike/RTOR Volume	0	0	0	0	0	0	0	0	0	0	0	0
Lane Width		12.0		12.0	12.0		12.0	12.0	12.0		12.0	
Parking (Y or N)	N		N	N		N	N		N	N		N
Parking/hr												
Bus stops/hr		0		0	0		0	0	0		0	

	WB Only	Thru & RT	03	04	NB Only	06	07	08
Timing	G = 35.0	G = 45.0	G = 0.0	G = 0.0	G = 32.0	G = 0.0	G = 0.0	G = 0.0
	Y = 0	Y = 4	Y = 0	Y = 0	Y = 4	Y = 0	Y = 0	Y = 0

Duration of Analysis (hrs) = 0.25 Cycle Length C = 120.0

CAPACITY AND LOS WORKSHEET

General Information

Project Description *UH West Oahu - Farrington/Rd F PM Pk Build Yr 2015*

Capacity Analysis

	EB		WB		NB			SB	
Lane group	TR		L	T	L		R		
Adj. flow rate	1199		292	817	370	0	221	0	
Satflow rate	3470		1805	3618	1805		1615		
Lost time	2.0		2.0	2.0	2.0	2.0	2.0	2.0	
Green ratio	0.38		0.29	0.67	0.27	0.00	0.27	0.00	
Lane group cap.	1301		526	2412	481		431		
v/c ratio	0.92		0.56	0.34	0.77		0.51		
Flow ratio	0.35		0.16	0.23	0.20		0.14		
Crit. lane group	Y		Y	N	Y	N	N	N	
Sum flow ratios	0.71								
Lost time/cycle	8.00								
Critical v/c ratio	0.76								

Lane Group Capacity, Control Delay, and LOS Determination

	EB		WB		NB			SB	
Lane group	TR		L	T	L		R		
Adj. flow rate	1199		292	817	370	0	221	0	
Lane group cap.	1301		526	2412	481		431		
v/c ratio	0.92		0.56	0.34	0.77		0.51		
Green ratio	0.38		0.29	0.67	0.27	0.00	0.27	0.00	
Unif. delay d_1	35.8		35.9	8.6	40.6		37.4		
Delay factor k	0.44		0.15	0.11	0.32		0.12		
Increm. delay d_2	10.9		1.3	0.1	7.4		1.0		
PF factor	1.000		1.000	1.000	1.000		1.000		
Control delay	46.7		37.2	8.7	48.0		38.4		
Lane group LOS	D		D	A	D		D		
Apprch. delay	46.7		16.2		44.4				
Approach LOS	D		B		D				
Intersec. delay	34.6		Intersection LOS					C	

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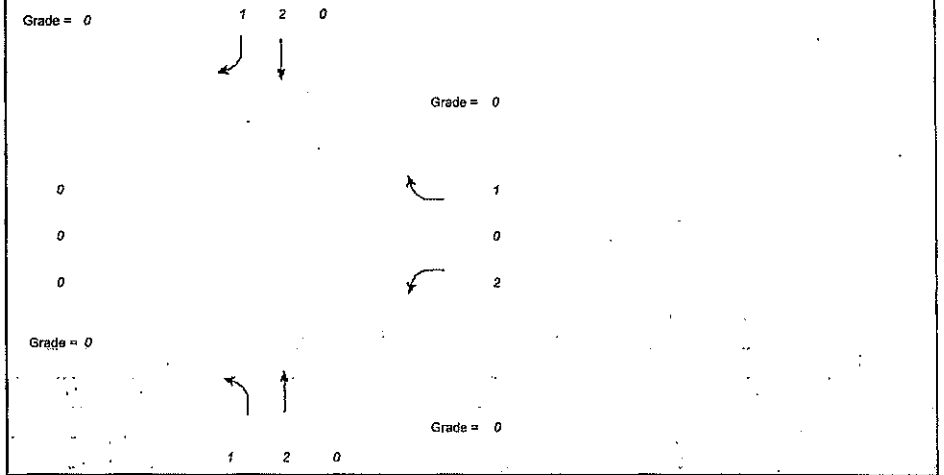
INPUT WORKSHEET

General Information		Site Information	
Analyst	JW	Intersection	N-S Rd/H-1 WB Off
Agency or Co.	PBQD	Area Type	All other areas
Date Performed	5/15/2006	Jurisdiction	Honolulu
Time Period	~~AM Peak (2008 Phase 1)~~	Analysis Year	2008 Phase 1

Project Description *UH-West Oahu - NS Rd/H-1 WB Off Ramp - AM Pk Hr 2008 Phase 1*

Intersection Geometry



Volume and Timing Input

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume (vph)				627		85	230	127			845	45
% Heavy veh	0	0	0	0	0	0	0	0	0	0	0	0
PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Actuated (P/A)				A		A	A	A			A	A
Startup lost time		2.0		2.0	2.0	2.0	2.0	2.0			2.0	2.0
Ext. eff. green		2.0		2.0	2.0	2.0	2.0	2.0			2.0	2.0
Arrival type		3		3	3	3	3	3			3	3
Unit Extension		3.0		3.0	3.0	3.0	3.0	3.0			3.0	3.0
Ped/Bike/RTOR Volume	0	0	0	0	0	0	0	0	0	0	0	0
Lane Width		12.0		12.0	12.0	12.0	12.0	12.0			12.0	12.0
Parking (Y or N)	N		N	N		N	N		N	N		N
Parking/hr												
Bus stops/hr		0		0	0	0	0	0			0	0

	WB Only	02	03	04	NB Only	Thru & RT	07	08
Timing	G = 38.0	G =	G =	G =	G = 33.0	G = 41.0	G =	G =
	Y = 4	Y =	Y =	Y =	Y = 0	Y = 4	Y =	Y =

Duration of Analysis (hrs) = 0.25 Cycle Length C = 120.0

 HCS+™ Version 5.1 Generated: 5/18/2006 9:21 AM

CAPACITY AND LOS WORKSHEET

General Information

Project Description *UH-West Oahu - NS Rd/H-1 WB Off Ramp - AM Pk Hr 2008 Phase 1*

Capacity Analysis

	EB			WB			NB				SB		
Lane group				L		R	L	T			T	R	
Adj. flow rate		0		697	0	94	256	141			939	50	
Satflow rate				3505		1615	1805	3618			3618	1615	
Lost time		2.0		2.0	2.0	2.0	2.0	2.0			2.0	2.0	
Green ratio		0.00		0.32	0.00	0.32	0.28	0.62			0.34	0.69	
Lane group cap.				1110		511	496	2231			1236	1117	
v/c ratio				0.63		0.18	0.52	0.06			0.76	0.04	
Flow ratio				0.20		0.06	0.14	0.04			0.26	0.03	
Crit. lane group		N		Y	N	N	Y	N			Y	N	
Sum flow ratios	0.60												
Lost time/cycle	8.00												
Critical v/c ratio	0.64												

Lane Group Capacity, Control Delay, and LOS Determination

	EB			WB			NB				SB		
Lane group				L		R	L	T			T	R	
Adj. flow rate		0		697	0	94	256	141			939	50	
Lane group cap.				1110		511	496	2231			1236	1117	
v/c ratio				0.63		0.18	0.52	0.06			0.76	0.04	
Green ratio		0.00		0.32	0.00	0.32	0.28	0.62			0.34	0.69	
Unif. delay d_1				35.0		29.7	36.8	9.2			35.1	5.9	
Delay factor k				0.21		0.11	0.12	0.11			0.31	0.11	
Increm. delay d_2				1.1		0.2	0.9	0.0			2.8	0.0	
PF factor				1.000		1.000	1.000	1.000			1.000	1.000	
Control delay				36.1		29.9	37.7	9.2			37.9	5.9	
Lane group LOS				D		C	D	A			D	A	
Apprch. delay				35.4			27.6				36.3		
Approach LOS				D			C				D		
Intersec. delay	34.4			Intersection LOS							C		

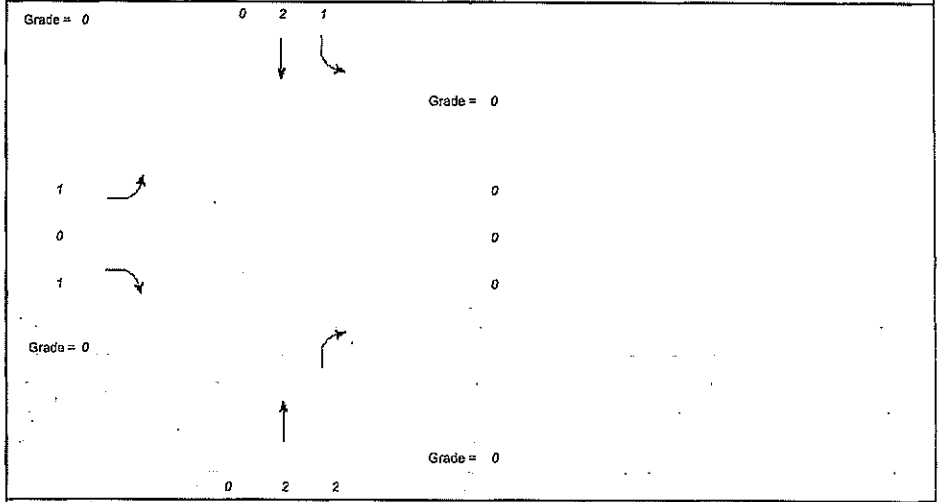
 HCS+™ Version 5.1 Generated: 5/18/2006 9:21 AM

INPUT WORKSHEET

General Information		Site Information	
Analyst	JW	Intersection	N-S Rd/H-1 EB Off
Agency or Co.	PBQD	Area Type	All other areas
Date Performed	5/15/2006	Jurisdiction	Honolulu
Time Period	AM Peak (2008 Phase 1)	Analysis Year	2008 Phase 1

Project Description *UH-West Oahu - NS Rd/H-1 EB Off Ramp - AM Pk Hr 2008 Phase 1*

Intersection Geometry



Volume and Timing Input

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume (vph)	45		256					312	1180	335	1137	
% Heavy veh	0	0	0	0	0	0	0	0	0	0	0	0
PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Actuated (P/A)	A		A					A	A	A	A	
Startup lost time	2.0	2.0	2.0		2.0			2.0	2.0	2.0	2.0	
Ext. eff. green	2.0	2.0	2.0		2.0			2.0	2.0	2.0	2.0	
Arrival type	3	3	3		3			3	3	3	3	
Unit Extension	3.0	3.0	3.0		3.0			3.0	3.0	3.0	3.0	
Ped/Bike/RTOR Volume	0	0	0	0	0	0	0	0	0	0	0	0
Lane Width	12.0	12.0	12.0		12.0			12.0	12.0	12.0	12.0	
Parking (Y or N)	N		N	N		N	N		N	N		N
Parking/hr												
Bus stops/hr	0	0	0		0			0	0	0	0	

	EB Only	02	03	04	NS Perm	Thru & RT	07	08
Timing	G = 27.0	G =	G =	G =	G = 42.0	G = 43.0	G =	G =
	Y = 4	Y =	Y =	Y =	Y = 0	Y = 4	Y =	Y =

Duration of Analysis (hrs) = 0.25 Cycle Length C = 120.0

 HCS+™ Version 5.1 Generated: 5/18/2006 9:20 AM

CAPACITY AND LOS WORKSHEET

General Information

Project Description *UH-West Oahu - NS Rd/H-1 EB Off Ramp - AM Pk Hr 2008 Phase 1*

Capacity Analysis

	EB			WB			NB		SB	
Lane group	L		R				T	R	L	T
Adj. flow rate	50	0	284		0		347	1311	372	1263
Satflow rate	1805		1615				3618	2859	1805	3618
Lost time	2.0	2.0	2.0		2.0		2.0	2.0	2.0	2.0
Green ratio	0.22	0.00	1.00		0.00		0.36	1.00	0.35	0.71
Lane group cap.	406		1615				1296	2859	632	2563
v/c ratio	0.12		0.18				0.27	0.46	0.59	0.49
Flow ratio	0.03		0.18				0.10	0.46	0.21	0.35
Crit. lane group		N	N		N		N	Y		N
Sum flow ratios	0.46									
Lost time/cycle	0.00									
Critical v/c ratio	0.46									

Lane Group Capacity, Control Delay, and LOS Determination

	EB			WB			NB		SB	
Lane group	L		R				T	R	L	T
Adj. flow rate	50	0	284		0		347	1311	372	1263
Lane group cap.	406		1615				1296	2859	632	2563
v/c ratio	0.12		0.18				0.27	0.46	0.59	0.49
Green ratio	0.22	0.00	1.00		0.00		0.36	1.00	0.35	0.71
Unif. delay d_1	37.1		0.0				27.3	0.0	31.9	7.8
Delay factor k	0.11		0.11				0.11	0.11	0.18	0.11
Increm. delay d_2	0.1		0.1				0.1	0.1	1.4	0.2
PF factor	1.000		0.950				1.000	0.950	1.000	1.000
Control delay	37.2		0.1				27.4	0.1	33.4	8.0
Lane group LOS	D		A				C	A	C	A
Apprch. delay	5.6						5.8		13.8	
Approach LOS	A						A		B	
Intersec. delay	9.4			Intersection LOS					A	

INPUT WORKSHEET

General Information

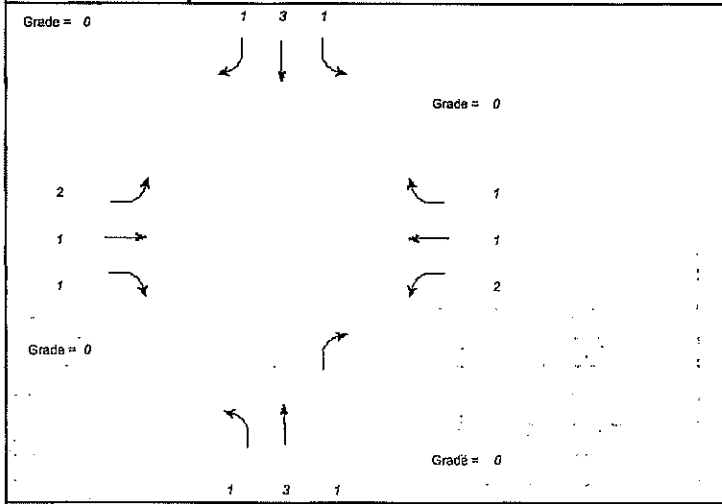
Analyst *JW*
Agency or Co. *PBQ&D*
Date Performed *5/15/2006*
Time Period *AM Peak (2008 Phase 1)*

Site Information

Intersection *North-South Rd/Farrington Hwy*
Area Type *All other areas*
Jurisdiction *Honolulu*
Analysis Year *2015 (AM Pk 2008 Phase 1*

Project Description *UH West Oahu - NSR/Farrington AM Pk Phase 1 Yr 2008*

Intersection Geometry



Volume and Timing Input

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume (vph)	239	250	63	64	561	265	59	988	50	335	727	331
% Heavy veh	0	0	0	0	0	0	0	0	0	0	0	0
PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Actuated (P/A)	A	A	A	A	A	A	A	A	A	A	A	A
Startup lost time	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Ext. eff. green	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Arrival type	3	3	3	3	3	3	3	4	3	3	4	3
Unit Extension	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Ped/Bike/RTOR Volume	0	0	0	0	0	0	0	0	0	0	0	0
Lane Width	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
Parking (Y or N)	N		N	N		N	N		N	N		N
Parking/hr												
Bus stops/hr	0	0	0	0	0	0	0	0	0	0	0	0

	Excl. Left	EB Only	Thru & RT	04	Excl. Left	SB Only	Thru & RT	08
Timing	G = 5.0	G = 5.0	G = 43.0	G =	G = 12.0	G = 11.0	G = 28.0	G =
	Y = 4	Y = 0	Y = 4	Y =	Y = 4	Y = 0	Y = 4	Y =
Duration of Analysis (hrs) = 0.25						Cycle Length C = 120.0		

CAPACITY AND LOS WORKSHEET

General Information

Project Description *UH West Oahu - NSR/Farrington AM Pk Phase 1 Yr 2008*

Capacity Analysis

	EB			WB			NB			SB		
Lane group	L	T	R	L	T	R	L	T	R	L	T	R
Adj. flow rate	266	278	70	71	623	294	66	1098	56	372	808	368
Satflow rate	3505	1900	1615	3505	1900	1615	1805	5176	1615	1805	5176	1615
Lost time	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Green ratio	0.12	0.40	0.53	0.04	0.36	0.62	0.10	0.23	0.31	0.22	0.32	0.40
Lane group cap.	409	760	861	146	681	996	181	1208	498	406	1682	646
v/c ratio	0.65	0.37	0.08	0.49	0.91	0.30	0.36	0.91	0.11	0.92	0.48	0.57
Flow ratio	0.08	0.15	0.04	0.02	0.33	0.18	0.04	0.21	0.03	0.21	0.16	0.23
Crit. lane group	Y	N	N		Y	N		Y	N	Y	N	N
Sum flow ratios	0.82											
Lost time/cycle	8.00											
Critical v/c ratio	0.88											

Lane Group Capacity, Control Delay, and LOS Determination

	EB			WB			NB			SB		
Lane group	L	T	R	L	T	R	L	T	R	L	T	R
Adj. flow rate	266	278	70	71	623	294	66	1098	56	372	808	368
Lane group cap.	409	760	861	146	681	996	181	1208	498	406	1682	646
v/c ratio	0.65	0.37	0.08	0.49	0.91	0.30	0.36	0.91	0.11	0.92	0.48	0.57
Green ratio	0.12	0.40	0.53	0.04	0.36	0.62	0.10	0.23	0.31	0.22	0.32	0.40
Unif. delay d_1	50.7	25.3	13.7	56.2	36.8	10.8	50.4	44.8	29.7	45.4	32.4	28.0
Delay factor k	0.23	0.11	0.11	0.11	0.43	0.11	0.11	0.43	0.11	0.43	0.11	0.16
Increm. delay d_2	3.6	0.3	0.0	2.5	17.0	0.2	1.3	10.2	0.1	25.3	0.2	1.2
PF factor	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.965	1.000
Control delay	54.3	25.6	13.7	58.8	53.8	10.9	51.7	55.0	29.8	70.6	31.5	29.2
Lane group LOS	D	C	B	E	D	B	D	D	C	E	C	C
Apprch. delay	36.7			41.4			53.6			40.4		
Approach LOS	D			D			D			D		
Intersec. delay	43.8			Intersection LOS						D		

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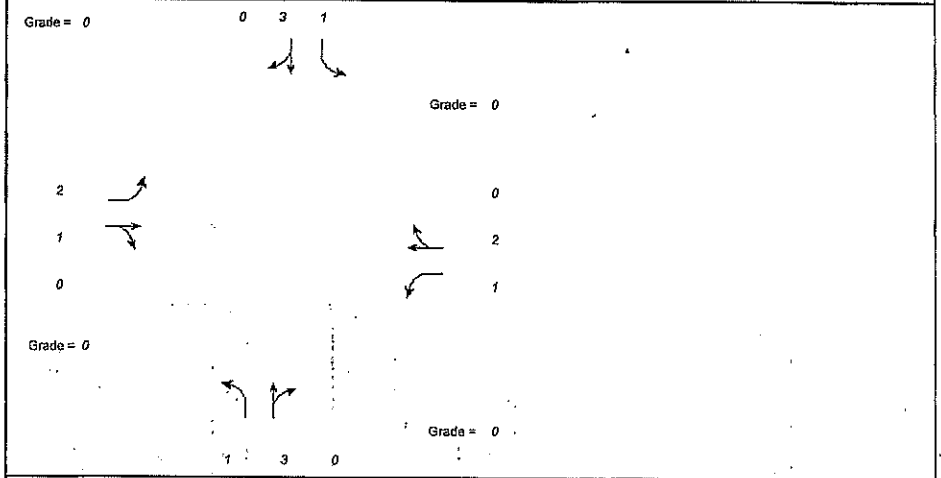
INPUT WORKSHEET

General Information		Site Information	
Analyst	JW	Intersection	North-South Rd/Road B
Agency or Co.	PBQ&D	Area Type	All other areas
Date Performed	5/15/2006	Jurisdiction	Honolulu
Time Period	AM Peak (2008 Phase 1)	Analysis Year	2008 (AM Pk Phase 1)

Project Description *UH West Oahu - NSR/Road B AM Pk 2008 Phase 1*

Intersection Geometry



Volume and Timing Input

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume (vph)	76	18	22	89	29	99	56	922	78	77	627	128
% Heavy veh	0	0	0	0	0	0	0	0	0	0	0	0
PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Actuated (P/A)	A	A	A	A	A	A	A	A	A	A	A	A
Startup lost time	2.0	2.0		2.0	2.0		2.0	2.0		2.0	2.0	
Ext. eff. green	2.0	2.0		2.0	2.0		2.0	2.0		2.0	2.0	
Arrival type	3	3		3	3		3	4		3	4	
Unit Extension	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
Ped/Bike/RTOR Volume	0	0	0	0	0	0	0	0	0	0	0	0
Lane Width	12.0	12.0		12.0	12.0		12.0	12.0		12.0	12.0	
Parking (Y or N)	N		N	N		N	N		N	N		N
Parking/hr												
Bus stops/hr	0	0		0	0		0	0		0	0	

	Excl. Left	Thru & RT	03	04	Excl. Left	Thru & RT	07	08
Timing	G = 17.0	G = 21.0	G =	G =	G = 18.0	G = 48.0	G =	G =
	Y = 4	Y = 4	Y =	Y =	Y = 4	Y = 4	Y =	Y =
Duration of Analysis (hrs) = 0.25						Cycle Length C = 120.0		

 HCS+™ Version 5.1 Generated: 5/19/2006 9:42 AM

CAPACITY AND LOS WORKSHEET

General Information

Project Description *UH West Oahu - NSR/Road B AM Pk 2008 Phase 1*

Capacity Analysis

	EB		WB		NB		SB	
Lane group	L	TR	L	TR	L	TR	L	TR
Adj. flow rate	84	44	99	142	62	1111	86	839
Satflow rate	3505	1745	1805	3197	1805	5115	1805	5044
Lost time	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Green ratio	0.14	0.17	0.14	0.17	0.15	0.40	0.15	0.40
Lane group cap.	497	305	256	559	271	2046	271	2018
v/c ratio	0.17	0.14	0.39	0.25	0.23	0.54	0.32	0.42
Flow ratio	0.02	0.03	0.05	0.04	0.03	0.22	0.05	0.17
Crit. lane group		N	Y	Y		Y	Y	N
Sum flow ratios	0.36							
Lost time/cycle	16.00							
Critical v/c ratio	0.42							

Lane Group Capacity, Control Delay, and LOS Determination

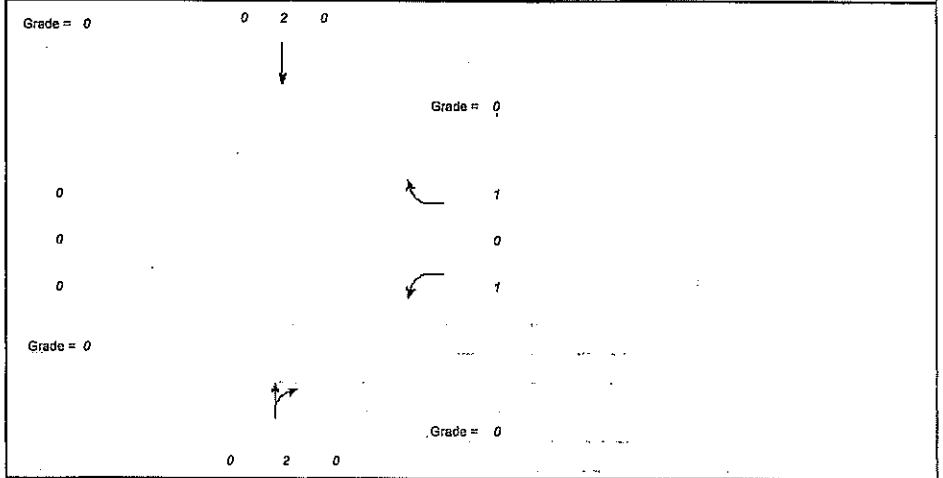
	EB		WB		NB		SB	
Lane group	L	TR	L	TR	L	TR	L	TR
Adj. flow rate	84	44	99	142	62	1111	86	839
Lane group cap.	497	305	256	559	271	2046	271	2018
v/c ratio	0.17	0.14	0.39	0.25	0.23	0.54	0.32	0.42
Green ratio	0.14	0.17	0.14	0.17	0.15	0.40	0.15	0.40
Unif. delay d_1	45.3	41.9	46.8	42.7	44.9	27.6	45.5	25.9
Delay factor k	0.11	0.11	0.11	0.11	0.11	0.14	0.11	0.11
Increm. delay d_2	0.2	0.2	1.0	0.2	0.4	0.3	0.7	0.1
PF factor	1.000	1.000	1.000	1.000	1.000	0.894	1.000	0.894
Control delay	45.5	42.1	47.7	43.0	45.3	25.0	46.2	23.3
Lane group LOS	D	D	D	D	D	C	D	C
Apprch. delay	44.3		44.9		26.1		25.4	
Approach LOS	D		D		C		C	
Intersec. delay	28.6		Intersection LOS				C	

INPUT WORKSHEET

General Information		Site Information	
Analyst	JW	Intersection	North-South Rd/Road F
Agency or Co.	PBQ&D	Area Type	All other areas
Date Performed	5/15/2006	Jurisdiction	Honolulu
Time Period	AM Peak (2008 Phase 1)	Analysis Year	2008 (AM Pk Phase 1)

Project Description *UH West Oahu - NSR/Road F AM Pk 2008 Phase 1*

Intersection Geometry



Volume and Timing Input

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume (vph)				5		34		1022	5	108	630	
% Heavy veh	0	0	0	0	0	0	0	0	0	0	0	0
PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Actuated (P/A)				A		A		A	A	A	A	
Startup lost time		2.0		2.0	2.0	2.0		2.0		2.0	2.0	
Ext. eff. green		2.0		2.0	2.0	2.0		2.0		2.0	2.0	
Arrival type		3		3	3	3		3		3	3	
Unit Extension		3.0		3.0	3.0	3.0		3.0		3.0	3.0	
Ped/Bike/RTOR Volume	0	0	0	0	0	0	0	0	0	0	0	0
Lane Width		12.0		12.0	12.0	12.0		12.0		12.0	12.0	
Parking (Y or N)	N		N	N		N	N		N	N		N
Parking/hr												
Bus stops/hr		0		0	0	0		0		0	0	

	WB Only	02	03	04	SB Only	NS Perm	07	08
Timing	G = 48.0	G =	G =	G =	G = 7.0	G = 53.0	G =	G =
	Y = 4	Y =	Y =	Y =	Y = 4	Y = 4	Y =	Y =
Duration of Analysis (hrs) = 0.25						Cycle Length C = 120.0		

CAPACITY AND LOS WORKSHEET

General Information

Project Description *UH West Oahu - NSR/Road F AM Pk 2008 Phase 1*

Capacity Analysis

	EB			WB			NB		SB	
Lane group			L		R		TR		DefL	T
Adj. flow rate		0	6	0	38		1142		120	700
Satflow rate			1805		1615		3615		1805	1900
Lost time		2.0	2.0	2.0	2.0		2.0		2.0	2.0
Green ratio		0.00	0.40	0.00	0.49		0.44		0.53	0.53
Lane group cap.			722		794		1597		198	1013
v/c ratio			0.01		0.05		0.72		0.61	0.69
Flow ratio			0.00		0.02		0.32		0.06	0.37
Crit. lane group		N	Y	N	N		Y			Y
Sum flow ratios	0.69									
Lost time/cycle	12.00									
Critical v/c ratio	0.76									

Lane Group Capacity, Control Delay, and LOS Determination

	EB			WB			NB		SB	
Lane group			L		R		TR		DefL	T
Adj. flow rate		0	6	0	38		1142		120	700
Lane group cap.			722		794		1597		198	1013
v/c ratio			0.01		0.05		0.72		0.61	0.69
Green ratio		0.00	0.40	0.00	0.49		0.44		0.53	0.53
Unif. delay d_1			21.7		15.9		27.3		20.3	20.7
Delay factor k			0.11		0.11		0.28		0.19	0.26
Increm. delay d_2			0.0		0.0		1.6		5.2	2.0
PF factor			1.000		1.000		1.000		1.000	1.000
Control delay			21.7		15.9		28.9		25.5	22.7
Lane group LOS			C		B		C		C	C
Apprch. delay			16.7				28.9		23.1	
Approach LOS			B				C		C	
Intersec. delay	26.3		Intersection LOS						C	

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INPUT WORKSHEET

General Information

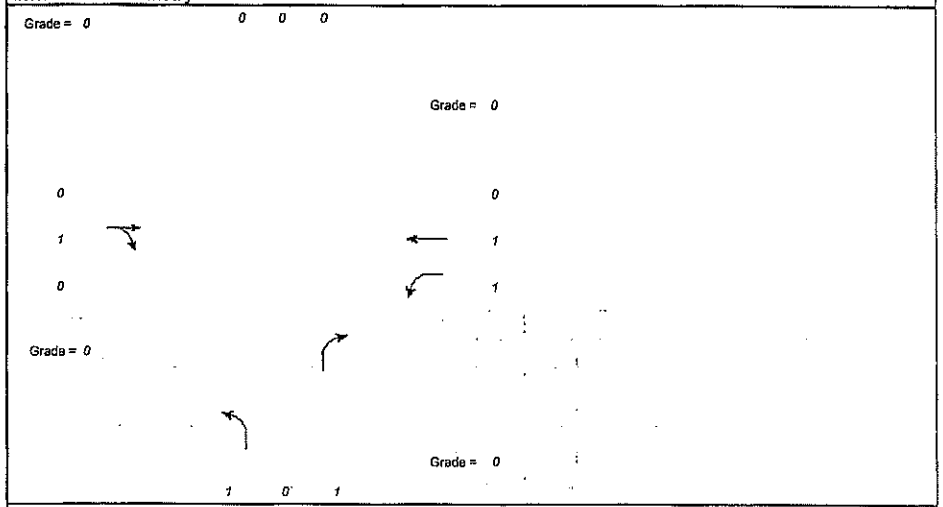
Analyst *JW*
Agency or Co. *PBQ&D*
Date Performed *5/15/2006*
Time Period *AM Peak (2008 Phase 1)*

Site Information

Intersection *Farrington Hwy/Road A*
Area Type *All other areas*
Jurisdiction *Honolulu*
Analysis Year *2015 (AM Pk 2008 Phase 1)*

Project Description *UH West Oahu - Farrington/Rd A AM Pk Phase 1 Yr 2008*

Intersection Geometry



Volume and Timing Input

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume (vph)		532	4	80	871		2		20			
% Heavy veh	0	0	0	0	0	0	0	0	0	0	0	0
PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Actuated (P/A)		A	A	A	A		A		A			
Startup lost time		2.0		2.0	2.0		2.0	2.0	2.0		2.0	
Ext. eff. green		2.0		2.0	2.0		2.0	2.0	2.0		2.0	
Arrival type		3		3	3		3	3	3		3	
Unit Extension		3.0		3.0	3.0		3.0	3.0	3.0		3.0	
Ped/Bike/RTOR Volume	0	0	0	0	0	0	0	0	0	0	0	0
Lane Width		12.0		12.0	12.0		12.0	12.0	12.0		12.0	
Parking (Y or N)	N		N	N		N	N		N	N		N
Parking/hr												
Bus stops/hr		0		0	0		0	0	0		0	

	WB Only	Thru & RT	03	04	NB Only	06	07	08
Timing	G = 25.0	G = 61.0	G =	G =	G = 22.0	G =	G =	G =
	Y = 4	Y = 4	Y =	Y =	Y = 4	Y =	Y =	Y =

