Fig. 3. Managed Land Vegetation at the study site.

Fig. 4. View from a hill showing quarrying deposits and Buffel Grass Grassland.

Fig. 5. Buffel Grass Grassland with scattered trees.

Appendix F

Noise Impact Analysis

ACOUSTIC STUDY FOR THE KA MAKANA ALI`I PROJECT KAPOLEI, HAWAII

Prepared for:

HAWAII DEBARTOLO LLC

Prepared by:

Y. EBISU & ASSOCIATES
1126 12th Avenue, Room 305
Honolulu, Hawaii 96816

JUNE 2011

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER I. SUMMARY

The existing and future traffic noise levels in the vicinity of the proposed Ka Makana Ali'i Project in Kapolei were evaluated for their potential impacts and their relationship to the current FHA/HUD noise standard of 65 DNL. The traffic noise level increases along the roadways in the project environs (see FIGURE 1) were calculated. Low to moderate increases in traffic noise are predicted to occur as a result of project traffic following project build-out by CY 2015. Increases in traffic noise due to non-project traffic are typically greater than increases due to project traffic.

Kapolei Parkway, Kualakai Parkway, Renton Road, and Roosevelt Avenue are the dominant traffic noise corridors in the project environs. Existing traffic noise levels probably exceed 65 DNL at existing residences which front Kapolei Parkway, Renton Road, and Roosevelt Avenue. Existing traffic noise levels along Roosevelt Avenue are approximately 65 DNL at 136 feet setback distance from the centerline of that roadway. By 2015, traffic noise levels along Roosevelt Avenue are predicted to increase by 0.9 DNL units without the project and by an additional 0.2 to 0.3 DNL units with the project.

Along Kualakai Parkway north of the project, traffic noise levels are expected to be approximately 65 DNL at 333 feet distance from the centerline in CY 2015, with increases of 2.9 DNL and 2.7 DNL associated with non-project and project traffic, respectively. Along Kapolei Parkway, traffic noise levels are expected to increase by 1.2 to 2.0 DNL by CY 2015 as a result of non-project traffic, and by 0.4 to 1.5 DNL by CY 2015 as a result of project traffic. Future traffic noise levels will continue to exceed 65 DNL at existing residences which front Kapolei Parkway, Renton Road, and Roosevelt Avenue. The proposed hotel on the project site should be outside the 65 DNL traffic noise contour, and has adequate setback from Kapolei Parkway's centerline.

The proposed project will be a contributor to increased traffic noise levels along the existing major roadways which will service the project. The future traffic noise contributions from project traffic should be less than the contributions from non-project traffic. Traffic noise mitigation measures should not be required for buildings on the project site since the planned buildings have adequate setback distances from Kapolei Parkway and the Kualakai Parkway Extension.

The planned hotel included with the project is located outside (or beyond) the 60 DNL aircraft noise contour associated with Honolulu International Airport and Kalaeloa Airport aircraft operations. Through 2025, the planned hotel should not be exposed to aircraft noise levels which are considered to be incompatible for hotel uses by the State Department of Transportation, Airports Division.

Unavoidable, but temporary, noise impacts may occur during construction of the proposed project, particularly during the excavation and site preparation activities on the project site. Because construction activities are predicted to be audible within the project site and at adjoining properties, the quality of the acoustic environment may be

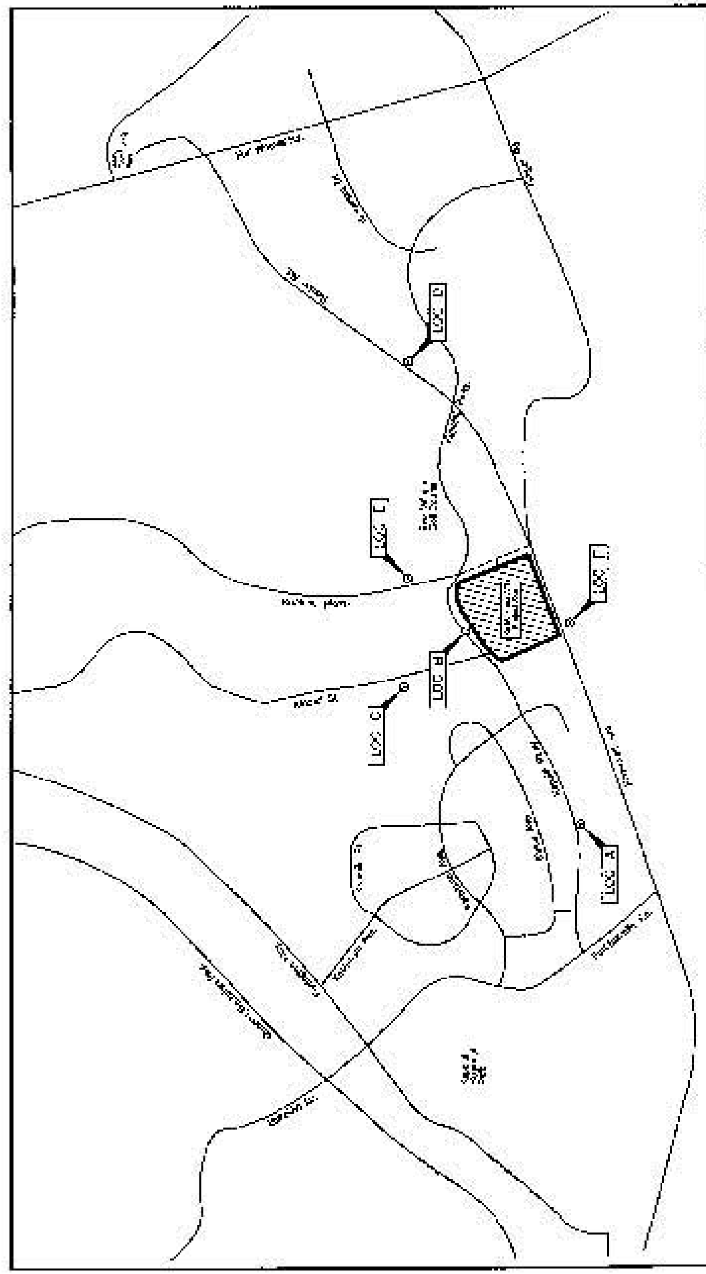


FIGURE 1

PROJECT LOCATION MAP AND NOISE MEASUREMENT LOCATIONS degraded to unacceptable levels during periods of construction. Mitigation measures to reduce construction noise to inaudible levels will not be practical in all cases, but the use of quiet equipment and the use of the State Department of Health curfew periods are recommended as standard mitigation measures.

CHAPTER II. PURPOSE

The primary objective of this study was to describe the existing and future traffic noise environment in the environs of the proposed Makana Ali'i Project in Kapolei on the island of Oahu. Traffic forecasts for 2015 were used. Traffic noise level increases and impacts associated with the proposed development were to be determined along the public roadways which are expected to service the project traffic. A specific objective was to determine future traffic noise level increases associated with both project and non-project traffic, and the potential noise impacts associated with these increases.

The proposed location of the project's Hotel was compared to previously developed aircraft noise contours for Honolulu International Airport and Kalaeloa Airport. The projected aircraft noise levels at the proposed Hotel site were compared to Hawaii State Department of Transportation recommendations for acceptable aircraft noise levels at resort developments.

Impacts from short term construction noise at the project site were also included as noise study objectives. Recommendations for minimizing potential construction noise impacts were also to be provided as required.

CHAPTER III. NOISE DESCRIPTORS AND THEIR RELATIONSHIP TO LAND USE COMPATIBILITY

The noise descriptor currently used by federal agencies (such as FHA/HUD) to assess environmental noise is the Day-Night Average Sound Level (Ldn or DNL). This descriptor incorporates a 24-hour average of instantaneous A-Weighted Sound Levels as read on a standard Sound Level Meter. By definition, the minimum averaging period for the DNL descriptor is 24 hours. Additionally, sound levels which occur during the nighttime hours of 10:00 PM to 7:00 AM are increased by 10 decibels (dB) prior to computing the 24-hour average by the DNL descriptor. A more complete list of noise descriptors is provided in APPENDIX B to this report.

TABLE 1, derived from Reference 1, presents current federal noise standards and acceptability criteria for residential land uses. Land use compatibility guidelines for various levels of environmental noise as measured by the DNL descriptor system are shown in FIGURE 2. As a general rule, noise levels of 55 DNL or less occur in rural areas, or in areas which are removed from high volume roadways. In urbanized areas which are shielded from high volume streets, DNL levels generally range from 55 to 65 DNL, and are usually controlled by motor vehicle traffic noise. Residences which front major roadways are generally exposed to levels of 65 DNL, and as high as 75 DNL when the roadway is a high speed freeway.

For purposes of determining noise acceptability for funding assistance from federal agencies (FHA/HUD and VA), an exterior noise level of 65 DNL or less is considered acceptable for residences. This standard is applied nationally (Reference 2), including Hawaii. Because of our open-living conditions, the predominant use of naturally ventilated dwellings and the relatively low exterior-to-interior sound attenuation afforded by these naturally ventilated structures, an exterior noise level of 65 DNL does not eliminate all risks of noise impacts. Because of these factors, and as recommended in Reference 3, a lower level of 55 DNL is considered as the "Unconditionally Acceptable" (or "Near-Zero Risk") level of exterior noise. However, after considering the cost and feasibility of applying the lower level of 55 DNL, government agencies such as FHA/HUD and VA have selected 65 DNL as a more appropriate regulatory standard.

For commercial, industrial, and other non-noise sensitive land uses, exterior noise levels as high as 75 DNL are generally considered acceptable. Exceptions to this occur when naturally ventilated office and other commercial establishments are exposed to exterior levels which exceed 65 DNL.

On the island of Oahu, the State Department of Health (DOH) regulates noise from construction activities through the issuance of permits for allowing excessive noise during limited time periods. State DOH noise regulations are expressed in maximum allowable property line noise limits rather than DNL (see Reference 4). Al-

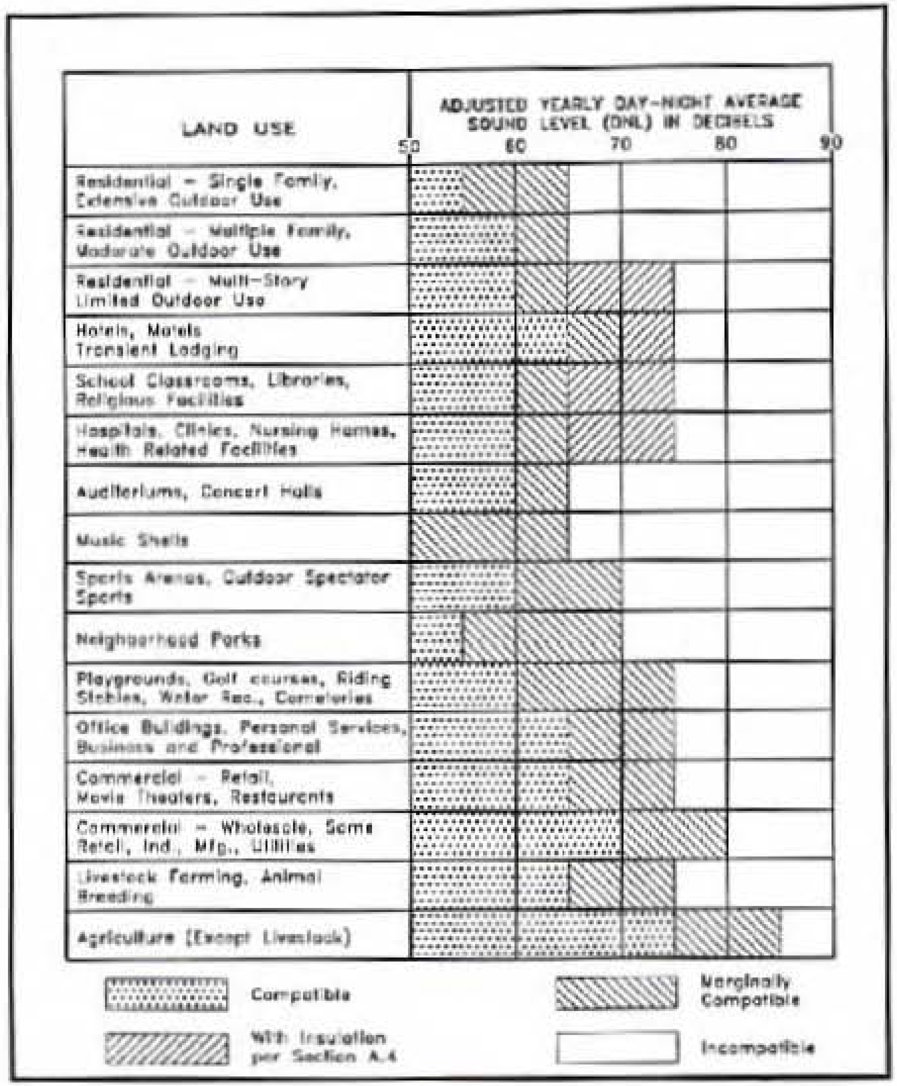
TABLE 1

EXTERIOR NOISE EXPOSURE CLASSIFICATION (RESIDENTIAL LAND USE)

NOISE EXPOSURE CLASS	DAY-NIGHT SOUND LEVEL	EQUIVALENT SOUND LEVEL	FEDERAL (1) STANDARD
Minimal Exposure	Not Exceeding 55 DNL	Not Exceeding 55 Leq	Unconditionally Acceptable
Moderate Exposure	Above 55 DNL But Not Above 65 DNL	Above 55 Leq But Not Above 65 Leq	Acceptable(2)
Significant Exposure	Above 65 DNL But Not Above 75 DNL	Above 65 Leq But Not Above 75 Leq	Normally Unacceptable
Severe Exposure	Above 75 DNL	Above 75 Leq	Unacceptable

Notes: (1) Federal Housing Administration, Veterans Administration, Department of Defense, and Department of Transportation.

(2) FHWA uses the Leq instead of the Ldn descriptor. For planning purposes, both are equivalent if: (a) heavy trucks do not exceed 10 percent of total traffic flow in vehicles per 24 hours, and (b) traffic between 10:00 PM and 7:00 AM does not exceed 15 percent of average daily traffic flow in vehicles per 24 hours. The noise mitigation threshold used by FHWA for residences is 67 Leq.



LAND USE COMPATIBILITY WITH YEARLY AVERAGE DAY-NIGHT AVERAGE SOUND LEVEL (DNL) AT A SITE FOR BUILDINGS AS COMMONLY CONSTRUCTED.
(Source: American National Standards Institute S12.9-1998/Part 5)

FIGURE 2

though they are not directly comparable to noise criteria expressed in DNL. State DOH noise limits for residential, commercial, and industrial lands equate to approximately 55, 60, and 76 DNL, respectively.

For aircraft noise, the State Department of Transportation, Airports Division (HDOTA), has recommended that 60 DNL be used as the common level for determining land use compatibility in respect to noise sensitive uses (such as hotels) near its airports. In order to further reduce risks of adverse noise impacts from airport noise in the State of Hawaii, Reference 5 requires that disclosure of the airport noise levels be provided prior to real property transactions concerning properties located within Air Installation Compatibility Use Zones (AICUZ) or located within airport noise maps developed under Federal Aviation Regulation (FAR) Part 150 - Airport Noise Compatibility Planning (14 CFR Part 150).

It should be noted that the noise compatibility guidelines and relationships to the DNL noise descriptor may not be applicable to impulsive noise sources such as pile drivers. The use of penalty factors (such as adding 10 dB to measured sound levels or the use of C-Weighting filters) have been proposed. However, the relationships between levels of impulsive noise sources and land use compatibility have not been as firmly established as have the relationships for non-impulsive sources. The State DOH limits for impulsive sounds which exceed 120 impulses in any 20 minute period are 10 dB above the limits for non-impulsive sounds. If impulsive sounds do not exceed 120 impulses in any 20 minute time period, there are no regulatory limits on their sound levels under the State DOH regulations.

CHAPTER IV. GENERAL STUDY METHODOLOGY

Existing traffic noise levels were measured at six locations (A through F) in the project environs to provide a basis for developing the project's traffic noise contributions along the roadways which will service the proposed development. The locations of the measurement sites are shown in FIGURE 1. Traffic noise measurements were performed during the month of May 2011. The results of the traffic noise measurements were compared with calculations of existing traffic noise levels to validate the computer model used. The traffic noise measurement results, and their comparisons with computer model predictions of existing traffic noise levels are summarized in TABLE 2.

Traffic noise calculations for the existing conditions as well as noise predictions for 2015 were performed using the Federal Highway Administration (FHWA) Traffic Noise Model (Reference 6). Traffic data entered into the noise prediction model were: roadway and receiver locations; hourly traffic volumes; average vehicle speeds; estimates of traffic mix; and propagation loss factors for various ground covers. The traffic data and forecasts for the project (Reference 7), plus the spot traffic counts obtained during the noise measurement periods were the primary sources of data inputs to the model. APPENDIX C summarizes the AM and PM peak hour traffic volumes for CY 2010 and 2015, which were used to model existing and future traffic noise along the streets in the project environs. Hawaii State Department of Transportation counts on Kapolei Parkway (Reference 8) and Renton Road (Reference 9) were also used to develop the relationship between the 24-hour DNL and the AM or PM peak hour Leq traffic noise levels. For existing and future traffic on Kapolei Parkway, Kamaaha Avenue, Kinoiki Street, and Kualakai Parkway, it was assumed that the average noise levels, or Leq(h), during the AM peak hour were 2 dB greater than the 24-hour DNL along these roadways in the project environs. For existing and future traffic on Renton Road west of Kapolei Parkway and Roosevelt Avenue, it was assumed that the average noise levels, or Leq(h), during the PM peak hour were 2 dB less than the 24-hour DNL along these roadways in the project environs. For existing and future traffic on Renton Road east of Kapolei Parkway, it was assumed that the average noise levels, or Leq(h), during the AM peak hour were 1 dB greater than the 24-hour DNL along this roadway in the project environs. These assumptions were based on computations of both the hourly Leq and the 24-hour DNL of traffic noise along Kapolei Parkway (see FIGURE 3) and Renton Road (see FIGURE 4).

Traffic noise calculations for both the existing and future conditions in the project environs were developed for ground level receptors without the benefit of shielding from buildings. Traffic noise levels were also calculated for future conditions with and without the proposed project. The forecasted changes in traffic noise levels over existing levels were calculated with and without the project, and noise impact risks evaluated. The relative contributions of non-project and project traffic to the total noise levels were also calculated, and an evaluation of possible traffic noise impacts was made.

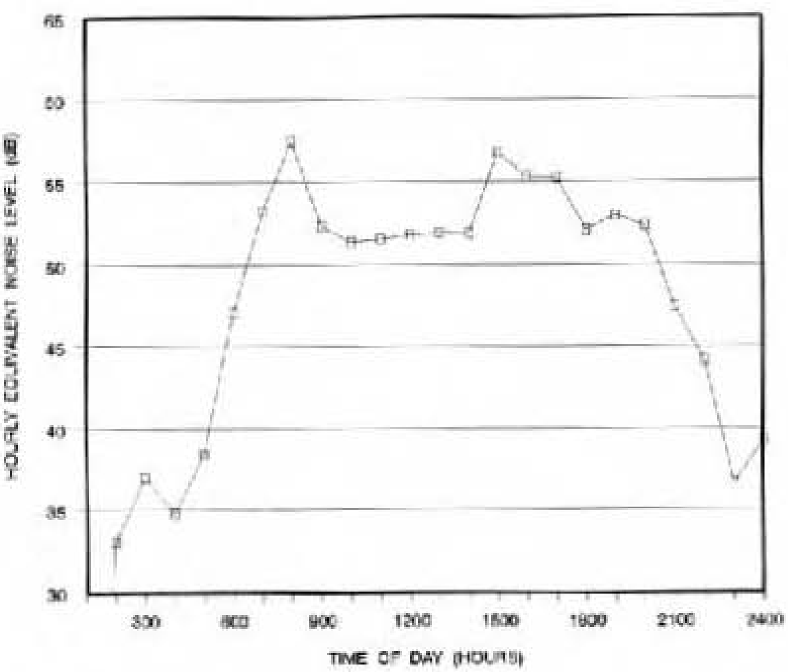
TABLE 2

TRAFFIC AND BACKGROUND NOISE MEASUREMENT RESULTS

LOCATION	Time of Day (HRS)	Ave. Speed (MPH)	Hourly Traffic Volume: AUTO	Hourly Traffic Volume: M.TRUCK	Hourly Traffic Volume: H.TRUCK	Measured Leq (dB)	Predicted Leq (dB)
A. 39 FT from the center of Kapolei Parkway (5/25/11)	0657 TO 0857	39	247	0	14	59.3	59.3
B. 64 FT from the center line of Kapolei Pkwy. (5/25/11)	0703 TO 0803	38	925	11	22	64.4	64.3
C. 46 FT from the center of Kinoiki Street (5/25/11)	0812 TO 0912	38	92	1	0	54.9	54.9
D. 60 FT from the center of Renton Road (5/25/11)	0921 TO 1021	40	292	3	11	61.8	61.8
E. 99 FT from the center of Kualakai Parkway (5/25/11)	1033 TO 1133	45	319	8	13	65.0	65.0
F. 95 FT from the center of Roosevelt Avenue (5/25/11)	1151 TO 1251	42	704	4	20	62.4	62.4

FIGURE 3

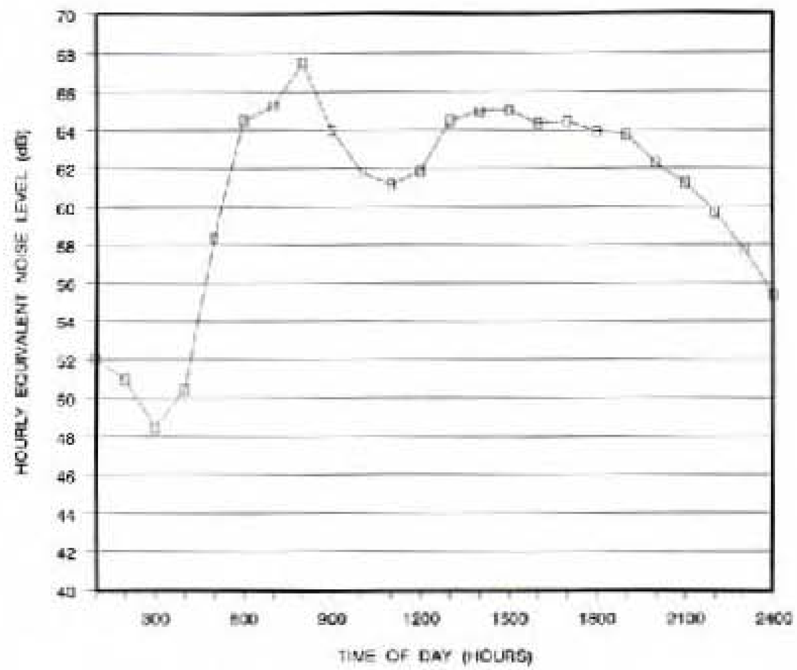
HOURLY VARIATIONS OF TRAFFIC NOISE AT 100 FT SETBACK DISTANCE FROM THE CENTERLINE OF KAPOLEI PARKWAY 0.2 MILES EAST OF KAMAAHA AVENUE (AUGUST 18, 2009)



□ 100 FT from Roadway Centerline (53.2 DNL)

FIGURE 4

HOURLY VARIATIONS OF TRAFFIC NOISE AT 60 FT SETBACK DISTANCE FROM THE CENTERLINE OF RENTON ROAD BETWEEN ALAIKI STREET AND KAPOLEI PARKWAY (FEBRUARY 4, 2009)



□ 60 FT from Roadway Centerline (66.9 DNL)

Because of the proposed hotel located within the project's boundaries, the results of a previous aircraft noise study for the Kalaeloa Airport environs were used to determine if the proposed hotel was located outside the 60 DNL airport noise contour associated with aircraft operations in the study area. The locations of the forecasted aircraft noise contours for years 2004 and 2025 developed in Reference 10 were compared with the proposed hotel's location on the project site.

Calculations of average exterior and interior noise levels from construction activities were performed for typical naturally ventilated and air conditioned buildings. Predicted noise levels were compared with existing background ambient noise levels, and the potential for noise impacts was assessed.

V. EXISTING ACOUSTICAL ENVIRONMENT

The existing background ambient noise levels within the project area are controlled by motor vehicle traffic along Kapolei Parkway, Kualakai Parkway, Renton Road, and Roosevelt Avenue. Jet, propeller, and helicopter aircraft are some of the other noise events which are intermittently audible.

Existing traffic noise level measurements were obtained at Locations A through F where shown in FIGURE 1. The results of the traffic noise measurements are summarized in TABLE 2. All of the measurement sites were located at street level. As shown in TABLE 2, correlation between measured and predicted traffic noise levels was considered acceptable for predicting both existing and future traffic noise levels in the project environs.

APPENDIX C contains the existing traffic volumes on the roadways in the project environs during 2010. Calculations of existing traffic noise levels during the applicable AM or PM peak traffic hour using the traffic volumes contained in APPENDIX C are presented in TABLE 3. The hourly Leq (or Equivalent Sound Level) contribution from each roadway section in the project environs was calculated for later comparison with forecasted traffic noise levels with and without the project. It should be noted that, for the wider roadways (Kapolei Parkway and Kualakai Parkway), traffic noise levels were calculated at 75 feet instead of the 50 feet distance indicated in the column heading of TABLE 3 (as well as in TABLE 5).

The existing setback distances from the roadways' centerlines to their associated 65 and 70 DNL contours were also calculated as shown in TABLE 4. The contour line setback distances do not take into account noise shielding effects from existing buildings or the additive contributions of traffic noise from intersecting street sections. Based on the results of TABLE 4, it was concluded that the existing 65 DNL traffic noise contour is located at approximately 138 feet from the centerline of Roosevelt Avenue, 120 feet from the centerline of Kualakai Parkway, 51 to 75 feet from the centerline of Renton Road, 56 to 74 feet from the centerline of Kapolei Parkway, and less than 50 feet from the centerlines of Kamaaha Avenue and Kinoiki Street.

Existing traffic noise levels at residences makai of Roosevelt Avenue, along Renton Road, and at the second floor living units along Kapolei Parkway are probably greater than 65 DNL due to the relatively high traffic noise levels along those roadways. The ground floor living units along Kapolei Parkway probably experience traffic noise levels less than 65 DNL due to the sound attenuation provided by the existing walls along the Kapolei Parkway Rights-of-Way. The existing traffic noise levels at other residences in the project environs along Kamaaha Avenue and Kinoiki Street are in the "Moderate Exposure, Acceptable" category, and are typically less than 65 DNL.

The project site is currently located outside the 60 DNL aircraft noise contour associated with operations at both Kalaeloa and Honolulu International Airport. As

TABLE 3

EXISTING (CY 2010) TRAFFIC VOLUMES AND NOISE LEVELS ALONG ROADWAYS IN PROJECT AREA (AM OR PM PEAK HOUR)

LOCATION	SPEED (MPH)	TOTAL VPH	****** VOLUMES (VPH) ******** AUTOS	M TRUCKS	H TRUCKS	50' Leq	100' Leq	200' Leq
Kapolei Parkway West of Kamaaha Ave. (AM)	39	798	763	4	31	66.0 (1)	63.9	59.8
Kapolei Pkwy. Between Kamaaha & Kinoiki St. (AM)	39	984	941	5	38	66.9 (1)	64.8	60.8
Kapolei Pkwy. Between Kinoiki & Kualakai Pkwy. (AM)	39	1,031	986	5	40	65.9 (1)	63.2	56.6
Kapolei Pkwy. Between Kualakai & Renton Rd. (AM)	38	762	729	4	29	64.6 (1)	61.9	55.3
Kapolei Pkwy. South of Renton Rd. (AM)	38	1,177	1,126	6	45	66.7 (1)	63.9	57.3
Kamaaha Ave. North of Kapolei Pkwy. (AM)	38	874	864	10	0	65.0	58.9	51.5
Kamaaha Ave. South of Kapolei Pkwy. (AM)	38	887	876	11	0	65.0	58.9	51.6
Kinoiki St. North of Kapolei Pkwy. (AM)	38	270	267	3	0	59.4	52.4	47.4
Kinoiki St. South of Kapolei Pkwy. (AM)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Kualakai Pkwy. North of Kapolei Pkwy. (PM)	45	723	679	17	27	70.1(1)	68.0	64.2
Kualakai Pkwy. South of Kapolei Pkwy. (PM)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Kualakai Pkwy. North of Roosevelt Ave. (PM)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Renton Rd. West of Kapolei Pkwy. (PM)	40	326	311	3	12	63.1	59.5	56.0
Renton Rd. East of Kapolei Pkwy. (AM)	40	1,040	993	10	37	68.1	64.5	61.0
Roosevelt Ave. West of Project Entrance Rd. (PM)	42	1,243	1,203	6	34	68.2	64.6	60.7
Roosevelt Ave. Between Entrance & Kualakai (PM)	42	1,243	1,203	6	34	68.2	64.6	60.7
Roosevelt Ave. East of Kualakai Pkwy. (PM)	42	1,243	1,203	6	34	68.2	64.6	60.7

NOTE:
(1) Traffic noise level calculated at 75 feet instead of 50 feet from roadway centerline.

TABLE 4

EXISTING AND CY 2015 DISTANCES TO 65 AND 70 DNL CONTOURS

STREET SECTION	65 DNL SETBACK (FT) EXISTING	CY 2015	70 DNL SETBACK (FT) EXISTING	CY 2015
Kapolei Parkway West of Kamaaha Ave. (AM)	65	90	< 40	< 50
Kapolei Pkwy. Between Kamaaha & Kinoiki St. (AM)	74	107	< 40	< 55
Kapolei Pkwy. Between Kinoiki & Kualakai Pkwy. (AM)	67	82	< 40	< 50
Kapolei Pkwy. Between Kualakai & Renton Rd. (AM)	58	84	< 40	< 50
Kapolei Pkwy. South of Renton Rd. (AM)	73	85	< 50	< 55
Kamaaha Ave. North of Kapolei Pkwy. (AM)	40	41	23	23
Kamaaha Ave. South of Kapolei Pkwy. (AM)	40	41	23	23
Kinoiki St. North of Kapolei Pkwy. (AM)	24	33	14	20
Kinoiki St. South of Kapolei Pkwy. (AM)	N/A	48	N/A	29
Kualakai Pkwy. North of Kapolei Pkwy. (PM)	120	333	76	134
Kualakai Pkwy. South of Kapolei Pkwy. (PM)	N/A	144	N/A	66
Kualakai Pkwy. North of Roosevelt Ave. (PM)	N/A	67	N/A	34
Renton Rd. West of Kapolei Pkwy. (PM)	51	52	19	20
Renton Rd. East of Kapolei Pkwy. (AM)	75	95	29	32
Roosevelt Ave. West of Project Entrance Rd. (PM)	136	160	52	64
Roosevelt Ave. Between Entrance & Kualakai (PM)	136	162	52	65
Roosevelt Ave. East of Kualakai Pkwy. (PM)	136	162	52	64

Notes:

(1) All setback distances are from the roadways' centerlines.
(2) See TABLES 3 and 5 for traffic volume, speed, and mix assumptions.
(3) Setback distances are for ground level receptors.

such, the location of a noise sensitive land use such as a hotel on the project site is considered acceptable by the land use compatibility guidelines of the State Department of Transportation, Airports Division.

CHAPTER VI. FUTURE NOISE ENVIRONMENT

Predictions of future traffic noise levels were made using the traffic volume assignments of Reference 7 for CY 2015 with and without the proposed project. The future projections of project plus non-project traffic noise levels on the roadways which would service the project are shown in TABLE 5 for the applicable AM or PM peak traffic hour, under the Build Alternative. The changes in setback distances to the 65 and 70 DNL contours along the streets in the project environs are shown in TABLE 4. TABLE 6 presents the predicted changes in traffic noise levels along the various roadway sections resulting from non-project and project traffic. The largest increase (5.6 DNL) in future traffic noise levels is expected to occur along Kualakai Parkway north of Kapolei Parkway, with approximately half of the total increase associated with non-project traffic. The total increases in future traffic noise along the other street sections are expected to be less than 4 DNL units, with non-project traffic typically contributing 50 percent or greater proportion of the increases.

Kualakai Parkway is expected to become the dominant traffic noise corridor in the project area, and Kapolei Parkway is expected to become the second most dominant traffic noise corridor in the project environs. Roosevelt Avenue and Renton Road are expected to experience smaller increases in future traffic noise levels, and are expected to become less dominant traffic noise contributors in the project environs.

Future traffic noise levels at the first row and second floors of existing residences which front Kapolei Parkway, at the first row of residences fronting Renton Road, and at the first row of existing residences on the makai side of Roosevelt Avenue are expected to remain above 65 DNL. The proposed hotel on the project site should be outside the 65 DNL traffic noise contour along Kapolei Parkway. Future traffic noise levels at existing residences along Kinoiki Street and Kamaaha Avenue are expected to continue to be less than 65 DNL. Where existing residences are located along Kapolei Parkway, future traffic noise level increases are predicted to range from 1.3 to 1.5 DNL due to non-project traffic and to range from 0.8 to 1.3 DNL due to project traffic. Along Renton Road and Roosevelt Avenue where residents are located, future traffic noise level increases due to non-project traffic are predicted to range from 0.4 to 0.9 DNL, and are predicted to range from 0.2 to 0.3 DNL due to project traffic.

The project site is currently located outside the 60 DNL aircraft noise contour associated with projected year 2025 operations at both Kalaeloa and Honolulu International Airport. FIGURE 5, which was extracted from Reference 10, depicts the northern extent of the 60 DNL contour. Because the 60 DNL contour does not go beyond Roosevelt Avenue, and because the project site is located north of Roosevelt Avenue, noise sensitive land uses on the project site should remain outside the 60 DNL airport noise contour associated with projected year 2025 operations at both Kalaeloa and Honolulu International Airport. As such, the location of a noise sensitive land use such as a hotel on the project site is considered acceptable by the land use compatibility guidelines of the State Department of Transportation, Airports Division.

TABLE 5

FUTURE (CY 2015) TRAFFIC VOLUMES AND NOISE LEVELS ALONG ROADWAYS IN PROJECT AREA (AM OR PM PEAK HOUR, BUILD)

LOCATION	SPEED (MPH)	TOTAL VPH	****** VOLUMES (VPH) ******** AUTOS	M.TRUCKS	H.TRUCKS	50' Leq	100' Leq	200' Leq
Kapolei Parkway West of Kamaaha Ave. (PM)	30	1,387	1,327	7	53	68.3 (1)	66.2	62.2
Kapolei Pkwy. Between Kamaaha & Kinoiki St. (PM)	38	1,794	1,716	9	69	69.5 (1)	67.4	63.3
Kapolei Pkwy. Between Kinoiki & Kualakai Pkwy. (PM)	38	1,568	1,500	8	60	67.9 (1)	65.1	58.5
Kapolei Pkwy. Between Kualakai & Renton Rd. (PM)	38	1,681	1,608	8	65	68.1 (1)	65.4	58.8
Kapolei Pkwy. South of Renton Rd. (AM)	38	1,723	1,648	9	66	68.2 (1)	65.5	58.9
Kamaaha Ave. North of Kapolei Pkwy. (AM)	38	919	908	11	0	65.2	58.1	51.7
Kamaaha Ave. South of Kapolei Pkwy. (AM)	38	932	921	11	0	65.2	59.1	51.8
Kinoiki St. North of Kapolei Pkwy. (PM)	38	577	570	7	0	62.8	56.7	50.7
Kinoiki St. South of Kapolei Pkwy. (PM)	35	1,434	1,417	17	0	66.5	59.4	54.3
Kualakai Pkwy. North of Kapolei Pkwy. (PM)	45	2,603	2,442	62	99	75.7 (1)	73.6	69.8
Kualakai Pkwy. South of Kapolei Pkwy. (PM)	35	1,632	1,531	39	62	71.1 (1)	69.0	65.2
Kualakai Pkwy. North of Roosevelt Ave. (PM)	35	521	488	13	20	66.2 (1)	64.1	60.2
Renton Rd. West of Kapolei Pkwy. (PM)	40	344	329	3	12	63.2	59.6	56.2
Renton Rd. East of Kapolei Pkwy. (AM)	40	1,191	1,136	12	43	68.7	65.1	61.6
Roosevelt Ave. West of Project Entrance Rd. (PM)	42	1,597	1,546	8	43	69.3	65.7	61.7
Roosevelt Ave. Between Entrance & Kualakai (PM)	42	1,636	1,586	6	44	69.4	65.8	61.8
Roosevelt Ave. East of Kualakai Pkwy. (PM)	42	1,606	1,557	6	43	69.3	65.7	61.8

NOTE:

(1) Traffic noise level calculated at 75 feet instead of 50 feet from roadway centerline.

