DAVID Y. IGE
GOVERNOR

CRAIG K. HIRAI
EXECUTIVE DIRECTOR

STATE OF HAWAII
DEPARTMENT OF BUSINESS, ECONOMIC DEVELOPMENT AND TOURISM
HAWAII HOUSING FINANCE AND DEVELOPMENT CORPORATION
677 QUEEN STREET, SUITE 300
Honolulu, Hawaii 96813
FAX: (808) 587-0600

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March 24, 2015

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APR 08 2015

Ms. Jessica Wooley, Director
Office of Environmental Quality Control
Department of Health
235 S. Beretania Street, Room 702
Honolulu, Hawai'i 96813

Dear Director Wooley:

Re: Draft Environmental Assessment for Hale Kewalo

With this letter, the Hawai'i Housing Finance and Development Corporation (HHFDC) hereby transmits the draft environmental assessment and anticipated finding of no significant impact (DEA-AFONSI) for the Hale Kewalo Project situated at TMK Number: (1) 2-3-007: 026 and 049, in the Honolulu District on the island of O'ahu for publication in the next available edition of the Environmental Notice.

Enclosed is a completed OEQC Publication Form, two copies of the DEA-AFONSI, an Adobe Acrobat PDF file of the same, and an electronic copy of the publication form in MS Word. Simultaneous with this letter, we have submitted the summary of the action in a text file by electronic mail to your office.

If there are any questions, please contact Janice Takahashi, Chief Planner, at 587-0639.

Sincerely,

Craig K. Hirai
Executive Director

Enclosures

APPLICANT ACTIONS
SECTION 343-5(C), HRS
PUBLICATION FORM (JANUARY 2013 REVISION)

Project Name	**Hale Kewalo**
Island:	**Oahu**
District:	**Honolulu**
TMK:	**2-3-007: 026 and 049**
Permits:	**HCDA Development Permit, 201-H Exemptions, Building Permits**
Approving Agency:	**Hawaii Housing Finance and Development Corporation** 677 Queen Street, 3rd Floor, Honolulu, HI 96813 Mr. Stan Fujimoto, 587-0541
Applicant:	**Stanford Carr Developmet. LLC** 1100 Alakea Street, 27 Floor, Honolulu, HI 96813 Mr. Christopher Oakes, 537-5220
Consultant:	**Environmental Communications, Inc.** P.O. Box 236097, Honolulu, HI 96823 Mr. Taeyong Kim, 528-4661

Status (check one only):

_X_DEA-AFNSI	Submit the approving agency notice of determination/transmittal on agency letterhead, a hard copy of DEA, a completed OEQC publication form, along with an electronic word processing summary and a PDF copy (you may send both summary and PDF to oeqchawaii@doh.hawaii.gov; a 30-day comment period ensues upon publication in the periodic bulletin.
__FEA-FONSI	Submit the approving agency notice of determination/transmittal on agency letterhead, a hard copy of the FEA, an OEQC publication form, along with an electronic word processing summary and a PDF copy (send both summary and PDF to oeqchawaii@doh.hawaii.gov; no comment period ensues upon publication in the periodic bulletin.
__FEA-EISPN	Submit the approving agency notice of determination/transmittal on agency letterhead, a hard copy of the FEA, an OEQC publication form, along with an electronic word processing summary and PDF copy (you may send both summary and PDF to oeqchawaii@doh.hawaii.gov; a 30-day consultation period ensues upon publication in the periodic bulletin.
__Act 172-12 EISPN	Submit the approving agency notice of determination on agency letterhead, an OEQC publication form, and an electronic word processing summary (you may send the summary to oeqchawaii@doh.hawaii.gov. NO environmental assessment is required and a 30-day consultation period upon publication in the periodic bulletin.
__DEIS	The applicant simultaneously transmits to both the OEQC and the approving agency, a hard copy of the DEIS, a completed OEQC publication form, a distribution list, along with an electronic word processing summary and PDF copy of the DEIS (you may send both the summary and PDF to oeqc@doh.hawaii.gov); a 45-day comment period ensues upon publication in the periodic bulletin.
__FEIS	The applicant simultaneously transmits to both the OEQC and the approving agency, a hard copy of the FEIS, a completed OEQC publication form, a distribution list, along with an electronic word processing summary and PDF copy of the FEIS (you may send both the summary and PDF to oeqc@doh.hawaii.gov); no comment period ensues upon publication in the periodic bulletin.
__ Section 11-200-23 Determination	The approving agency simultaneous transmits its determination of acceptance or nonacceptance (pursuant to Section 11-200-23, HAR) of the FEIS to both OEQC and the applicant. No comment period ensues upon publication in the periodic bulletin.
__Statutory hammer Acceptance	The approving agency simultaneously transmits its notice to both the applicant and the OEQC that it failed to timely make a determination on the acceptance or nonacceptance of the applicant's FEIS under Section 343-5(c), HRS, and that the applicant's FEIS is deemed accepted as a matter of law.
__Section 11-200-27 Determination	The approving agency simultaneously transmits its notice to both the applicant and the OEQC that it has reviewed (pursuant to Section 11-200-27, HAR) the previously accepted FEIS and determines that a supplemental EIS is not required. No EA is required and no comment period ensues upon publication in the periodic bulletin.
__Withdrawal (explain)	

Summary (Provide proposed action and purpose/need in less than 200 words. Please keep the summary brief and on this one page)**:**

Stanford Carr Development, LLC (SCD) is proposing the development of 128 unit affordable rental project. This 11 story high building will consist of 27 one bedroom, 72 two bedroom, and 29 three bedroom units. This project is planned as an essential component in providing critical affordable rental housing inventory within this rapidly growing population center. This project will also fulfill the reserved housing obligation for the landowner required by the Hawaii Community Development Authority (HCDA) for other market housing projects presently under construction.

The project is also integral in providing valued housing within the transit oriented development area of the Honolulu Area Rapid Transit (HART) terminus at Ala Moana Center. Within easy walking distance to the transit station, the proposed project is viewed as a beneficial and desirable workforce housing project.

In addition to the 128 affordable rental units, the project will also include 77 parking stalls, a commercial space located on Waimanu Street, and other accessory uses to support the residential units. Vehicular access to the site is located on Kona Street and Waimanu Street. Pedestrian access is located along Kona Street.

DRAFT ENVIRONMENTAL ASSESSMENT

HALE KEWALO

TMK 2-3-007: 026 AND 049
450 PIIKOI STREET
HONOLULU, OAHU, HAWAII

APPLICANT:
STANDFORD CARR DEVELOPMENT, LLC

APPROVING AGENCY:
HAWAII HOUSING FINANCE & DEVELOPMENT CORPORATION

MARCH 2015

DRAFT ENVIRONMENTAL ASSESSMENT

HALE KEWALO

TMK 2-3-007: 026 AND 049
450 PIIKOI STREET
HONOLULU, OAHU, HAWAII

APPLICANT:
STANDFORD CARR DEVELOPMENT, LLC

APPROVING AGENCY:
HAWAII HOUSING FINANCE & DEVELOPMENT CORPORATION

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B *Environmental Harzard Evaluation and Environmental Hazard Management Plan*, EnviroServices & Training Center, LLC

C *Senior Residence at Piikoi National Historic Preservation Act Section 109 Consultation*, Kewalo Development LLC

D *Final Archaeological Monitoring Plan for the Senior Residence at Piikoi*, Cultural Surveys Hawaii, Inc.

E *Draft Traffic Evaluation Piikoi Affordable Housing*, Parsons Brinkerhoff

F *Acoustic Study for the Hale Kewalo*, D.L. Adams Asssoicates

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SECTION ONE
PROJECT SUMMARY

APPLICANT:	Stanford Carr Development, LLC 1100 Alakea Street, 27th Floor Honolulu, Hawaii 96813
APPROVING AGENCY:	Hawaii Housing Finance & Development Corp 677 Queen Street, Suite 300 Honolulu, HI 96813
AGENT:	Environmental Communications, Inc. P.O. Box 236097 Honolulu, Hawaii 96823
PROJECT NAME:	Hale Kewalo
PROJECT LOCATION:	The project is located at southwestern corner of the intersection of Piikoi and Kona Streets in Kakaako, Honolulu, Hawaii.
TAX MAP KEY:	2-3-007: 026 and 049
OWNERSHIP:	Kewalo Development LLC and Hawaii Community Development Authority
LOT AREA:	Approximately 31,952 SF (0.734 acres)
ZONING:	The project area is designated Mixed Use Residential in the Hawaii Community Development Authority Kakaako Community Development District (KCDD) Mauka Area Plan applicable to this project.
SPECIAL DISTRICT:	Kakaako Community Development District (KCDD) Mauka Area
STATE LAND USE:	Urban
EXISTING LAND USE:	The project site is located on the block within KCDD Mauka Area bounded by Kona Street to the north (mauka), Piikoi Street to the east (Diamond Head), Waimanu Street to the south (makai), and Pensacola Street to west (Ewa). Presently, the project site is occupied by a warehouse used for

parking, a former retail showroom, and a lot presently used as a construction office.

Other uses on the project block include industrial warehouse uses, dining and drinking establishments, and commercial and office uses.

Adjacent uses include mixed industrial, commercial, dining and drinking establishments, and offices in the mauka blocks, the Ala Moana Shopping Center complex in the Diamond Head direction, six large high rise residential complexes in the makai direction, and assorted industrial and commercial uses in the Ewa direction.

NATURE OF DEVELOPMENT: Stanford Carr Development, LLC (SCD) is proposing the development of 128 unit affordable rental project. This 11 story high building will consist of 27 one bedroom, 72 two bedroom, and 29 three bedroom units. This project is planned as an essential component in providing critical affordable rental housing inventory within this rapidly growing population center. This project will also fulfill the reserved housing obligation for the landowner required by the Hawaii Community Development Authority (HCDA) for other market housing projects presently under construction.

The project is also integral in providing valued housing within the transit oriented development area of the Honolulu Area Rapid Transit (HART) terminus at Ala Moana Center. Within easy walking distance to the transit station, the proposed project is viewed as a beneficial and desirable workforce housing project.

In addition to the 128 affordable rental units, the project will also include 77 parking stalls, a commercial space located on Waimanu Street, and other accessory uses to support the residential units. Vehicular access to the site is located on Kona Street and Waimanu Street. Pedestrian access is located along Kona Street.

PROJECT COST: Approximately $61,000,000

PROJECT SCHEDULE: The project is anticipated to be completed mid-year 2017.

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SECTION TWO
PROPOSED PROJECT AND STATEMENT OF OBJECTIVES

2.1 PROJECT LOCATION

The project is located at southwestern corner of the intersection of Piikoi and Kona Streets in Kakaako, Honolulu, Hawaii. The site is identified as Tax Map Key: 2-3-007: 026 and 049. The fee interest in the project site is held by Kewalo Development LLC.

The project site is located within the Kakaako Community Development District (KCDD) Mauka Area which dictates the regulatory zoning laws for the project site. The project area is zoned for public use under the KCDD Mauka Area Plan and is subject to the KCDD Mauka Area Rules.

The project site is located on the block within KCDD Mauka Area bounded by Kona Street to the north (mauka), Piikoi Street to the east (Diamond Head), Waimanu Street to the south (makai), and Pensacola Street to west (Ewa). Presently, the project site is occupied by a warehouse used for parking, a former retail showroom, and a lot presently used as a construction office.

Other uses on the project block include industrial warehouse uses, dining and drinking establishments, and commercial and office uses.

Adjacent uses include mixed industrial, commercial, dining and drinking establishments, and offices in the mauka blocks, the Ala Moana Shopping Center complex in the Diamond Head direction, six large high rise residential complexes in the makai direction, and assorted industrial and commercial uses in the Ewa direction.

The project site is located approximately 800-feet from the future Ala Moana transit station and is located immediately across from the street from Ala Moana Center, a major bus transit location.

2.2 PROJECT DESCRIPTION

2.2.1 PROJECT NEED

The proposed development will fulfill the landowners reserved housing obligations for other market level housing presently under construction. In addition to satisfying the landowners reserved housing development obligation, the project is also a critical component in the vision of the HCDA Mauka Plan. By providing affordable rental housing within a rapidly growing urban district, the project will provide opportunities for future residents to reside and work within the same area and have the convenience of public transportation, services and new employment opportunities within a single community.

Figure 1: Location Map

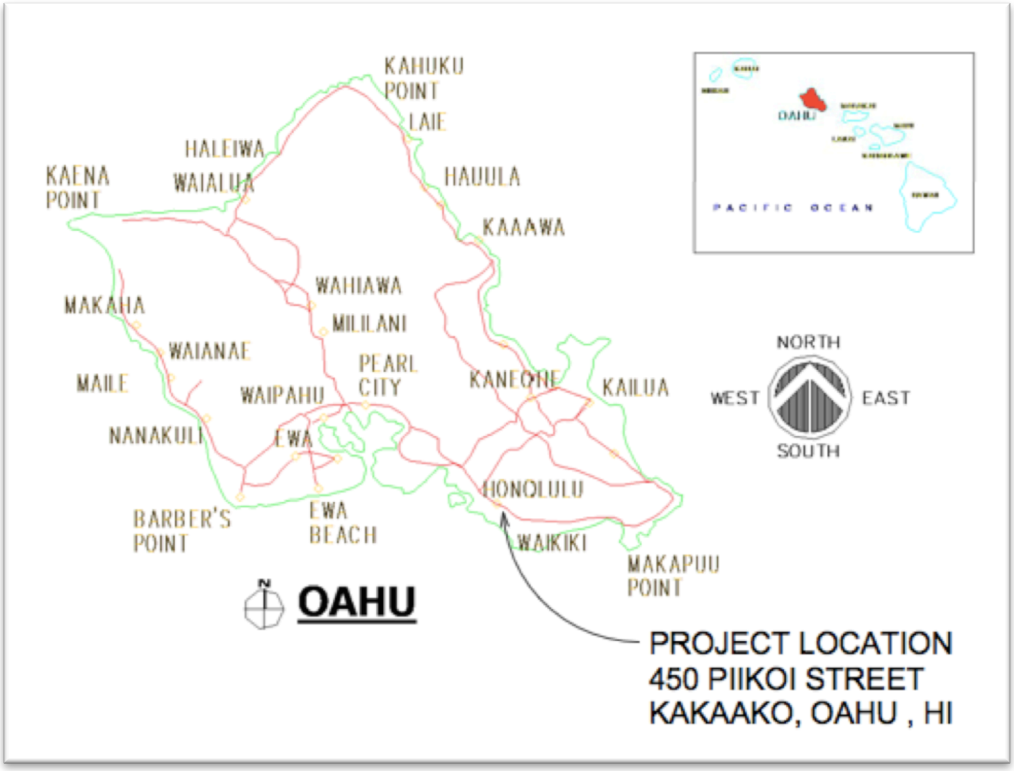


Figure 2: Vicinity Map Source: City and County of Honolulu

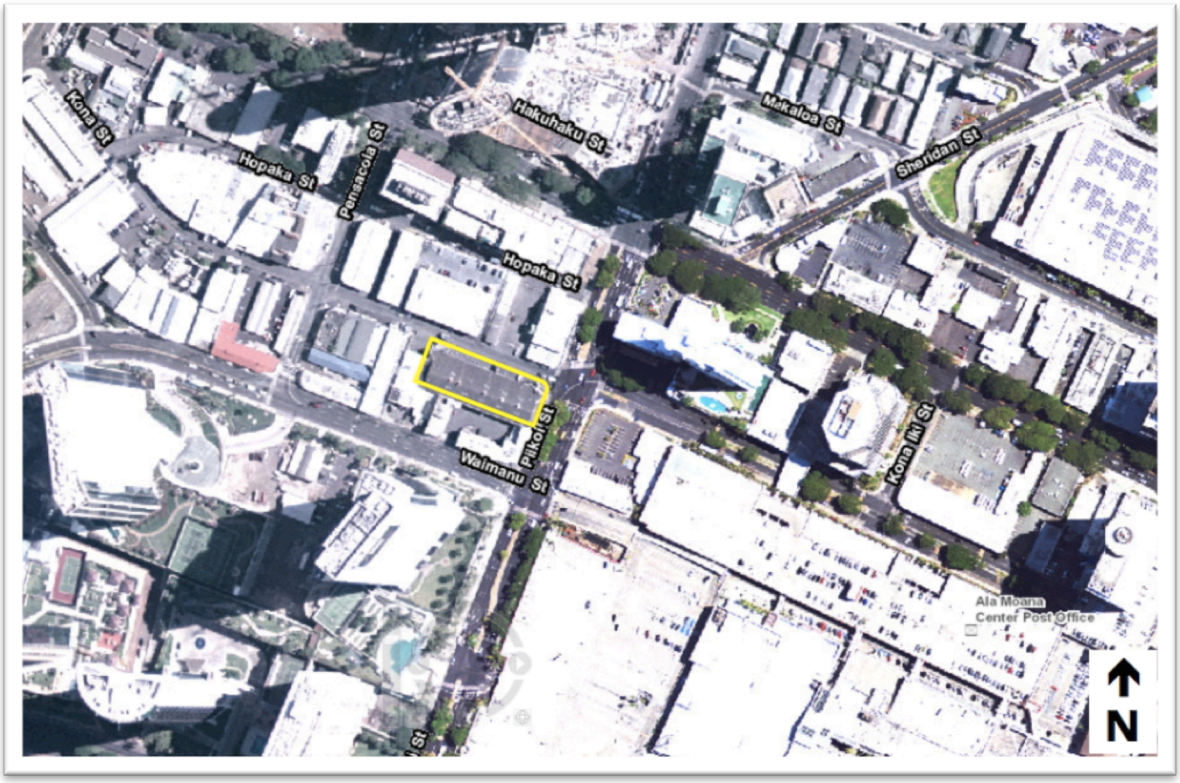
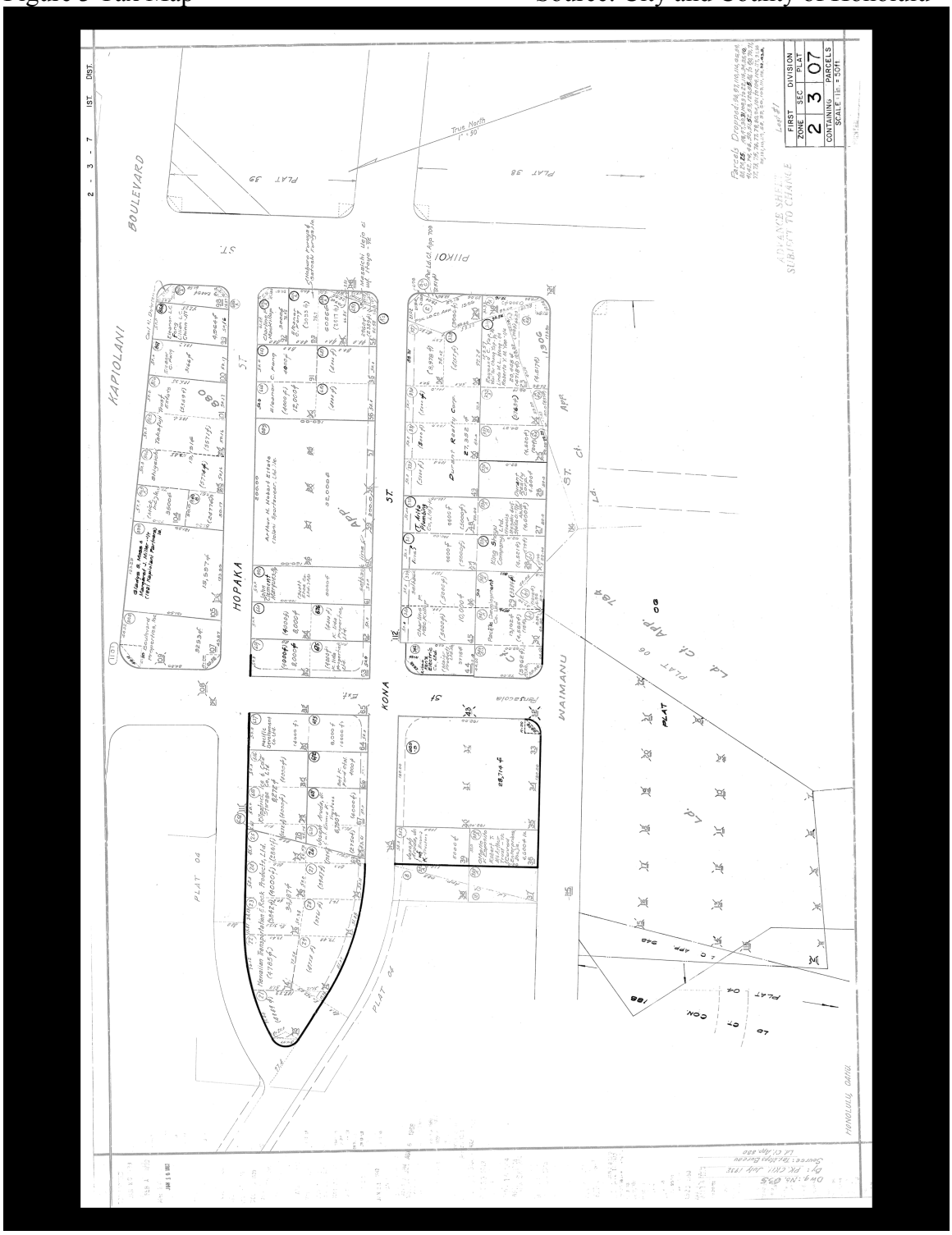


Figure 3 Tax Map Source: City and County of Honolulu



2.2.2 PROJECT DESIGN

The conceptual design of the project was developed to provide a model for optimal density. The conceptual design was produced to 1) establish the feasibility of an optimal density model that would serve as the basis for establishing maximum project associated benefit, and 2) determine that the siting and mass of the design is conducive to the proposed future uses of the project block. A significant design consideration is the linearity of the primary parcel, and the location of the future HART guideway along Kona Street.

As presently proposed, the project will consist of approximately 120,857 square feet and will provide approximately 458 square feet of open space on the 31,952 square foot consolidated site (see Figures 4).

2.2.3 RESIDENTIAL UNITS

The project will consist of approximately 27 one-bedroom, 72 two-bedroom, and 29 three-bedroom units located on floors 2 to 11. These units will be arranged in a double-loaded configuration with the three-bedroom units located at the ends. Common laundry facilities will be located on each residential floor. Mauka facing units will be exposed to the planned transit line so units will include insulated double glazed glass and individual packaged terminal air conditioner units (PTAC) for energy efficiency, noise attenuation and ventilation.

2.2.4 PARKING, VEHICULAR ACCESS AND PUBLIC TRANSPORTATION

Seventy-seven (77) resident parking stalls will be provided within the structure on two parking levels. A driveway/porte-cochere located along Kona Street will provide a convenient pick-up and drop-off point for the facility. A separate loading area will accommodate refuse service and heavy vehicles will also be located on Kona Street. Ingress and egress for residential parking will be located on both Kona and Waimanu Streets.

2.2.5 LOBBY LEVEL

The lobby level of the structure will include a lobby, service and mechanical areas, parking, restrooms and a recreation center. The recreation will also provide a covered lanai and an enclosed garden space at the corner of Piikoi and Kona Streets.

2.3 PROJECT OBJECTIVE

The Applicant is proposing the development of an affordable housing facility which will provide critical affordable housing inventory for Honolulu's high growth Kakaako District.

This project is consistent with the Blueprint for Affordable Housing to increase rental housing and supportive opportunities for special needs segments of Hawaii's population. Except for one resident manager's unit, all of the units in the project will remain affordable to households earing 60% or below the U.S. Department of Housing and Urban Development (HUD) area median income for 60 years. Current HUD affordable guidelines presently call for maximum allowable income per household as shown below:

		LIMITS BY FAMILY SIZE							
MEDIAN $95,800		1 PERSON	2 PERSON	3 PERSON	4 PERSON	5 PERSON	6 PERSON	7 PERSON	8 PERSON
Adjustments for family size		0.7000	0.8000	0.9000	1.0000	1.0800	1.1600	1.2400	1.3200
% of Income	10%	$6,710	$7,670	$8,630	$9,580	$10,350	$11,120	$11,880	$12,650
	20%	$13,420	$15,340	$17,260	$19,160	$20,700	$22,240	$23,760	$25,300
	30%	$20,150	$23,000	$25,900	$28,750	$31,050	$33,350	$35,650	$37,950
	40%	$26,840	$30,680	$34,520	$38,320	$41,400	$44,480	$47,520	$50,600
	50%	$33,550	$38,350	$43,150	$47,900	$51,750	$55,600	$59,400	$63,250
	60%	$40,260	$46,020	$51,780	$57,480	$62,100	$66,720	$71,280	$75,900
	70%	$46,970	$53,690	$60,410	$67,060	$72,450	$77,840	$83,160	$88,550
	80%	$53,700	$61,350	$69,000	$76,650	$82,800	$88,950	$95,050	$101,200
	90%	$60,390	$69,030	$77,670	$86,220	$93,150	$100,080	$106,920	$113,850
	100%	$67,100	$76,700	$86,300	$95,800	$103,500	$111,200	$118,800	$126,500
	110%	$73,810	$84,370	$94,930	$105,380	$113,850	$122,320	$130,680	$139,150
	120%	$80,520	$92,040	$103,560	$114,960	$124,200	$133,440	$142,560	$151,800
	130%	$87,230	$99,710	$112,190	$124,540	$134,550	$144,560	$154,440	$164,450
	140%	$93,940	$107,380	$120,820	$134,120	$144,900	$155,680	$166,320	$177,100

Source: Hawaii Housing Finance and Development Corporation

2.4 FUNDING AND SCHEDULE

State Rental Housing Trust Funds are anticipated to be used to fund the project. The other development costs will be borne by the developer. The project total development cost is approximately $61,000,000.

The anticipated construction start date is early 2016. The project is anticipated to be mid-year 2017.

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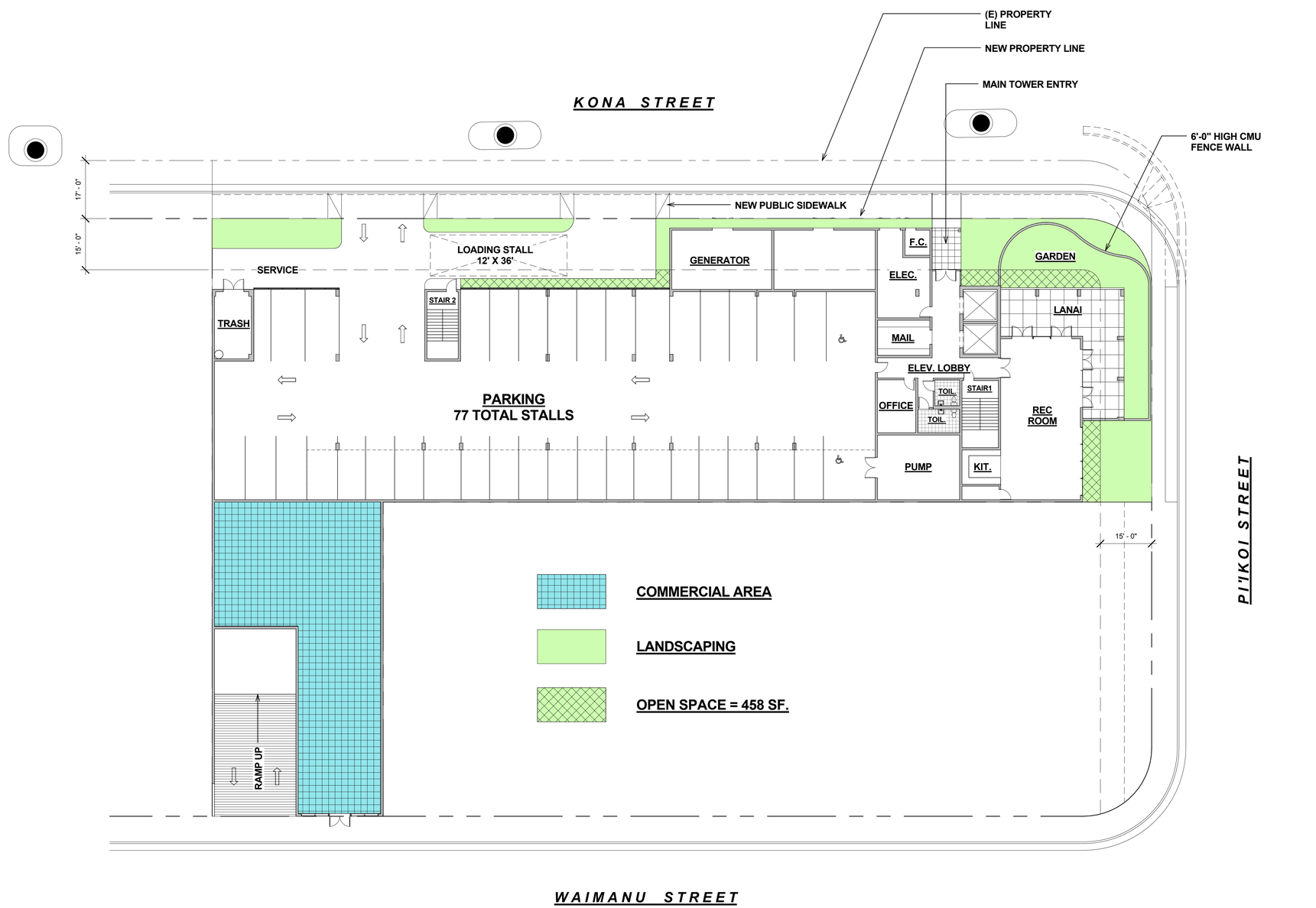

1 **SITE PLAN**
1/16" = 1'-0"

TRUE NORTH

0' 8' 16' 32' 64'

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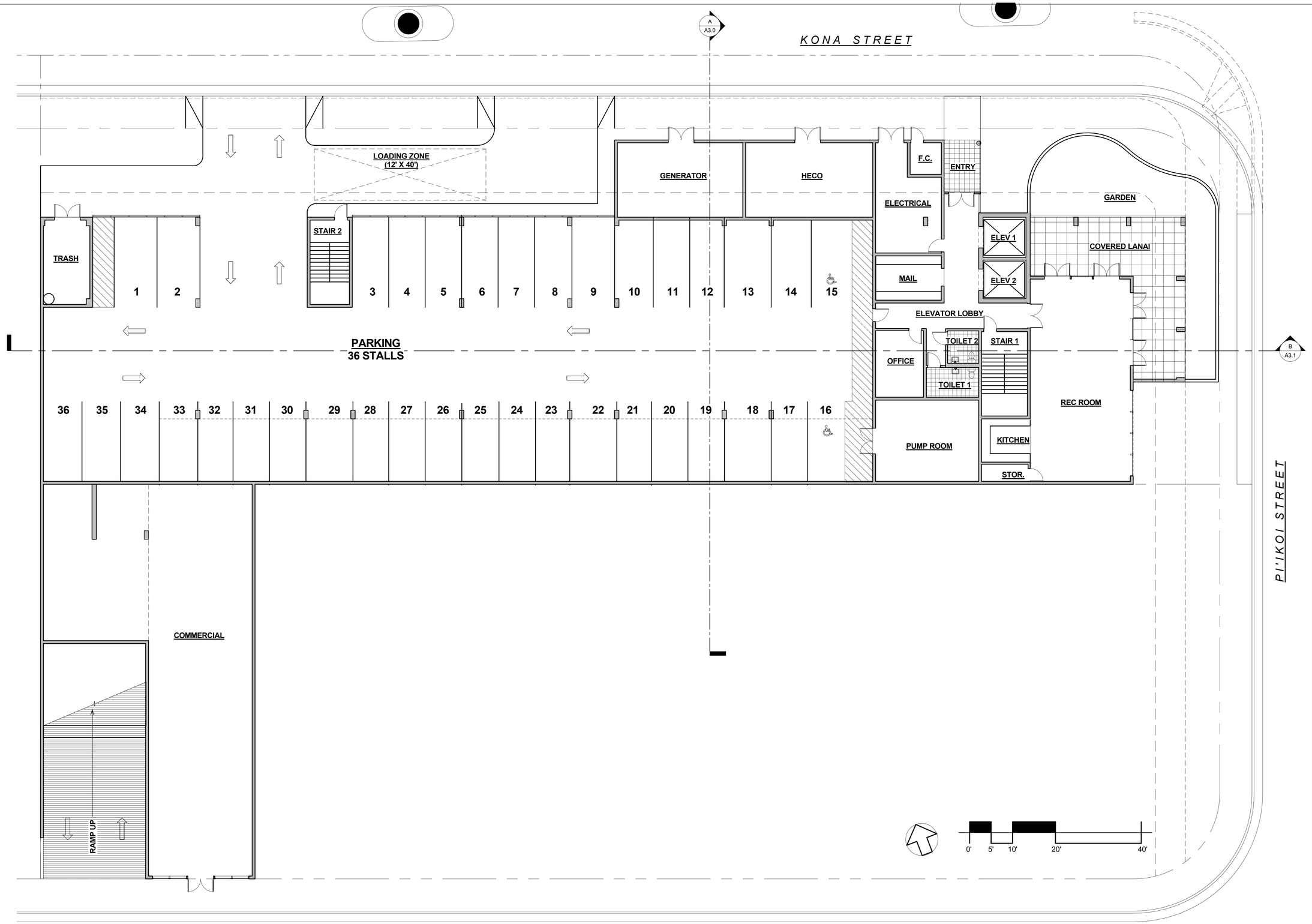