Duration of Analysis (hrs) = 0.25 Cycle Length C = 120.0

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CAPACITY AND LOS WORKSHEET

General Information

Project Description *UH West Oahu - Farrington/Rd A AM Pk Phase 1 Yr 2008*

Capacity Analysis

	EB		WB		NB			SB	
Lane group	TR		L	T	L		R		
Adj. flow rate	595		89	968	2	0	22	0	
Satflow rate	1898		1805	1900	1805		1615		
Lost time	2.0		2.0	2.0	2.0	2.0	2.0	2.0	
Green ratio	0.51		0.21	0.75	0.18	0.00	0.43	0.00	
Lane group cap.	965		376	1425	331		686		
v/c ratio	0.62		0.24	0.68	0.01		0.03		
Flow ratio	0.31		0.05	0.51	0.00		0.01		
Crit. lane group	N			Y	Y	N	N	N	
Sum flow ratios	0.51								
Lost time/cycle	8.00								
Critical v/c ratio	0.55								

Lane Group Capacity, Control Delay, and LOS Determination

	EB		WB		NB			SB	
Lane group	TR		L	T	L		R		
Adj. flow rate	595		89	968	2	0	22	0	
Lane group cap.	965		376	1425	331		686		
v/c ratio	0.62		0.24	0.68	0.01		0.03		
Green ratio	0.51		0.21	0.75	0.18	0.00	0.43	0.00	
Unif. delay d_1	21.1		39.6	7.6	40.1		20.1		
Delay factor k	0.20		0.11	0.25	0.11		0.11		
Increm. delay d_2	1.2		0.3	1.3	0.0		0.0		
PF factor	1.000		1.000	1.000	1.000		1.000		
Control delay	22.3		39.9	9.0	40.1		20.1		
Lane group LOS	C		D	A	D		C		
Apprch. delay	22.3		11.6		21.8				
Approach LOS	C		B		C				
Intersec. delay	15.5		Intersection LOS					B	

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INPUT WORKSHEET

General Information

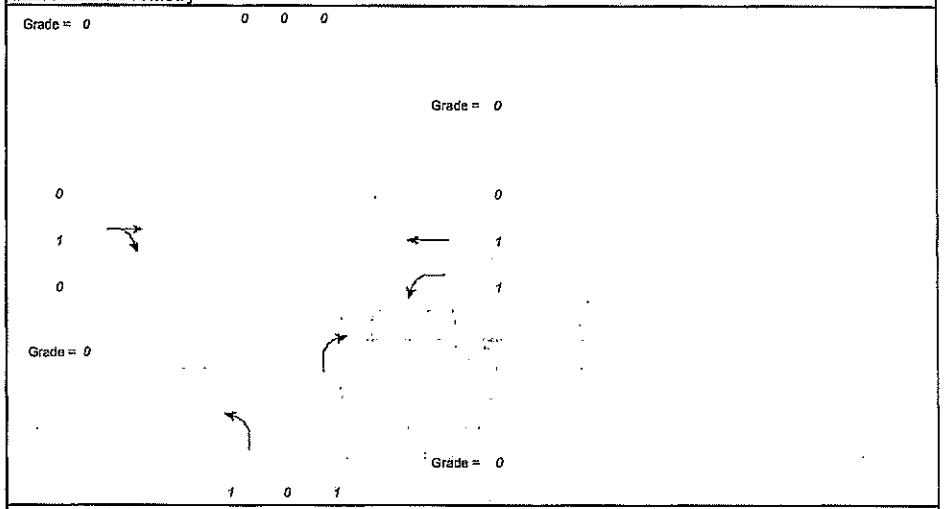
Analyst *JW*
Agency or Co. *PBQ&D*
Date Performed *5/15/2006*
Time Period *AM Peak (2008 Phase 1)*

Site Information

Intersection *Farrington Hwy/ Road F*
Area Type *All other areas*
Jurisdiction *Honolulu*
Analysis Year *2015 (AM Pk 2008 Phase 1)*

Project Description *UH West Oahu - Farrington/Rd F AM Pk Phase 1 Yr 2008*

Intersection Geometry



Volume and Timing Input

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume (vph)		386	13	99	774		37		150			
% Heavy veh	0	0	0	0	0	0	0	0	0	0	0	0
PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Actuated (P/A)		A	A	A	A		A		A			
Startup lost time		2.0		2.0	2.0		2.0	2.0	2.0		2.0	
Ext. eff. green		2.0		2.0	2.0		2.0	2.0	2.0		2.0	
Arrival type		3		3	3		3	3	3		3	
Unit Extension		3.0		3.0	3.0		3.0	3.0	3.0		3.0	
Ped/Bike/RTOR Volume	0	0	0	0	0	0	0	0	0	0	0	0
Lane Width		12.0		12.0	12.0		12.0	12.0	12.0		12.0	
Parking (Y or N)	N		N	N		N	N		N	N		N
Parking/hr												
Bus stops/hr		0		0	0		0	0	0		0	

	WB Only	Thru & RT	03	04	NB Only	06	07	08
Timing	G = 27.0	G = 54.0	G = 0.0	G = 0.0	G = 27.0	G = 0.0	G = 0.0	G = 0.0
	Y = 4	Y = 4	Y = 0	Y = 0	Y = 4	Y = 0	Y = 0	Y = 0

Duration of Analysis (hrs) = 0.25 Cycle Length C = 120.0

 HCS+™ Version 5.1 Generated: 5/18/2006 9:22 AM

CAPACITY AND LOS WORKSHEET

General Information

Project Description *UH West Oahu - Farrington/Rd F AM Pk Phase 1 Yr 2008*

Capacity Analysis

	EB			WB			NB				SB			
Lane group		TR			L	T		L			R			
Adj. flow rate		443			110	860		41	0		167		0	
Satflow rate		1892			1805	1900		1805			1615			
Lost time		2.0			2.0	2.0		2.0	2.0		2.0		2.0	
Green ratio		0.45			0.22	0.71		0.22	0.00		0.48		0.00	
Lane group cap.		851			406	1346		406			781			
v/c ratio		0.52			0.27	0.64		0.10			0.21			
Flow ratio		0.23			0.06	0.45		0.02			0.10			
Crit. lane group		N				Y		Y	N		N		N	
Sum flow ratios	0.48													
Lost time/cycle	8.00													
Critical v/c ratio	0.51													

Lane Group Capacity, Control Delay, and LOS Determination

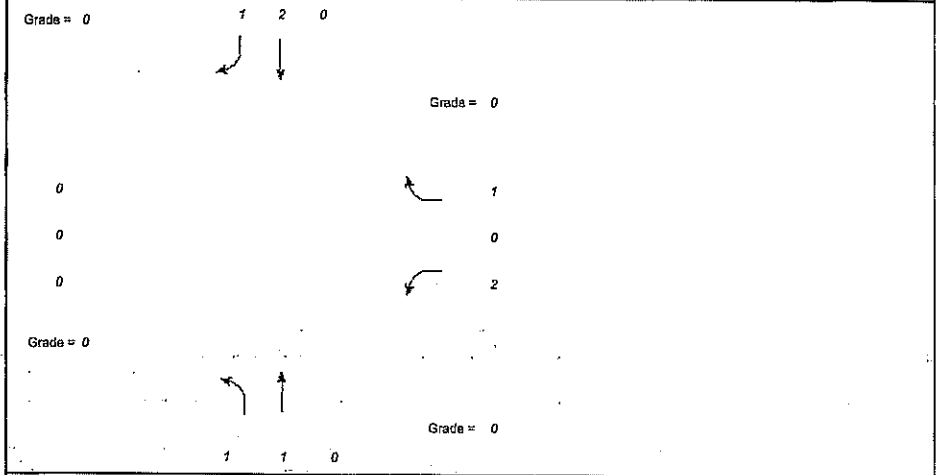
	EB			WB			NB				SB			
Lane group		TR			L	T		L			R			
Adj. flow rate		443			110	860		41	0		167		0	
Lane group cap.		851			406	1346		406			781			
v/c ratio		0.52			0.27	0.64		0.10			0.21			
Green ratio		0.45			0.22	0.71		0.22	0.00		0.48		0.00	
Unif. delay d_1		23.7			38.4	9.3		36.9			17.9			
Delay factor k		0.13			0.11	0.22		0.11			0.11			
Increm. delay d_2		0.6			0.4	1.0		0.1			0.1			
PF factor		1.000			1.000	1.000		1.000			1.000			
Control delay		24.3			38.7	10.4		37.0			18.0			
Lane group LOS		C			D	B		D			B			
Apprch. delay	24.3			13.6			21.7							
Approach LOS	C			B			C							
Intersec. delay	17.5			Intersection LOS							B			

INPUT WORKSHEET

General Information		Site Information	
Analyst	JW	Intersection	N-S Rd/H-1 WB Off
Agency or Co.	PBQD	Area Type	All other areas
Date Performed	5/15/2006	Jurisdiction	Honolulu
Time Period	~~PM Peak (2008 Phase 1)~~	Analysis Year	2008 Phase 1

Project Description *UH-West Oahu - NS Rd H-1 WB Off Ramp - PM Pk Hr 2008 Phase 1*

Intersection Geometry



Volume and Timing Input

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume (vph)				1255		230	450	414			392	135
% Heavy veh	0	0	0	0	0	0	0	0	0	0	0	0
PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Actuated (P/A)				A		A	A	A			A	A
Startup lost time		2.0		2.0	2.0	2.0	2.0	2.0			2.0	2.0
Ext. eff. green		2.0		2.0	2.0	2.0	2.0	2.0			2.0	2.0
Arrival type		3		3	3	3	3	3			3	3
Unit Extension		3.0		3.0	3.0	3.0	3.0	3.0			3.0	3.0
Ped/Bike/RTOR Volume	0	0	0	0	0	0	0	0	0	0	0	0
Lane Width		12.0		12.0	12.0	12.0	12.0	12.0			12.0	12.0
Parking (Y or N)	N		N	N		N	N		N	N		N
Parking/hr												
Bus stops/hr		0		0	0	0	0	0			0	0

	WB Only	02	03	04	NB Only	Thru & RT	07	08
Timing	G = 50.0	G =	G =	G =	G = 39.0	G = 23.0	G =	G =
	Y = 4	Y =	Y =	Y =	Y = 0	Y = 4	Y =	Y =

Duration of Analysis (hrs) = 0.25 Cycle Length C = 120.0

CAPACITY AND LOS WORKSHEET

General Information

Project Description *UH-West Oahu - NS Rd H-1 WB Off Ramp - PM Pk Hr 2008 Phase 1*

Capacity Analysis

	EB			WB			NB			SB	
Lane group				L		R	L	T		T	R
Adj. flow rate		0		1394	0	256	500	460		436	150
Satflow rate				3505		1615	1805	1900		3618	1615
Lost time		2.0		2.0	2.0	2.0	2.0	2.0		2.0	2.0
Green ratio		0.00		0.42	0.00	0.42	0.32	0.52		0.19	0.64
Lane group cap.				1460		673	587	982		693	1036
v/c ratio				0.95		0.38	0.85	0.47		0.63	0.14
Flow ratio				0.40		0.16	0.28	0.24		0.12	0.09
Crit. lane group		N		Y	N	N	Y	N		Y	N
Sum flow ratios	0.80										
Lost time/cycle	8.00										
Critical v/c ratio	0.85										

Lane Group Capacity, Control Delay, and LOS Determination

	EB			WB			NB			SB	
Lane group				L		R	L	T		T	R
Adj. flow rate		0		1394	0	256	500	460		436	150
Lane group cap.				1460		673	587	982		693	1036
v/c ratio				0.95		0.38	0.85	0.47		0.63	0.14
Green ratio		0.00		0.42	0.00	0.42	0.32	0.52		0.19	0.64
Unif. delay d_1				33.9		24.3	37.8	18.5		44.6	8.5
Delay factor k				0.46		0.11	0.38	0.11		0.21	0.11
Increm. delay d_2				14.2		0.4	11.5	0.4		1.8	0.1
PF factor				1.000		1.000	1.000	1.000		1.000	1.000
Control delay				48.1		24.6	49.4	18.8		46.4	8.6
Lane group LOS				D		C	D	B		D	A
Apprch. delay				44.5			34.7			36.7	
Approach LOS				D			C			D	
Intersec. delay	40.1			Intersection LOS						D	

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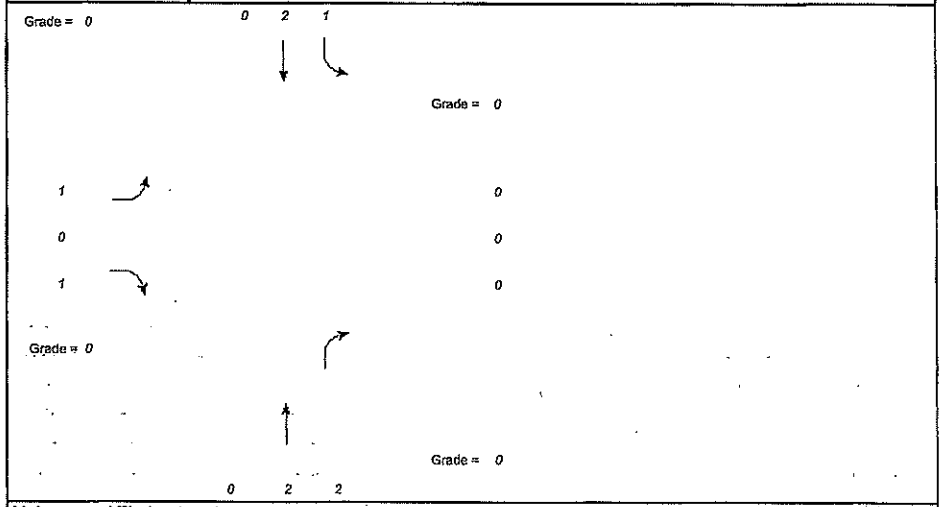
INPUT WORKSHEET

General Information		Site Information	
Analyst	JW	Intersection	N-S Rd/H-1 EB Off
Agency or Co.	PBQD	Area Type	All other areas
Date Performed	5/15/2006	Jurisdiction	Honolulu
Time Period	PM Peak (2008 Phase 1)	Analysis Year	2008 (PM Pk Phase 1)

Project Description *UH-West Oahu - NS Rd H-1 EB Off Ramp - PM Pk Hr 2008 Phase 1*

Intersection Geometry



Volume and Timing Input

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume (vph)	15		261					623	606	160	913	
% Heavy veh	0	0	0	0	0	0	0	0	0	0	0	0
PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Actuated (P/A)	A		A					A	A	A	A	
Startup lost time	2.0	2.0	2.0		2.0			2.0	2.0	2.0	2.0	
Ext. eff. green	2.0	2.0	2.0		2.0			2.0	2.0	2.0	2.0	
Arrival type	3	3	3		3			3	3	3	3	
Unit Extension	3.0	3.0	3.0		3.0			3.0	3.0	3.0	3.0	
Ped/Bike/RTOR Volume	0	0	0	0	0	0	0	0	0	0	0	0
Lane Width	12.0	12.0	12.0		12.0			12.0	12.0	12.0	12.0	
Parking (Y or N)	N		N	N		N	N		N	N		N
Parking/hr												
Bus stops/hr	0	0	0		0			0	0	0	0	

	EB Only	02	03	04	NS Perm	Thru & RT	07	08
Timing	G = 33.0	G =	G =	G =	G = 37.0	G = 42.0	G =	G =
	Y = 4	Y =	Y =	Y =	Y = 0	Y = 4	Y =	Y =
Duration of Analysis (hrs) = 0.25						Cycle Length C = 120.0		

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CAPACITY AND LOS WORKSHEET

General Information

Project Description *UH-West Oahu - NS Rd H-1 EB Off Ramp - PM Pk Hr 2008 Phase 1*

Capacity Analysis

	EB			WB			NB		SB	
Lane group	L		R				T	R	L	T
Adj. flow rate	17	0	290	0			692	673	178	1014
Satflow rate	1805		1615				3618	2859	1805	3618
Lost time	2.0	2.0	2.0	2.0			2.0	2.0	2.0	2.0
Green ratio	0.28	0.00	1.00	0.00			0.35	1.00	0.31	0.66
Lane group cap.	496		1615				1266	2859	557	2382
v/c ratio	0.03		0.18				0.55	0.24	0.32	0.43
Flow ratio	0.01		0.18				0.19	0.24	0.10	0.28
Crit. lane group	Y	N	N	N			Y	N	Y	N
Sum flow ratios	0.30									
Lost time/cycle	8.00									
Critical v/c ratio	0.32									

Lane Group Capacity, Control Delay, and LOS Determination

	EB			WB			NB		SB	
Lane group	L		R				T	R	L	T
Adj. flow rate	17	0	290	0			692	673	178	1014
Lane group cap.	496		1615				1266	2859	557	2382
v/c ratio	0.03		0.18				0.55	0.24	0.32	0.43
Green ratio	0.28	0.00	1.00	0.00			0.35	1.00	0.31	0.66
Unif. delay d_1	31.8		0.0				31.3	0.0	31.8	9.7
Delay factor k	0.11		0.11				0.15	0.11	0.11	0.11
Increm. delay d_2	0.0		0.1				0.5	0.0	0.3	0.1
PF factor	1.000		0.950				1.000	0.950	1.000	1.000
Control delay	31.9		0.1				31.8	0.0	32.2	9.9
Lane group LOS	C		A				C	A	C	A
Apprch. delay	1.8						16.2		13.2	
Approach LOS	A						B		B	
Intersec. delay	13.4			Intersection LOS					B	

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INPUT WORKSHEET

General Information

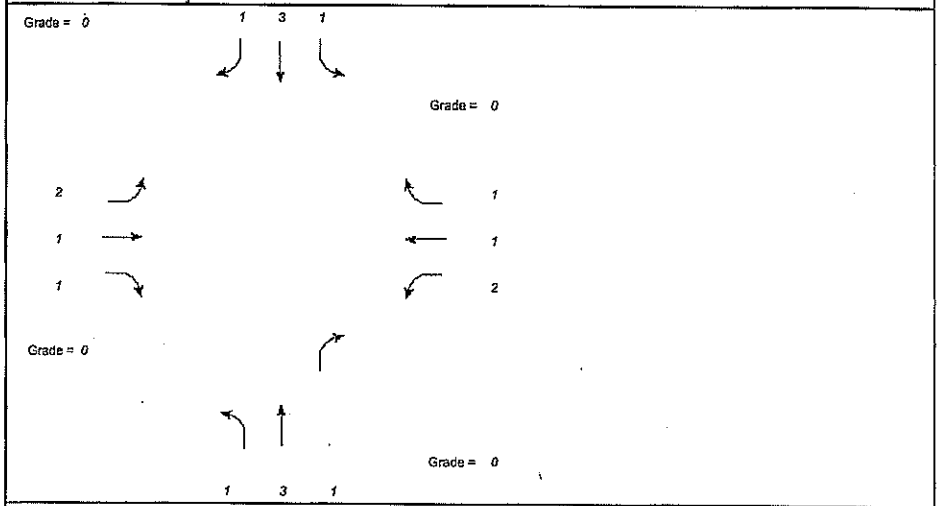
Analyst	JW
Agency or Co.	PBQ&D
Date Performed	5/15/2006
Time Period	PM Peak (2008 Phase 1)

Site Information

Intersection	North-South Rd/Farrington Hwy
Area Type	All other areas
Jurisdiction	Honolulu
Analysis Year	2008 (PM Pk Phase 1)

Project Description *UH West Oahu - NSR/Farrington PM Pk 2008 Phase 1*

Intersection Geometry



Volume and Timing Input

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume (vph)	357	405	264	350	489	200	59	988	50	215	738	221
% Heavy veh	0	0	0	0	0	0	0	0	0	0	0	0
PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Actuated (P/A)	A	A	A	A	A	A	A	A	A	A	A	A
Startup lost time	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Ext. eff. green	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Arrival type	3	3	3	3	3	3	3	4	3	3	4	3
Unit Extension	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Ped/Bike/RTOR Volume	0	0	0	0	0	0	0	0	0	0	0	0
Lane Width	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
Parking (Y or N)	N		N	N		N	N		N	N		N
Parking/hr												
Bus stops/hr	0	0	0	0	0	0	0	0	0	0	0	0

	Excl. Left	Thru & RT	03	04	Excl. Left	NB Only	Thru & RT	08
Timing	G = 16.0	G = 38.0	G = 0.0	G =	G = 22.0	G = 5.0	G = 23.0	G = 0.0
	Y = 4	Y = 4	Y = 0	Y =	Y = 4	Y = 0	Y = 4	Y = 0

Duration of Analysis (hrs) = 0.25 Cycle Length C = 120.0

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CAPACITY AND LOS WORKSHEET

General Information

Project Description *UH West Oahu - NSR/Farrington PM Pk 2008 Phase 1*

Capacity Analysis

	EB			WB			NB			SB		
Lane group	L	T	R	L	T	R	L	T	R	L	T	R
Adj. flow rate	397	450	293	389	543	222	66	1098	56	239	820	246
Satflow rate	3505	1900	1615	3505	1900	1615	1805	5176	1615	1805	5176	1615
Lost time	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Green ratio	0.13	0.32	0.53	0.13	0.32	0.53	0.26	0.23	0.40	0.18	0.19	0.36
Lane group cap.	467	602	861	467	602	861	466	1208	646	331	992	579
v/c ratio	0.85	0.75	0.34	0.83	0.90	0.26	0.14	0.91	0.09	0.72	0.83	0.42
Flow ratio	0.11	0.24	0.18	0.11	0.29	0.14	0.04	0.21	0.03	0.13	0.16	0.15
Crit. lane group	Y	N	N		Y	N		Y	N	Y	N	N
Sum flow ratios	0.74											
Lost time/cycle	16.00											
Critical v/c ratio	0.86											

Lane Group Capacity, Control Delay, and LOS Determination

	EB			WB			NB			SB		
Lane group	L	T	R	L	T	R	L	T	R	L	T	R
Adj. flow rate	397	450	293	389	543	222	66	1098	56	239	820	246
Lane group cap.	467	602	861	467	602	861	466	1208	646	331	992	579
v/c ratio	0.85	0.75	0.34	0.83	0.90	0.26	0.14	0.91	0.09	0.72	0.83	0.42
Green ratio	0.13	0.32	0.53	0.13	0.32	0.53	0.26	0.23	0.40	0.18	0.19	0.36
Unif. delay d_1	50.8	36.7	16.0	50.7	39.2	15.2	34.3	44.8	22.4	46.1	46.6	29.1
Delay factor k	0.38	0.30	0.11	0.37	0.42	0.11	0.11	0.43	0.11	0.28	0.36	0.11
Increm. delay d_2	13.9	5.1	0.2	12.2	16.9	0.2	0.1	10.2	0.1	7.5	5.9	0.5
PF factor	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Control delay	64.7	41.8	16.2	62.9	56.1	15.3	34.4	55.0	22.4	53.7	52.5	29.6
Lane group LOS	E	D	B	E	E	B	C	D	C	D	D	C
Apprch. delay	43.2			50.5			52.4			48.4		
Approach LOS	D			D			D			D		
Intersec. delay	48.7			Intersection LOS						D		

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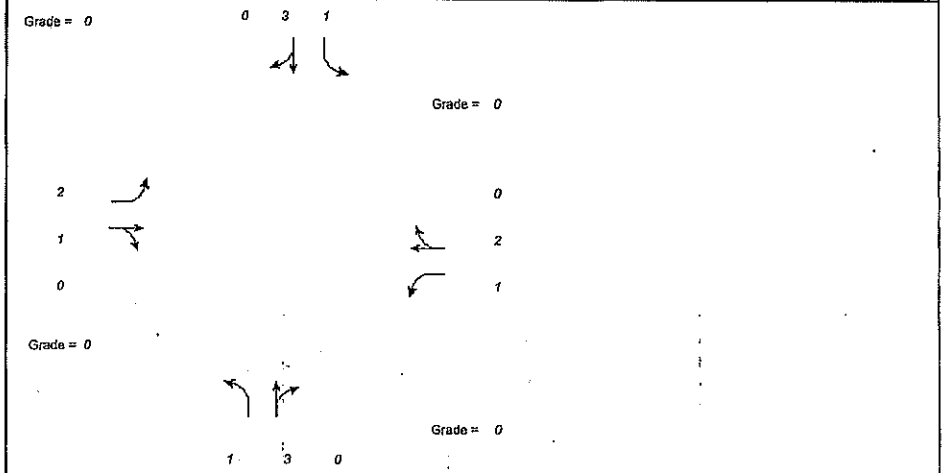
INPUT WORKSHEET

General Information		Site Information	
Analyst	JW	Intersection	North-South Rd/Road B
Agency or Co.	PBQ&D	Area Type	All other areas
Date Performed	5/15/2006	Jurisdiction	Honolulu
Time Period	PM Peak (2008 Phase 1)	Analysis Year	2008 (PM Pk Phase 1)

Project Description *UH West Oahu - NSR/Road B PM Pk 2008 Phase 1*

Intersection Geometry



Volume and Timing Input

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume (vph)	156	44	66	35	36	70	42	890	96	121	1122	109
% Heavy veh	0	0	0	0	0	0	0	0	0	0	0	0
PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Actuated (P/A)	A	A	A	A	A	A	A	A	A	A	A	A
Startup lost time	2.0	2.0		2.0	2.0		2.0	2.0		2.0	2.0	
Ext. eff. green	2.0	2.0		2.0	2.0		2.0	2.0		2.0	2.0	
Arrival type	3	3		3	3		3	4		3	4	
Unit Extension	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
Ped/Bike/RTOR Volume	0	0	0	0	0	0	0	0	0	0	0	0
Lane Width	12.0	12.0		12.0	12.0		12.0	12.0		12.0	12.0	
Parking (Y or N)	N		N	N		N	N		N	N		N
Parking/hr												
Bus stops/hr	0	0		0	0		0	0		0	0	

	Excl. Left	EB Only	Thru & RT	04	Excl. Left	SB Only	Thru & RT	08
Timing	G = 14.0	G = 5.0	G = 13.0	G =	G = 15.0	G = 14.0	G = 43.0	G =
	Y = 4	Y = 0	Y = 4	Y =	Y = 4	Y = 0	Y = 4	Y =

Duration of Analysis (hrs) = 0.25 Cycle Length C = 120.0

 HCS+™ Version 5.1 Generated: 5/19/2006 9:42 AM

CAPACITY AND LOS WORKSHEET

General Information

Project Description *UH West Oahu - NSR/Road B PM Pk 2008 Phase 1*

Capacity Analysis

	EB		WB		NB		SB	
Lane group	L	TR	L	TR	L	TR	L	TR
Adj. flow rate	173	122	39	118	47	1096	134	1368
Satflow rate	3505	1729	1805	3259	1805	5100	1805	5107
Lost time	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Green ratio	0.19	0.15	0.12	0.11	0.13	0.36	0.28	0.47
Lane group cap.	672	259	211	353	226	1827	496	2426
v/c ratio	0.26	0.47	0.18	0.33	0.21	0.60	0.27	0.56
Flow ratio	0.05	0.07	0.02	0.04	0.03	0.21	0.07	0.27
Crit. lane group		Y	Y	N	Y	N		Y
Sum flow ratios	0.39							
Lost time/cycle	16.00							
Critical v/c ratio	0.45							

Lane Group Capacity, Control Delay, and LOS Determination

	EB		WB		NB		SB	
Lane group	L	TR	L	TR	L	TR	L	TR
Adj. flow rate	173	122	39	118	47	1096	134	1368
Lane group cap.	672	259	211	353	226	1827	496	2426
v/c ratio	0.26	0.47	0.18	0.33	0.21	0.60	0.27	0.56
Green ratio	0.19	0.15	0.12	0.11	0.13	0.36	0.28	0.47
Unif. delay d_1	41.2	46.6	47.8	49.5	47.2	31.5	34.1	22.6
Delay factor k	0.11	0.11	0.11	0.11	0.11	0.19	0.11	0.16
Increm. delay d_2	0.2	1.4	0.4	0.6	0.5	0.6	0.3	0.3
PF factor	1.000	1.000	1.000	1.000	1.000	0.936	1.000	0.803
Control delay	41.4	48.0	48.3	50.1	47.6	30.0	34.4	18.4
Lane group LOS	D	D	D	D	D	C	C	B
Apprch. delay	44.2		49.6		30.7		19.9	
Approach LOS	D		D		C		B	
Intersec. delay	27.7		Intersection LOS				C	

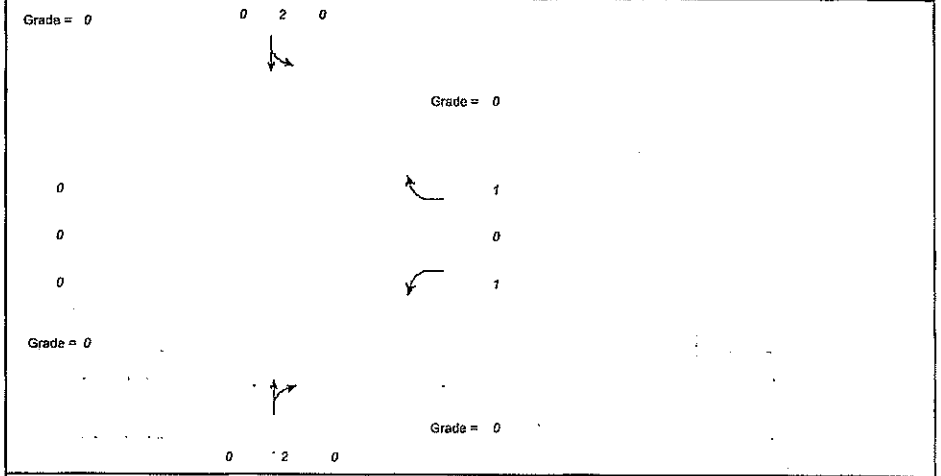
 HCS+™ Version 5.1 Generated: 5/19/2006 9:42 AM

INPUT WORKSHEET

General Information		Site Information	
Analyst	JW	Intersection	North-South Rd/Road F
Agency or Co.	PBQ&D	Area Type	All other areas
Date Performed	5/15/2006	Jurisdiction	Honolulu
Time Period	PM Peak (2008 Phase 1)	Analysis Year	2008 (PM Pk Phase 1)

Project Description *UH West Oahu - NSR/Road F PM Pk 2008 Phase 1*

Intersection Geometry



Volume and Timing Input

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume (vph)				5		58		970	5	179	1044	
% Heavy veh	0	0	0	0	0	0	0	0	0	0	0	0
PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Actuated (P/A)				A		A		A	A	A	A	
Startup lost time		2.0		2.0	2.0	2.0		2.0			2.0	
Ext. eff. green		2.0		2.0	2.0	2.0		2.0			2.0	
Arrival type		3		3	3	3		3			3	
Unit Extension		3.0		3.0	3.0	3.0		3.0			3.0	
Ped/Bike/RTOR Volume	0	0	0	0	0	0	0	0	0	0	0	0
Lane Width		12.0		12.0	12.0	12.0		12.0			12.0	
Parking (Y or N)	N		N	N		N	N		N	N		N
Parking/hr												
Bus stops/hr		0		0	0	0		0			0	

	WB Only	02	03	04	SB Only	NS Perm	07	08
Timing	G = 35.0	G =	G =	G =	G = 22.0	G = 51.0	G =	G =
	Y = 4	Y =	Y =	Y =	Y = 4	Y = 4	Y =	Y =
Duration of Analysis (hrs) = 0.25						Cycle Length C = 120.0		

 HCS+™ Version 5.1 Generated: 5/18/2006 9:35 AM

CAPACITY AND LOS WORKSHEET

General Information

Project Description *UH West Oahu - NSR/Road F PM Pk 2008 Phase 1*

Capacity Analysis

	EB			WB			NB			SB		
Lane group				L		R	TR			LT		
Adj. flow rate		0		6	0	64	1084			1359		
Satflow rate				1805		1615	3615			3591		
Lost time		2.0		2.0	2.0	2.0	2.0			2.0		
Green ratio		0.00		0.29	0.00	0.51	0.43			0.64		
Lane group cap.				526		821	1536			1495		
v/c ratio				0.01		0.08	0.71			0.91		
Flow ratio				0.00		0.04	0.30			0.18		
Cril. lane group		N		Y	N	N	N			Y		
Sum flow ratios	0.57											
Lost time/cycle	8.00											
Critical v/c ratio	0.61											