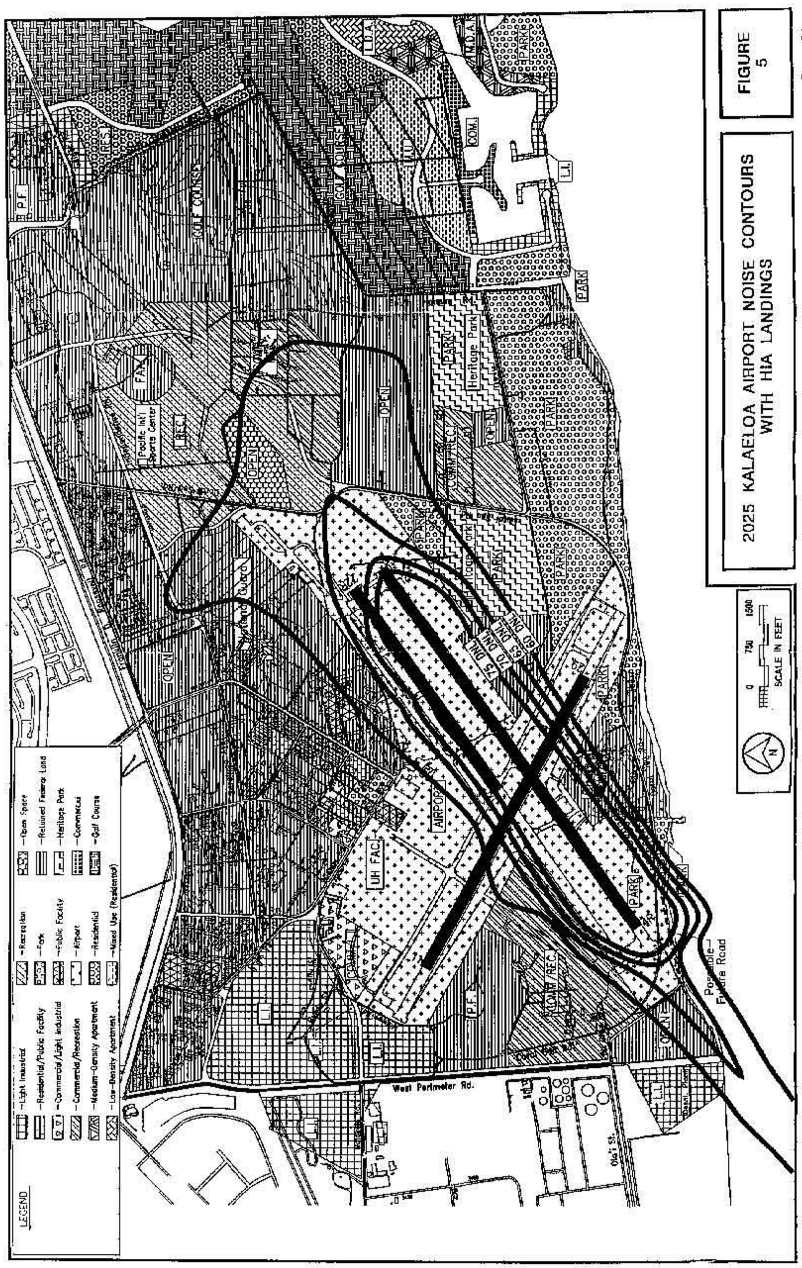
TABLE 6

CALCULATIONS OF PROJECT AND NON-PROJECT TRAFFIC NOISE CONTRIBUTIONS (CY 2015) (IN LEQ OR DNL)

STREET SECTION	NOISE LEVEL INCREASE DUE TO: NON-PROJECT TRAFFIC	PROJECT TRAFFIC
Kapolei Parkway West of Kamaaha Ave. (AM)	1.5	0.8
Kapolei Pkwy. Between Kamaaha & Kinoiki St. (AM)	1.3	1.3
Kapolei Pkwy. Between Kinoiki & Kualakai Pkwy. (AM)	1.4	0.5
Kapolei Pkwy. Between Kualakai & Renton Rd. (AM)	2.0	1.5
Kapolei Pkwy. South of Renton Rd. (AM)	1.2	0.4
Kamaaha Ave. North of Kapolei Pkwy. (AM)	0.2	0.0
Kamaaha Ave. South of Kapolei Pkwy. (AM)	0.2	0.0
Kinoiki St. North of Kapolei Pkwy. (AM)	1.9	1.4
Kinoiki St. South of Kapolei Pkwy. (AM)	N/A	ALL (1)
Kualakai Pkwy. North of Kapolei Pkwy. (PM)	2.9	2.7
Kualakai Pkwy. South of Kapolei Pkwy. (PM)	N/A	ALL (1)
Kualakai Pkwy. North of Roosevelt Ave. (PM)	N/A	ALL (1)
Renton Rd. West of Kapolei Pkwy. (PM)	0.1	0.0
Renton Rd. East of Kapolei Pkwy. (AM)	0.4	0.2
Roosevelt Ave. West of Project Entrance Rd. (PM)	0.9	0.2
Roosevelt Ave. Between Entrance & Kualakai (PM)	0.9	0.3
Roosevelt Ave. East of Kualakai Pkwy. (PM)	0.9	0.2

Note:

(1) All of future traffic noise increases on new roadways are associated with project traffic.

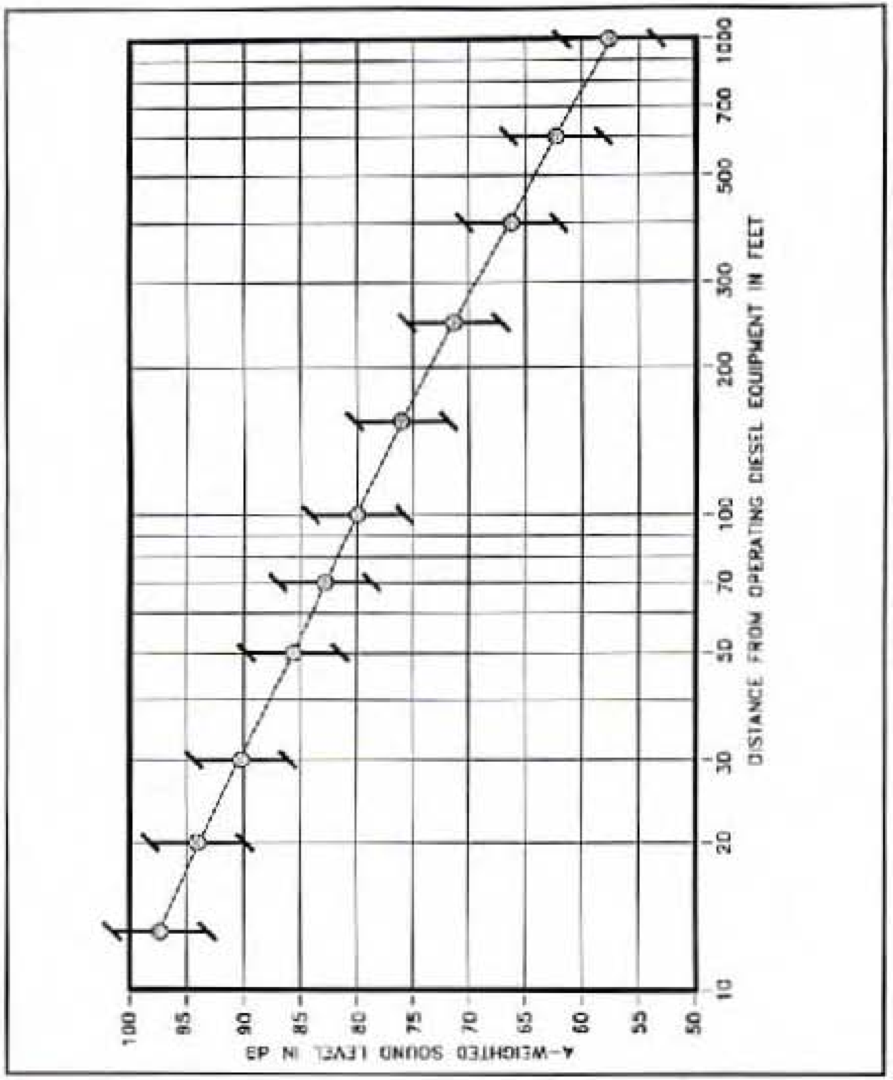


CHAPTER VII. DISCUSSION OF PROJECT RELATED NOISE IMPACTS AND POSSIBLE MITIGATION MEASURES

Traffic Noise. Closure and air conditioning of residences is an effective traffic noise mitigation measure, particularly at second floor living areas which are difficult to shield with sound attenuating walls. Except for those noise sensitive structures which are air conditioned or which are shielded by sound attenuating walls, existing traffic noise levels could result in adverse noise impacts at residences which front Kapolei Parkway, Roosevelt Avenue, and Renton Road. By 2015, with or without the proposed project, traffic noise levels at these same residences are predicted to increase, with most of the increases associated with non-project traffic. Traffic noise mitigation measures are typically implemented by individual homeowners and/or developers of noise sensitive properties located along roadways, and these mitigation measures typically involve closure and air conditioning and/or the addition of sound attenuating walls. Along public roadways, traffic noise mitigation measures are also considered for implementation in conjunction with roadway improvement projects, with mitigation measures typically involving sound attenuating walls which can be constructed within the public Rights-of-Way. Because motor vehicle traffic noise usually originates from multiple sources and from multiple contributors to total traffic along public roadways, its mitigation has historically been the responsibility of individual homeowners, developers who locate noise sensitive properties along roadways, or government agencies who are involved in roadway improvement projects.

General Construction Noise. Audible construction noise will probably be unavoidable during the entire project construction period. The total time period for construction is unknown, but it is anticipated that the actual work will be moving from one location on the project site to another during that period. Actual length of exposure to construction noise at any receptor location will probably be less than the total construction period for the entire project. Typical levels of exterior noise from construction activity (excluding pile driving activity) at various distances from the job site are shown in FIGURE 6. The impulsive noise levels of impact pile drivers are approximately 15 dB higher than the levels shown in FIGURE 6, while the intermittent noise levels of vibratory pile drivers are at the upper end of the noise level ranges depicted in the figure.

FIGURE 6 is useful for predicting exterior noise levels at short distances (within 100 feet) from the work when visual line of sight exists between the construction equipment and the receptor. Direct line-of-sight distances from the construction equipment to existing residential buildings will range from 350 feet to 2,600 feet, with corresponding average noise levels of 68 to 27 dBA (plus or minus 5 dBA). For receptors along a cross-street, the construction noise level vs. distance curve of FIGURE 6 should be reduced by approximately 8 dBA when the work is occurring at the intersection with the cross street, and should be reduced by 15 dBA when work is occurring at least 100 feet from the intersection (and the visual line-of-sight is blocked



ANTICIPATED RANGE OF CONSTRUCTION NOISE LEVELS VS. DISTANCE

FIGURE 6

by intervening buildings). Typical levels of construction noise inside naturally ventilated and air conditioned structures are approximately 10 and 20 dB less, respectively, than the levels shown in FIGURE 6.

The existing residences along Nanahu Street and located west of the project site are predicted to experience the highest noise levels during construction activities. The highest noise levels are expected to occur during the earthwork and site preparation phase of construction. Adverse impacts from construction noise are not expected to be in the "public health and welfare" category due to the temporary nature of the work, and due to the administrative controls available for regulation of construction noise. Instead, these impacts will probably be limited to the temporary degradation of the quality of the acoustic environment in the immediate vicinity of the project site.

Mitigation of construction noise to inaudible levels will not be practical in all cases due to the intensity of construction noise sources (80 to 90+ dB at 50 feet distance), and due to the exterior nature of the work (sheet pile driving, grading and earth moving, trenching, concrete pouring, hammering, etc.). The use of properly muffled construction equipment should be required on the job site.

Peak airborne noise levels from pile driving may be as much as 15 dBA greater than noise levels shown in FIGURE 6 for non-impulsive (steady) construction noise sources. Although the pile driving can produce more intense noise levels, each pulse is of short individual duration (less than one second). Therefore, its impact on speech communication is not as severe as that of steady source of the same noise level.

Severe noise impacts are not expected to occur inside air conditioned structures which are beyond 350 feet of the project construction site. Inside naturally ventilated structures, interior noise levels (with windows or doors opened) are estimated to range between 54 to 64 dBA at 350 feet distance from the construction site. Closure of all doors and windows facing the construction site would generally reduce interior noise levels by an additional 5 to 10 dBA.

The incorporation of State Department of Health construction noise permit procedures (in Reference 4) is another noise mitigation measure which is normally applied to construction activities. FIGURE 7 depicts the normally permitted hours of construction. Noisy construction activities are not allowed on Sundays and holidays, during the early morning, and during the late evening and nighttime periods under the DOH permit procedures.

Potential Noise Impacts Associated with New Fire Station. A new fire station is expected to be constructed across Kapolei Parkway from the project site, and the average sound level from sirens is predicted to be in the order of 86 dBA in the vicinity of the planned hotel on the project site. Because the hotel is expected to service business travelers, is expected to be air conditioned, and can therefore utilize sound attenuation measures (increased setbacks or the use of sound attenuation glazing), adverse noise impacts should be avoidable.

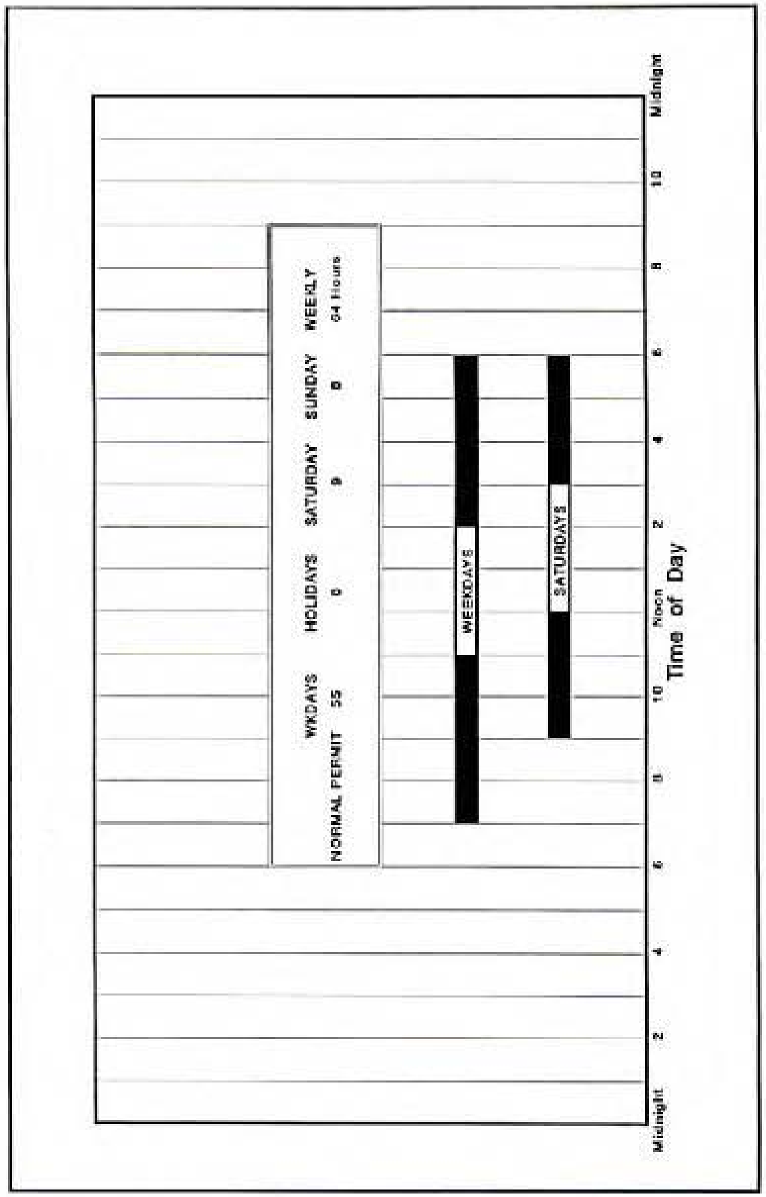


FIGURE 7

AVAILABLE WORK HOURS UNDER DOH PERMIT PROCEDURES FOR CONSTRUCTION NOISE

APPENDIX A. REFERENCES

(1) "Guidelines for Considering Noise in Land Use Planning and Control;" Federal Interagency Committee on Urban Noise; June 1980.

(2) "Environmental Criteria and Standards, Noise Abatement and Control, 24 FR, Part 51, Subpart B;" U.S. Department of Housing and Urban Development; As Amended March 29, 1984.

(3) "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety;" Environmental Protection Agency (EPA 550/9-74-004); March 1974.

(4) "Title 11, Administrative Rules, Chapter 46, Community Noise Control;" Hawaii State Department of Health; September 23, 1996.

(5) "Mandatory Seller Disclosures in Real Estate Transactions," Chapter 508D, Hawaii Revised Statutes; July 1, 1996.

(6) "FHWA Traffic Noise Model User's Guide;" FHWA-PD-96-009, Federal Highway Administration; Washington, D.C.; January 1998 and Version 2.5 Upgrade (April 14, 2004).

(7) Existing (2010) and Future (2015) Traffic Turning Movements for Makana Ali'i Project; PB Americas, Inc; May 2011.

(8) 24-Hour Traffic Counts, Kapolei Parkway 0.2 Miles East of Kamaaha Avenue; State Department of Transportation; August 18, 2009.

(9) 24-Hour Traffic Counts, Renton Road Between Alaiki Street and Kapolei Parkway; State Department of Transportation; February 4, 2009.

(10) "Acoustic Working Paper for the Kalaeloa Community Development Plan; Kalaeloa Airport; Kapolei, Oahu; Y. Ebisu & Associates; August 2005.

APPENDIX B

EXCERPTS FROM EPA'S ACOUSTIC TERMINOLOGY GUIDE

Descriptor Symbol Usage

The recommended symbols for the commonly used acoustic descriptors based on A-weighting are contained in Table I. As most acoustic criteria and standards used by EPA are derived from the A-weighted sound level, almost all descriptor symbol usage guidance is contained in Table I.

Since acoustic nomenclature includes weighting networks other than "A" and measurements other than pressure, an expansion of Table I was developed (Table II). The group adopted the ANSI descriptor-symbol scheme which is structured into three stages. The first stage indicates that the descriptor is a level (i.e., based upon the logarithm of a ratio), the second stage indicates the type of quantity (power, pressure, or sound exposure), and the third stage indicates the weighting network (A, B, C, D, E.....). If no weighting network is specified, "A" weighting is understood. Exceptions are the A-weighted sound level and the A-weighted peak sound level which require that the "A" be specified. For convenience in those situations in which an A-weighted descriptor is being compared to that of another weighting, the alternative column in Table II permits the inclusion of the "A". For example, a report on blast noise might wish to contrast the LCdn with the LAdn.

Although not included in the tables, it is also recommended that "LpN" and "LepN" be used as symbols for perceived noise levels and effective perceived noise levels, respectively.

It is recommended that in their initial use within a report, such terms be written in full, rather than abbreviated. An example of preferred usage is as follows:

The A-weighted sound level (LA) was measured before and after the installation of acoustical treatment. The measured LA values were 85 and 75 dB respectively.

Descriptor Nomenclature

With regard to energy averaging over time, the term "average" should be discouraged in favor of the term "equivalent". Hence, Leq, is designated the "equivalent sound level". For Ld, Ln, and Ldn, "equivalent" need not be stated since the concept of day, night, or day-night averaging is by definition understood. Therefore, the designations are "day sound level", "night sound level", and "day-night sound level", respectively.

The peak sound level is the logarithmic ratio of peak sound pressure to a reference pressure and not the maximum root mean square pressure. While the latter is the maximum sound pressure level, it is often incorrectly labelled peak. In that sound level meters have "peak" settings, this distinction is most important.

"Background ambient" should be used in lieu of "background", "ambient", "residual", or "indigenous" to describe the level characteristics of the general background noise due to the contribution of many unidentifiable noise sources near and far.

With regard to units, it is recommended that the unit decibel (abbreviated dB) be used without modification. Hence, DBA, PNdB, and EPNdB are not to be used. Examples of this preferred usage are: the Perceived Noise Level (LpN) was found to be 75 dB. LpN = 75 dB). This decision was based upon the recommendations of the National Bureau of Standards, and the policies of ANSI and the Acoustical Society of America, all of which disallow any modification of bel except for prefixes indicating its multiples or submultiples (e.g., deci).

Noise Impact

In discussing noise impact, it is recommended that "Level Weighted Population" (LWP) replace "Equivalent Noise Impact" (ENI). The term "Relative Change of Impact" (RCI) shall be used for comparing the relative differences in LWP between two alternatives.

Further, when appropriate, "Noise Impact Index" (NII) and "Population Weighted Loss of Hearing" (PHL) shall be used consistent with CHABA Working Group 69 Report Guidelines for Preparing Environmental Impact Statements (1977).

TABLE I

A-WEIGHTED RECOMMENDED DESCRIPTOR LIST

TERM	SYMBOL
1. A-Weighted Sound Level	L_A
2. A-Weighted Sound Power Level	L_{WA}
3. Maximum A-Weighted Sound Level	L_{max}
4. Peak A-Weighted Sound Level	L_{Apk}
5. Level Exceeded x% of the Time	L_x
6. Equivalent Sound Level	L_{eq}
7. Equivalent Sound Level over Time (T) (1)	$L_{eq(T)}$
8. Day Sound Level	L_d
9. Night Sound Level	L_n
10. Day-Night Sound Level	L_{dn}
11. Yearly Day-Night Sound Level	$L_{dn(Y)}$
12. Sound Exposure Level	L_{SE}

(1) Unless otherwise specified, time is in hours (e.g. the hourly equivalent level is $L_{eq(1)}$). Time may be specified in non-quantitative terms (e.g., could be specified a $L_{eq(WASH)}$ to mean the washing cycle noise for a washing machine).

SOURCE: EPA ACOUSTIC TERMINOLOGY GUIDE, BNA 8-14-78.

APPENDIX B (CONTINUED)

TABLE II

RECOMMENDED DESCRIPTOR LIST

TERM	A-WEIGHTING	ALTERNATIVE[1] A-WEIGHTING	OTHER[2] WEIGHTING	UNWEIGHTED
1. Sound (Pressure)[3] Level	L_A	L_{pA}	L_B, L_{pB}	L_p
2. Sound Power Level	L_{WA}		L_{WB}	L_W
3. Max. Sound Level	L_{max}	L_{Amax}	L_{Bmax}	L_{pmax}
4. Peak Sound (Pressure) Level	L_{Apk}		L_{Bpk}	L_{pk}
5. Level Exceeded x% of the Time	L_x	L_{Ax}	L_{Bx}	L_{px}
6. Equivalent Sound Level	L_{eq}	L_{Aeq}	L_{Beq}	L_{peq}
7. Equivalent Sound Level[4] Over Time(T)	$L_{eq(T)}$	$L_{Aeq(T)}$	$L_{Beq(T)}$	$L_{peq(T)}$
8. Day Sound Level	L_d	L_{Ad}	L_{Bd}	L_{pd}
9. Night Sound Level	L_n	L_{An}	L_{Bn}	L_{pn}
10. Day-Night Sound Level	L_{dn}	L_{Adn}	L_{Bdn}	L_{pdn}
11. Yearly Day-Night Sound Level	$L_{dn(Y)}$	$L_{Adn(Y)}$	$L_{Bdn(Y)}$	$L_{pdn(Y)}$
12. Sound Exposure Level	L_S	L_{SA}	L_{SB}	L_{Sp}
13. Energy Average Value Over (Non-Time Domain) Set of Observations	$L_{eq(e)}$	$L_{Aeq(e)}$	$L_{Beq(e)}$	$L_{peq(e)}$
14. Level Exceeded x% of the Total Set of (Non-Time Domain) Observations	$L_{x(e)}$	$L_{Ax(e)}$	$L_{Bx(e)}$	$L_{px(e)}$
15. Average L_x Value	L_x	L_{Ax}	L_{Bx}	L_{px}

(1) "Alternative" symbols may be used to assure clarity or consistency.

(2) Only B-weighting shown. Applies also to C,D,E,...weighting.

(3) The term "pressure" is used only for the unweighted level.

(4) Unless otherwise specified, time is in hours (e.g., the hourly equivalent level is Leq(1). Time may be specified in non-quantitative terms (e.g., could be specified as Leq(WASH) to mean the washing cycle noise for a washing machine.

APPENDIX C

SUMMARY OF BASE YEAR AND YEAR 2015 TRAFFIC VOLUMES

ROADWAY LANES	**** CY 2010 **** AM VPH	PM VPH	CY 2015 (NO BUILD) AM VPH	PM VPH	CY 2015 (BUILD) AM VPH	PM VPH
Kapolei Pkwy.; W. of Kamaaha (EB)	340	335	501	409	655	581
Kapolei Pkwy.; W. of Kamaaha (WB)	452	196	627	359	681	730
Two-Way	736	431	1,128	768	1,336	1,287
Kapolei Pkwy.; Kamaaha to Kinoiki (EB)	464	332	547	531	796	796
Kapolei Pkwy.; Kamaaha to Kinoiki (WB)	520	458	716	655	779	999
Two-Way	984	790	1,257	1,175	1,505	1,794
Kapolei Pkwy.; Kinoiki to Kualakai Pkwy. (EB)	456	362	722	586	757	624
Kapolei Pkwy.; Kinoiki to Kualakai Pkwy. (WB)	575	454	640	827	803	744
Two-Way	1,031	816	1,342	1,388	1,560	1,563
Kapolei Pkwy.; Kualakai Pkwy. to Renton (EB)	288	418	472	670	535	933
Kapolei Pkwy.; Kualakai Pkwy. to Renton (WB)	474	280	725	521	851	748
Two-Way	762	735	1,197	1,191	1,389	1,681
Kapolei Pkwy.; S. of Renton (NB)	733	348	957	543	1,066	725
Kapolei Pkwy.; S. of Renton (SB)	444	498	609	726	657	937
Two-Way	1,177	846	1,563	1,269	1,723	1,662
Kamaaha Ave.; N. of Kapolei Pkwy. (NB)	441	319	464	332	464	332
Kamaaha Ave.; N. of Kapolei Pkwy. (SB)	433	211	455	222	456	222
Two-Way	874	527	919	554	919	554
Kamaaha Ave.; S. of Kapolei Pkwy. (NB)	487	142	512	149	512	140
Kamaaha Ave.; S. of Kapolei Pkwy. (SB)	400	213	420	225	420	225
Two-Way	887	355	932	374	932	374
Kinoiki St.; N. of Kapolei Pkwy. (NB)	154	83	189	173	220	333
Kinoiki St.; N. of Kapolei Pkwy. (SB)	118	106	234	161	302	274
Two-Way	272	189	423	334	522	577
Kinoiki St.; S. of Kapolei Pkwy. (NB)	N/A	N/A	N/A	N/A	182	804
Kinoiki St.; S. of Kapolei Pkwy. (SB)	N/A	N/A	N/A	N/A	214	573
Two-Way	N/A	N/A	N/A	N/A	396	1,434
Kualakai Pkwy.; N. of Kapolei Pkwy. (NB)	300	252	713	557	948	1,266
Kualakai Pkwy.; N. of Kapolei Pkwy. (SB)	367	471	524	832	825	1,337
Two-Way	667	723	1,237	1,389	1,773	2,603

APPENDIX C (CONTINUED)

SUMMARY OF BASE YEAR AND YEAR 2015
TRAFFIC VOLUMES

ROADWAY LANES	**** CY 2010 *****		CY 2015 (NO BUILD)		CY 2015 (BUILD)	
	AM VPH	PM VPH	AM VPH	PM VPH	AM VPH	PM VPH
Kualakai Pkwy.; S. of Kapolei Pkwy. (NB)	N/A	N/A	N/A	N/A	327	852
Kualakai Pkwy.; S. of Kapolei Pkwy. (SB)	N/A	N/A	N/A	N/A	545	780
Two-Way	N/A	N/A	N/A	N/A	872	1,632
Kualakai Pkwy.; N. of Roosevelt (NB)	N/A	N/A	N/A	N/A	234	319
Kualakai Pkwy.; N. of Roosevelt (SB)	N/A	N/A	N/A	N/A	142	202
Two-Way	N/A	N/A	N/A	N/A	376	521
Renton Rd.; W. of Kapolei Pkwy. (EB)	97	210	102	226	102	228
Renton Rd.; W. of Kapolei Pkwy. (WB)	192	116	202	118	202	116
Two-Way	289	326	304	344	304	344
Renton Rd.; E. of Kapolei Pkwy. (EB)	524	366	577	419	589	471
Renton Rd.; E. of Kapolei Pkwy. (WB)	516	270	575	327	602	372
Two-Way	1,040	636	1,152	746	1,191	843
Roosevelt Ave.; W. of Project Entrance (EB)	293	788	309	828	385	1,019
Roosevelt Ave.; W. of Project Entrance (WB)	657	455	478	691	761	578
Two-Way	950	1,243	786	1,519	1,146	1,597
Roosevelt Ave.; Proj. Entr. to Kualakai (EB)	293	785	308	828	385	1,045
Roosevelt Ave.; Proj. Entr. to Kualakai (WB)	657	455	478	691	777	893
Two-Way	950	1,240	786	1,519	1,162	1,938
Roosevelt Ave.; E. of Kualakai Pkwy. (EB)	293	788	308	828	398	971
Roosevelt Ave.; E. of Kualakai Pkwy. (WB)	657	455	478	691	857	637
Two-Way	950	1,243	786	1,519	1,255	1,608

Appendix G

Air Quality Impact Analysis

AIR QUALITY STUDY

FOR THE PROPOSED

KA MAKANA ALII PROJECT

EAST KAPOLEI, OAHU, HAWAII

Prepared for:

Hawaii DeBartolo LLC

June 2011

B.D. NEAL & ASSOCIATES

*Applied Meteorology * Air Quality * Computer Science*

P.O. BOX 1808 * KAILUA-KONA, HAWAII 96745 * TELEPHONE (808) 329-1627 * FAX (808) 331-8428

EMAIL: bdneal@kona.net

CONTENTS

FIGURES

TABLES

TABLES(cont.)

1.0 SUMMARY

Hawaii DeBartolo LLC is proposing to develop the Ka Makana Alii Project at East Kapolei, Oahu. The proposed project will consist of retail, hotel and office space on approximately 67 acres of land leased from the Department of Hawaiian Home Lands. The project is expected to be completed and fully occupied 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.

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 generally comparable to the national standards although the state standards for carbon monoxide 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. It is possible, however, that 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 of active work areas, using wind screens, keeping adjacent paved

roads clean, and by covering of open-bodied trucks. Other dust control measures could include limiting the area that can be disturbed at any given time and/or mulching or chemically stabilizing inactive areas that have been worked. Paving and landscaping of project areas early in the construction schedule will also reduce dust emissions. Monitoring dust at the project boundary during the period of construction could be considered as a means to evaluate the effectiveness of the project dust control program. Exhaust emissions can be mitigated by moving construction equipment and workers to and from the project site during off-peak traffic hours.

After construction, motor vehicles coming to and from the proposed 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, a computer 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 present 1-hour and 8-hour carbon monoxide concentrations are within both the state and the national ambient air quality standards. In the year 2015 without the project, carbon monoxide concentrations were predicted to generally increase somewhat in the project area, but worst-case concentrations should remain well within air quality standards. With the project in the year 2015, project-related traffic would result in higher carbon monoxide concentrations compared to the without-project case at some locations, but worst-case concentrations should remain well within air quality standards. With the project and with the North-South Road (Kualakai Parkway) extension to Roosevelt Avenue, worst-case carbon monoxide concentrations were estimated to remain about the same or increase only slightly at some locations compared to without the roadway extension. Implementing mitigation measures for traffic-related air quality impacts is probably unnecessary and unwarranted.

Depending on the demand levels, long-term impacts on air quality are also possible due to indirect emissions associated with a development's electrical power and solid waste disposal requirements. Quantitative estimates of these potential impacts were not made, but based on the estimated demand levels and emission rates involved, any impacts will likely be negligible. Nevertheless, incorporating energy conservation design features and promoting conservation and recycling programs within the proposed development could serve to further reduce any associated impacts.

2.0 INTRODUCTION

Hawaii DeBartolo LLC is proposing to develop the Ka Makana Alii Project on approximately 67 acres of vacant lands leased from the Department of Hawaiian Home Lands. The project site is situated between Kapolei Parkway and Roosevelt Avenue in East Kapolei immediately makai of the Department of Hawaiian Home Lands offices (see Figure 1 for project location). The development will include: a major department store, a family entertainment complex, a mixed-use village with specialty retail and restaurants, two hotels, low-rise office buildings, and a neighborhood commercial center with specialty market, drugstore and convenience shops and services. Construction of the project is expected to occur in two phases commencing during 2013. Full build out is anticipated by 2015.

The purpose of this study is to describe existing air quality in the project area and to assess the potential short- and long-term direct and indirect air quality impacts that could result from construction and use of the proposed facilities as planned. Measures to mitigate potential project impacts 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. On the other hand, the current Hawaii AAQS for sulfur dioxide are probably less stringent than the national standards. During the early part of 2010, the national primary annual and 24-hour standards for sulfur dioxide were revoked in favor of a new national 1-hour standard which is considered to be more stringent than the Hawaii short-term standards. The Hawaii AAQS for sulfur dioxide have not yet been updated to bring them in line with the national standards.

In 1993, the state revised its particulate standards to follow those set by the federal government. During 1997, the federal

government again revised its standards for particulate, but the new standards were challenged in federal court. A Supreme Court ruling was issued during February 2001, and as a result, the new standards for particulate were finally implemented during 2005. To date, the Hawaii Department of Health has not updated the state particulate standards.

In September 2001, the state vacated the state 1-hour standard for ozone and an 8-hour standard was adopted that was the same as the national standard. During 2008, the national standard for ozone was again revised and made more stringent. The Hawaii standard for ozone has not yet been amended to follow the national standard.

During the latter part of 2008, EPA revised the standard for lead making the standard more stringent. So far, the Hawaii Department of Health has not revised the corresponding state standard for lead.

During early 2010, a national 1-hour primary standard for nitrogen dioxide was implemented. To date, Hawaii has not promulgated a 1-hour standard for nitrogen dioxide, but the Hawaii annual standard for this pollutant is more stringent than the national annual standard.

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 8 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 concentrations because contaminants emitted from or near the surface can become trapped within the mixing layer. In Hawaii, minimum mixing heights tend to be high because of mechanical mixing caused by the trade winds and because of the temperature moderating effect of the surrounding ocean. Low mixing heights may sometimes occur, however, at inland locations and even at times along coastal areas early in the morning following a clear, cool, windless night. Coastal areas also may experience low mixing levels during sea breeze conditions when cooler ocean air rushes in over warmer land. Mixing heights in Hawaii typically are above 3000 feet (1000 meters).

Rainfall can have a beneficial affect on the air quality of an area in that it helps to suppress fugitive dust emissions, and it also may "washout" gaseous contaminants that are water soluble. Rainfall in Hawaii is highly variable depending on elevation and on location with respect to the trade wind. 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. This is the most recent information available. The emission rates shown in the table pertain to manmade emissions only, i.e., emissions from natural sources are not included. As suggested in the table, much of the particulate emissions on Oahu originate from area sources, such as the mineral products industry and agriculture. Sulfur oxides are emitted almost exclusively by point sources, such as power plants and refineries. Nitrogen oxides emissions emanate predominantly from industrial point sources, although area sources (mostly motor vehicle traffic) also contribute a significant share. The majority of carbon monoxide emissions occur from area sources (motor vehicle traffic), while hydrocarbons are emitted mainly from point sources. Based on previous emission inventories that have been reported for Oahu, emissions of particulate and nitrogen oxides may have increased during the past several years, while emissions of sulfur oxides, carbon monoxide and hydrocarbons probably have declined.

The H-1 Freeway, which passes near 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 about 4 miles to the southwest of the project site at Barbers Point. 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 pasture-land or for diversified agriculture. Long-range uses for the land have not yet been fully 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 2005 through 2009. These are the most recent data that are currently available.

During the 2005-2009 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 0.004 to 0.011 parts per million (ppm), while the annual second-highest 24-hour concentrations were consistently at 0.003 ppm. Annual average concentrations were only about 0.001 to 0.002 ppm. There were no exceedances of the state/national 3-hour or 24-hour AAQS for sulfur dioxide during the 5-year period. Data pertaining to the new 1-hour standard have not yet been reported.

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 36 to 58 $\mu g/m^3$ between 2005 and 2009. Average annual concentrations ranged from 15 to 18 $\mu g/m^3$. All values reported were within the state and national AAQS.

Particulate matter less than 2.5 microns in diameter (PM-2.5) measured at the Kapolei monitoring station had annual 98^{th} percentile 24-hour concentrations ranging from 7 to 21 $\mu g/m^3$ between 2005 and 2009. Average annual concentrations ranged from 4 to 6 $\mu g/m^3$. 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 0.9 to 2.6 ppm. The annual second-highest 8-hour concentrations ranged from 0.7 to 1.2 ppm. These values are well within the standards, and 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 0.004 to 0.005 ppm, safely inside the state and national AAQS.

The nearest available ozone measurements were obtained at Sand Island (about 11 miles east of the project area). The fourth-highest 8-hour concentrations (which are most relevant to the standard) for the period 2005 through 2009 ranged between 0.033 and 0.048 ppm, 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 in the project area. 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 specific 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 annual standard for nitrogen dioxide is not likely to be violated by short-term construction equipment emissions. Also, the new short-term (1-hour) standard for nitrogen dioxide is based on a three-year average; thus it is unlikely that relatively short-term construction emissions would exceed the standard. Carbon monoxide emissions from diesel engines 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 required further emission reductions, which have been phased in since 1994. More recently, additional restrictions were signed into law during the Clinton administration, and these began to take effect during the past 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 20 to 30 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, four scenarios were selected for the carbon monoxide modeling study: (1) year 2010 with present conditions, (2) year 2015 without the project, (3) year 2015 with the project, and year 2015 with the project and with the North-South Road (Kualakai Parkway) extension. To begin the modeling study of the four scenarios, critical receptor areas in the vicinity of the project were identified for analysis. Generally speaking, roadway intersections are the primary concern because of traffic congestion and because of the increase in vehicular emissions associated with traffic queuing. For this study, several of the key intersections identified in the traffic study were also selected for air quality analysis. These included the following intersections:

- Kapolei Parkway at Kamaaha Avenue
- Kapolei Parkway at Kinoiki Street
- Kapolei Parkway at Kualakai Parkway
- Kapolei Parkway at Renton Road

- Kualakai Parkway at East Entrance
- Kualakai Parkway at Roosevelt Avenue
- Roosevelt Avenue at South Entrance

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 four scenarios studied. To evaluate the significance of the estimated concentrations, a comparison of the predicted values for each scenario can be made. Comparison of the estimated values to the national and state AAQS was also used to provide another measure of significance.

Maximum carbon monoxide concentrations typically coincide with peak traffic periods. The traffic impact assessment report evaluated morning and afternoon peak traffic periods. These same periods were evaluated in the air quality impact assessment.

The EPA computer model MOBILE6.2 [5] was used to calculate vehicular carbon monoxide emissions for each year studied. One of the key inputs to MOBILE6.2 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 35.4% light-duty gasoline-

powered automobiles, 51.7% light-duty gasoline-powered trucks and vans, 3.6% heavy-duty gasoline-powered vehicles, 0.2% light-duty diesel-powered vehicles, 8.6% heavy-duty diesel-powered trucks and buses, and 0.5% motorcycles. For the future scenarios studied, the vehicle mix was estimated to change slightly with fewer light-duty gasoline-powered automobiles and more light-duty gasoline-powered trucks and vans.

Ambient temperatures of 59 and 68 degrees F were used for morning and afternoon peak-hour emission computations, respectively. These are conservative assumptions since morning/afternoon ambient temperatures will generally be warmer than this, and emission estimates given by MOBILE6.2 generally have an inverse relationship to the ambient temperature.

After computing vehicular carbon monoxide emissions through the use of MOBILE6.2, these data were then input to an atmospheric dispersion model. EPA air quality modeling guidelines [6] currently recommend that the computer model CAL3QHC [7] be used to assess carbon monoxide concentrations at roadway intersections, or in areas where its use has previously been established, CALINE4 [8] may be used. Until a few years ago, CALINE4 was used extensively in Hawaii to assess air quality impacts at roadway intersections. In December 1997, the California Department of Transportation recommended that the intersection mode of CALINE4 no longer be used because it was thought the model has become outdated. Studies have shown that CALINE4 may tend to over-predict maximum concentrations in some situations. Therefore, CAL3QHC was used for the subject analysis.