1 **1ST FLOOR**
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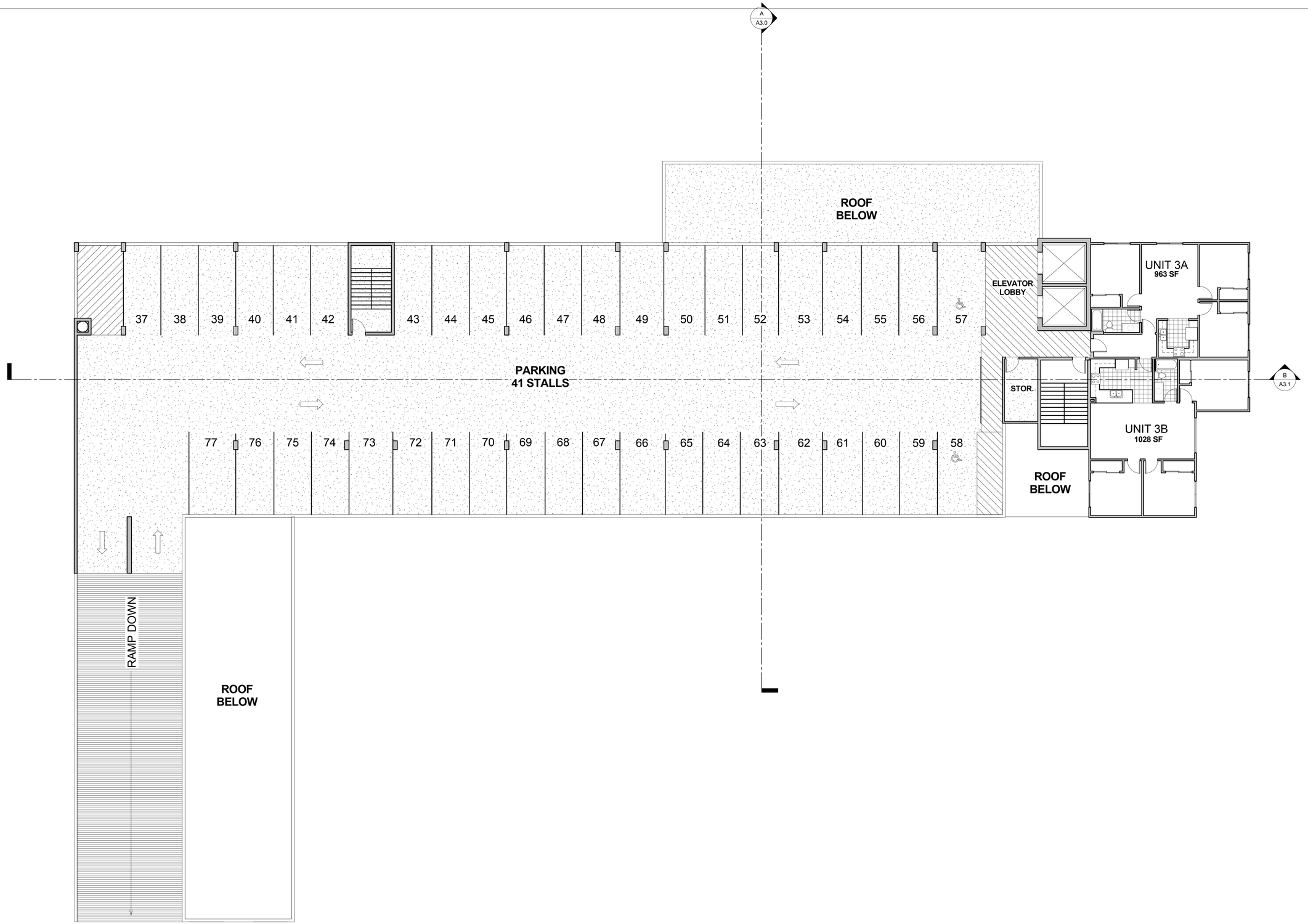

1 **2ND FLOOR PLAN**
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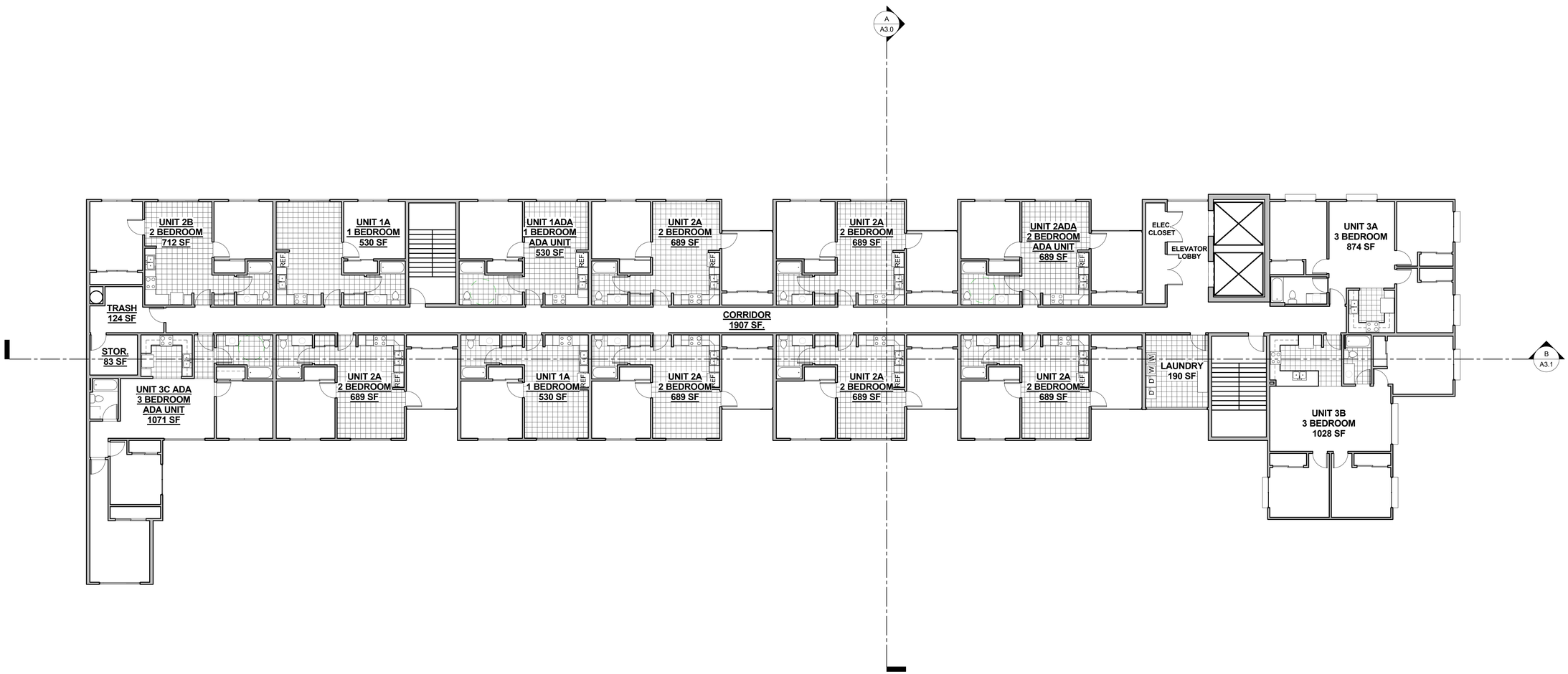

1 **3RD FLOOR PLAN**
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3RD FLOOR PLAN

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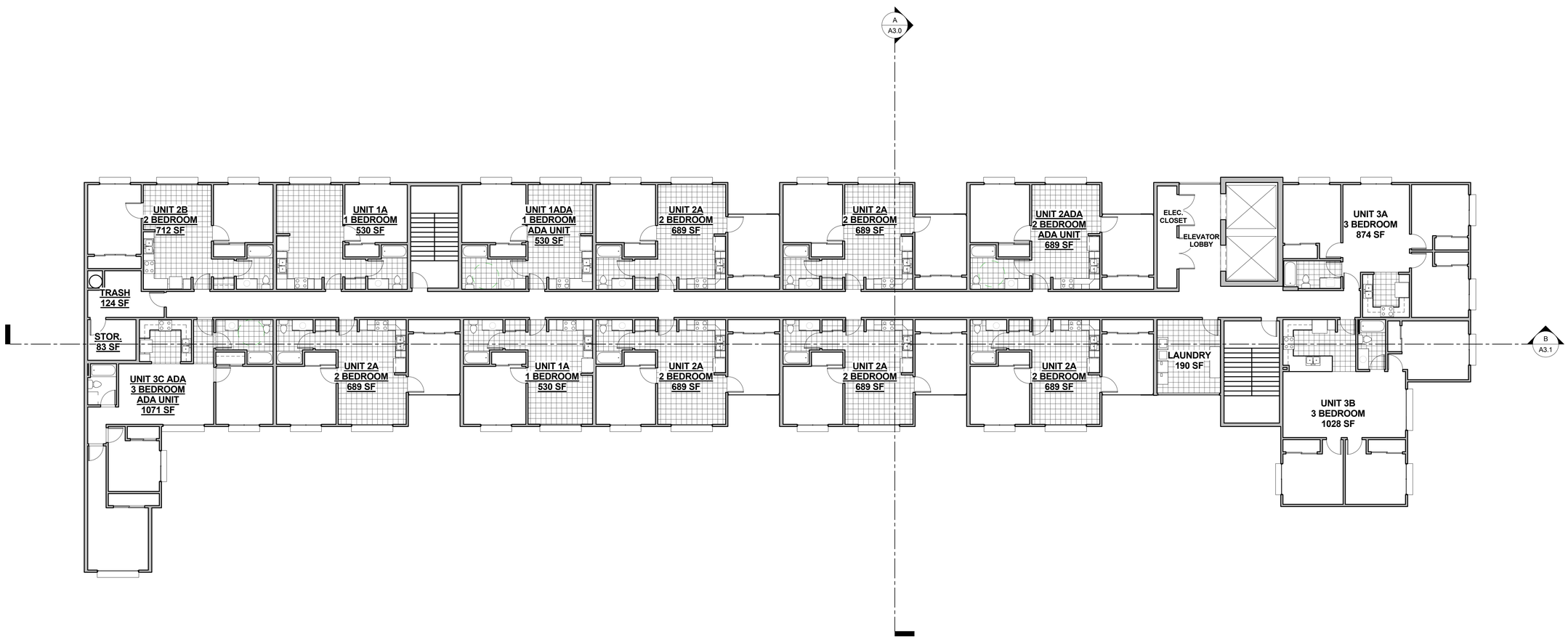

1 4TH FLOOR PLAN

1" = 10'-0"

0' 8' 16' 32' 64'

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4TH FLOOR PLAN

Project Number	Project Number
Date	Issue Date
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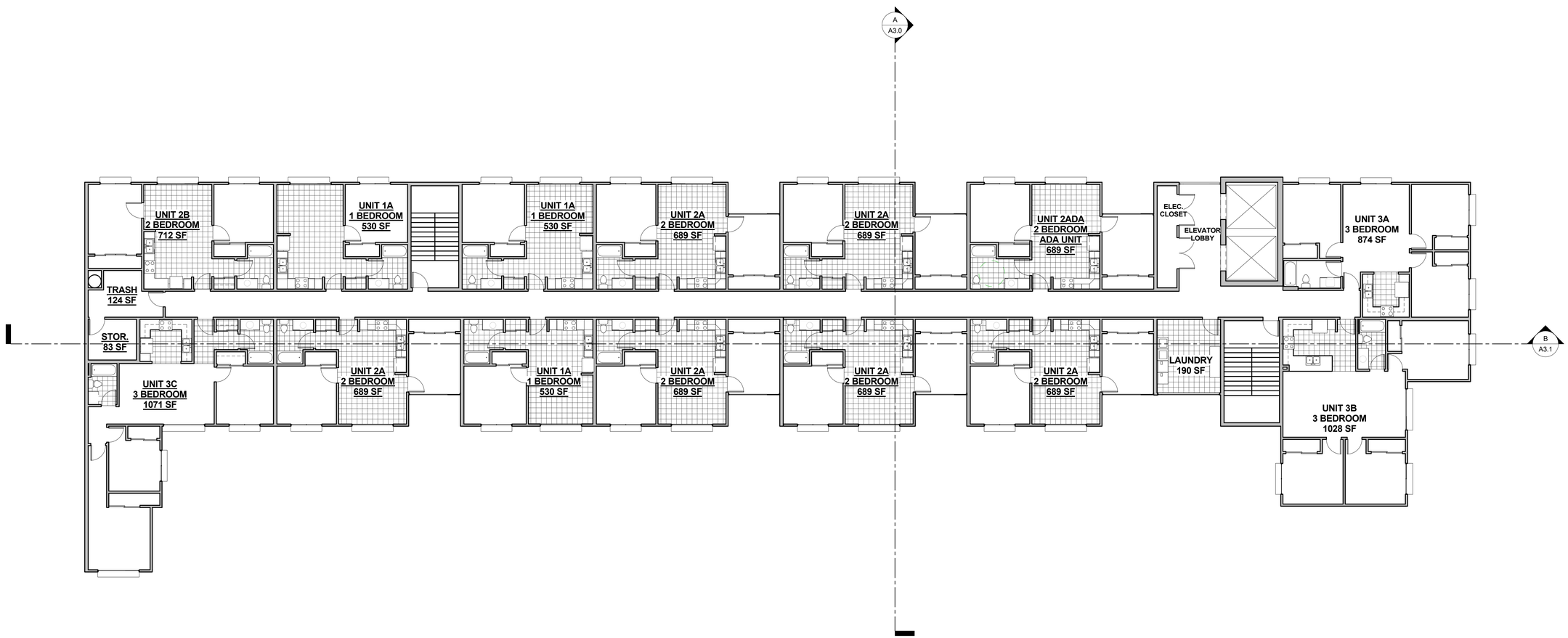

1 **5TH FLOOR**
1" = 10'-0"

0' 5' 10' 20' 40'

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ARCHITECTURE, PLANNING, INTERIORS

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Honolulu, Hawaii 96813

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450 PI'IKOI

No.	Description	Date

5TH FLOOR PLAN

Project Number	Project Number
Date	Issue Date
Drawn By	Author
Checked By	Checker

A1.4

Scale 1" = 10'-0"

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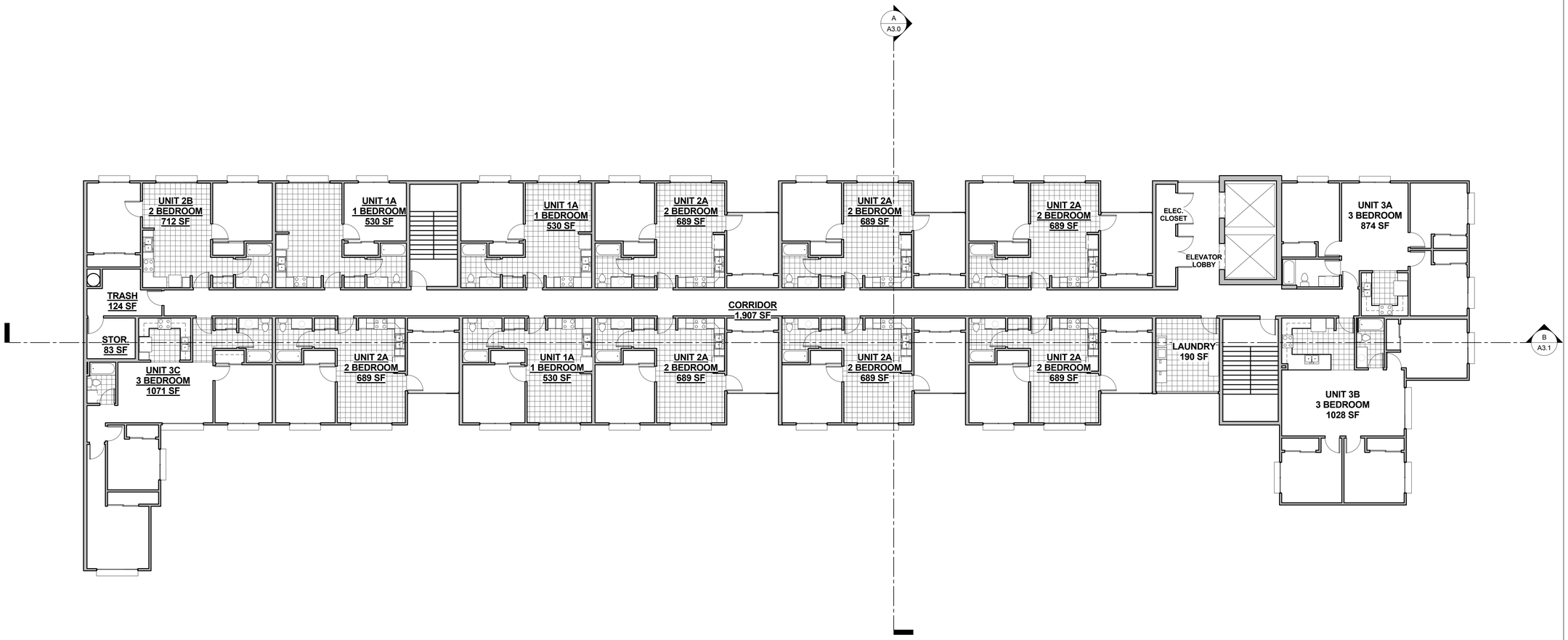

1 TYPICAL PLAN 6TH THRU 11TH FLOOR

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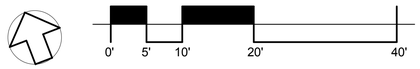

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450 PI'IKOI

No.	Description	Date

TYPICAL PLAN 6TH THRU 11TH FLOOR

Project Number	Project Number
Date	Issue Date
Drawn By	Author
Checked By	Checker

A1.5

Scale 1" = 10'-0"

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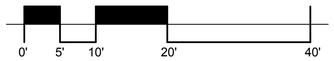
1 NORTH ELEVATION (KONA STREET)

1" = 10'-0"



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450 PI'IKOI

No.	Description	Date

NORTH ELEVATION (KONA STREET)

Project Number	Project Number
Date	Issue Date
Drawn By	Author
Checked By	Checker

A2.0

Scale	1" = 10'-0"

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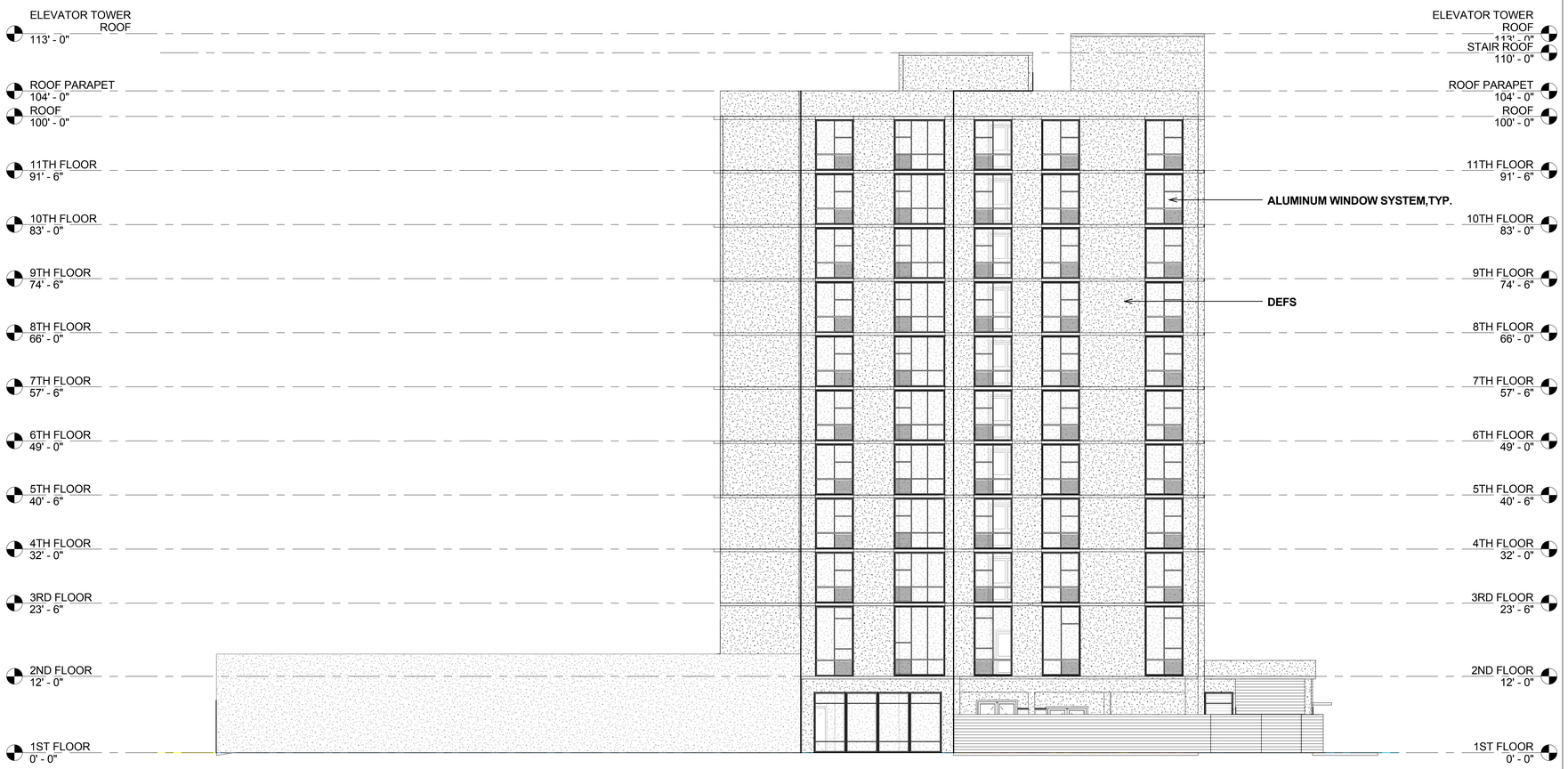

1 EAST ELEVATION (PI'IKOI STREET)

1" = 10'-0"

0' 5' 10' 20' 40'

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450 PI'IKOI

No.	Description	Date

EAST ELEVATION (PI'IKOI STREET)

Project Number	Project Number
Date	Issue Date
Drawn By	Author
Checked By	Checker

A2.1

Scale 1" = 10'-0"

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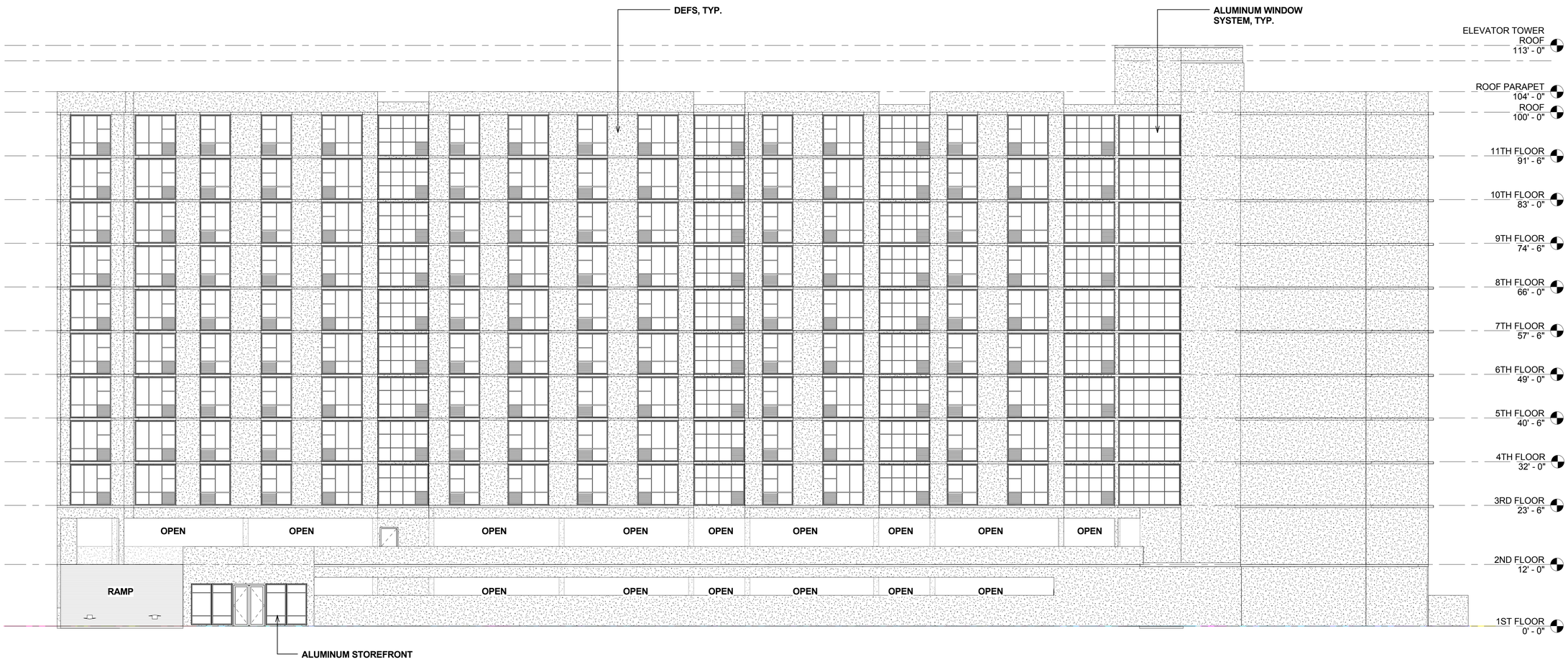

1 SOUTH ELEVATION (WAIMANU STREET)

1" = 10'-0"

0' 5' 10' 20' 40'

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450 PI'IKOI

No.	Description	Date

SOUTH ELEVATION (WAIMANU STREET)

Project Number	Project Number
Date	Issue Date
Drawn By	Author
Checked By	Checker

A2.2

Scale	1" = 10'-0"

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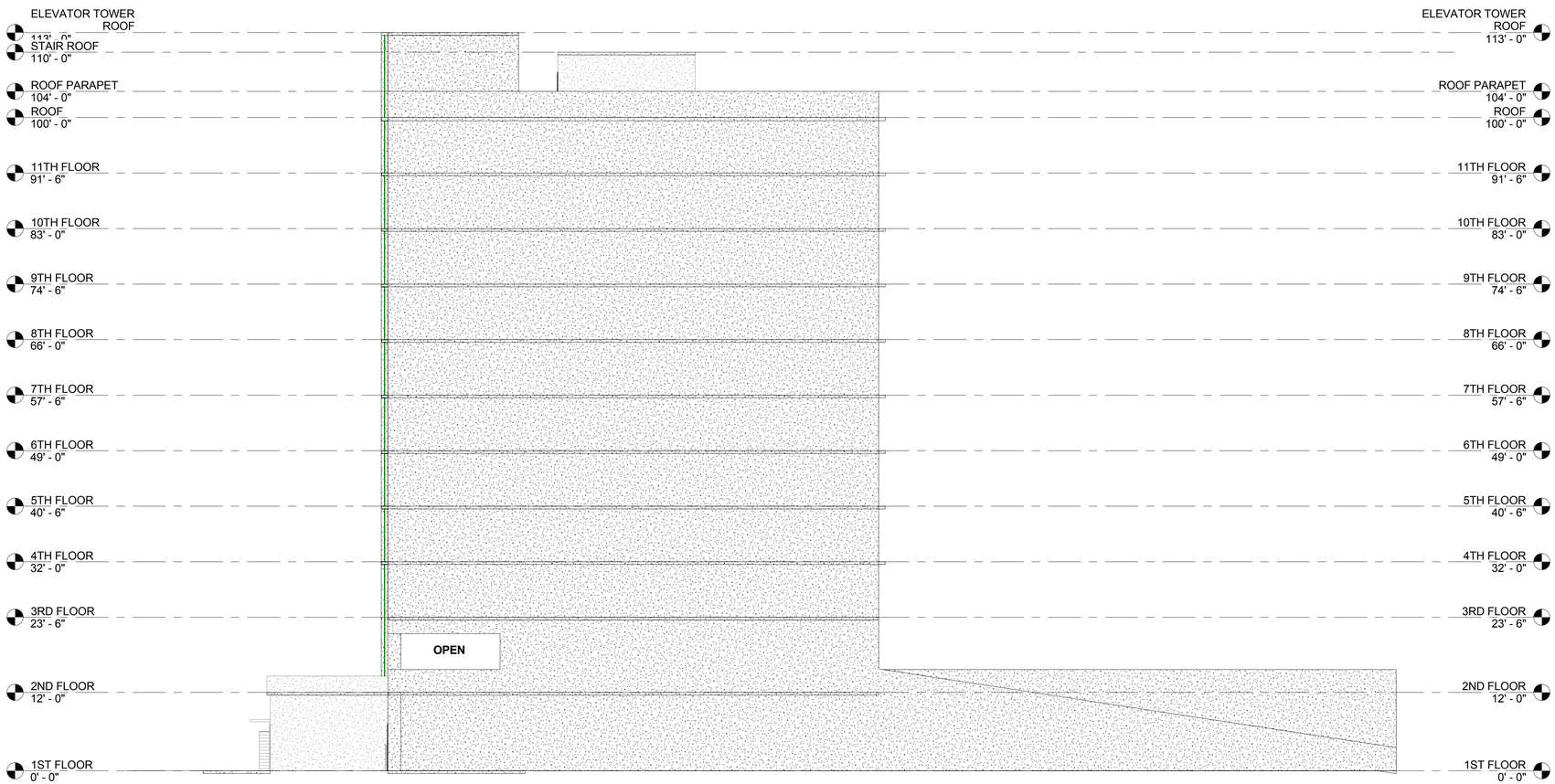

1 **WEST ELEVATION (EWA)**
1" = 10'-0"

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450 PI'IKOI

No.	Description	Date

WEST ELEVATION (EWA)

Project Number	Project Number
Date	Issue Date
Drawn By	Author
Checked By	Checker

A2.3

Scale 1" = 10'-0"

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SECTION THREE
DESCRIPTION OF ENVIRONMENT, ANTICIPATED IMPACTS AND MITIGATION MEASURES

3.1 ENVIRONMENTAL SETTING

The project site represents a portion of a large block that is located within a highly urbanized area located within the Primary Urban Center. A mix of high-rise residential structures, warehouses, commercial and industrial uses are located within the project vicinity. The site is also located along the perimeter of the KCDD Mauka Area.

The project site is located on a relatively flat open urban site that is presently used as a public day-rate parking lot housed within an warehouse structure. The building was formerly in use for warehousing and other light industrial operations. A retail operation was located along the Piikoi frontage but has since been closed and is vacant. The Waimanu Street frontage is presently used as a temporary construction base office and was formerly used for industrial storage and light construction work. The site is fully developed and is devoid of any significant vegetation.

Other uses on the project block, include a spa located immediately Ewa of the project site, warehouse and industrial use further Ewa, a sports bar located at the corner of Kona and Pensacola Street, a restaurant and appurtenant parking on the Ewa-makai corner of the block, a two-story restaurant and office building along Waimanu Street, and an office and bar complex located on the Diamond Head-makai corner of the block. Above ground utilities are located presently located along Kona and Waimanu Streets.

The Honolulu Area Rapid Transit (HART) rail station will be located adjacent to the Ala Moana Shopping Center on Kona Street. The transit station will be located approximately 800-feet from the project property and is within easy walking distance.