Lane Group Capacity, Control Delay, and LOS Determination

	EB			WB			NB			SB		
Lane group				L		R	TR			LT		
Adj. flow rate		0		6	0	64	1084			1359		
Lane group cap.				526		821	1536			1495		
v/c ratio				0.01		0.08	0.71			0.91		
Green ratio		0.00		0.29	0.00	0.51	0.43			0.64		
Unif. delay d_1				30.2		15.1	28.3			18.5		
Delay factor k				0.11		0.11	0.27			0.43		
Increm. delay d_2				0.0		0.0	1.5			8.5		
PF factor				1.000		1.000	1.000			1.000		
Control delay				30.2		15.1	29.8			27.0		
Lane group LOS				C		B	C			C		
Apprch. delay				16.4			29.8			27.0		
Approach LOS				B			C			C		
Intersec. delay	27.9			Intersection LOS						C		

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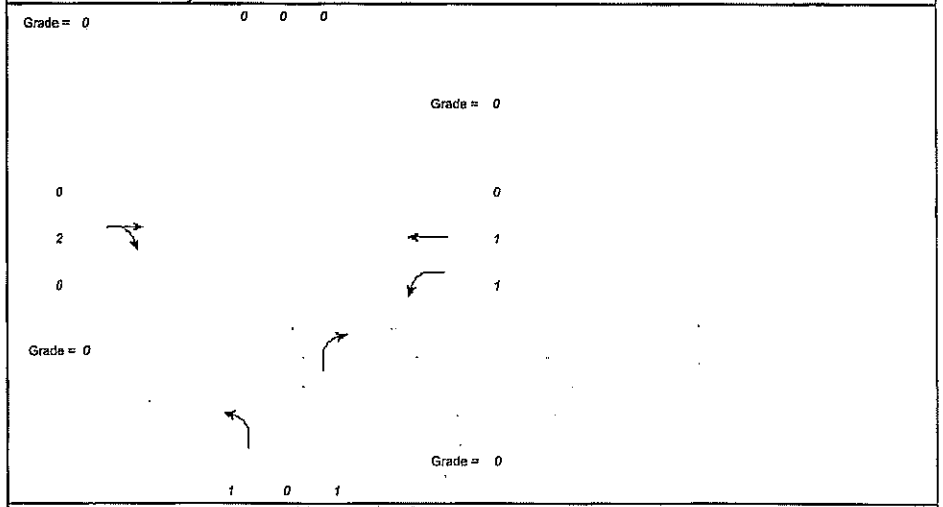
INPUT WORKSHEET

General Information		Site Information	
Analyst	JW	Intersection	Farriington Hwy/ Road A
Agency or Co.	PBQ&D	Area Type	All other areas
Date Performed	5/15/2006	Jurisdiction	Honolulu
Time Period	PM Peak (2008 Phase 1)	Analysis Year	2008 (PM Pk Phase 1)

Project Description *UH West Oahu - Farrington/Rd A PM Pk 2008 Phase 1*

Intersection Geometry



Volume and Timing Input

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume (vph)		954	2	80	871		2		20			
% Heavy veh	0	0	0	0	0	0	0	0	0	0	0	0
PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Actuated (P/A)		A	A	A	A		A		A			
Startup lost time		2.0		2.0	2.0		2.0	2.0	2.0		2.0	
Ext. eff. green		2.0		2.0	2.0		2.0	2.0	2.0		2.0	
Arrival type		3		3	3		3	3	3		3	
Unit Extension		3.0		3.0	3.0		3.0	3.0	3.0		3.0	
Ped/Bike/RTOR Volume	0	0	0	0	0	0	0	0	0	0	0	0
Lane Width		12.0		12.0	12.0		12.0	12.0	12.0		12.0	
Parking (Y or N)	N		N	N		N	N		N	N		N
Parking/hr												
Bus stops/hr		0		0	0		0	0	0		0	

	WB Only	Thru & RT	03	04	NB Only	06	07	08
Timing	G = 35.0	G = 43.0	G =	G =	G = 30.0	G =	G =	G =
	Y = 4	Y = 4	Y =	Y =	Y = 4	Y =	Y =	Y =

Duration of Analysis (hrs) = 0.25 Cycle Length C = 120.0

 HCS+™ Version 5.1 Generated: 5/18/2006 9:30 AM

CAPACITY AND LOS WORKSHEET

General Information

Project Description *UH West Oahu - Farrington/Rd A PM Pk 2008 Phase 1*

Capacity Analysis

	EB	WB		NB			SB	
Lane group	TR	L	T	L		R		
Adj. flow rate	1062	89	968	2	0	22	0	
Satflow rate	3617	1805	1900	1805		1615		
Lost time	2.0	2.0	2.0	2.0	2.0	2.0	2.0	
Green ratio	0.36	0.29	0.68	0.25	0.00	0.57	0.00	
Lane group cap.	1296	526	1298	451		929		
v/c ratio	0.82	0.17	0.75	0.00		0.02		
Flow ratio	0.29	0.05	0.51	0.00		0.01		
Crit. lane group	N		Y	Y	N	N	N	
Sum flow ratios	0.51							
Lost time/cycle	8.00							
Critical v/c ratio	0.55							

Lane Group Capacity, Control Delay, and LOS Determination

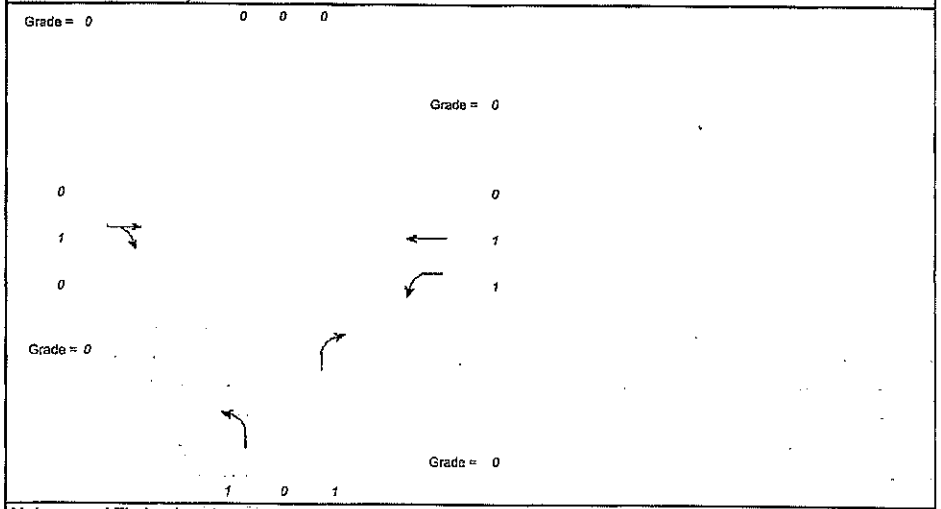
	EB	WB		NB			SB	
Lane group	TR	L	T	L		R		
Adj. flow rate	1062	89	968	2	0	22	0	
Lane group cap.	1296	526	1298	451		929		
v/c ratio	0.82	0.17	0.75	0.00		0.02		
Green ratio	0.36	0.29	0.68	0.25	0.00	0.57	0.00	
Unif. delay d_1	35.0	31.7	12.3	33.8		11.0		
Delay factor k	0.36	0.11	0.30	0.11		0.11		
Increm. delay d_2	4.3	0.2	2.4	0.0		0.0		
PF factor	1.000	1.000	1.000	1.000		1.000		
Control delay	39.3	31.8	14.7	33.8		11.0		
Lane group LOS	D	C	B	C		B		
Apprch. delay	39.3	16.1		12.9				
Approach LOS	D	B		B				
Intersec. delay	27.6	Intersection LOS					C	

INPUT WORKSHEET

General Information		Site Information	
Analyst	JW	Intersection	Farrlington Hwy/ Road F
Agency or Co.	PBQ&D	Area Type	All other areas
Date Performed	5/15/2006	Jurisdiction	Honolulu
Time Period	PM Peak (2008 Phase 1)	Analysis Year	2008 (PM Pk Phase 1)

Project Description *UH West Oahu - Farrington/Rd F PM Pk 2008 Phase 1*

Intersection Geometry



Volume and Timing Input

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume (vph)		761	37	220	713		39		150			
% Heavy veh	0	0	0	0	0	0	0	0	0	0	0	0
PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Actuated (P/A)		A	A	A	A		A		A			
Startup lost time		2.0		2.0	2.0		2.0	2.0	2.0		2.0	
Ext. eff. green		2.0		2.0	2.0		2.0	2.0	2.0		2.0	
Arrival type		3		3	3		3	3	3		3	
Unit Extension		3.0		3.0	3.0		3.0	3.0	3.0		3.0	
Ped/Bike/RTOR Volume	0	0	0	0	0	0	0	0	0	0	0	0
Lane Width		12.0		12.0	12.0		12.0	12.0	12.0		12.0	
Parking (Y or N)	N		N	N		N	N		N	N		N
Parking/hr												
Bus stops/hr		0		0	0		0	0	0		0	

	WB Only	Thru & RT	03	04	NB Only	06	07	08
Timing	G = 29.0	G = 61.0	G = 0.0	G = 0.0	G = 22.0	G = 0.0	G = 0.0	G = 0.0
	Y = 0	Y = 4	Y = 0	Y = 0	Y = 4	Y = 0	Y = 0	Y = 0

Duration of Analysis (hrs) = 0.25 Cycle Length C = 120.0

CAPACITY AND LOS WORKSHEET

General Information

Project Description *UH West Oahu - Farrington/Rd F PM Pk 2008 Phase 1*

Capacity Analysis

	EB		WB			NB			SB		
Lane group	TR		L	T		L		R			
Adj. flow rate	887		244	792		43	0	167		0	
Satflow rate	1888		1805	1900		1805		1615			
Lost time	2.0		2.0	2.0		2.0	2.0	2.0		2.0	
Green ratio	0.51		0.24	0.75		0.18	0.00	0.18		0.00	
Lane group cap.	960		436	1425		331		296			
v/c ratio	0.92		0.56	0.56		0.13		0.56			
Flow ratio	0.47		0.14	0.42		0.02		0.10			
Crit. lane group	Y		Y	N			N	Y		N	
Sum flow ratios	0.71										
Lost time/cycle	8.00										
Critical v/c ratio	0.76										

Lane Group Capacity, Control Delay, and LOS Determination

	EB		WB			NB			SB		
Lane group	TR		L	T		L		R			
Adj. flow rate	887		244	792		43	0	167		0	
Lane group cap.	960		436	1425		331		296			
v/c ratio	0.92		0.56	0.56		0.13		0.56			
Green ratio	0.51		0.24	0.75		0.18	0.00	0.18		0.00	
Unif. delay d_1	27.3		39.9	6.4		41.0		44.6			
Delay factor k	0.44		0.16	0.15		0.11		0.16			
Increm. delay d_2	14.2		1.6	0.5		0.2		2.5			
PF factor	1.000		1.000	1.000		1.000		1.000			
Control delay	41.5		41.5	6.9		41.2		47.1			
Lane group LOS	D		D	A		D		D			
Apprch. delay	41.5		15.1			45.9					
Approach LOS	D		B			D					
Intersec. delay	29.1		Intersection LOS						C		

APPENDIX I

INFRASTRUCTURE STUDY

UNIVERSITY OF HAWAII WEST OAHU

INFRASTRUCTURE STUDY

Ewa, Oahu, Hawaii

Prepared for:

PBR HAWAII

Prepared by:

Engineering Concepts, Inc.
1150 South King Street, Suite 700
Honolulu, HI 96814

June 2006

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FIGURES

SECTION 1
INTRODUCTION

1.1 General Background Information

For the last decade, the population in the west Oahu region has been rapidly growing. To meet the increasing need for higher education in this region, the University of Hawaii Board of Regents has decided to relocate the University of Hawaii West Oahu campus from its current location within the Leeward Community College site in Pearl City to a permanent location, the UH West Oahu Makai Property, in the Ewa District (Figure 1.1).

The UH West Oahu Makai site, approximately 500 acres, is bordered to the north by Farrington Highway and to the east by the proposed North-South Road, with Villages of Kapolei Malanai subdivision and Kapolei Golf Course on the west, and the Department of Hawaiian Home Lands' (DHHL) vacant land on the south (Figure 1.2). The property was used previously for sugar cane production, but presently the majority of the site is used for vegetable cultivation.

The University's Long Range Development Plan (LRDP, July 2004) has built a framework for the development of the UH West Oahu campus that will ultimately accommodate 7,600 students. The initial phase of development is planned to accommodate 1,520 students (Phase 1). The LRDP includes a comprehensive master plan that encourages "town and gown" interaction between the University and the surrounding community. Per the revised Land Use Plan of the LRDP Update (May 2006), the campus occupies about 103.5 acres. The remainder of the 500 acres will be developed by the University or a private development partner. The development will include residential, mixed use (residential and commercial), student housing in possible lands for campus expansion, an elementary school, and parks.

1.2 Purpose and Scope

The purpose of this preliminary engineering study is to identify the utility improvements needed for the development of the UH West Oahu Makai property based on the LRDP.

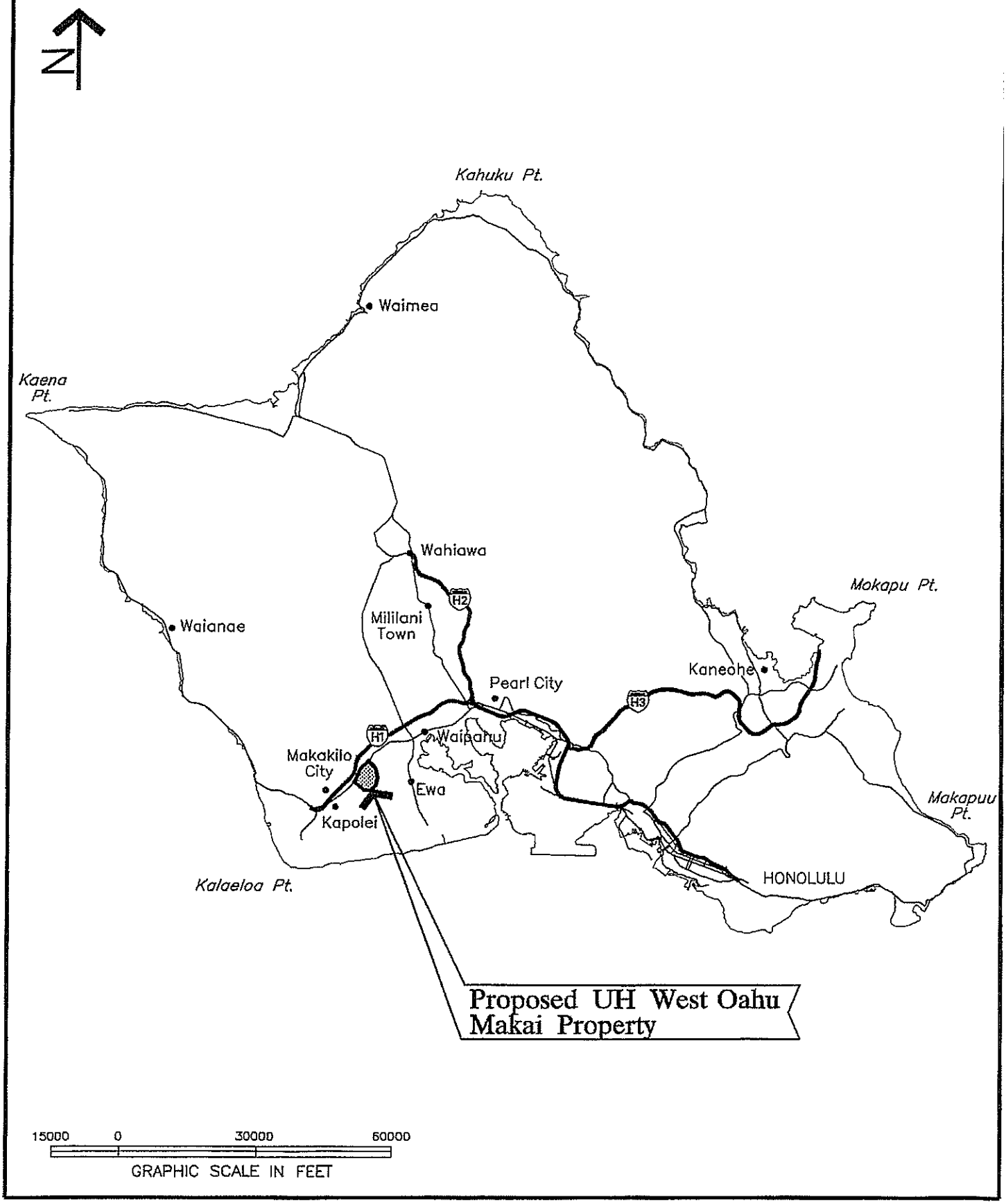

Fig. 1.1 **Location Map**

UNIVERSITY OF HAWAII WEST OAHU
INFRASTRUCTURE STUDY
EWA, OAHU, HAWAII

Prepared By: ENGINEERING CONCEPTS, INC.

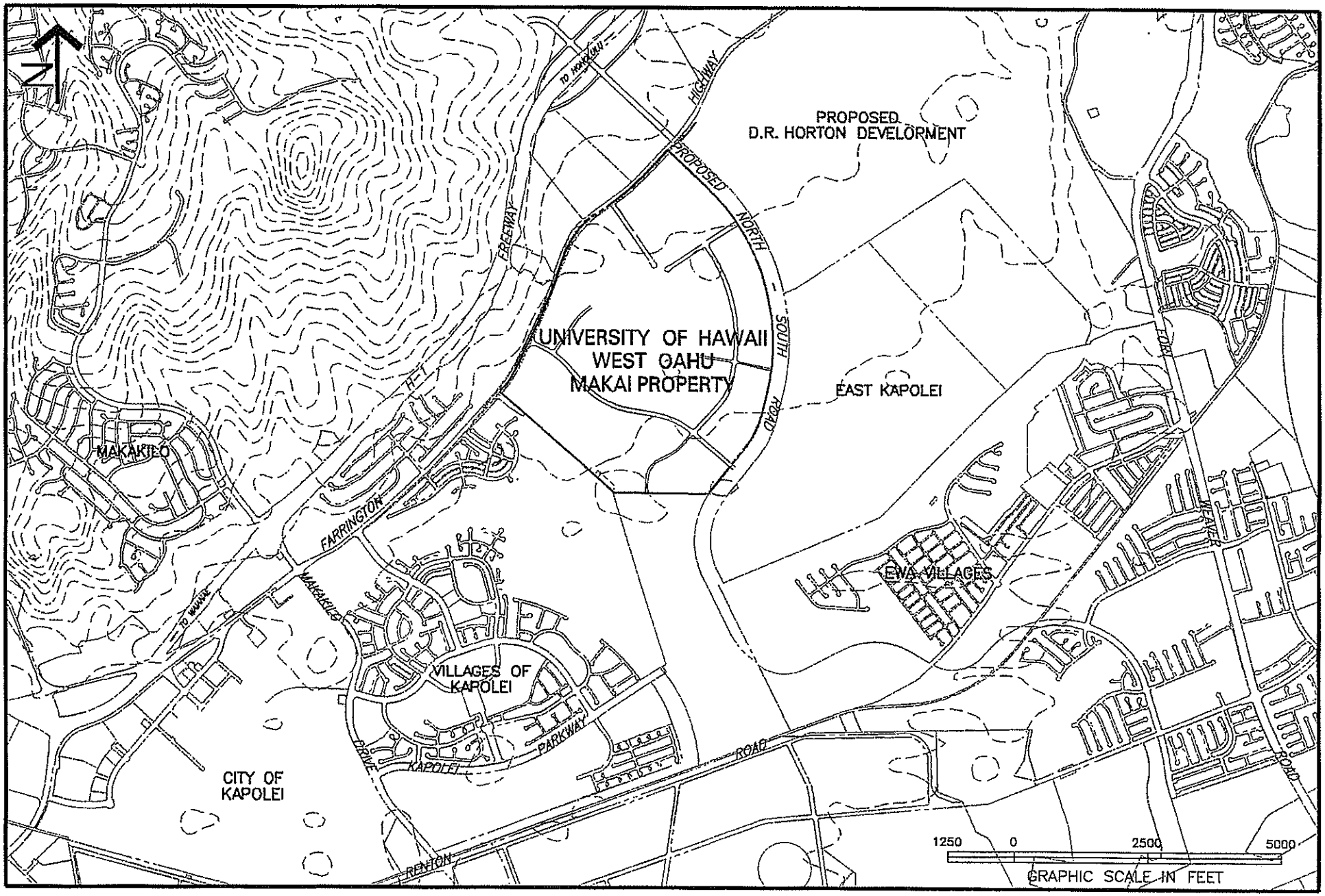

Fig. 1.2	Vicinity Map

UNIVERSITY OF HAWAII WEST OAHU
INFRASTRUCTURE STUDY

EWA, OAHU, HAWAII

Prepared By: ENGINEERING CONCEPTS, INC.

This study outlines the required infrastructure systems at a master planning level. The scope of this study includes:

- Assessment of potable water demands.
- Assessment of non-potable water demands.
- Identification of possible water supply sources.
- Schematic layout of proposed main potable water systems.
- Assessment of wastewater contributions.
- Schematic layout of proposed sewage systems.
- Assessment of existing drainage conditions.
- Assessment of developed drainage conditions.
- Schematic layout of proposed onsite drainage facilities.

1.3 Related Studies

1.3.1 Ewa Water Master Plan

This master plan was prepared by Belt Collins for the Ewa Plain Water Development Corporation (August 1987). It established guidelines for calculating water demands for future developments in the Ewa Plain.

1.3.2 East Kapolei Development Master Plan Water System Study

The master plan was prepared for DHHL by Akinaka & Associates, Ltd. (January 2005). The water demand calculated for UH West Oahu site was based on 100 percent potable water use and a different residential density compared with the current Land Use Plan in the LRDP.

1.3.3 Wastewater Master Plan for East Kapolei

Community Planning and Engineering, Inc. (formerly Community Planning, Inc.) prepared this master plan for DHHL. It used the same Land Use Plan as the water study in Section 1.3.2.

1.3.4 University of Hawaii West Oahu Infrastructure Study

This previous study was conducted by R. M. Towill Corporation for the University of Hawaii during an earlier iteration of the Land Use Plan. Since then, the land use and development plan have been revised.

1.3.5 Engineering Report for the Kapolei Interceptor Sewer

This report was prepared by Community Planning and Engineering, Inc. for a group of developers who are participating in the developments in Kapolei region: Estate of James Campbell, Housing and Community Development Corporation of Hawaii (HCDCH), Ko Olina Intangibles, LLC, and Finance Realty (January 2002). The Kapolei Interceptor proposed by this study was constructed and completed in October 2005.

1.3.6 Ewa Village Drainage Master Plan

R. M. Towill Corporation designed this master plan (April 1996) for the development of Ewa Villages, which is located southeast of the UH West Oahu Makai property. The plan laid out the requirements for the regional drainage facilities.

1.3.7 North-South Road and Kapolei Parkway Environmental Assessment

The assessment was prepared by Parsons Brinckerhoff Quade & Douglas Inc. for the proposed connector road between Ewa Beach and the H-1 Freeway. This road will be one of the main access routes to the UH West Oahu site and will serve as a utility corridor for the East Kapolei area. Phase 1A, a portion of the planned road from Kapolei Parkway to Farrington Highway, is currently under construction.

1.3.8 Environmental Assessment of the Ewa Nonpotable Water System

The Honolulu Board of Water Supply (BWS) plans to utilize non-potable water from the City's Water Reclamation Facility in Ewa and has developed the Ewa Nonpotable Master Plan (prepared by R. M. Towill Corporation). A 215-foot elevation non-potable water supply system is proposed in the master plan. The lower section of the UH West Oahu Makai property falls within the service zone of the 215-foot elevation system. Gray,

Hong Nojima & Associates, Inc. conducted the environmental assessment for the master plan.

1.4 Existing Site Conditions

1.4.1 Climatology

The climate in this area is warm and dry year-round, with prevailing northeasterly tradewinds. The average annual rainfall is about 23 inches. The tradewinds do not bring much rain to the region. Most of the rainfall occurs from October through April when southerly Kona winds cause heavy rain and thunderstorms.

Based on the data collected over 50 years at the Ewa Plantation, average daily temperatures in the area range from 65°Fahrenheit (F) to 84°F. The extreme temperatures experienced are a low of 47°F and a high of 93°F.

1.4.2 Topography

The site is located within the Ewa plain below the base of the Waianae mountain range. The ground is relatively flat, with slopes varying from one to two percent. Elevations vary from a high of 155 feet above mean sea level (MSL) at the intersection of Farrington Highway and the proposed North-South Road (at the northern property boundary), to a low of 75 feet above MSL adjacent to the DHHL property (at the southern property boundary).

Two dry gulches, Kaloi Gulch and Hunehune Gulch, run through the site. Hunehune Gulch converges with Kaloi Gulch in the lower portion of the site.

1.4.3 Soils

The soil survey published by the Soil Conservation Service (presently known as the Natural Resources Conservation Service) indicates that the site contains four soil types: predominantly Honouliuli clay (HxA and HxB), Waialua silty clay (WkA), Ewa silty clay (EaB and EwC), and Waipahu silty clay (WzA). These soils are characterized by moderate permeability, slow runoff, slight erosion hazard, moderate to high shrink-swell

potential, and low concrete corrosivity. The soils are categorized in Hydrologic Soil Group B.

1.5 Developed Site Conditions

The LRDP Land Use Plan (Figure 1.3) provides a vision for development of the UH West Oahu campus in conjunction with the surrounding lands within the 500-acre property. Approximately 110.5 acres of the property (including the initial 1,520-student campus) will be development in Phase 1. Ultimately, the UH West Oahu Lands will include a 7,600-student campus; University Village (student housing/mixed use or campus expansion); work force/affordable housing; a Hawaiian Electric Company, Inc. (HECO) substation; and roads. The Private Development lands will include single- and multi-family residential uses; mixed-use areas; a detention basin; an elementary school; a HECO substation; and roads.

Five access points are planned to serve the UH West Oahu Makai property, two from Farrington Highway and three from North-South Road. Currently, the State Department of Transportation is constructing the Phase 1A of the North-South Road. The North-South Road provides an important link between the UH West Oahu Makai property and the existing and proposed developments in the surrounding areas. It also provides a crucial connection to the H-1 Freeway. It is anticipated that the North-South Road and the interchange will be completed in about the same time frame as the opening of Phase 1 of UH West Oahu campus.

The City Department of Transportation Service (DTS) has planned to widen Farrington Highway from the existing 2-lane road to 4 lanes from Kapolei Golf Course to North-South Road, and widen the road to six lanes from North-South Road to Fort Weaver Road. However, the planned widening is not budgeted in the Fiscal Year 2006-2008 Transportation Improvement Program and will not likely be completed before the construction of the campus. The University is planning to construct the road improvements required for access at the two intersections with Farrington Highway. Discussion and coordination with DTS are required on this issue.

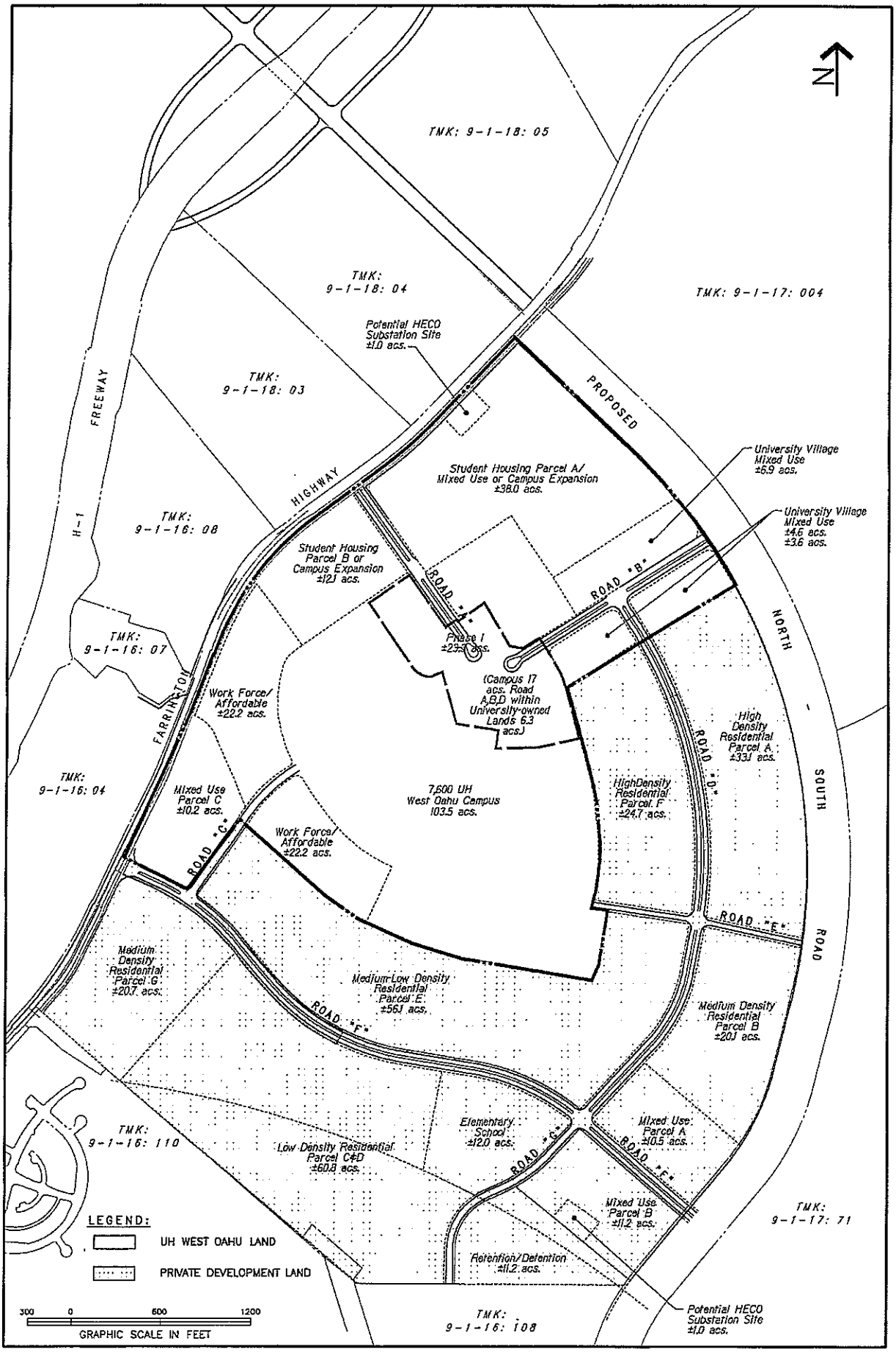

Fig. 1.3 **Land Use Plan**

UNIVERSITY OF HAWAII WEST OAHU INFRASTRUCTURE STUDY
EWA, OAHU, HAWAII
Prepared By: ENGINEERING CONCEPTS, INC.

A hierarchical network of roadways will be provided within the property. Road A, Road B, Road D, Road E, and Road F will service the regional roadway network, providing access from the UH West Oahu Makai property to the surrounding Ewa/Kapolei region. Road C and Road G are planned as collector roadways, providing access to the various land uses within the property. Road A and Road B are envisioned as the major entry roadways to the campus. A pedestrian/bikeway network is integrated with the roadways. Accessible routes are planned throughout the campus.