CAL3QHC was developed for the U.S. EPA to simulate vehicular movement, vehicle queuing and atmospheric dispersion of vehicular emissions near roadway intersections. It is designed to predict 1-hour average pollutant concentrations near roadway intersections based on input traffic and emission data, roadway/receptor geometry and meteorological conditions.

Although CAL3QHC is intended primarily for use in assessing atmospheric dispersion near signalized roadway intersections, it can also be used to evaluate unsignalized intersections. This is accomplished by manually estimating queue lengths and then applying the same techniques used by the model for signalized intersections. Currently, one of the study intersections is unsignalized, Kapolei Parkway at Kinoiki Street. For the future scenarios (with or without the project), in accordance with the traffic report, this intersection was assumed to become signalized. For the future with-project scenario, the intersections of Kualakai Parkway at Roosevelt Avenue and Roosevelt Avenue at the South Entrance were assumed to be unsignalized.

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 MOBILE6.2 based on assumed free-flow vehicle speeds corresponding to the posted speed limits (25 to 35 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 1000 meters were used in all cases. Worst-case wind conditions were defined as a wind speed of 1 meter per second with a wind direction resulting in the highest predicted concentration. Concentration estimates were calculated at wind directions of every 5 degrees.

Existing background concentrations of carbon monoxide in the project vicinity are believed to be at low levels. Thus, background contributions of carbon monoxide from sources or roadways not directly considered in the analysis were accounted for by adding a background concentration of 1.0 ppm to all predicted concentrations for 2010. Although increased traffic is expected to occur within the project area during the next several years with or without the project, background carbon monoxide concentrations may not change significantly since individual emissions from motor vehicles are forecast to decrease with time. Hence, a background value of 1.0 ppm was assumed to persist for the future scenarios studied.

Predicted Worst-Case 1-Hour Concentrations

Table 5 summarizes the final results of the modeling study in the form of the estimated worst-case 1-hour morning and afternoon ambient carbon monoxide concentrations. These results can be compared directly to the state and the national AAQS. Estimated worst-case carbon monoxide concentrations are presented in the table for four scenarios: year 2010 with existing traffic, year 2015 without the project, year 2015 with the project and year 2015 with the project and with the North-South Road extension. The locations of these estimated worst-case 1-hour concentrations all occurred at or very near the indicated intersections.

As indicated in the table, the highest estimated 1-hour concentration within the project vicinity for the present (2010) case was 4.9 ppm. This was projected to occur during the morning peak traffic hour near the intersection of Kapolei Parkway and Kamaaha Avenue. Concentrations at other locations and times studied were 3.9 ppm or lower. All predicted worst-case 1-hour concentrations for the 2010 scenario were within both the national AAQS of 35 ppm and the state standard of 9 ppm.

In the year 2015 without the proposed project, the highest worst-case 1-hour concentration was again predicted to occur during the morning at the intersection of Kapolei Parkway and Kamaaha Avenue. A value of 4.5 ppm 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 2.2 and 4.0 ppm. Compared to the existing case, concentrations generally increased somewhat, but all projected worst-case concentrations for this scenario remained well within the state and national standards.

In the year 2015 with the proposed project, the predicted highest worst-case 1-hour concentration occurred during the morning at the intersection of Kapolei Parkway and Kualakai Parkway with a value of 4.7 ppm. Other concentrations for this scenario ranged between 2.6 and 4.6 ppm. Although the predicted concentrations increased at most of the locations studied compared to the without project scenario, the values remained well within the state and federal standards.

In the year 2015 with the proposed project and with the extension of the North-South Road (Kualakai Parkway) to Roosevelt Avenue, worst-case 1-hour concentrations changed only slightly with a slightly higher concentration of 5.0 ppm occurring during the morning at the intersection of Kapolei Parkway and Kualakai Parkway. All predicted worst-case 1-hour concentrations remained well within the standards.

Predicted Worst-Case 8-Hour Concentrations

Worst-case 8-hour carbon monoxide concentrations were estimated by multiplying the worst-case 1-hour values by a persistence factor of 0.5. This accounts for two factors: (1) traffic volumes averaged over eight hours are lower than peak 1-hour values, and (2) meteorological conditions are more variable (and hence more favorable for dispersion) over an 8-hour period than they are for a single hour. Based on monitoring data, 1-hour to 8-hour persistence factors for most locations generally vary from 0.4 to 0.8 with 0.6 being the most typical. One study based on modeling [9] concluded that 1-hour to 8-hour persistence factors could typically be expected to range from 0.4 to 0.5. EPA guidelines [10] recommend using a value of 0.7 unless a locally derived persistence factor is available. Recent monitoring data for locations on Oahu reported by the Department of Health [11] suggest that this factor may range between about 0.2 and 0.6 depending on location and traffic variability. Considering the location of the project and the traffic pattern for the area, a 1-hour to 8-hour persistence factor of 0.5 will likely yield reasonable estimates of worst-case 8-hour concentrations.

The resulting estimated worst-case 8-hour concentrations are indicated in Table 6. For the 2010 scenario, the estimated worst-case 8-hour carbon monoxide concentrations for the four locations studied ranged from 1.4 ppm at the Kapolei Parkway/Kinoiki Street intersection to 2.4 ppm at the Kapolei Parkway/Kamaaha Avenue intersection. The estimated worst-case concentrations for the existing case were within both the state standard of 4.4 ppm and the national limit of 9 ppm.

For the year 2015 without project scenario, worst-case concentrations ranged between 1.6 and 2.2 ppm, with the highest concentration occurring at Kapolei Parkway and Kamaaha Avenue. All predicted concentrations were within the standards.

For the 2015 with project scenario, worst-case concentrations were predicted to increase somewhat at compared to the without project case. Predicted worst-case concentrations ranged from 2.0 to 2.4 ppm with the highest concentration occurring at the intersection of Kapolei Parkway and Kualakai Parkway. All predicted 8-hour concentrations for this scenario were within both the national and the state AAQS.

In the year 2015 with the project and with the North-South Road extension to Roosevelt Avenue, predicted worst-case 8-hour concentrations remained the same or changed only slightly. All predicted concentrations for this scenario were well within the national and the state AAQS.

Conservativeness of Estimates

The results of this study reflect several assumptions that were made concerning both traffic movement and worst-case meteorological conditions. One such assumption concerning worst-case meteorological conditions is that a wind speed of 1 meter per second with a steady direction for 1 hour will occur. A steady wind of 1 meter per second blowing from a single direction for an hour is extremely unlikely and may occur only once a year or less. With wind speeds of 2 meters per second, for example, computed carbon monoxide concentrations would be only about half the values given above. The 8-hour estimates are also conservative in that it is unlikely that anyone would occupy the assumed receptor sites (within 3 m of the roadways) for a period of 8 hours.

7.2 Electrical Demand

The proposed project also will cause indirect air pollution emissions from power generating facilities as a consequence of electrical power usage. The annual electrical demand of the project is estimated to reach approximately 41 million kilowatt-hours [12]. 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, or from renewable energy resources that are currently being developed. In order to meet the electrical power needs of the proposed project, power generating facilities may be required to burn more fuel and hence more air pollution may 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.

7.3 Solid Waste Disposal

Solid waste generated by the proposed development when fully completed and occupied is not expected to exceed about 13 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 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 due to emissions from project-related motor vehicle traffic, but worst-case concentrations should remain within both the state and the national ambient air quality standards. Implementing any air quality mitigation measures for long-term traffic-related impacts is probably unnecessary and unwarranted.

Any long-term impacts on air quality due to indirect emissions from supplying the project with electricity and from the disposal of waste materials generated by the project will likely be negligible based on the magnitudes of the estimated emissions compared to the current island-wide emissions. To further moderate any impacts, any related air pollution could likely be

reduced somewhat by the promotion of energy conservation and recycling programs within the proposed development.

REFERENCES

1. "Climatic Summary of the United States, Supplement for 1951 through 1960, Hawaii and Pacific", U.S. Department of Commerce, Weather Bureau, Washington, D.C., 1965.

2. Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources, Fifth Edition, AP-42, U.S. Environmental Protection Agency, Research Triangle Park, NC, January 1995.

3. State of Hawaii. Hawaii Administrative Rules, Chapter 11-60, Air Pollution Control.

4. PB Americas, Inc., Traffic Impact Assessment Report for Ka Makana Alii, Draft, May 2011.

5. User's Guide to MOBILE6.0, Mobile Source Emission Factor Model, U.S. Environmental Protection Agency, Office of Transportation and Air Quality, Assessment and Standards Division, Ann Arbor, Michigan, January 2002.

6. Guideline on Air Quality Models (Revised), Including Supplements A and B, EPA-450/2-78-027R, U.S. Environmental Protection Agency, Research Triangle Park, NC, July 1986.

7. User's Guide to CAL3QHC Version 2.0: A Modeling Methodology for Predicting Pollutant Concentrations Near Roadway Intersections, U.S. Environmental Protection Agency, November 1992.

8. CALINE4 - A Dispersion Model for Predicting Air Pollutant Concentrations Near Roadways, FHWA/CA/TL-84/15, California State Department of Transportation, November 1984 with June 1989 Revisions.

9. "Persistence Factors for Mobile Source (Roadway) Carbon Monoxide Modeling", C. David Cooper, Journal of the Air & Waste Management Association, Volume 39, Number 5, May 1989.

10. Guideline for Modeling Carbon Monoxide from Roadway Intersections, U.S. Environmental Protection Agency, EPA-454/R-92-005, November 1992.

11. Annual Summaries, Hawaii Air Quality Data, 2005-2009, State of Hawaii Department of Health.

12. Personal communication via email, Lee Sichter, to Barry Neal, B.D. Neal & Associates, May 3, 2011, “Ka Makana Alii Preliminary Energy Consumption Budget”.

13. Personal communication via email, Lee Sichter, to Barry Neal, B.D. Neal & Associates, May 3, 2011, “Ka Makana Alii Solid Waste Generation”.

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	-	-	50
		24 Hours	150[a]	150[a]	150[b]
Particulate Matter (<2.5 microns)	µg/m³	Annual	15[c]	15[c]	-
		24 Hours	35[d]	35[d]	-
Sulfur Dioxide	ppm	Annual	-	-	0.03
		24 Hours	-	-	0.14[b]
		3 Hours	-	0.5[b]	0.5[b]
		1 Hour	0.075[e]	-	-
Nitrogen Dioxide	ppm	Annual	0.053	0.053	0.04
		1 Hour	0.100[f]	-	-
Carbon Monoxide	ppm	8 Hours	9[b]	-	4.4[b]
		1 Hour	35[b]	-	9[b]
Ozone	ppm	8 Hours	0.075[g]	0.075[g]	0.08[g]
Lead	µg/m³	3 Months	0.15[h]	0.15[h]	-
		Quarter	1.5[i]	1.5[i]	1.5[i]
Hydrogen Sulfide	ppm	1 Hour	-	-	35[b]

[a] Not to be exceeded more than once per year on average over three years.
[b] Not to be exceeded more than once per year.
[c] Three-year average of the weighted annual arithmetic mean.
[d] 98th percentile value of the 24-hour concentrations averaged over three years.
[e] Three-year average of annual fourth-highest daily 1-hour maximum.
[f] 98th percentile value of the daily 1-hour maximum averaged over three years.
[g] Three-year average of annual fourth-highest daily 8-hour maximum.
[h] Rolling 3-month average.
[i] Quarterly average.

Table 2

ANNUAL WIND FREQUENCY FOR HONOLULU INTERNATIONAL AIRPORT (%)

Wind Direction	Wind Speed (knots)									Total
	0-3	4-6	7-10	11-16	17-21	22-27	28-33	34-40	>40	
N	0.5	2.5	1.3	0.5	0.0	0.0	0.0	0.0	0.0	4.8
NNE	0.3	1.2	1.6	1.5	0.2	0.0	0.0	0.0	0.0	4.7
NE	0.3	2.1	6.1	11.0	3.2	0.3	0.0	0.0	0.0	23.0
ENE	0.2	2.5	10.9	16.6	4.1	0.3	0.0	0.0	0.0	34.7
E	0.1	1.0	2.5	2.8	0.5	0.0	0.0	0.0	0.0	7.0
ESE	0.0	0.3	0.4	0.3	0.0	0.0	0.0	0.0	0.0	1.1
SE	0.0	0.3	0.8	1.0	0.1	0.0	0.0	0.0	0.0	2.2
SSE	0.1	0.4	1.2	0.7	0.1	0.0	0.0	0.0	0.0	2.4
S	0.1	0.5	1.4	0.6	0.1	0.0	0.0	0.0	0.0	2.7
SSW	0.0	0.3	0.8	0.3	0.0	0.0	0.0	0.0	0.0	1.5
SW	0.0	0.2	0.8	0.4	0.0	0.0	0.0	0.0	0.0	1.5
WSW	0.0	0.3	0.5	0.4	0.0	0.0	0.0	0.0	0.0	1.2
W	0.1	0.5	0.2	0.0	0.0	0.0	0.0	0.0	0.0	1.1
WNW	0.2	1.4	0.3	0.1	0.0	0.0	0.0	0.0	0.0	2.0
NW	0.4	2.3	0.8	0.1	0.0	0.0	0.0	0.0	0.0	3.8
NNW	0.5	2.3	0.8	0.2	0.0	0.0	0.0	0.0	0.0	3.8
Calm	2.5									2.5
Total	5.4	18.3	30.6	36.5	8.5	0.7	0.0	0.0	0.0	100.0

Source: Climatography of the United States No. 90 (1965-1974), Airport Climatological Summary, Honolulu International Airport, Honolulu, Hawaii, U.S. Department of Commerce, National Climatic Center, Asheville, NC, August 1978.

Table 3

AIR POLLUTION EMISSIONS INVENTORY FOR ISLAND OF OAHU, 1993

Air Pollutant	Point Sources (tons/year)	Area Sources (tons/year)	Total (tons/year)
Particulate	25,891	49,374	75,265
Sulfur Oxides	39,230	nil	39,230
Nitrogen Oxides	92,436	31,141	123,577
Carbon Monoxide	28,757	121,802	150,559
Hydrocarbons	4,160	421	4,581

Source: Final Report, “Review, Revise and Update of the Hawaii Emissions Inventory Systems for the State of Hawaii”, prepared for Hawaii Department of Health by J.L. Shoemaker & Associates, Inc., 1996

Table 4

ANNUAL SUMMARIES OF AIR QUALITY MEASUREMENTS FOR MONITORING STATIONS NEAREST KA MAKANA ALII PROJECT

Parameter / Location	2005	2006	2007	2008	2009
Sulfur Dioxide / Kapolei					
3-Hour Averaging Period:					
Highest Concentration (ppm)	0.025	0.005	0.010	0.009	0.010
2nd Highest Concentration (ppm)	0.011	0.004	0.008	0.009	0.007
No. of State AAQS Exceedances	0	0	0	0	0
24-Hour Averaging Period:					
Highest Concentration (ppm)	0.008	0.003	0.003	0.005	0.003
2nd Highest Concentration (ppm)	0.003	0.003	0.003	0.003	0.003
No. of State AAQS Exceedances	0	0	0	0	0
Annual Average Concentration (ppm)	0.001	0.002	0.002	0.001	0.001
Particulate (PM-10) / Kapolei					
24-Hour Averaging Period:					
Highest Concentration ($\mu g/m^3$)	53(a)	59	75(a)	61	37
2nd Highest Concentration ($\mu g/m^3$)	36	58	57	44	36
No. of State AAQS Exceedances	0	0	0	0	0
Annual Average Concentration ($\mu g/m^3$)	15	16	17	18	16
Particulate (PM-2.5) / Kapolei					
24-Hour Averaging Period:					
Highest Concentration ($\mu g/m^3$)	55(a)	34(a)	20	35	25
98th percentile Concentration ($\mu g/m^3$)	11	7	8	21	13
No. of State AAQS Exceedances	0	0	0	0	0
Annual Average Concentration ($\mu g/m^3$)	4	4	4	5	6
Carbon Monoxide / Kapolei					
1-Hour Averaging Period:					
Highest Concentration (ppm)	1.5	1.4	3.8	2.2	3.7
2nd Highest Concentration (ppm)	1.4	1.4	0.9	1.7	2.6
No. of State AAQS Exceedances	0	0	0	0	0
8-Hour Averaging Period:					
Highest Concentration (ppm)	0.9	1.0	0.8	0.7	1.2
2nd Highest Concentration (ppm)	0.9	1.0	0.7	0.7	1.2
No. of State AAQS Exceedances	0	0	0	0	0
Nitrogen Dioxide / Kapolei					
Annual Average Concentration (ppm)	0.005	0.005	0.005	0.004	0.004
Ozone / Sand Island					
8-Hour Averaging Period:					
Highest Concentration (ppm)	0.047	0.042	0.035	0.048	0.049
4th Highest Concentration (ppm)	0.046	0.042	0.033	0.043	0.048
No. of State AAQS Exceedances	0	0	0	0	0

(a) Data flagged due to fireworks.

Source: State of Hawaii Department of Health, “Annual Summaries, Hawaii Air Quality Data, 2005 - 2009”

Table 5

ESTIMATED WORST-CASE 1-HOUR CARBON MONOXIDE CONCENTRATIONS ALONG ROADWAYS NEAR KA MAKANA ALII PROJECT (parts per million)

Roadway Intersection	Year/Scenario							
	2010/Present		2015/Without Project		2015/With Project[a]		2015/With Project[b]	
	AM	PM	AM	PM	AM	PM	AM	PM
Kapolei Parkway at Kamaaha Ave	4.9	2.5	4.5	3.1	4.6	3.3	4.6	3.2
Kapolei Parkway at Kinoiki Street	2.7	1.7	3.3	2.2	3.9	3.5	3.9	3.5
Kapolei Parkway at Kualakai Parkway	3.1	2.0	3.4	2.7	4.7	4.4	5.0	4.7
Kapolei Parkway at Renton Road	3.9	2.5	4.0	2.8	4.4	2.9	4.4	2.9
Kualakai Parkway at East Entrance	-	-	-	-	-	-	2.3	2.5
Kualakai Parkway at Roosevelt Ave	-	-	-	-	-	-	3.4	2.6
Roosevelt Ave at South Entrance	-	-	-	-	2.8	2.6	2.8	2.4

Hawaii State AAQS: 9
National AAQS: 35

[a]Without North-South Road extension
[b]With North-South Road extension

Table 6

ESTIMATED WORST-CASE 8-HOUR CARBON MONOXIDE CONCENTRATIONS ALONG ROADWAYS NEAR KA MAKANA ALII PROJECT (parts per million)

Roadway Intersection	Year/Scenario			
	2010/Present	2015/Without Project	2015/With Project[a]	2015/With Project[b]
Kapolei Parkway at Kamaaha Ave	2.4	2.2	2.3	2.3
Kapolei Parkway at Kinoiki Street	1.4	1.6	2.0	2.0
Kapolei Parkway at Kualakai Parkway	1.6	1.7	2.4	2.5
Kapolei Parkway at Renton Road	2.0	2.0	2.2	2.2
Kualakai Parkway at East Entrance	-	-	-	1.2
Kualakai Parkway at Roosevelt Ave	-	-	-	1.7
Roosevelt Ave at South Entrance	-	-	1.4	1.4

Hawaii State AAQS: 4.4
National AAQS: 9

[a]Without North-South Road extension
[b]With North-South Road extension

Table 7

ESTIMATED INDIRECT AIR POLLUTION EMISSIONS FROM KA MAKANA ALII PROJECT ELECTRICAL DEMAND[a]

Air Pollutant	Emission Rate (tons/year)
Particulate	1
Sulfur Dioxide	14
Carbon Monoxide	1
Volatile Organics	<1
Nitrogen Oxides	6

[a]Based on U.S. EPA emission factors for utility boilers [2]. Assumes electrical demand of 41 million kilowatt-hrs per year and low-sulfur oil used to generate power.

Table 8

ESTIMATED INDIRECT AIR POLLUTION EMISSIONS FROM KA MAKANA ALII PROJECT SOLID WASTE DISPOSAL DEMAND[a]

Air Pollutant	Emission Rate (tons/year)
Particulate	<1
Sulfur Dioxide	1
Carbon Monoxide	5
Nitrogen Oxides	12
Lead	<1

[a]Assumes solid waste disposal demand of 13 tons per day and that solid waste is burned in a refuse-derived fuel-fired power plant equipped with spray dryer and fabric filter. Emission rates based on U.S. EPA emission factors for refuse-derived fuel-fired combustors [2].

Appendix H

Archaeological Assessment

Pacific Legacy

Historic Preservation

CULTURAL RESOURCES CONSULTANTS

Hawai'i Offices:
Kailua, O'ahu
Hilo, Hawai'i

California Offices:
Arnold
Berkeley
El Dorado Hills
Quartz Hill

ARCHAEOLOGICAL ASSESSMENT OF THE PROPOSED KA MAKANA ALIʻI MIXED-USE COMPLEX KAPOLEI, HONOULIULI AHUPUAʻA ʻEWA DISTRICT, OʻAHU ISLAND [TMK (1) 9-1-016:142]

Pacific Legacy: Exploring the past, informing the present, enriching the future.

ARCHAEOLOGICAL ASSESSMENT
OF THE PROPOSED
KA MAKANA ALIʻI
MIXED-USE COMPLEX
KAPOLEI, HONOULIULI AHUPUAʻA
ʻEWA DISTRICT, OʻAHU ISLAND
[TMK (1) 9-1-016:142]

Prepared by:
Kimberly M. Mooney, B.A.
and
Paul L. Cleghorn, Ph.D.

Pacific Legacy, Inc.
30 Aulike Street, Suite 301
Kailua, HI 96734
(808) 263-4800

Prepared for:
Hawaiʻi DeBartolo, LLC
15436 Florida Avenue, Suite 200
Tampa, FL 33613

August 2011

ABSTRACT

As part of the Environmental Impact Statement process, Hawai‘i DeBartolo, LLC, has requested an Archaeological Assessment for the for the proposed Ka Makana Ali‘i mixed-use complex and *mauka* half of Keoneula Road, which is slated for a parcel in central ‘Ewa Plain, Honouliuli Ahupua‘a, ‘Ewa District, O‘ahu [TMK (1) 9-1-016:142]. This assessment is based upon archival research as well as archaeological testing.

The results of archival research indicate that this general area of ‘Ewa Plain has a long and rich cultural and legendary history. However, little is mentioned of the subject property in which the Ka Makana Ali‘i is to be built.

It was predicted that this area had the potential to contain sinkholes containing cultural or paleontological remains. However, no such remains were found either on the surface or in the 62 backhoe test trenches and 6 test scrapes that were performed across the project area. Test excavations revealed that nearly the entire project area is overlain with 0.45 meters to more than 3.7 meters of sediment relating to modern construction and/or plantation agriculture. Test trench depths ranged from ca. 20 inches (ca. 0.5 meters) to ca. 12 feet, 2 inches (ca. 3.7 meters), with 54 of the 62 trenches revealing the karst layer. The stratigraphy encountered was thoroughly recorded in soil profiles, photographs, and soil analyses to provide a better understanding of the project area’s substrate and its potential to contain archaeological deposits.

Given the lack of finding any archaeological resources or even finding evidence of the karst topography within the project area, we conclude that no further archaeological work is necessary within this area.

In the event that buried sinkholes are encountered during construction excavations, they should be archaeologically investigated to determine if they contain potentially significant archaeological deposits, including human burials.

If at any time during construction potentially significant archaeological remains are encountered, work in the immediate vicinity should halt and the State Historic Preservation Division should be contacted (808-692-8015).

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Frontispiece: Proposed Ka Makana Ali'i Location (courtesy of Hawai'i DeBartolo LLC).

1.0 INTRODUCTION

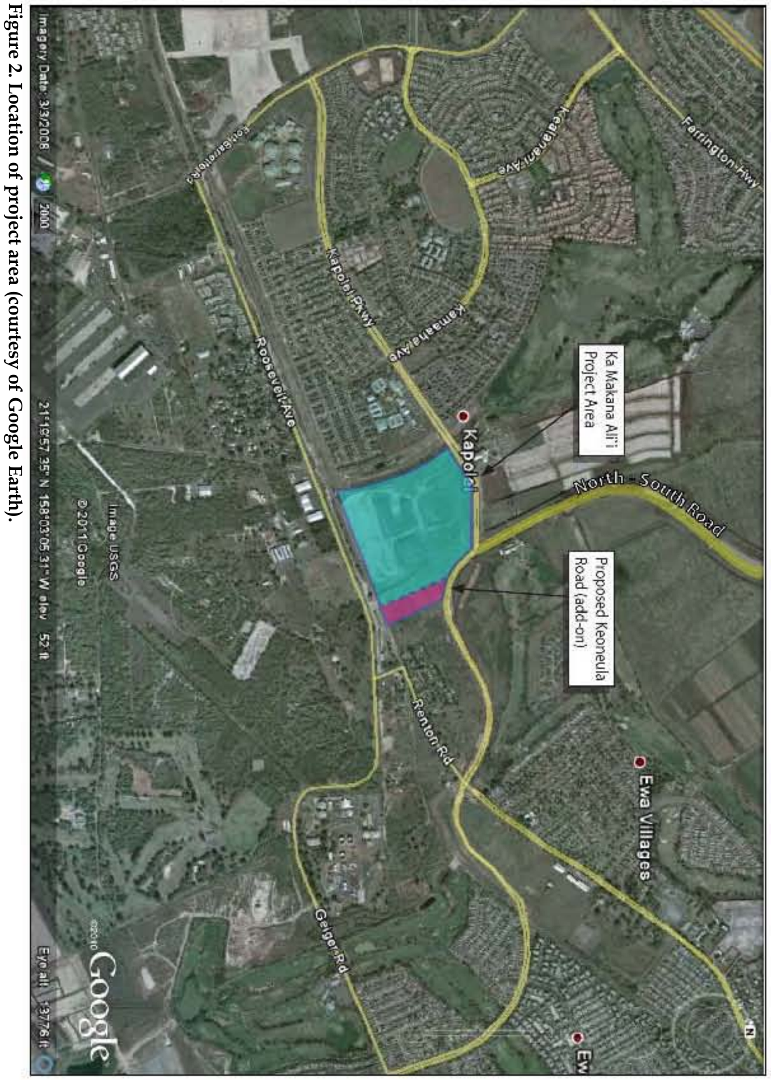
Pacific Legacy Inc., under contract to Hawai'i DeBartolo, LLC, conducted an archaeological assessment for the proposed Ka Makana Ali'i and *mauka* half of Keoneula Road in East Kapolei, Honouliuli Ahupua'a, 'Ewa District, O'ahu, Hawai'i [TMK (1) 9-1-016:142] (Figures 1 and 2). The purpose of this assessment is to determine if any archaeological or human remains will be impacted by the proposed development of the mixed-use complex. The Archaeological Assessment consisted of archival research, archaeological survey, and backhoe testing.

This archaeological assessment is one of the supporting studies for the Environmental Impact Statement (EIS) being conducted by Hawai'i DeBartolo, LLC. The purpose of this assessment is to determine if any significant or potentially significant historical or archaeological resources are present and if they would be impacted by proposed project. If potentially significant resources are present within the project area, impacts to these resources will need to be addressed and mitigation measures for potential adverse effects to these resources will be recommended.

The assessment of what resources are present in the project area was accomplished by conducting archival research, reviewing previous archaeological investigations, conducting a surface survey, and subsurface testing with a backhoe. The main source for previous archaeological investigations was the State Historic Preservation Division (SHPD) library at Kapolei, which houses a relatively complete collection of archaeological reports, as well as the Office of Environmental Quality Control (OEQC) website (http://video.doh.hawaii.gov), which carries most of the Environmental Impact Assessments and Statements for the state of Hawai'i. Surface survey and subsurface testing was conducted by Pacific Legacy archaeologist, Kimberley Mooney, B.A. The principal investigator of the overall project was Paul L. Cleghorn, Ph.D.

Figure 1. Location of project area (courtesy of National Geographic).

Figure 2. Location of project area (courtesy of Google Earth).



2.0 PROJECT AREA DESCRIPTIONS

2.1 ENVIRONMENTAL SETTING

A number of reports have been written on the geological formations and environmental conditions of the ‘Ewa Plain (Allen 1990; Cline 1955; Foote et al. 1972; MacDonald and Abbott 1970; Stearns 1946, 1978; Stearns and Vaksvik 1935; Zeigler 2002), which address broad characteristics of the ‘Ewa Plain.

2.1.1 Geology, Hydrology, and Sediments

Based on terrain and availability of water, the ‘Ewa Plain can be separated into three main geographical regions that are described by Tuggle and Tomonori-Tuggle (1997:9) as: “lowland limestone exposure, the upland alluvial terrain, and a locale of floodplain and alluvial fans.” Fresh water on the barren coral plain has often been reported as being insufficient to support a permanent or substantial Hawaiian settlement during pre-Contact years. However, Tuggle and Tomonari-Tuggle (1997:18-21) summarize various research projects on the availability of water in ‘Ewa Plain asserting that there may have been permanent Hawaiian settlements in a number of locales, if not generally across the entire area. Water sources were identified in several locations on the plain, including: sink holes that reach the water-table, wetlands, sheet runoff, spring and creek water from gulches, natural limestone water traps, Honouliuli Stream, and other water features in Honouliuli Ahupua‘a (Malden 1825). The proposed Ka Makana Ali‘i project area is located on the lowland limestone just southwest of Kalo‘i Gulch at roughly 50-60 ft above mean sea level (AMSL).

Generally, the ‘Ewa Plain is an expansive limestone shelf that begins 3-5 miles (5 to 8 km) south of the Waianae Mountain range to the southern coast of O‘ahu, stretching from the western coast of Ko‘Olina east to Pearl Harbor. This elevated coralline reef was formed during an interglacial period approximately from 120,000 to 38,000 years ago, when sea levels in Hawai‘i were some 6-8m above the present sea level, which has been termed the Waimānalo Sea Stand. During this period, coral reefs developed upwards with the gradually rising sea levels. During the next period of glaciation, sea levels dropped leaving exposed coral reefs that were then eroded by marine level fluctuation, wave/sediment abrasion, as well as weathering by rain, run-off, and wind after sea levels dropped to their present level. Further, rain water naturally absorbs carbon dioxide in the air to form a weak carbonic acid, which dissolves portions of the limestone with prolonged exposure, subsequently forming karst topography. Hallmark features of karst topography are caverns and sinkholes, which are formed as acids build up and dissolve soluble portions and natural voids in the limestone. Several miles east of the project area is an escarpment approximately 15 meters high, often referred to as “fossil cliffs” and/or “fossil bluffs,” where the alluvial clay layer has been eroded away, exposing Pleistocene limestone that is laden with fossils.

Sinkholes of the ‘Ewa Plain are typically bell-shaped in cross-section with openings commonly 3.28 feet (1 m) in diameter with base diameters increasing to 6.56 to 9.84 feet (2–3 m) (MacDonald and Abbott 1970; Stearns 1946, 1978; Stearns and Vaksvik 1935; Zeigler 2002:96-97).

These sinkholes became important resources for avian populations prior to human settlement in Hawai‘i. Later, sinkholes became significant resource locales, temporary shelters, agricultural features, as well as burial locations for early Hawaiian populations on the ‘Ewa Plain (Barrera 1975; Davis 1995; Lewis 1970; Miller 1993; Sinoto 1976, 1978a, 1978b, 1979). Sinkholes containing archaeological and/or paleontological remains encapsulated under alluvial soils or construction fills can be encountered anywhere within the ‘Ewa Plain.

The ‘Ewa Plain gently slopes *mauka* or towards the mountains, due to the deposition of alluvial clays and silts that are derived from weathered basalt from upslope. The alluvial substrate forms a wedge that lies atop the limestone bench, itself positioned above the basalt foundation (Geolabs-Hawai‘i 1987; Stearns and Vaksvik 1935). This limestone shelf contains artesian basal aquifers that are the source of potable water found in springs and wells in several locations across the plains; two of the most prominent locations, Honouliuli Gulch “Watering Place” and Waihuna in Kalo‘i Gulch, are within two miles of the project area (Malden 1825; Sterling and Summers 1978; Mooney and Cleghorn 2008c).

Soils in the project area are currently described as Honouliuli clay with 0-2% slopes (HxA) and Mamala stony silty clay loam with 0 to 12 percent slopes (MnC) according to the Department of Agriculture Natural Resources Conservation Service (USDA/NRCS 2011; Figure 3; Table 1). The soil types roughly bisect the project area (*mauka-makai*), where the *mauka* portion is Honouliuli clay and the *makai* portion is Mamala stony silty clay. This is greatly due to agricultural practices of the early 1800’s, where natural forests of the Waianae Range were extensively harvested, causing severe erosion of the mountain sides. Erosion was further advanced unintentionally by the over-grazing of livestock in the uplands and then intentionally by the intensive plowing of these soils to encourage fertile sediment deposition onto the lower plains for farming (Lewis 1970; Tuggle and Tomonari-Tuggle 1997; Wolforth and Wulzen 1998). Hence, the deposition of sediments onto the ‘Ewa Plain was unnaturally increased from the early 1800s to the present time.

Also worthy of note, are the three volcanic cones lying on the northern margin of the ‘Ewa Plain: Pu‘u Pālailai, Pu‘u Kapolei, and Pu‘u Makakilo. Pu‘u Pālailai, which lies ca. 2.5 miles (4 km) west of the project area, is one of only three known volcanic glass quarries on O‘ahu (Manhoff and Uyehara 1976:46; Wolforth and Wulzen 1998). As volcanic glass was a choice material for stone tool manufacture, Pu‘u Pālailai would have been an important locality in pre-contact times.

2.1.2 Climate

Honouliuli, the largest *ahupua‘a* of O‘ahu, is situated on the leeward side of O‘ahu. ‘Ewa Plain covers the lower half of the *ahupua‘a* . This is one of the driest regions of O‘ahu, having an average of 18 inches of annual rainfall (Juvik and Juvik 1998). The proposed Ka Makana Ali‘i Center is situated on the northern border of Kalaeloa (former NAS Barbers Point), whose temperatures range between 72°F (40°C) in January to 78.5°F (43°C) in August, with a variance of 13°F (7°C) throughout the day (Orr 2008:3-1). The hottest days of the year typically fall between August and September (Armstrong 1973).

2.1.3 Vegetation

Generally, the most common types of plants in the ʻEwa Plain are xeric and hardy exotics, with the exception of relatively undisturbed coastal marshlands. Previous to human settlement in the area, Cuddihy and Stone (1990) claim that the region would have been more like a savannah: a plain of grasses with sparse groves trees and shrubs. Pre-contact plant species would have included, but not limited to: *wiliwili* (*Erythrina sandwicensis*), *lama* (*Diospyros ferrea*), *pili* grass (*Heteropogon contortus*), *ʻaʻaliʻi* (*Dodonea ericarpa*), scrub *ʻōhiʻa* (*Metrosideros collina*), and possibly sandalwood or *ʻiliʻahi* (*Santalum* sp.). Ground cover may have included cayenne vervain (*Stachytarpheta urticaefolia*), *ʻilima ku kula* (Sida cordifola), morning glory (*Ipomoea indica*), *koʻokoʻolau* (*Bidens pilosa*) according to Moore and Kennedy (2002:3).

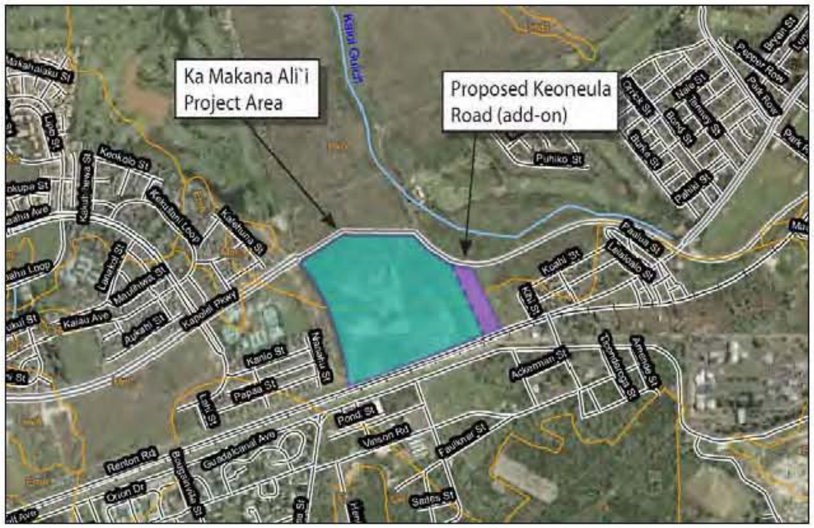


Figure 3. Ka Makana Aliʻi soil map (courtesy of NRCS/USDA Soil Survey 2011).

Table 1. Ka Makana Aliʻi Project Area– Custom Soil Report (USDA/NRCS Soil Survey 2011)

Map Unit Symbol	Map Unit Name	Acres in Project Area	Percent of Project Area
HxA	Honouliuli clay, 0 to 2 percent slopes	38	56.8%
MnC	Mamala stony silty clay loam, 0 to 12 percent slopes	29	43.2%
	Totals for Area of Interest	67	100.0%

2.2 Current State of Project Area

An archaeological survey and backhoe testing was performed by Kimberly M. Mooney, B.A., under the general guidance of Paul L. Cleghorn, Ph.D., from 11 July to 22 July 2011 on the 70-plus acres of land slated for the Ka Makana Aliʻi mixed-use complex and the proposed Keoneula Road. The pedestrian survey yielded no new archaeological sites visible on the ground surface. Rather, the project area appeared to have evidence of multiple ground disturbing activities from the time of sugarcane cultivation until recent years. Ground disturbing activities include extremely deep and vast excavations resulting in a ca. 1,345 foot by 390 foot borrow pit at the south end of the property. Further, a number of soil stockpiles cover much of the interior of the lot (Figure 4). The remaining areas have evidence of recent construction and rubbish dumping, major modifications for unofficial off-road vehicle riding (i.e. built up berms, jumps, and trails), as well as dense feral growth of grasses, weeds, shrubs, and trees. However, during a site visit 7 July 2001 with Kupuna Eaton and Makua Kalani to reintroduce them to the project area, both informants were able to spot *ʻilima*, *ʻuha loa*, and *mauna loa*, which are used in traditional medicine and crafts.

Figure 4. Current state of Ka Makana Aliʻi project area and proposed Keoneula Road corridor (courtesy of Google Earth).