3.2 SURROUNDING USES

Adjacent uses reflect the dynamically changing environment of the Kakaako District. The landmark Ala Moana Shopping Center and residential and commercial highrises are located across Piikoi Street. A highly urbanized high rise residential block containing six tower buildings lie directly makai on Waimanu Street while the blocks mauka and Ewa of the project block contain a mix of industrial, retail, office, service and dining establishments. The proposed affordable rental project represents the first reserved housing development in the immediate vicinity. Its proximity to the future Ala Moana HART Transit station makes this project highly desirable and well conceived in utilizing this major transportation hub.

3.3 MASTER PLAN

The proposed project represents the required reserved housing component of the landowner's development interests in the area. As such, the project is consistent with the intent of the mixed uses of the HCDA 2011 Kakaako Mauka Plan. More specifically, the project site is located within the Central Kakaako neighborhood where smaller lot development is encouraged. The project site is located within a Transit Oriented Development (TOD) area of the Honolulu Area Rapid Transit Ala Moana station. TOD plans generally encourage the development of residential projects within walking distance of the transit stations. Most importantly, by providing affordable rental housing, housing options are provided in an area that is predominantly ownership oriented.

3.4 ENVIRONMENTAL CONSIDERATIONS

3.4.1 GEOLOGICAL CHARACTERISTICS

Topography

The project site consists of flat urban lands that have been formerly in commercial uses. The parcel located along Kona Street was predominantly in warehouse use and is occupied by a metal building with paved flooring. The area located at the corner of Piikoi and Kona Street contains a vacant two story concrete commercial building that was formerly in retail use. The Waimanu Street parcel is presently occupied by two portable buildings that serve as a field office for a nearby construction project. It is located over paved ground. The site is essential devoid of any plant material and does not serve as a habitat for wildlife.

Climate

The geography of the Honolulu District is typically warm and dry in climate. Prevailing tradewinds arrive from the northeast. According to the National Weather Service Honolulu Office, over a period of 30 years, normal monthly high temperatures range from 80 degrees in January to a high of 89 degrees in August for an average of 84 degrees. Normal month low temperatures range from a low of 65 degrees in February and a high of 74 degrees in August for a monthly average of 70 degrees. Precipitation typically ranges from 0.44 inches in August to a high of 3.8 inches in December. The annual average rainfall in Honolulu is 70 inches per year.

USDA Soil Survey Report

The project site is located on soils classified FL fill land according to the Soil Survey of Islands of Kauai, Oahu, Maui, Molokai, and Lanai, State of Hawaii by the U.S. Department of Agriculture Soil Conservation Service. Fill land is typically found near Pearl Harbor and in Honolulu, adjacent to the ocean. It consists of areas filled with material dredged from the ocean or hauled from nearby areas, garbage, and general material from other sources. This land type is used for urban development including airports, housing areas, and industrial facilities.

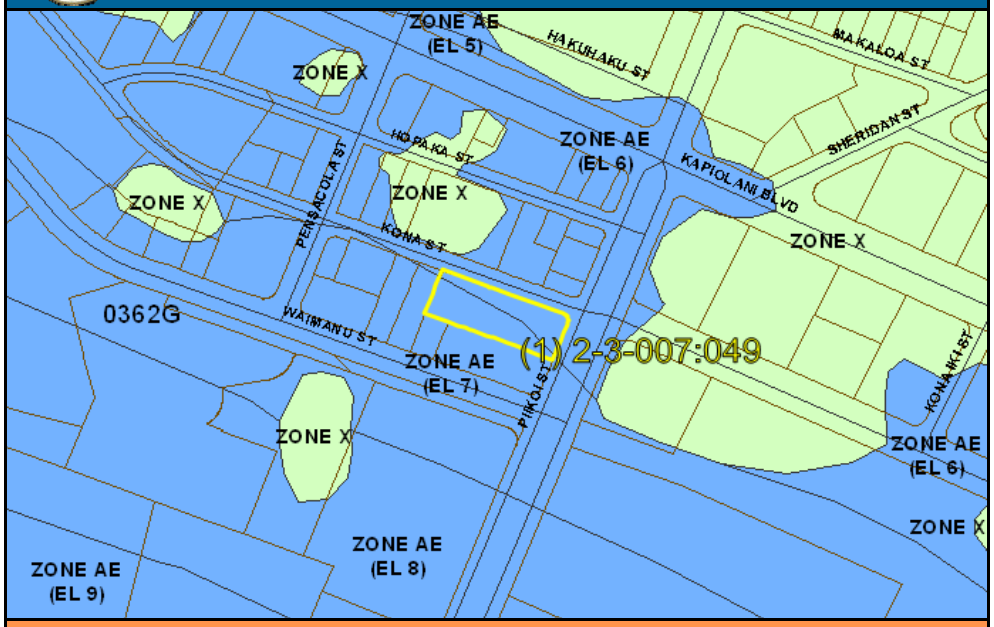
3.4.2 WATER RESOURCES

Hydrologic Hazards and Resources

According to Panel 150003 C 0362 G of the Federal Emergency Management Agency Flood Insurance Rate Map, the project site is located in Zone AE (EL7), an area where the base flood elevation has been determined to be seven feet.

State of Hawaii

FLOOD HAZARD ASSESSMENT REPORT



NATIONAL FLOOD INSURANCE PROGRAM

FLOOD ZONE DEFINITIONS

SPECIAL FLOOD HAZARD AREAS SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD – The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zone A, AE, AH, AO, V, and VE. The Base Flood Elevation (BFE) is the water-surface elevation of the 1% annual chance flood. Mandatory flood insurance purchase applies in these zones:

- **Zone A:** No BFE determined.
- **Zone AE:** BFE determined.
- **Zone AH:** Flood depths of 1 to 3 feet (usually areas of ponding); BFE determined.
- **Zone AO:** Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined.
- **Zone V:** Coastal flood zone with velocity hazard (wave action); no BFE determined.
- **Zone VE:** Coastal flood zone with velocity hazard (wave action); BFE determined.
- **Zone AEF:** Floodway areas in Zone AE. The floodway is the channel of stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without increasing the BFE.

NON-SPECIAL FLOOD HAZARD AREA – An area in a low-to-moderate risk flood zone. No mandatory flood insurance purchase requirements apply, but coverage is available in participating communities.

- **Zone XS (X shaded):** Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.
- **Zone X:** Areas determined to be outside the 0.2% annual chance floodplain.

OTHER FLOOD AREAS

- **Zone D:** Unstudied areas where flood hazards are undetermined, but flooding is possible. No mandatory flood insurance purchase requirements apply, but coverage is available in participating communities.

PROPERTY INFORMATION

COUNTY:	HONOLULU
TMK NO:	(1) 2-3-007-049
PARCEL ADDRESS:	1235 KONA ST HONOLULU, HI 96814
FIRM INDEX DATE:	NOVEMBER 05, 2014
LETTER OF MAP CHANGE(S):	NONE
FEMA FIRM PANEL(S):	15003C0362G
PANEL EFFECTIVE DATE:	JANUARY 19, 2011

PARCEL DATA FROM:	APRIL 2014
IMAGERY DATA FROM:	MAY 2006

IMPORTANT PHONE NUMBERS

County NFIP Coordinator	
City and County of Honolulu	
Mario Siu-Li, CFM	(808) 768-8098
State NFIP Coordinator	
Carol Tyau-Beam, P.E., CFM	(808) 587-0267

Disclaimer: The Department of Land and Natural Resources (DLNR) assumes no responsibility arising from the use of the information contained in this report. Viewers/Users are responsible for verifying the accuracy of the information and agree to indemnify the DLNR from any liability, which may arise from its use.

If this map has been identified as 'PRELIMINARY' or 'UNOFFICIAL', please note that it is being provided for informational purposes and is not to be used for official/legal decisions, regulatory compliance, or flood insurance rating. Contact your county NFIP coordinator for flood zone determinations to be used for compliance with local floodplain management regulations.

Source: Department of Land and Natural Resources

Tsunami Inundation

According to the National Ocean and Atmospheric Administration (NOAA), the project site is located within an evacuation area of the Tsunami Hazard Map. This zone generally encompasses the entire area makai of Kapiolani Boulevard. While the area is designated as an area that should be evacuated in the event of an impeding tsunami, it does not infer that the areas are subject to hazard.

Special Management Area

The project site is not located within the boundaries of the Special Management Area (SMA) Map.

3.4.3 HISTORICAL AND ARCHAEOLOGICAL ASSESSMENT

A study titled *Archaeological Monitoring Plan for the Senior Residence at Pi'ikoi, Kaka'ako Ahupua'a, Kona District, O'ahu Island TMK: [1] 2-3-007:026 & 049* was prepared by Cultural Surveys Hawaii in May 2013. The study, which covered the entire project block, is summarized in this section and included in its entirety as Appendix D.

Background Summary

The current project area is located outside the two most intensely populated and cultivated areas during pre-contact times - Waikīkī and Honolulu (or Kou) - along this portion of O'ahu's southern shore. It was nonetheless well utilized by the Hawaiians for activities appropriate to the specific environment, such as salt making, farming of fishponds, and wetland agriculture. The study area was also among the last areas of urban Honolulu to be built on and developed.

The project area is located within the *'ili* of Kewalo which was awarded as LCA 10605 to Kamake'e Pi'ikoi, wife of an *ali'i* Jonah Pi'ikoi. Unfortunatly no additional land use data on LCA 10605 has been found. Other LCAs in the near vicinity of the project area were originally awarded as fort lands. To the south of the current project area is LCA 97 F.L./ Royal Patent 3782. LCAs to the east of the project area include Royal Patent 7553 issued for LCA 100 F.L. and Royal Patent 3781 issued for LCA 101 F.L. As LCA 97 F.L. explains, the land was gifted "since Nu'uanu", suggesting these fort lands were granted by Kamehameha I after the battle of Nu'uanu, likely to loyal warriors and their families. The LCA testimonies indicate these lands were passed down through generations of Hawaiian families. LCAs in the vicinity of the project area indicate these lands were used for fishponds, taro patches, salt pans, and houselots.

Historic maps and photographs indicate the land was utilized for agriculture in the mid 1800s (see Figure 11). In the early twentieth century several houses were erected adjacent to ponds in the near vicinity of the project area (see Figure 25). However, the project area does not appear to have been heavily utilized until the

late 1940s when a warehouse was erected within the project area. No other land use within the project area is indicated by historic maps other than the previous alignment of Sheridan Street, subsequently straightened and re-named to Pi‘ikoi Street. The former Sheridan Street is not shown on the 1881 map (see Figure 16) but is shown on the 1884 map (see Figure 15), suggesting roads in the immediate vicinity were developing at that time. Once the land was filled (circa 1930s), it became more commercialized and became part of the system of sprawling city blocks. By the mid-twentieth century, the project area was covered over with warehouses and became heavily commercialized.

Summary of Inventory Survey Results

Surface Survey

The fieldwork component of this archaeological inventory survey (AIS) was conducted between May 19, 2010 and November 16, 2011. A brief 100 percent pedestrian inspection of the project area's surface identified the existing warehouse structure covering the project area to be older than 50 years old (Figure 60 and Figure 61). On March 4, 2011, through consultation with the Architecture Branch of the SHPD, the building was determined not to merit listing on the Hawai‘i Register of Historic Places (Log No. 2011.0599, Doc No. 1103RS06) (Appendix A).

The existing warehouse structure was erected in 1948 and was completed by 1949 (refer to Figure 33). The structure was built specifically for the Durant-Irvine Company which specialized in plumbing equipment for small companies and large industries, such as plantations. More recent changes to the warehouse included a 1961 addition fronting Pi‘ikoi Street. Over time the warehouse has been used for storage and car parking and presently is being used by a single tenant for a contractor business.

Subsurface Testing

The subsurface testing program included the excavation of 13 test trenches, comprising a total of approximately 56 m^2 or approximately 1.8% of the project area (Figure 59 and Table 3). Ten test trenches (Trenches 1-10) were excavated within the main warehouse and three trenches (Trenches 11-13) were excavated in proposed utility corridors outside of the main warehouse.

Representative trench profiles (Trenches 3, 7, 10 and 12) and corresponding stratigraphic descriptions are presented in this report (Figure 60 through Figure 69 and Table 4 through Table 7). Observed and documented stratigraphy was relatively consistent throughout the project area. In general, project stratigraphy included a concrete or asphalt surface overlying various layers of imported historic and modern fill (Stratum I), including gravelly sandy clay, clay loam with sparse historic material (cinder, metal, and red brick), crushed coral, and hydraulic fill or pump dredge, over natural wetland (SIHP # -6636) (Stratum II),

and coral shelf. Imported fill sediments extended to a minimum of 1.6 mbs (over 5 feet) in all trenches except one (Trench 7). Trench 7 was unique in that under the imported fill material (Stratum I) was a natural sandy clay deposit (Stratum II), which was not observed in any of the other trenches. The natural deposit was documented overlying natural sandy clay wetland (Stratum III) and coral shelf.

One historic property (SIHP # 50-80-14-6636) was documented during the subsurface investigation (see Figure 59). SIHP # 50-80-14-6636 consists of buried Kewalo wetland sediments. The site contains a very dark brown silty clay loam buried A-Horizon containing abundant decomposing organic materials (peat), snail shells, rootlets and charcoal flecking, overlying gleyed sandy clay sediments, over the coral shelf. In most trenches, within SIHP -6636 it was possible to discern between a very dark brown silty clay loam buried A-Horizon (Stratum IIa), and underlying gleyed sandy clay wetland sediment (Stratum IIb) (refer to the Trench 3 profile). The buried wetland sediment (SIHP # -6636) was observed within all trenches within the project area. A photo of a bulk sample collected from SIHP # -6636 is shown in Figure 68. Historic documentation suggests the site was capped with imported fill during early 20th century Land Reclamation fill events. The site has been previously documented in nearby areas in Kakaʻako (O'Hare et al. 2003, O'Hare et al. 2004, Tulchin and Hammatt 2005, and Runyon et al. 2011a).

A sediment sample collected from SIHP # -6636 was analyzed by Dr. Carl Christensen, professional malacologist. In general, the analysis found that the wetland site, SIHP # -6636, contains fauna typical of other similar wetland environmental sites in Hawaiʻi. The analysis also notes that the snail species represented in the samples were "little changed from those present there and in similar environments in pre-Contact times" (Christensen 2011:9). Of three snail species commonly found in these wetland environments (*T. porrecta*, *M. tuberculata*, and *T. granifera*), one species (*T. porrecta*) found within SIHP # -6636 is now virtually extinct.

Summary and Interpretation

At the request of Kewalo Development LLC, CSH completed this archaeological monitoring plan for the approximately 0.74-acre proposed Senior Residence at Piʻikoi project in Kakaʻako Ahupuaʻa (TMK: [1] 2-3-007:026 & 049). Based on traditional accounts and historic background information, the current project area is located outside the two most intensely populated and cultivated areas during pre-contact times - Waikīkī and Honolulu (or Kou) - along this portion of Oʻahu's southern shore. It was nonetheless well utilized by the Hawaiians for activities appropriate to the specific environment, such as salt making, farming of fishponds, and wetland agriculture.

The project area is located within the *ʻili* of Kewalo which was awarded as LCA 10605 to Kamakeʻe Piʻikoi, wife of an *aliʻi* Jonah Piʻikoi. Unfortunately no additional land use data on LCA 10605 has been found. Other LCAs in the near

vicinity of the project area were originally awarded as fort lands. To the south of the current project area is Royal Patent 3782 issued to Kapapa for Land Commission Award 97 F.L. (Fort Land). LCAs to the east of the project area include Royal Patent 7553 issued for LCA 100 F.L. and Royal Patent 3781 issued for LCA 101 F.L. As LCA 97 F.L. explains, the land was gifted "since Nu'uanu", suggesting these fort lands were granted by Kamehameha I after the battle of Nu'uanu, likely to loyal warriors and their families. The LCA testimonies indicate these lands were passed down through generations of Hawaiian families. LCAs in the vicinity of the project area indicate these lands were used for fishponds, taro patches, salt pans, and house lots.

A brief 100 percent pedestrian inspection of the project area's surface identified the existing warehouse structure covering the project area to be older than 50 years. On March 4, 2011, through consultation with the Architecture Branch of the SHPD, the warehouse was determined not to merit listing on the Hawai'i Register of Historic Places (Log No. 2011.0599, Doc No. 1103RS06) (Appendix A).

The subsurface testing program included the excavation of 13 test trenches, comprising a total of approximately 56 m^2 or approximately 1.8% of the project area. One historic property (SIHP # 50-80-14-6636) was documented during the project investigation. SIHP # 50-80-14-6636 consists of buried Kewalo wetland sediments. SIHP # 50-80-14-6636 had been previously designated for buried wetland deposits in the vicinity of the project area. The site was originally identified approximately 140 meters (approximately 470 feet) *mauka* of the the current project area by O'Hare et al. (2003). The site was also identified within Phase 1 and Phase II of the Ko'olani Condominium project located across Waimanu Street from the current project area (O'Hare et al. 2004, Tulchin and Hammatt 2005, and Runyon et al. 2011a).

The site contains a very dark brown silty clay loam buried A-Horizon containing abundant decomposing organic materials (peat), snail shells, rootlets and charcoal flecking, overlying gleyed sandy clay sediments containing rootlets and small snail shells, over the coral shelf. A sample of the wetland site, SIHP # -6636, was sent to Dr. Carl Christenson for snail analysis. The analysis concluded the fauna assemblage represented in the sample was similar to what would be expected in a wetland environment in pre-contact times.

Based on the AIS results, it is unlikely that historic properties, other than the documented buried wetland sediments (SIHP # -6636), will be encountered within the project area. It is likely that if any surface structures or features had existed on the property prior to the 1930s, they would have likely been destroyed during the filling in of the area with imported sediments. However, it is possible that remnants of former agricultural and/or aquacultural features, including but not limited to irrigation ditches and/or constructed berms, may be encountered within the project area. Based on previous archaeological studies in the vicinity, potential

sub- surface deposits may include pre- and/or post-Contact cultural deposits, artifacts, and/or human burials. The monitoring program will further document the wetland site, SIHP # -6636, as well as facilitate the identification and treatment of any additional historic properties that may be discovered during project construction.

Documented stratigraphy indicates very thick fill deposits exist within the project area. Therefore, the monitoring program is recommended to include a combination of on-call and on- site monitoring. On-call monitoring will consist of weekly site visits to document and assess exposed project stratigraphy. On-site monitoring will consist of the monitoring of excavations which are planned to extend below 1 meter (approximately 3 feet) in depth. Any departure from this will only occur with written concurrence from SHPD.

Archaeological Monitoring Provisions

In consultation with SHPD, it was determined that a monitoring program was warranted as an historic preservation mitigation measure for the proposed Senior Residence at Pi‘ikoi Project. The following discussion outlines the provisions and procedures that will govern the project’s archaeological monitoring program.

Under Hawai‘i State historic preservation legislation, “Archaeological monitoring may be an identification, mitigation, or post-mitigation contingency measure. Monitoring shall entail the archaeological observation of, and possible intervention with, on-going activities which may adversely affect historic properties” (HAR Chapter 13-279-3). For this project, the proposed monitoring program will serve as a mitigation measure that insures proper documentation should historic properties be encountered.

Hawai‘i State historic preservation legislation governing archeological monitoring programs requires that each monitoring plan discuss eight specific items (HAR Chapter 13-279-4). The monitoring provisions below address those eight requirements in terms of the archaeological monitoring for the construction within the project area.

- Anticipated Historic Properties: The project area contains wetland sediments (SIHP # -6636) underlying thick imported fill materials. It is possible additional cultural deposits (pre- and/or post- Contact), including but not limited to former agricultural/aquacultural features (irrigation ditches, constructed berms, etc.), cultural deposits, artifacts, and/or human burials, may exist within the project area.

- Locations of Historic Properties: It is likely that any encountered historic properties would be found below the thick imported fill materials ubiquitous to the project area. The wetland site (SIHP # -6636) was documented occurring at a minimum of 1.6 meters below the ground surface. However, previously disturbed but still significant finds may be present within imported fill deposits.

Fieldwork: As stated in the archaeological inventory survey report (Runyon et al. 2012) for this project, "The project development should proceed under an archaeological monitoring program to help alleviate the project's impact on the historic property documented during the current project investigation (SIHP # -6636) as well as to facilitate the identification and treatment of any additional historic properties, including cultural deposits, artifacts, and/or human burials, that may be discovered during project construction." The monitoring fieldwork will include standard archaeological documentation techniques. This will include drawing and recording the stratigraphy of excavation profiles where cultural features or artifacts are exposed as well as representative profiles. These exposures will be photographed, located on project area maps, and sampled. Photographs and representative profiles of excavations will be taken even if no historically-significant sites are documented. As appropriate, sampling will include the collection of representative artifacts, bulk sediment samples, and/or the on-site screening of measured volumes of feature fill to determine feature contents.

If non-human remains are identified, SHPD will be consulted regarding appropriate mitigation measures, pursuant to HAR 13-280-3.

If human remains are identified, no further work will take place, including no screening of back dirt, no cleaning and/or excavation of the burial area, and no exploratory work of any kind unless specifically requested by the SHPD. All human skeletal remains that are encountered during construction will be handled in compliance with HRS Chapter 6E-43 and HAR Chapter 13-300 and in consultation with SHPD/DLNR.

- Archaeologist's Role: The monitoring archaeologist will have the authority to stop work immediately in the area of any findings so that documentation can proceed and appropriate treatment can be determined. In addition, the archaeologist will have the authority to slow and/or suspend construction activities in order to insure that the necessary archaeological sampling and recording can take place.

- Coordination Meeting: Before work commences on the project, the monitoring archaeologist shall hold a coordination meeting to orient the construction crew to the requirements of the archaeological monitoring program. At this meeting the monitor will emphasize his or her authority to temporarily halt construction and that all historic finds, including objects such as bottles, are the property of the landowner and may not be removed from the construction site. During the coordination meeting it will be made clear that a combination of on-call and on-site monitoring will be conducted for this project. On-call monitoring will consist of weekly site visits to document and assess exposed project stratigraphy. On- site monitoring will consist of the monitoring of excavations which are planned to extend below 1 meter (approximately 3 feet) in depth. On-site and on-call monitoring will be coordinated by CSH archaeologists with the project construction manager and construction crew. Any departure from this will

only occur with written concurrence from SHPD.

- Laboratory work: Laboratory work will be conducted in accordance of HAR 13-279-5-(6). Laboratory analysis of non-burial related finds will be tabulated into table form and standard artifact and midden recording will be conducted as follows: artifacts will be documented as to provenience, weight, length, width, type of material, and presumed function. Photographs of representative artifacts will be taken for inclusion into the archaeological monitoring report. Bone and shell midden materials will be sorted down to species, when possible, and then tabulated by provenience.

As appropriate, collected charcoal material obtained within intact cultural deposits will be analyzed for species identification. Subsequently, suitable identifiable samples will be sent to Beta Analytic, Inc. for radiocarbon dating. If appropriate, artifacts may be sent to the University of Hawai‘i-Hilo Geoarchaeology lab for Energy-Dispersive X-ray Fluorescence (EDXRF) analysis in order to identify and possibly geographically locate the source material. All analyzed samples, provenience information, and results will be presented in table form within the archaeological monitoring report.

- Report Preparation: One of the primary objectives of the report will be to present a stratigraphic overview of the project area which will allow for predictive assessments of adjacent properties, which may be the subject of future development. The report will contain a section on stratigraphy, description of archaeological findings, monitoring methods, and results of laboratory analyses. The report will address the requirements of a monitoring report (HAR section 13-279-5). Photographs of excavations will be included in the monitoring report even if no historically-significant sites are documented. Should burial treatment be completed as part of the monitoring effort, a summary of this treatment will be included in the monitoring report. Should burials and/or human remains be identified, then other letters, memos, and/or reports may be requested by the Burial Sites Program.

- Archiving Materials: Materials not associated with burials will be temporarily stored at the contracted archaeologist’s facilities until an appropriate curation facility is selected, in consultation with the landowner and SHPD. In the event that human remains are encountered and relocation is deemed appropriate by the SHPD then any interim curation of human remains and any associated grave goods is the responsibility of the landowner and will be done at the direction of the SHPD.

- Research Focus Based on the AIS results, it is unlikely that historic properties, other than the documented buried wetland sediments (SIHP # -6636), will be encountered within the project area. It is likely that if any surface structures or features had existed on the property prior to the 1930s, they would have likely been destroyed during the filling in of the area with imported

sediments. However, it is possible that remnants of former agricultural/aquacultural features, including but not limited to irrigation ditches and/or constructed berms, may be encountered within the project area. Research questions that could be answered as a result of monitoring activities related to the proposed redevelopment project include:

- Does SIHP # -6636 extend across the entire project area or can it be defined within the project area boundaries?

- Do any cultural features exist within the project area which could relate to use of the land prior to it being filled in with imported materials?

If the above questions can be addressed, then we may be able to more fully characterize the past land-use of this portion of Kaka'ako and better predict the archaeological deposits that can be expected in the general area.

3.4.4 TRAFFIC CONDITIONS

A Traffic Impact Assessment Study was conducted by Parsons Brinkerhoff for the proposed project. The study, titled ***Traffic Evaluation Piikoi Affordable Housing***, is summarized in this section and included in its entirety as Appendix F. The study was completed in September of 2014.

Existing Conditions

The Piikoi Affordable Housing development is located on the makai side of Kona Street Ewa of Piikoi Street. This site is currently occupied by a mixture of restaurant and commercial and restaurant land uses.

Existing Roadway Network

1. Waimanu Street
Waimanu Street is a two-lane local roadway between Dreier Street and Queen Street providing access throughout the mostly industrial area. Between Queen Street and Pensacola Street, Waimanu Street becomes a four-lane roadway. Koko Head (KKHD) of Pensacola Street becomes one-way in the KKHD-direction, providing access to Ala Moana Center via a driveway KKHD of Piikoi Street. The posted speed limit on Waimanu Street is 25 miles per hour.

2. Kona Street
Kona Street is an unstriped two-lane local roadway between Kamakee Street and Piikoi Street and a divided four-lane roadway KKHD of Piikoi Street. KKHD of Piikoi Street, Kona Street runs along the mauka side of Ala Moana Center. Ewa

of Piikoi Street it provides access to industrial land uses. Within the vicinity of the project, Kona Street is signalized at Piikoi Street and unsignalized at Pensacola Street. There is no posted speed limit on Kona Street within the vicinity of the project.

3. Pensacola Street
Pensacola Street extends from Prospect Street in Makiki makai to Waimanu Street. Within the project's vicinity, Pensacola Street is a two-lane, one-way principal arterial in the makai-bound direction. Pensacola Street intersects Waimanu Street at a signalized intersection. The posted speed limit is 25 miles per hour.

4. Piikoi Street
Piikoi Street is a minor arterial which extends from Ala Moana Boulevard mauka to Pensacola Street in Makiki. Within the vicinity of the project, Piikoi Street is a six-lane, divided roadway with a median. There are two makai-bound lanes and four mauka-bound lanes. Piikoi Street is signalized at Waimanu Street and Kona Street. The posted speed limit in the project vicinity is 25 miles per hour. Mauka of Kapiolani Boulevard, Piikoi Street is a one-way road, forming a one-way couplet with Pensacola Street to provide mauka-makai mobility and access to H-1 Freeway on-ramps. The couplet also provides access to the primary KKHD-Ewa streets serving the urban area of Honolulu.

Existing Traffic Volumes

Manual traffic counts, pedestrian counts, and bicycle counts were conducted on Tuesday, January 10 and Wednesday, January 11, 2012 during the AM and PM peak periods at the following intersections:

- Pensacola Street/Waimanu Street/Koolani East Driveway
- Piikoi Street/Waimanu Street/Ala Moana Driveway
- Piikoi Street/Kona Street
- Pensacola Street/Kona Street

The traffic volumes were summarized into AM and PM peak hour volumes and a growth factor of 1% was applied to obtain existing 2014 traffic volumes shown in Figure 4. The study AM and PM peak hours were 8:00-9:00 AM and 5:00-6:00 PM, respectively.

The pedestrian counts showed that Piikoi Street saw more pedestrian activities than Pensacola Street with concentration mostly on Ala Moana Shopping Center sidewalk. At the Piikoi Street/Waimanu Street/Ala Moana Driveway intersection, 158 pedestrians used the three crosswalks during the AM peak hour and 222 pedestrians used the three crosswalks during the PM peak hour.

At the Piikoi Street/Kona Street intersection, 143 pedestrians used the three crosswalks with a majority (120) using the Kona Street KKHD crosswalk. During the PM peak hour, 209 pedestrians used the three crosswalks with 119 using the Kona Street KKHD crosswalk. At the Pensacola Street/Waimanu Street/Koolani East Driveway intersection, 16 pedestrians used the three crosswalks during the AM peak hour and 61 pedestrians used the three crosswalks during the PM peak hour. The two-way stop-controlled Pensacola Street/Kona Street intersection does not have any striped crosswalks. Still, 17 pedestrians crossed through the intersection during the AM peak hour and 27 pedestrians crossed through the intersection during the PM peak hour.

No intersection in the project vicinity attracted more than 18 bicycles in either peak hour.

Transit

The closest bus stop to the project vicinity is stop #4334 (Piikoi Street and Ala Moana Shopping Center ramp opposite Waimanu Street). This bus stop is serviced by bus routes #6 (Waikiki Beach & Hotels), #8 (Waikiki Beach & Hotels), #19 (Waikiki Beach & Hotels), #20 (Waikiki Beach & Hotels), #56 (Honolulu – Ala Moana Center), #57 (Honolulu – Ala Moana Center), #57A (Honolulu – Ala Moana), #65 (Honolulu – Ala Moana Center), and #88A (North Shore Express).

Existing Traffic Operations

The study area intersections were analyzed using the methodologies for signalized and unsignalized intersections outlined in the 2010 and 2000 Highway Capacity Manual (HCM). Operating conditions at an intersection are expressed as a qualitative measure known as Level of Service (LOS) with letter designations ranging from A through F, with LOS A representing free-flow conditions and LOS F representing over-capacity conditions.

Summary of Existing Operations

All intersections and individual movements operate at LOS B or better overall during both peak hours with the exception of the Piikoi/Waimanu intersection. This intersection operates at LOS D during the PM peak hour largely due to the Ewa-bound right turn leaving Ala Moana which is projected to operate at LOS F.

Table 1: Existing Levels of Service

	Existing			
	AM		PM	
	LOS	Delay	LOS	Delay
Pensacola Street and Kona Street	**Unsignalized**		**Unsignalized**	
Kona EB Approach	C	16	C	24
Kona WB Approach	C	15	D	30
Pensacola Street and Waimanu Street	**B**	**12**	**B**	**17**
Pensacola SB Left	B	10	B	14
Pensacola SB Right	B	11	B	20
Waimanu EB Approach	B	15	B	17
Koolani East NB Left	B	17	C	25
Koolani East NB Right	B	15	C	24
Piikoi Street and Kona Street	**A**	**6**	**B**	**10**
Piikoi NB Approach	A	5	A	8
Piikoi SB Approach	A	4	A	6
Kona EB Approach	B	10	B	15
Kona WB Left	B	11	B	19
Kona WB Left-Through	B	11	B	16
Kona WB Right	B	11	B	17
Piikoi Street and Waimanu Street	**B**	**10**	**D**	**37**
Piikoi NB Through-Right	B	11	B	13
Piikoi SB Through	A	10	B	12
Waimanu EB Left	B	11	C	27
Waimanu EB Through	A	7	B	10
Waimanu EB Right	A	8	B	12
Ala Moana Driveway Approach	B	18	F	130

*Delay is expressed in seconds per vehicle

Projected Year 2017 Conditions Without Project

The Year 2017 represents the future conditions horizon year for the project area without the Piikoi Affordable Housing development. Queen Lane, a new roadway connection between Queen Street and Auahi Street, was opened in late 2011. No additional new roadways are projected to be constructed in the vicinity of the project by the build-out year.

Projected Year 2017 Roadway Network Without Project

General Growth Properties (GGP) is proposing to convert Waimanu Street to a two-way facility between Pensacola Street and Piikoi Street. The timeline of this improvement is undefined at this time, and was not considered for the year 2017 analysis. Regardless, the project is not anticipated to have a significant impact on the project's main access point.

The 2017 roadway network is assumed to be the same as the 2014 roadway network. Intersection geometry at the study area intersections and roads are expected to be the same as the 2014 scenario.

Projected Year 2017 Traffic Volumes Without Project

The 2017 background traffic was estimated utilizing an annual growth rate of 1%. This growth rate is based on the Oahu Metropolitan Planning Organization (MPO) Oahu Regional Transportation Plan (ORTP) 2035 model. This model takes into account all future Kakaako developments.

Projected Year 2017 Operations Without Project

The projected 2017 intersection LOS without the Piikoi Affordable Housing development is shown in the next table.