The finish grades will generally follow the existing terrain. According to a preliminary assessment by Geolabs, Inc. (based on soil literature review and site visual observations), the upper 3 feet of soils at the site may have been disturbed by past agriculture land use and would need to be properly engineered to support of planned new structures. It is anticipated that over-excavation and replacement of the excavated material with compacted fill may be required. The assessment letter report addressed the concerns on the potential shrink/swell effects, low California Bearing Ratio (CBR) value, and the development of shrinkage cracks in the ground due to the dry weather conditions in Ewa. A final geotechnical engineering report must be completed prior to the design phase of this project.

The following sections of this preliminary engineering study will discuss the required water system, sanitary sewer, and drainage system for the development of the UH West Oahu campus.

SECTION 2
WATER SYSTEMS

2.1 Existing Supply System

The UH West Oahu campus lies within the Board of Water Supply's (BWS) 215-foot and 440-foot service zones. Based on discussion with BWS, water is available to both service zones from the 215-foot system. The existing 30-inch and 36-inch potable water transmission mains in Farrington Highway are providing water to the Kapolei 215-foot reservoirs and the Barbers Point 215-foot reservoirs via the Honouliuli Line Booster and the Kapolei Line Booster. A 4-million gallon (MG) 215-foot reservoir has been planned and designed for the East Kapolei developments, which covers portions of the UH West Oahu site. Presently, there are no 440-foot system facilities in the vicinity to support the East Kapolei developments. A new system will need to be constructed for the development. The water will be conveyed from the 215-foot water system to the proposed 440-foot reservoir through booster pumps. Figure 2.1 depicts the existing and proposed regional potable water systems.

The BWS has planned to utilize the R-1 reclaimed water from the Honouliuli Wastewater Treatment Plant, which is currently producing 12 mgd of R-1 quality effluent, as a nonpotable water source for the Ewa Plain. To accomplish this, BWS plans to construct a reservoir with a spillway elevation at 215 feet and install irrigation systems along the North-South Road corridor.

2.2 Basis of Design

The onsite water systems proposed in this report for the UH West Oahu campus will be designed in conformance with the BWS Water System Standards (2002) and based on the guidelines established in Ewa Water Master Plan. The criteria are summarized in Table 2.1. This table provides both potable and nonpotable average daily demands for various land uses. The average daily demands are derived by applying a 1.2 factor to the average daily water use as defined in the Table 2.1.

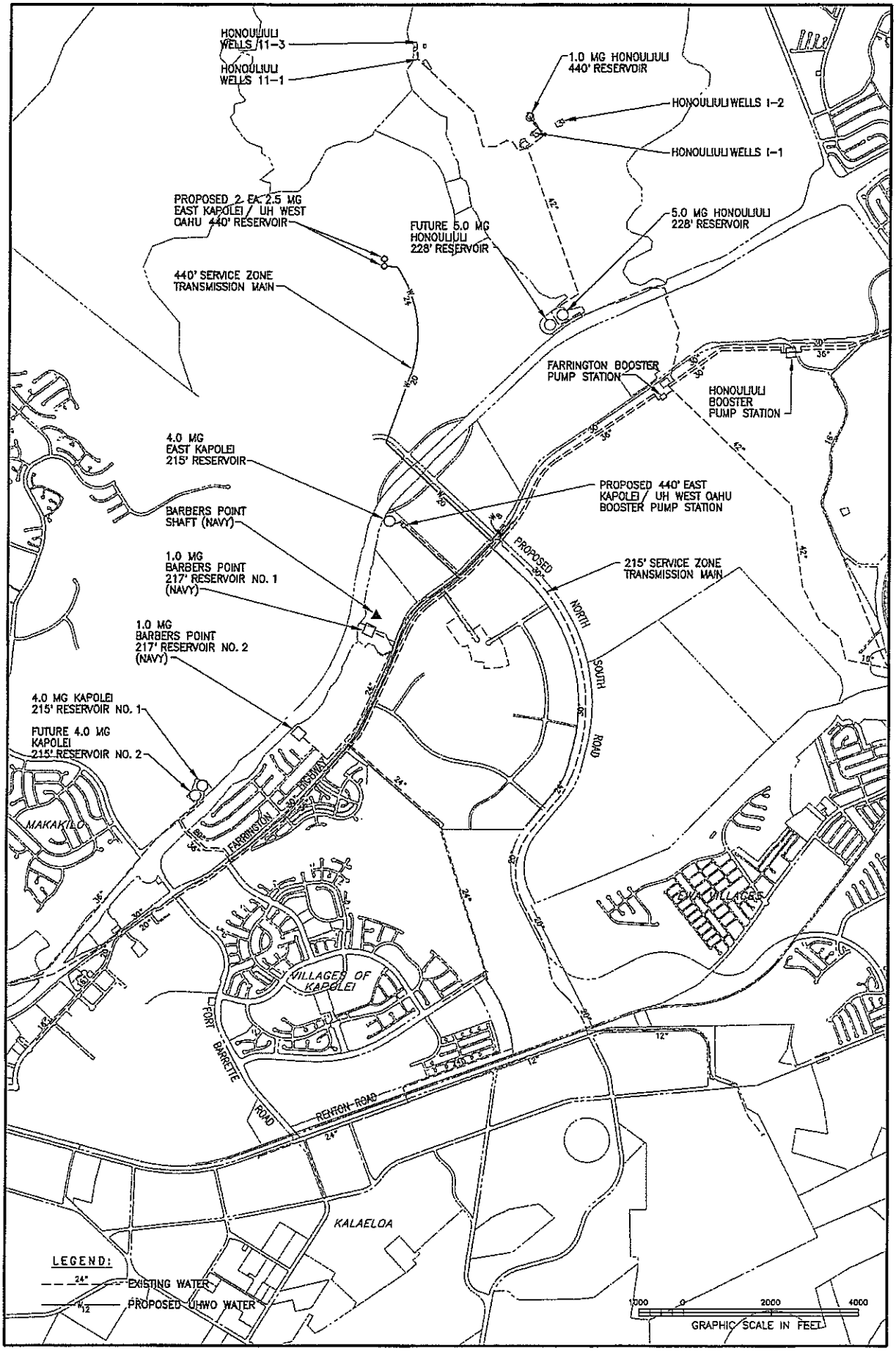

Fig. 2.1	Regional Potable Water Systems Supply	UNIVERSITY OF HAWAII WEST OAHU INFRASTRUCTURE STUDY EWA, OAHU, HAWAII Prepared By: ENGINEERING CONCEPTS, INC.

TABLE 2.1
WATER SYSTEM DESIGN CRITERIA

Land Use	Unit Demand	All Potable System	Dual System			
			Avg. Water Use		Avg. Daily Demand	
			Potable	Non-Potable	Potable	Non-Potable
Residential						
-Single Family	GPD/Unit	500	345	155	414	186
-Multi-Family Low Rise	GPD/Unit	400	276	124	331	149
-Multi-Family High Rise	GPD/Unit	300	207	93	248	112
Commercial, Offices	GPD/Acre	3,000	1,800	1,200	2,160	1,440
Resort	GPD/Unit	350	203	147	244	176
	GPD/Acre	4,000	2,320	1,680	2,784	2,016
Parks	GPD/Acre	4,000	600	3,400	720	4,080
School	GPD/Student	60	35	25	42	30
UH West Oahu[6]	GPD/Student	60	60		60	
Industrial	GPD/Acre	4,000	1,184	2,816	1,421	3,379
Commercial / Industrial	GPD/1,000 Ft^2	100	60	40	72	48
Commercial / Residential	GPD/1,000 Ft^2	120	83	37	100	44

PIPELINE, STORAGE, AND WELL PUMP SIZING CRITERIA

1. Demand Factors
   a. AVERAGE DAY DEMAND. For land uses to be served by a dual system, a 1.2 factor is applied to the AVERAGE WATER USE rates to derive the AVERAGE DAY DEMAND. For land uses served only by the potable system, AVERAGE WATER USE and AVERAGE DAY DEMAND are identical.
   b. MAXIMUM DAY DEMAND = (1.5) x AVERAGE DAY DEMAND.
   c. PEAK HOUR RATE = (3.0) x AVERAGE DAY DEMAND.
2. Fire protection can be met in either the potable or non-potable system subject to meeting all present fire protection standards.
3. Reservoir Size
   a. The potable reservoir volume shall be equivalent to MAXIMUM DAY DEMAND.
   b. The non-potable reservoir volume shall be equivalent to AVERAGE DAY DEMAND.
4. Potable and non-potable pipelines shall be sized for PEAK HOUR flow rates with a minimum residual pressure of 40 psi and maximum velocity in the main of 6 feet per second. Hydraulic analyses will utilize tank spillway elevations as the initial hydraulic grade line elevations. Pipelines providing fire protection shall also be sized for MAXIMUM DAY flow plus fire flow with a residual of 20 psi at the critical fire hydrant. Hydraulic analyses will use three-quarters full tank water surface elevations as initial hydraulic grade line elevations.
5. Well pumps for potable and non-potable systems shall provide MAXIMUM DAY in an operating time of 16 hours.
6. For the UH West O'ahu campus, 60 GPD/Student was used because the proposed use of the campus is for an extended day.

SOURCE: "Ewa Water Master Plan", prepared by Belt Collins for the Ewa Plain Water Development Corporation, August, 1987.

2.3 Proposed Onsite Water Systems

The proposed water systems for the UH West Oahu campus are part of the East Kapolei regional system. The regional water system outlined in the East Kapolei Development Master Plan Water System Study (Akinaka & Associates, January 2005) is sized for the ultimate East Kapolei development and also to accommodate the future demand of the Kalaeloa area. The construction of the 215-foot reservoir and its transmission main in the North-South Road is imminent with the onset of phase 1 of the DHHL project.

According to BWS, potable and nonpotable water sources will be available for the 215-foot system. A dual system is planned for the 215-foot service zone. About half of the UH West Oahu Makai property lies in this service zone, while the majority of the campus site is in 440-foot service zone. Application of a dual system for the 440-foot service zone is currently being discussed with BWS.

2.3.1 UH West Oahu Land Uses for Water Demand Calculations

The water demands of UH West Oahu Makai property are based on the current Land Use Plan (Figure 1.3) of LRDP Update dated May 2006. The land use information is summarized in Table 2.2.

TABLE 2.2
UH West Oahu Makai Property Land Use Summary

Land Use	Residential Units	Approx. Area (acres)
UH West Oahu Campus Site		103.5
Work Force/Affordable Housing (Multi-Family)	355	22.2
Student Housing/Mixed Use (FAR 0.2) or Campus Expansion	876	50.1
Mixed Use (FAR 0.25)	470	47.0
High Density Residential (Multi-Family)	925	57.8
Medium Density Residential (Multi-Family)	489	40.8
Medium/Low Density Residential (Single Family)	561	56.1
Low Density Residential (Single Family)	365	60.8
Elementary School		12
Detention Basin		11.2
HECO Substations		2
Roads and Farrington Highway Expansion		36.8

2.3.2 Water Demands for Proposed Developments

Planning for the project is ongoing and land uses and densities have not yet been finalized. For the purpose of this study the following assumptions are applied in the calculations.

1) According to the LRDP Update dated April 20, 2006, the UH West Oahu campus population is defined as 8,640 at the full built-out, 7,600 students plus 1,040 faculty and staff.

2) Based on the information provided by the Department of Education, the total population for the proposed elementary school is assumed 610, including 550 students and 60 faculty and staff.

3) As mentioned earlier, the UH West Oahu Makai property falls within two water service zones, the 440-foot service zone and the 215-foot service zone. The 115-foot contour was initially used as the boundary between the two zones. However, a preliminary hydraulic analysis indicated that the upper limits of the 215-foot service zone would experience low pressure during the peak flows. Therefore, it is assumed in the study that the 440-foot system will serve the entire UH West Oahu campus plus some areas in the Private Development Lands.

4) Water demands for other proposed developments in East Kapolei region are obtained from the East Kapolei Development Master Plan Water System Study.

5) The supply to Kalaeloa Development District is a projection by BWS. No storage for Kalaeloa is considered in this study.

Based on conventional development, the estimated water demands in million gallons per day (MGD) for the proposed developments on the UH West Oahu Makai property are listed below:

	Potable			Non-Potable		
Service Zone	Ave. Day (MGD)	Max. Day (MGD)	Peak (MGD)	Ave. Day (GPD)	Max. Day (GPD)	Peak (GPD)
440-foot System	1.971	2.956	5.912	0	0	0
215-foot System	0.613	0.919	1.837	0.334	0.501	1.002
Total	**2.584**	**3.875**	**7.749**	**0.334**	**0.501**	**1.002**

The total water demand for ultimate developed East Kapolei is summarized as following:

	Potable			Non-Potable		
Service Zone	Ave. Day (MGD)	Max. Day (MGD)	Peak (MGD)	Ave. Day (GPD)	Max. Day (GPD)	Peak (GPD)
440-foot System						
UH West Oahu	1.971	2.956	5.912	0	0	0
Offsite Developments	1.069	1.603	3.206	0	0	0
440' Sub Total	**3.040**	**4.559**	**9.118**	**0**	**0**	**0**
215-foot level						
UH West Oahu	0.613	0.919	1.838	0.334	0.501	1.002
DHHL	1.711	2.567	5.134	0	0	0
215' Sub Total	**2.324**	**3.486**	**6.972**	**0.334**	**0.501**	**1.002**
East Kapolei Total	**5.364**	**8.045**	**16.090**	**0.334**	**0.501**	**1.002**
Kalaeloa (215')	2.00	3.00	6.00	0	0	0
Grand Total	**7.364**	**11.045**	**22.090**	**0.334**	**0.501**	**1.002**

The list above shows that the projected average daily demand for the East Kapolei area is approximately 5.36 MGD. With the estimated demand for Kalaeloa added to the 215-foot system, the average daily demand for potable water is about 7.36 MGD. A detailed breakdown is included in Appendix A. It should be noted that the UH West Oahu campus development is striving for LEED silver certification and if water saving measures are implemented, water usage may end up less than currently estimated.

2.3.3 Storage Requirements

For the 215-foot potable water system, based on the estimated demands and the criteria on storage specified in Table 2.2, the required storage for the developments on UH West Oahu Makai property is 0.92 MG, which is already included in the master planned 4-MG storage for the East Kapolei development. For the 440-foot system, 4.56 MG storage is needed. In conformance with BWS Standards, one 5.0-MG reservoir or two 2.5-MG reservoirs will be constructed.

It should be noted that the total storage for the 440-foot system for East Kapolei area is about 2.5 MG higher than previously projected in the East Kapolei Development Master Plan Water System Study. The increase is due to the larger service area and a higher residential density for the UH West Oahu Makai property.

Although the proposed residential densities on the UH West Oahu Makai property increased, potable water demand in the 215-foot system actually decreased compared to the previous demand projected in the Master Plan study. This is a result of the implementation of a dual water system in 215-foot service zone.

Discussions with the BWS regarding the nonpotable system are ongoing. Requirements for the nonpotable system from BWS and coordination with adjacent developments are necessary to deliver the 0.33 MG of nonpotable water to the site.

2.3.4 Booster Pumps Requirements

The estimated maximum daily demand on the 440-foot system is 4.55 MG. The criteria stated in the Table 2.2 for pump sizing requires meeting the maximum daily demand over a 16-hour period. The total pump capacity needed is about 5,000 gallon per minute (gpm). In accordance with BWS Standards, two pumps will be needed to provide the required 5,000 gpm pumping rate with a third pump as a standby.

2.3.5 System Descriptions

The 500-acre UH West Oahu Makai property falls within two service zones, the 215-foot and 440-foot service zones. Development on the property will require upgrades to the existing Kapolei 215-foot potable water system, and the construction of new 440-foot potable and 215-foot non-potable water systems.

Upgrades to the existing 215-foot potable water system, which includes installing a 4-MG reservoir and a transmission main in North-South Road, will be completed with the ongoing developments in the area. The new 440-foot system, including construction of one 5MG reservoir or two 2.5MG reservoirs and a transmission main in North-South Road will be constructed concurrently with the development of UH West Oahu campus. The construction of the 215-foot non-potable water system is expected to be completed by the BWS before the completion of the campus site.

The onsite potable water systems will connect to the transmission mains in the North-South Road and Farrington Highway. The systems consist of pipes from 8 to 24 inches in diameter laid out in loops to provide some redundancy (Figure 2.2).

The possibility of expanding the 440-foot system to service adjacent developments is currently being studied. This will require an analysis of the existing 215-foot system, along with the re-approval of the current Water Master Plan for the 440-foot system.

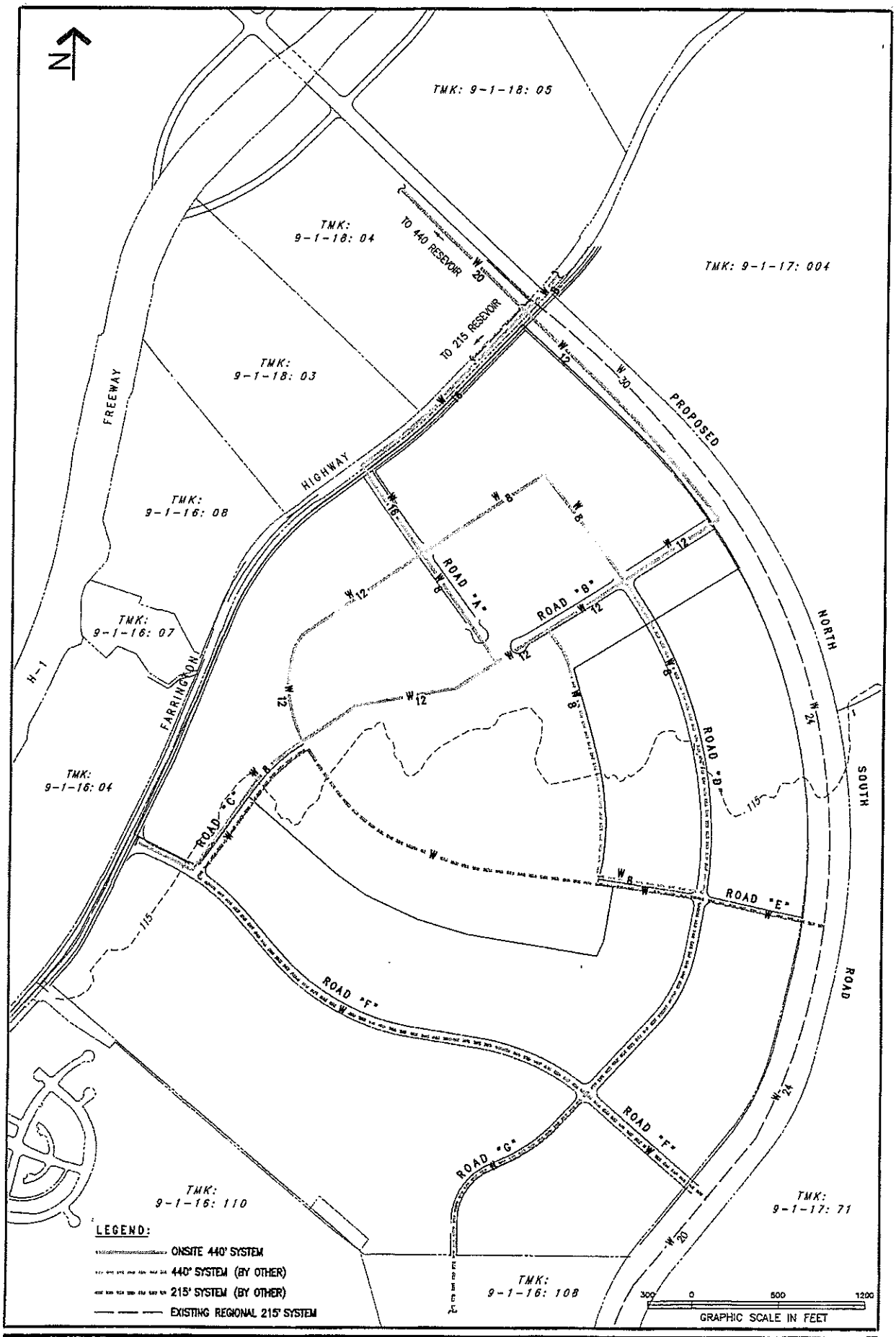

Fig. 2.2 **Onsite Water Systems**

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INFRASTRUCTURE STUDY
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SECTION 3
SANITARY SEWER SYSTEM

3.1 Existing Regional Sewer System

The UH West Oahu Makai property is within the service area of the Honouliuli Wastewater Treatment Plant (WWTP), which has a treatment capacity of 38 million gallon per day (mgd) and future plans to expand its capacity to 51 mgd. Currently, two existing regional interceptor sewers, the Makakilo Interceptor Sewer and the recently completed Kapolei Interceptor Sewer, are transporting wastewater from existing developments located west of the UH West Oahu Makai property to the WWTP (Figure 3.1). The average wastewater flow allocation in the interceptor sewers for the East Kapolei development is 3.118 mgd.

Presently, there is no sewer service to the UH West Oahu Makai property. A 30-inch stub-out was provided with the installation of the Kapolei Interceptor Sewer for future connection.

3.2 Basis of Design

The criteria set forth in the Design Standards of the Department of Wastewater Management, City and County of Honolulu, 1993, is used as the basis for developing wastewater requirements. Table 3.1 summarizes the sewer rates used for calculating average daily flow and the hydraulic design criteria.

Based on the boring data for the adjacent North-South Road (Geotechnical Engineering Exploration North-South Road, Phase 1A, F.A.I. Project No. STP-8930 (1), Ewa, Oahu, Hawaii, September 10, 2004), it is reasonable to assume that groundwater is not expected at the planned depth of the sewer lines. Consequently, the weather infiltration/inflow for the above groundwater condition is used in the flow calculations.

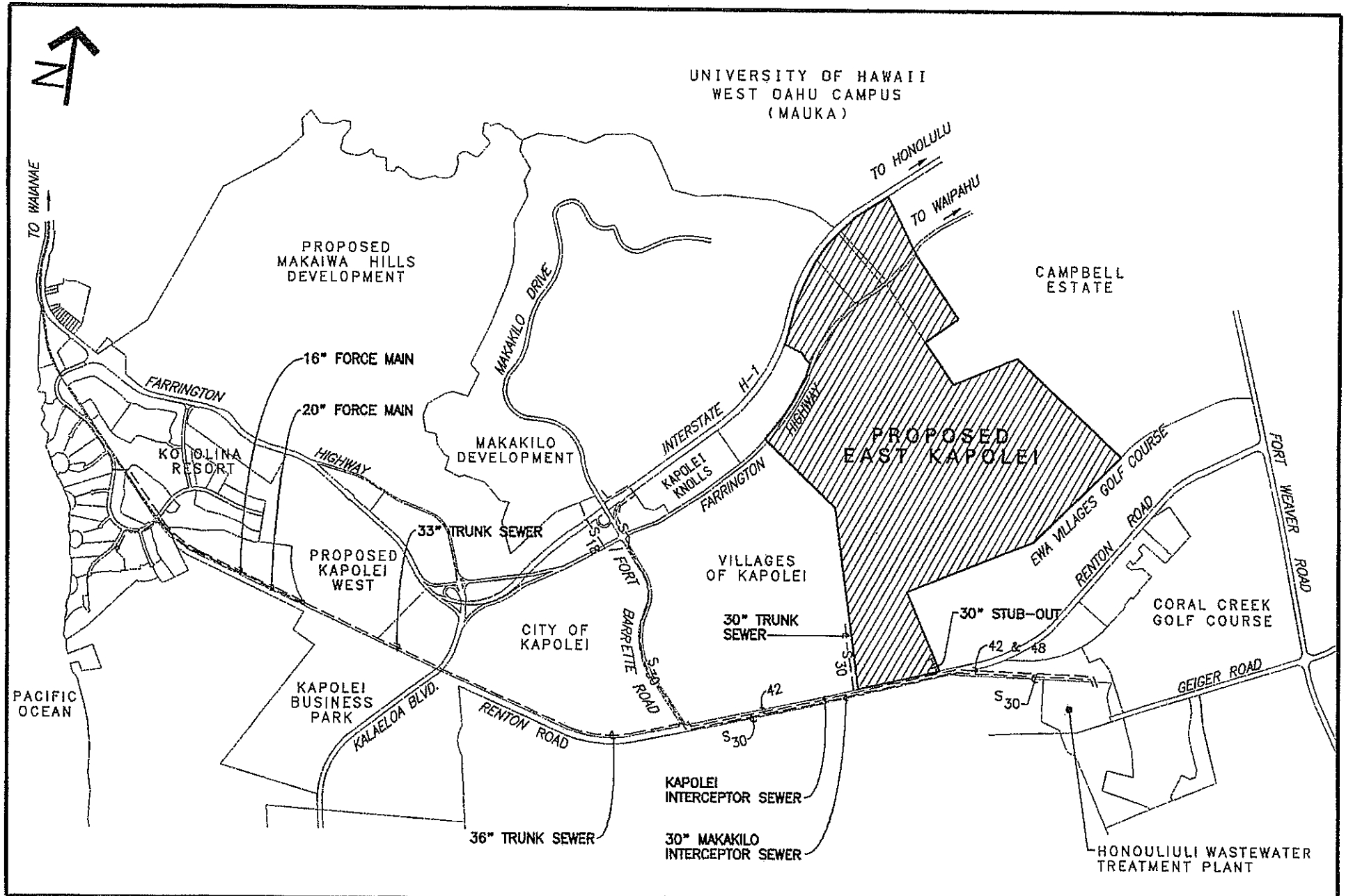

Fig. 3.1 **Existing Regional Sewer System**

UNIVERSITY OF HAWAII WEST OAHU
INFRASTRUCTURE STUDY
EWA, OAHU, HAWAII

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TABLE 3.1

SEWER SYSTEM DESING CRITERIA

Sewer Demand Rates

(Average daily per capita flow = 80 gallon per capita per day (gpcd))

Single-Family Residential	4 persons/unit
Multi-Family Residential	2.8 persons/unit
Student Housing	3 persons/unit
Community Business	140 persons/acre
Neighborhood Business	40 persons/acre
Parks	5 persons/acre
School	25 gals/person/day

Maximum Flow = average daily flow x max flow factor

Dry Weather Infiltration/Inflow (I/I) = 5 gal/person/day (above ground water table)

Wet Weather Infiltration/Inflow (I/I) = 1250 gal/acre/day (above ground water table)

Design Average Flow = average daily flow + dry weather I/I

Design Maximum Flow = maximum flow + dry weather I/I

Design Peak Flow + design maximum flow + wet weather I/I

Hydraulic Criteria

Design based on Manning's Formula:

$$\text{Velocity} = \frac{1.486\, r^{2/3} s^{1/2}}{n}$$

n=0.013 for all pipes larger than 18 inches in diameter

n=0.015 for all pipes 18 inches and smaller in diameter

Pipe Capacity: Based on 85% actual pipe capacity.

Source:

Design Standards of the Department of Wastewater Management, Volume I, City and County of Honolulu, July 1993 (currently referred to as Department of Planning and Permitting, Wastewater Branch).

3.3 Proposed Onsite Sanitary Sewer System

A wastewater master plan for the East Kapolei area, including the UH West Oahu Makai property, was prepared by Community Planning and Engineering, Inc. The master plan indicated the area to be sewed by a major trunk line in the North-South Road, which collects wastewater from the adjacent developments. The trunk sewer conveys the flows to the Kapolei Interceptor Sewer.

In the wastewater master plan, the major trunk system was planned to be placed entirely within the North-South Road. However, as a result of value engineering, it was decided to realign a portion of the trunk sewer through the UH West Oahu Makai property to reduce costs associated with constructing two parallel lines. The proposed sewer systems within the UH West Oahu Makai property are depicted in Figure 3.2.

3.3.1 Wastewater Flows for Proposed Developments

Based on the defined land uses on the UH West Oahu Makai property presented in Table 2.2 and the defined school population, the calculated equivalent population is 19,603. The estimated flows from UH West Oahu Makai property are listed below:

Average Wastewater Flow at 80 gpcd = 1.68 mgd

Maximum Flow = 3.19 mgd

Design Average Flow = 1.79 mgd

Design Maximum Flow = 3.29 mgd

Design Peak Flow = 3.95 mgd

3.3.2 System Description

The major trunk sewer line enters the UH West Oahu Makai property from Farrington Highway, runs down along Road D, then exits the property to the North-South Road through Road F. The line, ranging in size from 24 to 30 inches in diameter, carries the wastewater from the properties located to the north of the UH West Oahu Makai property and the flows from the UH West Oahu Makai property to the 30-inch trunk line in the

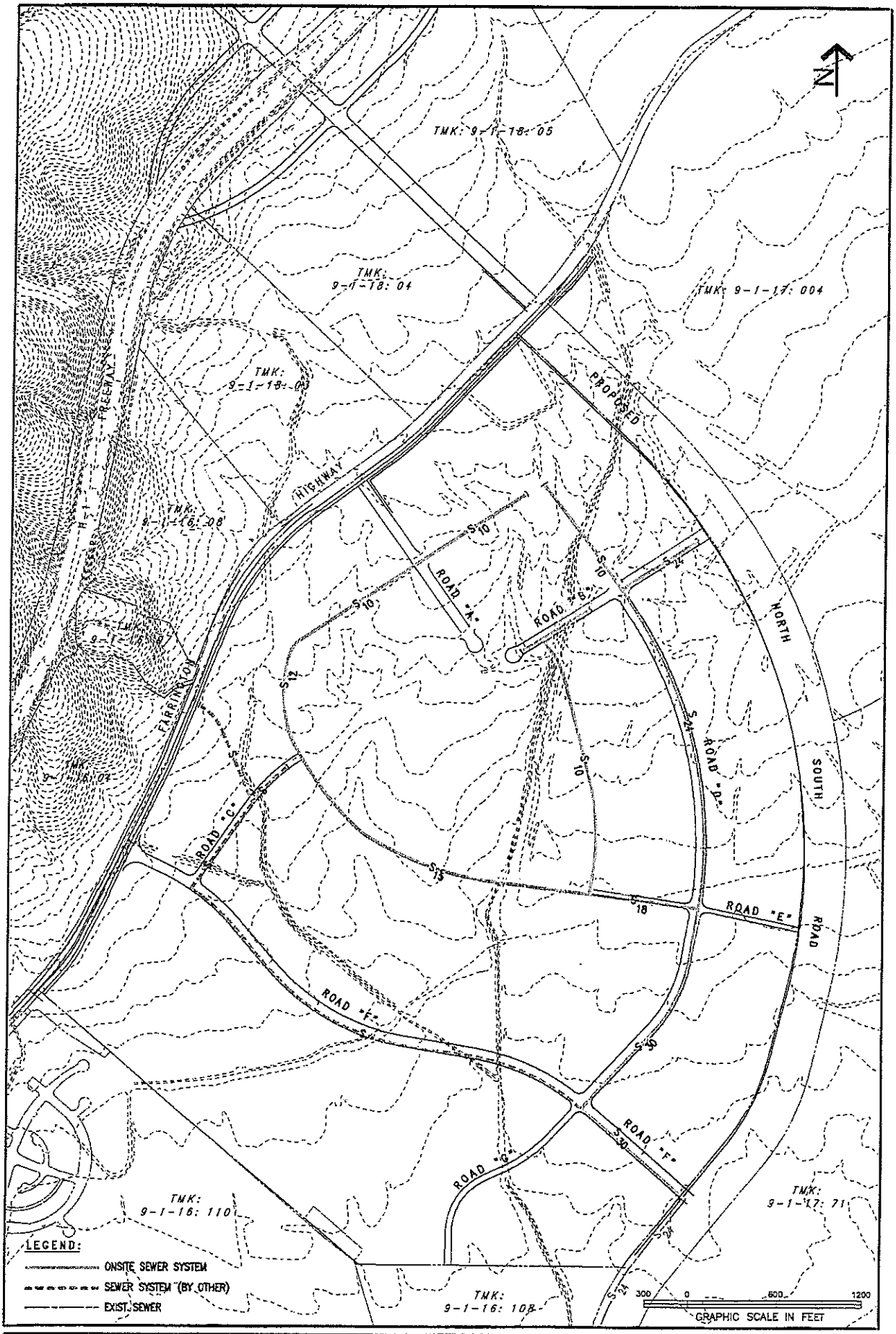

Fig. 3.2 **Onsite Sanitary Sewer System**

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North-South Road. Smaller sewers (8 to 18 inches) branch off from the major trunk line to serve the site.