3.0 TRADITIONAL AND MYTHOLOGICAL ACCOUNTS

A number of oral traditions have been recorded that help describe the physical, mystical, and cultural landscapes of Honouliuli Ahupuaʻa. Although Ka Makana Aliʻi is located in an area that has diminutive mythological significance, it is situated amidst several areas within Honouliuli Ahupuaʻa that are well known in Hawaiian legends and history.

3.1 THE NAMING OF ʻEWA AND HONOULIULI

Honouliuli is the westernmost *ahupuaʻa* of ʻEwa District, or *moku*, which stretches from Red Hill on the west edge of Kona District to Pili O Kahe just north of KoʻOlina and Waimanalo (Figure 5). Sterling and Summers (1978) state that the Gods Kane and Kaneloa gave ʻEwa District its name, which translates as, "the stone that strayed," since the stone used to determine district boundaries had landed a great distance away from where it was thrown (Sterling and Summers 1978: 1). Pukui et al. (1974:28) maintain that ʻEwa literally translates as 'crooked' and comes from the same story of Kane and Kaneloa determining ʻEwa's *moku* boundaries at the landing place of their divinely thrown stone.

The name, Honouliuli, applies to the entire *ahupuaʻa* as well as a village within the *ahupuaʻa*, which is located less than two miles northeast of Ka Makana Aliʻi. Noted as the largest *ahupuaʻa* on the island of Oʻahu, Honouliuli stretches from the West Loch of Pearl Harbor to what is now called KoʻOlina to the west and north all the way to Wahiawa. Honouliuli is literally translated as 'dark bay' by Pukui et al. (1974:50). Yet, Thrum (1923) and Westervelt (1963) offer a different origin for the name Honouliuli, which comes from the "Legend of Lepeamoa." According to this legend, Honouliuli is the name of Lepeamoa's grandfather and Chiefess Kapalama's husband who gave his name "to a land district west of Honolulu" (Thrum 1923: 170).

3.2 MYTHOLOGICAL TALES OF ʻEWA AND HONOULIULI

Honouliuli Ahupuaʻa is the setting for a number of legendary accounts concerning the activities of Gods, Goddesses, demi-gods, and head Oʻahu chiefs or *mōʻī* , as well as supernatural beings such as *moʻo,* mystical creatures, and wandering spirits. Compilations of Honouliuli's mythology have been created by Sterling and Summers (1978), Hammatt and Folk (1981), Kelly (1991), Charvet-Pond and Davis (1992), Maly (1992), Tuggle and Tomonori-Tuggle (1997), Mitchell and Hammatt (2004), and O'Hare et al. (2006).

Some tales paint the plains of ʻEwa as a mystical and somewhat foreboding place, where gods and goddesses frequent. For example, Sterling and Summers (1978) report a story from a January 13, 1900 *Ka Loea Kālaiʻāina* newspaper article, "The Old Women Who Turned to Stone" which reads:

> If a traveler should go by the government road to Waianae, after leaving the village of gold, Honouliuli, he will first come to the plain of Puu-ainako and

> when that is passed, Ke-one-ae. Then there is a straight climb up to Puu-o-Kapolei and there look seaward from the government road to a small hill. That is Puu-o-Kapolei…You go down some small inclines, then to a plain. This plain is Pukaua (sic.) and on the mauka side of the road, you will see a large rock standing on the plain. This stone has a legend that made this plain noted…There were two supernatural old women or rather peculiar women with strange powers and Puukaua (sic.) belonged to them. While they were down fishing at Kualakai in the evening, they caught these things[:] aama crabs, pipipi shell fish and whatever they could get with their hands. As they were returning home to the plain from the shore and thinking of getting home while it was yet dark, they failed for they met a one-eyed person. It became light as they came near to the plain, so that passing people were distinguishable. They were still below the road and became frightened lest they be seen by men. They began to run, running, leaping, falling[,] sprawling, rising up and running on, without a thought to the aama crabs and seaweeds that dropped on the way, so long as they would reach the upper side of the road. They did not go far for by then it was broad daylight. One woman said to the other, "Let us hide lest people see us," and so they hid. Their bodies turned to stone and that is one of the famous things on this plain to this day, the stone body. This is the end of these strange women…(*Ka Loea Kālaiʻāina,* 13 January 1900 as cited in Sterling and Summers 1978: 39).

Another version of this tale is offered in an article found in the *Ka Hōkū o Hawaiʻi*, February 15, 1927 (translated by Maly 1997: 19), where the women were *moʻo* and changed into lizard form as they crossed the goddess Hiʻiaka on her journey to the ʻEwa coast, for they feared she would kill them. The *moʻo* hid near the trail and Hiʻiaka greeted them and passed without harm (Maly 1997 as cited by O'Hare et al. 2006: 20). This story not only illustrates the enchantment of ʻEwa Plain in lore, but also the wealth (in one form or another) of nearby Honouliuli Village, deemed the "village of gold," which is upheld by early maps of the region where it is depicted as the largest permanent settlement of the ʻEwa District in pre-plantation times. Additionally, it accounts significant foot traffic from Honouliuli Village to Waianae in pre-Contact times.

The legend of Namakaokapaoo originates in Honouliuli Village area. This is a story of a young 2 ½ foot tall boy, named Namakaokapaoo, who killed his stepfather and threw his head five miles away before conquering Oʻahu's king and his warriors, and subsequently replaced the king with his mother as ruler (Beckwith 1970). Honouliuli Village is also the place that Ka ihu o Palaʻai, the sister of mythological figure, Maikoha, fell in love and settled (Sterling and Summers 1978:53).

Pearl Harbor, just east of Honouliuli Village, is the source of many legends. Sterling and Summers (1978) offer several stories about the shark goddess, Kaʻahupahau (translated as Cloak-well-cared-for), her origin having several interpretations. In one interpretation, Kaʻahupahau was thought to have been a miscarriage by her mother and left in the waters of Pearl Harbor, but still alive, she transformed into a shark. In another version, Kaʻahupahau and her brother were born as human, but were later transformed into sharks by a shark god. The two remained in Pearl Harbor, where they were fed *ʻawa* by their human relatives. In return, Kaʻahupahau protected her human kin from other sharks. Another major figure in Pearl Harbor mythology is Papio, the beautiful surfing chiefess, who had several conflicts with the

Figure 5. Ahupuaʻa of ʻEwa District (from Sterling and Summers 1978).

shark goddess, Kaʻahupahau, and is often said to have eventually been devoured by her (Sterling and Summers 1978: 54-56). Kapakule is the tennis racket shaped fishpond located at the entrance to Pearl Harbor, which is the setting of many tales. One of which is of the *menehune,* or little people, building the fishpond in one night at the command of the gods, Kāne and Kanaloa (Sterling and Summers 1978: 42-43).

Located approximately 1.8 miles (1.9 km) west of Ka Makana Aliʻi, Puʻu Kapolei, was subject of numerous local ancient myths and chronicles. Sterling and Summers (1978) mention Puʻu Kapolei as being one of the most famous hills in the olden days and a major point of reference for travelers going east or west through Honouliuli. Additionally, Puʻu Kapolei was the landmark (juxtaposed to the setting sun) used to mark the end of Makaliʻi, or the Kau season, and the beginning of the Hoʻoilo season, when young sprouts emerged from the ground (Kamakau as cited in Sterling and Summers 1978).

The very name Kapolei translates as "beloved Kapo," who was the sister of the Goddess Pele (Pukui et al. 1974:89). Colorful tales further link the *puʻu* to Hawaiʻi's pantheon of gods and goddesses, including dramatic conflicts between them. One such tale involves Kamapuaʻa, the Goddess Pele, and her sister Kapo, where the amorous pig-god Kamapuaʻa assaults Pele at Puʻu Kapolei and is subsequently lured away from her as he pursues Kapo's detached "flying vagina"(*kohe lele*) that she placed on Puʻu Kuua (Pukui et al. 1974:200; Beckwith 1970). Additionally, the deity Kamaunuaniho was supplanted at Puʻu Kapolei by her grandson, Kamapuaʻa, to exact tribute from the commoners of the area (Nukuina as cited by Sterling and Summers 1978). Sterling and Summers (1978) list several accounts of a dwelling or heiau in Puʻu Kapolei belonging to the grandmother of Kamapuaʻa. As nearby Puʻu Kapolei has been home to deities, the setting for legends, as well as the landmark for the seasons, the nearby lands have likely been significant to Hawaiians in pre-Contact times.

Further to the west and south are a number of additional myths. Kamakau described western ʻEwa as the "rough country (*wiliwili*) of Kaupeʻa" and "the home of wandering spirits with no holdings, who ate spiders and moths for sustenance" (Kamakau 1964:83). Kamakau adds that the wandering souls of Kaupeʻa are often helped by *ʻaumakua* to escape from this domain (Kamakau 1991: 49). The description of west ʻEwa as being the "realm of wandering spirits" is supported by Pukui's chant on the subject (Pukui 1983: #1666 as cited by O'Hare et al. 2006) and Fornander's lament for Kahahana (Fornander 1919, Vol. 6, Part 2: 297 as cited by O'Hare et al. 2006).

3.3 Chronicles and Conflicts in Honouliuli Ahupuaʻa

Some tales portray Honouliuli Ahupuaʻa as being a place of "firsts," such as the origin of humans on Oʻahu and breadfruit in Hawaiʻi. The *ahupuaʻa* of Honouliuli was also noted for being the origin, home, refuge, and vacationing place for some of Oahu's earlier *mōʻī*, or ruling chiefs (Kamakau 1961, 1991; Lewis 1970). Yet, *kauwā* (slaves) lived in the ʻEwa District's as well. In addition, the *ahupuaʻa* was the location of key battles and treaties in Oʻahu's pre-Contact annals.

Some tales suggest that the first Hawaiians had settled in Honouliuli. In the legend, Ka-Lua-ʻŌlohe, Pearl Harbor was said to be the place where human beings first came to Oʻahu. This area is said to have many caves, which belong to the *ʻōlohe*, who were "born in the day" (Beckwith 1970).

The first planting of breadfruit in Hawaiʻi is said to have occurred at Puʻuloa, located about 4 miles (6.4 km) southeast of Ka Makana Aliʻi. According to tradition, Kahai, son of Moikeha, transported the species from Upolu, an island in Samoa, on his return trip home from Tahiti (Thrum 1907; McAllister 1933). Fornander (1919, Vol IV, Part I: 392) and Kamakau (1964) confirms that Puʻuloa is the location of Hawaiʻi's first breadfruit.

The story of Maʻili-kukahi, one of the chiefs who was celebrated for leading Oʻahu out of chaos and into a period of prosperity, confirms Honouliuli Ahupuaʻa as being the homeland of some Oʻahu *mōʻī*. Kamakau refers to Māʻili-kūkahi as a 'kind' chief and not culpable for abandoning Hawaiian taboos although he is said to have "relinquished [his] position as ruling chief and gave it to the commoners; and took the firstborn children of the commoners to rear and care for" (Kamakau 1961: 223). Māʻili-kūkahi's sovereign realm was eventually challenged by chiefs from Maui and Hawaiʻi Island, one of which was named Hilo. The Oʻahu chief came out victorious after a bloody battle and placed the heads of his foes for all to see at a major trail junction just outside of Honouliuli Village, which was thereafter called Poʻo-hilo (head of Hilo), after the decapitated chief from the island of Hawaiʻi (Kamakau 1991: 56).

According to the 1883 Dictionary of Hawaiian Localities, ʻEwa was a "…favorite residence of Oahu kings of olden times…" (Sterling and Summers 1978:1). Kamakau mentions that ʻEwa, from Puʻu Kuua to Maunauna at the northern extreme of the *ahupuaʻa*, was quite populous where Oʻahu *mōʻī* reigned before they ruled from Waikiki (Kamakau 1991: 54). Fornander tells the story of Keaunui, "the head of the powerful and celebrated Ewa chiefs" who is credited with cutting a navigable channel into the estuary of Pearl River near the Puʻuloa saltworks (Fornander 1880: 48 as cited in Sterling and Summers 1978:46).

Coastal Honouliuli was sought as a refuge and vacation area on Oʻahu, as is clear in several texts. For instance, the beach area now called KoʻOlina, was noted as the favored vacationing place of Chief Kakuhihewa, a *mōʻī* of ancient times (Fornander as quoted by Lewis 1970). In addition, when Kahekili conquered Oʻahu, Kahahana, his wife, and 'friend' fled together to various locations in ʻEwa. One location was Poʻo-hilo in Honouliuli where they went into hiding before giving themselves up to the commoners, as they were "weary with life in the forest"(Sterling and Summers 1978: 6).

However, some traditional accounts paint a rather disparaging picture of central Honouliuli *ahupuaʻa* inhabitants. According to an 1899 newspaper, "the very dirty ones" lived in the large hollow above Puʻu Kuua, which is approximately 4.6 miles (7.4 km) northwest of Ka Makana Aliʻi ("*Na Wahi Pana o Ewa*" 1899 as cited by Sterling and Summers 1978: 32). Another tradition explains the origin of stigmas placed on the peoples of Puʻu Kuua:

> The Chiefs of old, who lived at that time, were of divine descent. The two gods looked down on the hollow and saw how thickly populated it was. The mode of

> living here was so that the chiefs and commoners mixed freely and they were so like the lowest of people (*Kauwā*). That was what these gods said and that was the time when the term *kauwā* [an outcast or slave] was first used, and was used for many years afterwards.
>
> After the first generations of chiefs had passed away and their descendants succeeded them, a chiefess became the ruler. It was customary for the chiefs of Oahu to visit this place to see the local chiefs. They did this always. When the time came in which a new chiefess ruled, an armless chiefess, she ran away to hide when other chiefs came to visit as usual because she was ashamed of the lack of an arm. Because she was always running away because of being ashamed the chiefs that visited called her the low-born (*kauwā*). Thus the term remained in the thoughts down to this enlightened period. She was not truly a kauwa but was called that because she behaved like one. This was how they were made to be kauwas. When the ruling chief wished to go to Waikiki for sea bathing he asked the chief just below him in rank, "how are my planting places at Puu-Kuua, have they not produced young suckers?" The chief next to him answered, "There are some suckers," and sent someone for them. When the men, women and children least expected it, the messenger came to get some of the children. The father stood up and took his sons to Waikiki. Then when the ruling chief went sea bathing, he sent an attendant to get the boys and take them to a shallow place where the ruling chief would come. Then the ruler placed a hand on each of the boys, holding them by the necks. The words he uttered were, "My height has not been reached (by the sea)! My height has not been reached!" (*Aole i pau kuu loa, aole pau kuu loa*). He advanced and held on to the boys until the sea was up to his chest. The boys floated on the water face down. The father on shore called out, "Lie still in the sea of your Lord," and so on.
>
> The sea of Waikiki is said to have been used to kill men in and the other place is Kualoa. The inhabitants of Puu-Kuua were so mixed, like taro beside an imu. There were two important things concerning this place. (1) This place is entirely deserted and left uninhabited and it seems that this happened before the coming of righteousness to Hawaii Nei. Not an inhabitant is left. (2) The descendants of the people of this place were so mixed that they were all of one class. Here the gods became tired of working and returned to Kahiki. ("Na Wahi Pana o Ewa" 1899 as cited by Sterling and Summers 1978:32-33).

The peoples of Puʻu Kuua became viewed as pariahs for not abiding by social codes, and as a result, they were persecuted to near extinction. This story also suggests that the pre-Contact population of central upland Honouliuli Ahupuaʻa may have thrived previous to this campaign of extermination.

Warfare was another constant theme in the ʻEwa District. Fornander (1919, Vol IV, part II: 364) wrote about the "battle" of Keahumoa Plain, which was supposed to be the final battle of celebrated chief, Kualiʻi. In this account, two warrior brothers sought higher positions in life, so they arranged for 12,000 of Kualiʻi's men to meet with 1,200 Koʻolau warriors to battle at Keahumoa, ʻEwa. However, they did not plan to fight, but to unite both sides. The youngest brother, Kamakaaulani, presented a *mele*, or chant, to Kualiʻi while the older brother, Kapaahulani, led the opposing side to the battleground. When the two sides met, the *mele* was successful and the battle was prevented. After the treaty, the island of Oʻahu was united. When chiefs of other islands found out about the unity, they joined forces to unite under Kualiʻi. Sterling and Summers (1978: 38) list several versions of this battle. Another battle referred to as "Battle of Kipapa" was part of the story of Maʻili-kukahi, where Big Island's chief, Hilo, attempted to take over Oʻahu unsuccessfully in a particularly bloody battle. His head was placed at a crossroads just above Honouliuli Village, which was since called Poʻohilo (Kamakau 1991: 56). A later conflict was the Battle of ʻEwa, which took place in several places within ʻEwa in the mid-1790's. In this battle, Ka-ʻeo and Kalani-ka-pule fought, and with the aid of European weaponry, Kalani-ku-pule overcame Ka-'eo (Kamakau 1961; as cited in Sterling and Summers 1978: 12).

3.4 Traditional Accounts of Natural Resources in ʻEwa Plains

Although historic accounts of water in west ʻEwa are rare, fresh water is documented at the spring Hoaka lei at Kualakaʻi on the ʻEwa coastline, in the oral history chant, He Moʻolelo Kaʻao No Hiʻiaka I Ka Poli O Pele, translated by Pukui et al. (1974:119) and by Kepā Maly (1999:31).

According to ancient myths, the ʻEwa Plain was home to a variety of wild plants and birds. The legend, He Moʻolelo Kaʻao No Hiʻiaka I Ka Poli O Pele, is the goddess Hiʻiaka's account of her journey across ʻEwa. In this legend, first published in Hawaiian in the newspaper *Ka Hoku o Hawaiʻi* (September 18, 1924 -July 17, 1928), important geographical locales as well as many trees, plants, and flowers were mentioned. Flora mentioned in the tale included: *nene* grasses, *kupukupu* ferns, *noni* trees, *maʻo*, varieties of *lehua*, *koaiʻa*, *ʻilima*, *ʻohai*, *kukui*, *kaunoʻa*, *ʻuala*, *pilipili-ʻula*, *wiliwili*, and *noho*. Emerson (1978:167) translated parts of this legend, and more recently Kepā Maly (1999:31) translated parts relating to ʻEwa. Maly (1999) paraphrases a portion of his translations of the Hiʻiaka legend chant:

> Descending to the flat lands of Honouliuli, Hiʻiaka then turned and looked at Puʻuokapolei and Nawahineokamaʻomaʻo who dwelt there in the shelter of the growth of the ʻohai (*Sesbania tomentosa*), upon the hill…When Hiʻiaka finished her chant, PuʻuoKapolei said…So it is that you pass by without visiting the two of us. Lo, we have no food with which to host you. Indeed, the eyes roll dizzily with hunger. So you do not visit us two elderly women who have cultivated the barren and desolate plain. We have planted the ʻ*uwala* (sweet potato) shoots, that have sprouted and grown, and have been dedicated to you, our lord. Thus as you travel by, pull the potatoes and make a fire in the *imu*, so there will be relief from the hunger. For we have no food, we have no fish and no blanket to keep us warm. We have but one Kapa (covering)…in the time when the grasses dry, and none is left on the plain, we two are left to live without clothing. (Maly 1999:35)

Traditional *mele,* or chants, refer to and other localities on lands stretching from Puʻu o Kapolei to Kalaeloa as well. The nature of these lands in ancient times is suggested through these *mele*. Kamakau, in the mid- to late-1800's wrote articles in newspapers titled, *Kuʻokoʻa* and *Ke Au ʻOkaʻa,* which shed light on ancient Hawaiian life, customs, and oral traditions. These articles

were translated into English and compiled in several manuscripts in the 1960's then reprinted several times. For instance, Samuel Mānaiakalani Kamakau published numerous *mele* in

Nupepa Kuokoa during the late 19th Century. One of which describes the people, terrain, vegetation, and climates of various locations within the ʻEwa Plain:

Me he kanaka la ka ohai o Kaupea,
People are like the *ohai* blossoms of Kaupeʻa

Ka wiliwili haoe kaune i ka la,
The *wiliwili* appear to stagger in the sun

Kulolia i ke kaha i Kanehili,
Stricken on the plain of Kānehili

I ke kaha kahakai o Kaolina – e,
At the shore of Ka-ʻolina (Koʻolina),

He wahi olina na ka la i Puuloa…
There is a place of joy from the sun at Puʻuloa

(Kamakau, in *Nupepa Kuakoa*, August 10, 1867:3; Translated by Maly, in Belt Collins 2006:2-15)

Kamakau also published several proverbs about the area in the Hawaiian newspaper, two of which are translated as:

A o kona oliliko ana e ulili haamalule ana i Puuokapolei,
And Puʻuokapolei which shimmers in the daylight;

A ua kolilii koliliko kona wailiula i ke kaha o Kanehili ka hele o ka wiliwili me ka lau o ka maomao
It is on the arid flat lands, of Kānehili,
with the mirage forming waters,
that the *wiliwili* and *maomao* grow,
with their leaves scattered in the wind

(Kamakau, in *Nupepa Kuakoa*, August 10, 1867:3; Translated by Maly, in Belt Collins 2006:2-14)

Another *mele* published in Nupepa Ka Oiaio in 1895 by Moses Manu, helps to reveal the lands of Kaupeʻa as the ancient Hawaiians viewed it. The *mele* is as follows:

O-u o lea ka manu o Kaupea,
The ʻŌʻū is the joyful bird of Kaupeʻa,

Ka O-o manu leo lea o Puuloa,
The joyful voiced `Ō`ō is of Puʻuloa,

E hoonaele ana i ka pua o ka Wiliwili,
Softening the blossoms of the Wiliwili,

Inu iaola i ke koena wai lau noni
Drinking the drops of nectar from the noni,

Inu ka manu ano kunewa…
The birds drink and pass time…

(M. Manu in *Nupepa Ka Oiaio*, May 10, 1895:1; Translated by Maly, in Belt Collins 2006:2-15)

Marine resources were also plentiful along the coasts of the ‘Ewa Plain. Kamakau (1991) in *Ka Po‘e Kahiko*: The People of Old, speaks of one ‘Ewa guardian ancestor deity, Kanekua‘ana, also interpreted as a *mo‘o,* or guardian water lizard, who was revered for providing her faithful descendants and *kama‘āina* with an abundance of *i‘a* or marine resources from Halawa to Honouliuli. Further, Mary Kawena Pukui (1943), states that Kanekua‘ana was responsible for bringing the *pipi,* or pearl oyster, from Tahiti in ancient times (Pukui 1943 as cited in Sterling and Summers 1978:49-51). During times of scarcity, her devotees erected *waihau* and *heiau* to Kanekua‘ana where pigs, bananas, and coconuts were sacrificed, rather than people. Kamakau (1991) reports on the outcome of one such sacrifice:

> What blessings did they obtain? *I‘a*. What kinds of *i‘a*? The *pipi* (pearl oyster) – strong along from Namakaohalawa to the cliffs of Honouliuli, from the *kuapā* [walled] fishponds of inland ‘Ewa clear out to Kapakule. That was the oyster that came in from the deep water to the mussel beds near shore, from the channel entrance of Pu‘uloa to the rocks along the edges of the fishponds. They grew right on the *nahawele* mussels, and thus was this *i‘a* obtained…the *pipi* were found in abundance – enough for all ‘Ewa – and fat with flesh. Within the oyster was a jewel (*daimana*) called a pearl (*momi*)…They were great bargaining value (*he waiwai kumuku‘ai nui*) in the ancient days, but were just “rubbish” (*‘opala*) in ‘Ewa (Kamakau 1991: 83)

Though the project area is located beyond the margins of the areas touted as abundant in natural resources, it appears central and nearly equidistant to these important areas. Thus, pre-Contact cultural activities may have taken place in this area, such as travelling to and from Honouliuli Village to other locales in the *ahupua‘a,* with the possibility of trails, trail markers, temporary encampments, or other activity areas. Conversely, this area was comparatively void of resources, yet abundant in sinkholes, making it ideal for human interments.

4.0 HISTORIC ACCOUNTS

Since the time of European Contact, ‘Ewa District has had an intriguing history and has been the stage for several significant milestones of the island’s history.

4.1 ‘EWA DISTRICT AND HONOULIULI AHUPUA‘A AT CONTACT

The written account of ‘Ewa begins with the arrival of Captain George Vancouver in 1793. Apparently, the lands of ‘Ewa garnered little comment in early written history, save for those of derogatory nature. According to Vancouver (1798), the conditions of the area between Waianae and Ko‘olau Mountains were not pleasant, stating:

> This tract of land was of some extent but did not seem to be populous, nor to possess any great degree of natural fertility; although we were told that a little distance from the sea, the soil is rich, and all necessaries of life are abundantly produced (Vancouver 1798 as cited by Sterling and Summers 1978: 31).

Vancouver’s crewmen commented further on the condition of the few canoes that came out to greet them from west ‘Ewa, calling them “small and indifferent” and “furnished with little for barter” (Vancouver 1798 as cited by Lewis 1970: 6). Later, Vancouver wrote of the relatively dismal condition of west Honouliuli coast, stating:

> From these shores we were visited by some of the natives, in the most wretched canoes I had ever yet seen amongst the South-sea islanders; they corresponded however with the appearance of the country, which from the commencement of the high land to the westward of Opooroah (Puuloa), was composed of one barren rocky waste, nearly destitute of verdure, cultivation or inhabitants, with little variation all the way to the west point of the island (Vancouver 1798 as cited by Lewis 1970: 6).

The political center of ‘Ewa during the Contact period is still disputed. McAllister (1933: 106) describes a place named Lepau, which sits on the Waipi‘o Peninsula, less than 4 miles (6.35 km) east of Ka Makana Ali‘i, as a “dwelling place of the alii.” Silva (1987) suggests that a place called Halaulani on the same peninsula was home to chiefs. Conversely, some argue that the political center was much further north at Lihue between Pu‘u Kuua and Maunauna (Cordy 1996).

The Battle of ‘Ewa is stated by Kamakau (1961) to have occurred in 1794, shortly after European Contact. This battle is said to have several phases, taking place in ‘Ewa District and utilizing European weaponry. It is said that Kalanikupule, high chief of O‘ahu, overcame Kaeokulani, who ruled Kauai and Maui at the time.

4.2 Honouliuli Ahupuaʻa in the Early to Mid-1800s

The ʻEwa Plain was described as a near uninhabitable place in early accounts, however, Honouliuli Village was viewed more as an oasis with a sizable population, aquatic abundance, and burgeoning agricultural system. As seen in the Land Commission Award's Native Testimonies and early maps of Honouliuli, land adjacent to West Loch was intensively farmed with a variety of traditional agricultural methods from early Contact times into the late 1800's (Dicks et al. 1987, Appendix A; Malden 1825; Monsarrat 1878; Figures 6 and 7). The coastal areas were also famous for their marine resources and inland fishponds, as evident in oral and written history. Connecting Honouliuli Village and the trail leading from Honolulu to Waianae was a trail, often referred to as Kualakaʻi Trail, which appears in the Malden 1825 map of the south coast of Oʻahu to pass through or adjacent to the Ka Makana Aliʻi project area (Figure 6). The ancient trail leads from Honouliuli Village to Keoneula (Hau Bush) with a leg leading to Kualakaʻi (Figures 6, 10, and 12).

Edwin Hall, Hawaiian Minister of Finance, described west ʻEwa as a "barren, desolate plain" in the early 1800s after traversing much of the island of Oʻahu (Hall 1839 as quoted in Lewis 1970: 8). Yet, according to maps of the early to late 1800s (Malden 1825; Monsarrat 1878; Figures 6 and 7), Honouliuli was labeled as the "Watering Place" and depicted as a relatively large agricultural community.

Honouliuli Village, which is located approximately 2.4 miles (3.9 km) northeast of Ka Makana Aliʻi, had an abundance of natural resources, such as rich soil, marine life, and fresh water since pre-Contact times as depicted by early maps (Malden 1825; Monsarrat 1878; Figures 6 and 7) and written accounts (A. Campbell 1819; Chamberlain Ms.; Kamakau 1991). These vital elements permitted the development of an extensive system of irrigated taro patches or *loʻi* as well as landlocked and shoreline fishponds previous to the drilling of the first artesian well commissioned by James Campbell in 1879. Captain George Vancouver described the ʻEwa plain as deficient in people and fertility, but said he was informed that inland "…a little distance from the sea, the soil is rich, and all necessaries of life are abundantly produced…" (Vancouver 1798, Vol 3: 361-363). Archibald Campbell later writes of his experience travelling through ʻEwa in his 1809 essay, "Voyage Round the World," by stating:

> We passed by foot-paths winding through an extensive and fertile plain, the whole of which is in the highest state of cultivation. Every stream was carefully embanked to supply water for the taro beds. Where there was no water, the land was under crops of yams and sweet potatoes. The roads and the sides of the mountains were covered with wood to a great height. We halted two or three times, and were treated by the natives with the utmost hospitality (A. Campbell 1819: 145).

Maps from early to mid-1800s depict Honouliuli as having extensive agricultural fields and fishponds (Malden 1825, Monsarrat 1878; Figures 6 and 7). Additionally, Native Testimony given at the time of the Mahele ʻĀina in 1848, list scores of taro patches (*loʻi kalo*), vegetable plots (*māla*), fishponds (*loko iʻa*), pig pens (*pā puaʻa*), pastures (*kula*), hala groves (*ulu hala*), and house sites within Honouliuli Valley (Dicks et al. 1987: Appendix A and B), attesting to

intensive agricultural activities and habitation density in the area. Furthermore, several well-known varieties of taro are associated with the area, one being the *kaikoi* taro that comes from the "land of the silent fish," which is another name for Pearl Harbor (Sterling and Summers 1978: 8).

However, after the arrival of Europeans, areas of natural abundance were severely impacted by exotic species and agricultural practices. S.E. Bishop wrote in 1836 that *mauka* areas were of denuded of vegetation due to intensive cattle ranching to the extent that "vast quantities of earth" were washed down into the lagoons, filling them with sediment, causing a near extinction of oysters and clams (Bishop 1901: 87 as cited in Sterling and Summers 1978). The reduction of marine resources and choking of wetland agriculture with upland sediments may have hastened the exodus of surviving Honouliuli villagers to seek employment and western comforts of the ʻEwa Plantation and villages.

Additionally, Honouliuli Ahupuaʻa was host to one of the earliest Roman Catholic Churches in Hawaiʻi (Figure 8), which helped indoctrinate Honouliuli inhabitants into a western lifestyle and values. By the mid-1800s, Honouliuli Village's population experienced a serious decline in Native Hawaiians, primarily due to disease. Following the development of ʻEwa Plantation in the late 1800's, parishioners of Honouliuli's Catholic Church moved their homes and subsequently their house of worship closer to the mill, which became ʻEwa Villages - the center of Honouliuli Ahupuaʻa's economy and its densest population center until the modern era.

Honouliuli Ahupuaʻa experienced a severe population decline in the early 1800s, despite the fecundity of the land. Levi Chamberlain, who circled Oʻahu in 1828 to inspect missions and schools, held a small assembly for scholars in Waimanalo, west ʻEwa. The assembly took place in the house of a "head man" and was attended by people who lived in the area (Lewis 1970:7). Thus, during the early 1800's ʻEwa still had a modest population of Native Hawaiians who were receptive to Christianity and European-style schools.

In 1832, missionaries carried out a census in Honouliuli, recording 1,026 people with 25% of ʻEwa living in Honouliuli. L. Smith wrote of Honouliuli Village's population in 1830s, stating that within the village was a "populous neighborhood" (Smith 1835: 4). Kamakau (1961) stated that east ʻEwa experienced a spike in Native Hawaiian population growth in the mid 1800s, followed by a severe drop, to near extinction, as a result of European diseases. Further, Kamakau stated "Honouliuli had over ten school houses with their teachers" and after the acute population decrease, "whole villages have vanished, leaving not a man" (Kamakau 1961: 424-425). L. Smith, who was the first missionary to build a house and church in ʻEwa, said in the 1830's that, "the people of Ewa are a dying people" and for each birth were at least eight to ten deaths (Smith 1835: 8 as quoted by Lewis 1970: 8). Artemis Bishop, Smith's successor, listed small-pox, cholera, and measles as responsible for decimating Native Hawaiians of ʻEwa.

Additionally, Bishop stated that after several years of population decline, about half of Honouliuli's remaining population died within a few months in 1854 despite his attempt to vaccinate them (Bishop 1835: 1). Unfortunately, the people of Honouliuli, like other Hawaiians, had little chance of survival from these foreign diseases.

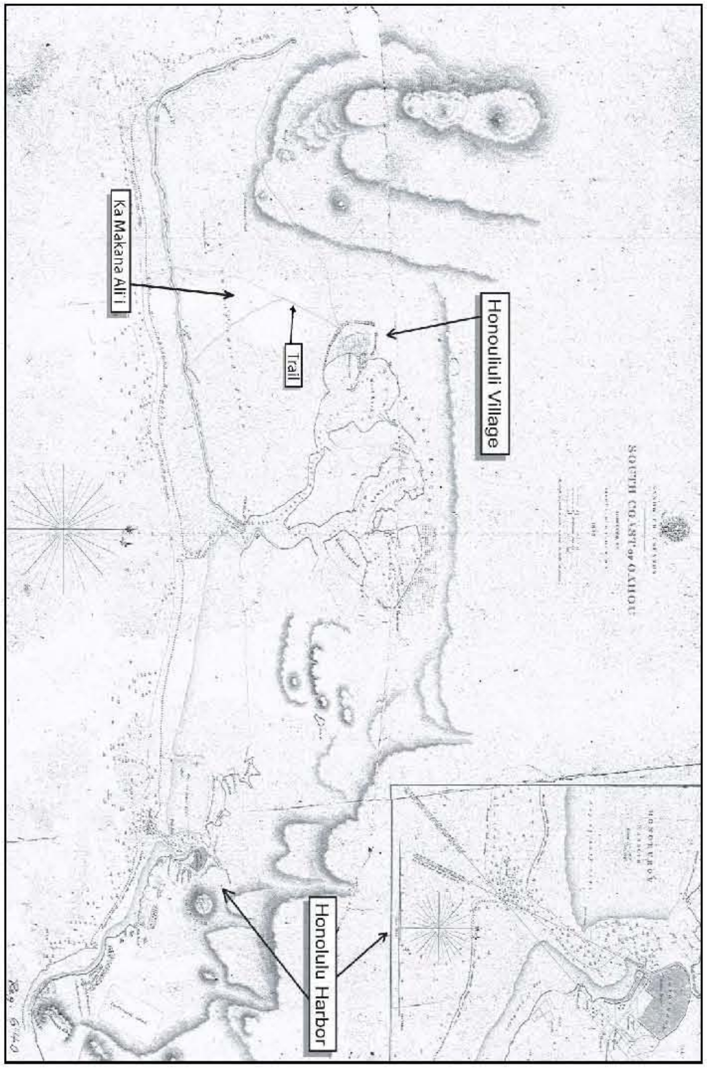


Figure 6. Malden (1825) map, south coast of O'ahu with Honouliuli and Honolulu depicted as well as the approximate location of Ka Makana Ali'i project area.

L. Smith, also noted in 1835 that the people of ‘Ewa were generally of ill health and over-taxed by O‘ahu’s chiefs (Smith 1835 as cited by Lewis 1970). Smith expanded, by saying that the people of Honouliuli were “almost constantly employed for the chiefs – making salt – getting timber-wood and money for their annual tax” (Smith 1835:1).

Christianity was met with mixed reception by Native Hawaiians of Honouliuli in the early 1800’s. However, some of the earliest detailed accounts of ‘Ewa are from mission station reports. These reports doubled as a commentary on Honouliuli’s demographics and as a progress report of conversions. Smith mentioned the presence of a school and provided a count of students tested in ‘Ewa District in his “Oahu Station Reports - ‘Ewa to Waianae, from 1835-1863,” stating:

> There have been but two other Schools at Ewa during the year [be]sides those taught at the station.
>
> Two young men residing at Honouliuli have taught one School of children & one of adults. These Schools have made considerable improvement. Samuel has been reading book[s] of the adults. They had also an exercise in the Almanac; & it appeared at our examination or “hoike” recently held, that they could answer almost any question that could be asked from that book.
>
> We have had but one hoike during the year, & that took place on the 20th of May, & was composed of persons who had attended School & no others. Others would have gladly joined us as Scholars on that occasion, but I told them they had no part nor lot in the matter except as Spectators.
>
> The following is a list of the Scholars as they were examined.

No. of children from Honouliuli		31
*Do of adults		19
	Total	50
No. of adult females at the Station		51
*Do of males		73
*Do of children		54
Choir of Singers		122
	Total taught at the Station	300
		50
	Total taught at Ewa	350

(Smith 1835:6)

*Do is a form of short-hand used by L. Smith that appears to imply number of types of individuals in Honouliuli.

Yet, while walking in ‘Ewa’s hinterland during the same year, Smith happened upon a mound of stones with a “heathen god” atop, described as a “small stone dressed in tapa” (Smith 1835:2 as quoted by Lewis 1970:8). Thus, it is likely that some Native Hawaiians still revered old gods in the early 1800s.

The conversion to Christianity proved to have some positive outcomes according to missionaries as seen in a later report from Artemis Bishop from the mid 1800s:

> Four protracted meetings have been held during the year, within the bounds of my field of labor, to wit, at Halawa, Waiawa, Honouliuli, and Waianae. They were all, with the exception of the one at Halawa, well attended, and solemn, and were followed by decidedly beneficial effects. The frequent repetition of these meetings however in the same place, does not appear to me to be attended with very striking effects, unless it be in a time of special seriousness among the people. Such meetings however continue to be popular, and prove beneficial or not in proportion to the spirit with which they are conducted. (Bishop 1841:1)

Another station report for ʻEwa was submitted in 1846 by Bishop, revealing the mixed reception of Christianity in Honouliuli during the mid-1800's. Bishop writes:

> The state of religious apathy continued as heretofore for several years past, down to the middle of last year, without anything remarkable to disturb the false security that pervaded the community. About the first of July last, I was visited by several inquirers from Honouliuli a settlement on the western part of the district, who appeared to be anxious about their salvation. This was the first indication of anything special among my people. Soon afterwards I was invited to spend a day at the place and meet the people in religious meetings. I went accordingly and we had a full house and attentive listeners. Several who attended from neighboring villages, requested that I would likewise spend a day in religious meetings with them. As I was desirous that the people should generally come out, I required that the invitation should come from them, and special effort be previously made to obtain their presence. As I had been so long discouraged with the slender attention paid to social religious meetings which I had appointed in the neighboring villages, I feared that without a special effort on the part of the *kamaainas*, the appointment might prove a failure. But as I was happily seconded by my elders and other *lunas*, my appointments were well attended, and the preaching was listened to with seriousness and solemnity. My first efforts were mainly directed to the slumbering [church] members. These however gradually began to awake to prayer and effort to arouse others. Daily prayer meetings were after a time established in every village in the district, and where suitable houses for meetings were not to be found, new ones were in the time of a few months erected, and two days meetings were appointed at their dedication. These houses that exist in all the principal villages are distinct from the school houses, and are consecrated exclusively to religious meetings. About the close of the year a general seriousness pervaded the minds of the people throughout the district, the church was filled on the sabbath, and religious were thronged. Many backsliding professers were awakened, and many apostates had publicly confessed their sins, and sought to be restored to the bosom of the church. The no. of inquiries from the ranks of the world now amounted to upwards of 200. But as there appeared so little excitement, and everything went on so still, I had not dared to call it a revival. Nor have I yet ventured to give it that name; or scarcely to write much about it to my brethren, lest it should prove in the end a false illusion to the greater part of the young converts. I have all along preached to them the terms of the law, as well as the invitations and hopes of the Gospel – to lead them to a sense of sinfulness as well as to faith in the

> blood of Jesus, but I fear that a great multitude of them, do not feel as deeply as they mouth their utter unworthiness, notwithstanding their full and ample confessions with the lips. But it is not easy for this people to feel without animal excitement, which I have from the first falling away for now nearly a year, my hopes are more confirmed that their repentance and faith are sincere. Still I would hope with trembling, knowing as I do the fickle character of this people (Bishop 1846:1).