Summary of Year 2017 Operations Without Project

All intersections and individual movements are projected to operate at LOS B or better overall during both peak hours with the exception of the Piikoi/Waimanu intersection. This intersection is projected to operate at LOS D during the PM peak hour largely due to the Ewa-bound right turn leaving Ala Moana which is projected to operate at LOS F.

Table 2: Projected Year 2017 LOS Without Project

	2017 Background			
	AM		PM	
	LOS	Delay	LOS	Delay
Pensacola Street and Kona Street	**Unsignalized**		**Unsignalized**	
Kona EB Approach	C	16	C	24
Kona WB Approach	B	15	D	26
Pensacola Street and Waimanu Street	**B**	**13**	**B**	**19**
Pensacola SB Left	A	10	B	15
Pensacola SB Right	B	11	C	23
Waimanu EB Approach	B	16	B	18
Koolani East NB Left	B	18	C	26
Koolani East NB Right	B	18	C	28
Piikoi Street and Kona Street	**A**	**6**	**A**	**10**
Piikoi NB Approach	A	5	A	8
Piikoi SB Approach	A	4	A	5
Kona EB Approach	B	11	B	15
Kona WB Left	B	12	B	19
Kona WB Left-Through	B	11	B	16
Kona WB Right	B	12	B	18
Piikoi Street and Waimanu Street	**B**	**11**	**D**	**42**
Piikoi NB Through-Right	B	11	B	13
Piikoi SB Through	B	10	B	12
Waimanu EB Left	B	12	D	37
Waimanu EB Through	A	7	B	11
Waimanu EB Right	A	8	B	13
Ala Moana Driveway Approach	B	18	F	153

*Delay is expressed in seconds per vehicle

Projected Year 2017 Conditions With Project

The Year 2017 "With Project" scenario represents the future conditions within the project area with the Piikoi Affordable Housing completion. A new access driveway is proposed to be constructed approximately 210 feet Ewa of Piikoi Street.

Year 2017 Project-Generated Traffic Volumes

Future traffic generated by the Piikoi Affordable Housing development was estimated.

Trip Generation

Trip generation estimates the number of vehicular trips in and out of the project based on the land use type and density. Piikoi Affordable Housing can be classified as high-rise/condominium land use. Trips were estimated using trip generation equations published by the Institute of Transportation Engineers (ITE) in Trip Generation, 8th Edition.

The following table shows the planned project land use and corresponding trips generated. Transit share was conservatively estimated to be 7% and pedestrian share was conservatively estimated to be 7% due to the close proximity to major shopping centers, dining, and entertainment venues.

Table 3: Piikoi Affordable Housing Trip Generation

	Land Use	Dwelling Units	AM Peak Hour			PM Peak Hour		
			Enter	Exit	Total	Enter	Exit	Total
High Rise/Condominium	High-Rise Condo	128	13	53	66	37	22	59
7% Transit Reduction			-1	-4	-5	-3	-2	-5
7% Ped Reduction			-1	-4	-5	-3	-2	-5
Total Trips			**11**	**45**	**56**	**31**	**18**	**49**

*ITE Trip Generation, 8th Edition, Land Use: High-Rise Condominium/Townhouse (232)

Projected Year 2017 Operations with Project The projected Year 2017 intersection Level of service with the Piikoi Affordable Housing development is shown below.

Summary of Year 2017 Operations with Project

All intersections and individual movements are projected to operate at LOS B or better overall during both peak hours with the exception of the Piikoi/Waimanu intersection. This intersection is projected to operate at LOS D during the PM peak hour largely due to the Ewa-bound right turn leaving Ala Moana which is projected to operate at LOS F.

Table 4: Projected Year 2017 LOS With Project

	2017 With Project			
	AM		PM	
	LOS	Delay	LOS	Delay
Pensacola Street and Kona Street	**Unsignalized**		**Unsignalized**	
Kona EB Approach	C	16	D	26
Kona WB Approach	C	16	D	30
Pensacola Street and Waimanu Street	**B**	**13**	**B**	**19**
Pensacola SB Left	A	10	B	15
Pensacola SB Right	B	12	C	24
Waimanu EB Approach	B	16	B	18
Koolani East NB Left	B	18	C	27
Koolani East NB Right	B	19	C	28
Piikoi Street and Kona Street	**A**	**7**	**B**	**10**
Piikoi NB Approach	A	5	A	8
Piikoi SB Approach	A	4	A	6
Kona EB Approach	B	11	B	15
Kona WB Left	B	12	B	19
Kona WB Left-Through	B	11	B	16
Kona WB Right	B	11	B	18
Piikoi Street and Waimanu Street	**B**	**11**	**D**	**43**
Piikoi NB Through-Right	B	11	B	13
Piikoi SB Through	B	10	B	12
Waimanu EB Left	B	12	D	37
Waimanu EB Through	A	8	B	11
Waimanu EB Right	A	8	B	13
Ala Moana Driveway Approach	B	18	F	155
Piikoi Affordable Housing Driveway and Kona Street	**Unsignalized**		**Unsignalized**	
Kona WB Left	A	1	A	1
Affordable Housing Driveway	A	9	A	9

*Delay is expressed in seconds per vehicle

Conclusions and Recommendations

The existing roadway network is sufficient to handle the additional traffic generated by the Hale Kewalo development.

Based on the operational analyses of intersections, the following are recommended to be implemented in conjunction with the proposed project:

• It is recommended that the Hale Kewalo development be accessed via a full-movement driveway on Kona Street. The driveway will be designed to meet sight distance requirements. A secondary driveway KKHD of the primary Kona Street access will be used by service trucks during limited hours only.

• The Waimanu Street driveway was analyzed as a left-in/left-out access. However, Waimanu Street is being converted to a two-way street between Pensacola Street and Piikoi Street in late 2014. In order to minimize traffic impact to Waimanu Street, it is recommended that the Waimanu Street access be configured as a right-in/right-out access.

• The City of Honolulu Department of Planning and Permitting (DPP) has requested the installation of a crosswalk across the makai leg of the intersection of Piikoi Street and Kona Street. This would be accompanied by the conversion of the middle lane of the Ewa-bound Kona Street approach from a shared left/through lane to a through lane. The Developer will continue working with GGP on an agreement to construct the crosswalk.

• The Honolulu Authority for Rapid Transportation (HART) will construct columns along Kona Street. The column location should be coordinated with the primary Kona Street driveway location.

• HART and the City & County of Honolulu will be responsible for constructing sidewalks fronting the development on Kona Street with the necessary curb ramps and curb cuts. The Developer will set aside 17' of right of way.

3.4.5 NOISE ENVIRONMENT

A noise impact study was conducted by D. L. Adams Associates, Ltd. This study, titled Environmental Noise Report Hale Kewalo, Honolulu, Hawaii is summarized as follows and is included in its entirety as Appendix G.

Existing Acoustical Environment

Noise measurements consisted of continuous long-term ambient noise level measurements, as described in the sections below. The noise measurements were conducted between August 1, 2014 and August 5, 2014.

The methodology, location, and results for each of the measurements are described below and the measurement locations are illustrated in Figure 4. Photographs of the measurements locations are provided in Appendix B.

Long Term Noise Measurements

Continuous long-term ambient noise level measurements were conducted to assess the existing acoustical environment in the vicinity of the project site. Long-term measurements (taken continuously over the course of multiple days) offer a baseline for establishing existing ambient noise levels in the area and are used for estimating future noise levels by adding the ambient levels to other noise levels generated from the proposed project.

Hourly equivalent sound levels ($L_{eq}(h)$) were recorded for approximately 4 days. The measurements were taken using a Larson-Davis, Model 831, Type 1 Sound Level Meter together with a Larson Davis, PRM831 Type 1 Microphone. Calibration was checked before and after the measurements with a Larson-Davis Model CAL200 calibrator. Both the sound level meter and the calibrator have been certified by the manufacturer within the recommended 2-year calibration period. The microphone was mounted a tripod at approximately 20 feet above grade. A windscreen covered the microphone during the entire measurement period. The sound level meter was secured in a weather-resistant case.

Location: The sound level meter was located on the rooftop of the existing building overlooking Piikoi Street at the project site location, between Waimanu and Kona Streets. The dominant noise source was vehicular traffic from the roadway. Secondary noise sources included birds, wind, and construction equipment.

The measured $L_{eq}(h)$ and the 90 percent exceedance level (L_{90}) in dBA are graphically presented in Figure 5. The ambient sound levels were dynamic and depended significantly on the vehicular traffic patterns along Piikoi Avenue. The range of $L_{eq}(h)$ during the day (7:00 AM to 10:00 PM) and during the night (10:00 PM to 7:00 AM) and average calculated day-night level are summarized as follows.

7 AM to 10 PM	68 to 70 $L_{eg(h)}$ Range
10 PM to 7 AM	63 to 64 $L_{eg(h)}$ Range

Average 71 L_{dn}

Potential Noise Impacts

Construction Noise and Compliance with HDOH Community Noise Control Rule

- The various construction phases of the project will generate significant amounts of noise. Depending on when construction occurs, the 450 Piikoi project may impact existing adjacent properties, such as the high-rise condominium tower across Waimanu Street (Hawaiki Tower) and single-story retail strip malls across Piikoi Avenue and Kona Street.

- Development of the project areas will involve excavation, grading, and other typical construction activities during construction. The use of impact equipment is not anticipated, as the foundation will be pre-drilled to avoid any need for pile driving. The actual noise levels produced during construction will be a function of the methods employed during each stage of the construction process. Earthmoving equipment, e.g., bulldozers and diesel-powered trucks, will probably be the loudest equipment used during construction. In cases where construction noise is expected to exceed the HDOH "maximum permissible" property line noise levels, a permit must be obtained to allow the operation of construction equipment.

Project Generated Stationary Mechanical Noise and Compliance with HDOH Community Noise Control Rule

- The Hale Kewalo Development is proposed to be a multi-family development, which will likely incorporate stationary mechanical equipment. Expected mechanical equipment may include HVAC equipment, emergency generators, etc. Noise from this mechanical equipment and other equipment must meet the State noise rules, which stipulate maximum permissible noise limits at the property line. For multi-family dwellings, business, and commercial areas, the noise limits are 60 dBA during the day and 50 dBA during the night. Mitigation of mechanical noise to meet the HDOH noise rules should be incorporated into the project design.

Transportation Noise Analysis

- A transportation noise analysis was completed using the DataKustik CadnaA (version 4.4) software program for the existing conditions, future year 2017 including the “with project” and “without project” conditions, and future year 2019 after the Honolulu Rail Transit Project (HART) is expected to start operation near the project site.

- Two noise metrics were used to evaluate traffic noise impact, based on the intended land or space use, as described below. These metrics are based FTA guidelines, discussed later in this report, but also apply to HUD and FHWA criteria for residential and commercial areas, respectively.

Commercial / Retail Area Noise Evaluation

Commercial / retail areas were evaluated based on the $L_{eq}(h)$ for worst-case peak-hour traffic volumes, which was determined to be PM hour as traffic volumes during this hour exceeded AM traffic volumes in all cases. This metric is used in areas that are typically only occupied during daytime hours.

Multi-Family Area Noise Evaluation

Multi-family areas were evaluated based on L_{dn} noise levels, which takes into account noise levels from both daytime (15-hour average) and nighttime (9-hour average) traffic volumes. Traffic volume data was not available for off-peak hours, and was estimated from the long term noise measurement data discussed above. Traffic volumes for future conditions were based on percentage increases shown in the Traffic Report. The L_{dn} metric is used in areas that are typically occupied during both daytime and nighttime hours, and where people are intended to sleep.

Traffic Noise

The traffic noise analysis was based on the peak hour AM and PM traffic volumes for existing, future without project, and future with project conditions shown in the Traffic Report. Intersection geometric configurations were also in this report.

Rail Noise

The elevated HART guideway will be routed along Kona Street, and adjacent to the 5th floor of the proposed Hale Kewalo building. To evaluate future rail noise into the residential units, the FTA's "Transit Noise and Vibration Impact Assessment" methodology was used. Additionally, the "Noise and Vibration Technical Report – Honolulu High-Capacity Transit Corridor Project" report and Addendum 1 of the report were used in the noise analysis of the building shell for the Hale Kewalo project.

The HART EIS states that no noise impact is expected along the Kona Street / Kapiolani Blvd. residential high-rises adjacent to the project site, and therefore no acoustically absorptive material is planned along the surface of the rail tracks. However, this project was not under design during the noise evaluation for the HART EIS so was not evaluated. Automatic track lubrication system will be not installed near the project site, as this section of track is generally straight and does not contain any significant turns which could result in tire squeal. Lastly, no crossover tracks are expected near the site.

Overall Transportation Noise Impacts on the Surrounding Community

Vehicular traffic noise levels were calculated throughout the surrounding community. In general, traffic noise increases along Waimanu, Piikoi, and Kona

Streets due to the project range from 0 dB to 1 dB change, which is not noticeable to the average person. A 3 dB increase is typically the minimum increase required to be perceptible by most listeners

Existing and future traffic noise level projections at the façade of the nearby commercial properties currently approach the FHWA's noise abatement criteria of 72 dBA, but these noise levels will not increase significantly due to the project.

Existing and future traffic noise level projections at adjacent multi-family properties will not increase significantly due to the project.

Overall Transportation Noise Impacts on the Project Site

Existing and future traffic noise level projections at the façade of the project's ground-floor commercial façade are less than the FHWA maximum noise limit of 72 dBA, so typical construction methods will be adequate.

Existing and future noise level projections, including traffic and transit noise, at the multi-family areas range from "acceptable" to "unacceptable" per HUD's exterior noise design criteria. Based on the existing noise environment and future rail noise projections, rail noise is expected to have a severe impact on the project site. Therefore, upgraded exterior façade elements such as glazing may be required in select areas to comply with the L_{dn} 45 dBA noise criteria inside the units.

Compliance with HUD Noise Guidelines

The results from the long-term noise measurements conducted at the project site and the transportation noise analysis indicate that the day-night level will be higher than the HUD 65 dBA site acceptability criteria, so a higher STC building shell will be required at the multi-family areas of the project.

It is important to note that the HUD noise guidelines are design goals and not enforceable regulations, although the HUD site acceptability standards must be satisfied for projects involving HUD or federal financing. However, these guidelines and design goals are useful tools for assessing the noise environment.

<u>Noise Impact Mitigation</u>

HDOH Noise Permit

In cases where construction noise exceeds, or is expected to exceed the State's "maximum permissible" property line noise levels, a permit must be obtained from HDOH to allow the operation of vehicles, cranes, construction equipment, power tools, etc., which emit noise levels in excess of the "maximum permissible" levels.

In order for HDOH to issue a construction noise permit, the contractor must

submit a noise permit application to HDOH, which describes the construction activities for the project. Prior to issuing the noise permit, HDOH may require action by the contractor to incorporate noise mitigation into the construction plan. HDOH may also require the contractor to conduct noise monitoring or community meetings inviting the neighboring residents and business owners to discuss construction noise. The contractor should use reasonable and standard practices to mitigate noise, such as using mufflers on diesel and gasoline engines, using properly tuned and balanced machines, etc. However, HDOH may require additional noise mitigation, such as temporary noise barriers, or time of day usage limits for certain kinds of construction activities.

Specific permit restrictions for construction activities are:

"No permit shall allow any construction activities which emit noise in excess of the maximum permissible sound levels ... before 7:00 AM and after 6:00 PM of the same day, Monday through Friday."

“No permit shall allow any construction activities which emit noise in excess of the maximum permissible sound levels... before 9:00 AM and after 6:00 PM on Saturday."

“No permit shall allow any construction activities which emit noise in excess of the maximum permissible sound levels on Sundays and on holidays."

Although not anticipated during construction of the housing development, the use of pile drivers, hoe rams and jack hammers 25 pounds (lbs.) or larger, high pressure sprayers, and chain saws are restricted to 9:00 AM to 5:30 PM, Monday through Friday. In addition, construction equipment and on-site vehicles or devices whose operations involve the exhausting of gas or air, excluding pile hammers and pneumatic hand tools weighing less than 15 pounds (lbs.), must be equipped with mufflers.

The HDOH noise permit does not limit the noise level generated at the construction site, but rather the times at which noisy construction can take place. However, when considering a noise permit application, consideration is also given to any proposed noise mitigation for the project. Therefore, noise mitigation for construction activities should be addressed using project management and the source and path noise control measures discussed in Section 6.3 below.

HDOH Noise Variance In cases where nighttime construction is expected, a variance must be obtained from the HDOH to allow the operation of a noise source which emits noise levels in excess of the maximum permissible levels and which operation does not conform to the requirements of the noise permit (i.e., nighttime construction activities which occur between 6:00 p.m. and 7:00 a.m., Monday through Friday). However, nighttime construction is not anticipated for this project so a variance will not be required.

Mitigation of Noise Source

Mitigating construction noise at the source is the most effective form of noise control. The source control methods listed in Table 5 below can be applied to most construction equipment.

Construction Noise Source Control Measures

Scheduling Limit activities that generate the most noise to less sensitive time periods (e.g. daytime hours).

Substitution Use quieter methods/equipment when possible (e.g low noise generators, smaller excavators, etc.).

Exhaust Mufflers Install quality mufflers on equipment.

Reduced Power Options Use smallest size and /or lowest power as required.

Quieter Backup Alarms Install manual adjustable or ambient sensitive alarms. Do not use backup alarms during night work.

Motors Insulate or enclose motors.

Equipment Selection Electric equipment is quieter than pneumatic equipment.

Equipment Retrofit Rubber chucks in jackhammers.

Equipment Maintenance Sharpen and balance tools, repair silencing equipment, replace worn parts and open airways.

Staging Area Maximize the distance between the construction staging areas and nearby receptors to the greatest extent possible

In general, a majority of the construction noise mitigation is in the form of scheduling, specifically, limiting the construction hours to the time frame specified by the HDOH. The jackhammer is expected to be the most disruptive piece of equipment used during the construction process so the allowable hours of operation are even more restrictive, as described in Section 6.1.

Mitigation of Noise Path

When source control measures are not sufficient to avoid a noise impact, path control measures must be considered. Non-permanent noise barriers or curtains and equipment enclosures could be installed at the construction site to reduce construction noise in noise sensitive locations. The general contractor could also conduct noise monitoring of construction during noisy or extensive activities at locations close to residential properties.

Mitigation of HART Construction Noise HART construction is expected to occur after the Hale Kewalo project is completed and occupied. For details regarding HART construction noise, refer to "Noise and Vibration Technical Report – Honolulu High-Capacity Transit Corridor Project" report.

Mitigation of Development Noise

Stationary Mechanical Equipment Noise The design of the Hale Kewalo building should give consideration to controlling the noise emanating from all stationary mechanical equipment such as air-cooled chillers, cooling towers, air-handling units, condensing units, emergency generators, etc. so as to comply with the State of Hawaii Community Noise Control rules . Noisy equipment should be located away from neighboring properties and residential units as much as possible. Enclosed mechanical rooms may be required for some equipment.

Parking Garage Noise Noise emanating from the parking garage to the neighboring buildings may be audible and cause complaints. Noise reduction measures such as rough, non- painted driving surfaces and acoustical absorption on the ceiling should be considered during the project's design phase.

Mitigation of Transportation Noise on the Development Units overlooking Kona Street and the future HART guideway will experience relatively high noise levels once the rail begins operation. High STC rated windows in the range of STC 40 – 45 should be considered to comply with the HUD interior noise design criteria. Smaller window sizes may reduce these STC requirements, assuming that the exterior wall is sufficiently massive. For unit glazing overlooking Waimanu Street away from the rail guideway, typical 1" IGU glazing will be sufficient to mitigate exterior noise to comply with the HUD interior noise design criteria.

The following preventative measures are recommended for implementation during the planning and design phases of the project:

In addition to the normal planning and design concerns regarding potential damage due to settling and heaving during construction, consideration should also be given to risks of damage due to vibration from pile driving. A damage criteria of 0.2 inches/second should be used in conjunction with the vibration prediction method to identify the potential damage risk distances to the driven piles.

If predicted vibration levels from pile driving exceed 0.2 inches/second at a building, and predicted levels cannot be reduced by sizing of the pile driver, test piles should be driven and their vibrations monitored and recorded prior to completion of the foundation design. The monitoring of the test piles should be designed to measure the expected peak, 3-axis vibration levels at the building. The results of the monitoring should be used to define empirical distance from the driven pile to the 0.2 inches/second damage risk location, and to evaluate the risks of structural damage to the adjacent structure during actual construction.

If predicted vibration levels from pile driving exceed 2.0 inches/second at a building, the use of alternate types of piles or shoring should be considered for implementation during the design phase.

3.4.6 AIR QUALITY AND HAZARDOUS MATERIALS

The proposed project will have short-term and long-term effect on ambient air quality. During demolition of the existing buildings, dust will be generated however fugitive dust is generally controlled by frequent watering and perimeter screening. Best management practices will be used to ensure that dust control during demolition of the existing buildings and during construction of the new building are kept to a minimum. These impacts are typical of any new construction project.

Some hazardous materials have been found in the existing buildings. Specially, asbestos material and lead paint were found and will need to be removed prior to demolition of the buildings. Hazardous materials are removed by encapsulating the affected areas, removing the material, and disposing the material at an approved site. Appendix B of this Environmental Assessment document provides detailed information regarding soil and ground contamination and a remediation plan for asbestos material and lead paint is presently being prepared by an environmental services consultant.

3.4.7 Biological Characteristics

Flora

The project lot is presently covered with asphalt paving. The project site is essential devoid of any plant material and no rare or endangered species of flora were identified on the site.

Fauna

The site does not serve as a wildlife habitat although avifauna, feral cats, dogs and rodents may be found on-site.

3.4.8 Infrastructure and Utilities

The proposed improvements are readily serviced by existing utilities located in the immediate vicinity. Waimanu Street has been subject of infrastructure improvement while Kona Street utilizes older above ground electrical systems.

Water

The project will continue to be serviced by the existing water system. The proposed action will result in an approximate total demand of 39,787 gallons per day. The new domestic water and fire protection water meters to serve the project will connect to either the existing 8-inch main in Kona Street or the 12-main in Piikoi Street. Water conservation efforts are likely to be implemented by the project operator upon completion.

Stormwater

The site is presently naturally drained with runoff entering Kona Street. Waimanu Street contains a curb and gutter system that handles stormwater. The proposed project will be required to control drainage according to prevailing drainage regulations. All storm water runoff from the proposed improvements will be reviewed for conformance with City and County of Honolulu Ordinance 96-34 regarding peak runoff.

Wastewater

On January 5, 2015, the City ad County of Honolulu Department of Planning and Permitting approved the application for municipal sewer system connection to accommodate the proposed project. The project will have a flow of approximately 29,209 gallons per day. This flow is proposed for connection to either of the 8-inch sewer mains located in Kona and Waimanu Streets.

Solid Waste

It is expected that private refuse collection service will be used to service the project location. The project operator may implement recycling programs upon project completion.

Telephone and Electrical Services

Telephone and electrical services are available to the site. Coordination with the local electric and telephone service providers will be expected during the design and construction phases.

3.4.9 Public Facilities

Kakaako Fire Station Number 9 provides fire protection service to the project area as well as emergency medical service. The station is located at 555 Queen Street and is located approximately one mile from the project site. Response time to the park is less than 5 minutes.

Police service is provided by the Honolulu Police Department (HPD) District 1, Sector 4. Response time to the site is less than 5 minutes.

Public transportation by TheBus is available along Piikoi Street and Ala Moana Boulevard. Most significantly, the project is located within convenient walking distance of the Ala Moana Transit Center which provide access to most bus routes through a single location. The Honolulu Area Rapid Transit (HART) rail line also terminates at Ala Moana Center near the project site. This will provide a desirable transit option for destinations in the western direction.

Public schools serving the project area are Kaahumanu Elementary School, Central Middle School and McKinley High School. The project may increase enrollment at these schools but it is also possible that future residents of the project already reside in this school district. The Department of Education (DOE) is required to provide education for all school-aged children. Discussions with DOE staff stated that for planning purposes, the Student Generation Rates (SGR) for the Downtown and Kakaako are 0.06 for elementary schools, 0.03 for middle schools and 0.03 for high schools. When applied to the proposed Hale Kewalo project, this would suggest that demand for educational facilities for 8 elementary school aged children, 4 middle school and 4 high school students will result from the development of the subject project. DOE also stated that these ratios are for planning purposes and actual counts may be higher or lower depending on the type of project developed. Public schools serving the area presently have capacity to accommodate the projected student demand however school enrollments vary year to year.

3.5 Relationship to Plans, Codes and Ordinances

The project site is located within the Kakaako Community Development District (KCDD) Mauka Area administrated by the Hawaii Community Development Authority (HCDA). The KCDD Mauka Area Plan is part of the Hawaii Administrative Rule Title 15, Department of Business, Economic Development & Tourism: Subtitle 4, Hawaii Community Development Authority, Chapter 22, Mauka Area.

A Final Environmental Impact Statement for the Mauka Area Plan was accepted in June 1983. Under this master FEIS, impacts relating to the implementation of the Mauka Area Plan and associated rules were assessed in accordance with Chapter 343, Hawaii Revised Statutes. This FEIS document serves as the principal disclosure and impact assessment document for KCDD Mauka Area Plan. The intent of the Draft EA for the Hale Kewalo project is to assess impacts that will result from the proposed use of State funds.

Under the KCDD Mauka Area Plan, the project site is identified as being within the Central Kakaako Neighborhood. The Plan states that the strategy for this neighborhood is to support the viability of small business while allowing for the

potential future re-use of small properties in this neighborhood through selective improvements of streets and parking.

The proposed action is generally consistent with the guideline as the project parcel is too small for conventional high-rise development yet it provides for optimal re-use of the property for an equally desirable option of affordable rental housing. This is further supported by the concept of Transit Oriented Development with the HART terminus located very close by.

The State Land Use Commission Boundary Maps identify the project site as being within the Urban area. This is consistent with the surrounding uses that include commercial uses and high-density residential development.

The City and County of Honolulu General Plan provides the overall vision for the island of Oahu and broadly outlines the objectives and policies shaping future growth. While the proposed action is consistent with the Plan overall, it is particularly pertinent to the Section IV, Housing. It is here where proposed action supports Objective A, to provide decent housing for all the people of Oahu at prices they can afford, and Objective C, To provide the people of Oahu with a choice of living environments which are reasonably close to employment, recreation, and commercial centers and which are adequately served by public utilities. The proposed action will provide affordable rental housing that is located within close proximity to major employment centers as well as having excellent access to public transit options.

The City's Primary Urban Center (PUC)development plan guides development in the central urban area of Oahu. While the project is generally consistent with all aspects of the PUC, particularly relevant to the proposed project is Section 3.3 In-Town Housing Choices. It states that the PUC "offers in-town housing choices for people of all ages and incomes". The policies of the PUC plan that support the Hale Kewalo project include:

- Promote people-scaled apartment and townhouse dwellings in low- or mid-rise buildings oriented to the street.
- Improve the feasibility of redeveloping small lots.
- Reduce costs for apartment homes.
- Provide for high-density housing options in mixed-use developments around transit stations.

Hale Kewalo is particularly well suited to meet these criteria in that it is a mid-rise project that maximizes density of a small lot.

Required permits will include an HCDA Development Permit, and grading and construction related permits from the City and County of Honolulu.

3.6 Probable Impact on the Environment

The proposed project represents a significant change from its current and former uses. The project is consistent with surrounding land uses and the intent of the prevailing KCDD Mauka Area Plan. Impacts associated with the proposed project have generally been determined to be negligible. Views will be impacted as a result of the new facility but should be considered in the context that any development of the site would likely impact views as well.

When viewed in the cumulative with the other components proposed for the project block, impacts to the environment will be more significant. In addition to significantly higher urban density resulting from the build out the project, traffic and noise impacts will rise significantly over the no-action alternative. These cumulative impacts are largely due to the intensive level of activity that are typically associated with residential use however it should be noted that as a Transit Oriented Development, the project provides fewer parking stalls than a traditional market level housing project and subsequently, lower traffic volumes. Traffic conditions will increase significantly as described in the Traffic section of this report. Noise impacts will also rise however is more likely due to the addition of the HART line adjacent to the proposed building. The Hale Kewalo project will require noise mitigation including PTAC air-conditioning and double glazed windows to keep sound levels within an acceptable level.

Positive environmental impacts are expected as a result of the affordable rental residential inventory. The convenience of residing near major employment centers will decrease the need for private cars resulting in decreased traffic volumes and the associated environmental benefits of reduced traffic.

3.7 Adverse Impacts Which Cannot be Avoided

Adverse impacts that cannot be avoided are generally related to short-term construction impacts. These impacts can be minimized by sound construction practices, Best Management Practices (BMPs) adherence to applicable construction regulations as prescribed by the Department of Health, and coordination with applicable County agencies. Primary construction related impacts are discussed in greater detail in the Traffic and Noise Study appendices.

The project is located outside of two heavily populated pre-contact habitation sites. Based on the archaeological inventory survey conducted for the site, it is unlikely that historic properties will be encountered within the project area. An archaeological monitoring plan has been developed for the site.

Increases in traffic and air and noise pollution will occur as is expected of any development of this nature.

3.8 Alternatives to the Proposed Action

No other use alternatives beyond the non-action alternative were considered for this project. Non-action was considered and rejected since no benefit to the community would be provided. The project is required to fulfill the reserve housing requirement for the nearby Waihonua project.

Within the scope of proposed improvements, alternative density configurations were considered however an optimal high-density mid-rise scheme was selected. Commercial space was not deemed consistent with the primary objectives however the inclusion of a commercial component within the project is provided in conformance with HCDA Mauka Area objectives.

Alternative locations were not considered. Privately owned lands in the project area could accommodate the proposed project however acquisition costs would be prohibitive and would be counterproductive to the reserve housing process.

3.9 Mitigation Measures

Long-term impacts resulting from the proposed improvements are expected to be minimal or non-existent based upon the subject environmental assessment. Long-term traffic, air and noise impacts are not expected to change significantly after improvements are completed. Short-term construction related noise and air quality impact mitigation measures include general good housekeeping practices and scheduled maintenance to avoid a prolonged construction period. The contractor will be directed to use best management practices (BMP) wherever applicable.

3.10 Irreversible and Irretrievable Commitment of Resources

Implementation of the proposed project will result in the irreversible and irretrievable commitment of resources in the use of non-recyclable energy expenditure and labor. Materials used for new construction may have salvage value; however, it is unlikely that such efforts will be cost-effective. The expenditure of these resources is offset by gains in construction-related wages, increased tax base and tertiary spending.

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4.0 NECESSARY PERMITS AND APPROVALS

Permits and approvals that may be required are contingent upon the actual design of the proposed project. The project will seek a discretionary Development Permit issued by the Hawaii Community Development Authority (HCDA). The project will also seek exemptions from statutes, ordinances and rules pursuant to HRS Chapter 201H which is a discretionary approval by the Hawaii Housing Finance and Development Corporation (HHFDC). All other permits and approvals are generally ministerial in nature. Permits listed below represent a general list that represents permits and approvals that may or may not be required depending on the selected RFP proposal.

State Agencies

Permit or Approval	Approving Agency
Kakaako Community Development District Permit	HCDA
National Pollutant Discharge Elimination System (NPDES) Permit	Dept. of Health
201H exemptions from statutes, ordinances and rules	HHFDC, HCDA, Honolulu City Council

County Agencies

Permit or Approval	Approving Agency
Building Permits	Dept. of Planning and Permitting
Certificate of Occupancy	Dept. of Planning and Permitting
Construction Dewatering Permit	Dept. of Environmental Services
Grading and Stockpiling Permits	Dept. of Environmental Services
Sewer Connection Permit	Dept. of Environmental Services

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5.0. FINDNGS AND REASONS SUPPORTING DETERMINATION OF FINDING OF NO SIGNIFICANT IMPACT

As stated in Section 11-200-12, EIS Rules, Significance Criteria: in determining whether an action may have a significant effort on the environment, every phase of a proposed action shall be considered. The expected consequences of an action, both primary and secondary, and the cumulative as well as the short-term and long-term effects must be assessed in determining if an action shall have significant effect on the environment. Each of the significance criteria is listed below and is followed by the means of compliance or conflict (if extant).

- Involves an irrevocable commitment to the loss or destruction of any natural or cultural resource.

The proposed action will occur on an existing developed site and will not impact any topographical resources other than the removal or relocation of some existing trees. Subsurface archaeological artifacts are a possibility; therefore, an archaeological inventory survey will be conducted prior to commencement of construction. In the event that any archaeological remains are uncovered during the course of construction, all work will stop and the State Historic Preservation Office will be contacted for appropriate action.