In the system hydraulic analysis (see Appendix B), the slopes of the pipes are assumed to match the existing grades based on the City's GIS information or controlled to meet the 85 percent pipe capacity requirement. Under assumed slopes, the flow velocities in all pipes meet the requirements of minimum 2 feet per second (fps) and maximum 10 fps.

SECTION 4
DRAINAGE SYSTEM

4.1 Existing Regional Condition

The proposed UH West Oahu Makai property is situated within the middle reaches of the Kaloi Gulch Watershed, with the West Loch watershed to the east and the Villages of Kapolei watershed to the west. Figure 4.1 depicts the current regional drainage pattern. Hunehune Gulch, a tributary to Kaloi Gulch, also runs through the site.

The Ewa Village Drainage Master Plan (R. M. Towill 1998) conducted a detailed hydrologic study for the East Kapolei and Ewa Villages tributary area. The study indicated that almost all the runoff from the area above the Ewa Villages are intercepted by the Ewa Villages Golf Course, which was sized with sufficient capacity to convey the 100-year peak flow from the Plate 6 of the City's drainage standards. The Ewa Villages Golf Course was designed as a detention/retention/water quality facility for the entire tributary area under the developed condition. However, at this time, discharge from the golf course is controlled due to the limited downstream channel capacity. Therefore, before the ultimate drainage improvement is completed, the discharges form the golf course will need to be maintained at the existing condition and this means that the discharge from UH West Oahu Makai property shall be limited to the existing releasing rate.

Presently, the area above the Ewa Villages is undeveloped and the runoff from this area is mainly carried by Kaloi Gulch and Hunehune Gulch. Both of the gulches are characterized as intermittent drainageways. The flows are ephemeral in response to storm events that are significant enough to generate direct runoff. The gulches were formerly used as irrigation ditches.

4.2 Existing Onsite Condition

Kaloi Gulch and Hunehune Gulch are currently running across the proposed UH West Oahu Makai property. Kaloi Gulch enters the site from the east at about 900 feet south of

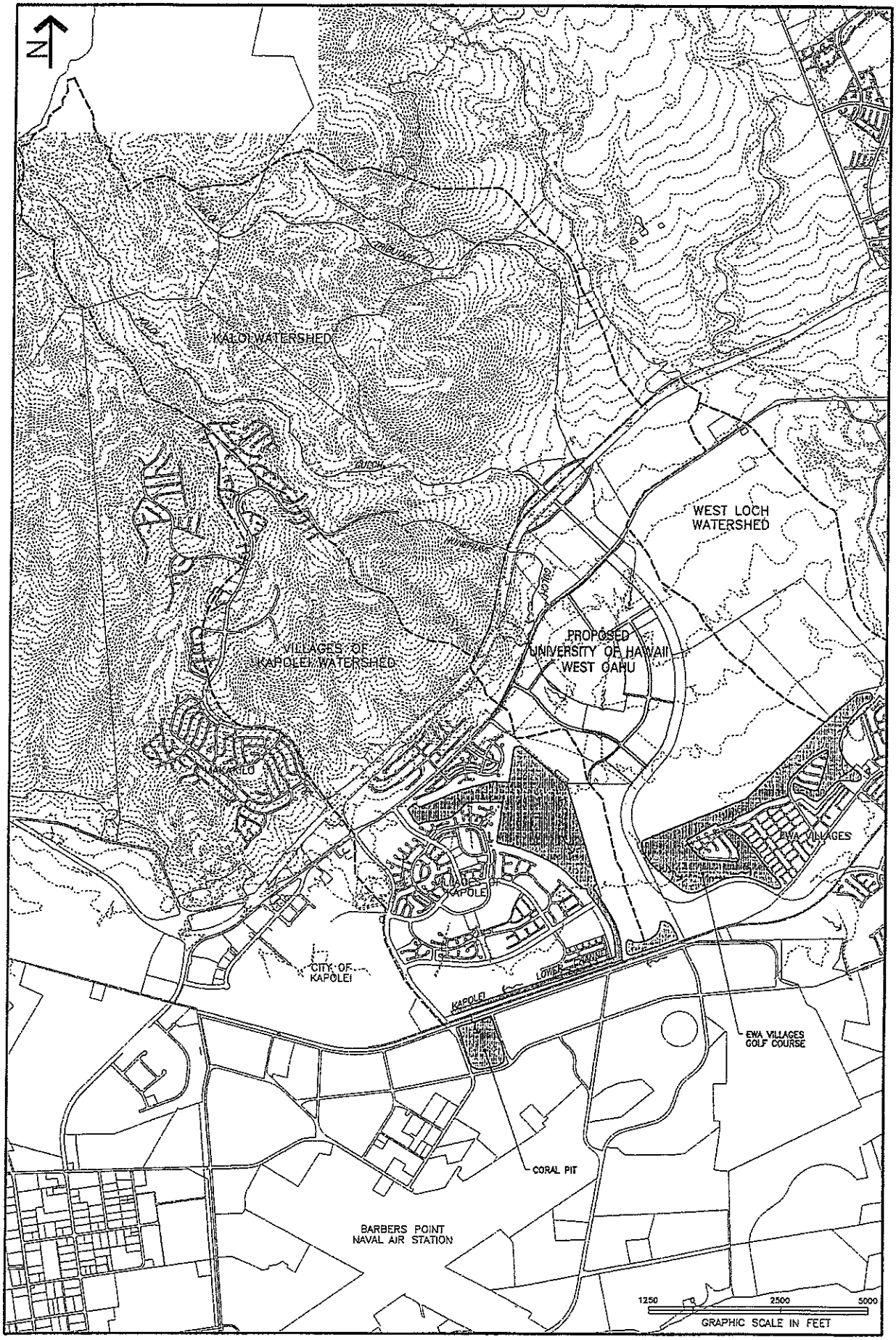

Fig. 4.1 **Existing Regional Drainage Systems**

Base Source: R.M. TOWILL "EWA VILLAGES DRAINAGE MASTER PLAN"

UNIVERSITY OF HAWAII WEST OAHU INFRASTRUCTURE STUDY

EWA, OAHU, HAWAII

Prepared By: ENGINEERING CONCEPTS, INC.

Farrington Highway. Hunehune Gulch comes into the site from the north at approximately 1,200 feet west of the intersection of Farrington Highway and the proposed North-South Road. The Hunehune Gulch merges with the Kaloi Gulch approximately 1,200 feet above the southern boundary of the site. The Kaloi Gulch continues downstream passing through DHHL land and into the northwest corner of the Ewa Village Golf Course via a 20 ft. x 8 ft. concrete box culvert. This culvert was sized to the capacity of the existing Kaloi Gulch gully.

There are no existing drainage improvements on the site and no well defined existing drainageway except the two gulches. The runoffs generated onsite primarily sheet flow overland. The Kaloi Gulch was previously used as an irrigation ditch. In many areas the banks of the gulch were built up to carry irrigation water to the lower land. Thus, overflow from the gulch in these areas usually cannot return to the ditch because the built-up banks are higher than the adjacent ground.

4.3 Basis of Design

The drainage analyses in this study are in conformance with the design guidelines specified in the Storm Drainage Standards of the City and County of Honolulu Department of Planning and Permitting (Standards). The design criteria are summarized as following:

Onsite Pipe/Culvert System Design Storm Recurrence Interval Tm:

Tm = 10 years for area under 100 acres;

Tm = 50 years for areas with sump conditions or backup effect; and

Tm = 100 years for areas greater then 100 acres.

Runoff Calculation:

Rational Method for area equal or smaller than 100 acres;

Plate 6 of Standards for area greater than 100 acre.

Rainfall Intensity for Rational Method Analysis:

i = 1.85 in/hr for Tm = 10 years;

i = 2.3 in/hr for Tm = 50 years.

24-hour Rainfall for Detention/Water Quality Volume Analysis:

P_{24} = 7.7 inches for 10-year event;

P_{24} = 12.3 inches for 100-year event.

4.4 Proposed Drainage Improvements

4.4.1 Regional Drainage System

The regional drainage pattern shown on Figure 4.1 will be altered by the construction of a drainage channel along the east side of the proposed North-South Road (currently Phase 1A is under construction). The channel will divert the flow in Kaloi Gulch away from the UH West Oahu Makai property and discharge the water into a detention basin located at the downstream end of the channel immediately above the Ewa Village Golf Course (Figure 4.2).

For Hunehune Gulch, Belt Collins Hawaii conducted an off-site drainage study and proposed a box drain system to divert the flow in the gulch to an onsite detention pond located at the southeast corner of the UH West Oahu Makai property. The flow would then discharge into the regional detention basin through box culverts under the North-South Road. Coordination between the University and its private development partner is required to determine an efficient way of integrating drainage systems. Belt Collins Hawaii's study is included in Appendix D of this report.

4.4.2 University Campus Onsite Drainage System

The proposed onsite drainage system for the UH campus area (not including private development land) will consist of grate inlets in parking lots and landscaped areas, curb inlets along the roadways, underground pipe/box drains, and a detention/water quality basin with a flow control structure.

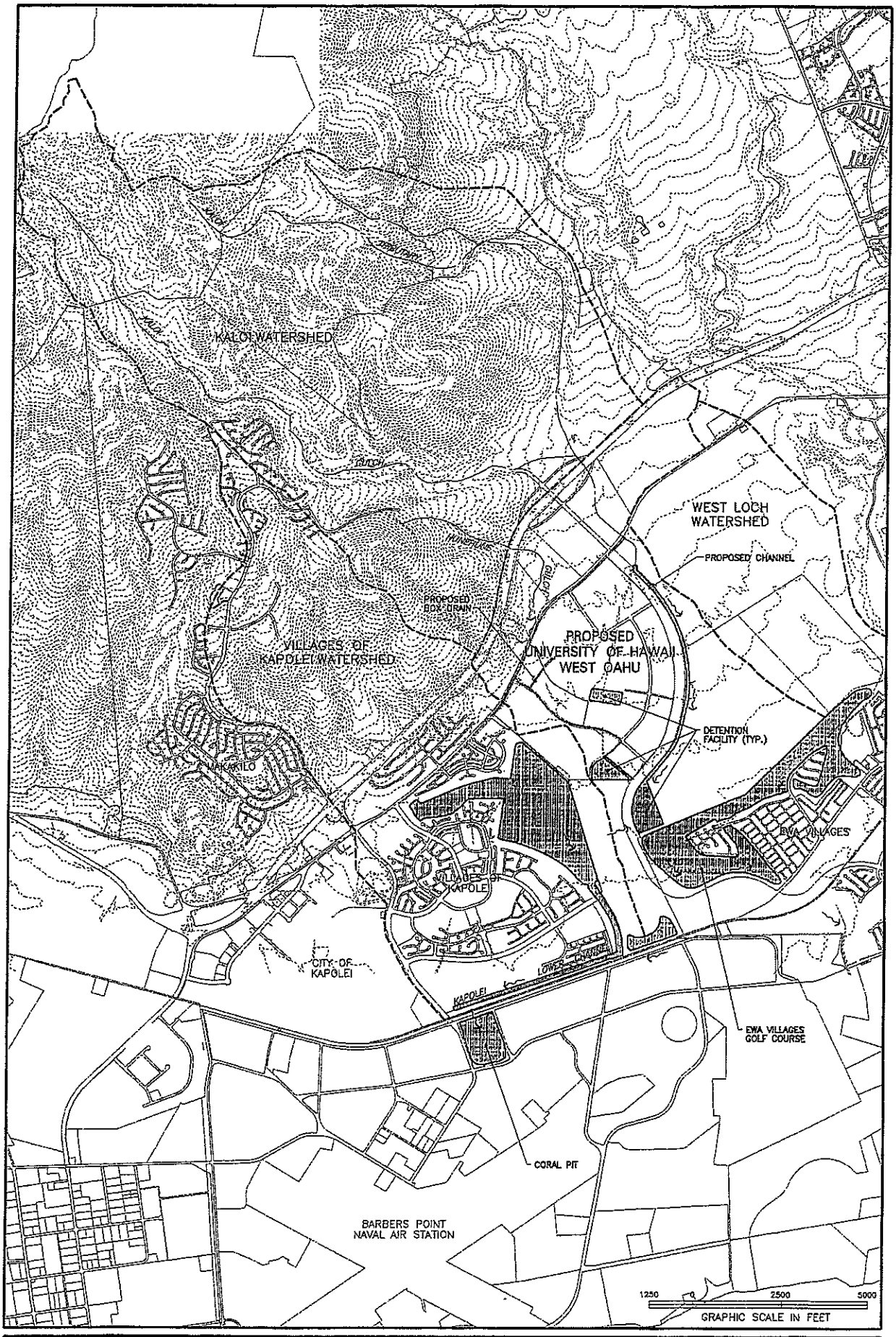

Fig. 4.2	Proposed Regional Drainage Systems	UNIVERSITY OF HAWAII WEST OAHU INFRASTRUCTURE STUDY EWA, OAHU, HAWAII
	Base Source: R.M. TOWILL "EWA VILLAGES DRAINAGE MASTER PLAN"	Prepared By: ENGINEERING CONCEPTS, INC.

4.4.2.1 UH Campus Site Phase 1 Development

For the Phase 1 campus development, only a small portion of the permanent drainage system will be constructed (Figure 4.3). The pipe system will not be extended to the detention basin in this phase. The collected runoff will be discharged overland, filtered through the ground vegetation, natural depressions and ultimately flow to Kaloi Gulch which leads to the detention pond. Temporary loose riprap protections should be provided at all discharge points to prevent erosion.

The detention basin and the cutoff swales will be constructed to catch all the runoffs from the developed Phase 1 area, plus the runoffs from a portion of undeveloped campus site above the detention basin. The planned basin area for the Phase 1 development is about 5 acres. The basin will serve two purposes: 1) attenuate the increased peak flows due to the increase of the impervious areas from the construction of buildings, roadways, parking lots and walkways; and 2) meet the City's water quality requirements. Since runoff is not to exceed the existing discharge rate from the site prior to the completion of the drainage improvement in Oneula Beach Park, the increased runoff will be detained in the detention basin and released into the existing Kaloi Gulch at a rate equal or less than the existing discharge rate through a two-stage weir, which will be designed to meet the 10-year and 100-year flows. This detention basin will be expanded and a discharge system will be constructed when the remainder of the campus site is developed.

Using TR-55 computer program, the calculated peak flows and estimated detention volume required for 10-year and 100-year storm events are for Phase 1 development are listed as follows:

Storm	Existing Peak	Developed Peak	Detention Volume
10-year	189 cfs	320 cfs	6.5 ac-ft
100-year	359 cfs	582 cfs	11.4 ac-ft

For water quality control, the calculated water quality design volume (WQDV) for the Phase 1 development per the procedure in the City's Standards is 1.75 acre-feet. This

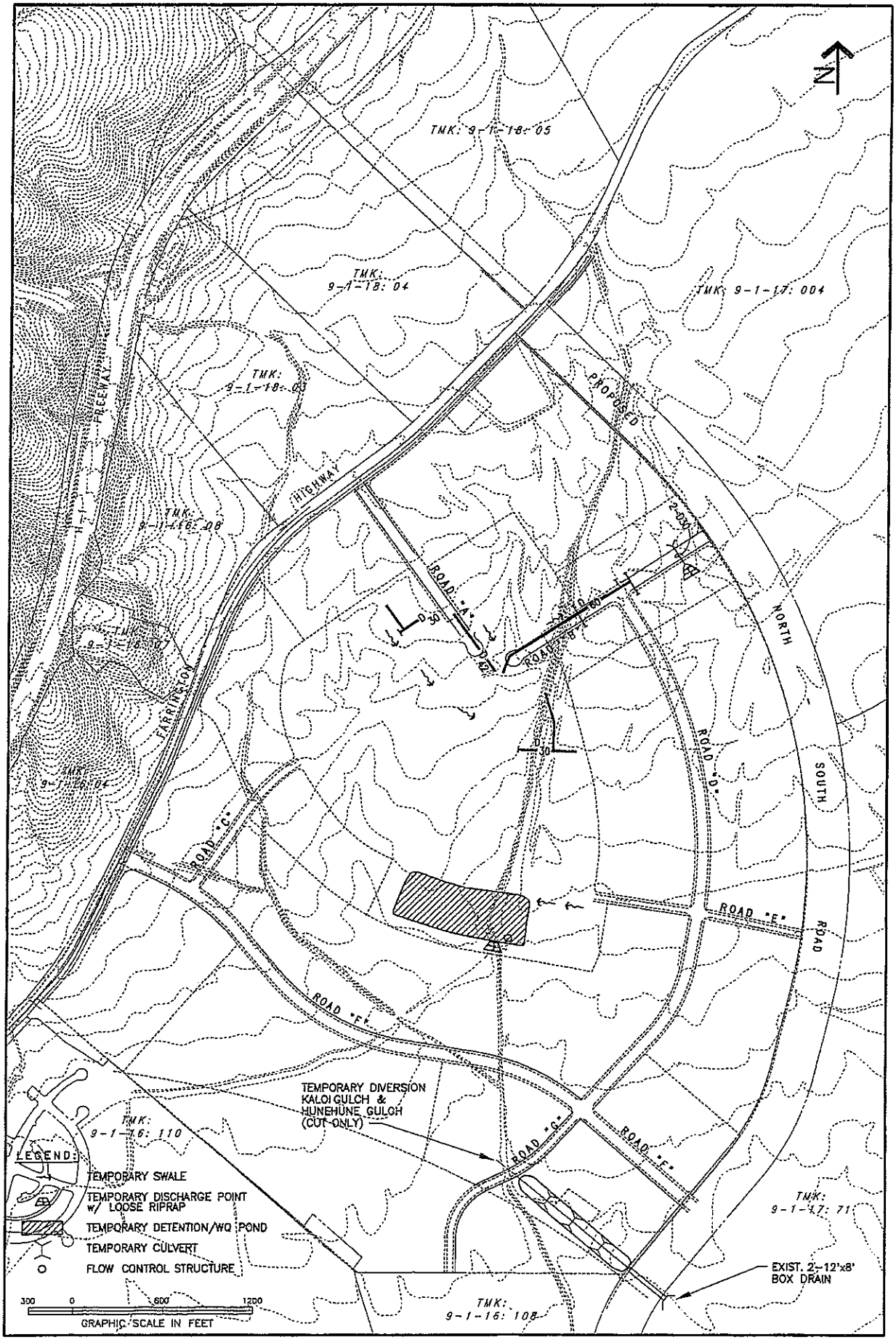

Fig. 4.3	Phase 1 Campus Onsite Drainage System	UNIVERSITY OF HAWAII WEST OAHU INFRASTRUCTURE STUDY EWA, OAHU, HAWAII Prepared By: ENGINEERING CONCEPTS, INC.

volume of water will be released at a controlled rate through a temporary discharge structure to meet the required release time period.

4.4.2.2 Full Build-out UH Campus Site

Figure 4.4 shows the proposed drainage system for the full build-out campus condition. The pipe system will be completed to carry all the runoff from the site into the enlarged 10-acre detention basin. The calculated peak runoffs and estimated detention volumes for the entire campus site are listed as follows:

Storm	Existing Peak	Developed Peak	Detention Volume
10-year	340 cfs	849 cfs	23.6 ac-ft
100-year	644 cfs	1462 cfs	36.9 ac-ft

The calculated water quality design volume WQDV for the UH West Oahu Lands is 12 acre-feet per the City's Standards.

A release structure will be designed to control the discharge rates to the existing peak flows for the 10-year and 100-year storm events. A perforated pipe riser will be designed to meet the City specified the releasing time period for water quality control.

The calculations for the detention volumes and the water quality volumes are included in Appendix C of this report. The calculations and the drainage system layout are based on the land use plan and site plan dated April 20, 2006, both plans were prepared by PBR HAWAII for the University of Hawaii - West Oahu Long Range Development Plan at the master planning level. More detailed analysis of the drainage systems will be needed during the design phase.

4.4.3 Private Development Land Onsite Drainage System

The proposed onsite drainage systems for the private developments lands have been prepared by Belt Collins Hawaii and are provided in the Appendix D.

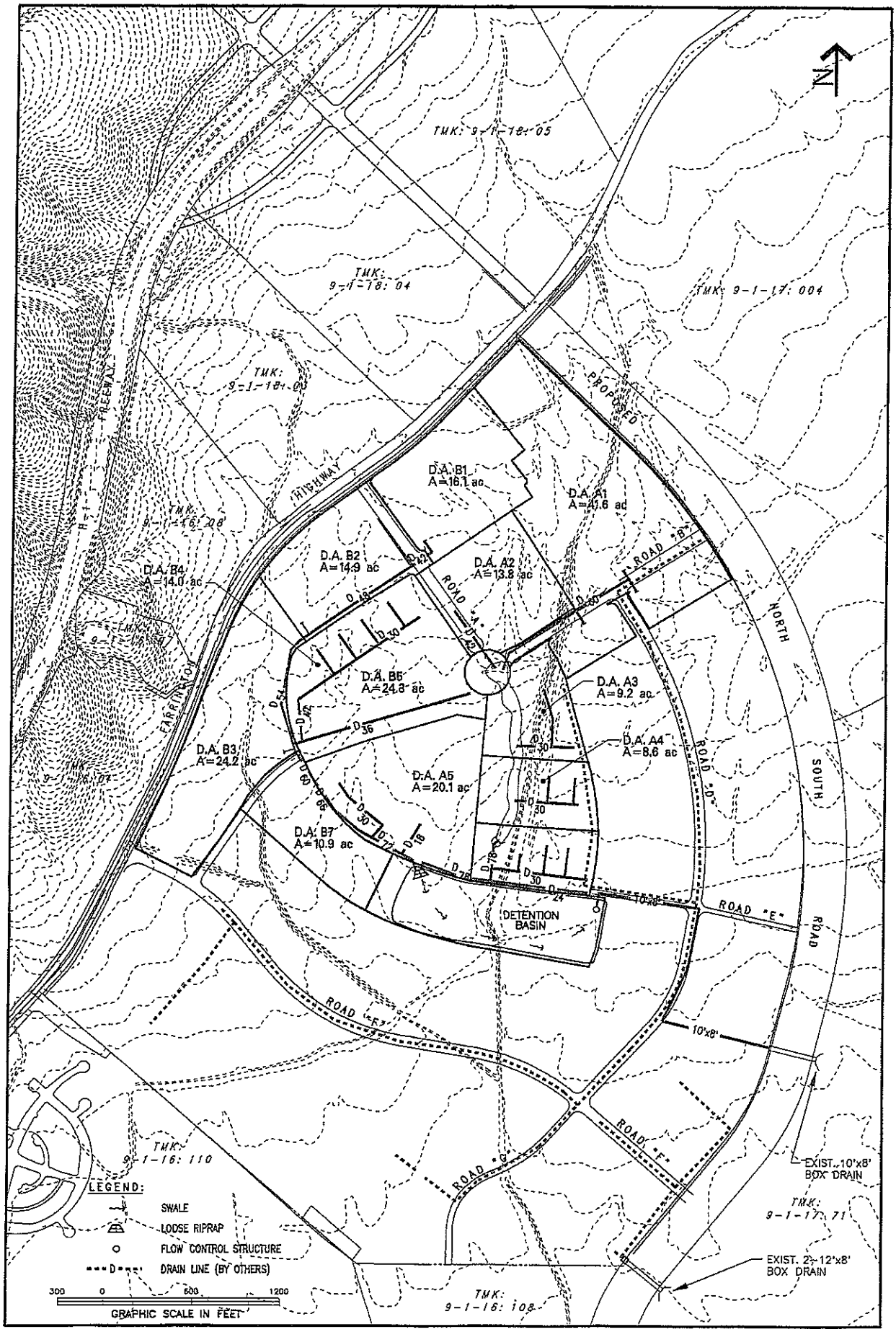

Fig. 4.4 **Full Build–Out Campus Onsite Drainage System**

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EWA, OAHU, HAWAII
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APPENDIX A

WATER DEMAND CALCULATIONS

University of Hawaii West Oahu Kapolei Makai Property
Revised LRDP Land Use Plan dated 4/20/2005
Water Demand Calculations (440' 100% Potable & 215' Dual System)

Land Use (440-foot system, 100% potable)	Unit Demand	Potable Demand
Residential: Single Family	GPD/Unit	500
Residential: Multi-Family Low Rise	GPD/Unit	400
Residential: Multi-Family High Rise	GPD/Unit	300
Commercial	GPD/Acre	3000
Resort	GPD/Unit	350
	GPD/Acre	4000
Park	GPD/Acre	4000
School	GPD/Student	50
Industrial	GPD/Acre	4000
Commercial/Industrial	GPD/1000 SF	100
Commercial/Residential	GPD/1000 SF	120

Land Use (215-foot dual system)	Unit Demand	Potable Demand	Non-Potable Demand
Residential: Single Family	GPD/Unit	414	186
Residential: Multi-Family Low Rise	GPD/Unit	331	149
Residential: Multi-Family High Rise	GPD/Unit	249	112
Commercial	GPD/Acre	2160	1440
Resort	GPD/Unit	244	176
	GPD/Acre	2784	2016
Park	GPD/Acre	720	4080
School	GPD/Student	42	30
Industrial	GPD/Acre	1421	3379
Commercial/Industrial	GPD/1000 SF	72	48
Commercial/Residential	GPD/1000 SF	100	44

Land Use	Approximate Area (AC)	Units	Unit Demand		POTABLE Average Demand (GPD)	Max. Demand (GPD)	Peak Demand (GPD)	Unit Demand		NON-POTABLE Average Demand (GPD)	Max. Demand (GPD)	Peak Demand (GPD)
440' Service Zone (100% potable)												
UH West Oahu Makai Property												
UHWO Campus												
Campus	95.5	12,540	60	GPD/Student	752,400	1,128,600	2,257,200					
Student Housing Parcel A (mixed use)	36.0											
Residential (multi-family)		648	400	GPD/Unit	259,200	387,600	775,200					
Commercial (assumes FAR=0.2)		331,056	120	GPD/1000 SF	39,727	59,590	119,180					
Student Housing Parcel B (multi-family)	12.1	230	400	GPD/Unit	91,960	137,940	275,880					
Mixed Use	25.3											
Residential (medium/low multi-family)		253	400	GPD/Unit	101,200	151,800	303,600					
Retail, Office, Residential (FAR=0.25)		275,517	120	GPD/1000 SF	33,062	49,593	99,186					
Affordable Housing (multi-family)	22.2	355	400	GPD/Unit	142,080	213,120	426,240					
Detention Basin	10.0		4,000	GPD/Acre	40,000	60,000	120,000					
HECO Substation	1.0				0	0	0					
Roads (Farrington HWY Expansion, Rd. A to D)	11.7				0	0	0					
UHWO Campus 440' Subtotal	215.8				1,458,829	2,188,243	4,376,486					
Private Development Properties												
Residential												
Residential Parcel A (high density multi-family)	33.1	530	400	GPD/Unit	211,840	317,760	635,520					
Residential Parcel F (high density multi-family)	24.7	395	400	GPD/Unit	158,080	237,120	474,240					
Residential Parcel G (medium density multi-family)	20.7	248	400	GPD/Unit	99,360	149,040	298,080					
Partial Res. Parcel E (medium/low density single family)	8.5	85	500	GPD/Unit	42,500	63,750	127,500					
Private Dev. 440' Subtotal	87.0				511,780	767,670	1,535,340					
UHWO Makai Property 440' Total	302.8				1,970,609	2,955,913	5,911,826					
Offsite 440' Total	464.1				1,068,777	1,603,165	3,206,331					
440' Total	766.9				3,039,386	4,559,079	9,118,157			0	0	0
215' Service Zone												
UH West Oahu Makai Property												
UHWO Campus												
Campus Population (0 of 11,500)	0.0	0	42	GPD/Student	0	0	0	30	GPD/Student	0	0	0
Affordable Housing	0.0	0	414	GPD/Unit	0	0	0	186	GPD/Unit	0	0	0
Detention Basin	0.0		720	GPD/Acre	0	0	0	4,080	GPD/Acre	0	0	0
UHWO Campus 215' Subtotal	0.0				0	0	0			0	0	0
Private Development Properties												
Residential												
Residential Parcel A (high density multi-family)	0.0	0	331	GPD/Unit	0	0	0	149	GPD/Unit	0	0	0
Residential Parcel B (medium density multi-family)	20.1	241	331	GPD/Unit	79,837	119,756	239,512	149	GPD/Unit	35,939	53,909	107,816
Residential Parcel C (low density single family)	22.0	132	414	GPD/Unit	54,648	81,972	163,944	186	GPD/Unit	24,552	36,828	73,656
Residential Parcel D (low density single family)	38.8	233	414	GPD/Unit	96,379	144,569	289,138	186	GPD/Unit	43,361	64,951	129,902
Residential Parcel E (medium/low density single family)	47.6	476	414	GPD/Unit	197,064	295,596	591,192	186	GPD/Unit	88,536	132,804	265,608
Residential Parcel F (high density multi-family)	0.0	0	331	GPD/Unit	0	0	0	149	GPD/Unit	0	0	0
Residential Parcel G (medium density multi-family)	0.0	0	331	GPD/Unit	0	0	0	149	GPD/Unit	0	0	0
Commercial												
Mixed Use Parcel A (FAR=0.25)	10.5											
Residential (medium/low single family)		105	414	GPD/Unit	43,470	65,205	130,410	186	GPD/Unit	19,530	29,295	58,590
Commercial		114,345	100	GPD/1000 SF	11,435	17,152	34,304	44	GPD/1000 SF	5,031	7,547	15,094
Mixed Use Parcel B (FAR=0.25)	11.2											
Residential (medium/low single family)		112	414	GPD/Unit	46,368	69,552	139,104	186	GPD/Unit	20,832	31,248	62,496
Commercial		121,968	100	GPD/1000 SF	12,197	18,295	36,590	44	GPD/1000 SF	5,367	8,050	16,100
Other												
Elementary School	12.0	1,500	42	GPD/Student	63,000	94,500	189,000	30	GPD/Student	45,000	67,500	135,000
Detention Basin	11.2		720	GPD/Acre	8,064	12,096	24,192	4,080	GPD/Acre	45,696	68,544	137,088
HECO Substation	1.0				0	0	0			0	0	0
Roads (Farrington HWY Expansion, Rd. C to G)	25.1				0	0	0			0	0	0
Private Dev. 215' Subtotal	199.5				612,462	918,693	1,837,385			333,783	500,675	1,001,350
UHWO Makai Property 215' Total	199.5				612,462	918,693	1,837,385			333,783	500,675	1,001,350
Offsite Properties												
DHHL Development (Community Planning MP, 100% Potable)					1,711,400	2,567,100	5,134,200					
Kalaeloa (BWS)					2,000,000	3,000,000	6,000,000					
Offsite 215' Total					3,711,400	5,567,100	11,134,200			0	0	0
215' Total					4,323,862	6,485,793	12,971,585			333,783	500,675	1,001,350
UHWO Makai Property Total	502.3	4,641	TOTAL DEMAND		2,583,870	3,874,606	7,749,211	TOTAL NON-POTABLE DEMAND		333,783	500,675	1,001,350
East Kapolei and Kalaeloa			TOTAL DEMAND		7,363,247	11,044,871	22,089,742	TOTAL NON-POTABLE DEMAND		333,783	500,675	1,001,350

APPENDIX B

WASTEWATER FLOW CALCULATIONS

COMPUTATION OF WASTERWATER FLOW

PROJECT: UH West Oahu Makai Property PER
SEWER:
REF. FILE: LRDP Land Use Dated 4/20/06, Mauka Campus Draft Land Use Dated 8/8/05, DHHL (Community Planning) Land Use Dated 8/0