Bishop's struggle with the Native Hawaiian conversion to Christianity was endured in vain, however, as the majority of Honouliuli peoples would be wiped out by disease.

4.3 Honouliuli from the Mid- to Late 1800s

Despite the severe population decline, Christianity and European ways persisted in Honouliuli Ahupuaʻa, as they did all over Hawaiʻi. Agriculture, however, would not only persist in the area - it would dominate in the form of sugarcane.

According to Tuggle and Tomonori-Tuggle (1997), tax records from 1855 to 1888 reveal that the principal communities of the *ahupuaʻa* were in or flanking Honouliuli Gulch, as well as Lihue, Puʻuloa, Kualakaʻi, and Waimānalo. Only a total of 44 individuals were taxed between these years, although this number likely represents head-of-households. Taxable assets included, but were not limited to, "fishnets, boats, and houses" (Tuggle and Tomonori-Tuggle 1997: 38). Hence, at this time, small pockets of Native Hawaiian communities persevered in Honouliuli.

Although Catholic missionaries under Father Alexis Bachelot arrived in Honolulu in 1827, Catholic missionaries did not find Hawaiʻi receptive until the Edict of Toleration was issued by King Kamehameha III in 1839, which allowed Catholics to set up their own church to convert Hawaiians (Schoofs 1978). Schoofs (1978) commented on the little known Roman Catholic Church of Honouliuli, which is also depicted on M.D Monsarrat (1878; Figure 8) and W.D. Alexander (1873) Honouliuli maps. According to Schoofs (1978), the Roman Catholic Church of Honouliuli was overseen by Father Raymond Delalande and the location where baptismal records of leeward Oʻahu were kept. O'Hare et al. (2006) refers to this church as "Kapalani Catholic Church," which is taken from the description of LCA No. 1720 by the claimant, Hilinae in the late 1840's (Dicks et al. 1987, Appendix A: 9; O'Hare et al. 2006: 38). Although no other sources were found referring to the church as "Kapalani," this is the earliest record of a church in this area. In addition to Hilinae's native testimony, another is given by Kaohai (LCA No. 5670B), stating that his house site adjoins "the Catholic Chapel yard" (Dicks et al. 1987, Appendix A: 10) further upholding the existence of Honouliuli's Roman Catholic Church.

O'Hare et al. (2006), in a very thorough report about a nearby property, mentions the relationship of the church to Kepelino (Zepherino) Keauokalani, which translates as 'to-be-the-chief-of-the-nine-districts', who was a descendant of Kamehameha I and the historian Namiki (on his mother's side). O'Hare et al. (2006) found that Kepolino was a Catholic School teacher in various areas and had acquired a bad reputation as a prankster. As a result of his reputation as a bad administrator and accusations of "dancing and thieving" during his tenure as a

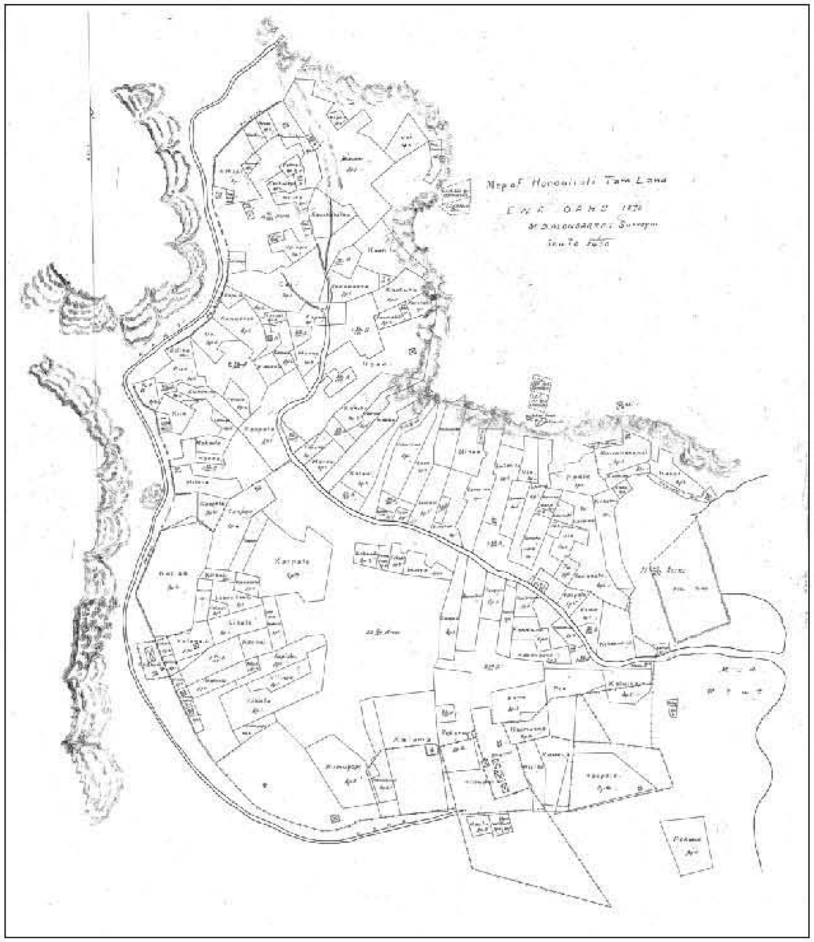


Figure 7. 1878 Monsarrat map of Honouliuli Taro Lands.

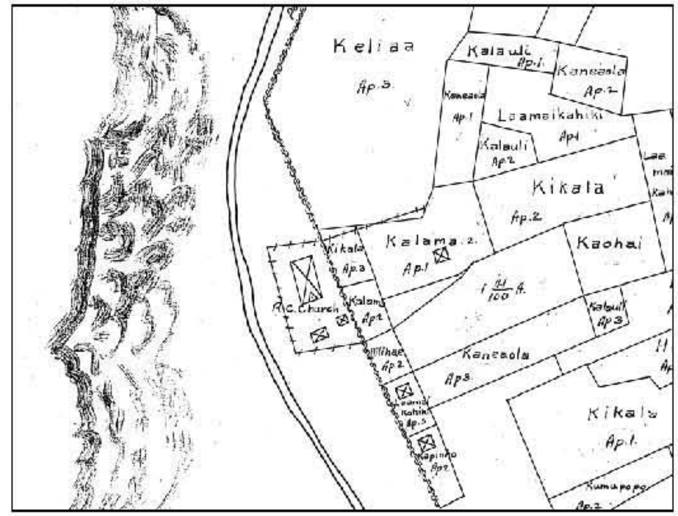


Figure 8. Portion of Monsarrat (1878) map showing old Roman Catholic Church.

Honouliuli school teacher in 1851, Kepolino was given a letter by the Minister of Public Education and Catholic Priests of Honouliuli denying further teaching positions, which were published in Catholic newspapers (O'Hare et al. 2006: 39). Kepolino's colorful story further verifies the establishment of a Catholic Church as well as Catholic school house in the village of Honouliuli located less than 2.25 miles (3.62 km) east of the project area in the mid-1800s.

‘Ewa Plain's growth, stemming from the development of sugar cane plantations, and the decline of Honouliuli's Native Hawaiian population due to disease were key factors in the abandonment of Honouliuli's Roman Catholic Church. According to Schoofs (1978), "there was no point in having a chapel in both places…" and further states:

> The Honouliuli Church, located close to Pearl Harbor, had by the 1880's outlived its usefulness and become dilapidated. It was therefore abandoned and replaced by a simple structure erected close, too close, to the mill [‘Ewa Plantation]. The location was unfortunate, but the little church had to accommodate the Catholic people of Ewa for 30 years.
>
> In the late 1920's, when the patchwork on the church had become impossible, plans were made for a new church in a better location. Fortunately the Catholic mission still owned the former church property in Honouliuli, and Bishop Alencastre was able to exchange it for a piece of land owned by the Campbell Estate and situated right in Ewa town, on the Renton Road, close to the Ewa public school (Schoofs 1978: 111-112).

Hence, the Roman Catholic Church of Honouliuli was not maintained and subsequently abandoned due to the exodus of Honouliuli Villagers, who survived European disease, into plantation centers such as ʻEwa Villages. Yet, Schoofs (1978) states that during the late 1800s, a Catholic cemetery existed in Honouliuli. Schoofs reported, "While most of the communities along the west coast of Oʻahu disappeared in the course of time, Honouliuli remained on the map until in its turn it was replaced by the growing plantation villages of ʻEwa. But, in 1891 Honouliuli was still important enough to acquire its own Catholic cemetery" (Schoofs 1978: 110). The location of the cemetery is still unknown.

As the drama of Honouliuli's Roman Catholic Church unfolded, another major event was occurring - the Great Mahele. The Land Commission granted approximately 43,250 acres of unclaimed lands in Honouliuli to chiefess Miriam Keʻahikuni Kekauʻōnohi in 1848. However, nearly 150 acres of Honouliuli Ahupuaʻa were designated as *kuleana* awards for commoners. Tuggle and Tomonori-Tuggle (1997) maintain that 72 awards were made, all of which appear to have been in or adjacent to Honouliuli Gulch (Tuggle and Tomonori-Tuggle 1997). Kekauʻōnohi's death in 1851 transferred her lands to her husband, Levi Haalelea. Most of Honouliuli was then sold to J.H. Coney for cattle ranching after Haalelea's death, who in turn sold 42,000 acres for $95,000 to James Campbell in 1877, an Irish born entrepreneur (Lewis 1970; Kelly 1991).

While the ʻEwa Plain had a sizeable cattle population by the mid-1800s, James Campbell consolidated great portions of Honouliuli for ranching, running over thirty-two thousand head of cattle. Honouliuli Village area became the nucleus of Campbell's prosperous ranch (Figure 7). In the summer of 1879, Campbell commissioned James Ashley to drill Hawaiʻi's first artesian well using a hand-operated rig near Campbell's ranch house in Honouliuli (Kuykendall 1967). The true location of the original well is disputed, but undoubtedly lies close to the intersection of Old Fort Weaver Road and Fort Weaver Road, which lies ca. 2.3 miles (3.7 km) northeast of the project area. In 1889, Campbell leased his lands, from Pearl Harbor to Waimanalo, to Mr. B.F. Dillingham of the Oʻahu Railway and Land Company for the next 50 years, who extended the railway from Pearl Harbor to Waianae (Lewis 1970; Figure 11). Dillingham then started the 11,000 acre ʻEwa Plantation Company in 1890 roughly to the west of West Loch and the Oʻahu Plantation in 1894 to the north of West Loch, initially planting sugarcane at Honouliuli and ʻEwa by irrigating with underground water (S. Campbell 1994; Figure 7). During that period, cattle were still ranched in the margins of the cane fields.

The rise of sugar plantations such as the ʻEwa and Oʻahu Plantations came with the increased demand for sugar in the United States, which was a result of the California gold rush in 1848 and the Civil War of 1861 as well as the 1875 Reciprocity Treaty that allowed Hawaiʻi sugar export rights to the U.S. (Hawaiʻi's Plantation Village n.d.). The plantations were also, in part, the outcome of James Campbell and B. F. Dillingham's "Great Land Colonization Scheme" failure of 1886, where the entrepreneurs originally set out to sell Honouliuli land to homesteaders, but opted instead for large-scale cultivation after drilling the first artesian well (OʻHare et al. 2006). These visionaries successfully transformed vast portions of the coral plains into fertile agricultural land by grubbing and deeply plowing upland areas and directing run-off sediments onto the plains. This feat allowed for both lucrative plantations, and subsequent merger of the two, to operate for nearly a century (S. Campbell 1994).

Part of the plantations' success came from the importation of cheap foreign labor to compensate for the severe Native Hawaiian population deficit due to European disease. At first, the Chinese were brought in to work the fields and mills for the length of their contracts. However, U.S. sugar demand mandated a rise in production, so the plantations began to recruit from Portugal, Japan, Puerto Rico, Okinawa, Korea, and the Philippines. The plantations were initially all- inclusive, providing housing, food, medical and meager wages to all employees and their families. A 1927/1928 US Geological Survey Map shows segregated villages for different ethnic groups represented at ʻEwa Plantation, which was incorporated into a map of Historic features located in Honouliuli Ahupuaʻa by Tuggle and Tomonori-Tuggle (1997; Figure 10). A full size copy of this map as well as key is provided in Appendix F.

4.4 ʻEWA PLAINS IN THE EARLY 1900S

By the turn-of-the-century, large-scale agriculture, primarily sugarcane and sisal, dominated the ʻEwa Plain, leaving only small pockets of traditional agriculture and family farms, primarily in Honouliuli Village area. As a result, plantation villages spread throughout the eastern ʻEwa Plain, including nearby Varona Village. Plantation sugar mills became the hub of activity and plantation life, attracting commerce and more settlers. By 1902, was able to produce over ten tons of sugar for every acre, outweighing its Hawaiian competitors by 6 tons an acre and Cuban competitors by 7.5 tons an acre. Another development would forever change the face of west ʻEwa – the leasing of land by the United States for military purposes (Lewis 1970; Kelly 1991; Tuggle and Tomonori-Tuggle 1997; Figures 9, 10, 12-14).

Agriculture was still the main focus of land use in Honouliuli Ahupuaʻa after the turn-of-the-century. Handy (1940) writes of agricultural terraces or vestigial agricultural structures being visible on the 1917 U.S. Geological Survey Map of Oʻahu, stating, "Large terrace areas are shown…bordering West Loch of Pearl Harbor, the indication being that these are still under cultivation. I am told that taro is still grown here. This is evidently what is referred to as "Ewa taro lands" (Handy 1940 as cited by Sterling and Summers 1978: 31). Of course, sugar cane dominated most of the ʻEwa Plain, yet sisal proved to be a lucrative crop for Honouliuli in the early 1900s. Sisal had gone from being an experimental crop in mid-1890 to being farmed on over 2000 acres, producing up to 445 tons of fiber a year (Kelly 1991; Figure 9 and 10). In addition, there are several testimonies from local *kūpuna* and longtime residents of the area that an area once existed just 0.6 miles northeast of Ka Makana Aliʻi where plants for *lāʻau lapaʻau,* Traditional Hawaiian herbal healing, were maintained, harvested, and administered (Mooney and Cleghorn 2008e).

By this time, Honouliuli Village, once considered the 'village of gold,' was no longer a destination, but a stopping point for those travelling on Old Ft. Weaver Road from Farrington Highway to Puʻuloa and plantation villages, and southeast ʻEwa Plain, now considered ʻEwa Beach. A handful of general and feed stores, a barber shop, a gas station, and mechanic shop had been erected sometime in the early 1900s to take advantage of this traffic. These were the western-most stores of the ʻEwa Plain. However, traffic along the old thoroughfare would sharply decline in later years with the coming of a new Ft. Weaver Road. As a result, Honouliuli Village would fall deeper into obscurity.

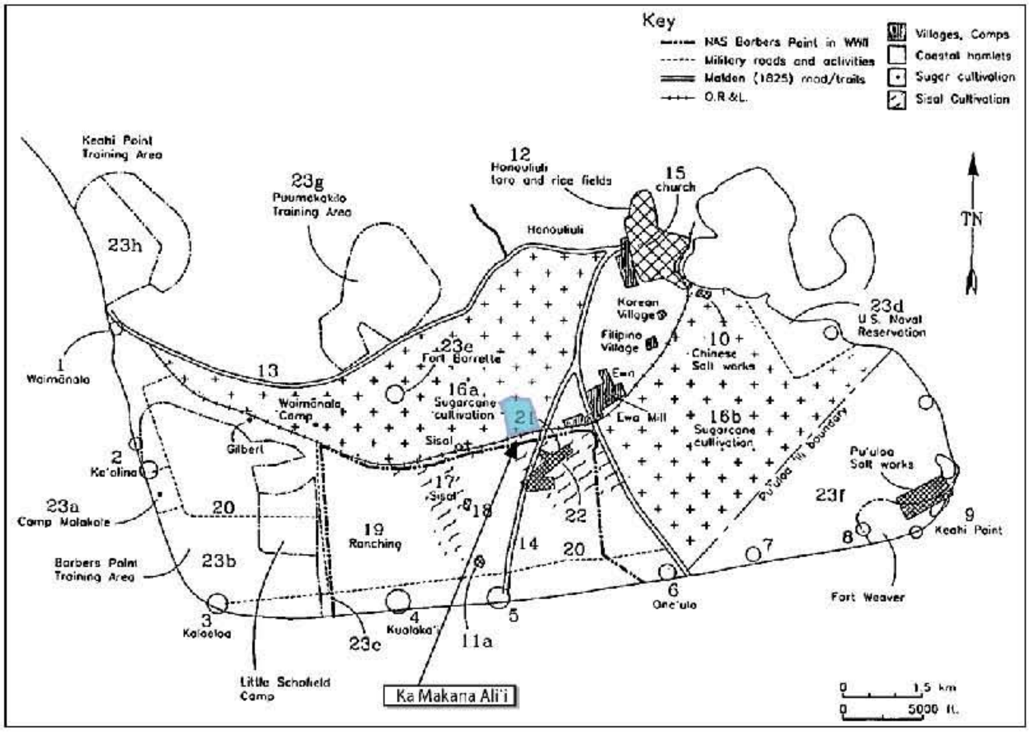


Figure 10. Historic features of Honouliuli (from Tuggle and Tomonori-Tuggle 1997, Figure 5; key provided in Appendix D of this report).

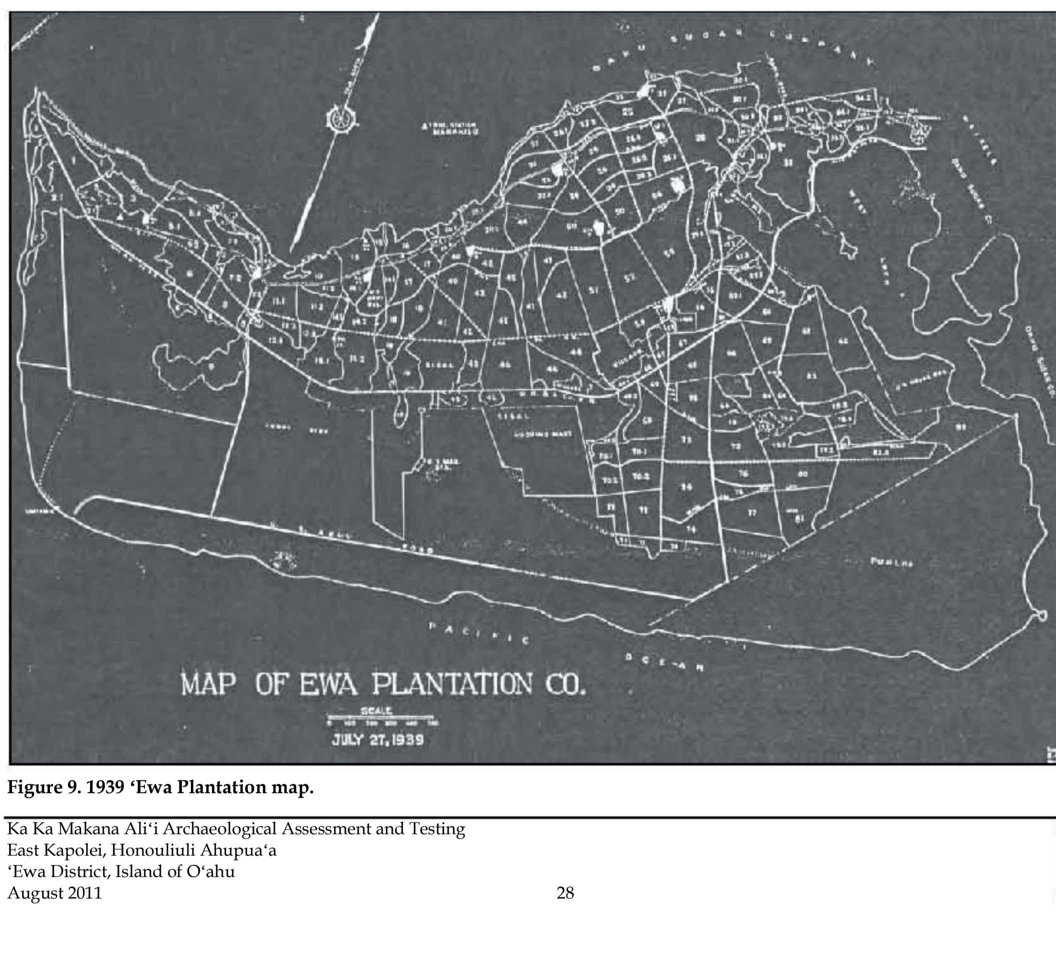


Figure 9. 1939 'Ewa Plantation map.

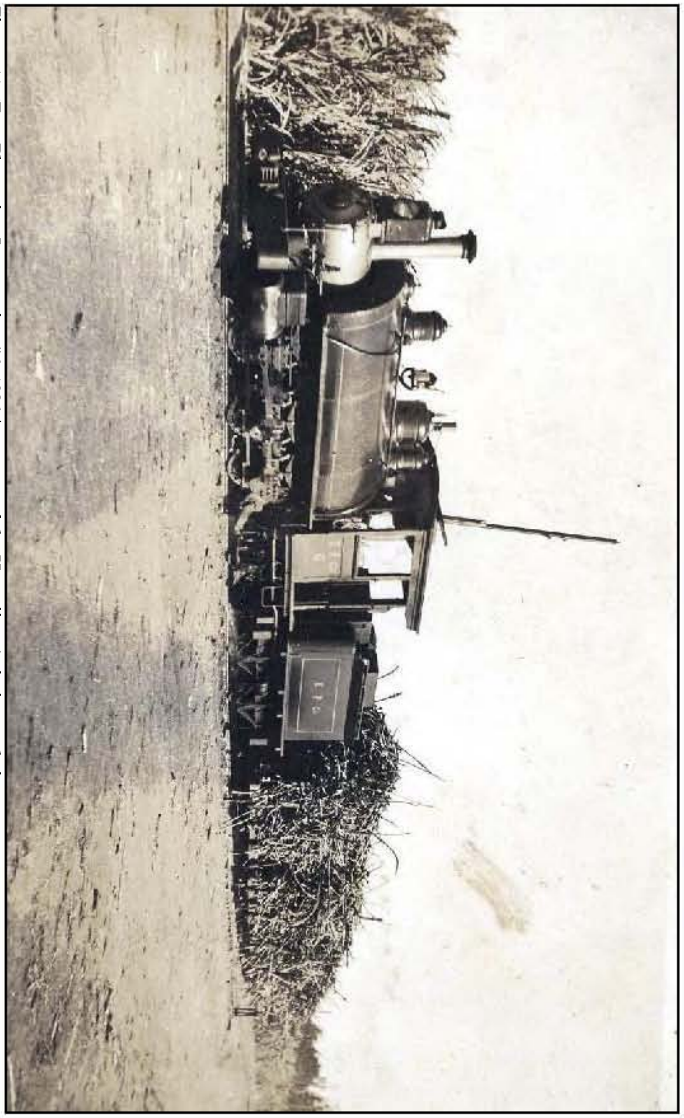


Figure 11. ‘Ewa Plantation Locomotive #6, 1926 (courtesy of the Hawaiian Aviation website Accessed 2011, State of Hawai‘i Department of Transportation, Airports Division).

The United States would show increased interest in this area after the annexation of the islands to the U.S. in 1899. In 1901, dredging began to deepen and widen Pearl Harbor and repeated in 1908 and in the 1920s. During this time, the U.S. Navy built support and dry dock facilities in the Pearl Harbor area. In the early 1930’s, the Navy constructed an ammunition depot on a 213 acre parcel at West Loch that was leased from the Campbell estate (O’Hare et al. 2006: 52). A Magnetic Observatory was built in Honouliuli near the U.S. Coast Guard Air Station Barber’s Point in 1902 by the U.S. Coast and Geodetic Survey. This facility was designed to measure movements of the earth and its magnetic field. (Kelly 1991; Tuggle and Tomonori-Tuggle 1997).

In the 1925, the U.S. Navy leased a 3,000 square foot piece of land from the Campbell estate to build a mooring mast for the dirigible *Akron* (Figures 9 and 10; Appendix D). However, records dispute the description of the property, suggesting that the ‘Ewa mooring mast was approximately 206 acres of grassy area that was used to land blimps. During this time, the Navy laid approximately 18 miles of roadway and built several camps and installations (O’Hare et al 2006: 52). By 1940, the U.S. Navy leased an additional 3,500 acres from Campbell estates to build the Marine Corps Air Station at ‘Ewa, which subsequently became NAS Barber’s Point (Kelly 1991: 166; Welch 1987).

In early 1941, the U.S. Marine Corps completed the airstrip, known as ‘Ewa Field, for peacetime training and began an expansion of Naval Aviation facilities at Barber’s Point. In October of the same year, construction of runways began at Barber’s Point, using excavated local coral for paving (Kelly 1991: 166; Welch 1987). ‘Ewa Field, now defunct, was constructed near to the old Mooring Mast and located across the train tracks and Roosevelt Road – less than 800 feet (300 meters) south of the project area (Figures 9, 10, 12; Appendix D). However, the Pearl Harbor attack on December 7, 1941, devastated much of the airstrip as well as its aircraft. As World War II commenced, the airstrip was swiftly completed by April 1942 – used as an active airstrip throughout its construction process. Upon completion, the main runway was over 8,000 feet long and 1,000 feet wide and the crossing runway 8,400 feet long and 750 feet wide.

The Marine and Naval Air Stations had some 12,000 enlisted personnel at its peak, but by 1947, the number went down to 1,645 (Kelly 1991: 168). To accommodate the military personnel, housing construction began for the men and their families at Barber’s Point in 1951. In 1956, plans for a second military housing complex were initiated.

During World War II, accommodations of a different sort were prepared approximately 3.5 miles (5.6 km) north of the project area. The Honouliuli Internment Camp was built on March 1, 1943, on 160 acres of land in Honouliuli Gulch just north of what is now the H-1 Freeway, west of Kunia Road (Figure 13). The camp, which was comprised mostly of crude wooden barracks and tents within barbed wire fences, was designed to hold up to 3,000 people, although its occupancy never exceeded 320 people. Most internees were non-combatant local males of Japanese ancestry. Yet, German, Italian, and Japanese prisoners of war were also held at the internment camp (Gabbard 2007; Wilson 2008).

Figure 12. ‘Ewa Field Auxiliary Base, July 29, 1941 (courtesy of the Hawaiian Aviation website Accessed 2011, State of Hawaii Department of Transportation, Airports Division).

Figure 13. Honouliuli Internment Camp 1940s (courtesy of Honolulu Advertiser, 17 December 2008).

5.0 PREVIOUS ARCHAEOLOGY

One of the earliest documentations of archaeological sites are the Boundary Commission survey records (1862-1935), which established boundaries and descriptions of features in properties slated for personal ownership according to new legislation under the Mahele ʻĀina of 1848. A list of noteworthy archaeological studies in the ʻEwa Plains of Honouliuli Ahupuaʻa is presented in Table 2. Initially, most research took place in west Honouliuli Ahupuaʻa, but in the early 1980's, the focus was turned to the east side of the *ahupuaʻa* as a result of increased residential and commercial development.

Table 2. Significant Archaeological Investigations of the ʻEwa Plains, Honouliuli Ahupuaʻa

Author and Date	Investigation Type	Focus/Findings	Location
Thrum, T. G. 1906, 1917	Survey, *heiau* study	108 *heiau* on Oʻahu; 1 heiau in Puʻu Kapolei	All Oʻahu; Puʻu Kapolei
Stokes, J.F.G. 1909	Inventory Survey	Walled fish traps	Pearl Harbor
Emory, Kenneth 1933	Inventory Survey	House site, possible *heiau*	Puʻu Kapolei
McAllister, J. Gilbert 1933	Inventory Survey	General archaeology; 8+ sites in Honouliuli Ahupuaʻa	All Oʻahu; Honouliuli Ahupuaʻa
Kikuchi, William 1959	Site Letter Report	12-16 Burial removals from limestone sinkhole	Campbell Industrial
Soehren, Lloyd 1962, 1966	Site Letter Report	Burial removal from sinkhole, recording of house site, fishing shrine, and modified sinkhole	NAS Barber's Point; west ʻEwa Plain
Lewis, Ernest 1970	Summary of Historical Data, Reconnaissance Survey	Historical background of Honouliuli; west ʻEwa Plain: house sites and house compounds, cairns, mounds, *ahu*, modified sinkholes (n=17)	Campbell Industrial Park, Barber's Point Deep Draft Harbor, Kalaeloa
McCoy, Patrick 1972	Survey	Stone structures within *ʻili*	Puʻuloa
Barrera, William 1975	Reconnaissance Survey	24 sites related to temporary habitation or fishing, Midden, artifacts, possible horticultural features	Campbell Industrial Park, Barber's Point
Sinoto, Aki 1976, 1978a	Survey, testing	44 new sites (B6-58 through 137); re-recorded Lewis 1970 and Barrera 1975 sites; extinct avifaunal analysis	Campbell Industrial Park, Barber's Point
Sinoto, Aki 1978b	Reconnaissance Survey	10 burials, some historic burials found in sinkhole	NAVMAG - West Loch
Jourdane, E. 1979	Reconnaissance Survey	8 sites	ʻEwa Marina, Oneʻula Beach
Davis, B. D. 1979	Survey	107 features	Oneʻula
Ahlo and Hommon 1983, 1984	Reconnaissance Survey, testing	No sites found	Honouliuli Solid Waste Processing and Recovery Facility
Rosendahl, Paul 1987	Reconnaissance Survey	4 sites (no. 3314-3317) midden, cemetery complex, occupation site, artifact collection area	West Loch Estates – Residential Increments I and II

Author and Date	Investigation Type	Focus/Findings	Location
Dicks et al. 1987	Reconnaissance Survey	7 sites (habitation site 3321 has dates from 6th-9th century w/ later occupations in 1300-1600AD, and 1700-1800's AD); other sites: fishponds, pondfields, and cemetery.	West Loch Estates (Golf Course and Parks)
Welch, David J. 1987	Archaeological Reconnaissance	2 sites (50-80-12-3721 is a complex of 5 traditional structures and 50-80-12-3722 is likely a historic wall used to separate cattle from the sisal plantation	Former ʻEwa Marine Corps Air Station, sites are located ca. 0.5 miles southwest of Ka Makana Aliʻi
Davis, Bert 1988	Subsurface Survey	No sites Found	ʻEwa Gentry
Kennedy, Joseph 1988	Letter Report	No sites Found	ʻEwa Gentry
Bath, Joyce 1989	Site Letter Report	Burial removal	Hōʻaeʻae Point
Hammatt et al. 1990	Archaeological Reconnaissance	No prehistoric sites found; no pre-ʻEwa Plantation historic sites found; Recordation of existing and demolished features in the ʻEwa Villages Complex	ʻEwa Villages Complex, from Fernandez Village to Varona Village and from Tenney Village to "C" Village area
National Park Service 1990	NRHP Registration (NPS Form 10-900)	ʻEwa Plantation Historic District defined and evaluated for significance; typical house structures described	ʻEwa Plantation Co. Mill complex and villages
Haun, Allen 1991	Survey	42 sites with 385 features (indigenous: habitation, agriculture, burial, religious, storage, collection of water, boundary marking; non-indigenous: cattle ranch and military)	NAS Barber's Point
Hammatt and Shideler 1991	Inventory Survey	No sites found	St. Francis Medical Center West, ʻEwa
Goodman and Cleghorn 1991	Testing	No sites found	Laulani Fairways Housing project at Puʻuloa
Kennedy et al. 1991	Inventory Survey and Testing	25 sites (ranching, military, and mining)	NAVMAG – West Loch
Landrum et al. 1993	Survey	Reviewed 197 previously identified sites; re-recorded 400 reported features	USN facilities on Oʻahu; NAVMAG West Loch
Moy, Tonia 1995	National Register of Historic Places - Registration Form	Historic American Buildings Survey (HABS) Forms for many Tenney Village homes and several Renton Village homes, but no HABS forms for Varona Village homes	ʻEwa Sugar Plantation Villages
Jensen and Head 1995	Reconnaissance Survey	On base: 8 isolated feature sites (historic and military); off base: 254 sites (historic, military, and Native Hawaiian)	West Loch Branch
Tuggle and Tomonori-Tuggle 1997	Synthesis of Archaeological Studies	General history, mythology, and archaeology	Entirety of ʻEwa Plain
Hammatt and Chiogioji 1997	Archaeological Reconnaissance Survey	Plantation era infrastructural remains; area previously disturbed	Road Corridor for Proposed North-South Road, linking Kapolei to ʻEwa Beach, adjacent to Ka Makana Aliʻi (to east)

Author and Date	Investigation Type	Focus/Findings	Location
Wolforth and Wulzen 1998	Data Recovery (controlled excavation, backhoe trenching, and monitoring	Agricultural pondfields: chronology and use	West Loch Estates – Residential Increment I and Golf Course and Shoreline Park
McIntosh and Cleghorn 2003	Archaeological Survey	No sites found	‘Ewa Gentry Makai
Collins and Jourdane 2005	Site letter report	Burial removal	Old Ft. Weaver Rd., Honouliuli
O’Hare et al. 2006	Inventory survey	5 sites: taro lands, Kapalani Church, Pipeline Village, Drivers/Stable Village	Ho’opili Project, 546 acres between Honouliuli Town and Kapolei
O’Hare et al. 2007	Archaeological Assessment	No sites found	‘Ewa Industrial Park, 48.18 acres
Mooney and Cleghorn 2007a, 2007b	Archaeological Assessment and CIA	No sites found	Campbell Industrial; near Barbers Point Deep Draft Harbor; ca.3.5 miles W of Ka Makana Ali‘i
Mooney and Cleghorn 2008c, 2008d	Archaeological Assessment, Backhoe Testing, and CIA	No sites found; area previously disturbed; project area in Honouliuli Village/Taro lands vicinity	23 acres N-NW of Old Ft. Weaver and Ft. Weaver Road, ca. 2.2 miles N-NE of Ka Makana Ali‘i
Mooney and Cleghorn 2008a, 2008b	Archaeological Assessment and CIA	No sites found; area developed for the Makakilo Golf Course, now defunct	34 acre Makakilo Quarry Expansion and associated 360 acres, ca. 2 miles NW of Ka Makana Ali‘i
Mooney and Cleghorn 2008f/Pacific Legacy, Inc.	Archaeological Monitoring Report	Three potential sinkholes, historic military structural remains, historic rubbish	Ke Kama Pono Facility At York Town Road, Kalaeloa (Former NAS Barber’s Point), ca. 1.5 miles southwest of Ka Makana Ali‘i
Fung Associates, Inc. 2009	Inventory and Condition Assessment of Historic Structures	Inventoried Homes in Tenney and Renton Village; no Varona Village homes were inventoried	‘Ewa Plantation Villages
Mooney and Cleghorn 2011b (report submitted to SHPD)	Archaeological Inventory Survey	Five Historic Sites: 4 associated with plantation homes, one Historic streetlamp	Varona Village

5.1 Early Archaeological Investigations of Honouliuli Ahupua‘a

During his extensive survey of O‘ahu in the early 1930s, McAllister (1933) recorded 14 sites in Honouliuli and Pu‘uloa Ahupua‘a including the remnants of Pu‘u Kapolei’s *heiau*. While Sites 133-137 are in the upland region of the *ahupua‘a*, sites 138 and 146 are located in the ‘Ewa Plains and sites 139-145 are positioned on the shore of West Loch – all under 5 miles from Ka Makana Ali‘i. Table 3 lists descriptions of sites 133-146 and Figure 14 maps their locations.

Table 3. McAllister’s (1933:107-108) sites located within Honouliuli and Pu‘uloa Ahupua‘a.

Site No.	Description	Location
133	Small enclosure 25’X30’, faced walls 2’-5’ tall filled w/smaller stones, purported *heiau*	Foot of Pu’u Kanehoa
134	Pu’u Kuina Heiau, destroyed, only a terrace remains	Foot of Mauna Kapu
135	Number of enclosures w/low faced walls, largest enclosure is 85’X100’, all on level terrain, possible kuleana sites	Kukuilua’s land
136	Small platform, destroyed, 4’-6’sq. made of coral and basalt	Near Mauna Kapu
137	Pu’u Kuua Heiau, destroyed	Waianae Mtns. 1,800’ AMSL
138	Pu’u Kapolei Heiau, destroyed	Kapolei, ca. 100’ from sea
139	Kalanamaihiki Fishing Shrine (*ko‘a*), 2 lrg. Rough stones 2.5’ in size, 6 or 7 stones avg. 1’ in size piled next to lrg. Stones	Kapapahui, (point of land where Honouliuli Gulch meets West Loch)
140	Fishpond adjoining Laulau-nui Island to Kapapahui, 4-5 acres, 900’ L X 7’ W X 3.5’ H outer wall, no outlet gates	Between Laulau-nui Island and Kapapahui
141	Kaihuopalaai, entire West Loch, starting point of the mullet run to Lā‘ie	Pearl Harbor, west
142	Kapamuku or Pamoku fishpond, 3 acres, 660’L X 6’ W X 3.5’H, no outlet gates, loosely piled stones	Pu’uloa/Waipi’o Peninsula
143	Okiokilepe fishpond, 6 acres, 1000’L X 6.5’W X 4’H outer wall (made of coral), no outlet gates	Pu’uloa, across from Waipi’o Peninsula
144	Fish traps and fishing shrine, destroyed	Pearl Harbor Inlet
145	Pu’uloa, place of first breadfruit planting	Southeast end of the ‘Ewa Plains
146	Ewa Coral Plains, area of many sites (e.g. Pu’uloa Salt Works, extent of old stone walls, and modified pits)	Entire ‘Ewa Plains

5.2 Recent Archaeological Investigations by Honouliuli Ahupua‘a Locality

<u>*‘Ewa Villages, ‘Ewa Gentry and ‘Ewa Gentry Makai*</u>

Davis (1988) conducted archaeological testing for Bishop Museum in Ewa Gentry, located ca. 0.95 miles east of Ka Makana Ali‘i, in an area previously utilized for sugar cane cultivation. No archaeological sites were identified during testing. Previously, Kennedy (1988) conducted a surface survey in the same area that failed to detect archaeological sites.