- Curtails the range of beneficial uses of the environment.

The proposed use will result in a significant change from its existing and former uses but represents an appropriate use that will benefit the public and will be environmentally consistent with the surrounding urban area. The proposed project will not curtail beneficial uses of the environment. The proposed project will provide needed housing inventory in central Honolulu and is considered a highest and best use in the public interest.

- Conflicts with the State's long-term environmental policies or guidelines as expressed in Chapter 344, HRS, and any revisions thereof and amendments thereto, court decisions, or executive orders.

The proposed action is consistent with the goals and guidelines expressed in Chapter 344, Hawaii Revised Statutes and NEPA. The proposed action is triggered by the use of State funds. The subject Environmental Assessment has been developed in compliance with the Chapter 343.

- Substantially affects the economic welfare, social welfare, and cultural practices of the community or State.

The proposed action will make a positive contribution to the welfare and economy of the State and City by providing desirable and needed affordable rental housing to the State of Hawaii. The proposed use will eliminate the existing temporary daily parking and construction baseyard office uses for a long-term use. The facility will also contribute positively to the community through the use of goods and services in the area, through construction related employment, and through secondary and tertiary spending and taxes. The proposed action will not have any impact on any native cultural practices as the site has been in urban use for over 60 years.

A historic and cultural resource plan for the Mauka Area Plan is assessed in the programmatic *Kakaako Community Development District Final Supplemental Environmental Impact Statement* prepared for the Hawaii Community Development Authority in May 2009. Section 2.8.1 Historic and Cultural Resources lists eight (8) sites that are considered important and selected for protection for their historic and cultural value. None of the properties is within or near the Hale Kewalo project site. The document also states that other sites of historic and cultural significance with the Mauka Area may be identified and added to HCDA's preservation list. None in the project vicinity have been subsequently added. For this reason, the Hale Kewalo Environmental Assessment will conclude that no historic or cultural practices will be impacted by the proposed action.

- Substantially affects public health.

The proposed improvements are not expected to have any direct impact on public health but will provide housing for a target market that may not otherwise have an opportunity for centrally located affordable housing. No recreational resources will be impacted by the project, nor will the project increase any undesirable environmental impacts.

- Involves substantial secondary impacts, such as population changes or effects on public facilities.

The proposed action will increase the population within the community and will increase the demand for public facilities. These impacts are consistent with residential development of this nature and are not considered adverse impacts. The change in population and demand for public facilities will be readily met by existing infrastructure and services.

- Involves a substantial degradation of environmental quality.

The proposed action will not degrade environmental quality. Impacts associated with the project, such as traffic impact and noise quality have been assessed to be minimal. The project is located in a highly urban environment that is expected to be heavily developed in the future. In that respect, the project is consistent with the overall land use of the district.

- Is individually limited but cumulatively has a considerable effect upon the environment or involves a commitment for larger actions.

The proposed action is not a first phase of, or related to, any larger action. The cumulative effect of the project is disclosed in this document (and associated figures and charts) and does not involve any planned future actions that will cumulatively impact the environment.

- Substantially affects a rare, threatened or endangered species, or its habitat.

The proposed action will not affect any rare, threatened or endangered species of flora or fauna, nor is it known to be near or adjacent to any known wildlife sanctuaries.

- Detrimentally affects air or water quality or ambient noise levels.

The proposed action will not impact air or water quality. Noise levels will change from those of an enclosed parking lot to a residential structure. The change in noise level is expected to be negligible and will not significantly affect surrounding properties.

Minimal impacts on air quality and noise are anticipated during construction, but will be limited by normal construction practices and Department of Health construction mitigation standards.

- Affects or is likely to suffer damage by being located in an environmentally sensitive area such as a flood plain, tsunami zone, beach erosion prone area, geologically hazardous land, estuary, fresh water, or coastal waters.

The project will not have any impact on an environmentally sensitive area.

- Substantially affects scenic vistas and viewplanes identified in County or State plans or studies.

The proposed action will not affect any scenic vistas or viewplanes as surrounding developments already tower around the proposed project. The project is located in a highly urban environment and while the Kakaako Community Development District Mauka Area Plan designates Piikoi as a view corridor street, it should be

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6.0 LIST OF PARTIES TO BE CONSULTED DURING THE DRAFT ENVIRONMENTAL ASSESSMENT

Agencies with ministerial or specific interests regarding the proposed project were contacted for their early comments regarding the proposed project. Parties contacted are listed below.

Federal Agencies

US Environmental Protection Agency
    Region IX Administrator

State Agencies

Department of Accounting and General Services
Department of Business Economic Development & Tourism
    Energy, Resources & Technology Division
Department of Defense
Department of Education
Department of Health
Department of Land and Natural Resources
Department of Land and Natural Resources
    State Historic Preservation Officer
Department of Transportation
Hawaii Community Development Authority
Office of Hawaiian Affairs
Office of Planning
University of Hawaii at Manoa
    Environmental Center

County Agencies

Board of Water Supply
Department of Community and Social Services
Department of Parks and Recreation
Department of Transportation Services
Honolulu Authority for Rapid Transit (HART)
Fire Department
Police Department

Officials and Organizations

Friends of Kewalo
Hawaiian Electric Company
Howard Hughes Corporation
Kakaako Improvement Association
Kamehameha Schools
Neighborhood Board No. 11

GEOTECHNICAL ENGINEERING EXPLORATION
SENIOR RESIDENCE AT PIIKOI
HONOLULU, OAHU, HAWAII

W.O. 6346-00 APRIL 6, 2012

Prepared for

A&B PROPERTIES, INC.

TEDDY S. T. KWOK
LICENSED PROFESSIONAL ENGINEER
No. 7951-C
HAWAII, U.S.A.

THIS WORK WAS PREPARED BY
ME OR UNDER MY SUPERVISION.

Teddy S T Kwok 4-30-14

SIGNATURE EXPIRATION DATE OF THE LICENSE

GEOLABS, INC.
Geotechnical Engineering and Drilling Services
2006 Kalihi Street • Honolulu, HI 96819

Hawaii • California

GEOLABS, INC.

Geotechnical Engineering and Drilling Services

April 6, 2012
W.O. 6346-00

Ms. Natalie Kiehm
A&B Properties, Inc.
822 Bishop Street
Honolulu, HI 96813

Dear **Ms. Kiehm:**

Geolabs, Inc. is pleased to submit our report entitled "Geotechnical Engineering Exploration, Senior Residence at Piikoi, Honolulu, Oahu, Hawaii" prepared in support of the design of the new senior housing project.

Our work was performed in general accordance with the scope of services outlined in our fee proposal dated May 7, 2010.

Please note that the soil and rock samples recovered during our field exploration (remaining after testing) will be stored for a period of two months from the date of this report. The samples will be discarded after that date unless arrangements are made for a longer sample storage period. Please contact our office for alternative sample storage requirements, if appropriate.

Detailed discussion and specific design recommendations are contained in the body of the report. If there is any point that is not clear, please contact our office.

Very truly yours,

GEOLABS, INC.

Clayton S. Mimura, P.E.
President

CSM:TK:mj

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Hawaii • California

GEOTECHNICAL ENGINEERING EXPLORATION

SENIOR RESIDENCE AT PIIKOI

HONOLULU, OAHU, HAWAII

W.O. 6346-00 APRIL 6, 2012

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GEOTECHNICAL ENGINEERING EXPLORATION

SENIOR RESIDENCE AT PIIKOI

HONOLULU, OAHU, HAWAII

W.O. 6346-00 APRIL 6, 2012

SUMMARY OF FINDINGS AND RECOMMENDATIONS

Our field exploration generally encountered a surface fill layer placed over soft and/or loose lagoonal deposits extending to depths of about 25 feet below the existing ground surface. Below the highly compressible lagoonal deposits, we generally encountered coral reef formation interbedded with coralline detritus extending to the maximum depth explored of about 112.5 feet below the ground surface. We encountered groundwater in the borings at depths of about 5.5 to 6.6 feet below the ground surface at the time of our field exploration.

Based on the subsurface conditions encountered in the borings and the building loads provided, we recommend supporting the new building on a deep foundation system consisting of either ACIP piles or cased micropiles. ACIP piles with a diameter of 18 inches and an embedded length of approximately 45 feet below the bottom of the foundation cap may be used to achieve an allowable compressive load capacity of up to 100 kips per pile. Cavities and voids are commonly encountered in the coralline materials in the project vicinity. Therefore, the actual volume of grout required to fill the ACIP piles may be appreciably more than the theoretical grout volume. Based on our experience in the Ala Moana/Kaka`ako area, we envision that average grout factor on the order of about 100 percent over the theoretical grout volume may be required for the ACIP piles.

Cased micropile foundation may also be used to support the new building structure. We believe that a cased micropile system with a minimum grout bulb diameter of 7.5 inches and a pile length of about 65 feet below the bottom of the foundation cap may be used to develop an allowable compressive load capacity of up to 100 kips per pile. In addition, a permanent casing extending about 25 feet below the bottom of the foundation cap should be provided, and the permanent casing should have an outside diameter of about 7.5 inches (same as the grout bulb size).

We recommend placing the new fills as soon as practical to allow the ground settlements to occur prior to construction of improvements, such as the asphalt concrete paving and slab-on-grade construction, to reduce the potential for adverse effects resulting from ground settlements

The text of this report should be referred to for detailed discussion and specific design recommendations.

END OF SUMMARY OF FINDINGS AND RECOMMENDATIONS

SECTION 1. GENERAL

1.1 Introduction

This report presents the results of our geotechnical engineering exploration and engineering analyses performed in support of the design of the proposed *Senior Residence at Piikoi* housing project in Honolulu on the Island of Oahu, Hawaii. The project location and general vicinity are shown on the Project Location Map, Plate 1.

This report summarizes the findings and presents our geotechnical recommendations based on our field exploration, laboratory testing, and engineering analyses. The recommendations presented herein are intended for the design of foundations, slabs-on-grade, retaining structures, site grading, and pavements only. In addition, discussions on the excavation and dewatering requirements are included in this report for information purposes. The findings and recommendations presented herein are subject to the limitations noted at the end of this report.

1.2 Project Considerations

The project site is at the southwestern corner of Kona and Piikoi Streets in the Ala Moana area of Honolulu on the Island of Oahu, Hawaii. The proposed development site is an L-shaped property comprised of eight parcels totaling approximately 31,952 square feet as shown on the Site Plan, Plate 2.

We understand the project plans call for the development of a low to moderate income rental building with four stories of living quarters over ground floor parking. The footprint of the building structure is about 250 feet by 55 feet in plan dimensions. We understand that the design finish floor elevation will need to be set at above +7.0 feet Mean Sea Level (MSL) to clear the flood elevation.

Based on the information provided by the project structural engineer, we understand that the new building will be of light gauge steel framing with column loads (dead-plus-live loads) on the order of about 150 kips. Because of the moderate structural loading of the building structure and the presence of highly compressible lagoonal deposits at the shallow subsurface, we recommend supporting the new building structure on a deep foundation system consisting of either augered cast-in-

place (ACIP) piles or cased micropiles. The feasibility of a shallow foundation support system for the project has been evaluated and is discussed in further details herein.

Based on the design finish floor elevation and the site topography at the time of our field exploration, we envision that site grading consisting of minor fills less than about 1 to 2 feet thick will be required. It should be noted that placement of new fills at this site will induce consolidation of the underlying soft and/or loose lagoonal deposits. Therefore, it is important to place the new fills as soon as practical to allow the ground settlements to occur first prior to construction of improvements, such as the ground floor slabs and pavements, to reduce the potential for adverse effects resulting from ground settlements.

Based on the project design, a basement level will not be constructed. However, we anticipate that several minor below-grade structures, such as the elevator pits, will likely be required. We anticipate that the bottom of the foundation cap will generally be placed about 5 feet below the finished grade or at about +2 feet MSL. In addition, where elevator pits are required, the bottom of the foundation cap may be placed about 7 to 8 feet below the finished grade. Due to the presence of soft and/or loose lagoonal deposits and groundwater table at shallow depths, we anticipate that excavation shoring and dewatering operations will be required for the deeper excavations during construction.

1.3 Purpose and Scope

The purpose of our field exploration was to obtain an overview of the surface and subsurface conditions to develop a generalized subsurface data set to formulate geotechnical recommendations for design of foundations, slabs-on-grade, retaining structures, site grading, and pavements only. The work was performed in general accordance with the scope of work outlined in our fee proposal dated May 7, 2010. The scope of work for this exploration included the following tasks and work efforts:

1. Review of available soil and geologic information for the project site and vicinity.

2. Coordination of our site access and field exploration work with the property owner's representative.

3. Coordination of the boring stake-out and utility clearances by our geologist.

4. Mobilization and demobilization of truck-mounted drilling equipment and operators to the project site and back.

5. Drilling and sampling of three borings extending to depths of about 111.3 to 112.5 feet below the existing ground surface for a total of 336.3 lineal feet of exploration.

6. Coordination of the field exploration and logging of the borings by our geologist.

7. Laboratory testing of selected soil and rock samples obtained during the field exploration as an aid in classifying the materials and evaluating their engineering properties.

8. Analyses of the field and laboratory data to develop geotechnical recommendations for the design of foundations, slabs-on-grade, retaining structures, site grading, and pavements.

9. Preparation of this report summarizing our work on the project and presenting our findings and geotechnical recommendations.

10. Coordination of our work on the project by our senior engineer.

11. Quality assurance of our overall work on the project and client/design team consultation by our principal engineer.

12. Miscellaneous work efforts such as drafting, word processing, clerical support, and reproductions.

Detailed descriptions of our field exploration methodology and the Logs of Borings are presented in Appendix A. Results of the laboratory tests performed on selected soil and rock samples obtained from our field exploration are presented in Appendix B. Photographs of the core runs are presented in Appendix C.

END OF GENERAL

SECTION 2. SITE CHARACTERIZATION

2.1 Regional Geology

The Island of Oahu was built by the extrusion of basalt and basaltic lavas from the Waianae and Koolau shield volcanoes. The older Waianae volcano is estimated to be middle to late Pliocene in age, and Koolau Volcano is estimated to be late Pliocene to early Pleistocene in age. After a long period of volcanic inactivity, during which time erosion incised deep valleys into the Koolau Shield, volcanic activity returned with a series of lava flows followed by cinder and tuff cone formations. These series are referred to as the Honolulu Volcanic Series.

The project site is on the southern flank of the Koolau Volcano and on the coastal plain of Southern Oahu. Therefore, the geomorphology and subsurface conditions in the area are directly related to the glacio-eustatic fluctuations of the sea level during the Pleistocene Epoch (Ice Age) and the genesis of the Honolulu Coastal Plain. The coastal plain was built on the eroded flanks of the Koolau Volcano, which forms the eastern two-thirds of the Island of Oahu. The coastal plain was built by extensive accumulation of alluvium derived from erosion of the volcano, interbedded with coral reefs and associated deposits.

During the Pleistocene Epoch (Ice Age), sea levels fluctuated in response to the cycles of continental glaciation. Most of the coastal plains were developed during the Pleistocene Epoch when the sea levels fluctuated significantly. As the glaciers grew and advanced, less water was available to fill the oceanic basins such that sea levels fell below the present stands of the sea. When the glaciers melted and receded, an excess of water became available such that the sea levels rose to above its present level.

The processes of erosion and deposition were affected by these glacio-eustatic sea level fluctuations. When the sea level was low, the erosional base level was correspondingly lower, and valleys were carved to depths below the present sea level. When the sea level was high, the erosional base level was raised such that sediments accumulated at higher elevations.

The subsurface conditions in the Ala Moana area are dominated by fossil Pleistocene Age coral/algal reef deposits and related deposits, which are intercalated with terrigenous sediments, laid during the higher stands of the sea. Therefore, the project site is generally underlain by deposits consisting of calcareous sediments and lagoonal deposits. A surface layer of man-made fill was placed over these deposits for the development of the Ala Moana area within the last century.

2.2 Site Description

The project site is at the southwestern corner of Kona and Piikoi Streets in the Ala Moana area of Honolulu on the Island of Oahu, Hawaii. The proposed development site is an L-shaped property comprised of eight parcels totaling approximately 31,952 square feet as shown on the Site Plan, Plate 2. The project site is bounded by Kona Street to the north, Piikoi Street to the east, existing development and Waimanu Street to the south, and existing development to the west.

The majority of the project site is presently occupied by a vacant warehouse structure with roll-up doors and open parking along Kona Street. The existing warehouse appears to be a pre-engineered steel structure with slab-on-grade construction. A number of archaeological trenches had been excavated through the existing concrete slab at the time of our field exploration. Based on the topographic survey map provided and our field observations, the project site is generally flat.

2.3 Subsurface Conditions

We explored the subsurface conditions by drilling and sampling three borings, designated as Boring Nos. 1 through 3, extending to depths of about 111.3 to 112.5 feet below the existing ground surface. The approximate boring locations are shown on the Site Plan, Plate 2.

Based on our field exploration, the subsurface conditions generally consist of surface fills placed over lagoonal and coralline deposits. The surface fills encountered at the project site consisted of medium dense sands and gravel with pockets of clayey soils extending down to depths of about 5 feet below the existing ground surface. The

surface fills were generally underlain by loose lagoonal deposits extending down to depths of about 25 feet below the ground surface.

The lagoonal deposits generally consist of silty sands and gravel with lenses of silty and/or clayey soils. The loose lagoonal deposits generally were underlain by coral reef formation interbedded with coralline detritus extending to the maximum depth explored of about 112.5 feet below the ground surface.

The coral reef formation encountered at the project site was highly variable, ranging from soft and highly weathered to hard and slightly weathered. The coralline detritus encountered generally consists of loose to medium dense sands and gravel.

For illustration purposes only, a Generalized Subsurface Profile depicting the interpreted subsurface conditions at the project site is provided on Plate 3. The approximate surface location of the subsurface profile prepared for this report is shown on the Site Plan, Plate 2.

We encountered groundwater in the borings at depths of about 5.5 to 6.6 feet below the existing ground surface at the time of our field exploration. Due to the proximity of the project site to the Pacific Ocean, water levels are expected to vary with tidal fluctuations and storm events. It should be noted that water levels may also vary with seasonal rainfall, time of the year, and other factors.

Detailed descriptions of the field exploration methodology and graphic representations of the materials encountered in the borings are presented on the Logs of Borings in Appendix A. We performed laboratory tests on selected soil and rock samples obtained during our field exploration and the test results are presented in Appendix B.

2.4 Seismic Design Considerations

Based on the International Building Code, 2006 Edition (IBC 2006), the project site may be subject to seismic activity and seismic design considerations will need to be addressed. The following sections provide discussions on the seismicity, soil profile for seismic design, and the potential for liquefaction at the project site.

2.4.1 Earthquakes and Seismicity

In general, earthquakes that occur throughout the world are caused solely by shifts in the tectonic plates. In contrast, earthquake activity in Hawaii is linked primarily to volcanic activity. Therefore, earthquake activity in Hawaii generally occurs before or during volcanic eruptions. In addition, earthquakes may result from the underground movement of magma that comes close to the surface but does not erupt. The Island of Hawaii experiences thousands of earthquakes each year, but most of the earthquakes are so small that they can only be detected by sensitive instruments. However, some of the earthquakes are strong enough to be felt, and a few cause minor to moderate damage.

In general, earthquakes (associated with volcanic activity) are most common on the Island of Hawaii. Earthquakes that are directly associated with the movement of magma are concentrated beneath the active Kilauea and Mauna Loa Volcanoes on the Island of Hawaii. Because the majority of the earthquakes in Hawaii (over 90 percent) are related to volcanic activity, the risk of high seismic activity and degree of ground shaking diminishes with increased distance from the Island of Hawaii. The Island of Hawaii has experienced numerous earthquakes greater than Magnitude 5 (M5+); however, earthquakes are not confined only to the Island of Hawaii.

To a lesser degree, the Island of Maui has experienced numerous earthquakes greater than Magnitude 5. Therefore, moderate to strong earthquakes have occurred in the County of Maui. The effects of earthquakes occurring on the Islands of Hawaii and Maui may be felt on the Island of Oahu. For example, several small landslides occurred on the Island of Oahu as a result of the Maui Earthquake of 1938 (M6.8). In addition, some houses on the Island of Oahu were reportedly damaged as a result of the Lanai Earthquake of 1871 (M7+).

Due to the relatively short period of documented earthquake monitoring in the State of Hawaii, information pertaining to earthquakes that were felt on the Island of Oahu may not be complete. In general, over the last 150 years of recorded history, we are not aware of reported earthquakes greater than Magnitude 6 occurring on

the Island of Oahu. Based on available information, we understand that an earthquake of about Magnitude 5.6 occurred on June 28, 1948 in the vicinity of the Island of Oahu, possibly along the hypothesized and controversial Diamond Head Fault feature.

The Diamond Head Fault feature is believed to extend northeasterly away from the southeastern tip of the Island of Oahu. The Diamond Head Fault feature may be related to the widely documented Molokai Fracture Zone on the sea floor in the vicinity of the Hawaiian Islands. Despite only the moderate tremor intensity, the resulting damage was reportedly widespread and included broken windows, ruptured masonry building walls, and a broken underground water main. In addition, some areas on the Island of Oahu, including the Tantalus, Iwilei, and Tripler areas, reported more intense ground shaking, severe enough to have cracked reinforced concrete.

2.4.2 Soil Profile

Our field exploration generally encountered a surface fill layer placed over soft and/or loose lagoonal deposits extending to depths of about 25 feet below the existing ground surface. Below the highly compressible lagoonal deposits, we generally encountered coral reef formation interbedded with coralline detritus extending to the maximum depth explored of about 112.5 feet below the ground surface.

Based on the shear wave velocity profiling performed in the project vicinity with similar subsurface conditions, the weighted average shear wave velocity for the materials within the upper 100 feet of the soil profile is on the order of about 1,500 feet per second.

We understand that the project will be designed in accordance with the requirements of the 2006 International Building Code (IBC 2006). Based on the subsurface materials encountered and our engineering analyses, we believe the project site may be underlain by liquefiable soils in the shallow subsurface. Therefore, the project site should be classified as Site Class F based on the

International Building Code (Table No. 1615.1.1), 2006 Edition. A site-specific response spectrum analysis will need to be performed to determine the appropriate values for seismic design considerations.

2.4.3 Liquefaction Potential

Based on the International Building Code (2006 Edition), the project site should be evaluated for the potential for soil liquefaction. Based on the subsurface conditions encountered and a design peak ground acceleration of 0.18g, liquefaction may occur resulting in appreciable settlements at the ground surface. Therefore, the effects of potential liquefaction should be taken into consideration in the design of the proposed development.

Soil liquefaction is a condition where saturated cohesionless soils near the ground surface undergo a substantial loss of strength due to the build-up of excess pore water pressures resulting from cyclic stress applications induced by earthquakes. In this process, when the loose saturated sand deposit is subjected to vibration (such as during an earthquake), the soil tends to densify and decrease in volume causing an increase in pore water pressure. If drainage is unable to occur rapidly enough to dissipate the build-up of pore water pressure, the effective stress (internal strength) of the soil is reduced. Under sustained vibrations, the pore water pressure build-up could equal the overburden pressure, essentially reducing the soil shear strength to zero and causing it to behave as a viscous fluid. During liquefaction, the soil acquires a mobility sufficient to permit both horizontal and vertical movements, and if not confined, will result in significant deformations.

Soils most susceptible to liquefaction are loose, uniformly graded, fine-grained sands and loose silts with little cohesion. The major factors affecting the liquefaction characteristics of a soil deposit are as follows:

FACTORS	LIQUEFACTION SUSCEPTIBILITY
Grain Size Distribution	Fine and uniform sands and silts are more susceptible to liquefaction than coarse or well-graded sands.
Initial Relative Density	Loose sands and silts are most susceptible to liquefaction. Liquefaction potential is inversely proportional to relative density.
Magnitude and Duration of Vibration	Liquefaction potential is directly proportional to the magnitude and duration of the earthquake.

In general, the subsurface information obtained from the borings indicates that the site is underlain by loose/soft lagoonal deposits overlying coral ledge and medium dense coralline detritus deposits at greater depths. The lagoonal deposits consisting of loose silty sands and soft sandy silts with little cohesion are potentially liquefiable during a seismic event of Magnitude 6 with an associated peak ground acceleration of 0.18g.

We evaluated the liquefaction potential of the saturated granular soils at the site using the computer software program LiquefyPro (Version 5) by CivilTech Software and the procedures outlined by Youd, et. al. (2001). Our analyses were performed on the drilled borings based on a seismic event of Magnitude 6 with an associated peak ground acceleration of 0.18g.

Based on our analyses, it appears that the loose lagoonal deposits below the surface fill have a factor of safety of 0.7 to 1.0 against liquefaction. Therefore, we believe that the project site could be subjected to appreciable ground settlements (on the order of about 3 to 8 inches) in the event of liquefaction during a moderate earthquake (M6+). However, we believe that lateral spreading associated with liquefaction would not be a significant design consideration based on the relatively flat site topography.

END OF SITE CHARACTERIZATION

SECTION 3. DISCUSSION AND RECOMMENDATIONS

Our field exploration generally encountered a surface fill layer placed over soft and/or loose lagoonal deposits extending to depths of about 25 feet below the existing ground surface. Below the highly compressible lagoonal deposits, we generally encountered coral reef formation interbedded with coralline detritus extending to the maximum depth explored of about 112.5 feet below the ground surface. We encountered groundwater in the borings at depths of about 5.5 to 6.6 feet below the ground surface at the time of our field exploration.

Based on the subsurface conditions encountered in the borings and the building loads provided, we recommend supporting the new building structure on a deep foundation system consisting of either ACIP piles or cased micropiles. ACIP piles with a diameter of 18 inches and an embedded length of approximately 45 feet below the bottom of the foundation cap elevations (assumed at about +2 feet MSL for ease of reference) may be used to achieve an allowable compressive load capacity of up to 100 kips per pile. Cavities and voids are commonly encountered in the coralline materials in the project vicinity. Therefore, the actual volume of grout required to fill the ACIP piles may be appreciably more than the theoretical grout volume. Based on our experience in the Ala Moana/Kaka`ako area, we envision that average grout factor on the order of about 100 percent over the theoretical grout volume may be required for the ACIP piles.

Cased micropile foundation may also be used to support the new building structure. We believe that a cased micropile system with a minimum grout bulb diameter of 7.5 inches and a pile length of about 65 feet below the bottom of the foundation cap elevations (assumed at about +2 feet MSL for ease of reference) may be used to develop an allowable compressive load capacity of up to 100 kips per pile. In addition, a permanent casing extending about 25 feet below the bottom of the micropile cap should be provided, and the permanent casing should have an outside diameter (OD) of about 7.5 inches (same as the grout bulb size).

We anticipate that only minor fills (on the order of about 1 to 2 feet thick) will be required to raise the existing ground surface to achieve the finished grades. We recommend placing the new fills as soon as practical to allow the ground settlements to occur prior to construction of improvements, such as the asphalt concrete paving and slab-on-grade construction, to reduce the potential for adverse effects resulting from ground settlements. Detailed discussions and recommendations for design of foundations, retaining structures, site grading, pavements and other geotechnical aspects of the project are presented in the following sections.

3.1 Shallow Foundation Support System Evaluation

We have evaluated the feasibility of utilizing a shallow foundation support system for the new building structure planned for the project. Based on our field exploration and the maximum column loads of about 150 kips, we believe the relatively thin upper fill crust and the underlying compressible soil deposits would not provide adequate foundation support for the proposed building without appreciable settlements (on the order of about 3 to 4 inches) under the building loads (static conditions). In addition, our engineering analyses also indicated that the project site could be subjected to appreciable ground settlement (on the order of about 3 to 8 inches) in the event of liquefaction during a moderate earthquake (M6+) with a peak ground acceleration of 0.18g. Therefore, a shallow foundation support system will experience appreciable settlement, and the building may sustain substantial damage that would disrupt the operation of the building. As a result, we do not recommend the use of shallow footing foundations for support of the new residential building planned at the project site.

Based on the anticipated structural demands on the building foundations and the poor subsurface conditions encountered at shallow depths, we recommend utilizing a deep foundation support system, such as ACIP piles or cased micropiles, for support of the proposed building structure. Detailed discussions and geotechnical engineering recommendations for these deep foundation support systems are presented in the following sections.

3.2 Augered Cast-In-Place (ACIP) Piles

Based on the anticipated subsurface conditions, we believe that a deep foundation support system consisting of augered cast-in-place (ACIP) piles may be used to support the new building planned for the housing development. ACIP piles are constructed by rotating a continuous flight hollow-stem auger (generally 10 to 24 inches in diameter) into the ground until either the planned pile tip depth or termination (refusal) criterion is achieved. At the termination depth, grout of a specified consistency is pumped into the augered hole through an orifice located in the drilling bit at the tip of the hollow stem auger. The auger is slowly withdrawn from the hole and the pile shaft is formed as a continuous flow of grout replaces the soil removed by the auger. After the auger stem is removed, the reinforcing steel cage is then inserted inside the grouted hole (through the fluid grout) within the set-time window allowed by the grout.

Based on the subsurface conditions anticipated at the project site, we believe that the new residential building may be supported by ACIP piles with a diameter of 18 inches and an embedded length of approximately 45 feet below the bottom of the foundation cap elevations (assumed at about +2 feet MSL for ease of reference) to achieve an allowable compressive load capacity of up to 100 kips per pile. In general, the ACIP piles should have a minimum center-to-center spacing of three (3) times the cast-in-place pile diameter to avoid reduction in vertical load capacity due to group action and to facilitate drilling of the ACIP piles. The allowable compressive load capacity for the ACIP piles is to support dead-plus-live loads and may be increased by up to one-third (1/3) for transient loads, such as wind or seismic forces. A factor of safety of 2.0 was used in arriving at the allowable compressive load provided above.

The load bearing capacity of the ACIP piles will depend largely on the relative density of the soils and quality of the coralline deposits within the bearing strata. Because local variations in the subsurface materials may occur at the project site, it is imperative that a Geolabs representative be present to observe the installation of the ACIP piles. In addition, contract documents should include provisions (unit prices) for additional drilling and extension of the ACIP pile during construction to account for unforeseen subsurface conditions.

Augered cast-in-place pile is a very specialized foundation support system and requires an experienced subcontractor for proper installation. Therefore, we recommend that consideration be given to requiring pre-qualification of the ACIP pile subcontractor for this project. The subsequent subsections address the design and construction of the ACIP pile foundations, which include the following:

- Downdrag Loads
- Uplift Load Resistance
- Lateral Load Resistance
- Foundation Settlements
- ACIP Pile Construction Considerations
- ACIP Test Pile Program
- Static Load Test

3.2.1 Downdrag Loads

As mentioned previously, the loose and/or soft lagoonal deposits at the project site may be susceptible to liquefaction during seismic events. Due to the potential for liquefaction of the loose and/or soft lagoonal deposits at the project site, settlement of the loose and/or soft lagoonal deposits will result in downdrag loading of the deep foundations extending through the potentially liquefiable materials. Therefore, the allowable compressive load capacity of the ACIP piles have been reduced by the expected downdrag loads in the ACIP pile foundation analyses. Based on our foundation analyses, we estimate that the downdrag loads imposed on the vertical ACIP piles due to liquefaction of the lagoonal deposits may be on the order of about 52 kips per pile for the 18-inch diameter ACIP piles. We believe that the downdrag loads imposed on the ACIP pile foundations as a result of soil liquefaction may be considered an extreme event condition or a transient load.

3.2.2 Uplift Load Resistance

The ultimate uplift load capacity of the ACIP pile was computed assuming that the entire length of the ACIP piles will be reinforced to provide proper load transfer to the surrounding soils. Based on this assumption, an ultimate uplift load capacity on the order of about 300 kips may be used for the ACIP piles. In addition, it is assumed that each of the augered cast-in-place piles will encounter a minimum of 25 feet of coral reef formation/dense coralline detritus within the length of the

augered cast-in-place piles. The ultimate uplift load capacity provided above should be used for transient loads only. To resist sustained uplift loads, a factor of safety of 2.0 should be applied to the ultimate uplift load capacity. The structural capacity of the pile member in tension should be checked by the project structural engineer.

3.2.3 Lateral Load Resistance

Lateral loads imposed on the building structure may be resisted by a combination of the passive pressure acting against the near-vertical faces of the foundation caps and/or grade beams and the lateral load capacity of the ACIP piles. Passive earth pressure against the near-vertical faces of the foundation caps and/or grade beams may be estimated using an equivalent fluid pressure of 350 pounds per square foot per foot of depth (pcf) above the groundwater level and 150 pcf below the groundwater level.