PAGE:
COMPUTED BY:
DATE:

SEWER LOCATION		TRIBUTARY AREA		TRIBUTARY EQUIVALENT POPULATION						WASTEWATER FLOW COMPUTATION								SEWER STUDY			
				RESIDENTIAL		OTHER		TOTAL										EXISTING		ULTIMATE	
DISTRICT ZONE OR STREET	POINT	INCR.	TOTAL	INCR.	TOTAL	INCR.	TOTAL	INCR.	TOTAL	AVE. WWF @ 80 GPCD (MGD)	MAX FLOW FACTOR	MAX. FLOW (MGD)	DRY WEATH. INFIL. (MGD)	DES. AVE. FLOW (MGD)	DES. MAX. FLOW (MGD)	WET WEATH INFIL. (MGD)	DESIGN PEAK FLOW (MGD)	PIPE DIAM. (IN)	SLOPE (%)	VEL. (FPS)	CAP. (MGD)
Trunk Line																					
UHWO Mauka		991.0	991.0	5,210	5,210	18,340	18,340	23,550	23,550	1.884	2.658	5.01	0.116	2.002	5.126	1.239	6.364	24	0.50	5.1	10.34
Parcel G (Commercial)		44.9	1035.9		5,210	6,286	24,626	6,286	29,836	2.387	2.535	6.05	0.149	2.536	6.201	1.295	7.495	24	0.50	5.1	10.34
Parcel F1 (Low Den. M.F.)		15.7	1051.6	526	5,736		24,626	526	30,362	2.429	2.526	6.14	0.152	2.581	6.288	1.315	7.603	24	0.50	5.1	10.34
Parcel F2 (Low Den. M.F.)		16.7	1068.3	560	6,296		24,626	560	30,922	2.474	2.517	6.23	0.155	2.628	6.382	1.335	7.717	24	0.50	5.1	10.34
Parcel E (Low Den. M.F.)		22.8	1091.1	767	7,064		24,626	767	31,690	2.535	2.505	6.35	0.158	2.694	6.509	1.364	7.873	24	0.80	6.4	13.06
Stu. Housing A (Mixed Use)		22.2	1113.3	1,132	8,196	178	24,804	1,310	32,999	2.640	2.485	6.56	0.165	2.805	6.724	1.392	8.116	24	1.30	8.2	16.67
Univ. Village (Mixed Use)		15.1	1128.4	604	8,800	529	25,332	1,133	34,132	2.731	2.468	6.74	0.171	2.901	6.910	1.411	8.320	24	1.30	8.2	16.67
Private Dev. Res. A (High Den. M.F.)		33.1	1161.5	1,483	10,283		25,332	1,483	35,615	2.849	2.447	6.97	0.178	3.027	7.150	1.452	8.602	24	1.30	8.2	16.67
@ Rd. D & E Intersection		178.3	1339.8	3,597	13,880	3,720	29,052	7,317	42,932	3.435	2.357	8.10	0.215	3.649	8.311	1.675	9.986	24	1.30	8.2	16.67
Private Dev. Res. E (Med/Low Den. S.F.)		17.5	1357.3	700	14,580		29,052	700	43,632	3.491	2.350	8.20	0.218	3.709	8.420	1.697	10.117	30	0.60	6.5	20.54
Private Dev. Res. B (Med. Den. M.F.)		20.1	1377.4	675	15,255		29,052	675	44,307	3.545	2.342	8.30	0.222	3.766	8.525	1.722	10.246	30	0.60	6.5	20.54
@Rd. D & F Intersection		216.3	1593.7	5,932	21,187	832	29,884	6,764	51,071	4.086	2.277	9.30	0.255	4.341	9.558	1.992	11.550	30	0.60	6.5	20.54
@Rd F & N-S Rd		21.7	1615.4	868	22,055	760	30,644	1,628	52,699	4.216	2.263	9.54	0.263	4.479	9.802	2.019	11.822	30	0.80	7.5	23.71
In N-S Rd.			1615.4		22,055		30,644		52,699	4.216	2.263	9.54	0.263	4.479	9.802	2.019	11.822	30	0.28	4.4	14.03
Stu. Housing A (Mixed Use)		15.8	15.8	806	806	126	126	932	932	0.075	5.000	0.37	0.005	0.079	0.378	0.020	0.397	10	0.20	1.6	0.55
Student Housing B		12.1	27.9	690	1,496		126	690	1,622	0.130	4.539	0.59	0.008	0.138	0.597	0.035	0.632	10	0.75	3.0	1.06
Affordable Housing (M.F.)		22.2	50.1	995	2,490		126	995	2,616	0.209	4.125	0.86	0.013	0.222	0.877	0.063	0.939	12	0.75	3.4	1.73
UHWO Campus		103.5	153.6		2,490	3,594	3,720	3,594	6,210	0.497	3.470	1.72	0.031	0.528	1.755	0.192	1.947	15	0.50	3.2	2.56
Private Dev. Res. F (High Den. M.F.)		24.7	178.3	1,107	3,597		3,720	1,107	7,317	0.585	3.358	1.97	0.037	0.622	2.002	0.223	2.225	18	0.50	3.6	4.16
Along Rd. F (West to Rd. D)																					
Parcel H1 (Low Den. S.F.)		70.0	70.0	1,400	1,400		0	1,400	1,400	0.112	4.675	0.52	0.007	0.119	0.531	0.088	0.619	10	0.36	2.1	0.74
Parcel H2 (Park)		4.0	74.0		1,400	6	6	6	1,406	0.112	4.671	0.53	0.007	0.120	0.532	0.093	0.625	10	0.36	2.1	0.74
UH Mixed Use Parcel C (FAR=0.25)		10.2	84.2	408	1,808	357	363	765	2,171	0.174	4.282	0.74	0.011	0.185	0.755	0.105	0.860	12	0.36	2.4	1.20
Private Dev. Res. G (Med. Den. M.F.)		20.7	104.9	812	2,620		363	812	2,983	0.239	4.018	0.96	0.015	0.254	0.974	0.131	1.105	12	0.80	3.5	1.79
Private Dev. Res. E (Med./Low Den. S.F.)		38.6	143.5	1,853	4,473		363	1,853	4,836	0.387	3.648	1.41	0.024	0.411	1.436	0.179	1.615	15	0.80	4.1	3.24
Private Dev. Res. D (Low Den. S.F.)		38.8	182.3	931	5,404		363	931	5,767	0.461	3.522	1.62	0.029	0.490	1.654	0.228	1.882	15	0.80	4.1	3.24
Private Dev. Res. C (Low Den. S.F.)		22.0	204.3	528	5,932		363	528	6,295	0.504	3.461	1.74	0.031	0.535	1.774	0.255	2.030	15	0.80	4.1	3.24
Elementary School		12.0	216.3		5,932	469	832	469	6,764	0.541	3.411	1.85	0.034	0.575	1.880	0.270	2.150	15	0.80	4.1	3.24
Along Rd. F (East to Rd. D)																					
Private Dev. Mixed Use Parcel A (FAR=0.25)		10.5	10.5	420	420	368	368	788	788												
Private Dev. Mixed Use Parcel B (FAR=0.25)		11.2	21.7	448	868	392	760	840	1,628												

REMARKS: UH Campus-11,500 Students; S.H. Parcel A 17 units/ac; S.H. Parcel B 19 units/ac; Mixed Use Res. 10 units/ac; A.H. 16 units/ac; Private Dev. Res. A & F 16 units/ac, Parcel B & G 12 units/ac, Parcel E 1

Assumptions

Sewer Demand Rates:

S.F. Residential	4	persons/unit
M.F. Residential	2.8	persons/unit
Student Housing	3	persons/unit
Community Business	140	persons/acre
Neighborhood Business	40	persons/acre
Schools	25/80	persons/student
Stu. Housing Parcel A	51	persons/acre (student res plus neighbor bus. w/ FAR=0.25)

APPENDIX C

DRAINAGE CALCULATIONS

ENGINEERING CONCEPTS, INC.
1150 South King Street, Suite 700
Honolulu, Hawaii 96814
Tel. (808) 591-8820 Fax (808) 591-9010

PROJECT UHNO Campus Phase 1
ITEM Tc, CN
CALCULATED BY JT DATE 2/3/06 CHECKED BY _____ DATE _____

Pre-developed Condition : Veggie Farm

Time of Concentration (to Det. Pond) :

<<Std.>> Tbl. 3

Over-Land Flow : $L_{OL} = 1500$ ft, $S_{OL} = 2.33\%$

$V = 2$ fps $\Rightarrow T_{OL} = \frac{1500}{2 \times 60} = 12.5$ min

Natural Gully : $L_t = 1450$ ft., $S_t = 0.55\%$

<<Ewa Drainage MP.>> @SEC 45 $n = 0.035$

Based on X-sec data and n value in Ewa rpt.
Estimated flow velocity ~ 6 fps (100-yr)

$\Rightarrow T_{t2} = \frac{1450}{6 \times 60} = 4$ min

$\Rightarrow T_c = T_{t1} + T_{t2} = 12.5 + 4 = 16.5$ min
$= 0.28$ hr

Curve Number:

<<TR-55>> Tbl 2-2b

Hydrologic Soil Group : B

Ground Cover : Good

<<Botanical Survey>>

Assume Row Crops, straight row

$\Rightarrow CN_{ex} = 75$

ENGINEERING CONCEPTS, INC.
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PROJECT UHNO Campus Phase 1
ITEM Tc, CN
CALCULATED BY JT DATE 5/30/06 CHECKED BY _____ DATE _____

Post-developed Condition :

Time of Concentration (to Det Pond)

<<Std.>> Tbl. 3

- Overland Flow to DI in Road "B":
  $L \sim 4000$ ft, $S = \frac{140 - 115}{1000} = 2.5\%$
  $V = 2$ fps $\Rightarrow T_{t1} = \frac{1000}{2 \times 60} = 8.3$ min
- Neglect travel time to Gully through pipes
- From end of lower parking to det pond:
  Similar to pre-condition, estimated flow velocity ~ 7 fps (100-yr storm)

<<EWA Drainage MP>> @ SEC 45 $n = 0.035$

$\Rightarrow T_{t2} = \frac{1450}{7 \times 60} = 3.5$ min

$\Rightarrow T_c = T_{t1} + T_{t2} = 8.3 + 3.5 = 11.8$ min
~ 0.2 hr

Curve Number

Based on LRDP Update dated 4/20/06

- Phase 1 Campus area + Roads = 23.3 ac
  w/ Imp. area ~ 11 ac
  $\Rightarrow CN_{camp} = \frac{98 \times 11.0 + 61 \times 12.3}{23.3} \sim 79$
- University Village Mixed Use = 2.4 + 3.6 = 6.0 ac
  Assume 85% Imp. area : $CN_{VU} = 92$
- Additional areas at existing condition
  $15.6 + 37.9 + 5 = 58.5$ ac, $CN_{ex} = 75$

<<TR-55>> Tbl : 2-2.a

Pond area = 5 ac

$CN_{Dev.} = \frac{79 \times 20 + 92 \times 6 + 75 \times 58.5}{(20 + 6 + 58.5)} \sim 77$

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PROJECT UHWO Campus Phase 1
ITEM Water Quality Control
CALCULATED BY JT DATE 5/30/06 CHECKED BY _____ DATE _____

Use Detention Based Control (dry pond):

<<Std.>> §1-5.1.C

Runoff Coefficient =

Ph. 1 dev. area + UH Village = 23.2 + 6 = 29.2 ac

Impervious area = 11.0 + 5.1 = 16.1 ac

Additional area at existing condition = 58.5 ac

$\Rightarrow IMP = \frac{16.1}{(29.2+58.5)} \sim 19\%$

$\Rightarrow C = 0.05 + (0.009) \times IMP$
$= 0.05 + (0.009) \times (19) = 0.22$

$\Rightarrow WQDV = C \times 1'' \times A \times 3630$
$= 0.22 \times 1'' \times 194.5 \times 3630$
$= 75810 \text{ cu-ft} = 1.75 \text{ ac-ft}$

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PROJECT UHWO Campus Site – Full Dev.
ITEM CN, Tc
CALCULATED BY JT DATE 2/14/06 CHECKED BY _____ DATE _____

Pre-developed Condition: Veggie Farm

Curve Number:

<<TR-55>> Tbl. 2-2b

Hydrologic Soil Group: B

Assume: Straight row crop, good ground cover

$\Rightarrow CN_{ex} = 75$

Time of Concentration (to Det. Pond):

Overland flows:

$L_1 = 1050$ ft, $S_1 = \frac{155+135}{1050} = 1.9\%$

$L_2 = 1000$ ft, $S_2 = \frac{135-125}{1000} = 1\%$

<<Std.>> Tbl. 3

Use $V = 2$ fps $\Rightarrow T_{OL} = \frac{1050+1000}{2} = 17$ min.

Natural Gully:

$L_3 = 1200$ ft, $S_3 = \frac{125-100}{1200} = 2.08\%$

$L_4 = 1450$ ft, $S_4 = \frac{100-92}{1450} = 0.55\%$

<<EWA Drainage MP>> @ SEC 4.5 $n = 0.035$

Estimated flow velocity ~ 5 fps

$\Rightarrow T_{it} = \frac{2650}{5} = 9$ min.

$\Rightarrow T_c = T_{OL} + T_{it} = 17 + 9 = 26$ min
$= 0.43$ hr

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PROJECT UHWO Campus Site - Full Dev.
ITEM CN, Tc
CALCULATED BY JT DATE 5/30/06 CHECKED BY _____ DATE _____

Post-developed Condition:

«LRDP Land Use» 4-20-06

Curve Number:

- Campus: $A_{camp} = 103.5$ ac

«LRDP Site Plan» 4-20-06

Assume: 65% impervious
35% open space

LRDP Update Tbl. 1-4

⇒ Imp. Area = 67.3 ac, Perv. Area = 36.2 ac

«TR-55» Tbl. 2-2a

$$\Rightarrow CN_{camp} = \frac{98 \times 67.3 + 61 \times 36.2}{103.5} \sim 85$$

- Student Housing Parcel A Mixed Use:
  $A_{SH-A} = 38$ ac
  Assume 85% Imp. Area: $CN_{SH-A} = 92$

- Student Housing Parcel B:
  $A_{SH-B} = 12.4$ ac
  Assume 65% Imp. Area: $CN_{SH-B} = 85$

- Mixed Use (Univ. Village & Parcel C)
  $A_{mix} = 15.1 + 10.2 = 25.3$ ac
  Assume 85% Imp. Area: $CN_{vil} = 92$

- Affordable Housing:
  $A_{AH} = 22.2$ ac
  Assume 65% Imp. Area: $CN_{AH} = 85$

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PROJECT UHWO Campus Site - Full Dev.
ITEM CN, Tc
CALCULATED BY JT DATE 5/30/06 CHECKED BY _____ DATE _____

(Post-developed Cont'd.)

- Roads (A, B, C, & D) within Campus area
  = 7.3 ac
  $CN_{Rd} = 98$

- Farrington Hwy Exp.: $A_{HWY} = 4.4$ ac
  $CN_{HWY} = 98$

- HECO Substation: $A_{HECO} = 2.0$ ac
  Assume 85% Imp. Area: $CN_{HECO} = 92$

⇒ Composite CN = 88

Time of Concentration:

Assume 5 min. overland flow and
5 min. travel time to pond

Tc = 10 min

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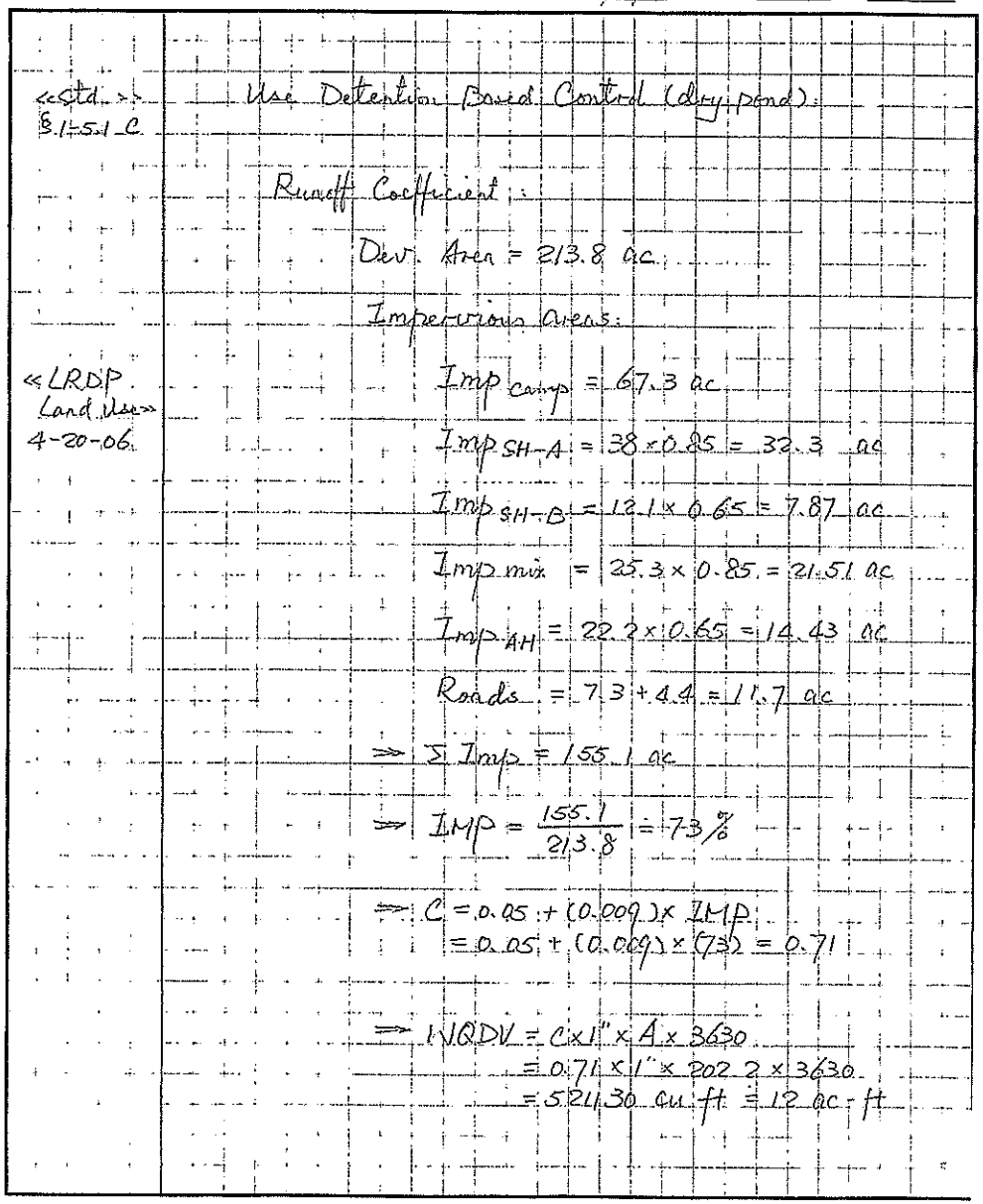
PROJECT UHWO Campus Site - Full Dev
ITEM Water Quality Control
CALCULATED BY JT DATE 5/30/06 CHECKED BY _____ DATE _____



<<Std.>> Use Detention Based Control (dry pond):
§.1.5.1.C

Runoff Coefficient:

Dev. Area = 213.8 ac

Impervious Areas:

<<LRDP Land Use>> 4-20-06

Imp camp = 67.3 ac

Imp SH-A = 38 × 0.85 = 32.3 ac

Imp SH-B = 12.1 × 0.65 = 7.87 ac

Imp mix = 25.3 × 0.85 = 21.51 ac

Imp AH = 22.2 × 0.65 = 14.43 ac

Roads = 7.3 + 4.4 = 11.7 ac

⇒ Σ Imp = 155.1 ac

⇒ $IMP = \frac{155.1}{213.8} = 73\%$

⇒ C = 0.05 + (0.009) × IMP
= 0.05 + (0.009) × (73) = 0.71

⇒ WQDV = C × 1" × A × 3630
= 0.71 × 1" × 202.2 × 3630
= 521,130 cu ft = 12 ac-ft

Table 2-2a Runoff curve numbers for urban areas [1]

Cover description: Cover type and hydrologic condition	Average percent impervious area [2]	Curve numbers for hydrologic soil group: A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) [3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	(61)	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	(98)	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	(85)	89	(92)	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation) [5]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

[1] Average runoff condition, and $I_a = 0.2S$.
[2] The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.
[3] CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.
[4] Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.
[5] Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4 based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

Table 2-2b Runoff curve numbers for cultivated agricultural lands [1]

Cover description			Curve numbers for hydrologic soil group			
Cover type	Treatment [2]	Hydrologic condition [3]	A	B	C	D
Fallow	Bare soil	—	77	86	91	94
	Crop residue cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90
Row crops	Straight row (SR)	Poor	72	81	88	91
		Good	67	78	85	89
	SR + CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	C + CR	Poor	69	78	83	87
		Good	64	74	81	85
	Contoured & terraced (C&T)	Poor	66	74	80	82
		Good	62	71	78	81
	C&T+ CR	Poor	65	73	79	81
		Good	61	70	77	80
Small grain	SR	Poor	65	76	84	88
		Good	63	75	83	87
	SR + CR	Poor	64	75	83	86
		Good	60	72	80	84
	C	Poor	63	74	82	85
		Good	61	73	81	84
	C + CR	Poor	62	73	81	84
		Good	60	72	80	83
	C&T	Poor	61	72	79	82
		Good	59	70	78	81
	C&T+ CR	Poor	60	71	78	81
		Good	58	69	77	80
Close-seeded or broadcast legumes or rotation meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C&T	Poor	63	73	80	83
		Good	51	67	76	80

[1] Average runoff condition, and I_a=0.2S

[2] Crop residue cover applies only if residue is on at least 5% of the surface throughout the year.

[3] Hydraulic condition is based on combination factors that affect infiltration and runoff, including (a) density and canopy of vegetative areas, (b) amount of year-round cover, (c) amount of grass or close-seeded legumes, (d) percent of residue cover on the land surface (good ≥ 20%), and (e) degree of surface roughness.

Poor: Factors impair infiltration and tend to increase runoff.