A series of evaluations have been conducted in the ‘Ewa Plantation Mill Complex and Village area from the mid-1980’s to the present day (Pagliaro 1987; National Park Service 1990; Hammatt et al. 1990; Moy 1995; Fung Associates, Inc. 2009) to determine the Historic significance, restoration potential, and monitor the condition of the Historic District. Pagliaro (1987) states that ‘Ewa Plantation manager, George F. Renton, Jr., decided to invest five million dollars in 1920 on infrastructure and housing upgrades, nearby Varona Village being one of the last housing improvements to the plantation under this fund. According to the NHRP Registration form (National Park Service 1990), Varona Village was initially built in 1939 under the name of “B” Village. Another moniker given to Varona Village was “Filipino Camp” (Moy 1995). Locals also called the village “Brooklyn,” because this village was separated from the other villages by a bridge crossing Kalo‘i Gulch, which they nick-named the “Brooklyn Bridge” (National Park Service 1990). The homes were described as mostly “Varona Village Types A and B,” which were “small, simple rectangular homes 20 feet wide by 38 feet deep, with corrugated metal roof, small eaves, board-n-batten single wall construction, pine floors and

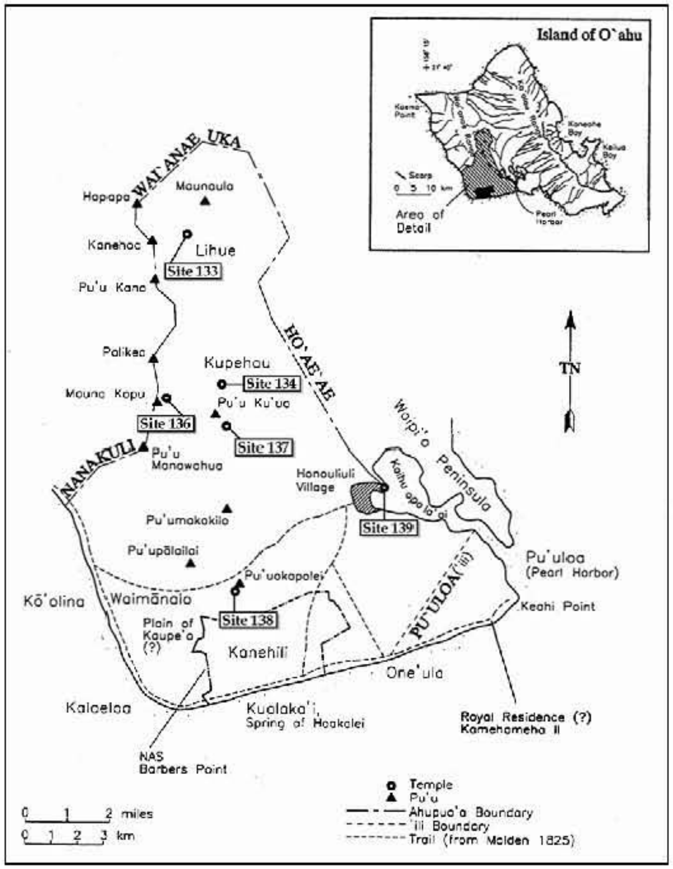


Figure 14. Points of interest in Honouliuli Ahupuaʻa, see Table 3 for site descriptions (map adapted from Tuggle and Tomonori-Tuggle 1997: Figure 4).

canec ceilings" (Moy 1995: 9). However, there were a few houses brought in from Puʻuloa in 1943, which are similar to those of Renton Village (Moy 1995). Additionally, Varona Village sported a large, board-and-batten community hall that was constructed in 1934 for the Filipino Community Association, which is now demolished (Moy 1995). Cultural Surveys Hawaiʻi completed an archaeological reconnaissance of 616 acres of ʻEwa Villages, which included: various sites associated with ʻEwa Plantation infrastructure (e.g. depot, reservoir, etc.), Plantation Cemetery, Buddhist Temple, Japanese School, Renton, Tenney, and Varona Villages as well as former "C", Mill, and Middle Villages (Hammatt et al. 1990). In this study, a sum of 9 sites were recorded, including a historic cemetery, reservoir, a communal bathhouse, OR&L tracks, village store with saimin stand, and a roundhouse. However, no prehistoric sites were detected.

In 1997, Hammatt and Chiogioji performed an archaeological survey of approximately 2.8 mile (4.5 km) long corridor for the proposed North-South Road in Honouliuli Ahupua'a. A segment of this corridor borders the subject property's northern edge. In this study, Hammatt and Chiogioji found that, "virtually the entire corridor has been extensively graded repeatedly over the past century by the ʻEwa Plantation Company…in association with sugar cultivation and the construction of plantation infrastructure" (Hammatt and Chiogioji 1997: i). The ʻEwa Plantation Villages Historic District and Oʻahu Railway and Land Co. Right-of-Way, which had previously been placed on the National Register of Historic Places, were encountered in this survey. Yet, no prehistoric sites were detected.

McIntosh and Cleghorn (2003) conducted an archaeological survey for the ʻEwa Gentry Makai residential housing, commercial and industrial mixed uses, community facilities and open spaces development at a 283-acre parcel in ʻEwa (TMK 9-1-10:7 and 9-1-69:5). The project area was, at the time, agricultural land formerly used for sugar cane production and limited grazing activities. No sites were found.

Puʻu Kapolei

The first investigation was in the early 1900's, where T. G. Thrum documented a *heiau* at Puʻu Kapolei (Thrum 1906:46), which is located in south-central Honouliuli. Thrum revisited the site in his second monograph on *heiau*, misnaming it Paloleʻi (Thrum 1917). Later, Emory (1933) took pictures and mapped a well-preserved house site and possible *heiau* near Puʻu Kapolei before the remnants were dismantled. McAllister arrived at Puʻu Kapolei shortly after and noted that the site, which he numbered 138, was ruined as its stones were removed and crushed to provide material for new construction (McAllister 1933: 108). He registered that on the side of Puʻu Kapolei was a large rock shelter, rumored to be the dwelling of legendary Kamapuaʻa and his grandmother, as well as a *heiau* that was later destroyed.

Honouliuli Village Area

The earliest recording of a site in this area was done by McAllister (1933), which was a *koʻa* named Kalanamaihiki (site 139). This fishing shrine is still perched on a hill within West Loch's Shoreline Park on a spit of land called Hōʻaeʻae Point across from Laulau-nui Island. This site is located 2.65 miles east of the project area (Figure 14; Table 2).

In 1987, Paul Rosendahl, Ph.D., Inc. (PHRI) performed an archaeological survey of the 232 acre West Loch Estates Residential Increment I, Golf Course, and Shoreline Park development. This project, which divides the area into upper valley, lower valley, coastal margin, and Hōʻaeʻae Point, covered a small section of the current project area's east side and spanned east to the shores of West Loch. The survey revealed four new sites (No. 3314-3317) despite the fact that most of the project area was modified by historic period agriculture. Sites 3315 through 3317 were of historic age, with 3316 being a small cemetery complex located less than 200 meters from the southern tip of the project area and the other two sites being surface artifact scatters. Site 3314 was a disputed midden layer (Wolforth and Wulzen 1998: I-28). Later in the year, PHRI (Jensen et al. 1988) conducted a field survey and subsurface testing in the same area, which yielded seven additional sites (No. 3318-3324). These sites consisted of pre- and post-Contact era habitation and burial sites. This study also suggested that traditional agricultural use of Honouliuli Gulch may have been ongoing for nearly one thousand years. Wolforth and Wulzen (1998) performed data recovery, which peered deeper into the intensity of habitation and agriculture as well as the chronology of these activities in the Honouliuli Stream Floodplain. Further, Wolforth and Wulzen (1998) surmised that the lower valley eventually filled with sediment from upland erosion, which caused the lowland marsh and pond-field system to dry out. As a result, the region became a collage of wet and dry fields with some houses, pastures, and gardens.

Perhaps the most thorough of recent archival investigations performed in the area was O'Hare et al. (2006), which was conducted on several parcels encompassing nearly 1,630 acres, one of which is located less than 1.7 miles east-northeast of Ka Makana Aliʻi. Backhoe testing was performed in areas that were identified by Hammatt and Shideler (1991) as historic habitation and/or agriculture. The findings were four additional features related to sugar cane cultivation, which were attributed to previously recorded Site 50-80-12-4344 that is located approximately 2.5 kilometers south of the current project area. While O'Hare et al. (2006) were not successful in finding physical remains of Honouliuli Taro Lands, "Kapalani" Catholic Church, Drivers and Stable Village, nor Pipeline Village, their report functions as a well-researched and comprehensive synthesis of these areas within Honouliuli.

More recently, Mooney and Cleghorn (2008c and 2008d) performed a CIA as well as archaeological survey and backhoe test excavations in two parcels at the corner of Old Fort Weaver and new Fort Weaver Roads. The archaeological testing yielded no new archaeological sites. However, results indicated a 3 to 5 feet (0.9 to 1.5 m) deep layer of construction fill with a significant amount of illegal dumping that lies over nearly all of the original ground surface.

Puʻu Makakilo Area

Puʻu Makakilo is located approximately 2.1 miles (3.4 km) north of the proposed Ka Makana Aliʻi. In 1988, a letter report was written by Aki Sinoto for the Makakilo Golf Course survey. On the southeastern flank of Pu'u Makakilo, Sinoto sates:

> As anticipated, large portions of the project area have been and still undergo severe erosion. Barren areas of exposed substrate is interspersed with areas dominated by dry grasses and small kiawe. Steep erosional gullies with vertical walled heads, bare areas of sheet wash, and pedestaled rocks attest to the severe and continuing erosion (Sinoto 1988:1).

While no significant archaeological sites were located in the survey, Sinoto did discover a deteriorated wall segment inside of Puʻu Makakilo that may have served as erosion control in historic times. However, due to its deteriorated state the site did not warrant further archaeological investigation nor preservation (1988:1).

In more recent times, four archaeological investigations have been performed within a mile radius of Puʻu Makakilo with modest finds (Hammatt et al. 1991, Nakamura et al. 1993, and Rasmussen 2006). However, several other investigations have been conducted in nearby Waimanalo, Kaloʻi, and Makaiwa Gulches, recording abundant archaeological sites (Bath 1989, Bordner 1977, Hammatt et al. 1991).

Mooney and Cleghorn completed archaeological and cultural impact assessments for the 34 acre expansion of the Makakilo Quarry and associated 360 acre visual impact modifications (Mooney and Cleghorn 2008a and 2008b). Review of previous archaeological investigations indicated that most the project area was part of a larger area surveyed previously. Further, most of the project area was found to be heavily bulldozed and reshaped for the now defunct Makakilo Golf Course during the January 2008 surface survey. No new sites were found.

Oneʻula

Elaine Jourdane (1979) performed a reconnaissance survey at Oneʻula, located about 2.15 miles (3.5 km) south of the project area, where she recorded eight pre-contact sites outside of the cane fields (as cited in Wolforth and Wulzen 1998). Davis (1979) returned to the area later that year and found 107 pre-Contact features. Shortly after, the area was revisited by Hommon and Ahlo (1983) who performed subsurface testing without any findings. Hammatt (1984) returned to the same area to evaluate the previous surface findings and relocated 33 of the features found by Davis (1979), which he attributed to 8 new sites. Hammatt (1984) suggested further investigations be performed on the features that would be impacted.

Kalaeloa/Barber's Point and Campbell Industrial

Little archaeological investigation was performed in Honouliuli Ahupuaʻa during the 1940s-50s, however, investigations picked up just prior to 1960. In 1959, William Kikuchi was the first to investigate the area when he was called to remove 12-16 inadvertently discovered burials at the Standard Oil Refinery at Barber's Point (Kikuchi 1959). Soon after, Lloyd Soehren (1962) recorded and removed a burial before excavating and recording a fishing shrine in NAS Barbers Point (Soehren 1966). This shrine was reported to be destroyed by Barrera (1975:1) and re-examined by Davis in 1982, where he performed supplementary excavations (Davis 1995).

By 1970, archaeological methods had evolved to standards with a more scientific and thorough approach. Lewis' 1970 investigation of Barber's Point and Campbell Industrial area was the first to address the ʻEwa Plain in this manner. In this study, Lewis (1970) recorded an array of house structures and habitation complexes, cairns and mounds (*ahu*), as well as modified sinkholes. Equally important, Lewis (1970) compiled a wealth of Historic documents and traditional chronicles on the ʻEwa Plains as a background for his report. With more innovative methods, Lewis (1970) was able to make some viable postulations about lifeways and the decline of early ʻEwa Plain populations.

In 1975, Barrera revisited the Campbell Industrial Park/Barber's Point area, studied by Lewis in 1970, and located twenty-four sites related to temporary habitation or fishing as well as midden, artifacts, and possible horticultural features (Barrera 1975). Just a year later, Aki Sinoto (1976) performed mapping and test excavations in the same area that would further enlighten archaeologists about the dynamics of early ʻEwa Plain populations and their environment. During his investigations, Sinoto (1976, 1978a) discovered many well-preserved habitation sites, including: C-shapes, enclosures, and modified sinkholes. Additionally, Sinoto (1976, 1978a) found a wealth of *in situ* cultural deposits and extinct avifaunal remains within the sinkholes.

An extensive archaeological and paleontological study was carried out on 89 acres for the Barber's Point Deep Draft Harbor in the early 1980's by the Bishop Museum (Davis 1990). In this investigation, 79 sites were identified, including modified sinkholes and habitation sites.

Haun (1991) performed an archaeological survey of NAS Barber's Point, where he identified 385 features within 42 sites that he claimed were "some of the best preserved and most extensive prehistoric remains known for the ʻEwa Plain" (Haun 1991:1).

Tuggle and Tomonori-Tuggle (1997) authored a synthesis of archaeological and historical investigations performed on the ʻEwa Plain. This comprehensive manuscript examines the prehistory, history, previous archaeology, and the natural resources found on ʻEwa Plain. In 2008, Mooney and Cleghorn (2008f) performed archaeological monitoring for the construction of the Ke Kama Pono Project located on York Town Road within the former Naval Air Station (NAS) Barber's Point. Three potential sinkholes were encountered; one after the site was cleared of vegetation and two during excavations. While foundation remnants from a late historic military structure (demolished in the late 1980's) were encountered and one historic bottle was found, no significant cultural remains were identified during excavations.

<u>*West Loch, Pearl Harbor*</u>
On the eastern edge of Honouliuli Ahupuaʻa, John F. Stokes (1909) composed a detailed study on the fish traps, ponds, and shrines that were located in and around Pearl Harbor. Later, McAllister (1933:28-32) mapped and recorded several fish ponds and traps of Pearl Harbor (sites 140, 142-3), revisiting one (site 144) previously recorded by Stokes in 1909. Additionally, McAllister (1933) gave West Loch itself the site number 141.

Situated under 4.5 miles (7.15 km) to the east is National Register site 9992, which is the Pearl Harbor Naval Base. This site is comprised of all three lochs of Pearl Harbor and associated U.S. Naval facilities as well as several islands and islets within.

<u>*Puʻuloa*</u>
Puʻuloa, which lies approximately 3-4 miles (4.8 – 6.4 km) southeast of Ka Makana Aliʻi, has been the focus of several investigations. The first report was written by Patrick McCoy (1972), who documented several stone structures when surveying *ʻili* in the proposed Puʻuloa Elementary site. Kennedy et al. (1991) conducted an archaeological inventory survey for the then proposed Puʻuloa Golf Course, now named the New Ewa Beach Golf Club. This survey yielded 72 prehistoric, historic and modern sites. Sinkholes containing cultural material, C-shapes, enclosures and mounds dominated the site types. Later, Kennedy and Denham (1992)

performed data recovery at sites scheduled for impact during golf course construction, which concluded that the earliest occupation of the area occurred between A.D. 1020-1480.

5.3 ʻEWA PLAIN SETTLEMENT PATTERNS

In the first and foremost synthesis of archaeological investigations conducted in the ʻEwa Plain, Tuggle and Tomonori-Tuggle (1997) proposed a pre-Contact Hawaiian settlement model. In this model, eight major zones of settlement were suggested for the period representing the height of Hawaiian occupation in the area. According to the ʻEwa Settlement Model map (Tuggle and Tomonari-Tuggle 1997:Figure 22), the project area is located on the southern edge of zone 2 (Figure 13). All settlement zone descriptions are provided in Appendix C. Zone 2 is described by Tuggle and Tomonari-Tuggle (1997:117) as follows:

> 2. Permanent agriculture settlements developed along the upper ʻEwa Plain, associated with the alluvial fans and soil of the upper Plain. Most of the cultivation was dryland, but included some runoff cultivation and some irrigation in a few of the spring-fed gully mouths.
>
> This is based on the environmental conditions of the area and archival data regarding water potential. It is probably not testable, except for the possiblilty of site discovery in small undeveloped gulches.
>
> 2a. This area was the first area of agricultural expansion outside the Honouliuli floodplain region, and probably consisted of small settlements at the mouths of gullies.
>
> This proposition is based on the agricultural potential, but may not be testable because of site destruction.

Hence, according to this settlement model, the Ka Makana Aliʻi project area and Keoneula Road corridor could have been an area utilized for permanent habitation and agriculture in pre-Contact times. It is possible that cultural deposits lie encapsulated under plantation era soils.

Another major feature of ʻEwa Plain is the Kualakaʻi Trail (Figure 6). While the exact location is unknown and physical evidence of the trail has not been identified, there is a high probability that archaeological deposits relating to the trail may still exist under plantation era soils. Archaeological deposits that may be encountered subsurface could include features of the trail itself, such as curbing and/or features related to temporary camp sites as well as isolated artifacts left behind by travelers.

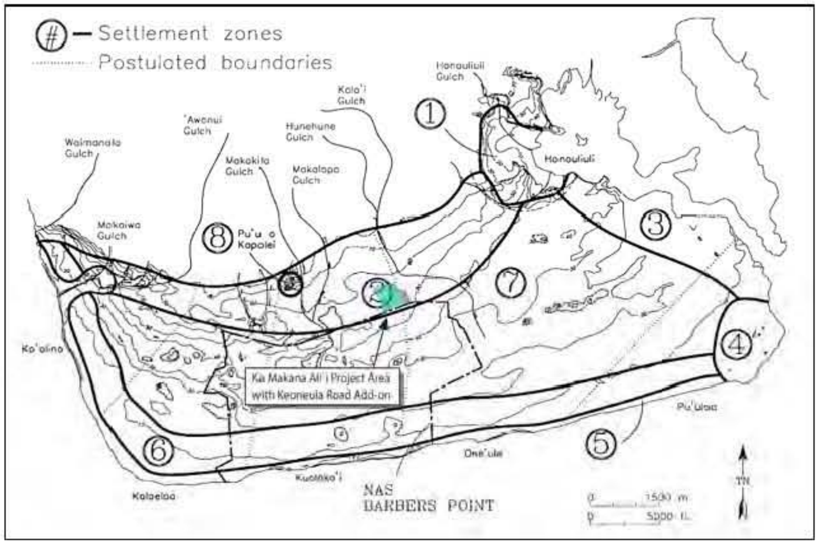


Figure 15. ʻEwa Settlement Model with Ka Makana Aliʻi project area and Keoneula Road Corridor distinguished (adapted from Tuggle and Tomonari-Tuggle 1997:Figure 22).

6.0 FIELD METHODS

As much of the ʻEwa Plain is a buried *karst* landscape, characterized by numerous solution pits or sinkholes that may have been utilized for human burials and other cultural practices, the Office of Hawaiian Affairs (OHA) argues that subsurface testing aimed at locating and investigating buried sink holes must be performed prior to development in the ʻEwa Plain. To address the concern that buried sinkholes may be disturbed during project construction, a surface survey and subsurface testing was performed in the proposed Ka Makana Aliʻi project area and the projected Keoneula Road corridor by Kimberly M. Mooney, B.A., between 11 July through 22 July 2011 under the general direction of Paul L. Cleghorn, Ph.D.

Surface Survey was performed by sweeping the project area and additional ca. 6 acres of road corridor on foot, inspecting all areas – avoiding all modern construction features, including the large borrow pit, the three stockpiles of excavated sediment, and large excavated area surrounded with a circular berm (Figure 16). These modern features represented a total of nearly 32 acres of the ca. 67 acres making up the Ka Makana Aliʻi project area and roughly 6 acres of the Keoneula Road corridor. Appendix A provides a sample of project area photographs.

To improve manageability of gathered data for the relatively large property, the entire project area was divided into four quadrants representing the Northwest, Northeast, Southeast, and Southwest portions of the property (Figures 16, 26, 37, 46, and 54; Table 4). Initially, a virtual grid system was designed to plan out locations to perform subsurface testing, using a Google Earth aerial image of the project area matching landmarks visible at ground level with those seen on the aerial image. A Garmin GPS unit was then used to mark tested areas, which helped to gauge distance from already tested areas and was used to update the aerial images daily to test the project area as evenly as possible.

The strategy for testing was established in the Revised Testing Proposal, where construction plans for the development assumed that removing approximately 8 inches of top soil would expose the limestone *karst* deposits. As the estimated depth of alluvial overburden was ca. 8 inches, the initial plan to test for the presence or absence of sinkholes was to remove the alluvium by grading down to the limestone *karst* with a backhoe, also referred to as a wheeled excavator or hoptoe, exposing the tops of sinkholes visible in the base of the excavation as reddish brown circular stains contrasting to a white karst plain. This alluvium removal process, referred to in this investigation as a "test scrape," was to be performed by scraping the inner blade of a backhoe loader bucket against the ground surface over a distance of 30 feet and removing the spoils repeatedly until the limestone karst, and potentially sinkholes, were revealed.

However, following four unsuccessful attempts in four different locations to expose the *karst* layer (scraping down ≥19.7 inches or 0.5 meters) using the test scrape method, the strategy was modified. Backhoe trench excavations were then performed to locate the depths of the *karst* limestone in all areas of the property, including the proposed Keoneula Connector Road corridor (200 ft. east of HECO lines), excluding the borrow pit and stock piles.

Subsurface testing consisted of closely monitored backhoe trenching, which was carried out by a backhoe with a 12 inch (30.48 cm.) wide scoop for the first week and a 24 inch (60.96 cm) wide scoop during the second week, as the 12 inch scoop created a trench too skinny to record properly. The stratigraphy of each trench was recorded by scaled soil profile drawings and by taking photographs of trench walls. Sediment layers were then analyzed by color, using a Munsell Soil Color Chart (2000), as well as texture, structure, consistency, and boundary. All trench locations were marked by GPS, which is proved in Appendix B and uploaded into Google Earth, which rendered an aerial map of the test trench and test scrape locations and is provided in Figure 25. Photographs of test excavations are also provided in Appendix A.

7.0 SURFACE SURVEY RESULTS

An archaeological pedestrian survey was performed in the project area by Kimberly Mooney, B.A. on 11 July 2011.

The project area topography is marked by several modern construction related features, such as the large Borrow Pit located at the south, three distinct areas of stockpiled sediment, varying in size and shape, and large excavated areas (Figures 16-24). However, some scattered areas, particularly on the central west and east margins, appeared relatively level and free of modern disturbances. Dirt access and old plantation roads criss-cross the landscape as well. Scatters of construction debris and irrigation material as well as mounds dumped household and landscaping rubbish can be found throughout the east and west margins of the project area. Much of the dumped materials are found beneath vegetation, suggesting that the dumping occurred a number of years ago.

Vegetation in the subject area, appeared to be by and large unused property dominated by hardy exotics such as *kiawe* (*Prosopis pallida*), *koa haole* (*Leucaena leucocephala*), *klu* (*Acacia farnesiana*), lantana (*Lantana camara*), *ʻopiuma* (*Pithecellobium dulce*), amaranth (*Amaranthaceae sp.),* and *cherry tomato (Solanum lycopersicum var. cerasiforme)* with various grasses (*Pennisetum spp.*), shrubs and vines. However, some native plants were spotted in the project area, such as red and yellow *ʻilima* (*Sida fallax*), *ʻuha loa* (*Waltheria indica*), and *maunaloaʻula ʻula* (*Canavalia cathartica).*

Dirt roads, dirt paths, jumps, and berms related to access and unofficial dirt biking and off-roading can be found throughout the property (Figures 17 and19). These features had evidence of very recent use by a variety of off-road vehicles, including motorcycles, four-wheelers, cars, and trucks as well as non-motorized dirt bikes. The highest concentration of off-roading features were found on and around the Borrow Pit and Stockpile 2.

Several existing utility features were also found in the Northeast Quadrant of the project area. Several modern Sewer main manholes protected by bollards were identified as well as storm drains, telephone poles, and HECO power lines.

No archaeological sites were encountered during the survey. Photographs of the survey area are presented in Appendix A.

Figure 17. Ka Makana Ali‘i Borrow Pit (view to southwest).

Figure 18. Stockpile 1, east side, backhoe for scale (view to west).

Figure 16. Modern construction features of project area (adapted from Google Earth image).

Figure 19. Stockpile 2, west side, backhoe for scale (note ORV jumps, view to north).

Figure 20. Stockpile 3, north end (view to southeast).

Figure 21. Access road between OR&L tracks and Borrow Pit (view to west).

Figure 22. West side of property, relatively flat and open (view to southwest).

Figure 23. Interior of Excavation Area A, backhoe for scale (view to southwest).

Figure 24. Northern edge of Excavation Area A (view to southwest).

8.0 SUBSURFACE TESTING RESULTS

According to the Revised Testing Proposal, construction plans for the development assumed that removing approximately 8 inches of top soil would expose the limestone karst deposits, which is the proposed grade that the majority of the structures will be built upon. As the estimated depth of alluvial overburden was ca. 8 inches, the initial plan to test for the presence or absence of sinkholes was to remove the alluvium by grading down to the limestone *karst* with a backhoe, exposing the tops of sinkholes visible in the base of the excavation as reddish brown circular stains contrasting to the white *karst* plain. This alluvium removal process, referred to in this investigation as a "test scrape," was performed by scraping the inner blade of a backhoe loader bucket against the ground surface over a distance of 30 feet, removing the spoils repeatedly until the limestone karst, and potentially sinkholes, were revealed.

However, after four unsuccessful attempts in four different locations (TS-1, 3-5; Figures 25 and 37) to expose the *karst* layer (scraping down ≥19.7 inches or 0.5 meters) using the test scrape method, the strategy was modified. Backhoe trench excavations were then performed to locate the depths of the *karst* limestone in all areas of the property, including the proposed Keoneula Connector Road corridor (200 ft. east of HECO lines), but excluding the Borrow Pit and stock piles (Figure 25; Table 4).

A total of 62 test trenches were excavated, revealing varying strata throughout the project area. Trench depths ranged from ca. 20 inches (ca. 0.5 meters) to ca. 12 feet, 2 inches (ca. 3.7 meters), with 54 of the 62 trenches revealing the karst layer. During trench testing, a single trench appeared to reveal a sink hole in the base of excavation and was hand excavated down only 0.45 meters before reaching the karst layer. This depression was ruled out as being a sink hole due to its shallow nature. In another test trench, the *karst* surface was found to be < 0.3 meters deep and appeared to be undisturbed and encapsulated under the topsoil. A test scrape was subsequently performed in the vicinity, which revealed that the top surface of *karst* was not a flat horizon, but rather, an undulating and irregular surface with many natural depressions. This caused some confusion as to what may or may not be a sink hole. Two darkly colored depressions in the base of the test scrape that appeared to be sink holes were hand excavated, but were found to contain only a thin layer of alluvium (< 0.2 meters). Thus, no sink holes were encountered during the testing phase.

Subsurface testing results are arranged by quadrant (Figure 25; Table 4), to help organize the stratigraphy data for analysis and interpretation. This system allows anomalies and patterns in the data to be ordered into a more observable spatial context, as opposed to a collection of individual points with associated data scattered throughout a relatively large subject area. A complete database for Test Trenches is provided in Appendix B.

Neither sinkholes nor cultural materials were encountered during the subsurface testing. Nonetheless, the current stratigraphy of the project area has been comprehensively recorded to provide a better understand the land's varying topography and past land use as well as providing information on which to generate an accurate monitoring plan.

Table 4. Test Trenches and Test Scrapes by Quadrant

Northwest Quad	Northeast Quad	Southeast Quad	Southwest Quad
TT-17	TT-1	TT-9	TT-25
TT-18	TT-2	TT-10	TT-26
TT-19	TT-3	TT-11	TT-27
TT-20	TT-4	TT-12	TT-48
TT-21	TT-5	TT-13	TT-49
TT-22	TT-6	TT-38	TT-50
TT-23	TT-7	TT-39	
TT-24	TT-8	TT-40	
TT-28	TT-14	TT-41	
TT-29	TT-15	TT-43	
TT-30	TT-16	TT-51	
TT-31	TT-34	TT-55	
TT-32	TT-35	TT-56	
TT-33	TT-36	TT-57	
TT-46	TT-37	TS-2	
TT-52	TT-42	TS-6	
TT-53	TT-44		
TT-54	TT-45		
TT-58	TT-60		
TT-59	TT-47		
TT-61	TS-1		
TT-62	TS-3		
	TS-4		
	TS-5		

Note:

TT = Test Trench
TS = Test Scrape

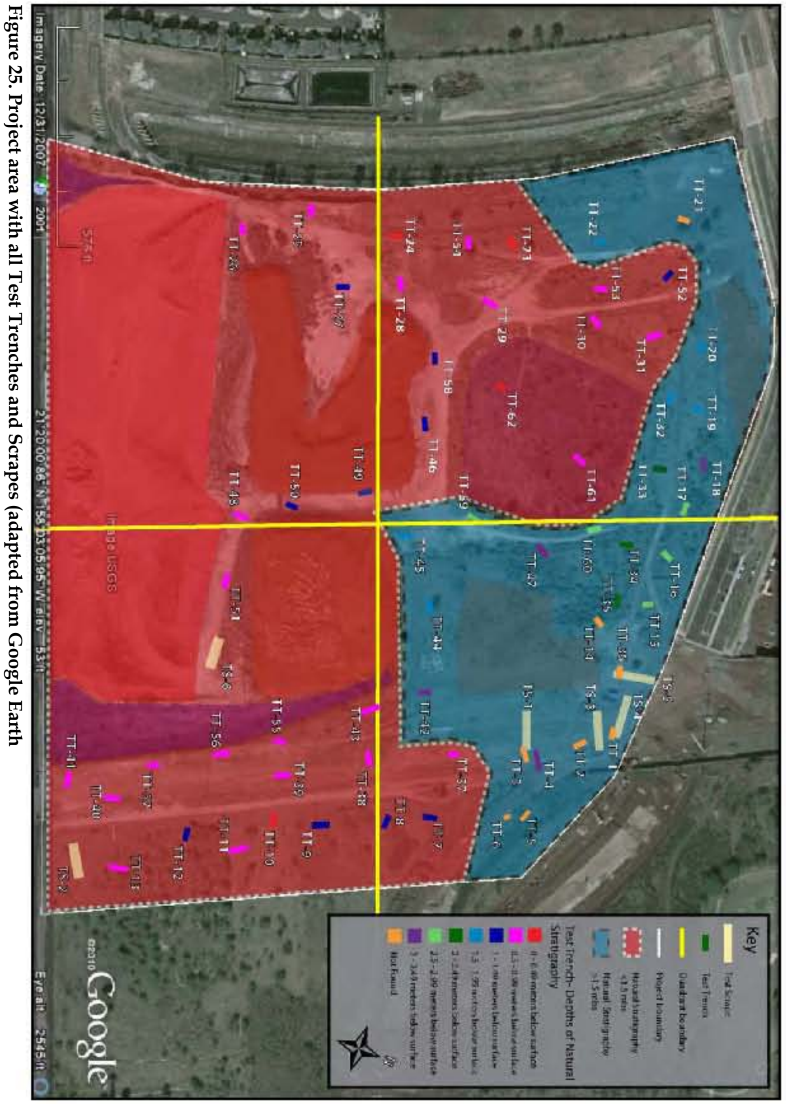


Figure 25. Project area with all Test Trenches and Scrapes (adapted from Google Earth image).

8.1 Northwest Quadrant

A total of 22 test trenches were excavated in the Northwest Quadrant (Figure 26), with depths ranging from ca. 0.5 meters below surface to ca. 3.7 meters below surface. This quadrant was found to have relatively deep sediment, consisting of construction fill and possibly plantation era red clay soil above the natural strata in its northern margin (Figures 27 and 28). The southern portion of this quadrant, omitting the previously excavated areas and modern stockpiles, appeared to have relatively thin layers of construction fill and/or red clay soils. Neither true sinkholes nor archaeological deposits were encountered during these test excavations.

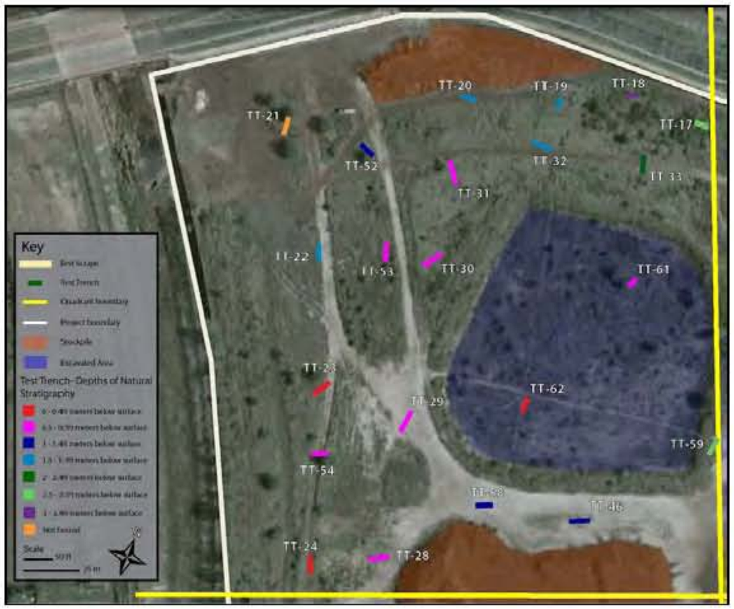


Figure 26. Northwest Quadrant (adapted from Google Earth image).

In most cases, natural strata was situated above the *karst* bedrock, which was represented by either a thin layer of natural alluvium, sometimes followed by an underlying layer of decomposing limestone. In general, these natural layers followed the contours of the *karst* bedrock. However, where natural depressions in the *karst* were encountered, the natural alluvium tended to be deeper. The boundaries between these two layers were usually irregular and gradual. The average depth of natural strata below surface was 1.36 meters.

With the exception of Test Trench 21, *karst* bedrock was encountered at depths varying from 0.3 meters below surface to 3.1 meters below surface. It is interpreted that substrate in the area of Test Trench 21, which was excavated to 3.7 meters below surface without encountering bedrock, has been disturbed by modern construction activities related to the drainage ditch located about 100 ft. west of the trench. While *karst* was encountered in Test Trenches 61 and 62, the excavated area in which they are located appears to have been disturbed deeper than the natural strata, as the fill layers appeared to rest directly on the *karst* with a smooth and abrupt boundary.

The soil profiles, photographs, and soil descriptions of four Test Trenches (numbers 20, 28, 30, and 46), were chosen to illustrate the diversity of layers and stratigraphies in this quadrant (Figures 29-36; Tables 5-8).

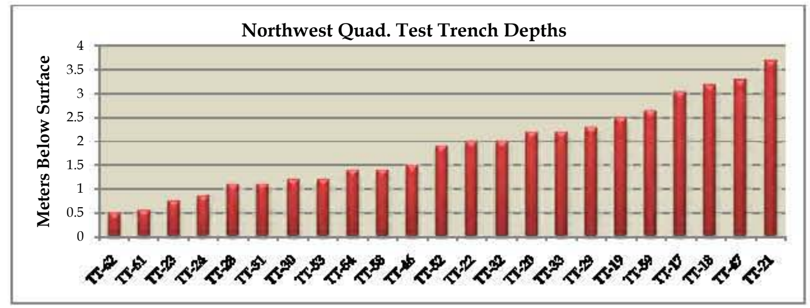


Figure 27. Overall trench depths for Northwest Quadrant.

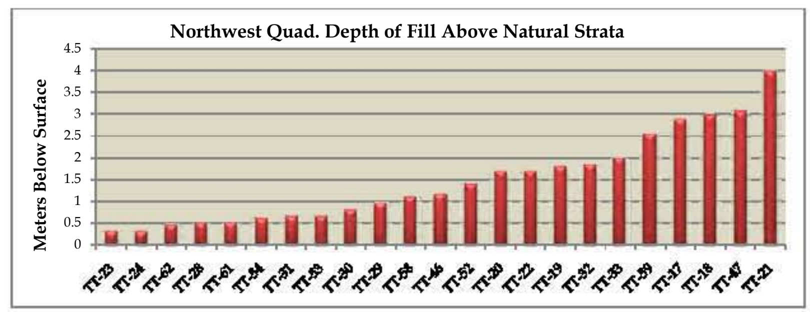


Figure 28. Depth of natural strata in Northwest Quadrant trenches.

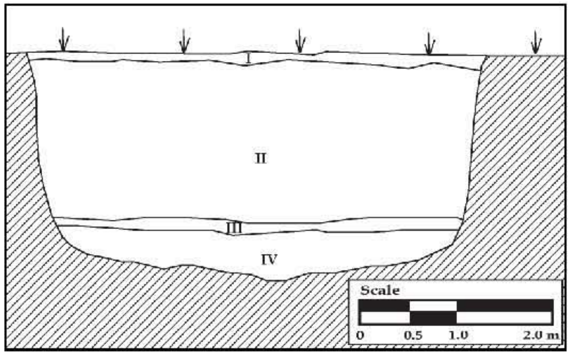


Figure 29. Test Trench 20 soil profile (south wall).

Figure 30. South wall of Test Trench 20 (view to southeast).