In general, lateral load resistance of the ACIP piles is a function of the stiffness of the surrounding soil, the stiffness of the ACIP pile, allowable deflection at the top of pile, and induced moment in the pile. The ACIP piles should be spaced at a minimum of three (3) times the diameter of the pile from center-to-center.

The lateral load analyses were performed using the program LPILE-plus for Windows, which is a microcomputer adaptation of a finite difference, laterally loaded pile program originally developed at the University of Texas at Austin. The lateral loads (10, 20, 30, 40, and 50 kips) acting at the top of the ACIP pile, the maximum induced moments, and the depths at which the maximum moments occur in the ACIP piles are presented on the Summary of Lateral Load Analysis for ACIP Piles, Plate 4. The lateral load analyses were conducted based on two boundary conditions, where the tops of the ACIP piles are either free or fixed against rotation.

3.2.4 Foundation Settlements

Total settlements of the 45-foot deep ACIP piles are estimated to be less than about 0.5 inches. Differential settlements between the piles may be approximately

one-half of the total settlements. We believe that a significant portion of the settlement is elastic and should occur as the loads are applied.

3.2.5 ACIP Pile Construction Considerations

The proper installation of the ACIP piles is dependent upon the procedures and equipment used by the foundation subcontractor. Therefore, the foundation subcontractor's personnel on the project site who will be responsible for the installation should have the relevant experience with the augering and pumping equipment, experience with placing ACIP piles under similar subsurface conditions, as well as experience with handling the special grout mixes, admixtures, etc.

The importance of grouting pressure varies with soil type and other factors. It is important that a sufficient grout pressure is maintained to assure a constant flow of grout to the tip of the auger. This will allow adequate grout quantities to be built up on and around the auger flight. The grout build-up or "head" of grout is necessary to insure an adequate grout supply to replace the volume of soil removed when withdrawing the auger during installation and to maintain adequate pressure to prevent collapsing of the sidewalls. The incremental volume of grout placed generally is the single most important installation control used during installation of the ACIP piles. Therefore, the foundation subcontractor and the on-site inspector need to continuously monitor the grout volume being placed.

In order to assure that the ACIP piles are installed in accordance with the project plans and specifications, we recommend that automated monitoring equipment be required to monitor the installation of the ACIP piles during construction on a real time basis to provide the necessary data for evaluation and assessment. In general, the automated monitoring equipment selected should be capable of automatically monitoring and digitally recording key elements, such as the time, depth and torque of the auger during drilling; the time, depth, grout volume and grout pressure during grouting; as well as producing a real time graph, hard copy printout, and digital record for evaluation and documentation.

As indicated previously, cavities and voids are commonly encountered in the coralline deposits in the project vicinity. Therefore, the actual volume of grout required to fill the ACIP piles may be appreciably more than the theoretical grout volume. Based on our experience in the Ala Moana/Kaka`ako area, we envision that average grout factor on the order of about 100 percent over the theoretical grout volume may be required for the ACIP piles.

In addition to the automatic monitoring equipment discussed above, we recommend that a Geolabs representative observe the installation of the ACIP piles and performance of the instrumented load test on the ACIP piles. It should be noted that the ACIP pile design was developed from our analysis using the field exploration data. Therefore, observation of the ACIP pile installation operations by Geolabs is a vital part of the foundation design to confirm the design assumptions.

3.2.6 ACIP Test Pile Program

An ACIP test pile program is recommended for this project considering that the ACIP pile foundation is a very specialized foundation system and requires a high level of expertise for proper installation. Therefore, we recommend that an ACIP test pile program be undertaken to fulfill the following objectives:

- To examine the adequacy of the methods and equipment proposed by the contractor to install the ACIP piles into the coral ledges and coralline detritus deposits.
- To confirm or modify the lengths of the ACIP piles.
- To assess the contractor's method of auger drilling and withdrawal.
- To assess the contractor's method of grout injection.

To achieve these objectives, we recommend that the ACIP test pile program consist of drilling about 10 to 15 ACIP piles (at production pile locations) extending to depths of about 45 feet below the bottom of the foundation cap elevations. The test piles may be incorporated into the actual foundation system upon the evaluation of the load test results. When the final foundation plans are available, Geolabs should be consulted for selection of the ACIP test pile locations. In addition, a Geolabs representative should be present during the ACIP test pile

program to evaluate the contractor's method of ACIP pile installation and to evaluate the subsurface materials encountered during the drilling operations.

3.2.7 Static Load Test

As part of the pre-construction activities, we recommend conducting a static load test for the project. The load test should be conducted on the 18-inch diameter ACIP pile extending to a depth of about 50 feet below the ground surface. The results of the load test will be used to confirm or modify the estimated tip elevations of the production ACIP piles. The load test pile should be structurally reinforced and instrumented with embedment strain gages for load testing purposes. As a minimum, one embedment strain gage should be placed at each level, starting at about 5 feet above the tip of the ACIP pile and subsequently at about 10-foot intervals.

The ACIP pile load test should be performed in general accordance with the Quick Load Test Method of ASTM D 1143. The load test pile should be loaded to at least 250 percent of the allowable compressive load capacity of the ACIP pile. A Geolabs representative should observe the installation and performance of the instrumented load test on the ACIP pile. It should be noted that the ACIP pile design was developed from our analysis using the field exploration data. Therefore, observation of the ACIP pile installation operations by Geolabs is a vital part of the foundation design to confirm the design assumptions.

3.3 Micropile Foundations

Cased micropile foundation may also be used to support the new building structure planned. In general, the cased micropile foundation system consists of a small diameter (usually less than 12 inches), drilled and grouted, pile with steel reinforcing. The micropile foundation typically is constructed by drilling a hole (with or without casing), placing reinforcing steel in the hole, and grouting the hole. Micropiles are desirable because they can be installed readily in access restrictive environments and in numerous soil types and ground conditions. In addition, the micropile installation generally causes minimal disturbance to adjacent structures, the adjacent soils, and the environment.

Based on the subsurface conditions encountered at the project site, we recommend utilizing a micropile system with a grout bulb diameter of 7.5 inches to support the new structural elements. Based on the subsurface conditions encountered at the project site, we recommend designing each micropile based on an allowable compressive load capacity of 100 kips. The allowable compressive load capacity of the micropiles is for supporting dead-plus-live loads and may be increased by up to one-third (1/3) for transient loads, such as wind or seismic forces.

To provide an allowable compressive load capacity of 100 kips, we believe that the micropiles may be embedded a minimum of 65 feet below the bottom of the micropile cap. The micropiles would derive its vertical support primarily from skin friction between the grout and the surrounding medium dense coralline detritus materials and/or coral ledge/formation.

Based on the subsurface conditions at the project site, we recommend casing the micropiles (permanent casing) at the top. The permanent casing should have an outside diameter (OD) of about 7.5 inches (same as the grout bulb size), and the permanent casing should extend about 25 feet below the bottom of the micropile cap. Due to the appreciable depth of soft and loose soil deposits at the project site, we strongly recommend conducting a micropile load test program consisting of at least one static load test to further evaluate and validate our assumptions in providing the above micropile recommendations for support of the new building at the project site.

In the event of seismically induced liquefaction, settlement of the highly compressible deposits will occur at the project site. When the soft and/or loose soil deposits move downward relative to the micropile, the downward movement will result in negative skin friction forces, generally known as downdrag forces, acting on the micropile shaft. The magnitude of the downdrag force depends on the thickness of the liquefiable layer, relative density of the potentially liquefiable deposits, and the micropile perimeter. Based on our foundation analyses, we estimate that the downdrag loads imposed on the micropiles due to the potential for liquefaction of the lagoonal deposits may be on the order of about 22 kips per pile. The allowable compressive load capacity

of up to 100 kips per pile recommended above has already taken into account of these downdrag loads.

3.3.1 Micropile Load Test Program

It should be noted that the compressive load capacity of the micropiles is highly dependent on the drilling procedures and the grouting methods employed by the contractor to install the micropile. Therefore, the compressive load capacity of the micropile may vary considerably between different contractors and micropile foundation systems. In order to determine whether the contractor's methods of micropile installation are adequate and to determine the ultimate compressive load capacity, we recommend performing at least one pre-production compressive load test on a sacrificial micropile. In general, the purpose of the pre-production load test on a micropile is to fulfill the following objectives:

- To examine the adequacy of the methods and equipment proposed by the contractor to install the micropiles to the depths required
- To assess the contractor's method of drilling and grout injection
- To evaluate the degree of long-term settlements of the micropile bearing in the coralline detritus materials

In general, the pre-production load test should be performed in accordance with ASTM D 1143 (Standard Loading Procedure). Based on experience, we believe that the load test should be conducted no earlier than 7 days after completion of the micropile installation to allow the grout adequate time to cure. Two additional micropiles may be used for reaction during the compressive load testing of the pre-production load test micropile. The reaction micropiles may be installed to depths as deep as the load test micropile to provide adequate reaction in uplift (to be determined by the contractor).

The load test micropile should be loaded gradually to at least 200 percent of the allowable design load in compression. We recommend holding the maximum test load (200 percent of the design load) for a minimum of 4 to 8 hours depending on the recorded movements of the load test micropile. The pre-production load test is

an integral part of the design of the micropile foundation system. Therefore, we recommend a Geolabs representative observe the pre-production load test.

In addition to the pre-production load tests, we also recommend performing pullout tests (proof tests) on selected micropiles during construction to confirm the load carrying capacity of the installed micropiles. We recommend testing a minimum 10 percent of the total number of micropiles for pullout. The pullout tests should consist of subjecting the micropile to at least 133 percent of the design loads, and the maximum test load should be held for at least 10 or 60 minutes. Pullout tests on the micropiles also are integral parts of the design of the micropile foundation system.

3.3.2 Lateral Load Resistance

It should be noted that the micropile foundation system provides low lateral load resistance due to the relatively small diameter of the micropile. Therefore, the lateral load resistance contributed by the vertical micropiles should be neglected. Lateral loads imposed on the new structure foundations may be resisted primarily by passive pressure resistance against the vertical faces of the pile cap and grade beams and by shear acting along the sides of the pile caps and grade beams.

Passive pressure resistance against the vertical faces of the pile cap and grade beams may be estimated using an equivalent fluid pressure of 350 pcf above the groundwater level and 150 pcf below the groundwater level. Additional resistance to lateral loads may be provided by shear resistance between the sides of the pile caps and grade beams and the adjacent soils. A side shear resistance of up to 150 pounds per square foot (psf) may be used for transient loads such as wind or seismic forces only.

3.3.3 Micropile Foundation Settlements

Settlements of the micropile foundations will result primarily from elastic compression of the pile member and subgrade response. We estimate the total settlement of the pile-supported foundations to be 0.5 inches or less with differential settlements between columns supported on micropiles not exceeding about

one-half of the total settlement. We believe that these settlements are essentially elastic and should occur as the loads are applied.

3.3.4 Construction Considerations

A specialty subcontractor, experienced in the construction of a cased micropile foundation system, should perform the micropile installation. Based on the subsurface conditions at the project site, it should be noted that hard drilling (such as cobbles, boulders, and concrete) may be encountered locally within the fill materials at the site considering the urban nature of the project site.

Due to the specialized nature of the micropile foundation construction, observation of the micropile foundation installation system and testing of the micropiles should be designated a “Special Inspection” item. Therefore, observation of the micropile installation operations by Geolabs (Special Inspector) is necessary to confirm our design assumptions and should be designated a “Special Inspection” item in accordance with Section 1704 of IBC 2006.

3.4 Shallow Foundations

We envision that minor structures with relatively light structural loads (requirement of less than 50 kips) may be supported on shallow foundations consisting of spread and/or continuous footings. In addition, structures supported on a shallow foundation system should be structurally separated from the structures supported on deep foundations. Adjacent structures with structural connections to the building (supported on ACIP piles or cased micropiles) should be supported on the same type of foundation as the building development unless structurally separated by an expansion joint.

It should be noted that soft and/or loose subgrade soils may be encountered at the footing subgrades due to the relatively low elevation of the finished grades. Where soft and/or loose soils are encountered at the foundation subgrades, we recommend providing a stabilization layer (minimum 24 inches thick) below the footings to provide uniform support of the foundations. The stabilization layer also should extend a minimum of 2 feet laterally beyond the edges of the footing. The stabilization layer

should consist of 24 inches of No. 2 Rock (ASTM C 33, No. 4 gradation) wrapped on all sides in a non-woven filter fabric (Mirafi 180N or equivalent).

An allowable bearing pressure of up to 2,500 pounds per square foot (psf) may be used for the design of footings bearing on the re-compacted on-site materials (minimum 90 percent relative compaction). This bearing value is for dead-plus-live loads and may be increased by one-third (1/3) for transient loads, such as those caused by wind or seismic forces. Footings should be embedded a minimum of 18 inches and a maximum of 30 inches below the lowest adjacent finished grade. In addition, the bottom of footing elevation for the shallow foundations should be placed at or above Elevation +3 feet MSL. Foundations next to utility trenches or easements should be embedded below a 45-degree imaginary plane extending upward from the bottom edge of the utility trench, or the footings should be extended to a depth as deep as the inverts of the utility lines.

If the foundations are designed and constructed as recommended herein, we estimate that footing settlements under the anticipated static design loads for footings bearing on the re-compacted on-site soils to be on the order of about 1 to 1.5 inches. Differential settlements between adjacent footings supported on similar materials should be on the order of about 0.75 inches or less (static loading only).

Lateral loads acting on the structures supported on shallow foundations may be resisted by a combination of friction between the base of the foundation and the bearing materials and by passive earth pressure developed against the near-vertical faces of the embedded portion of the footings. A coefficient of friction of 0.35 may be used for footings bearing on the re-compacted on-site fill soils. Resistance due to passive earth pressure may be calculated using an equivalent fluid pressure of 350 pcf (above groundwater level) or 150 pcf (below groundwater level) for footings embedded in the on-site fill materials. This value assumes that the concrete for the footings is cast neat against dense/stiff on-site materials. Otherwise, the soils around the footings should be well compacted (minimum of 90 percent relative compaction). Unless covered by pavements or slabs, the passive pressure resistance in the upper 12 inches below the finished grade should be neglected.

A Geolabs representative should observe the footing excavations to evaluate the competency of the bearing materials and the embedment depths. If unsuitable materials are encountered in the footing excavations, these materials should be over-excavated to expose the underlying firm materials and replaced with compacted fills. Considering the relatively thin layer of existing fill materials at the project site, provisions should be made in the contract documents to over-excavate below the footings and backfill with compacted select granular fill or lean concrete (controlled low strength materials) in the event that soft and/or loose materials are encountered at the footing subgrades for shallow foundations.

3.5 Slabs-On-Grade

We anticipate that the ground floor slabs consisting of reinforced concrete slabs-on-grade will be required for the lobby, office, commercial or multi-purpose room, restroom, and storage. Based on the existing topography and the anticipated finished floor elevation, we envision that the slabs-on-grade will be supported on new compacted fills placed to raise the existing ground surface to the finished subgrades.

As previously mentioned, the project site could be subject to ground settlements in the event of liquefaction caused by a moderate seismic event (M6+). Seismically induced ground settlements on the order of about 3 to 8 inches may be anticipated, and these slabs-on-grade may sustain some damage. Therefore, there exists the potential for damage and distress to the building slabs-on-grade (not structurally supported). However, we believe that the potential for damage may be reduced significantly by increasing the building slab thickness (5 inches minimum) and by incorporating steel reinforcement into the concrete slab (No. 4 reinforcing bars spaced at 12 inches each direction).

As discussed above, concrete slabs-on-grade may be subject to ground settlements and distress in the event of seismically induced soil liquefaction. As an alternative to slabs-on-grade, consideration may be given to structurally supporting the ground floor slabs-on-grade on the ACIP pile or cased micropile foundations to reduce the potential for damage to the building slab in the event of seismically induced ground settlements.

New fills needed to raise the project site to the finished subgrades will induce some ground settlements due to consolidation of the underlying compressible lagoonal deposits. Therefore, we recommend placing the new fills as soon as practical to allow the anticipated ground settlements to occur prior to asphalt concrete paving or slab-on-grade construction.

For the slabs-on-grade mentioned above, we recommend providing a minimum 4-inch thick layer of cushion fill consisting of open-graded gravel (ASTM C 33, No. 67 gradation) below the slabs. The open-graded gravel cushion fill would serve as a capillary moisture break and would provide uniform support of the slabs. To reduce the potential for excessive future moisture infiltration through the slab and subsequent damage to floor coverings, an impervious moisture barrier is recommended on top of the open-graded gravel cushion layer. Interior walls should be designed to incorporate some flexibility to accommodate a small amount of possible ground movements.

Where the slabs will be subjected to equipment vibration, we recommend providing a 6-inch layer of aggregate subbase below the slabs in lieu of the 4-inch thick gravel cushion layer. The moisture barrier may be omitted for these slabs. The aggregate subbase should consist of crushed basaltic aggregates compacted to a minimum of 95 percent relative compaction.

For the design of structural slabs supported on 6 inches of aggregate subbase, a modulus of subgrade reaction of about 200 pounds per square inch per inch of deflection (pci) may be used for the slab resting on the compacted aggregate subbase. Where slabs are intended to function as rigid pavements for trucks, a minimum slab thickness of 6 inches may be used for preliminary design purposes. In addition, provisions should be made for proper load transfer across the slab joints that will be subject to vehicular traffic.

The thickened edges of slabs adjacent to unpaved areas should be embedded at least 12 inches below the lowest adjacent grade. It should be emphasized that the areas adjacent to the slab edges should be backfilled tightly against the edges of the

slabs with relatively impervious soils. These areas should also be graded to divert water away from the slabs and to reduce the potential for water ponding around the slabs.

3.6 Retaining Structures

Based on the information provided, we understand that retaining structures, such as the elevator pits, will be required. Parameters for design of foundations for retaining structures that are structurally connected to (or abutting) the building structure should be designed in accordance with the "Augered Cast-in-Place (ACIP) Piles" or "Micropile Foundations" sections herein. Design of foundations for the other walls (not structurally connected to or abutting the building structure) may be based on the parameters presented in the following "Retaining Structure Foundations" subsection herein.

3.6.1 Retaining Structure Foundations

Based on the medium dense surface fill soils were generally encountered, we believe that shallow continuous footings may be used to support low retaining walls that are planned. An allowable bearing pressure of up to 2,500 psf may be used for the design of shallow foundations bearing on the recompacted surface fill soils. This bearing value is for dead-plus-live loads and may be increased by up to one-third (1/3) for transient loads, such as those caused by wind or seismic forces.

Wall footings should have a minimum width of 18 inches. In addition, wall footings on relatively flat areas should be embedded a minimum depth of 24 inches below the lowest adjacent finished grade. In addition, embedment of the shallow footings should be limited to a maximum of 30 inches below the lowest adjacent grade due to the relatively thin surface fill crust. In addition, the bottom of footing elevation for the shallow foundations should be placed at or above +3 feet MSL.

The bottom of footing excavations should be recompacted to a minimum of 90 percent relative compaction to provide a relatively firm and smooth bearing surface prior to the placement of reinforcing steel or concrete. Soft and/or loose materials encountered at the bottom of footing excavations should be over-excavated to expose the underlying firm and/or dense materials. The over-excavation may be backfilled with on-site soils compacted to a minimum of

90 percent relative compaction, or the footing bottom may be extended down to bear directly on the underlying competent materials.

Lateral loads acting on the retaining structure may be resisted by friction developed between the bottom of the foundation and the bearing soil and by passive earth pressure acting against the near-vertical faces of the foundation system. A coefficient of friction of 0.35 may be used for footings bearing on the compacted on-site fill materials. Resistance due to passive earth pressure may be estimated using an equivalent fluid pressure of 350 and 150 pcf for above and below groundwater conditions, respectively. This assumes that the soils around the footings are well compacted. The passive pressure resistance should be reduced for foundations located on slopes. Unless covered by pavements or slabs, the passive resistance in the upper 12 inches of soil should be neglected.

3.6.2 Static Lateral Earth Pressures

Retaining structures, such as the elevator pits and/or other retaining walls, should be designed to resist the lateral earth pressures due to the adjacent soils and surcharge effects. The recommended lateral earth pressures for design of retaining structures, expressed in equivalent fluid pressures of pcf, are presented in the following table.

LATERAL EARTH PRESSURES FOR DESIGN OF RETAINING STRUCTURES			
Level Backfill Condition	**Water Condition**	**Active** (pcf)	**At-Rest** (pcf)
Above Groundwater	Without Hydrostatic Pressure	37	56
Below Groundwater	With Hydrostatic Pressure	80	90
	Without Hydrostatic Pressure	18	27

The values provided above assume that the on-site granular soils with a maximum particle size of 3 inches or less or select granular fill materials will be used to backfill behind the walls. It is assumed that the backfill behind retaining structures will be compacted to between 90 and 95 percent relative compaction. Over-compaction of the retaining structure backfill should be avoided.

In general, an active condition may be used for gravity walls and retaining walls that are free to deflect by as much as 0.5 percent of the wall height. If the tops of the walls are not free to deflect beyond this degree, or are restrained, the walls should be designed for the at-rest condition. The lateral earth pressures presented for the above groundwater conditions do not include hydrostatic pressures that might be caused by groundwater trapped behind the walls.

Surcharge stresses due to areal surcharges, line loads, and point loads within a horizontal distance equal to the depth of the wall should be considered in the design. For uniform surcharge stresses imposed on the loaded side of the wall, a rectangular distribution with uniform pressure equal to 31 percent of the vertical surcharge pressure acting over the entire height of the wall, which is free to deflect (cantilever), may be used in design. For walls that are restrained, a rectangular distribution equal to 47 percent of the vertical surcharge pressure acting over the entire height of the wall may be used for design. Additional analyses during design may be needed to evaluate the surcharge effects of point loads and line loads.

3.6.3 Drainage

Retaining structures (above the groundwater) should be well drained to reduce the potential for build-up of hydrostatic pressures. A typical drainage system for site retaining walls would consist of 1 cubic foot of permeable material, such as open graded gravel (ASTM C 33, No. 67 gradation), wrapped with non-woven filter fabric placed at each of the weephole locations. The weepholes should be spaced no more than 6 feet apart.

The backfill from the bottom of the wall to the bottom of the weephole should consist of relatively impervious material to reduce the potential for significant water

infiltration into the subsurface. In addition, the upper 12 inches of the retaining wall backfill should consist of relatively impervious material to reduce the potential for significant water infiltration behind the retaining structure unless covered by concrete slabs at the surface.

3.7 Site Grading

We anticipate that site grading consisting of fills on the order of about 1 to 2 feet thick may be required to achieve the finished grades. In addition, foundation excavations and subsequent backfills on the order of about 5 to 8 feet deep may be required for construction of the building foundations and elevator pits. It should be noted that placement of new fills at this site likely will induce consolidation of the soft and/or loose lagoonal deposits underlying the site. Therefore, it is important to place the new fills as soon as practical to allow the ground settlements to occur first prior to construction of improvements, such as the asphalt concrete paving and slab-on-grade construction, to reduce the potential for adverse effects resulting from ground settlements. The following site grading items are addressed in the succeeding subsections:

- Site Preparation
- Fills and Backfills
- Fill Placement and Compaction Requirements

A Geolabs representative should monitor the grading operations to observe whether undesirable materials are encountered during the excavation and scarification process, and to confirm whether the exposed soil conditions are similar to those encountered in our field exploration.

3.7.1 Site Preparation

At the on-set of earthwork, areas within the contract grading limits should be cleared thoroughly. Debris, deleterious materials, existing structures to be demolished, and other unsuitable materials, should be removed and disposed properly off-site to reduce the potential for contaminating the excavated materials.

It is our opinion that the existing building slab may remain in place provided that the new ground floor slabs and pavements may be accommodated over the existing

concrete slabs. It should be noted that demolition of parts of the existing concrete slabs will be required for the installation of the new ACIP piles or cased micropiles and the new elevator pits.

Foundations of the existing structure to be demolished should be completely removed. Over-excavations resulting from the demolition operations should be backfilled with compacted granular fill material. Existing underground utilities to be abandoned should be removed, and the resulting excavation should be properly backfilled with the excavated on-site materials. The on-site materials should be moisture-conditioned to above the optimum moisture content, placed in 6 to 8-inch level loose lifts, and compacted to a minimum of 90 percent relative compaction. Utilities to be abandoned in-place under the proposed structure should be backfilled by pumping lean concrete or CLSM (Controlled Low Strength Material) under low pressure.

If it is desired to demolish the existing building slab, the resulting subgrades and areas designated to receive fills should be scarified to a depth of about 8 inches, moisture-conditioned to above the optimum moisture content, and recompacted to a minimum of 95 percent relative compaction. Relative compaction refers to the in-place dry density of soil expressed as a percentage of the maximum dry density as determined by ASTM D 1557. Optimum moisture is the water content (percentage by dry weight) corresponding to the maximum dry density.

3.7.2 Fills and Backfills

In general, the near-surface sandy and gravelly soils encountered during our field exploration should be suitable for use as general fill materials provided that the maximum particle size is less than 3 inches in largest dimension. The on-site materials generated from the excavations may be used as a source of general fill or backfill materials provided that they are screened of the over-sized materials and/or processed to meet the above gradation requirements (less than 3 inches in largest dimension).Imported materials to be used as select granular fill should be non-expansive granular material, such as crushed coral or basalt. The select granular fill should be well graded from coarse to fine with particles no larger than

3 inches in largest dimension. The material should have a California Bearing Ratio (CBR) value of 20 or higher, and a swell potential of 1 percent or less when tested in accordance with ASTM D 1883. The material should also contain between 10 and 30 percent particles passing the No. 200 sieve.

Aggregate subbase and base course required for the project should consist of crushed basaltic aggregates and should meet the requirements of Section 30 and 31 of the City and County Standard Specifications (September 1986). Aggregate subbase and base course materials should be moisture-conditioned to above the optimum moisture content, placed in level lifts not exceeding 8 inches in loose thickness, and compacted to a minimum of 95 percent relative compaction. Imported fill materials should be tested for conformance with these recommendations prior to delivery to the project site for the intended use.

Where groundwater is encountered (within the excavations), backfill materials should consist of free-draining granular materials, such as No. 3B Fine gravel (ASTM C 33, No. 67 gradation), wrapped on all sides with non-woven filter fabric. The free-draining granular materials should be used up to a level of about 12 inches above the groundwater level to facilitate compaction of the fill materials.

3.7.3 Fill Placement and Compaction Requirements

In general, fills and backfills should be moisture-conditioned to above the optimum moisture content, placed in level lifts not exceeding 8 inches in loose thickness, and compacted to at least 90 percent relative compaction. Compaction requirements for the subgrades of improvements subjected to vehicular traffic, such as ground floor parking level and loading dock subgrades, should be increased to a minimum of 95 percent relative compaction. Relative compaction refers to the in-place dry density of soil expressed as a percentage of the maximum dry density as determined by ASTM D 1557. Optimum moisture is the water content (percentage by dry weight) corresponding to the maximum dry density. Compaction should be accomplished by sheepsfoot rollers, vibratory rollers, or other types of acceptable compaction equipment. Water tamping, jetting, or ponding should not be allowed to compact the fills.

3.8 Excavation

As previously mentioned, we anticipate that excavations on the order of up to about 5 to 8 feet below the ground surface will be required for construction of the building foundations and elevator pits. Based on the subsurface conditions encountered and the limited working space, we envision that temporary shoring of some of the deeper excavations may be required.

The field exploration encountered a surface fill layer underlain by soft and/or loose lagoonal deposits near the existing ground surface. Therefore, we envision that conventional excavation techniques using a backhoe excavator may be used for the planned excavations. In general, we believe that interlocking steel sheet piling may be used for temporary shoring purposes, especially where dewatering of the excavations will be necessary. However, it should be noted that use of a vibratory hammer to install the interlocking steel sheet piles should be avoided to reduce the potential for inducing a liquefaction condition in the underlying loose lagoonal deposits, which would cause some settlements of the ground adjacent to the sheet pile shoring.

We also recommend that the contractor develop and implement a monitoring program to detect ground movement and/or subsidence adjacent to the excavations, which may result in damage to nearby structures and pavements. It should be noted that minor settlements of the adjacent ground may occur during and after installation of the interlocking steel sheet piles. Therefore, we recommend that the contractor retain a qualified geotechnical engineer to design and evaluate the shoring system planned.

In general, the contractor should determine the method and equipment to be used for excavations, subject to practical limits and safety considerations. Based on the field exploration, the surface fill materials and underlying soft and/or loose lagoonal deposits encountered in the borings may be excavated with conventional earthmoving equipment. However, some localized areas of hard materials and/or obstructions may be encountered at the site. Therefore, the contractor may encounter difficult excavation conditions at localized areas and should be expected considering the urban nature of the project site.

3.9 Dewatering

Dewatering of excavations will be necessary where the existing groundwater level is above the bottom of the proposed excavation. Groundwater was encountered in the borings drilled at about 5.5 to 6.6 feet below the ground surface at the time of our field exploration.

Based on the groundwater levels anticipated and the generally permeable nature of the sandy/gravelly soils to be encountered within the excavations, dewatering will be required at the planned excavations of the project construction. Therefore, dewatering provisions will need to be included in the contract documents for the proposed construction. Because the excavation will involve discharge of groundwater, a National Pollutant Discharge Elimination System (NPDES) permit will be required for this discharge. The contractor should consult their independent consultant for the latest regulations and information pertaining to the permit application.

Because of the granular nature of the subsurface soils, we anticipate the granular soils encountered near the ground surface are relatively permeable. Therefore, dewatering of the excavation may involve large volumes of water. Because of the presence of loose and/or soft soils, we do not recommend dewatering by means of a well point system along the outside of the excavations. The resultant areal depression of the natural groundwater table could induce consolidation of the compressible subsurface soils resulting in potential ground settlements, which could affect the adjacent existing structures. The potential impact of the dewatering system selected on depressing the natural groundwater table must be carefully evaluated by the contractor prior to dewatering.

It is our opinion that a cut-off wall system, such as interlocking steel sheet piles, should be considered to aid in dewatering the excavation. However, sumps will be needed to collect water that percolates up into the base of the excavation or infiltrates through the sheet piles. The sheet piles should be driven to a sufficient depth to reduce the potential for areal ground subsidence and to reduce the amount of dewatering needed within the excavations in areas underlain by granular subsurface soils with generally high permeability. Use of an interlocking sheet pile shoring support system

with jet-grouted soils (or tremie concrete plug) is relatively watertight, which should allow the groundwater levels outside the excavations to be maintained close to the original pre-construction levels. Therefore, some type of groundwater control requirement should be specified in the contract documents.

It should be noted that installation of the sheet pile shoring to the desired depths at the site may require predrilling of the sheet pile locations. The presence of these predrilled holes directly adjacent to the sheet pile shoring may serve as conduits for groundwater to infiltrate the sheet pile shored excavation. This condition could result in large volumes of seepage water to infiltrate the shored excavation requiring additional dewatering efforts and disposal of the dewatered effluent. Therefore, the contractor should take precautionary measures to avoid these conditions, which could contribute significantly to the dewatering requirements for the project.

The contractor is responsible for dewatering for construction and disposal of the dewatered effluent. The contractor should select the equipment and methods of dewatering and should be aware that modifications to the dewatering system may be required during construction depending on the conditions encountered. The dewatering method selected should have minimal impact on the groundwater level surrounding the proposed excavation. The dewatering operations should be coordinated with the shoring support such that the stability of the excavations is not jeopardized. The operations should be carried-out without softening the bottom of the excavations.

It is our opinion that the definition of "Dewatering" in the contract documents should be written to include works or systems required to lower the natural groundwater table and/or to exclude water from the excavations to allow construction of the proposed structures under safe and dry conditions. These works or systems may include, but are not limited to, pumping, cut-off walls, tremie concrete plugs, etc.

3.9.1 Subsurface Soil Permeability

Percolation tests were not conducted at the project site. However, based on our experience in the project vicinity, we estimate that the subsurface permeability of

the on-site soils may be on the order of about 0.01 to 0.5 centimeters per second.

It is our opinion that the above estimated permeability value should be used with caution due to the normally heterogeneous nature of the coralline subsurface soils. The actual subsurface soil permeability may range broadly and also vary locally in terms of orders of magnitude. It should be noted that the permeability of the subsurface soils at the site appears to be highly permeable based on field observations and previous experience in the area. Therefore, special attention should be given to the site-specific dewatering plan for the proposed project by the contractor.