Good: Factors encourage average and better than average infiltration and tend to decrease runoff.


```
Job File: C:\HAESTAD\PPK6\UHWOC_~1\UHWOC~~1.PPK
Rain Dir: C:\HAESTAD\PPK6\UHWOC_~1\

                    ==========
                     JOB TITLE
                    ==========

      University of Hawaii West Oahu Campus Site
      Phase 1 Development.
      2-yr, 10-yr, and 100-yr 24-hr storms.

S/N: HOMOL0105938   Engineering Concepts, Inc.
Pond Pack Ver: 5-05-97 :050 Compute Time: 09:45:45 Date: 02-14-2006
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File.... C:\HAESTAD\PPK6\UHWOC_~1\UHWOC~~1.PPK
Title... Required Detention Volume for Phase 1

>>>>> DETENTION STORAGE ESTIMATE <<<<<

Inflow Data (Graphical Peak Discharge): Post-dev. Runoff
Outflow Data (Graphical Peak Discharge): Pre-dev. Runoff

Inflow Drainage Area = 94.500 acres

	RAINFALL DISTRIBUTION = TYPE I		
	Storm #1	Storm #2	Storm #3
Frequency (years)	2-yr	10-yr	100-yr
Rainfall, P, 24-hr (in)	4.6000	7.7000	12.3000
Inflow Runoff, Q (in)	2.5470	5.3443	9.7371
Peak Inflow, qi (cfs)	151	320	582
Peak Outflow, qo (cfs)	79	189	359
qo/qi Ratio	.52318	.59062	.61684
* Vs/Vr Ratio	.17115	.15382	.14879
Inflow Volume, Vr (ac-ft)	20.057	42.087	76.679
STORAGE VOLUME, Vs (ac-ft)	3.433	6.474	11.409

Summary of Volume Calcs

C0	.66000	.66000	.66000
C1	-1.76000	-1.76000	-1.76000
C2	1.96000	1.96000	1.96000
C3	-.73000	-.73000	-.73000
* Vs/Vr	.17115	.15382	.14879

* Vs/Vr = C0 + (C1*(qo/qi)) + (C2*(qo/qi)**2) + (C3*(qo/qi)**3)

File.... C:\HAESTAD\PPK6\UHWOC_~1\None Selecte
Title... Required Detention Volume for Phase 1

>>>>> GRAPHICAL PEAK DISCHARGE METHOD <<<<<

Drainage Area = 94.500 acres ---> .147656 sq.mi.
Runoff Curve Number = 80
Time of Concentration = .2000 hrs
Pond and Swamp Areas = .00 % ---> .000 acres

	RAINFALL DISTRIBUTION = TYPE I		
	Storm #1	Storm #2	Storm #3
Frequency (years)	2-yr	10-yr	100-yr
Rainfall, P, 24-hr (in)	4.6000	7.7000	12.3000
Initial Abstraction, Ia (in)	.5000	.5000	.5000
Ia/p Ratio	.1087	.0649	.0407
Unit Discharge, * qu (csm/in)	400	405	405
Runoff, Q (in)	2.5470	5.3443	9.7371
Pond & Swamp Adjustment, Fp	1.00	1.00	1.00
PEAK DISCHARGE, qp (cfs)	151	320	582

Summary of Computations for qu

Ia/p	#1		.10000	.10000	.10000
C0	#1		2.30550	2.30550	2.30550
C1	#1		-.51429	-.51429	-.51429
C2	#1		-.11750	-.11750	-.11750
qu	#1	(csm/in)	405.1049	405.1049	405.1049
Ia/p	#2		.20000	.10000	.10000
C0	#2		2.23537	2.30550	2.30550
C1	#2		-.50387	-.51429	-.51429
C2	#2		-.08929	-.11750	-.11750
qu	#2	(csm/in)	349.8940	405.1049	405.1049
* qu (csm/in)			400	405	405

* Interpolated for computed Ia/p ratio (between Ia/p #1 & Ia/p #2)
If computed Ia/p exceeds Ia/p limits, bounding limit for Ia/p is used.

log(qu) = C0 + (C1 * log(Tc)) + (C2 * (log(Tc))**2) Where: Tc=hours

qp (cfs) = qu(csm) * Area(sq.mi.) * Q(in) * (Fp)

File.... C:\HAESTAD\PPK6\UHWOC_~1\None Selecte
Title... Required Detention Volume for Phase 1

>>>>> GRAPHICAL PEAK DISCHARGE METHOD <<<<<

Drainage Area	=	94.500 acres ---> .147656 sq.mi.
Runoff Curve Number	=	75
Time of Concentration	=	.2800 hrs
Pond and Swamp Areas	=	3.00 % ---> 2.835 acres

RAINFALL DISTRIBUTION = TYPE I	Storm #1	Storm #2	Storm #3
Frequency (years)	2-yr	10-yr	100-yr
Rainfall, P, 24-hr (in)	4.6000	7.7000	12.3000
Initial Abstraction, Ia (in)	.6667	.6667	.6667
Ia/p Ratio	.1449	.0866	.0542
Unit Discharge, * qu (csm/in)	335	358	358
Runoff, Q (in)	2.1291	4.7718	9.0424
Pond & Swamp Adjustment, Fp	.75	.75	.75
PEAK DISCHARGE, qp (cfs)	79	189	359

Summary of Computations for qu

	Ia/p	#1	.10000	.10000	.10000
	C0	#1	2.30550	2.30550	2.30550
	C1	#1	-.51429	-.51429	-.51429
	C2	#1	-.11750	-.11750	-.11750
	qu	#1 (csm/in)	358.0215	358.0215	358.0215
	Ia/p	#2	.20000	.10000	.10000
	C0	#2	2.23537	2.30550	2.30550
	C1	#2	-.50387	-.51429	-.51429
	C2	#2	-.08929	-.11750	-.11750
	qu	#2 (csm/in)	306.6480	358.0215	358.0215
*	qu (csm/in)		335	358	358

* Interpolated for computed Ia/p ratio (between Ia/p #1 & Ia/p #2)
If computed Ia/p exceeds Ia/p limits, bounding limit for Ia/p is used.

log(qu) = C0 + (C1 * log(Tc)) + (C2 * (log(Tc))**2) Where: Tc=hours

qp (cfs) = qu(csm) * Area(sq.mi.) * Q(in) * (Fp)

JOB TITLE

University of Hawaii West Oahu Campus Site
Fully developed condition.
2-yr, 10-yr, and 100-yr 24-hr storms.

S/N: H0M0L0105938 Engineering Concepts, Inc.
Pond Pack Ver: 5-05-97 :050 Compute Time: 14:59:06 Date: 02-15-2006

File.... C:\HAESTAD\PPK6\UHWOC_~1\UHWOC.PPK
Title... Required Detention Volume for Campus Site

>>>>> DETENTION STORAGE ESTIMATE <<<<<

Inflow Data (Graphical Peak Discharge): Post-dev. Runoff
Outflow Data (Graphical Peak Discharge): Pre-dev. Runoff

Inflow Drainage Area = 202.200 acres

	RAINFALL DISTRIBUTION = TYPE I		
	Storm #1	Storm #2	Storm #3
Frequency (years)	2-yr	10-yr	100-yr
Rainfall, P, 24-hr (in)	4.6000	7.7000	12.3000
Inflow Runoff, Q (in)	3.2904	6.2752	10.8025
Peak Inflow, qi (cfs)	445	849	1462
Peak Outflow, qo (cfs)	142	340	644
qo/qi Ratio	.31910	.40047	.44049
* Vs/Vr Ratio	.27424	.22262	.20265
Inflow Volume, Vr (ac-ft)	55.443	105.736	182.022
STORAGE VOLUME, Vs (ac-ft)	15.205	23.540	36.886

Summary of Volume Calcs

C0	.66000	.66000	.66000
C1	-1.76000	-1.76000	-1.76000
C2	1.96000	1.96000	1.96000
C3	-.73000	-.73000	-.73000
* Vs/Vr	.27424	.22262	.20265

* Vs/Vr = C0 + (C1*(qo/qi)) + (C2*(qo/qi)**2) + (C3*(qo/qi) **3)

File.... C:\HAESTAD\PPK6\UHWOC_~1\None Selecte
Title... Required Detention Volume for Campus Site

>>>>> GRAPHICAL PEAK DISCHARGE METHOD <<<<<

Drainage Area = 202.200 acres ---> .315937 sq.mi.
Runoff Curve Number = 88
Time of Concentration = .1700 hrs
Pond and Swamp Areas = .00 % ---> .000 acres

	RAINFALL DISTRIBUTION = TYPE I		
	Storm #1	Storm #2	Storm #3
Frequency (years)	2-yr	10-yr	100-yr
Rainfall, P, 24-hr (in)	4.6000	7.7000	12.3000
Initial Abstraction, Ia (in)	.2727	.2727	.2727
Ia/p Ratio	.0593	.0354	.0222
Unit Discharge, * qu (csm/in)	428	428	428
Runoff, Q (in)	3.2904	6.2752	10.8025
Pond & Swamp Adjustment, Fp	1.00	1.00	1.00
PEAK DISCHARGE, qp (cfs)	445	849	1462

Summary of Computations for qu

Ia/p	#1		.10000	.10000	.10000
C0	#1		2.30550	2.30550	2.30550
C1	#1		-.51429	-.51429	-.51429
C2	#1		-.11750	-.11750	-.11750
qu	#1	(csm/in)	428.2406	428.2406	428.2406
Ia/p	#2		.10000	.10000	.10000
C0	#2		2.30550	2.30550	2.30550
C1	#2		-.51429	-.51429	-.51429
C2	#2		-.11750	-.11750	-.11750
qu	#2	(csm/in)	428.2406	428.2406	428.2406
* qu (csm/in)			428	428	428

* Interpolated for computed Ia/p ratio (between Ia/p #1 & Ia/p #2)
If computed Ia/p exceeds Ia/p limits, bounding limit for Ia/p is used.

log(qu) = C0 + (C1 * log(Tc)) + (C2 * (log(Tc))**2) Where: Tc=hours

qp (cfs) = qu(csm) * Area(sq.mi.) * Q(in) * (Fp)

Type.... Graphical Peak
Name.... Pre-dev. Runoff

File.... C:\HAESTAD\PPK6\UHWOC_~1\None Selecte
Title... Required Detention Volume for Campus Site

>>>>> GRAPHICAL PEAK DISCHARGE METHOD <<<<<

Drainage Area	=	202.200 acres ---> .315937 sq.mi.
Runoff Curve Number	=	75
Time of Concentration	=	.4300 hrs
Pond and Swamp Areas	=	3.00 % ---> 6.066 acres

	RAINFALL DISTRIBUTION = TYPE I		
	Storm #1	Storm #2	Storm #3
Frequency (years)	2-yr	10-yr	100-yr
Rainfall, P, 24-hr (in)	4.6000	7.7000	12.3000
Initial Abstraction, Ia (in)	.6667	.6667	.6667
Ia/p Ratio	.1449	.0866	.0542
Unit Discharge, * qu (csm/in)	281	301	301
Runoff, Q (in)	2.1291	4.7718	9.0424
Pond & Swamp Adjustment, Fp	.75	.75	.75
PEAK DISCHARGE, qp (cfs)	142	340	644

Summary of Computations for qu

Ia/p	#1		.10000	.10000	.10000
C0	#1		2.30550	2.30550	2.30550
C1	#1		-.51429	-.51429	-.51429
C2	#1		-.11750	-.11750	-.11750
qu	#1	(csm/in)	300.7585	300.7585	300.7585
Ia/p	#2		.20000	.10000	.10000
C0	#2		2.23537	2.30550	2.30550
C1	#2		-.50387	-.51429	-.51429
C2	#2		-.08929	-.11750	-.11750
qu	#2	(csm/in)	255.8930	300.7585	300.7585
* qu	(csm/in)		281	301	301

* Interpolated for computed Ia/p ratio (between Ia/p #1 & Ia/p #2)
If computed Ia/p exceeds Ia/p limits, bounding limit for Ia/p is used.

log(qu) = C0 + (C1 * log(Tc)) + (C2 * (log(Tc))**2) Where: Tc=hours

qp (cfs) = qu(csm) * Area(sq.mi.) * Q(in) * (Fp)

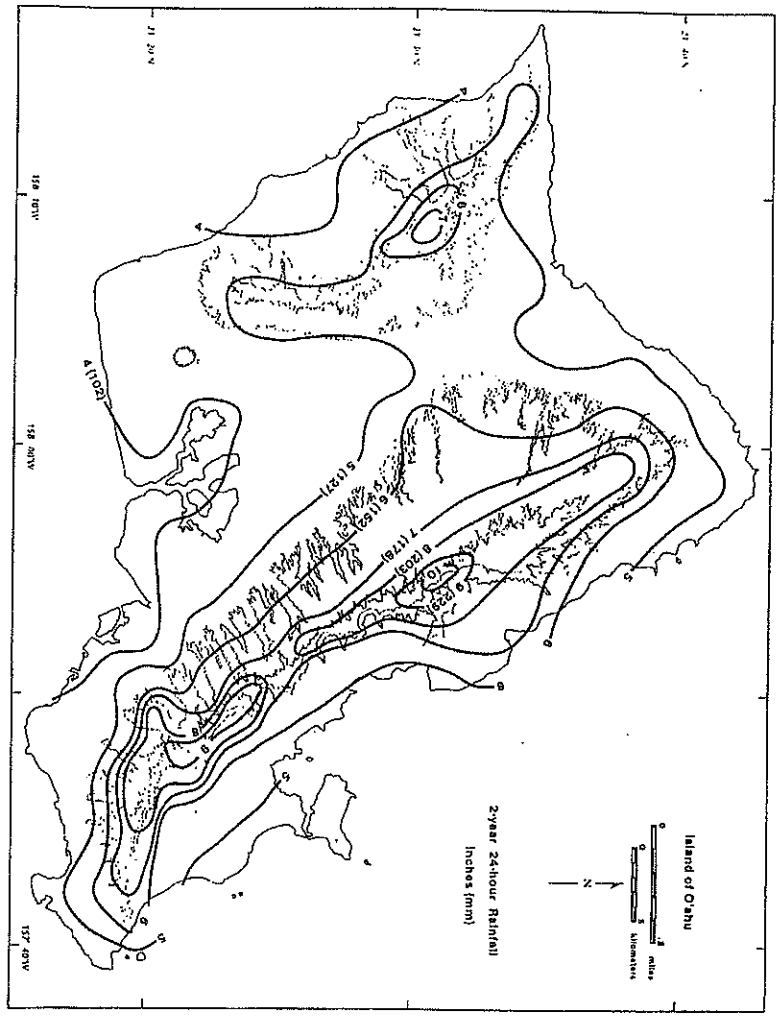


Figure 15. Map of 2-yr 24-hr rainfall, O'ahu, Hawai'i

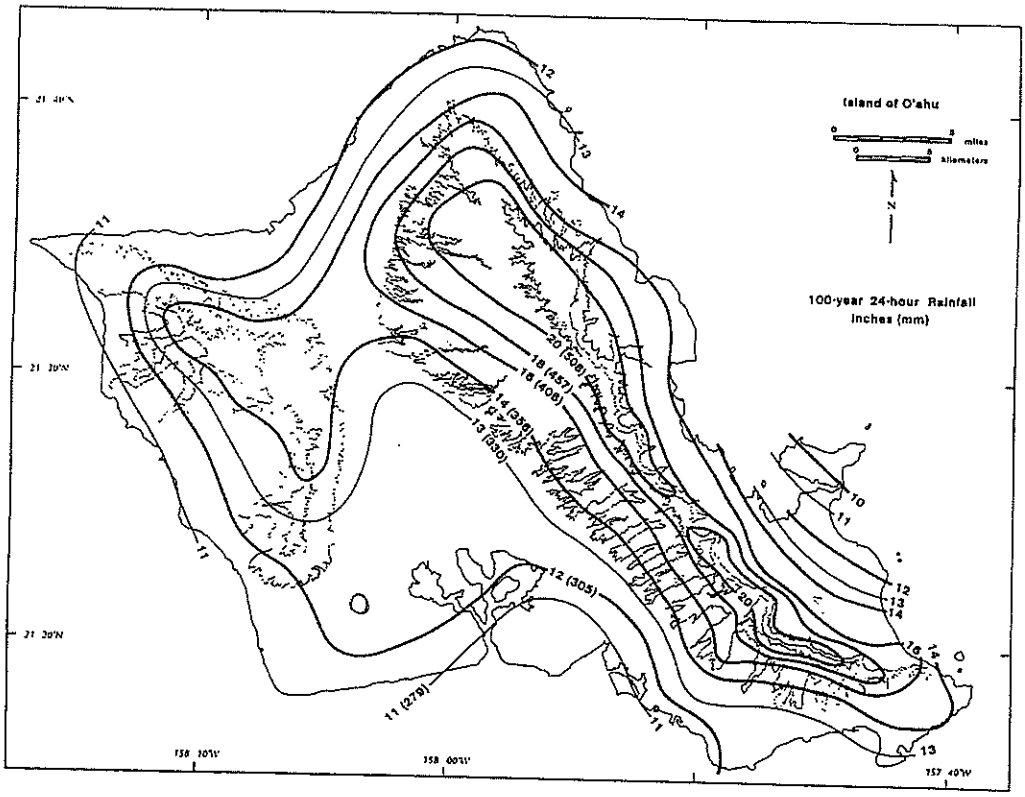


Figure 18. Map of 100-yr 24-hr rainfall, O'ahu, Hawai'i

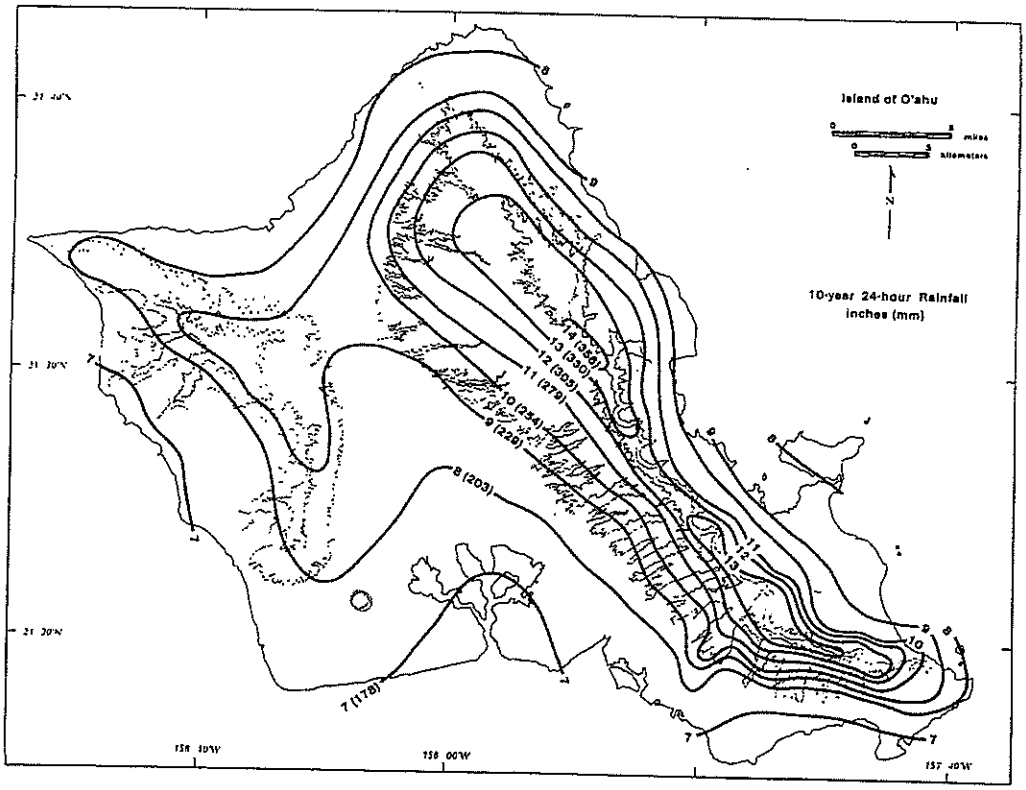


Figure 16. Map of 10-yr 24-hr rainfall, O'ahu, Hawai'i

APPENDIX D

Belt Collins Hawaii's Report

West O'ahu Campus

Development

Drainage Master Plan

Honouliuli, Ewa, O'ahu, Hawai'i

Tax Map Key: (1) 9-1-16:120, 127 & 129

DRAFT

For

West O'ahu Campus Development
737 Bishop Street
Mauka Tower, Suite 2750
Honolulu, Hawai'i, 96813

By:

Belt Collins Hawaii
2153 North King Street, Suite 200
Honolulu, Hawai'i 96819

March 30, 2006

1.0 INTRODUCTION

1.1 Purpose

This drainage analysis has been prepared to: assess the effect that the University of Hawaii West Oahu (UH West Oahu) development will have on storm water runoff flow rates and quantities; determine what drainage improvements would be required to convey runoff through the development; and identify measures to prevent a net increase in runoff down-gradient from the development.

1.2 Site Description

The UH West Oahu development is located in East Kapolei, as shown in Figure 1, Project Location Map. The site is situated between the proposed North-South Collector Road to the east, and Kapolei Golf Course to the west. Farrington Highway is located upgradient of the site and downgradient of the site is a parcel owned by the Department of Hawaiian Homelands. The only existing development on the site consists of agricultural cultivation of market garden crops. The site was previously used for sugar cane cultivation.

The UH West Oahu project parcels (TMK: (1) 9-1-16:120, 127 & 129) total approximately 500 acres. The UH West Oahu project consists of the UH West Oahu campus, student housing, and residential, commercial, and mixed use developments, as shown in Figure 2, Proposed Land Use.

1.3 Flood Insurance Rate Map

The project site is located in an area designated as Zone D on the Flood Insurance Rate Map (15003C0310 F, effective September 30, 2004), where flood hazards are undetermined.

1.4 Drainage Concept and Report Format

The drainage concept is premised on no net increase in storm runoff from the site. A detention basin is proposed to contain runoff generated by the development in excess of existing storm water discharge from the site. Section 2 (Existing and Developed Flows) of this report compares storm water runoff flows before and after the development to asses impacts to storm water quantities due to the development of the UH West Oahu. Section 3 of this report provides a summary of findings and recommended improvements.

2.0 EXISTING AND DEVELOPED FLOWS

The existing and developed flows from areas mauka (north) of the project site to areas makai (south) of the project site were evaluated to determine the effects of the development on storm water runoff. The increase in runoff due to the development will be retained on site so that runoff from the site will not exceed pre-development conditions.

2.1 Methodology

The Soil Conservation Services (SCS) TR-55 method was used to analyze the rate of storm water discharge from the site for a 100-year 24-hr storm event under pre- and post-development conditions. This method evaluates runoff flow rates by considering such factors as ground cover, soil characteristics, flow travel time and flood routing. Runoff analyses were performed for existing and developed conditions. PondPack, computer software by Haestad Methods was used to size the detention basin by generating a unit hydrograph that would correlate into runoff volumes based on SCS TR-55 computation for pre- and post-developed storm runoff. Post-developed runoff generated from UHWO campus is excluded from the post-developed runoff calculations because runoff from campus lands will be controlled by separate campus drainage facilities, not addressed in this report, thus only post-developed runoff for non-campus lands within the project boundary was calculated to size the detention basin. Results of the analyses are provided in Appendix A.

2.2 Existing Soil Conditions

The Soil Survey of Islands of Kauai, Oahu, Maui, Molokai, and Lanai, State of Hawaii; 1972 by the Soil Conservation Service of the U.S. Department of Agriculture classifies the soils at the project site as clays or silty clays as indicated in Table 1 and as shown on Figure 3, Hydrologic Soils Map.

Table 1: Soil Types and Properties

Description	Group	Permeability	Runoff	Erosion Hazard
EaB, Ewa Silty Clay Loam, 3 to 16% slopes	B	Moderate	Slow	Slight
EwC, Ewa Stony Silty Clay, 6 to 12% slopes	B	Moderate	Slow	Slight
HxA, Honouliuli Clay, 0 to 2% slopes	D	Slow	Slow	Slight
HxB, Honouliuli Clay, 2 to 6% slopes	D	Moderately Slow	Slow	Slight
KlaB, Kawaihapai Stony Clay Loam, 0 to 2% Slopes	B	Moderate	Slow	Slight
KlbC, Kawaihapai Very Stony Clay Loam, 0 to 15%	B	Moderate	Medium	Moderate
MuC, Molokai Silty Clay Loam, 7 to 15% Slopes	B	Moderate	Medium	Moderate
MuB, Molokai Silty Clay Loam, 3 to 7% Slopes	B	Moderate	Slow to Medium	Slight to Moderate
MuD, Molokai Silty Clay Loam, 15 to 25% Slopes	B	Moderate	Medium	Severe
McD2, Mahana Silty Clay Loam, 12 to 20% Slopes	B	Moderate	Rapid	Severe
MBL, Mahana Badland Complex	B	Rapid	Medium to Very Rapid	Very Severe
McC2, Mahana Silty Clay Loam	B	Moderate	Very Rapid	Very Severe
HLMG, Helemano Silty Clay, 30 to 90% Slopes	B	Moderate	Medium to Rapid	Severe
rSY, Stony Steep Land	B	Moderately Slow	Medium to Rapid	Moderate
WkA, Waialua Silty Clay, 0 to 3% Slopes	B	Moderate	Slow	Slight
WzA, Waipahu Silty Clay, 0 to 2% Slopes	C	Moderately Slow	Slow to Very Slow	None to Slight

Soils in Group B have moderate infiltration rates when thoroughly wetted. Soils in Group C have low infiltration rates when thoroughly wetted. Soils in Group D have high runoff potential with very low infiltration rates when thoroughly wetted (Urban Hydrology for Small Watersheds, United States Department of Agriculture Natural Resources Conservation Service, Technical Release 55, June 1986). These soil characteristics were used in the TR-55 program to determine the "curve number" for undeveloped areas, which is a representation of surface conditions relative to storm water runoff.

2.3 Drainage Area Descriptions and Existing and Post Development Runoff/Storage Volume

The total drainage area mauka and makai of UH West Oahu is approximately 1,075 acres. The total onsite drainage area is 500 acres. The existing and post development drainage areas are divided into three drainage basins designated as Basin 1, 2, and 3 on Figure 4, Pre-Development Drainage Basins, and Figure 5, Post-Development Drainage Basins.

Drainage Basin 1 is the largest of the drainage areas. It consists mostly of agricultural land use with slopes from 2 to 5%. Two gulches, Kaloi Gulch and Hunehune Gulch, flow into Drainage Basin 1 and merge within Drainage Basin 1. Drainage Basin 1 extends