Table 5. Test Trench 20 Soil Descriptions

Layer	Depth (cmbs)	Description
I	0-20	Dark brown (7.5YR 3/3) silty clay; weak, medium subangular blocky; loose, slightly sticky and moderately plastic; gradual boundary; topsoil
II	10-175	Dark reddish brown (5YR 3/3) clay, medium angular blocky; slightly-sticky, moderately-plastic; clear boundary; agricultural layer (some plastic and metal)
III	165-185	Reddish brown (5YR 5/4) gravelly clay; weak, fine subangular blocky, non- sticky, and moderately plastic;
IV	180-245 (BOE)	White (2.5YR 8/1) decomposing limestone bedrock

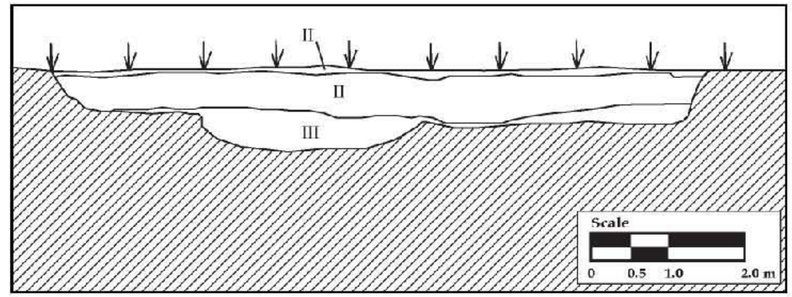


Figure 31. Test Trench 28 soil profile (south wall).

Figure 32. Test Trench 28 overview (view to east).

Table 6. Test Trench 28 Soil Descriptions

Layer	Depth (cmbs)	Description
I	0-18	Light gray (10 YR 7/1) silty loam; weak, medium subangular blocky; loose, non sticky and non plastic; clear boundary; topsoil/overburden
II	15-75	Weak red (10YR 4/2) silty clay, medium angular blocky; hard , slightly sticky and moderately plastic; contains construction debris
III	40-130(BOE)	White (2.5YR 8/1) decomposing limestone bedrock

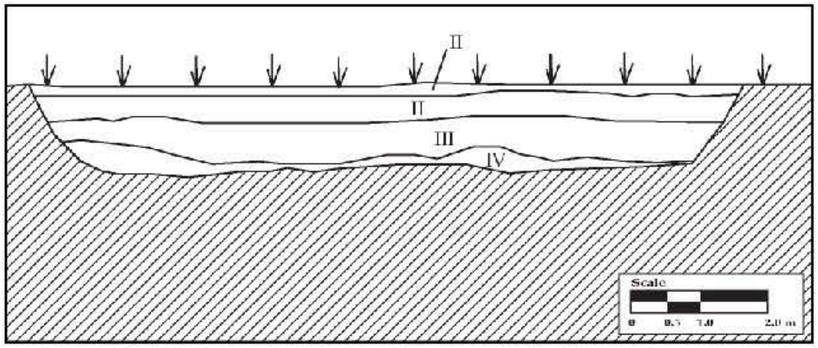


Figure 33. Test Trench 30 soil profile (south wall).

Figure 34. Test Trench 30, south wall, east end (showing coral bedrock).

Table 7. Test Trench 30 Soil Descriptions

Layer	Depth (cmbs)	Description
I	0-20	Dark reddish brown (5RY 3/3) gravelly clay; weak, medium subangular blocky; loose, slightly sticky and moderately plastic; clear boundary; topsoil/organics
II	10-50	Light gray (10YR 7/2) silt with coral gravel, fine to medium angular; hard , non-sticky, non-plastic; gradual irregular boundary; construction fill
III	45-110	Very dark grayish brown (10 YR 3/2) silty clay; weak, fine to medium subangular blocky; soft, slightly sticky, and moderately plastic; likely agricultural soil
IV	95-135 (BOE)	Pale red (10 YR 7/2) decomposing limestone bedrock, staining from clay

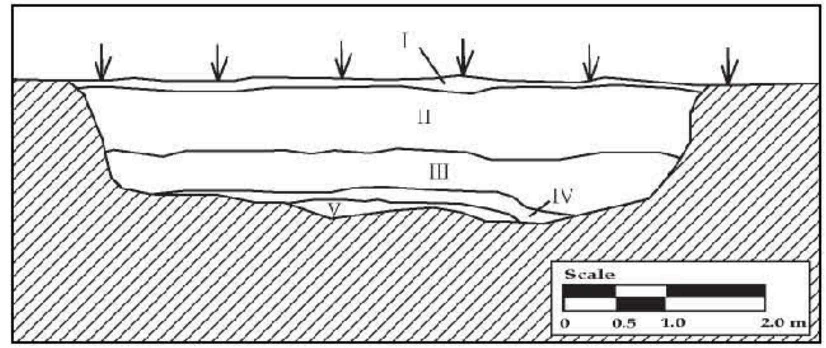


Figure 35. Test Trench 46 soil profile (north wall).

Figure 36. Test Trench 46 north wall, mid trench.

Table 8. Test Trench 46 Soil Descriptions

Layer	Depth (cmbs)	Description
I	0-23	Light gray (10YR 7/2) silt with coral gravel, fine to medium angular; hard , non-sticky, non-plastic; gradual boundary; some roots
II	15-110	White (10YR 8/1) silty coral gravel, medium angular blocky; hard , non-sticky, non-plastic; gradual boundary; construction fill
III	90-168	Reddish brown (2.5YR 5/3) clay loam; weak, fine to medium subangular blocky; soft, slightly sticky, and moderately plastic; mixed fills, gravel, and coral pebbles
IV	165-185	Reddish black (10YR 2.5/1) silty clay; fine angular; hard; sticky, and moderately plastic; possible agricultural sediment
V	181-190 (BOE)	White (2.5YR 8/1) decomposing limestone bedrock

8.2 NORTHEAST QUADRANT

A total of four test scrapes were performed, followed by 20 test trenches in the Northeast Quadrant (Figure 27). The grand majority of test scrapes for the investigation were performed in this quadrant. However, not one of these scrapes encountered the *karst* bedrock or any natural strata. After performing four test scrapes without encountering these natural layers, the mode of testing was changed to trench excavating to reveal how deep the natural layers were below the modern construction fills and agricultural soils. Test trenches in this quadrant revealed that this portion of the project area contained the deepest layers of soil above the natural strata, with the exception of Test Trench 21, located in the extreme northwest corner of the Northwest Quadrant (Figure 26).

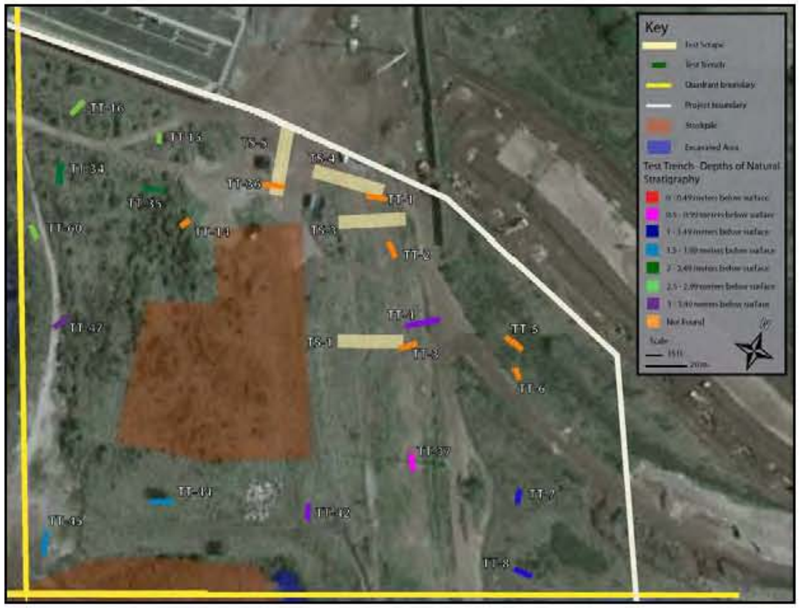


Figure 37. Northeast Quadrant (adapted from Google Earth image).

Test trench excavation depths ranged from ca. 1.15 meters below surface to ca. 3.4 meters below surface. This quadrant was found to have relatively deep sediment in its northern margin, similar to the Northwest Quadrant, consisting of construction fill and agricultural soil above the natural strata. Excavations revealed that the majority of trenches in the northern half of this quadrant encountered natural strata under sediment greater than 2.5 meters deep (Figure 38). The southern portion of this quadrant appeared to have relatively thin layers of

construction fill and/or red clay soils. Neither true sinkholes nor archaeological deposits were encountered during these test excavations. Test trenches 4 and 5 cross-cut modern trenches that appeared to contain existing, live utilities.

The natural stratigraphy was encountered in twelve out of nineteen test trenches, with depths ranging from 0.9 meters below surface to 3.5 meters below surface (Figure 39). Typically, natural sediment layers were situated above the *karst* bedrock, which was represented by either a thin layer of natural alluvium, followed by an underlying layer of decomposing limestone (Figures 44 and45; Table 12). As in the Northwest Quadrant, these natural layers followed the contours of the bedrock. The boundaries between these two layers were also irregular and gradual. The average depth of natural strata was 2.8 meters below surface. Soil profiles and soil descriptions are provided for Test Trench 4, 7, 35, and 44 (Figures 40, 42-44; Tables 9-12) and photographs for Test Trench 4 and 44 are visible in Figures 41 and 45.

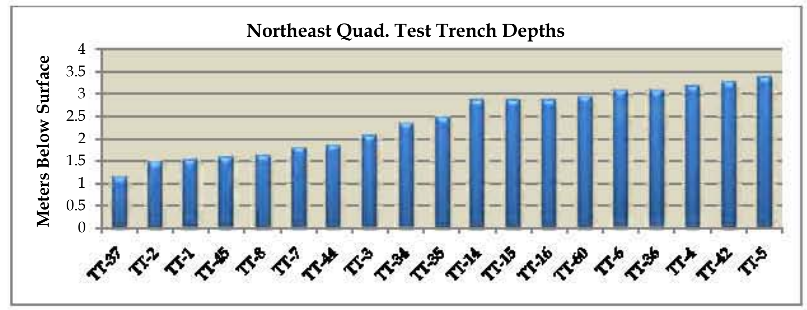


Figure 38. Overall trench depths for Northeast Quadrant.

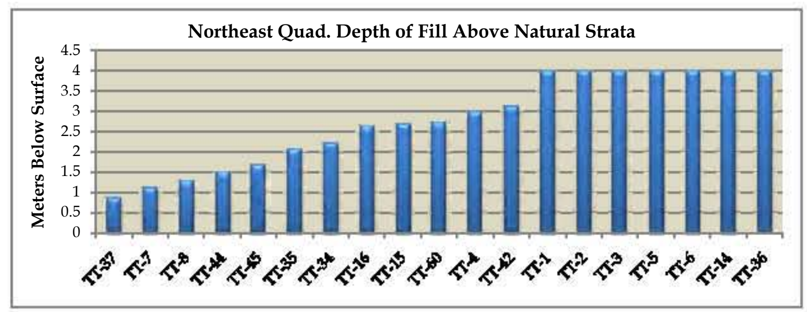


Figure 39. Depth of natural strata in Northeast Quadrant trenches.

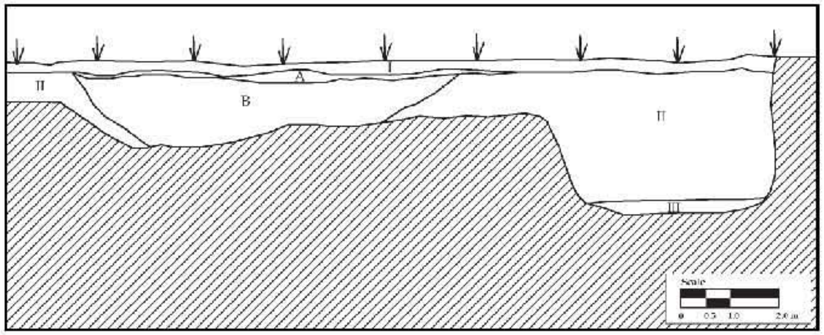


Figure 40. Test Trench 4 soil profile (east end, north wall).

Figure 41. Test Trench 4, north wall, east end (note construction fabric in cross-cut trench).

Table 9. Test Trench 4 Soil Descriptions

Layer	Depth (cmbs)	Description
I	0-23	Pale red (10YR7/3) silt with coral gravel, fine to medium angular; hard , non-sticky, non-plastic; gradual boundary; some roots
II	20-235	Dark reddish brown (5YR 3/3) clay, medium angular blocky; slightly-sticky, moderately-plastic; clear boundary; agricultural layer (with some plastic irrigation tubing)
III	300-320 (BOE)	White (2.5YR 8/1) decomposing limestone bedrock
A	15-35	**Cross-cut utility trench**: Light gray (5YR 7/1) silty gravel, medium subangular blocky; hard , non-sticky, non-plastic; clear boundary; coral fill
B	25-165 (BOE)	**Cross-cut utility trench**: White (5YR 8/1) silty gravel, medium subangular blocky; hard , non-sticky, non-plastic; clear boundary; coral fill

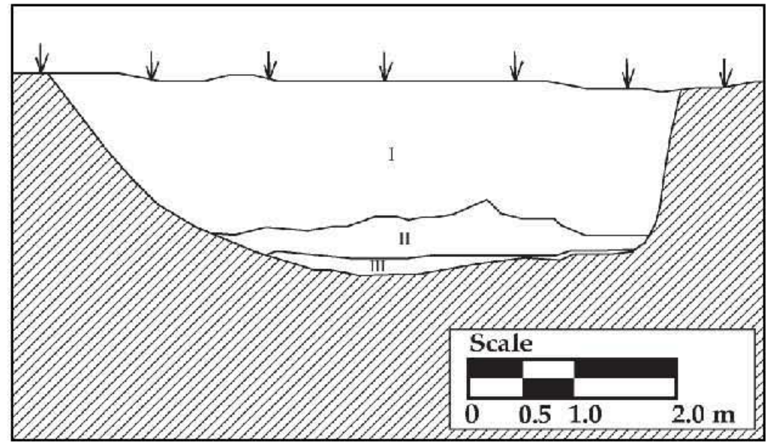


Figure 42. Test Trench 7 soil profile (east wall).

Table 10. Test Trench 7 Soil Description

Layer	Depth(cmbs)	Description
I	0-148	Dark reddish gray (5RY 4/2) loamy clay; weak, medium subangular blocky; loose, slightly sticky and moderately plastic; clear boundary; disturbed fill layer
II	125-175	Pinkish gray (5YR 7/2) silty clay with coral chunks, medium subangular blocky; soft, slightly sticky, non-plastic; clear irregular boundary; natural layer
III	170-200 (BOE)	White (2.5YR 8/1) solid limestone bedrock

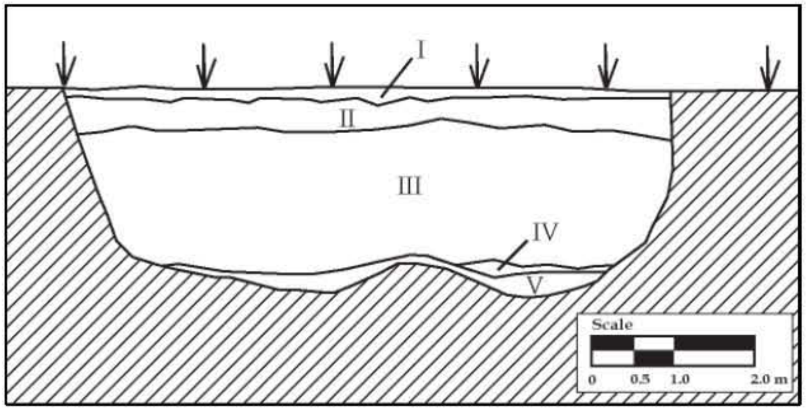


Figure 43. Test Trench 35 soil profile (north wall).

Table 11. Test Trench 35 Soil Description

Layer	Depth (cmbs)	Description
I	0-20	Light gray (10YR 7/2) silt with coral gravel, fine to medium angular; hard , non-sticky, non-plastic; clear boundary; some roots; topsoil
II	10-65	White (5YR 8/1) silty gravel, medium subangular blocky; hard , non-sticky, non-plastic; clear boundary; coral fill
III	45-270	Very dark grayish brown (10 YR 3/2) loamy clay; weak, fine subangular blocky; hard, slightly sticky, and moderately plastic; possible agricultural soil
IV	220-230	Pale red (10YR 6/4) gravelly clay; weak, fine with subangular coral gravel blocky, non-sticky, and moderately plastic;
V	205-250(BOE)	White (2.5YR 8/1) solid limestone bedrock

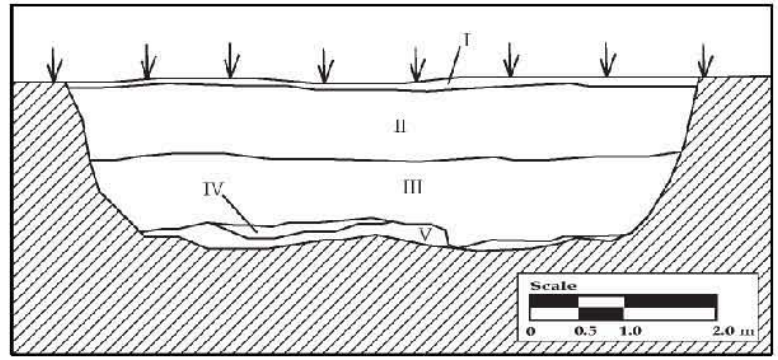


Figure 44. Test Trench 44 soil profile (south wall).

Figure 45. Test Trench 44 south wall.

Table 12. Test Trench 44 Soil Description

Layer	Depth (cmbs)	Description
I	0-12	Pale red (10YR7/3) silt with coral gravel, fine to medium angular; hard , non-sticky, non-plastic; clear boundary; some roots; topsoil
II	10-105	Light gray (10YR 7/2) coral gravel, medium angular blocky; hard , non-sticky, non-plastic; gradual irregular boundary; coral fill
III	90-175	Dark reddish brown (5YR 3/3) clay, medium angular blocky; slightly-sticky, moderately-plastic; clear boundary; agricultural layer (some plastic tubing)
IV	170-180	Pale red (10YR 6/4) gravelly clay; weak, fine with subangular coral gravel blocky, non-sticky, and moderately plastic;
V	180-185(BOE)	White (2.5YR 8/1) solid limestone bedrock

8.3 Southeast Quadrant

A total of two test scrapes and 14 test trenches were excavated in the Southeast Quadrant (Figure 46). Both of the test scrapes (numbers 2 and 6) encountered the *karst* bedrock. However, only Test Scrape 2 was interpreted as undisturbed natural strata. Test Scrape 6 appeared to have already been disturbed past the original upper horizon of the layer, likely due to bulldozing or excavations related to the Borrow Pit. Test trenches in this quadrant revealed that this portion of the project area contained the thinnest layers of fill and/or agricultural soil above the natural strata.

Figure 46. Southeast Quadrant (adapted from Google Earth image).

Test trench excavation depths ranged from ca. 0.65 meters below surface to ca. 1.8 meters below surface (Figure 47). This quadrant was found to have relatively shallow sediment in all areas not previously disturbed by construction. Generally the further south the trench, the thinner the fill or agricultural layer, except for Test Trench 10. Neither true sinkholes nor archaeological deposits were encountered during these test excavations. However, several perceived sinkholes were hand excavated in the base of Test Scrape 2, which turned out to only be depressions (≤20 cm deep) in the naturally undulating karst surface.

The natural stratigraphy was encountered in all test trenches, with depths ranging from 0.45 meters below surface to 1.1 meters below surface (Figure 48). Typically, natural sediment layers were situated above the *karst* bedrock, which was represented by either a thin layer of natural alluvium, followed by an underlying layer of decomposing limestone (Figure 49). As in the rest of the site, these natural layers followed the contours of the bedrock. The boundaries between these two layers were also irregular and gradual. The average depth of natural strata was 1.14 meters below surface.

Figures 49, 50, 52, and 53 illustrate the soil profiles of Test Trench 9, 10, 13, and 56. Tables 13-16 describe the soil observed in those profiles and Figure 51 is a photograph of the typical stratigraphy for the Southwest Quadrant as seen in Test Trench 10.

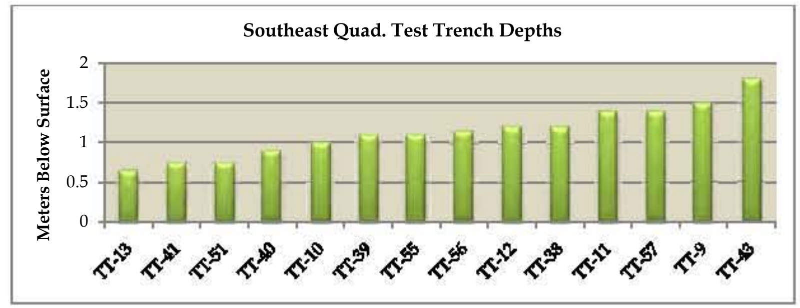


Figure 47. Overall Trench Depths for Southeast Quadrant.

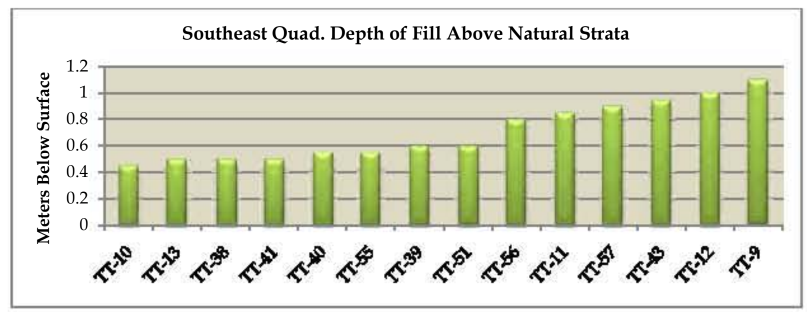


Figure 48. Depth of Natural Strata in Southeast Quadrant trenches.

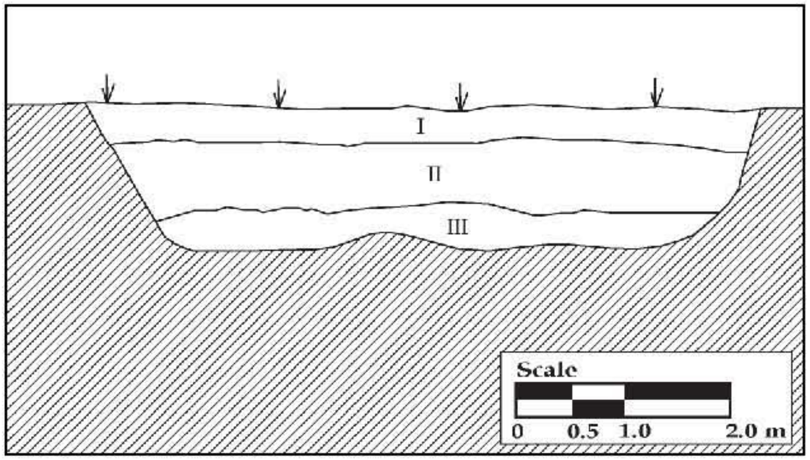


Figure 49. Test Trench 9 soil profile (east wall).

Table 13. Test Trench 9 soil descriptions

Layer	Depth (cmbs)	Description
I	0-45	Dark reddish gray (10RY 4/1) gravelly clay loam; weak, medium subangular blocky; loose, slightly sticky and moderately plastic; gradual boundary; fill layer with asphalt, gravel, plastic; organics scraped off
II	40-115	Dusky red (10YR 3/2) clay, medium angular blocky; slightly-sticky, moderately-plastic; clear boundary; agricultural layer (some plastic tubing)
III	110-150(BOE)	Pale red (10 YR 7/2) decomposing limestone bedrock, staining from clay

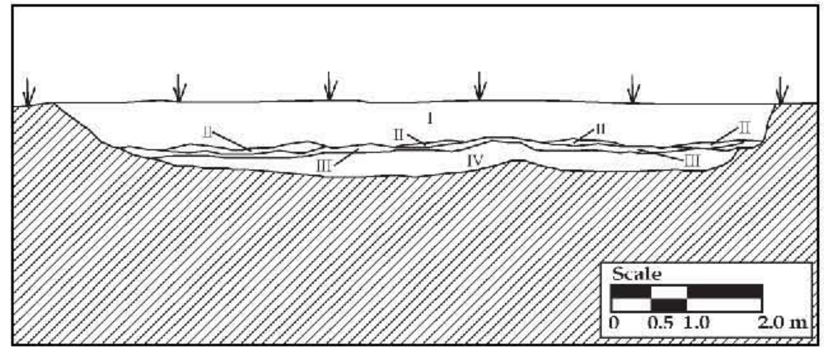


Figure 50. Test Trench 10 soil profile (south wall).

Figure 51. Test Trench 10, south wall.

Table 14. Test Trench 10 Soil Descriptions

Layer	Depth (cmbs)	Description
I	0-80	Very dusky red (10YR 2.5/2) gravelly clay; weak, medium subangular blocky; loose, slightly sticky, moderately plastic; gradual boundary; mixed fill and agricultural soil
II	77-85	Light gray (10YR 7/2) gravel, medium angular blocky; hard , non-sticky, non-plastic; clear boundary; coral fill with concrete and nails
III	80-90	Dusky red (10 YR ¾) silty gravel; weak, fine to medium subangular blocky; soft, slightly sticky, moderately plastic; possible interface of clay and decomposing bedrock
IV	70-100(BOE)	White (2.5YR 8/1) solid limestone bedrock

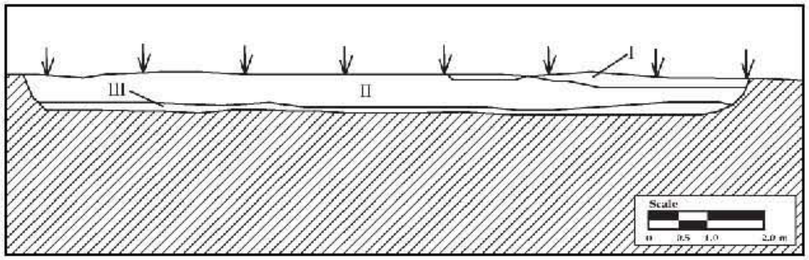


Figure 52. Test Trench 13 soil profile (east wall).

Table 15. Test Trench 13 Soil Descriptions

Layer	Depth (cmbs)	Description
I	0-30	Pale red (10YR7/3) silt with coral gravel, fine to medium angular; hard , non-sticky, non-plastic; gradual boundary; some roots
II	0-50	Light gray (10YR 7/2) gravel, medium angular blocky; soft , non-sticky, non-plastic; clear boundary; decomposing coral
III	55-65(BOE)	White (2.5YR 8/1) solid limestone bedrock

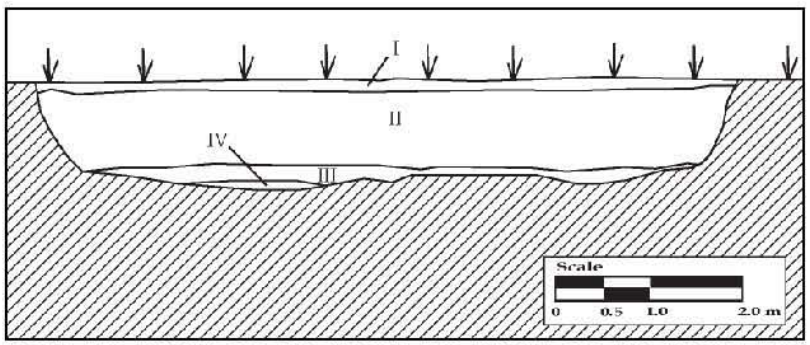


Figure 53. Test Trench 56 soil profile (east wall).

Table 16. Test Trench 56 soil description

Layer	Depth (cmbs)	Description
I	0-20	Weak red (10YR 4/2) silty clay, medium angular blocky; hard , slightly sticky and moderately plastic; contains construction debris
II	17-105	Light gray (10YR 7/2) gravel, medium angular blocky; hard , non-sticky, non-plastic; clear boundary; coral fill
III	90-115(BOE)	White (2.5YR 8/1) hard limestone bedrock

8.4 Southwest Quadrant

The least amount of testing was carried out in the Southwest Quadrant, due to the fact that the area was dominated by modern construction features, including the Borrow Pit and Stockpile 2 (Figure 54). A total of 6 Test Trenches were excavated, with all six encountering the natural strata.

Figure 54. Southwest Quadrant (adapted from Google Earth image).

Test trench excavation depths ranged from ca. 1.1 meters below surface to ca. 1.6 meters below surface (Figure 55). This quadrant was found to have relatively thin layers of sediment and very similar stratigraphy and soils as southern portion of the Northwest Quadrant. This suggests that the stratigraphy is continuous on the west side of the property between the modern construction features and the western edge.

The natural stratigraphy was encountered between 0.65 meters below surface to 1.3 meters below surface (Figure 56). In Test Trench 27, a soft deposit in the base of exaction, which was the upper horizon of the karst bedrock was hand excavated to test the notion that it may be a sinkhole. However, the soft natural alluvium was less than 40 cm deep and the depression did not exhibit the hallmarks of a sinkhole (Figure 58). Thus, neither true sinkholes nor archaeological deposits were encountered during test excavations in the Southwest Quadrant. Soil profiles and soil descriptions are provided for Test Trench 27 and 48 (Figures 57 and 59; Tables 17 and 18) and a photograph for the hand excavate area in Test Trench 27 is provided in Figure 58.

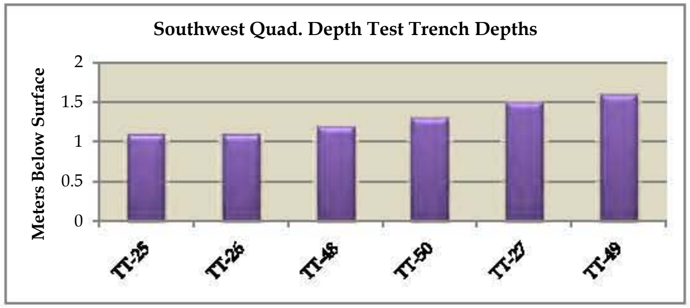


Figure 55. Overall Trench Depths for Southwest Quadrant.

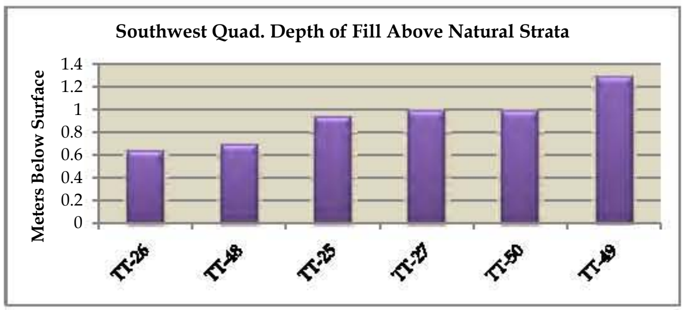


Figure 56. Depth of Natural Strata in Southwest Quadrant trenches.

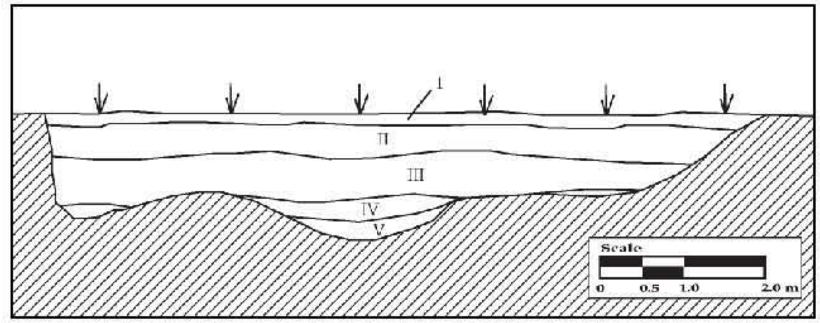


Figure 57. Test Trench 27 soil profile (west wall).

Figure 58. West wall of Test Trench 27 at hand excavated depression in bedrock.

Table 17. Test Trench 27 Soil Descriptions

Layer	Depth (cmbs)	Description
I	0-18	Light gray (10YR 7/2) silty gravel, medium angular blocky; hard , non-sticky, non-plastic; gradual boundary
II	17-65	Light gray (10YR 7/2) gravel, medium angular blocky; hard , non-sticky, non-plastic; clear boundary; coral fill
III	50-130	Dark reddish brown (5RY 3/3) clay; compacted, medium subangular blocky; loose, slightly sticky and moderately plastic; clear boundary; poss. Agricultural
IV	100-120	Pale red (10 YR 7/2) decomposing limestone bedrock, soft, staining from clay
V	115-150(BOE)	White (2.5YR 8/1) solid limestone bedrock

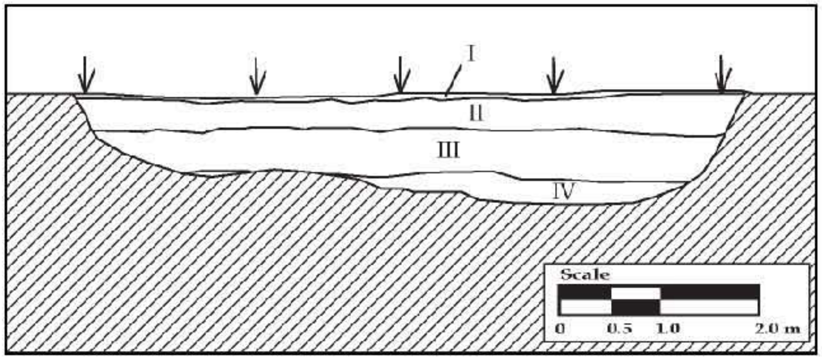


Figure 59. Test Trench 48 soil profile (west wall).

Table 18. Test Trench 48 Soil Description

Layer	Depth (cmbs)	Description
I	0-10	Pale red (10YR 6/2) silty gravel, medium angular blocky; hard , non-sticky, non-plastic; clear boundary; loose gravel mixed with Aeolian clay
II	7-55	Light gray (10YR 7/2) gravel, medium angular blocky; hard , non-sticky, non-plastic; clear boundary; coral fill
III	45-110	Very dark grayish brown (10 YR 3/2) gravelly clay; weak, fine subangular blocky; soft, slightly sticky, and moderately plastic; fill layer
V	100-120(BOE)	White (2.5YR 8/1) hard limestone bedrock

9.0 SUMMARY AND RECOMMENDATIONS

The 'Ewa Plain of Honouliuli Ahupua'a has a long and complex history, which is apparent from archival research and archaeological investigations carried out in the last 30 years. Archival research has allowed a glimpse of the varied lifeways on the plain. Peripheral areas, especially those bordering Pearl Harbor, offered rich natural resources for fishing and gathering and the perfect matrix for fruitful agriculture in pre-Contact times. Yet, central plain areas presented scant resources needed for survival. Traditional accounts echo this disparity in 'Ewa Plain resources. Local mythology and lore suggest that the entire region is has been the stage for legendary tales and the home of many mystical beings as well as *ali'i*. Archaeological investigations have shown that much of the area's cultural resources have been disturbed by sugar plantation activities. However, the most common features in this area are agricultural features and sinkholes containing archaeological and paleontological resources. Due to historic sugar cane and sisal cultivation activities as well as plantation related infrastructure development, features such as these have likely been covered with sediment, encapsulating them and obscuring their locations. The area's more recent past is also significant in understanding the region's economic evolution as well as local cultural dynamics and identities.

The surface survey yielded no archaeological sites. Rather, the project area exhibited signs of continuous disturbances in the form of construction excavations, bulldozing, and dumping. Further, there appeared to be a significant amount of modifications to the land in the form of jumps, tracks, roads, and berms, to help facilitate modern off-roading for off-road vehicles (ORV) and all-terrain bicycles, which are likely non-authorized activities.

While no archaeological sites nor true sinkholes were encountered during this investigation , test excavations revealed that the project area, omitting the borrow pit and other previously excavated areas, is overlain with 0.45 to more than 3.7 meters of sediment relating to modern construction and/or sugar cane cultivation. This is contrary to the previous assumption that the current substrate was all ready graded down to the *karst* bedrock, or within 8 inches of the karst. Further, the study was able to discern areas that appear to have relatively deep layers of modern fill, and conversely, areas where the natural strata is relatively shallow.

Given the lack of finding any archaeological resources or even finding evidence of sinkholes within the project area, we conclude that no further archaeological work is necessary within this area. However, in the event that limestone bedrock (*karst*) is encountered during construction activities, work in this area should halt and a qualified archaeologist should be summoned to the site to monitor excavations in the limestone areas. If any filled and buried sinkholes are encountered during these construction excavations, they should be archaeologically investigated to determine if they contain potentially significant archaeological deposits, including human burials. If at any time during construction potentially significant archaeological remains are encountered, work in the immediate vicinity should halt and the State Historic Preservation Division should be contacted (808-692-8015).

10.0 REFERENCES

Ahlo, Hamilton M Jr. and Robert J. Hommon

1983 *An Archaeological Reconnaissance Survey of the Site of the Proposed Solid Waste Processing and Resource Recovery Facility, Honouliuli, Ewa, O'ahu.* Report on File at the Historic Preservation Division Library, Kapolei.

1984 *Archaeological Test Excavations at the Site of the Proposed Solid Waste Processing and Resource Recovery Facility, Honouliuli, Ewa, O'ahu.* Report on File at the Historic Preservation Division Library, Kapolei.

Allen, Jane

1990 Geology, Soils, and Sediment at Barbers Point, O'ahu. In Paul L. Cleghorn and Bertell D. Davis (editors), *Archaeological Paleontological Investigation at Kalaeloa (Barber's Point), Honouliuli, 'Ewa, O'ahu.* Public Archaeology Section, Applied Research Group, Bishop Museum, Honolulu.

Armstrong, Warwick (ed.)

1973 *Atlas of Hawai'i.* University of Hawai'i Press, Honolulu.

Barrera, William Jr.

1975 *A Report on the Archaeological Reconnaissance Survey of the Proposed Barber's Point Harbor Area.* Report on File at the Historic Preservation Division Library, Kapolei.

Bath, Joyce

1989 *Burial of Hō'ae'ae Point in West Loch Project Area, Honouliuli, 'Ewa, O'ahu.* Department of Land and Natural Resources, State Historic Preservation Division, Kapolei, Hawai'i.

Beckwith, Martha

1970 *Hawaiian Mythology*. University of Hawaii Press, Honolulu, Hawai'i.

Belt Collins

2006 Kalaeloa Master Plan. Prepared for the Hawai'i Community Development Authority (HCDA) and U.S. Economic Development Administration (EDA).

Bishop, S.E.

1835 "Ewa 1835." *O'ahu Station Reports – 'Ewa to Wai'anae, from 1835-1863.* On File at the Hawaiian Historical Society Library.