3.9.2 Dewatering Considerations

We suggest considering the following three basic criteria when selecting a suitable method of dewatering:

a. The dewatering method should result in the least disturbance or damage to existing buildings, roads, and environment.

b. The dewatering method should maintain stability of, and also provide safe and dry working conditions in, the excavation.

c. The dewatering method should be sufficiently flexible to allow modifications to accommodate various ground conditions.

3.9.3 Dewatering Precaution and Monitoring

The potential impact of the dewatering system selected on depressing the natural groundwater table must be carefully evaluated by the contractor prior to dewatering. We recommend retaining a qualified geotechnical engineer by the contractor to design and evaluate the dewatering system used.

The impact and safety of the dewatering operations should be made the sole responsibility of the contractor. His/her qualified representative, who should be continuously present on-site during dewatering activities, will have the best opportunity to promptly observe the effects of dewatering during construction and to implement, as soon as possible, necessary precautionary or remedial measures including, but not limited to, slowing down or stopping the dewatering operations.

Where encountered at the bottom of excavations, permeable granular soils may be susceptible to piping and “quick” conditions. The dewatering operations should be carried-out without creating a “quick” condition or softening at the excavation bottoms. Therefore, the project dewatering operations should be performed without pumping out soil fines (pumping clear water only) and should be coordinated with the shoring installation such that the excavation stability is not adversely affected. Excessive pumping, which removes soil fines, may result in “blowing” or heaving of the excavation bottom or sides.

Groundwater drawdown outside the excavation will cause additional settlement resulting from consolidation of the soft and/or loose compressible soils. Therefore, the use of a deep well system outside the excavations to draw down the groundwater level should not be allowed.

Special caution should also be taken to avoid dewatering utility trenches connected to the excavations. If this occurs, the granular bedding and/or backfill in the utility trenches could act as subdrains and cause significant areal groundwater drawdown. Significant areal groundwater drawdown would result in appreciable ground settlements and potential damage to utility lines and/or other adjacent existing structures.

3.10 Pavement Design

We understand that flexible pavements will be used for new entry driveways and ground floor parking planned. In general, we anticipate that the vehicle loading for the proposed driveways and parking areas would primarily consist of passenger vehicles with some light trucks and occasional heavy trucks only. Therefore, we have assumed generally light traffic loading conditions for pavement design purposes. We have assumed that the pavement subgrade soils will consist of select granular fill materials placed over the existing concrete slab. On this basis, we recommend using the following pavement designs for this project.

Flexible Pavement Section (Standard Pavement for Parking Areas)

2.0-Inch Asphaltic Concrete
6.0-Inch Aggregate Base Course (95 Percent Relative Compaction)
8.0-Inch Total Pavement Thickness on Moist Compacted Subgrade

Flexible Pavement Section (Entryway and Loading Zones)

3.0-Inch Asphaltic Concrete
6.0-Inch Aggregate Base Course (95 Percent Relative Compaction)
9.0-Inch Total Pavement Thickness on Moist Compacted Subgrade

Rigid Pavement Section

6.0-Inch Portland Cement Concrete
6.0-Inch Aggregate Subbase Course (95 Percent Relative Compaction)
12.0-Inch Total Pavement Thickness on Moist Compacted Subgrade

The subgrade soils under the pavement areas should be scarified to a minimum depth of 8 inches, moisture-conditioned to above the optimum moisture, and compacted to at least 95 percent relative compaction. CBR tests and/or field observations should be performed on the actual subgrade soils during construction to confirm that the above design sections are adequate. The aggregate base and subbase courses should consist of crushed basaltic aggregates compacted to a minimum of 95 percent relative compaction.

In general, paved areas should be sloped, and drainage gradients should be maintained to carry surface water off the pavements. Surface water ponding should not be allowed on the site during or after construction. Where concrete curbs are used to isolate landscaping in or adjacent to the pavement areas, we recommend that the curbs extend a minimum of 2 inches into the subgrade soil to reduce the potential for migration of excessive landscape water into the pavement section.

3.11 Underground Utility Lines

We envision that new on-site utility lines (i.e., water, sewer, and drain lines) and utility line connections adjacent to the project site may be required for the development. We anticipate that most of the trenches for utilities will be excavated in the fills and/or loose lagoonal deposits. In general, we recommend using granular bedding consisting of 6 inches of free-draining granular materials (ASTM C 33, No. 67 gradation) below the pipes for uniform support. Free-draining granular materials, such as No. 3B Fine gravel

(ASTM C 33, No. 67 gradation), should also be used for the initial trench backfill up to about 12 inches above the pipes.

It is critical to use this free-draining material to reduce the potential for formation of voids below the haunches of the pipes and to provide adequate support for the sides of the pipes. Improper backfill material around the pipes and improper placement of the backfill could result in backfill settlement and pipe damage. Where groundwater is encountered, the bedding should be wrapped on all sides by non-woven filter fabric (Mirafi 180N or equivalent).

We envision that soft and/or loose lagoonal deposits will be encountered at or near the invert elevations along some of the on-site utility lines planned. Therefore, we recommend providing a subgrade stabilization layer consisting of 24 inches of No. 2 Rock (ASTM C 33, No. 4 gradation) wrapped in a non-woven filter fabric (Mirafi 180N or equivalent) below the bedding layer for uniform support. The stabilization layer should extend beyond the sides of the pipe a minimum width of one-fourth the outside diameter of the pipe or 12 inches, whichever is greater. A typical trench detail is provided on Plate 5.

In general, we anticipate that utility lines with an invert elevation deeper than about +1 foot feet MSL would encounter the soft and/or loose lagoonal deposits and will likely require the use of the stabilization layer. It should be noted that some of the lagoonal deposits at the site are highly sensitive and may be subjected to appreciable settlement due to disturbance caused by construction activities and shoring installation and/or extraction. Therefore, it may be necessary to support some of the more sensitive utility lines (specifically gravity sewer lines) on jet-grouted column foundations (similar to pile foundations) depending on the invert depths and pipe materials.

The upper portion of the trench backfill from a level of 12 inches above the pipes to the top of the subgrade or finished grade may consist of the excavated granular materials with a maximum particle size of 6 inches or select granular fill materials. The backfill material should be moisture-conditioned to above the optimum moisture content, placed in maximum 8-inch level loose lifts, and mechanically compacted to at least

90 percent relative compaction. In areas where trenches will be in paved areas, the upper 3 feet of the trench backfill below the pavement finish grade should be compacted to no less than 95 percent relative compaction.

3.12 Design Review

Final drawings and specifications for the proposed construction should be forwarded to Geolabs for review and written comments prior to construction. This review is necessary to evaluate conformance of the plans and specifications with the intent of the foundation and earthwork recommendations provided herein. If this review is not made, Geolabs cannot assume responsibility for misinterpretation of the recommendations presented herein.

3.13 Post-Design Services/Services During Construction

We highly recommend retaining Geolabs for geotechnical engineering support and continued services during construction. The following are critical items of construction monitoring that require "Special Inspection":

- Review of ACIP pile or micropile foundation installation submittals
- Observation of the ACIP test pile installation
- Observation of the ACIP pile or micropile load testing
- Observation of the production ACIP pile or micropile installation
- Observation of shallow foundation excavations
- Observation of the subgrade soil preparation
- Observation of fill placement and compaction

A Geolabs representative should monitor other aspects of the earthwork construction to observe compliance with the intent of the design concepts, specifications, or recommendations and to expedite suggestions for design changes that may be required in the event that subsurface conditions differ from those anticipated at the time this report was prepared. The recommendations provided herein are contingent upon such observations.

If the actual subsurface conditions encountered during construction are different from those assumed or considered in this report, then appropriate modifications to the design should be made.

END OF DISCUSSION AND RECOMMENDATIONS

SECTION 4. LIMITATIONS

The analyses and recommendations submitted herein are based in part upon information obtained from the field borings. Variations of the subsurface conditions between and beyond the field borings may occur, and the nature and extent of these variations may not become evident until construction is underway. If variations then appear evident, it will be necessary to re-evaluate the recommendations presented herein.

The field boring locations indicated in this report are approximate, having been estimated by taping from visible features shown on the Site Utility Plan transmitted by Design Partners Incorporated on April 3, 2012. The field boring locations should be considered accurate only to the degree implied by the method used.

The stratification breaks shown on the graphic representations of the borings depict the approximate boundaries between soil and/or rock types and, as such, may denote a gradual transition. Water level data from the borings were measured at the times shown on the graphic representations and/or presented in the text of this report. These data have been reviewed and interpretations made in the formulation of this report. However, it must be noted that fluctuation may occur due to variation in tides, rainfall, perched groundwater conditions, groundwater withdrawal, and other factors.

This report has been prepared for the exclusive use of A&B Properties, Inc. and their project consultants for specific application to the *Senior Residence at Piikoi* housing project in accordance with generally accepted geotechnical engineering principles and practices. No warranty is expressed or implied.

This report has been prepared solely for the purpose of assisting the architects and engineers in the preparation of the design documents for the new high-rise condominium project. Therefore, this report may not contain sufficient data, or the proper information, for use to form the basis for preparation of construction cost estimates or contract bidding. A contractor wishing to bid on this project should retain a competent geotechnical engineer to assist in the interpretation of this report and/or performance of site-specific exploration for bid estimating purposes.

The owner/client should be aware that unanticipated soil conditions are commonly encountered. Unforeseen subsurface conditions, such as perched groundwater, soft deposits, hard layers or cavities, may occur in localized areas and may require additional probing or corrections in the field (which may result in construction delays) to attain a properly constructed project. Therefore, a sufficient contingency fund is recommended to accommodate these possible extra costs.

This geotechnical engineering exploration conducted at the project site was not intended to investigate the potential presence of hazardous materials existing at the project site. It should be noted that the equipment, techniques, and personnel used to conduct a geo-environmental exploration differ substantially from those applied in geotechnical engineering.

END OF LIMITATIONS

CLOSURE

The following plates and appendices are attached and complete this report:

Project Location Map ..... Plate 1

Site Plan ..... Plate 2

Generalized Subsurface Profile ..... Plate 3

Summary of Lateral Load Analysis for ACIP Piles ..... Plate 4

Typical Trench Detail ..... Plate 5

Field Exploration ..... Appendix A

Laboratory Tests ..... Appendix B

Photographs of Core Runs ..... Appendix C

-ΩΩΩΩΩΩΩΩΩ-

Respectfully submitted,

GEOLABS, INC.

By _____
Teddy S.T. Kwok, P.E.
Senior Project Engineer

By _____
Clayton S. Mimura, P.E.
President

CSM:TK:mj

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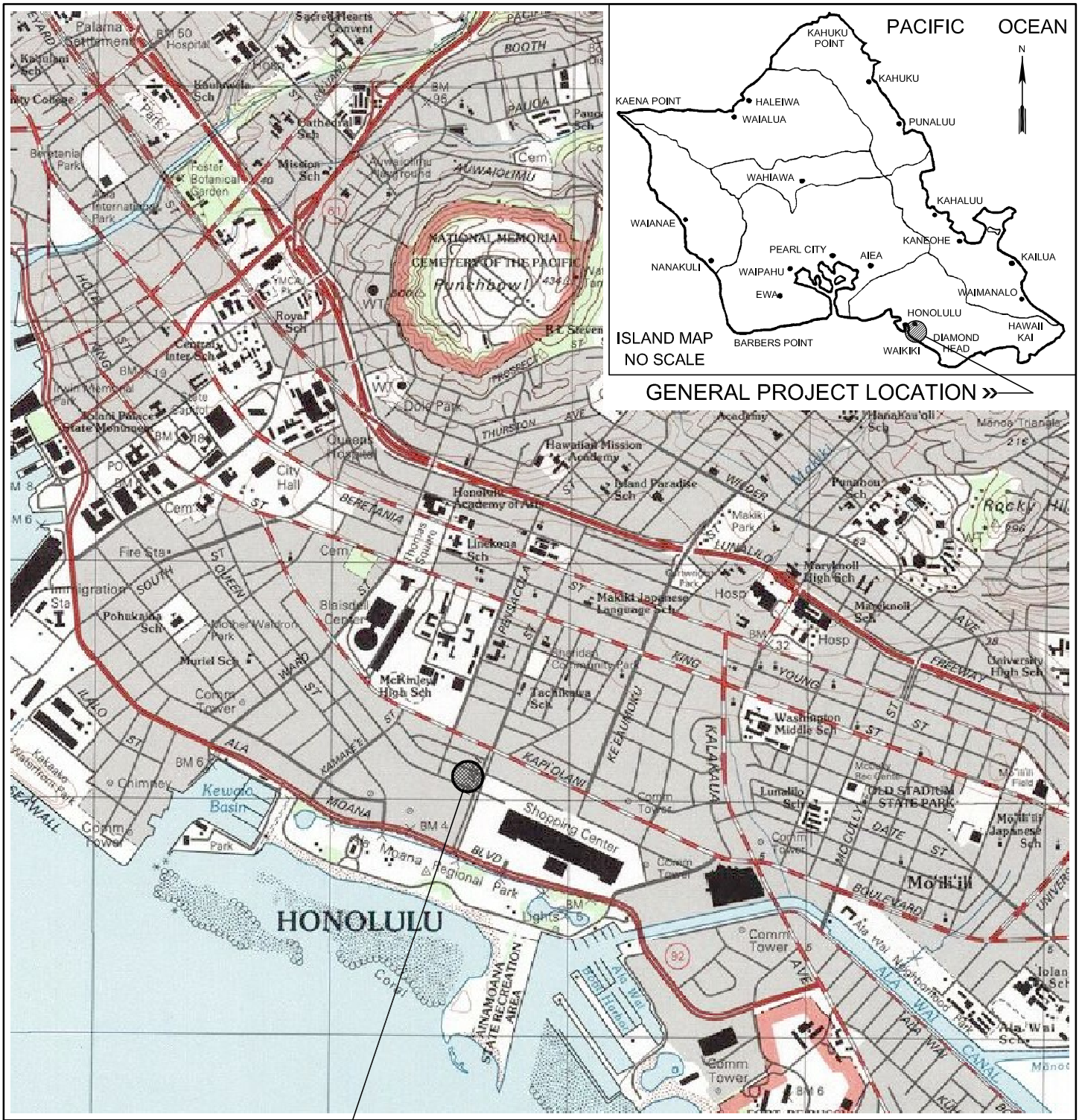
PLATES



PROJECT LOCATION MAP

SENIOR RESIDENCE AT PIIKOI
HONOLULU, OAHU, HAWAII

2000 1000 0 2000 FT.

GRAPHIC SCALE

N

REFERENCE: MAP CREATED WITH TOPO!® ©2001 NATIONAL GEOGRAPHIC (WWW.NATIONALGEOGRAPHIC.COM/TOPO).

GEOLABS, INC. Geotechnical Engineering		
DATE JUNE 2011	DRAWN BY HYC	PLATE 1
SCALE 1" = 2,000'	W.O. 6346-00	

CAD User: HENRY File Last Updated: June 08, 2011 4:28:40pm Plot Date: June 13, 2011 - 5:27:42pm
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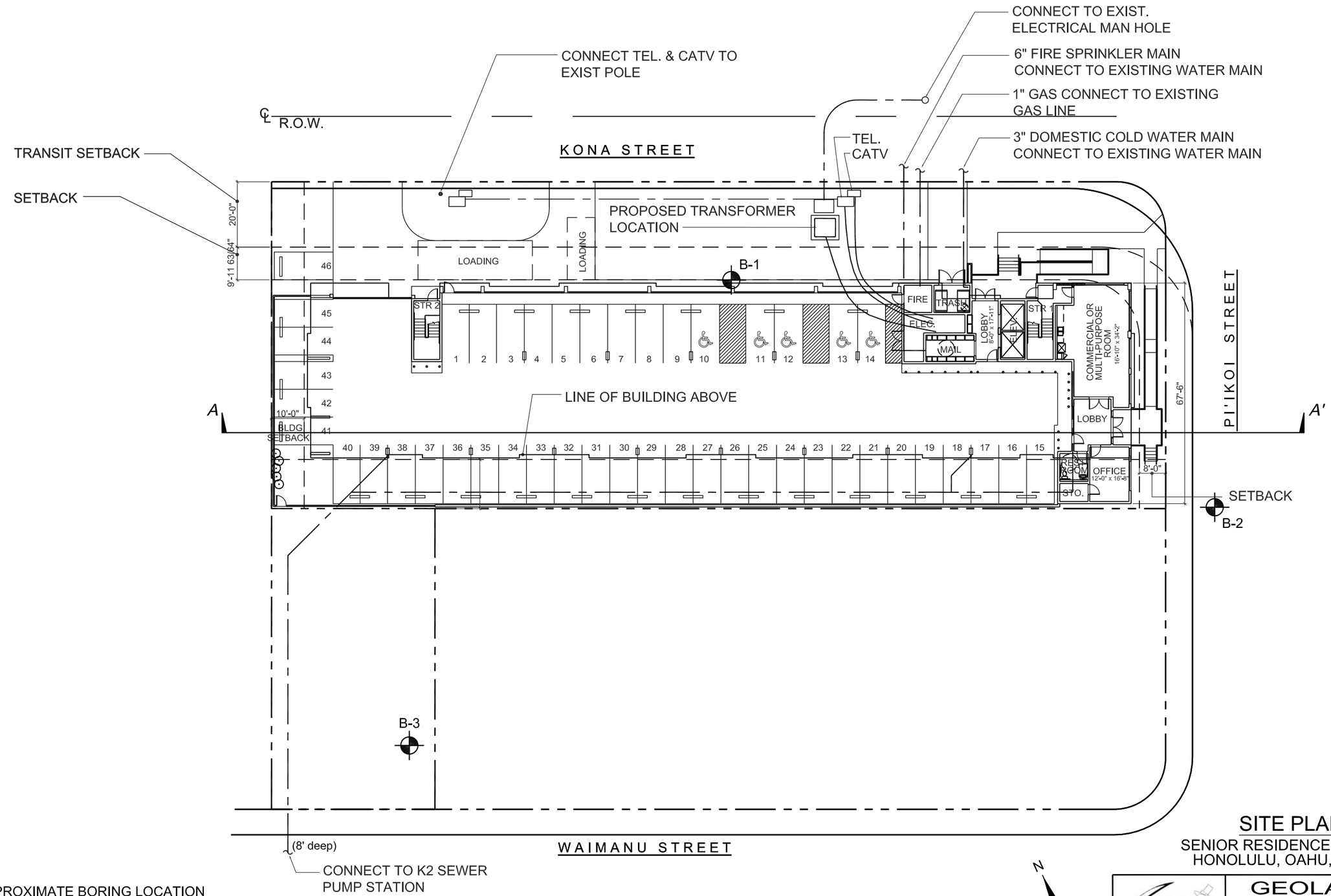

SITE PLAN

SENIOR RESIDENCE AT PIIKOI
HONOLULU, OAHU, HAWAII

LEGEND:

APPROXIMATE BORING LOCATION

GENERALIZED SUBSURFACE PROFILE

REFERENCE: SITE UTILITY PLAN TRANSMITTED BY DESIGN PARTNERS INCORPORATED ON APRIL 3, 2012.

0 10 20 30 60 90 FT.
GRAPHIC SCALE

GEOLABS, INC.
Geotechnical Engineering

DATE	DRAWN BY	PLATE
APRIL 2012	HYC	2
SCALE	W.O.	
1" = 30'	6346-00	

CAD User: HENRY File Last Updated: April 03, 2012 3:48:58pm Plot Date: April 03, 2012 - 3:49:08pm
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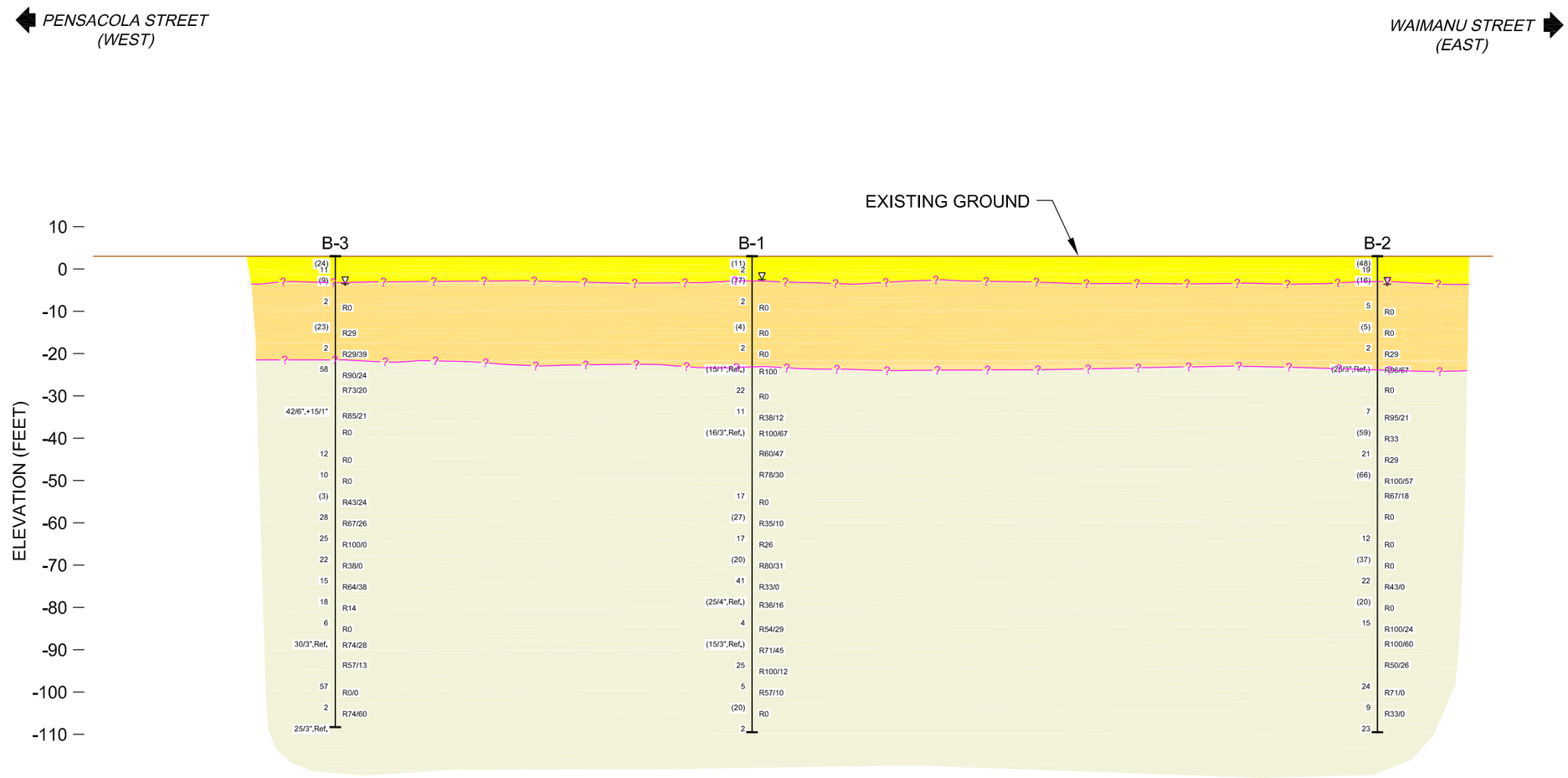
Plotter: Adobe PDF Plotstyle: GEOLABS-DC260-Modified-COLOR.ctb



SECTION A-A'

LEGEND:

20	BLOW COUNT REQUIRED FOR 12 INCHES OF PENETRATION OF A 2-INCH O.D. STANDARD PENETRATION SAMPLER
(20)	BLOW COUNT REQUIRED FOR 12 INCHES OF PENETRATION OF A 3-INCH O.D. MODIFIED CALIFORNIA SAMPLER
R100/50	REC/RQD VALUES IN PERCENT

- FILL
- LAGOONAL DEPOSIT
- CORAL REEF FORMATION INTERBEDDED WITH CORALLINE DETRITUS

NOTE: THE CONDITIONS ILLUSTRATED ARE BASED ON OUR BORINGS AND GEOLOGICAL INTERPRETATIONS. WHILE THESE ARE BELIEVED TO BE GENERALLY CORRECT, THE CONDITIONS MAY VARY LOCALLY FROM THOSE INDICATED.

0 15 30 60 90 FT.
GRAPHIC SCALE

GENERALIZED SUBSURFACE PROFILE

SENIOR RESIDENCE AT PIIKOI
HONOLULU, OAHU, HAWAII

GEOLABS, INC.
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DATE	DRAWN BY	PLATE
JUNE 2011	HYC	3
SCALE 1" = 30'	W.O. 6346-00	

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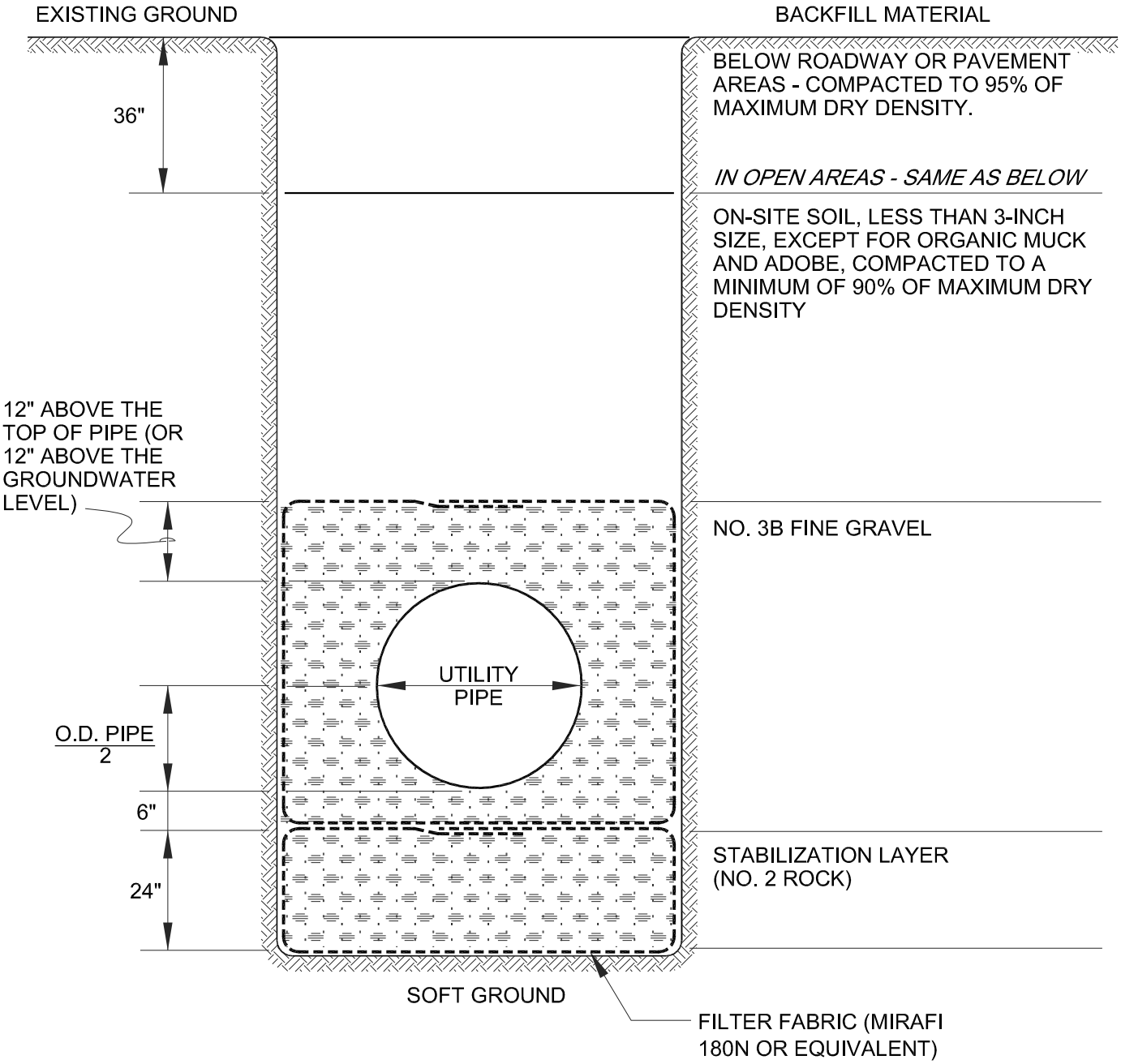
SENIOR RESIDENCE AT PIIKOI
HONOLULU, OAHU, HAWAII

Summary of Lateral Load Analysis for ACIP Piles					
Axial Load (kips)	Lateral Load (kips)	Shaft Head Connection	Lateral Deflection at Top of ACIP Pile (inches)	Max. Induced Moment (kip-ft)	Depth to Max. Moment (feet)
100	10	Free	0.15	20	4.5
100	20	Free	0.36	46	4.5
100	30	Free	0.63	74	5.0
100	40	Free	0.95	106	5.0
100	50	Free	1.45	151	5.5
100	10	Fixed	0.07	-27	0.0
100	20	Fixed	0.14	-57	0.0
100	30	Fixed	0.23	-90	0.0
100	40	Fixed	0.34	-126	0.0
100	50	Fixed	0.45	-162	0.0
-300	10	Free	0.14	18	4.5
-300	20	Free	0.33	41	4.5
-300	30	Free	0.56	65	5.0
-300	40	Free	0.82	91	5.0
-300	50	Free	1.19	124	5.5
-300	10	Fixed	0.06	-27	0.0
-300	20	Fixed	0.13	-55	0.0
-300	30	Fixed	0.22	-88	0.0
-300	40	Fixed	0.32	-122	0.0
-300	50	Fixed	0.43	-157	0.0



TYPICAL TRENCH DETAIL

SENIOR RESIDENCE AT PIIKOI
HONOLULU, OAHU, HAWAII

GEOLABS, INC.
Geotechnical Engineering

DATE	DRAWN BY	PLATE
JUNE 2011	HYC	5
SCALE	W.O.	
NOT TO SCALE	6346-00	

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File: T:\Drafting-9904\Working\6346-00KonaStreetResidentialDevelopment\6346-00TrenchDetail.dwg\Model

APPENDIX A

APPENDIX A

Field Exploration

We explored the subsurface conditions at the project site by drilling and sampling three borings, designated as Boring Nos. 1 through 3, extending to depths of about 111.3 to 112.5 feet below the existing ground surface. The approximate boring locations are shown on the Site Plan, Plate 2. The borings were drilled using a truck-mounted drill rig equipped with continuous flight augers and coring tools.

Our geologist classified the materials encountered in the borings by visual and textural examination in the field in general accordance with ASTM D 2488, Standard Practice for Description and Identification of Soils, and monitored the drilling operations on a near-continuous (full-time) basis. These classifications were further reviewed visually and by testing in the laboratory. Soils were classified in general accordance with ASTM D 2487, Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System), as shown on the Soil Log Legend, Plate A-0.1. Graphic representations of the materials encountered are presented on the Logs of Borings, Plates A-1 through A-3.

Relatively "undisturbed" soil samples were obtained in general accordance with ASTM D 3550, Ring-Lined Barrel Sampling of Soils, by driving a 3-inch OD Modified California sampler with a 140-pound hammer falling 30 inches. In addition, some samples were obtained from the drilled borings in general accordance with ASTM D 1586, Penetration Test and Split-Barrel Sampling of Soils, by driving a 2-inch OD standard penetration sampler using the same hammer and drop. The blow counts needed to drive the sampler the second and third 6 inches of an 18-inch drive are shown as the "Penetration Resistance" on the Logs of Borings at the appropriate sample depths. The penetration resistance shown on the logs of borings indicates the number of blows required for the specific sampler type used. The blow counts may need to be factored to obtain the Standard Penetration Test (SPT) blow counts.

Core samples of the rock materials encountered at the project site were obtained by using diamond core drilling techniques in general accordance with ASTM D 2113, Diamond Core Drilling for Site Investigation. Core drilling is a rotary drilling method that uses a hollow bit to cut into the rock formation. The rock material left in the hollow core of the bit is mechanically recovered for examination and description. Rock cores were described in general accordance with the Rock Description System, as shown on the Rock Log Legend, Plate A-0.2. The Rock Description System is based on the publication "Suggested Methods for the Quantitative Description of Discontinuities in Rock Masses" by the International Society for Rock Mechanics (March 1977).

Recovery (REC) may be used as a subjective guide to the interpretation of the relative quality of rock masses, where appropriate. Recovery is defined as the actual length of material recovered from a coring attempt versus the length of the core attempt. For example, if 3.7 feet of material is recovered from a 5.0-foot core run, the recovery would be 74 percent and would be shown on the Logs of Borings as REC = 74%.