from the H-1 Freeway on the west side of Hunehune Gulch and Farrington Highway on the east side of Hunehune Gulch to the makai boundary of the project where runoff, including Kaloi Gulch, flow onto the DHHL parcel under existing conditions. Surface runoff within Drainage Basin 1 primarily sheet flows into Kaloi and Hunehune Gulches; however, some runoff flows directly off site across the southern site boundary and also into the North-South Road alignment.

Drainage Basin 2 is the second largest drainage area. The ground cover conditions vary from sparse vegetation on steep rocky slopes exceeding 20% to moderately dense growth of small trees and brush that is visible along the trough of Hunehune Gulch with slopes ranging from 5 to 15%. Basin 2 begins at the top of Puu Makakilo Mountain. Runoff within Basin 2 primarily sheet flows into the main (eastern) branch of Hunehune Gulch.

Drainage Basin 3 is the smallest drainage area. The ground cover conditions are similar to that of Drainage Basin 2. Basin 3 also begins at the top of Puu Makakilo. Runoff sheet flows into the western tributary of Hunehune Gulch.

Under existing conditions runoff flows from mauka to makai through the site and discharges into the Kaloi\Hunehune Gulch system.

Under developed conditions, Kaloi Gulch will be diverted out of the project into a proposed drainage channel along the east side of the proposed North-South Road. Hunehune Gulch will continue to pass through the project site via a system of box culverts and/or open drainage channels. Figure 6, Conceptual Offsite Drainage System, shows a conceptual box culvert system for conveying Hunehune Gulch through the site. Runoff generated by the proposed lots and internal roads will be collected by catch basins and drain inlets and be routed through a drain pipe system that will terminate at the proposed detention basin. Figure 7, Conceptual Onsite Drainage System, shows a conceptual drainage system to collect onsite runoff and convey it to the proposed detention basin. Figure 7 also shows a conceptual onsite system to convey runoff from the campus lands to a planned 10-foot by 8-foot box culvert under North-South Road that would discharge to the Kaloi Gulch diversion channel on the west side of North-South Road. Hydrologic calculations are provided in Appendix A. Table 2 summarizes the hydrologic impact of the development.

Table 2: Existing and Post Development Runoff Flow

Drainage Area	Existing		Post Development	
	Area (acres)	Q100 (cfs)	Area (acres)	Q100 (cfs)
1	489	2103	539	3108
2	441	2502	400	2326
3	145	985	136	933
*Outlet	1075	5124	1075	4822

*Based on the outlet flow for the existing and post development conditions, post development discharge rates are less than existing rates after routing post development flows through a detention basin.

3.0 CONCLUSIONS AND RECOMMENDATIONS

Peak discharge increased from $Q_{Pre\text{-}Dev\ 100\text{-}yr} = 5124$ cfs to $Q_{Post\text{-}Dev.\ 100\text{-}yr} = 6367$ cfs. A detention basin is added to regulate post-development runoff to existing pre-development level. It is estimated that the detention basin would need to store approximately 96.76 acre-feet or 156,107 cubic yards. Detention basin sizing calculations can be found in Appendix A.

In addition to storing additional runoff developed from the project, the City requires that water quality must also be addressed. Thus, sizing of the basin is based on storing the increase in runoff volume between the pre-and post-developed conditions (Δ Storage Volume) and also the Water Quality Design Volume (WQDV):

The Water Quality Design Volume (WQDV):

WQDV = C x I" x A x 3630

Where:

WQDV = water quality design volume in cubic feet

C = runoff coefficient = 0.05+ (0.009)*IMP

IMP = Impervious Area = 65% assuming 65% of the project will be impervious

A = area of the site in acres

3630 = conversion factor

WQDV = 0.05+(0.009)*65 x 500 acres x 3630 = 1,152,525 cubic feet or 42,686 cubic yards.

Since the WQDV is less than the estimated water storage volume for the detention basin, the WQDV can be included as part of the detention basin water storage volume.

Approximately 11.2 acres is dedicated to the detention basin located adjacent to the southern project boundary as shown on Figure 2. The calculated basin size would need to be approximately 16-feet deep with 3 horizontal to 1 vertical side slopes to hold a storm runoff and water quality design volume of 96.76 acre-feet or 156,107 cubic yards. A 100-ft long spillway and six 11-ft wide by 3-ft high concrete box culverts were used in this analysis to limit the detention basin's outflow rate to the pre-existing site runoff rate. Outflow from the basin will discharge to the offsite Kaloi Gulch system, as is the case for existing conditions.

FIGURES

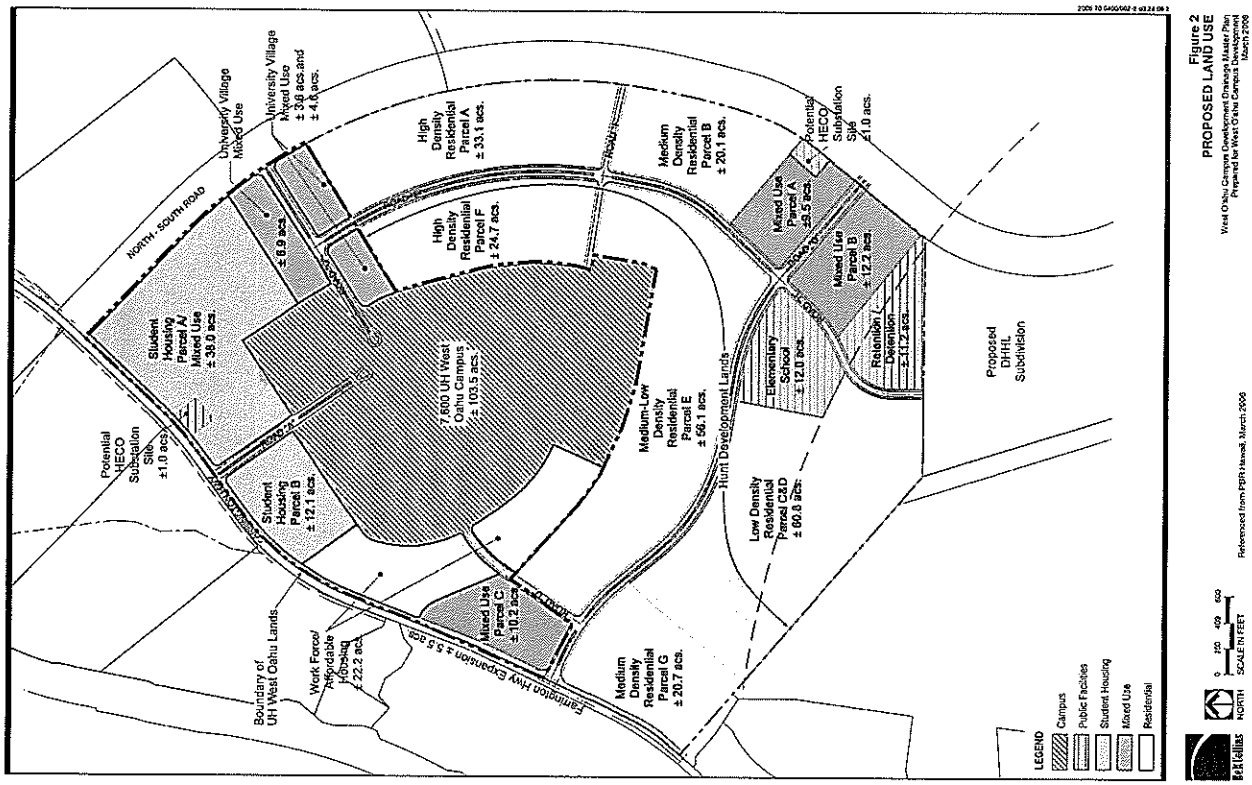
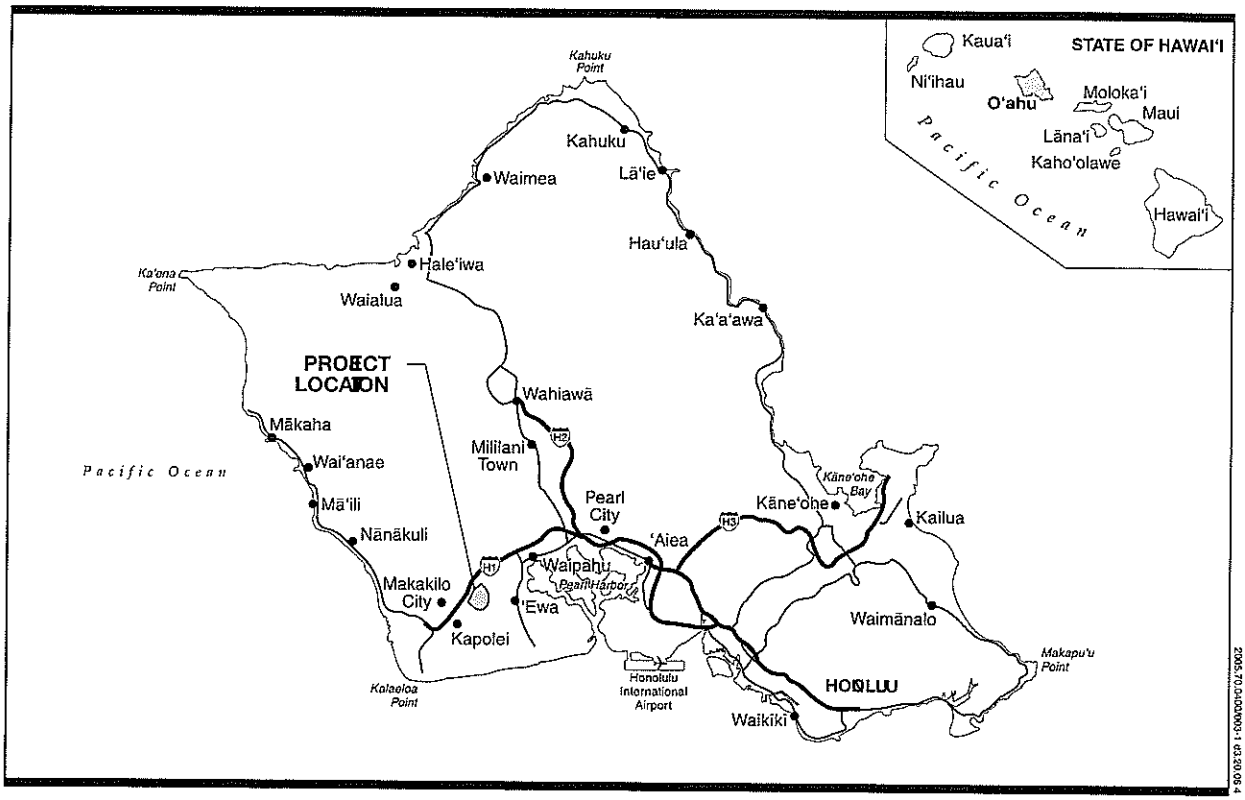


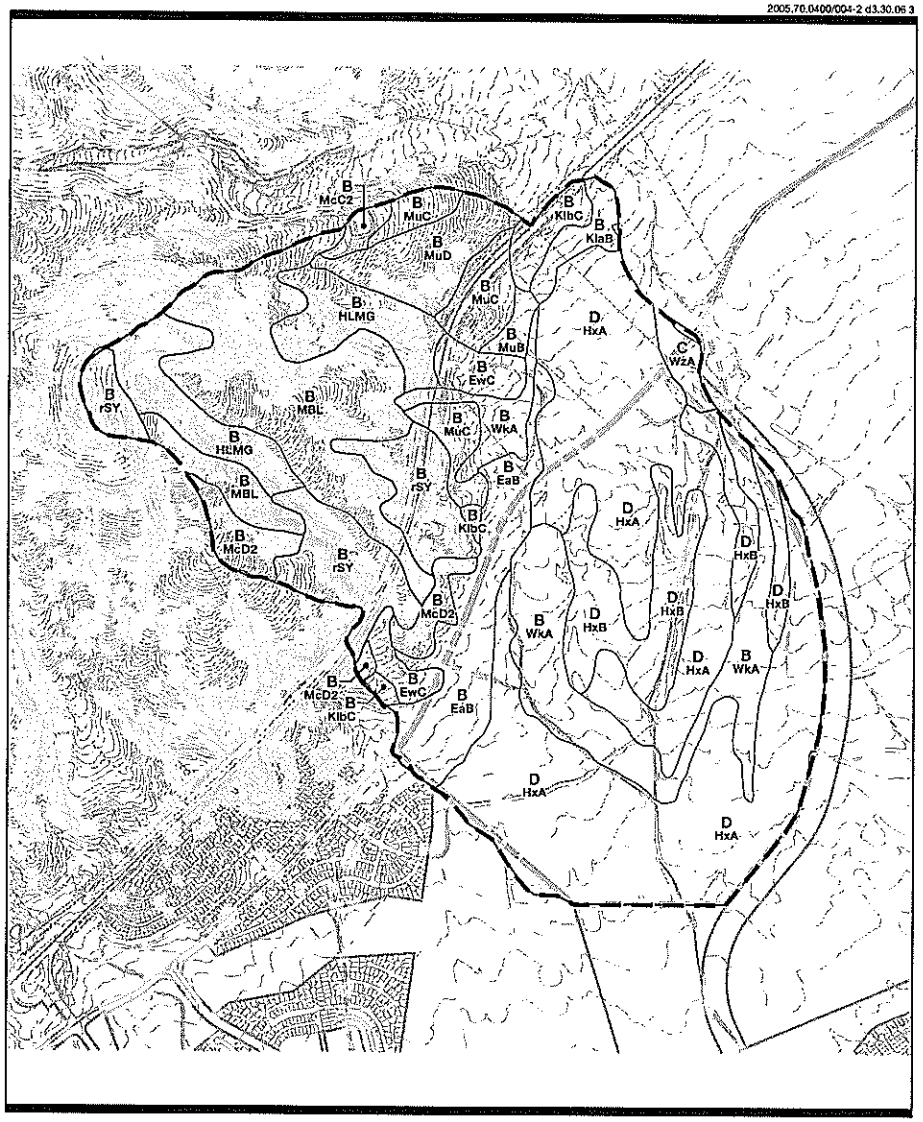
Figure 2
PROPOSED LAND USE
West O'ahu Campus Development Drainage Master Plan
Prepared for West O'ahu Campus Development
March 2006

Reference(s) from PBR Hawaii, March 2006



Belt Collins
NORTH
0 2 4 6
SCALE IN MILES

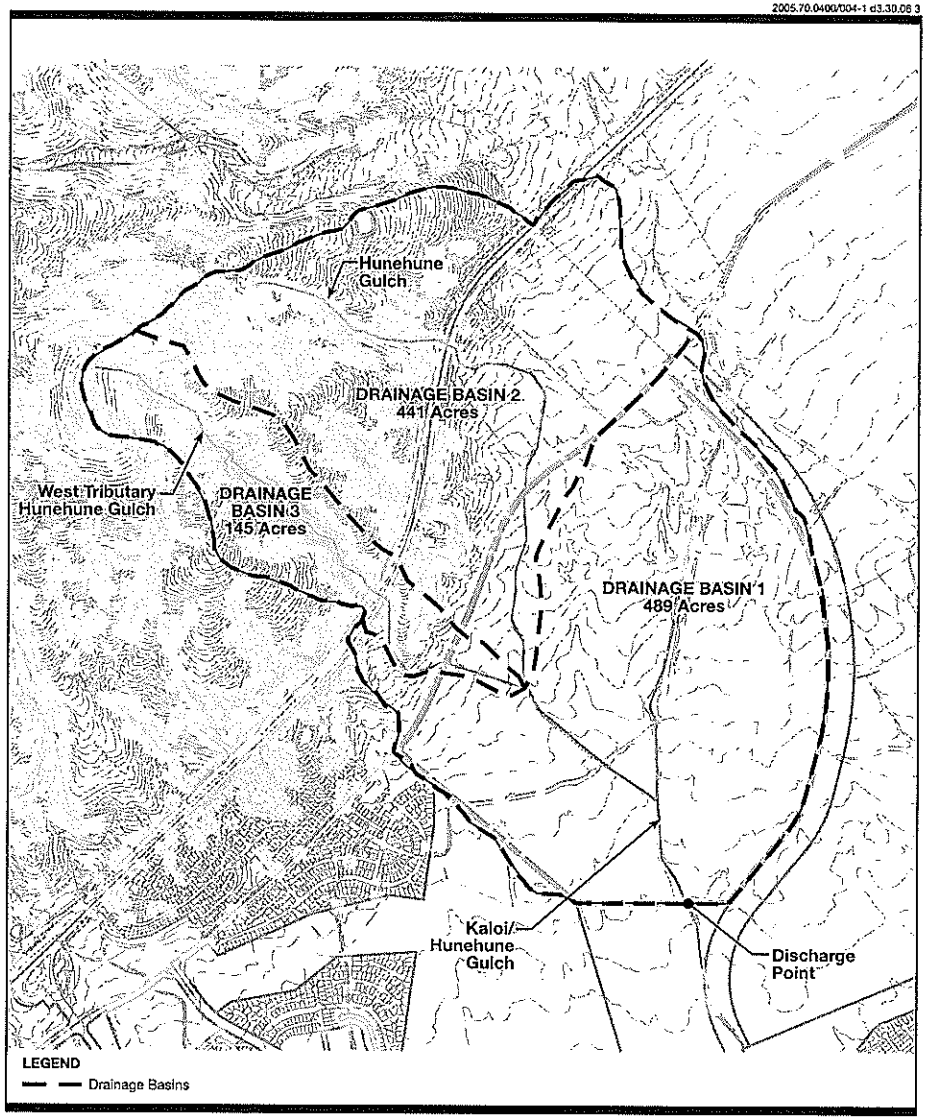
Figure 1
PROJECT LOCATION MAP
West O'ahu Campus Development Drainage Master Plan
Prepared for West O'ahu Campus Development
March 2006



BeltCollins NORTH 0 750 1500 SCALE IN FEET

Figure 3
HYDROLOGIC SOILS MAP

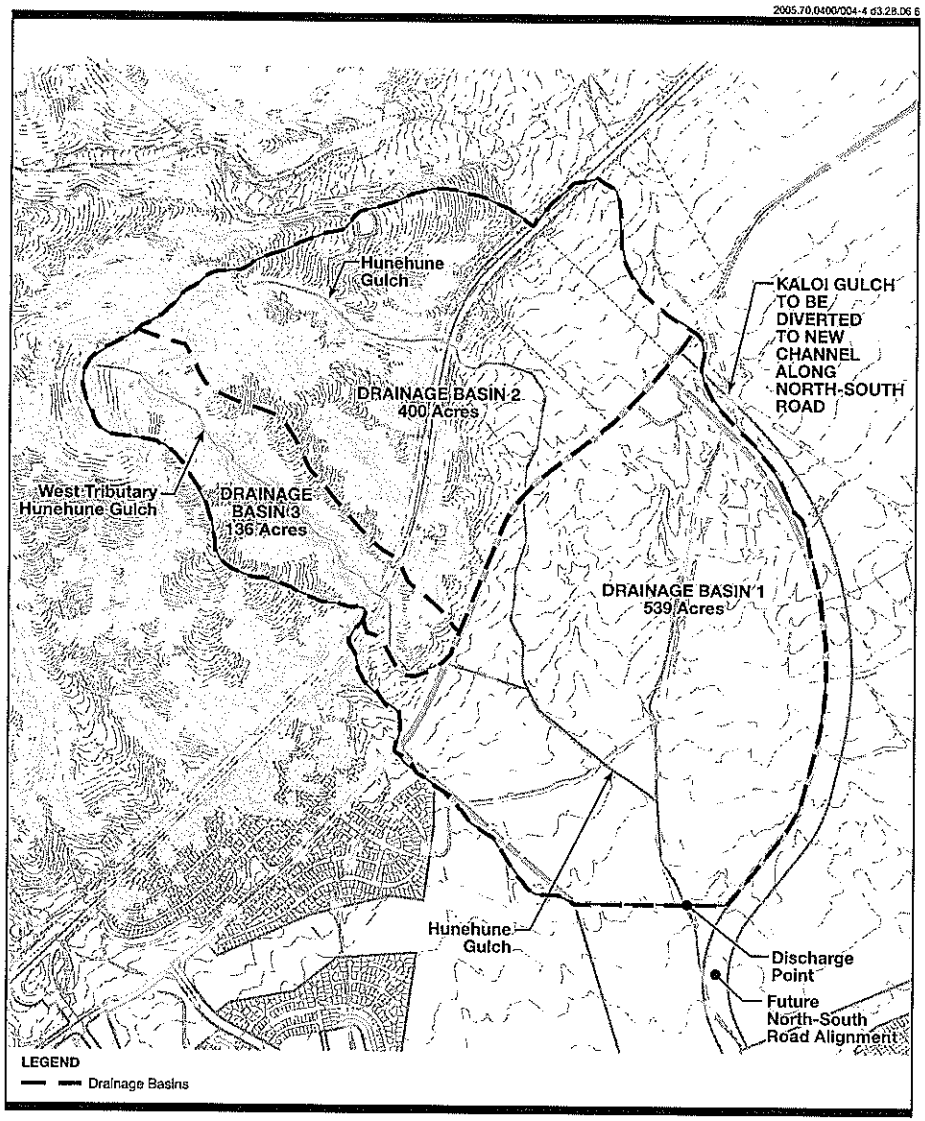
West O'ahu Campus Development Drainage Master Plan
Prepared for West O'ahu Campus Development
March 2006



BeltCollins NORTH 0 500 1000 1500 SCALE IN FEET

Figure 4
PRE-DEVELOPMENT DRAINAGE BASINS

West O'ahu Campus Development Drainage Master Plan
Prepared for West O'ahu Campus Development
March 2006



Belt Collins

NORTH

0 500 1000 1500
SCALE IN FEET

Figure 5
POST-DEVELOPMENT DRAINAGE BASINS

West O'ahu Campus Development Drainage Master Plan
Prepared for West O'ahu Campus Development
March 2006

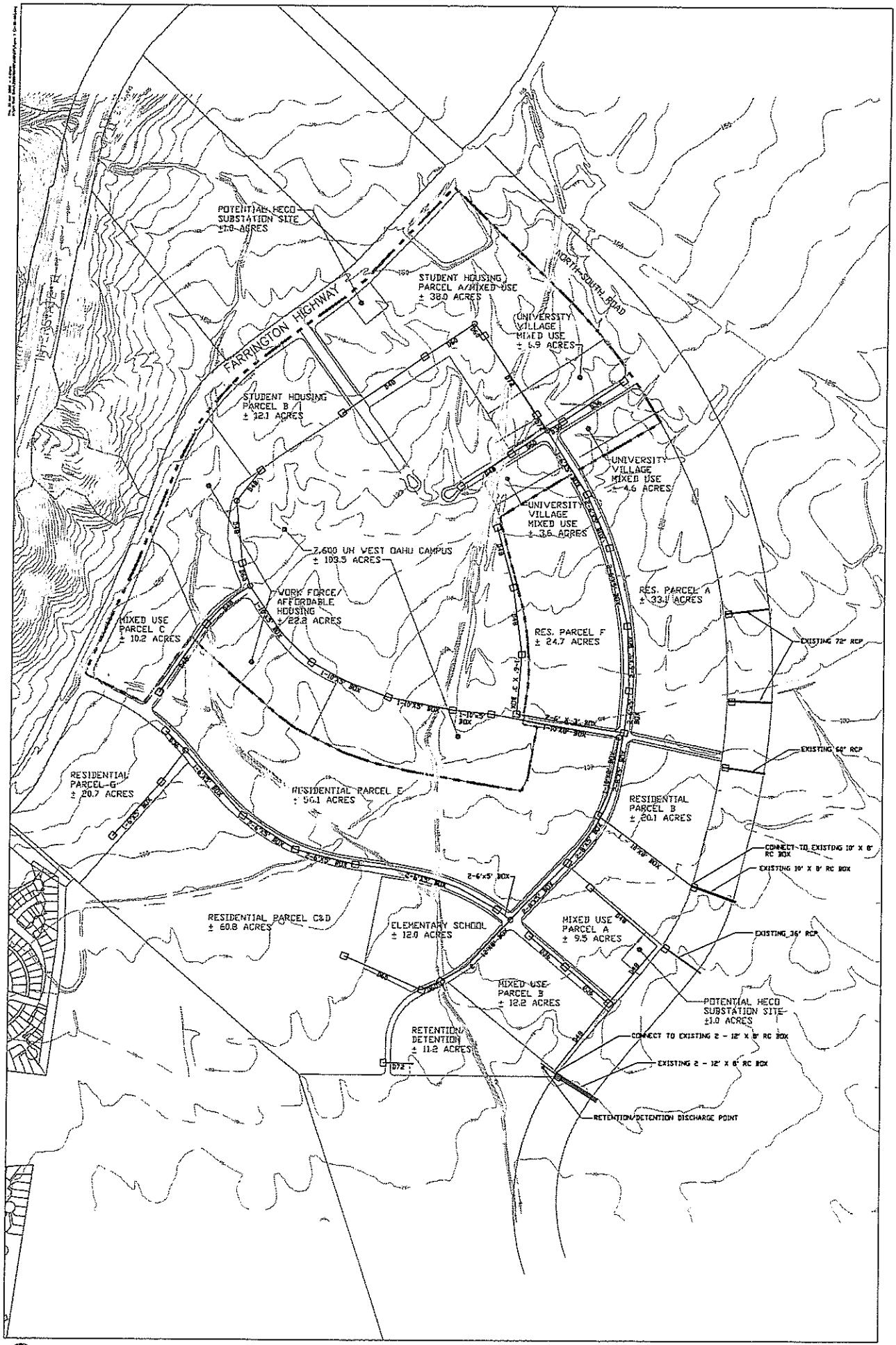


FIGURE 7: CONCEPTUAL ONSITE DRAINAGE SYSTEM

WEST OAHU CAMPUS DEVELOPMENT DRAINAGE MASTERPLAN
Prepared By: Belt Collins Hawaii
MARCH 2006

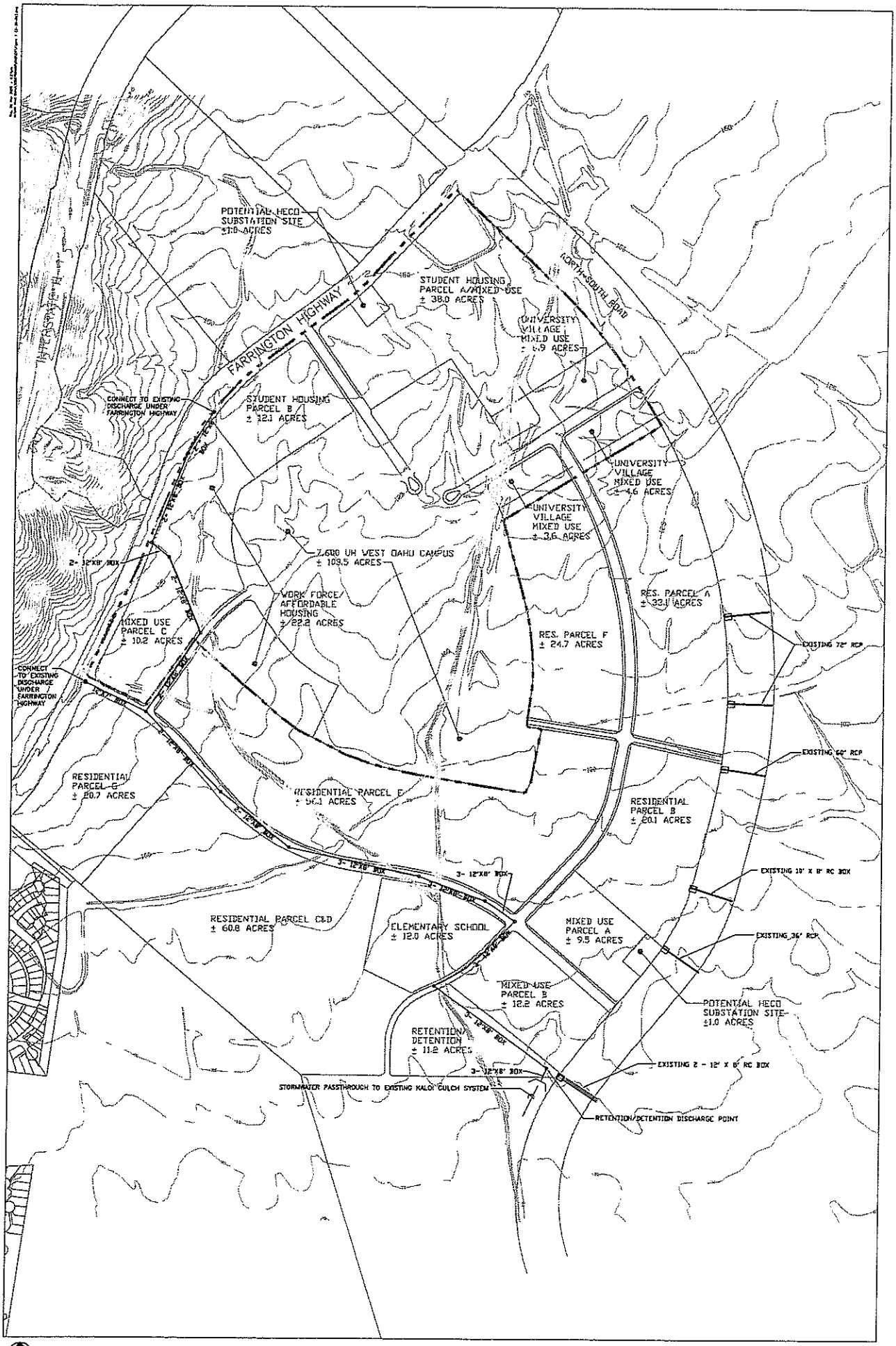


FIGURE 6: CONCEPTUAL OFFSITE DRAINAGE SYSTEM

WEST OAHU CAMPUS DEVELOPMENT DRAINAGE MASTERPLAN
Prepared By: Ball Collins Howell
MARCH 2006

APPENDIX A

HYDROLOGIC CALCULATIONS AND BASIN SIZING

PRE-DEVELOPED FLOW CALCULATION

MASTER DESIGN STORM SUMMARY

Network Storm Collection: SCS Type I - UH

Return Event	Total Depth in	Rainfall Type	RNF ID
Pre100	12.3000	Synthetic Curve	TypeI 24hr
Pre 2	4.5000	Synthetic Curve	TypeI 24hr

MASTER NETWORK SUMMARY
SCS Unit Hydrograph Method

(*Node=Outfall; +Node=Diversion;)
(Trun= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left&Rt)

Node ID	Type	Return Event	HYG Vol ac-ft	Trun	Qpeak hrs	Qpeak cfs	Max WSEL ft	Max Pond Storage ac-ft
BASIN 1	AREA	100	374.228		10.1500	2103.20		
BASIN 1	AREA	2	86.793		10.2000	453.37		
BASIN 2	AREA	100	321.876		10.0000	2501.76		
BASIN 2	AREA	2	69.668		10.0500	490.90		
BASIN 3	AREA	100	116.002		9.9500	985.10		
BASIN 3	AREA	2	28.716		10.0000	234.10		
*EXISTING OUTFALL	JCT	100	812.105		10.0500	5124.11		
*EXISTING OUTFALL	JCT	2	185.177		10.0500	1076.59		
JUNC 10	JCT	100	437.877		10.0000	3460.91		
JUNC 10	JCT	2	98.385		10.0000	719.65		

DEVELOPED FLOW CALCULATION

MASTER DESIGN STORM SUMMARY

Network Storm Collection: SCS Type I - UH

Return Event	Total Depth in	Rainfall Type	RNF ID
Dev100	12.3000	Synthetic Curve	TypeI 24hr
Dev 2	4.5000	Synthetic Curve	TypeI 24hr

MASTER NETWORK SUMMARY
SCS Unit Hydrograph Method

(*Node=Outfall; +Node=Diversion;)
(Trun= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left&Rt)

Node ID	Type	Return Event	HYG Vol ac-ft	Trun	Qpeak hrs	Qpeak cfs	Max WSEL ft	Max Pond Storage ac-ft
BASIN 1- 23	AREA	100	6.913		10.0400	49.88		
BASIN 1- 23	AREA	2	2.122		10.0400	15.93		
BASIN 1-1	AREA	100	26.528		10.1760	137.87		
BASIN 1-1	AREA	2	8.145		10.1760	43.61		
BASIN 1-10	AREA	100	26.275		9.9760	203.17		
BASIN 1-10	AREA	2	8.821		9.9760	71.13		
BASIN 1-11	AREA	100	5.374		10.0200	40.26		
BASIN 1-11	AREA	2	1.650		10.0200	12.86		
BASIN 1-12	AREA	100	8.757		9.9600	71.26		
BASIN 1-12	AREA	2	2.688		9.9640	22.68		
BASIN 1-13	AREA	100	4.710		9.9720	38.12		
BASIN 1-13	AREA	2	1.446		9.9720	12.15		
BASIN 1-14	AREA	100	8.145		10.0440	55.57		
BASIN 1-14	AREA	2	2.734		10.0440	19.46		

MASTER NETWORK SUMMARY
SCS Unit Hydrograph Method

(*Node=Outfall; +Node=Diversion;)
(Trun= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left&Rt)

Node ID	Type	Return Event	HYG Vol ac-ft	Trun	Qpeak hrs	Qpeak cfs	Max WSEL ft	Max Pond Storage ac-ft
BASIN 1-15	AREA	100	5.658		9.9640	46.03		
BASIN 1-15	AREA	2	1.801		9.9640	15.29		
BASIN 1-16	AREA	100	8.232		9.9800	63.98		
BASIN 1-16	AREA	2	2.621		9.9960	21.25		
BASIN 1-17	AREA	100	8.320		10.0240	59.40		
BASIN 1-17	AREA	2	2.793		10.0240	20.81		
BASIN 1-18	AREA	100	26.068		10.0400	191.95		
BASIN 1-18	AREA	2	5.508		10.0720	36.29		
BASIN 1-19	AREA	100	8.740		9.9680	73.52		
BASIN 1-19	AREA	2	2.027		9.9880	16.07		
BASIN 1-2	AREA	100	22.279		10.0800	141.86		
BASIN 1-2	AREA	2	6.840		10.0800	45.06		
BASIN 1-20	AREA	100	6.646		10.0120	52.03		
BASIN 1-20	AREA	2	1.302		10.0400	8.78		
BASIN 1-21	AREA	100	6.577		9.9840	54.67		
BASIN 1-21	AREA	2	1.289		10.0040	9.24		
BASIN 1-22	AREA	100	8.933		9.9640	75.06		
BASIN 1-22	AREA	2	2.353		9.9840	19.59		
BASIN 1-24	AREA	100	11.319		10.0440	80.98		
BASIN 1-24	AREA	2	3.475		10.0440	25.85		
BASIN 1-25	AREA	100	13.474		10.0440	90.81		
BASIN 1-25	AREA	2	4.523		10.0440	31.78		
BASIN 1-26	AREA	100	11.408		10.0200	80.62		
BASIN 1-26	AREA	2	3.830		10.0200	28.22		

MASTER NETWORK SUMMARY
SCS Unit Hydrograph Method

(*Node=Outfall; +Node=Diversion;)
(Trun= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left&Rt)

Node ID	Type	Return Event	HYG Vol ac-ft	Trun	Qpeak hrs	Qpeak cfs	Max WSEL ft	Max Pond Storage ac-ft
BASIN 1-27	AREA	100	9.773		10.0200	72.94		
BASIN 1-27	AREA	2	2.267		10.0480	15.99		
BASIN 1-28	AREA	100	7.346		10.0440	50.79		
BASIN 1-28	AREA	2	2.466		10.0440	17.79		
BASIN 1-29	AREA	100	12.636		10.0320	84.30		
BASIN 1-29	AREA	2	4.242		10.0680	29.50		
BASIN 1-3	AREA	100	25.025		10.0160	188.32		
BASIN 1-3	AREA	2	7.683		10.0160	60.11		
BASIN 1-30	AREA	100	7.278		9.9280	62.60		
BASIN 1-30	AREA	2	2.443		9.9280	21.92		
BASIN 1-31	AREA	100	12.617		10.0200	89.48		
BASIN 1-31	AREA	2	4.017		10.0200	29.68		
BASIN 1-32	AREA	100	4.920		10.0280	35.34		
BASIN 1-32	AREA	2	1.652		10.0280	12.38		
BASIN 1-33	AREA	100	12.183		10.0440	84.59		
BASIN 1-33	AREA	2	3.878		10.0440	28.10		
BASIN 1-34	AREA	100	7.888		10.0120	62.59		
BASIN 1-34	AREA	2	1.994		10.0160	15.52		
BASIN 1-35	AREA	100	7.933		10.0760	53.55		
BASIN 1-35	AREA	2	1.922		10.0760	12.35		
BASIN 1-36	AREA	100	6.568		10.0000	53.01		
BASIN 1-36	AREA	2	1.626		10.0000	12.72		
BASIN 1-37	AREA	100	10.561		10.0360	77.73		
BASIN 1-37	AREA	2	2.449		10.0680	16.92		

MASTER NETWORK SUMMARY
SCS Unit Hydrograph Method

(*Node=Outfall; +Node=Diversion;)
(Trun= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left&Rt)

Node ID	Type	Return Event	HYG Vol ac-ft	Trun	Qpeak hrs	Qpeak cfs	Max WSEL ft	Max Pond Storage ac-ft
BASIN 1-38	AREA	100	7.166		10.0560	48.36		
BASIN 1-38	AREA	2	2.281		10.0560	16.05		
BASIN 1-39	AREA	100	6.091		10.2720	27.74		
BASIN 1-39	AREA	2	1.939		10.2720	9.16		
BASIN 1-4	AREA	100	3.281		9.9640	27.21		
BASIN 1-4	AREA	2	1.007		9.9640	8.68		
BASIN 1-40	AREA	100	3.734		9.9840	30.24		
BASIN 1-40	AREA	2	1.064		9.9840	8.78		
BASIN 1-41	AREA	100	1.929		9.9400	16.03		
BASIN 1-41	AREA	2	.648		9.9400	5.61		
BASIN 1-42	AREA	100	33.828		10.1080	214.02		
BASIN 1-42	AREA	2	6.628		10.1560	35.22		
BASIN 1-6	AREA	100	15.107		10.0560	103.64		
BASIN 1-6	AREA	2	4.638		10.0560	33.02		
BASIN 1-7	AREA	100	7.356		10.0360	52.56		
BASIN 1-7	AREA	2	2.258		10.0360	16.75		
BASIN 1-8	AREA	100	15.006		10.0800	97.44		
BASIN 1-8	AREA	2	4.607		10.0800	31.01		
BASIN 1-9	AREA	100	15.393		9.9640	121.92		
BASIN 1-9	AREA	2	5.168		9.9640	42.69		
BASIN 2	AREA	100	296.710		10.0080	2326.13		
BASIN 2	AREA	2	65.750		10.0360	475.07		
BASIN 3	AREA	100	108.807		9.9600	932.62		
BASIN 3	AREA	2	26.935		9.9800	222.72		

MASTER NETWORK SUMMARY
SCS Unit Hydrograph Method

(*Node=Outfall; +Node=Diversion;)
(Trun= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left&Rt)

Node ID	Type	Return Event	HYG Vol ac-ft	Trun	Qpeak hrs	Qpeak cfs	Max WSEL ft	Max Pond Storage ac-ft
BASIN1-5	AREA	100	8.231		9.9760	65.35		
BASIN1-5	AREA	2	2.527		9.9760	20.81		
DETEN BASIN IN	POND	100	871.720		10.0080	6366.99		
DETEN BASIN IN	POND	2	228.061		10.0200	1613.71		
DETEN BASIN OUT	POND	100	866.876	R	10.1240	4822.19	69.41	101.531
DETEN BASIN OUT	POND	2	223.542	R	10.1640	1070.95	62.03	33.017
*EXISTING OUTFALL	JCT	100	866.876	R	10.1240	4822.19		
*EXISTING OUTFALL	JCT	2	223.542	R	10.1640	1070.95		
JUNC 10	JCT	100	405.517		10.0080	3211.93		
JUNC 10	JCT	2	92.685		10.0080	688.24		
JUNC 20	JCT	100	472.362		10.0080	3643.60		
JUNC 20	JCT	2	109.450		10.0080	795.61		
JUNC 30	JCT	100	649.832		10.0080	4804.58		
JUNC 30	JCT	2	164.744		10.0160	1170.31		
JUNC 40	JCT	100	56.422		10.0240	407.90		
JUNC 40	JCT	2	15.458		10.0240	110.08		
JUNC 50	JCT	100	221.889		10.0200	1567.48		
JUNC 50	JCT	2	63.318		10.0280	444.08		

DETENTION BASIN SIZING

PondMaker Design Wizard

Estimated Water Volume

Return Event	Pre Dev Peak (cfs)	Pre Dev Volume (ac-ft)	Post Dev Peak (cfs)	Post Total Volume (ac-ft)	Estimated Storage (ac-ft)	Interp. W.S. Elev. (ft)	Freeboard Depth (ft)
100	5124.1104	812.10451	6365.6953	871.68118	96.75642	68.9167	PASS
2	1076.5859	185.17718	1613.7458	228.05195	32.22371	61.9357	PASS

PondMaker Design Wizard

Exist. Peak Flow

Outflow From Det. Basins

Return Event	Target Peak (cfs)	Peak Outflow (cfs)	Peak Out vs Target	Maximum Elevation (ft)	Freeboard Depth (ft)	Maximum Storage (ac-ft)
100	5124.1104	4822.1934	PASS	69.40560	PASS	101.53090
2	1076.5859	1070.9487	PASS	62.02974	PASS	33.01707

Compute Det. Basin Volume

Type.... Vol: Elev-Area
Name.... DETEN BASIN Volume

File.... M:\UH West Oahu\2005700400\Design\Calculations\Drainage\Dev (2-28-2006).ppw

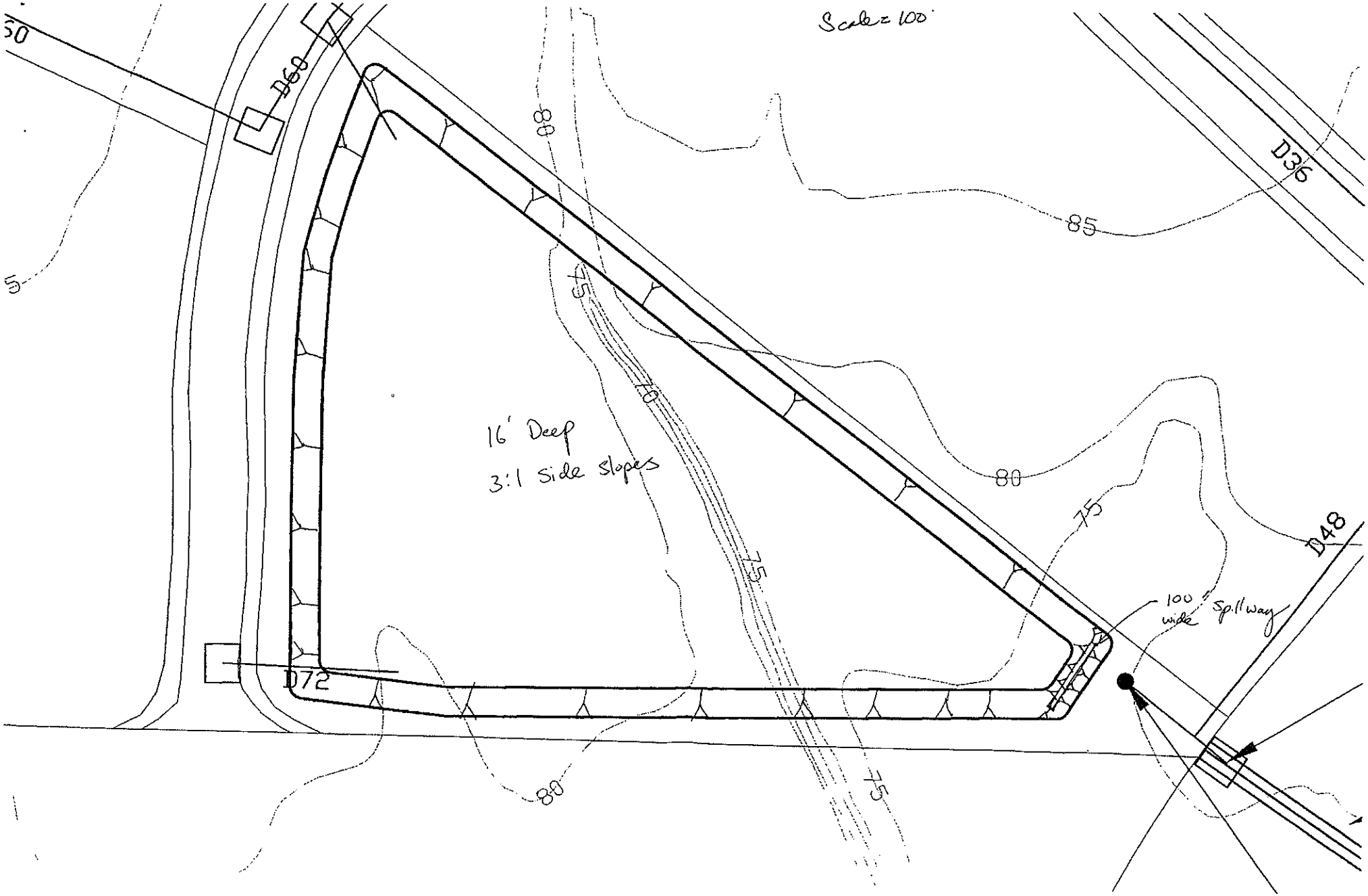
Elevation (ft)	Planimeter (sq.in)	Area (acres)	A1+A2+sqr(A1*A2) (acres)	Volume (ac-ft)	Volume Sum (ac-ft)
58.00	-----	7.8190	.0000	.000	.000
60.00	-----	8.1896	24.0107	16.007	16.007
62.00	-----	8.5669	25.1326	16.755	32.762
64.00	-----	8.9506	26.2741	17.516	50.278
66.00	-----	9.3409	27.4351	18.290	68.568
68.00	-----	9.7377	28.6157	19.077	87.646
70.00	-----	10.1410	29.8159	19.877	107.523
72.00	-----	10.5508	31.0356	20.690	128.213
74.00	-----	10.9672	32.2749	21.517	149.730

POND VOLUME EQUATIONS

* Incremental volume computed by the Conic Method for Reservoir Volumes.

Volume = (1/3) * (EL2-EL1) * (Area1 + Area2 + sq.rt.(Area1*Area2))

where: EL1, EL2 = Lower and upper elevations of the increment
Area1,Area2 = Areas computed for EL1, EL2, respectively
Volume = Incremental volume between EL1 and EL2


Scale = 100'
D60
D36
D48
D72
80
85
75
70
75
80
75
80
75
16' Deep
3:1 side slopes
100' wide Spillway

Detention Basin Inflow/Outflow Hydrographs (100-Yr, 24-Hr)