1841 "Report of the Station of Ewa and Waianae for the year ending April 30th 1841" *O'ahu Station Reports –'Ewa to Wai'anae, from 1835-1863.* On File at the Hawaiian Historical Society Library.

1846 "Report of the Station of Ewa and Wai'anae for the 2 years Ending May 1, 1846" *O'ahu Station Reports –'Ewa to Wai'anae, from 1835-1863.* On File at the Hawaiian Historical Society Library.

1901 'Ewa, O'ahu– Old Memories. *The Friend*: May 1901: 87.

Bordner, Richard M.

1977 *Archaeological Reconnaissance of the Proposed Makaiwa Gulch Landfill Site, 'Ewa, O'ahu.* Archaeological Research Center Hawai'i, Inc., Honolulu.

Campbell, Archibald

1819 *Voyage Round the World from 1806-1812*, New York.

Campbell, S. M.

1994 "Ewa Plantation Company History," Hawaiian Sugar Planters Association. University of Hawaii, Manoa Website. Viewed on January 22, 2002. http://www2.hawaii.edu/~speccoll/p_ewa.html

Chamberlain, Levi

Ms. Journals of Levi Chamberlain, 1822-1849, in Bishop Museum.

Chervet-Pond, A. and B. D. Davis

1992 *West Beach Data Recovery Program, Phase 4, Archaeology and Paleontological Excavations, 2 vols. Report for West Beach Estates.* Paul H. Rosendahl, Ph. D., Inc., Hilo.

Cline, M.G.

1955 Soil Survey of the Territory of Hawai'i. *Soil Survey Series 1939*, No. 25. United States Department of Agriculture.

Collins, S. and Muffet Jourdane

2005 *Recovery of Inadvertent Discovered Skeletal Remains Adjacent to 91-2168 Old Ft. Weaver Road (Site: 50-80-04-06665; SHPD Case #2004-1-0003-001) Honouliuli, 'Ewa, O'ahu TMK: (1) 9-1-017:061; (9-1-019:001 Tanaka Residence).* Report on File at the Historic Preservation Division Library, Kapolei.

Cordy, Ross

1996 The Rise and Fall of the O'ahu Kingdom: A Brief Overview of O'ahu's History. In J.M. Davidson, G. Irwin, B.F. Leach, A. Pawley, and D. Brown (editors) *Oceanic Culture History: Essays in Honour of Roger Green.* New Zealand Journal of Archaeology Special Publication, pp. 591-613.

Cuddihy, L. W. and C.P. Stone

1990 *Alteration of Native Hawaiian Vegetation, Effects of Humans, Their Activities and Introductions*. Honolulu: University of Hawaii Cooperative National Park Resources Studies Unit.

Davis, Bertell D.
1988 *Final Report Archaeological Subsurface Survey of the Proposed ʻEwa Gentry Project Area, Honouliuli, ʻEwa, Oʻahu*. Bernice P. Bishop Museum: Honolulu.

1979 *Report on Archaeological Survey of the Proposed Ewa-Marina Community Development, Ewa Beach, Oʻahu Island, Hawaii.* Report on File at the Historic Preservation Division Library, Kapolei.

1990 Summary and Conclusion of the 1981-1983 Barber's Point Research. In *Archaeological and Paleontological Investigations at the Barber's Point Deep Draft Harbor, ʻEwa, Oʻahu*. B.P. Bishop Museum. (P. Cleghorn and B. Davis, eds.)

1995 *Archaeological and Paleontological Investigations at the Barber's Point Deep Draft Harbor, ʻEwa District, Honouliuli Ahupuaʻa Oʻahu Island, Hawaiʻi, Volume I*. Report on File at the Historic Preservation Division Library, Kapolei.

Dicks, Merrill A., Alan E. Haun, and Paul H. Rosendahl
1987 *Archaeological Reconnaissance Survey for EIS, West Loch Estates – Golf Course and Parks, Honouliuli, Ewa, Oʻahu.* Report on File at the Historic Preservation Division Library, Kapolei.

Emerson, N. D.
1978 *Pele and Hiiaka: a Myth from Hawaii*. Originally published 1915. Charles E. Tuttle, Rutland.

Emory, Kenneth
1933 *Field Notes from Honouliuli Archaeological Survey*. Department of Anthropology, Bishop Museum, Honolulu.

Foote, D. E., E. L. Hill, S. Nakamura, and F. Stephens
1972 *Soil Survey of the Islands of Kauai, Oʻahu, Maui, Molokai, and Lanai, State of Hawaii*. U.S. Dept. Agriculture-Soil Conservation Service and University of Hawaiʻi Agriculture. Experiment Station. Government Printing Office, Washington, D.C.

Fornander, Abraham
1880 *An account of the Polynesian Race: Its Origin and Migrations and the Ancient History of the Hawaiian People to the Times of Kamehameha I*. Volume II. Trubner, London.

1919 *Fornander Collection of Hawaiian Antiquities and Folklore…from Original Sources.* Thomas G. Thrum (ed.), B.P. Bishop Museum Memoirs. Vols. IV, V. Honolulu, Hawai'i.

Fung Associates, Inc.
2009 Inventory and Condition Assessments of Historic Structures in 'Ewa Villages Historic District, Island of Oʻahu. Prepared for State of Hawaii Department for Land and Natural Resources State Historic Preservation Division.

Gabbard, Mike
2007 *In Memory of WWII Honouliuli Internees*. In Senate Majority Caucus Blog Archive online. 9 December 2007. Accessed on 9 July 2008. http://www.hawaiisenatemajority.com/2007/12/09/in-memory-of-wwii-honouliuli-internees/.

Geolabs – Hawaiʻi
1987 *Geotechnical Engineering Reconnaissance, West Loch Estates Development, Honouliuli, Oʻahu, Hawaiʻi*. C.W. Associates Inc. dba Geolabs – Hawaiʻi, Honolulu. Prepared for R.M. Towill Corporation.

Goodman, W.L. and P. Cleghorn
1991 *Historical Documents and Literature Search, and Archaeological Surface Survey of the Proposed Laulani City Housing Project at Puʻuloa, ʻEwa, Oʻahu Island*. Prepared for William E. Wanket, Inc. Applied Research Group, Bishop Museum, Honolulu.

Hall, Edwin Oscar
1839 *Notes of a Tour Around Oʻahu*. Hawaiian Spectator, Vol. 2: 94-112. Honolulu.

Hammatt, Hallett H.
1984 *Reconnaissance and Evaluation of Archaeological Sites in the Proposed Ewa Marina Community, Ewa, Oʻahu, Hawaii.* Report on File at the Historic Preservation Division Library, Kapolei.

Hammatt, Hallett H. and David W. Shideler
1991 *Archaeological Inventory Survey for a Proposed Expansion of Saint Francis Medical Center West (TMK 9-7-17: por. 56), Honouliuli, ʻEwa, Oʻahu*. Report on File at the Historic Preservation Division Library, Kapolei.

Hammatt, Hallett H. and Rodney Chiogioji
1997 *Archaeological Reconnaissance Survey of a 4.5-Kilometer (14,730-ft.) Long Land Corridor Within Honouliuli Ahupua'a, ʻEwa District, Oʻahu Island.* Cultural Surveys Hawaiʻi, Kailua. Report on File at the Historic Preservation Division Library, Kapolei.

Hammatt, Hallett H. and William H. Folk, II
1981 *Archaeological and Paleontological Investigation at Kalaeloa (Barber's Point), Honouliuli, ʻEwa, Oʻahu: Federal Study Areas 1a and 1b and State of Hawaii Optional Area 1*. Report on File at the Historic Preservation Division Library, Kapolei.

Hammatt, Hallett H., David W. Shideler, and William Folk
1990 *Archaeological Reconnaissance of the ʻEwa Villages Project Site, Honouliuli, ʻEwa, Oʻahu.* Cultural Surveys Hawaiʻi, Kailua, Hawaiʻi.

Hammatt, Hallet H., Jennifer Robbins, Mark Stride, and Matthew McDermott
1991 *An Archaeological Inventory Survey for the Makaiwa Hills Project Site, Honouliuli, ʻEwa, Oʻahu*. Cultural Surveys Hawai'i, Kailua.

Handy, E.S.C.
1940 *The Hawaiian Planter*, Vol. I: B.P. Bishop Museum Bulletin 161.

Haun, Allen E.
1991 *An Archaeological Survey of the Naval Air Station Barber's Point, O'ahu, Hawai'i*. Department of Anthropology, B.P. Bishop Museum, Honolulu.

Hawai'i Aviation
2011 "Ewa Field Auxiliary Base, July 29, 1941" and "Ewa Plantation Locomotive #6, 1926" photographs from the Hawaiian Aviation website. Accessed August 2011. State of Hawai'i Department of Transportation, Airports Division. http://hawaii.gov/hawaiiaviation/aviation

Hommon, R.J., and H.M. Ahlo, Jr.
1983 *Archaeological Survey and Subsurface Testing in Selected Areas of the Proposed Ewa Marina Community Development.* Science Management Inc.

Jensen, Peter M., Alan E. Haun, and Paul Rosendahl.
1988 *Phase I – Mitigation Plan for Archaeological Data Recovery Excavations: West Loch Estates Mitigation Program Residential Increment I and Golf Course and Shoreline Park, Land of Honouliuli, Ewa District, Island of O'ahu.* Report on File at the Historic Preservation Division Library, Kapolei.

Jensen, P.M. and J.A. Head
1995 *Pre-final Report: Phase I Archaeological Reconnaissance Survey, Naval Magazine Lualualei, NAVMAG – West Loch, Lands of Pu'uloa, Honouliuli, Waikele, and Waipi'o, 'Ewa District, Island of O'ahu*. PHRI Report 1547-041995. Prepared for Department of the Navy, Commander, Pacific Division, Naval Facilities Engineering Command.

Jourdane, E.
1979 *Archaeological Reconnaissance Survey of Proposed Ewa Marina Cove. Campbell Estate Properties, Oneula, Honouliuli, O'ahu, Hawai'i.* Report 03-0979. B.P. Bishop Museum.

Juvik, Sonia P. and James O. Juvik (ed.)
1998 *Rainfall Atlas of Hawai'i.* Third Edition. University of Hawai'i Press, Honolulu.

Kamakau, S.M.
1961 *Ruling Chiefs of Hawaii*. Revised Edition. Originally published 1868-1870. The Kamehameha Schools Press, Honolulu, Hawai'i.

1964 *Ka Po'e Kahiko: the People of Old.* Bishop Museum Special Publication d1. Originally published 1866-1871. Bishop Museum Press, Honolulu, Hawai'i.

1991 *Tales and Traditions of the People of Old: Na Mo'olelo Ka Po'e Kahiko*. Originally published 1865-1869. Bishop Museum Press, Honolulu, Hawai'i.

Kelly, Marion
1991 Notes on the History of Honouliuli. Appendix A In *An Archaeological Survey of the Naval Airstation, Barber's Point, O'ahu, Hawai'i.* By Alan E. Haun. Applied Research Group. Bishop Museum, Honolulu.

Kennedy, Joseph
1988 *Archaeological Reconnaissance Report Concerning the Proposed 'Ewa Gentry Project in Honouliuli, O'ahu.* Archaeological Consultants of Hawai'i.

Kennedy, J. and T. Denham.
1992 *Archaeological Data recovery Report for the Puuloa Golf Course located at 'Ewa, Island of O'ahu, TMK: 9-1-01:27 and 6.* Revised May 1992. Archaeological Consultants of Hawaii, Inc., Hawaii.

Kennedy, J., J. Berlin and T. Denham.
1991 *Archaeological Inventory Survey Report for the Puuloa Golf Course Site, TMK: 9-1-01: 27 and 6, located at 'Ewa, Island of O'ahu.* Archaeological Consultants of Hawai'i, Inc., Hawaii.

Kikuchi, William K.
1959 *Standard Oil Refinery Site Letter Report.* Bernice P. Bishop Museum, Honolulu.

Kuykendall, Ralph S.
1967 *The Hawaiian Kingdom, Volume III, 1874-1893: The Kalākaua Dynasty.* University of Hawai'i Press, Honolulu.

Landrum, J., S. Williams, and A.J. Schilz
1993 *Archaeological Reconnaissance and Limited Subsurface Testing at the Proposed Family Housing Construction Area Project No. 34863, Barbers Point Naval Air Station, Honouliuli Ahupua'a, 'Ewa District, O'ahu, Island.* Ogden Environmental and Energy Services, Honolulu.

Lewis, Ernest
1970 *The Campbell Project: a Preliminary Report.* Report on file in the State Historic Preservation Division Library, Kapolei.

MacDonald, G.A. and A.T. Abbott
1970 *Volcanoes in the Sea*. University of Hawai'i Press, Honolulu.

Manhoff, M. and M. Uyehara
1976 *Rockhounding in Hawai'i: Our Rocks, Minerals, and Semi-precious Stones.* Honolulu: Hawaiian Almanac Publishing Co.

Maly, Kepā
1992 Historical Documentary Research. In *Archaeological Reconnaissance Survey, Naval Magazine Lualualei, NAVMAG – West Loch, Lands of Pu'uloa, Honouliuli, Waikele, and Waipio, District of 'Ewa, Island of O'ahu*. By Peter M Jensen and James Head, pg. 7-59. Paul Rosendahl, Ph.D., Inc., Hilo, Hawai'i.

1997 Historical Documentary Research. In *Archaeological Reconnaissance Survey, Naval Magazine Lualualei, NAVMAG – West Loch, Lands of Pu'uloa, Honouliuli, Waikele, and Waipi'o, 'Ewa District, Island of O'ahu.* PHRI Report 1547-041995. Prepared for Department of the Navy, Commander, Pacific Division, Naval Facilities Engineering Command.

1999 *Phase III – Archaeological Site Preservation Plan Phased Mitigation Program 'Ewa Marina Community Project Land of Honouliuli, 'Ewa District, Island of O'ahu.* Prepared for HASEKO ('Ewa), Inc., Honolulu, Hawai'i. Paul H. Rosendahl, Ph.D., Inc., Hilo, Hawaii.

McAllister, J.G.
1933 *Archaeology of O'ahu.* B.P. Bishop Museum Bulletin 104. Bishop Museum Press: Honolulu.

McCoy, Patrick
1972 *Archaeological Survey of the Proposed Pu'uloa Elementary School Site, 'Ewa Beach, O'ahu.* Bernice P. Bishop Museum, Dept. of Anthropology, Honolulu.

McIntosh, James and Paul L. Cleghorn
2003 *Archaeological Survey for the Proposed 'Ewa Gentry Makai Development 'Ewa District, Ahupua'a of Honouliuli, Island of O'ahu (TMK 9-1-10:7 and 9-1-69-5).* Pacific Legacy, Inc., Kailua, Hawai'i.

Miller, Lynn
1993 *Archaeological Data Recovery of State Sites 50-80-12-2710 and 50-80-12-2711 at Barber's Point, Honouliuli Ahupua'a 'Ewa district, O'ahu Island.* Prepared for R.H.S. Lee, Inc. Report on File at the Historic Preservation Division Library, Kapolei.

Mitchell, Auli'i and Hallett H. Hammatt
2004 *A Cultural Impact Assessment of Approximately 595 Acres at Kapolei, Honouliuli Ahupua'a, 'Ewa District of O'ahu.* Prepared for Helber Hastert and Fee Planners, Inc. Report on file at the Historic Preservation Division Library, Kapolei.

Mooney, Kimberly M. and Paul L. Cleghorn
2007a *Archaeological Assessment for the Proposed Imperium Renewable Bio-Diesel Plant at Barber's Point, Honouliuli, 'Ewa, O'ahu [TMK (1) 9-1-14:24].* Pacific Legacy, Inc., Kailua. Report on file at the Historic Preservation Division Library, Kapolei.

2007b *Cultural Impact Assessment for the Proposed Imperium Renewable Bio-Diesel Plant at Barber's Point, Honouliuli, 'Ewa, O'ahu [TMK (1) 9-1-14:24].* Pacific Legacy, Inc., Kailua.

2008a *Archaeological Assessment for the Proposed Makakilo Quarry Expansion, Kapolei, Honouliuli Ahupua'a, 'Ewa O'ahu[TMK (1) 9-2-3:18].* Pacific Legacy, Inc., Kailua. Report on file at the Historic Preservation Division Library, Kapolei.

2008b *Cultural Impact Assessment for the Proposed Makakilo Quarry Expansion, Kapolei, Honouliuli Ahupua'a, 'Ewa O'ahu[TMK (1) 9-2-3:18].* Pacific Legacy, Inc., Kailua.

2008c *Archaeological Assessment for the Proposed Development of two parcels between Fort Weaver Road and Old Fort Weaver Road, Honouliuli Ahupua'a, 'Ewa, O'ahu TMK: (1) 9-1-17: 010 and 041.* Pacific Legacy, Inc., Kailua. Report on file at the Historic Preservation Division Library, Kapolei

2008d *Cultural Impact Assessment for the Proposed Development of two parcels between Fort Weaver Road and Old Fort Weaver Road, Honouliuli Ahupua'a, 'Ewa, O'ahu TMK: (1) 9-1-17: 010 and 041.* Pacific Legacy, Inc., Kailua.

2008e *Cultural Impact Assessment for the Proposed Development of Kroc Center in East Kapolei, Honouliuli Ahupua'a, 'Ewa District, Island of O'ahu [TMK: 9-1-17: 71].* Pacific Legacy, Inc., Kailua.

2008f *Archaeological Monitoring Report for the Ke Kama Pono Facility at York Town Road, Kalaeloa, Honouliuli Ahupua'a, O'ahu, Hawai'i [Tmk (1) 9-1-13:24].* Pacific Legacy, Inc., Kailua. Report on file at the Historic Preservation Division Library, Kapolei.

2011 *Revised Archaeological Inventory Survey of Varona Village, Honouliuli Ahupua'a, 'Ewa District, Island Of O'ahu [Tmk: (1) 9-1-17:069].* Pacific Legacy, Inc., Kailua. Report submitted for review to the Historic Preservation Division Library, Kapolei.

Moore, James R. and Joseph Kennedy
2002 *An Archaeological Archival Research Report for the 'Ewa Nonpotable Water System, Honouliuli Ahupua'a, 'Ewa District, Island of O'ahu.* Archaeological Consultants of the Pacific, Inc., Haleiwa, Hawai'i.

Moy, Tonia
1995 'Ewa Sugar Plantation Villages Registration Forms (OMB No. 1024-001). United States Department of the Interior, National Park Service, National Register of Historic Places. On file at the Historic Preservation Department.

Nakamura, Barry S., Jeffrey Pantaleo, and Aki Sinoto
1993 *Archaeological Inventory Survey of Proposed Development Parcels D and D-1 Makakilo, Honouliuli ahupua'a 'Ewa District, O'ahu Island (TMK 9-2-3:18 POR.; 75 POR.; 81 POR.).* Prepared for LandPlan Associates, Kailua, Hawai'i . Aki Sinoto Consulting, Honolulu. Report on File at the Historic Preservation Division Library, Kapolei.

National Park Service
1990 'Ewa Plantation Historic District Registration Forms (OMB No. 10024-0018; October 1990). United States Department of the Interior, National Park Service, National Register of Historic Places. On file at the Historic Preservation Department.

O'Hare, Constance R., David W. Shideler, and Hallett H. Hammett
2006 *An Archaeological Inventory Survey for the Ho'opili Project, Honouliuli Ahupua'a, 'Ewa District, Island of O'ahu. TMK: (1) 9-1-010:002, 9-1-017:004, 059, 072; 9-1-018:001, 004; 9-2-002:004, 005.* Cultural Surveys Hawaii. Prepared for D. R. Horton – Schuler Division. Report on File at the Historic Preservation Division Library, Kapolei.

2007 *Archaeological Assessment of the 'Ewa Industrial Park Project, Honouliuli Ahupua'a, 'Ewa District, O'ahu Island. TMK: (1) 9-1-069:003.* Cultural Surveys Hawai'i. Prepared for Mr. Valentine Peroff, Jr. Report on File at the Historic Preservation Division Library, Kapolei.

Pagliaro, Penny
1987 Ewa Plantaion: An Historical Survey, 1890 to 1940. Report on File at the Historic Preservation Division Library, Kapolei.

Pukui, Mary Kawena
1943 *Ke Awa Lau o Pu'uloa: The Many-Harbored Sea of Pu'uloa.* Hawaiian Historical Society Report 52: 56-62.

1983 *'Olelo No'eau: Hawaiian Proverbs and Poetical Sayings.* Bernice P. Bishop Museum Special Publication No. 71, Bishop Museum Press, Honolulu.

Pukui, Mary K., Samuel H. Elbert, and Esther Mookini
1974 *Place Names of Hawai'i.* University of Hawai'i Press, Honolulu.

Rasmussen, Coral
2006 Archaeological *Assessment for Makakilo, Honouliuli Ahupua'a, Island of O'ahu, TMK (portions) 9-2-003:081, (1) 9-2-019:003, 072, 081, 084, 085.* Prepared for D.R. Horton-Schuler Division. International Archaeological Research Institute, Inc. Honolulu. Report on File at the Historic Preservation Division Library, Kapolei.

Rosendahl, P.H.
1987 *Archaeological Reconnaissance Survey for Environmental Impact Statement, West Loch Estates – Residential Increments I and II.* PHRI Report 322-040787. Prepared for the City and County of Honolulu. (September).

Schoofs, Robert
1978 *Pioneers of the Faith: History of the Catholic Mission in Hawai'i (1827-1940).* Revised by Fay Wren Midkiff. Second Printing. Sturgis Printing Co. Inc., Hawai'i.

Silva, Carol
1987 Historical Documentary Research – West Loch Estates Project Area. In *Archaeological Reconnaissance Survey for Environmental Impact Statement, West Loch Estates Golf Course and Parks, Honouliuli, 'Ewa, O'ahu.* By Merrill A. Dicks, Alan E. Haun, and Paul H. Rosendahl, Appendix A. Paul H. Rosendahl, Ph.D., Inc., Hilo, Hawai'i.

Sinoto, Aki
1976 *A Report on Cultural Resources Survey at Barber's Point, Island of O'ahu. Manuscript 122476.* Department of Anthropology, B.P. Bishop Museum, Honolulu. Report on File at the Historic Preservation Division Library, Kapolei.

1978a *Archaeological and Paleontological Salvage at Barber's Point, O'ahu. Manuscript 030278.* Department of Anthropology, B.P. Bishop Museum, Honolulu. Report on File at the Historic Preservation Division Library, Kapolei.

1978b *Archaeological Reconnaissance Survey and Salvage of Burial at NAVMAG Lualualei, West Loch Branch, O'ahu Island.* Cultural Surveys Hawai'i, Inc. Kailua, Hawai'i.

1979 *Cultural Resources Survey of New Dredged Material Disposal Sites at Barbers Point, O'ahu, Hawai'i. Manuscript 050179.* Department of Anthropology, B.P. Bishop Museum, Honolulu. Report on File at the Historic Preservation Division Library, Kapolei.

1988 *Surface Survey of the Proposed Makakilo Golf Course, 'Ewa, O'ahu.* TMK 9-2-03:18. Bernice P. Bishop Museum, Department of Anthropology, Honolulu.

Smith, L.
1835 "Ewa 1835." *O'ahu Station Reports – 'Ewa to Waianae, from 1835-1863.* On File at the Hawaiian Historical Society Library.

Soehren, Lloyd
1962 *Burial Recording, Secondary Internment in Sinkhole.* In O'ahu Sites folder , Department of Anthropology and Education, B.P. Bishop Museum, Honolulu.

1966 *Recording and Excavation at Possible Fishing Shrine.* (Site 50-Oa-B6-13) In O'ahu Sites folder , Department of Anthropology and Education, B.P. Bishop Museum, Honolulu.

Stearns, H.T.
1946 *Geology of the Hawaiian Islands.* Division of Hydrography Bulletin 8. Territory of Hawai'i.

1978 *Quaternary Shorelines in the Hawaiian Islands*. Bernice P. Bishop Museum Bulletin 237. Bishop Museum Press, Honolulu.

Stearns, H.T. and K.N. Vaksvik
1935 *Geology and Groundwater Resources of the Island of O'ahu, Hawai'i*. Bulletin 1, Division of Hydrology, Territory of Hawai'i, Honolulu.

Sterling, E.P. and C.C. Summers
1978 *Sites of O'ahu*. Bishop Museum Press, Honolulu, Hawai'i.

Stokes, John F.
1909 *Walled Fish Traps of Pearl Harbor*. Occasional Papers of the Bishop Museum. 4(3): 199-212.

Thrum, T.
1906 Heiaus and Heiau Sites Throughout the Hawaiian Islands. *Hawaiian Almanac and Annual for 1907*. T.G. Thrum, Honolulu.

1907 Heiaus and Heiau Sites Throughout the Hawaiian Islands. *The Hawaiian Almanac and Annual for 1908*. Honolulu.

1917 List of Heiaus and Sites. *Hawaiian Almanac and Annual or 1918*. Pacific Commercial Advertiser, Honolulu.

1923 *More Hawaiian Folk Tales*. , Chicago.

Tuggle, David H. and M.J. Tomonari-Tuggle
1997 *Synthesis of Cultural Resource Studies of the 'Ewa Plain. Task 1a: Archaeological Research Services for the Proposed Cleanup, Disposal and Reuse of Naval Air Station Barbers Point, O'ahu, Hawai'i*. International Archaeological Research Institute, Inc. Prepared for Belt Collins Hawaii.

U. S. Department of Agriculture (USDA)/Natural Resources Conservation Service (NRCS)
2011 *Custom Soil Resource Report for Island of Oahu, Hawaii: Ka Makana Alii Project Area.* A Publication of Web Soil Survey. Produced 6/30/2011online at http://websoilsurvey.nrcs.usda.gov/. Copy available upon request.

Vancouver, G.
1798 *A Voyage of Discovery to the North Pacific Ocean, and Round the World*. 3 Volumes. Robinson and Edwards, London, England.

Welch, David J.
1987 *Archaeological Reconnaissance of Former Ewa Marine Corps Air Station, Barbers Point Naval Air Station, O'ahu, Hawai'i*. International Archaeological Research Institute, Inc., Honolulu.

Westervelt, William D.
1963 *Legends of Old Honolulu*. Collected and Translated from the Hawaiian by W.D. Westervelt. Press of George H. Ellis Co., Boston.

Wilson, Christie
2008 "Clues Sought to Honouliuli's Dark Past." The Honolulu Advertiser. 17 February 2008: A1.

Wolforth, Thomas R. and Warren Wulzen
1998 *Archaeological Data Recovery at West Loch Estates Residential Increment I, and Golf Course and Shoreline Park, Land of Honouliuli, 'Ewa District, Island of O'ahu*. Paul Rosendahl, Ph.D., Inc. Prepared for City and County of Honolulu. Report on File at the Historic Preservation Division Library, Kapolei.

Zeigler, Alan C.
2002 *Hawaiian Natural History, Ecology, and Evolution*. University of Hawai'i Press. Honolulu.

11.1 HISTORIC MAPS

Alexander, W. D.
1873 "Map of Honouliuli, O'ahu" Reg. No. 618, Hawai'i State Survey Office.

Malden, Leroy C.R.
1825 "Sandwich Islands, South Coast of Woahoo" Reg. No. 640, Hawai'i State Survey Office.

Monsarrat, M.D.
1878 "Map of Honouliuli Taro Land, Ewa, O'ahu" Reg. No. 630, Hawai'i State Survey Office.

APPENDIX A

Archaeological Surface Survey and Testing Photographs

North end of project area and Stockpile 3, with car for scale (view to southeast).

East side of project area with HECO power lines and telephone lines in background (view to north).

East side of project area, taken from old plantation dirt road, Stockpile 3 in background (view to northwest).

Old plantation access or cane haul road with HECO power lines flanking it on the west and old telephone lines flanking it on the east (view to south).

Pile of rubbish including appliance hardware, bedding, bottles, and car tires.

Existing utility manhole (Reclaimed water) located ca. 10 m west of the old plantation dirt road in NE Quad. (runs roughly parallel to dirt road), purple bollards in background (view to west).

Existing utility manhole (Sewer) located ca. 10 meters west of plantation dirt road in NE Quad. (view to southwest).

Another reclaimed water manhole near northeast corner of project area (view to northwest).

Test Trench 18, excavating from west to east (note cars in background are on Kapolei Pkwy. (view to northeast).

Test Trench 18, looking at coral limestone bedrock in BOE (3.2 mbs)(view to east).

Test Trench 21located in northwest extreme of property (view to northwest).


Test Trench 21, west wall showing 3.7 meters of tape (*karst* bedrock not found).


Excavating Test Trench 49 between Stockpiles 1 and 2, on edge of Stockpile 2 (view to south).


Test Trench 49 east wall and high spot in *karst* bedrock in the BOE (view to north).

Test Trench 51 at south end of Stockpile 1, showing previously disturbed *karst* bedrock (view to east).

Test Trench 56, east wall showing decomposing *karst* bedrock and solid *karst* bedrock in layers III and IV.

APPENDIX B

Ka Makana Ali'i Test Trench – Master Database

Kapolei Testing (Ka Makana Ali`i) Test Trenches - Master Database

*Unit No. KMA-	Location (Quad)	Trench Direction	GPS Coordinates			Dimensions (meters)			No. of Layers	Top Depth of Natural Strata (mbs)	Date
			Northing	Easting	Point Loc.	Length	Width	Depth			
TT-1	NE	E-W	598421	2359572	E end	2.5	0.4	1.55	3	not found	7/11/11
TT-2	NE	NW-SE	598432	2359555	NW end	2.5	0.4	1.5	3	not found	7/12/11
TT-3	NE	NE-SW	598460	2359511	NE end	7.3	0.4	2.1	4	not found	7/12/11
TT-4	NE	NE-SW	598467	2359526	NE end	15.2	0.4	3.2	5	3	7/12/11
TT-5	NE	E-W	598509	2359527	E end	9.7	0.4	3.4	2	not found	7/12/11
TT-6	NE	N-S	598509	2359527	N end	6	0.4	3.1	2	not found	7/12/11
TT-7	NE	N-S	598532	2359463	N end	6.15	0.4	1.8	3	1.15	7/13/11
TT-8	NE	E-W	598544	2359427	W end	7.7	0.4	1.65	3	1.3	7/13/11
TT-9	SE	N-S	598571	2359386	N end	6.8	0.4	1.5	3	1.1	7/13/11
TT-10	SE	E-W	598575	2359342	W end	9.5	0.4	1	4	0.45	7/13/11
TT-11	SE	NW-SE	598615	2359320	SE end	13	0.4	1.4	5	0.85	7/13/11
TT-12	SE	E-W	598618	2359283	E end	8.9	0.4	1.2	3	1	7/13/11
TT-13	SE	N-S	598658	2359248	N end	13.8	0.4	0.65	3	0.5	7/13/11
TT-14	NE	NE-SW	598336	2359525	SW end	4.5	0.75	2.9	2	not found	7/14/11
TT-15	NE	N-S	598311	2359559	S end	4	1.25	2.9	5	2.7	7/14/11
TT-16	NE	N-S	598368	2359563	N end	5	1	2.9	4	2.65	7/14/11
TT-17	NW	E-W	598231	2359557	W end	4.5	1	3.05	5	2.9	7/14/11
TT-18	NW	E-W	598189	2359556	W end	5	1	3.2	4	3	7/14/11
TT-19	NW	N-S	598152	2359536	S end	4.5	1	2.5	4	1.8	7/14/11
TT-20	NW	E-W	598098	2359522	W end	4.5	1	2.2	4	1.7	7/14/11
TT-21	NW	N-S	598008	2359471	S end	4.3	1	3.7	6	not found	7/14/11
TT-22	NW	N-S	598046	2359421	N end	4.2	1	2	3	1.7	7/15/11
TT-23	NW	NE-SW	598071	2359351	SW end	6.1	1	0.75	4	0.3	7/15/11
TT-24	NW	N-S	598098	2359264	S end	5.9	1	0.85	4	0.3	7/15/11
TT-25	SW	E-W	598109	2359198	E end	6.8	1	1.1	6	0.95	7/15/11
TT-26	SW	E-W	598143	2359152	E end	6	1	1.1	4	0.65	7/15/11
TT-27	SW	N-S	598162	2359240	S end	8.8	1	1.5	5	1	7/15/11
TT-28	NW	E-W	598131	2359282	W end	8.7	0.7	1.1	3	0.5	7/18/11
TT-29	NW	N-S	598125	2359351	S end	8.8	0.7	2.3	4	0.95	7/18/11
TT-30	NW	NE-SW	598107	2359434	SW end	9.5	0.7	1.2	4	0.8	7/18/11
TT-31	NW	NW-SE	598110	2359481	SE end	9	0.7	1.1	4	0.65	7/18/11
TT-32	NW	E-W	598146	2359515	E end	10.5	0.7	2	3	1.85	7/18/11
TT-33	NW	N-S	598209	2359522	S end	9.6	0.7	2.2	3	2	7/18/11
TT-34	NE	N-S	598272	2359525	S end	8.1	0.7	2.35	4	2.25	7/18/11
TT-35	NE	E-W	598314	2359535	W end	8.6	0.7	2.5	4	2.1	7/18/11
TT-36	NE	E-W	598366	2359558	W end	6.3	0.7	3.1	4	not found	7/19/11
TT-37	NE	N-S	598481	2359454	S end	8.2	0.7	1.15	5	0.9	7/19/11
TT-38	SE	E-W	598511	2359398	E end	8.3	0.7	1.2	5	0.5	7/19/11
TT-39	SE	N-S	598541	2359340	S end	9	0.7	1.1	5	0.6	7/19/11

Kapolei Testing (Ka Makana Ali`i) Test Trenches - Master Database

*Unit No. KMA-	Location (Quad)	Trench Direction	GPS Coordinates			Dimensions (meters)			No. of Layers	Top Depth of Natural Strata (mbs)	Date
			Northing	Easting	Point Loc.	Length	Width	Depth			
TT-40	SE	N-S	598609	2359213	S end	7.5	0.7	0.9	3	0.55	7/19/11
TT-41	SE	E-W	598603	2359178	W end	6.3	0.7	0.75	3	0.5	7/19/11
TT-42	NE	N-S	598440	2359420	N end	5	0.7	3.3	4	3.15	7/19/11
TT-43	SE	N-S	598465	2359388	N end	5.7	0.7	1.8	3	0.95	7/19/11
TT-44	NE	E-W	598368	2359396	W end	6.9	0.7	1.85	5	1.5	7/20/11
TT-45	NE	N-S	598329	2359356	S end	5.3	0.7	1.6	4	1.7	7/20/11
TT-46	NW	E-W	598231	2359340	W end	6	0.7	1.5	5	1.15	7/20/11
TT-47	NW	NE-SW	598296	2359459	SW end	5	0.7	3.3	4	3.1	7/20/11
TT-48	SW	N-S	598361	2359228	S end	5.6	0.7	1.2	4	0.7	7/20/11
TT-49	SW	NW-SE	598311	2359314	S end	8	0.7	1.6	4	1.3	7/21/11
TT-50	SW	N-S	598339	2359263	W end	7.6	0.7	1.3	4	1	7/21/11
TT-51	SE	E-W	598409	2359240	W end	5.3	0.7	0.75	2	0.6	7/21/11
TT-52	NW	NW-SE	598053	2359479	NW end	9	0.7	1.9	4	1.4	7/21/11
TT-53	NW	N-S	598085	2359429	N end	6.75	0.7	1.2	5	0.65	7/21/11
TT-54	NW	E-W	598081	2359321	W end	7	0.7	1.4	4	0.6	7/21/11
TT-55	SE	N-S	598591	2359322	S end	6.8	0.7	1.1	3	0.55	7/22/11
TT-56	SE	N-S	598547	2359281	S end	7.6	0.7	1.15	4	0.8	7/22/11
TT-57	SE	N-S	598570	2359242	N end	7	0.7	1.4	3	0.9	7/22/11
TT-58	NW	E-W	598329	2359329	W end	6.9	0.7	1.4	4	1.1	7/22/11
TT-59	NW	N-S	598296	2359401	S end	5.9	0.7	2.65	3	2.55	7/22/11
TT-60	NE	NW-SE	598273	2359496	SE end	4.6	0.7	2.95	3	2.75	7/22/11
TT-61	NW	NE-SW	598223	2359466	SW end	3.5	0.7	0.55	2	0.5	7/22/11
TT-62	NW	NE-SW	598187	2359385	SW end	3.6	0.7	0.5	3	0.45	7/22/11

* TT stands for Test Trench, **but** in log book notes and profiles all Test Trenches were referred to as Test Probes (TP) and Test Scrapes were referred as Test Trenches (TT). So, when referring to log book notes or profiles, substitute TT for TP and TS for TT. Photo log has already been amended, so do not substitute.

APPENDIX C

'Ewa Plain: A Hawaiian Settlement Model
In *Synthesis of Cultural Resource Studies of the 'Ewa Plain.*
By David Tuggle and M.J. Tomonari-Tuggle
(1997: Section VIII, pp.115-119)

VIII. 'EWA PLAIN: A HAWAIIAN SETTLEMENT MODEL

At its maximum development during Hawaiian occupation, the main portion of the 'Ewa Plain was a dryland agricultural landscape, comparable in broad terms to leeward Kohala on the island of Hawai'i, the Kaunakakai region of Moloka'i, or upper Mākaha Valley on O'ahu (although certainly with a much lower overall yield than these other regions). The distinctive characteristic of the 'Ewa Plain is that the agricultural system was developed on a karst landform. Adapted to this, the 'Ewa cultivation system emphasized mounds and sinkholes (and possibly the use of wetlands such as swamps), rather than dry terraces. Variation in 'Ewa Plain cultivation occurred on the Honouliuli floodplain and at the base of the Waianae slopes.

'Ewa Plain Settlement Model

With this perspective, the following is proposed as a general model for pre-contact 'Ewa Plain settlement (the primary numbers in the following list refer to corresponding numbers in Figure 22):

I. The population center of the region was the irrigation complex of lower Honouliuli (or Makali'i) Stream, lying at the northeastern edge of the Plain. Although lower Honouliuli is not part of the physiographic region of the Plain, its proximity and cultural history define it as crucial to the settlement of the Plain itself.

   This is based on the archival data for the area, with the assumption that similar conditions existed in pre-contact times, partly corroborated by traditions that refer to the many place names recorded for this area (e.g., Po'ohilo).

   Some evaluation of this proposition may be testable through archaeological research, depending on the nature and extent of buried deposits.

Ia. Honouliuli floodplain is an area that included chiefly residential complexes.

   This is based on general models of Hawaiian settlement. It may not be testable because of site destruction.

Ib. Honouliuli floodplain was one of the areas of earliest settlement of 'Ewa and one of the earliest settlements in Hawai'i.