The Rock Quality Designation (RQD) is also a subjective guide to the relative quality of rock masses. RQD is defined as the percentage of the core run in rock that is sound material in excess of 4 inches in length without any discontinuities, discounting any drilling, mechanical, and handling induced fractures or breaks. If 2.5 feet of sound material is recovered from a 5.0-foot core run in rock, the RQD would be 50 percent and would be shown on the Logs of Borings as RQD = 50%. Generally, the following is used to describe the relative quality of the rock based on the "Practical Handbook of Physical Properties of Rocks and Minerals" by Robert S. Carmichael (1989).

Rock Quality	**RQD** (%)
Very Poor	0 – 25
Poor	25 – 50
Fair	50 – 75
Good	75 – 90
Excellent	90 – 100

The excavation characteristic of a rock mass is a function of the relative hardness of the rock, its relative quality, brittleness, and fissile characteristics. A dense rock formation with a high RQD value would be very difficult to excavate and probably would require more arduous methods of excavation.

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Soil Log Legend

UNIFIED SOIL CLASSIFICATION SYSTEM (USCS)

MAJOR DIVISIONS			USCS	TYPICAL DESCRIPTIONS
COARSE-GRAINED SOILS MORE THAN 50% OF MATERIAL RETAINED ON NO. 200 SIEVE	GRAVELS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS LESS THAN 5% FINES	GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
			GP	POORLY-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES MORE THAN 12% FINES	GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES
			GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
	SANDS 50% OR MORE OF COARSE FRACTION PASSING THROUGH NO. 4 SIEVE	CLEAN SANDS LESS THAN 5% FINES	SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
			SP	POORLY-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
		SANDS WITH FINES MORE THAN 12% FINES	SM	SILTY SANDS, SAND-SILT MIXTURES
			SC	CLAYEY SANDS, SAND-CLAY MIXTURES
FINE-GRAINED SOILS 50% OR MORE OF MATERIAL PASSING THROUGH NO. 200 SIEVE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50	ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
			CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
			OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT 50 OR MORE	MH	INORGANIC SILT, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
			CH	INORGANIC CLAYS OF HIGH PLASTICITY
			OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS			PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

LEGEND

- (2-INCH) O.D. STANDARD PENETRATION TEST
- (3-INCH) O.D. MODIFIED CALIFORNIA SAMPLE
- SHELBY TUBE SAMPLE
- GRAB SAMPLE
- CORE SAMPLE
- WATER LEVEL OBSERVED IN BORING

LL	LIQUID LIMIT (NP=NON-PLASTIC)
PI	PLASTICITY INDEX (NP=NON-PLASTIC)
TV	TORVANE SHEAR (tsf)
PEN	POCKET PENETROMETER (tsf)
UC	UNCONFINED COMPRESSION (psi)
UU	UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION (ksf)

Plate

A-0.1

GEOLABS, INC.

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Rock Log Legend

ROCK DESCRIPTIONS

	BASALT		**FINGER CORAL**
	BOULDERS		**LIMESTONE**
	BRECCIA		**SANDSTONE**
	CLINKER		**SILTSTONE**
	COBBLES		**TUFF**
	CORAL		**VOID/CAVITY**

ROCK DESCRIPTION SYSTEM

ROCK FRACTURE CHARACTERISTICS

The following terms describe general fracture spacing of a rock:

Massive: Greater than 24 inches apart

Slightly Fractured: 12 to 24 inches apart

Moderately Fractured: 6 to 12 inches apart

Closely Fractured: 3 to 6 inches apart

Severely Fractured: Less than 3 inches apart

DEGREE OF WEATHERING

The following terms describe the chemical weathering of a rock:

Unweathered: Rock shows no sign of discoloration or loss of strength.

Slightly Weathered: Slight discoloration inwards from open fractures.

Moderately Weathered: Discoloration throughout and noticeably weakened though not able to break by hand.

Highly Weathered: Most minerals decomposed with some corestones present in residual soil mass. Can be broken by hand.

Extremely Weathered: Saprolite. Mineral residue completely decomposed to soil but fabric and structure preserved.

HARDNESS

The following terms describe the resistance of a rock to indentation or scratching:

Very Hard: Specimen breaks with difficulty after several "pinging" hammer blows.
Example: Dense, fine grain volcanic rock

Hard: Specimen breaks with some difficulty after several hammer blows.
Example: Vesicular, vugular, coarse-grained rock

Medium Hard: Specimen can be broked by one hammer blow. Cannot be scraped by knife. SPT may penetrate by ~25 blows per inch with bounce.
Example: Porous rock such as clinker, cinder, and coral reef

Soft: Can be indented by one hammer blow. Can be scraped or peeled by knife. SPT can penetrate by ~100 blows per foot.
Example: Weathered rock, chalk-like coral reef

Very Soft: Crumbles under hammer blow. Can be peeled and carved by knife. Can be indented by finger pressure.
Example: Saprolite

Plate
A-0.2

GEOLABS, INC. Geotechnical Engineering	SENIOR RESIDENCE AT PIIKOI HONOLULU, OAHU, HAWAII	Log of Boring 1

Approximate Ground Surface Elevation : N/A

Other Tests (Laboratory)	Moisture Content (%) (Laboratory)	Dry Density (pcf) (Laboratory)	Core Recovery (%) (Field)	RQD (%) (Field)	Penetration Resistance (blows/foot) (Field)	Pocket Pen. (tsf) (Field)	Depth (feet)	USCS	Description
								SW	4-inch **CONCRETE**
	12	79			11				White with black mottling **GRAVELLY SAND (CORALLINE)**, loose, moist (fill)
	40				2			CH	Tan **SILTY CLAY**, very soft, moist
	52	69			17		5		
								GW	Gray **SANDY GRAVEL**, medium dense
Sieve - #200 = 18.4%	45		0		2		10	SM	Gray **SILTY SAND** with gravel, very loose
							15		
Sieve - #200 = 6.1%	32	63	0		4			GP-GM	Light gray poorly graded **GRAVEL (CORALLINE)** with sand and some silt, loose
							20	CL	Light gray **SANDY CLAY**, very soft
LL=35 PI=14	43		0		2				
							25	GP	White with black and gray mottling **GRAVEL (CORALLINE)**, very dense (coral formation)
	19	84	100		15/1" Ref.				grades with light tan cobbles (coralline)
							30		
	29		0		22			SC	Light tan **CLAYEY SAND (CORALLINE)**, medium dense
							35		

Date Started:	June 5, 2010	Water Level: ▽ 5.5 ft. 06/05/2010 1045 HRS	Plate
Date Completed:	June 7, 2010		
Logged By:	M. Nolasco	Drill Rig: CME-45C	
Total Depth:	112.5 feet	Drilling Method: 4" Auger & PQ Coring	A - 1.1
Work Order:	6346-00	Driving Energy: 140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	SENIOR RESIDENCE AT PIIKOI HONOLULU, OAHU, HAWAII	Log of Boring 1

Laboratory			Field								
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	(Continued from previous plate) Description
										SC	
	47				11					GW	Light tan to tan **SANDY GRAVEL (CORALLINE)** with silt, medium dense
			38	12							grades with light tan cobbles (coralline)
							40				
UC	3		100	67	16/3" Ref.						White massive **CORAL**, moderately fractured, slightly weathered, medium hard
							45				
			60	47							grades to vugular, moderately weathered, medium hard to soft
							50				
			78	30							Light grayish white vugular and scoriaceous **CORAL**, moderately to closely fractured, moderately to highly weathered, soft
							55				
	23				17					SW	Grayish white **GRAVELLY SAND (CORALLINE)**, medium dense
			0								
							60				
Direct Shear	24	90			27						grades to light gray
			35	10							Light gray vugular **CORAL**, closely fractured, moderately weathered, soft
							65				
	23				17					SW	White to light gray **GRAVELLY SAND (CORALLINE)**, medium dense
			26							GW	Off-white **SANDY GRAVEL (CORALLINE)**, medium dense
							70				

Date Started:	June 5, 2010	Water Level: ▽	5.5 ft. 06/05/2010 1045 HRS	Plate
Date Completed:	June 7, 2010			
Logged By:	M. Nolasco	Drill Rig:	CME-45C	
Total Depth:	112.5 feet	Drilling Method:	4" Auger & PQ Coring	A - 1.2
Work Order:	6346-00	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	SENIOR RESIDENCE AT PIIKOI HONOLULU, OAHU, HAWAII	Log of Boring 1

Laboratory			Field								
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	(Continued from previous plate) Description
										GW	
Direct Shear	24	96			20						Light tan **SANDSTONE**, moderately to closely fractured, moderately weathered, soft (coralline sandstone)
			80	31							
							75				
	17				41						
			33	0							Light tan **CORAL**, severely fractured, moderately weathered, soft
							80				
	24	97			25/4" Ref.						
			36	16							
											grades to moderately to closely fractured, medium hard to soft
							85				
	37				4						Light tan vugular **CORAL**, moderately to closely fractured, moderately weathered, medium hard to soft
			54	29							
							90				
	20	135			15/3" Ref.						
			71	45							Light tan vugular **CORAL**, moderately to closely fractured, moderately to slightly weathered, medium hard to soft
							95				
	23				25						
			100	12							grades with orange and white mottling, moderately weathered, medium hard
							100				Light tan **SANDSTONE**, moderately to severely fractured, moderately weathered, medium hard (coralline sandstone)
	21				5						
			57	10							
							105				

Date Started:	June 5, 2010	Water Level: ▽ 5.5 ft. 06/05/2010 1045 HRS	Plate
Date Completed:	June 7, 2010		
Logged By:	M. Nolasco	Drill Rig: CME-45C	
Total Depth:	112.5 feet	Drilling Method: 4" Auger & PQ Coring	A - 1.3
Work Order:	6346-00	Driving Energy: 140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	SENIOR RESIDENCE AT PIIKOI HONOLULU, OAHU, HAWAII	Log of Boring 1

Laboratory			Field								
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	(Continued from previous plate) Description
	28	79			20					GW	Light tan **SANDY GRAVEL (CORALLINE)**, medium dense
			0								
							110				
	35				2					SP	Light gray **SAND (CORALLINE)**, loose
											Boring terminated at 112.5 feet
							115				
							120				
							125				
							130				
							135				
							140				

Date Started:	June 5, 2010	Water Level: ▽	5.5 ft. 06/05/2010 1045 HRS	Plate
Date Completed:	June 7, 2010			
Logged By:	M. Nolasco	Drill Rig:	CME-45C	
Total Depth:	112.5 feet	Drilling Method:	4" Auger & PQ Coring	A - 1.4
Work Order:	6346-00	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	SENIOR RESIDENCE AT PIIKOI HONOLULU, OAHU, HAWAII	Log of Boring 2

Approximate Ground Surface Elevation : N/A

Other Tests (Laboratory)	Moisture Content (%) (Laboratory)	Dry Density (pcf) (Laboratory)	Core Recovery (%) (Field)	RQD (%) (Field)	Penetration Resistance (blows/foot) (Field)	Pocket Pen. (tsf) (Field)	Depth (feet)	USCS	Description
								GW	2.5-inch **ASPHALTIC CONCRETE**
	15	81			48			GP	Brown and gray **SANDY GRAVEL**, dense, dry (base course)
	21				19			SW	Light tan **GRAVEL (CORALLINE)**, very dense, damp
									Gray **GRAVELLY SAND**, medium dense, damp
	29	98			16		5		grades to wet
							10	GP-GM	Light gray poorly graded **GRAVEL (CORALLINE)** with sand and some silt, loose
Sieve - #200 = 6.4%	36		0		5				
							15	GP	Gray poorly graded **GRAVEL (CORALLINE)**, loose
Sieve - #200 = 2.3%	33		0		5				
					2		20		
			29						grades to light tan to gray
			96	67	25/3" Ref.		25		
									Light tan to gray vugular **CORAL**, moderately to closely fractured, moderately weathered, hard
							30		
			0					SW	Tan **GRAVELLY SAND (CORALLINE)**, loose
							35		

Date Started:	June 8, 2010	Water Level: ∇ 6.6 ft. 06/08/2010 1215 HRS	Plate
Date Completed:	June 9, 2010		
Logged By:	M. Nolasco	Drill Rig: CME-75	
Total Depth:	112.5 feet	Drilling Method: 4" Auger & PQ Coring	A - 2.1
Work Order:	6346-00	Driving Energy: 140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	SENIOR RESIDENCE AT PIIKOI HONOLULU, OAHU, HAWAII	Log of Boring 2

Laboratory			Field								
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	(Continued from previous plate) Description
	45		95	21	7					SW	
							40				Light gray **CORAL**, hard
Direct Shear	25	94	33		59					GP	Light gray to grayish white **GRAVEL (CORALLINE)**, very dense
							45				
	24		29		21						grades to medium dense
							50				
Direct Shear	34	91	100	57	66						Light gray vugular **CORAL**, moderately fractured, moderately weathered, medium hard
							55				
			67	18							grades to soft to medium hard
							60				
			0							SC	White **CLAYEY SAND (CORALLINE)** with gravel, medium dense
							65				
	23		0		12						
							70				

Date Started:	June 8, 2010	Water Level: ▽ 6.6 ft. 06/08/2010 1215 HRS	Plate
Date Completed:	June 9, 2010		
Logged By:	M. Nolasco	Drill Rig: CME-75	
Total Depth:	112.5 feet	Drilling Method: 4" Auger & PQ Coring	A - 2.2
Work Order:	6346-00	Driving Energy: 140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	SENIOR RESIDENCE AT PIIKOI HONOLULU, OAHU, HAWAII	Log of Boring 2

Laboratory			Field								
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	(Continued from previous plate) Description
					37					SC	
			0								
							75			SW	Light yellowish tan **GRAVELLY SAND (CORALLINE)**, medium dense
	24				22						
			43	0							Light tan **CORAL**, medium hard
							80			GP	Gray **GRAVEL (CORALLINE)**, medium dense
	23				20						
			0								
							85				
	27				15						
			100	24							Light tan to gray **CORAL**, moderately fractured, moderately weathered, medium hard to soft
							90				
			100	60							
											grades to light tan to white, slightly to moderately fractured, slightly to moderately weathered, medium hard to hard
							95				
			50	26							
											grades to light tan with yellowish orange mottling, moderately to closely fractured, moderately weathered
							100				
	55				24						Light tan to gray **CORAL**, severely fractured, highly weathered, soft
			71	0							
							105				

Date Started:	June 8, 2010	Water Level: ▽ 6.6 ft. 06/08/2010 1215 HRS	Plate
Date Completed:	June 9, 2010		
Logged By:	M. Nolasco	Drill Rig: CME-75	
Total Depth:	112.5 feet	Drilling Method: 4" Auger & PQ Coring	A - 2.3
Work Order:	6346-00	Driving Energy: 140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	SENIOR RESIDENCE AT PIIKOI HONOLULU, OAHU, HAWAII	Log of Boring 2

Laboratory			Field								
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	Description
											(Continued from previous plate)
	33				9						
			33	0							Light tan to yellowish tan **SANDSTONE**, closely to severely fractured, moderately weathered, soft
							110				
	26				23						
											Boring terminated at 112.5 feet
							115				
							120				
							125				
							130				
							135				
							140				

Date Started:	June 8, 2010	Water Level: ▽ 6.6 ft. 06/08/2010 1215 HRS	Plate
Date Completed:	June 9, 2010		
Logged By:	M. Nolasco	Drill Rig: CME-75	
Total Depth:	112.5 feet	Drilling Method: 4" Auger & PQ Coring	A - 2.4
Work Order:	6346-00	Driving Energy: 140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	SENIOR RESIDENCE AT PIIKOI HONOLULU, OAHU, HAWAII	Log of Boring 3

Approximate Ground Surface Elevation : N/A

Other Tests (Laboratory)	Moisture Content (%) (Laboratory)	Dry Density (pcf) (Laboratory)	Core Recovery (%) (Field)	RQD (%) (Field)	Penetration Resistance (blows/foot) (Field)	Pocket Pen. (tsf) (Field)	Depth (feet)	USCS	Description
								SW	2-inch **ASPHALTIC CONCRETE**
	12	84			24			SW	Light tan **GRAVELLY SAND (CORALLINE)**, medium dense, moist
Sieve - #200 = 4.9%	16				11				Light tan **GRAVELLY SAND (CORALLINE)**, medium dense, moist grades to loose at 2.5 feet
Consol.	13	82			9		5		
Sieve - #200 = 10.7%	39		0		2		10	GP-GM	Light gray poorly graded **GRAVEL (CORALLINE)** with sand and some silt, loose
							15		
	47		29		23				Light tan and gray **GRAVEL AND COBBLES**, medium dense
							20	SM	Light gray **SILTY SAND (CORALLINE)** with gravel, very loose
Sieve - #200 = 27.5%	37		29	39	2				
							25		Light tan **CORAL**, moderately to closely fractured, moderately weathered, soft
	22		90	24	58			SW	Light tan **GRAVELLY SAND (CORALLINE)**, very dense
									Light tan vugular **CORAL**, moderately to closely fractured, moderately weathered, medium hard
			73	20			30		
							35		grades to brown with white mottling, rough texture, closely fractured, medium hard to soft

Date Started:	June 3, 2010	Water Level: ▽ 6.5 ft. 06/03/2010 1200 HRS	Plate
Date Completed:	June 4, 2010		
Logged By:	M. Nolasco	Drill Rig: CME-75	
Total Depth:	111.3 feet	Drilling Method: 4" Auger & PQ Coring	A - 3.1
Work Order:	6346-00	Driving Energy: 140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	SENIOR RESIDENCE AT PIIKOI HONOLULU, OAHU, HAWAII	Log of Boring 3

Laboratory			Field								
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	(Continued from previous plate) Description
	16				42/6" +15/1"						Light tan vugular **CORAL**, slightly to severely fractured, moderately weathered, medium hard
UC			85	21							
							40				
			0							GW	Light tan **SANDY GRAVEL (CORALLINE)**, medium dense
							45				
	23				12						
			0								
							50				
	25				10					SW	Light tan **GRAVELLY SAND (CORALLINE)**, loose
			0								
							55				
	17	106			3						grades to light gray
			43	24							
							60				Light tan and light gray vugular **CORAL**, moderately to closely fractured, moderately weathered, medium hard
	15				28						
			67	26							
							65				
	14				25						
			100	0							White with black pigmentation vugular **CORAL**, moderately to closely fractured, moderately weathered, medium hard to soft
							70				

Date Started:	June 3, 2010	Water Level: ▽ 6.5 ft. 06/03/2010 1200 HRS	Plate
Date Completed:	June 4, 2010		
Logged By:	M. Nolasco	Drill Rig: CME-75	
Total Depth:	111.3 feet	Drilling Method: 4" Auger & PQ Coring	A - 3.2
Work Order:	6346-00	Driving Energy: 140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	SENIOR RESIDENCE AT PIIKOI HONOLULU, OAHU, HAWAII	Log of Boring 3

Laboratory			Field								
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	(Continued from previous plate) Description
	21		38	0	22		75				Light tan **CORAL**, moderately to closely fractured, moderately weathered, medium hard to soft
	33		64	38	15		80				grades to slightly to closely fractured, soft
	28		14		18		85			GW	Light tan **SANDY GRAVEL (CORALLINE)**, medium dense to loose
	28		0		6		90			SW	Grayish white **GRAVELLY SAND (CORALLINE)** with traces of clay, loose
	28		74	28	30/3" Ref.		95				Light tan with orange mottling **CORAL**, rough texture, moderately to closely fractured, moderately weathered, medium hard to soft
			57	13			100				
	20		0	0	57		105				

Date Started:	June 3, 2010	Water Level: ▽ 6.5 ft. 06/03/2010 1200 HRS	Plate
Date Completed:	June 4, 2010		
Logged By:	M. Nolasco	Drill Rig: CME-75	
Total Depth:	111.3 feet	Drilling Method: 4" Auger & PQ Coring	A - 3.3
Work Order:	6346-00	Driving Energy: 140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	SENIOR RESIDENCE AT PIIKOI HONOLULU, OAHU, HAWAII	Log of Boring 3

Laboratory			Field								
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	Description
											(Continued from previous plate)
	28				2						
			74	60							White massive **CORAL**, slightly fractured, unweathered, hard
							110				
					25/3" Ref.						Boring terminated at 111.3 feet
							115				
							120				
							125				
							130				
							135				
							140				

Date Started:	June 3, 2010	Water Level: ▽ 6.5 ft. 06/03/2010 1200 HRS	Plate
Date Completed:	June 4, 2010		
Logged By:	M. Nolasco	Drill Rig: CME-75	
Total Depth:	111.3 feet	Drilling Method: 4" Auger & PQ Coring	A - 3.4
Work Order:	6346-00	Driving Energy: 140 lb. wt., 30 in. drop	

APPENDIX B

APPENDIX B

Laboratory Tests

Moisture Content (ASTM D 2216) and Unit Weight (ASTM D 2937) determinations were performed on selected soil samples as an aid in the classification and evaluation of soil properties. The test results are presented on the Logs of Borings at the appropriate sample depths.

One one-inch Ring Swell test was performed on a remolded sample to evaluate the swelling potential of the near-surface clayey soils. The test results are summarized on Plate B-1.

One Atterberg Limits test (ASTM D 4318) was performed on a selected soil sample to evaluate the liquid and plastic limits. The test results are summarized on the Logs of Borings at the appropriate sample depth. Graphic presentations of the test results are provided on Plate B-2.

Seven Sieve Analysis tests (ASTM C 117 & C 136) were performed on selected samples of the soils to evaluate the gradation characteristics of the soils and to aid in soil classification. Graphic presentations of the grain size distributions are provided on Plates B-3 and B-4.

Two Unconfined Compression tests (ASTM D 7012 Method C) were performed on selected core runs to evaluate the unconfined compressive strength of the coral formation encountered. The test results are presented on Plate B-5.

Four Direct Shear tests (ASTM D 3080) were performed on selected samples to evaluate the shear strength characteristics of the materials tested. Results of the direct shear tests are presented on Plates B-6 through B-9.

One Consolidation test with time rates (ASTM D 2435) was performed on a sample of the potentially compressible soils to evaluate the compressibility characteristics of the materials encountered. Results of the consolidation test are presented on Plate B-10.

One laboratory California Bearing Ratio test (ASTM D 1883) was performed on a bulk sample of the near-surface soils to evaluate the pavement support characteristics of the soils. The test results are presented on Plate B-11.

Two sets of Corrosivity tests, including pH (ASTM G51), Minimum Resistivity (ASTM G57), Chloride Content (EPA 300.0), and Sulfate Content (EPA 300.0) tests, were performed by our office and TestAmerica Analytical Testing Corporation on selected soil samples obtained from our field exploration. The test results are summarized on Plate B-12.

Location	Depth (feet)	Soil Description	Dry Density (pcf)	Moisture Contents Initial (%)	Air-Dried (%)	Final (%)	Ring Swell (%)
B-1**	2.5 - 4.0	Tan silty clay	95.2	21	15	29	4.7

NOTE: Samples tested were either relatively undisturbed or remolded in 2.4-inch diameter by 1-inch high rings. They were air-dried overnight and then saturated for 24 hours under a surcharge pressure of 55 psf.

* Relatively Undisturbed
** Remolded

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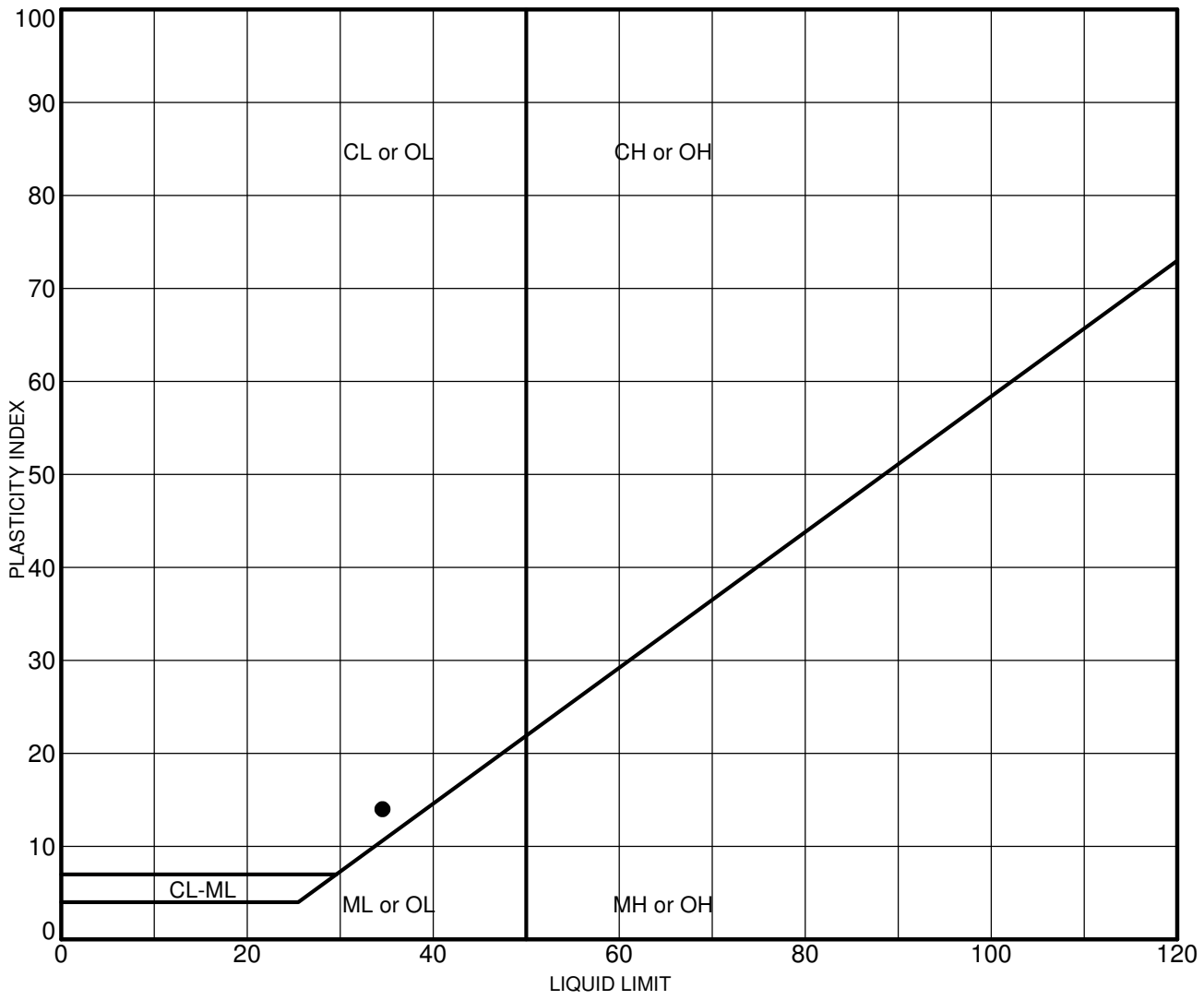
SUMMARY OF RING SWELL TESTS

SENIOR RESIDENCE AT PIIKOI
HONOLULU, OAHU, HAWAII

Plate
B - 1



	Sample	Depth (ft)	LL	PL	PI	Description
●	B-1	21.0-22.5	35	21	14	Light gray sandy clay (CL)

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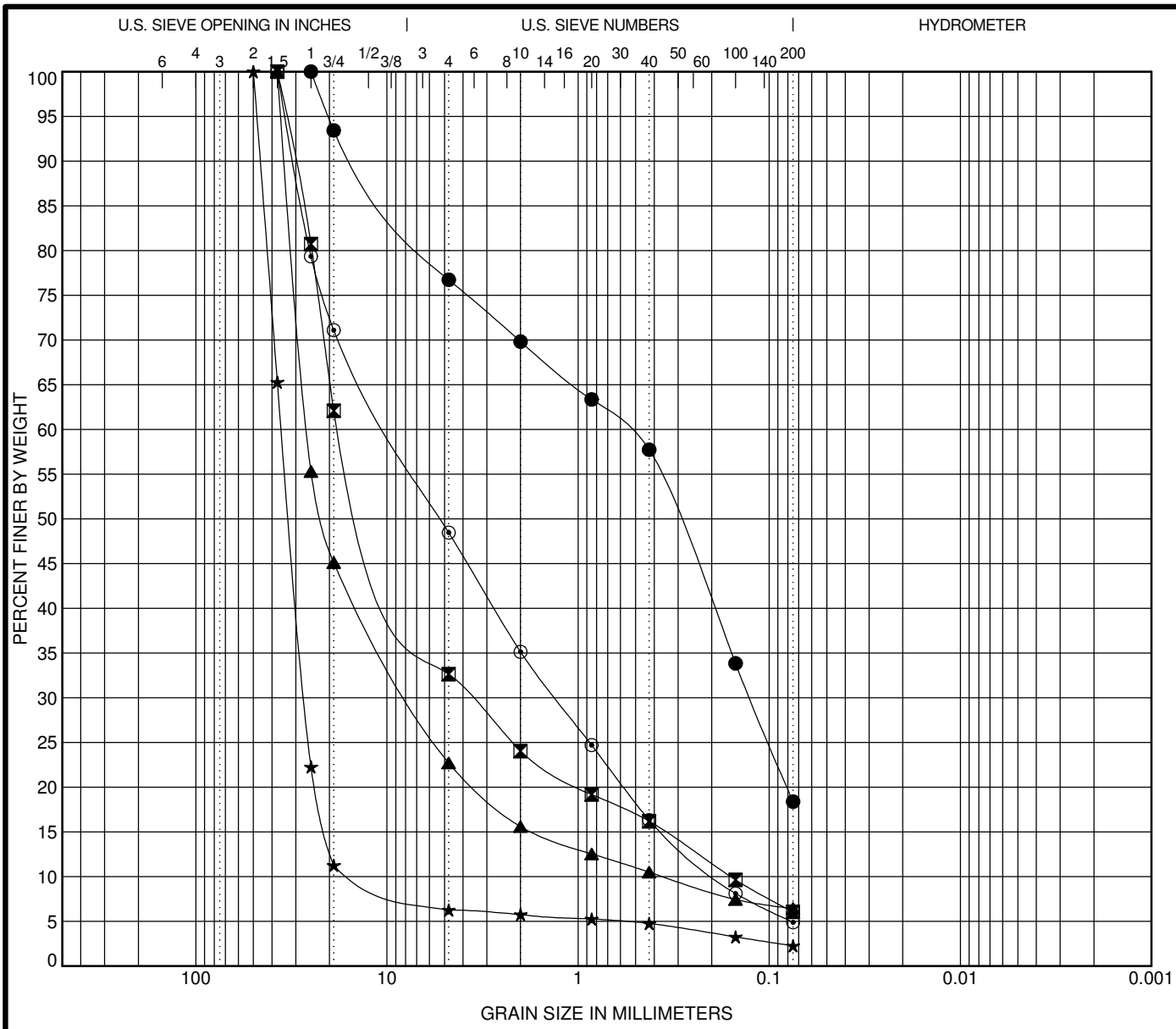
ATTERBERG LIMITS TEST RESULTS - ASTM D 4318

SENIOR RESIDENCE AT PIIKOI
HONOLULU, OAHU, HAWAII

Plate
B - 2

G ATTERBERG 6346-00.GPJ GEOLABS.GDT 6/13/11



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Sample	Depth (ft)	Description	LL	PL	PI	Cc	Cu
●	B-1	10.0-11.5	Gray silty sand (SM) with gravel					
⊠	B-1	16.5-18.0	Light gray poorly graded gravel (GP-GM) w/ sand & some silt				4.9	108.3
▲	B-2	11.0-12.5	Light gray poorly graded gravel (GP-GM) w/ sand & some silt				5.9	72.5
★	B-2	16.0-17.5	Gray poorly graded gravel (GP)				1.5	2.7
⊙	B-3	2.5-4.0	Tan gravel (GP) w/ some sand & traces of silt				0.9	50.5

	Sample	Depth (ft)	D100 (mm)	D60 (mm)	D30 (mm)	D10 (mm)	%Gravel	%Sand	%Fine
●	B-1	10.0-11.5	25	0.562	0.126		23.3	58.3	18.4
⊠	B-1	16.5-18.0	37.5	17.216	3.645	0.159	67.4	26.6	6.1
▲	B-2	11.0-12.5	37.5	26.09	7.458	0.36	77.3	16.3	6.4
★	B-2	16.0-17.5	50	35.679	26.892	13.416	93.7	4.0	2.3
⊙	B-3	2.5-4.0	37.5	9.633	1.313	0.191	51.5	43.6	4.9

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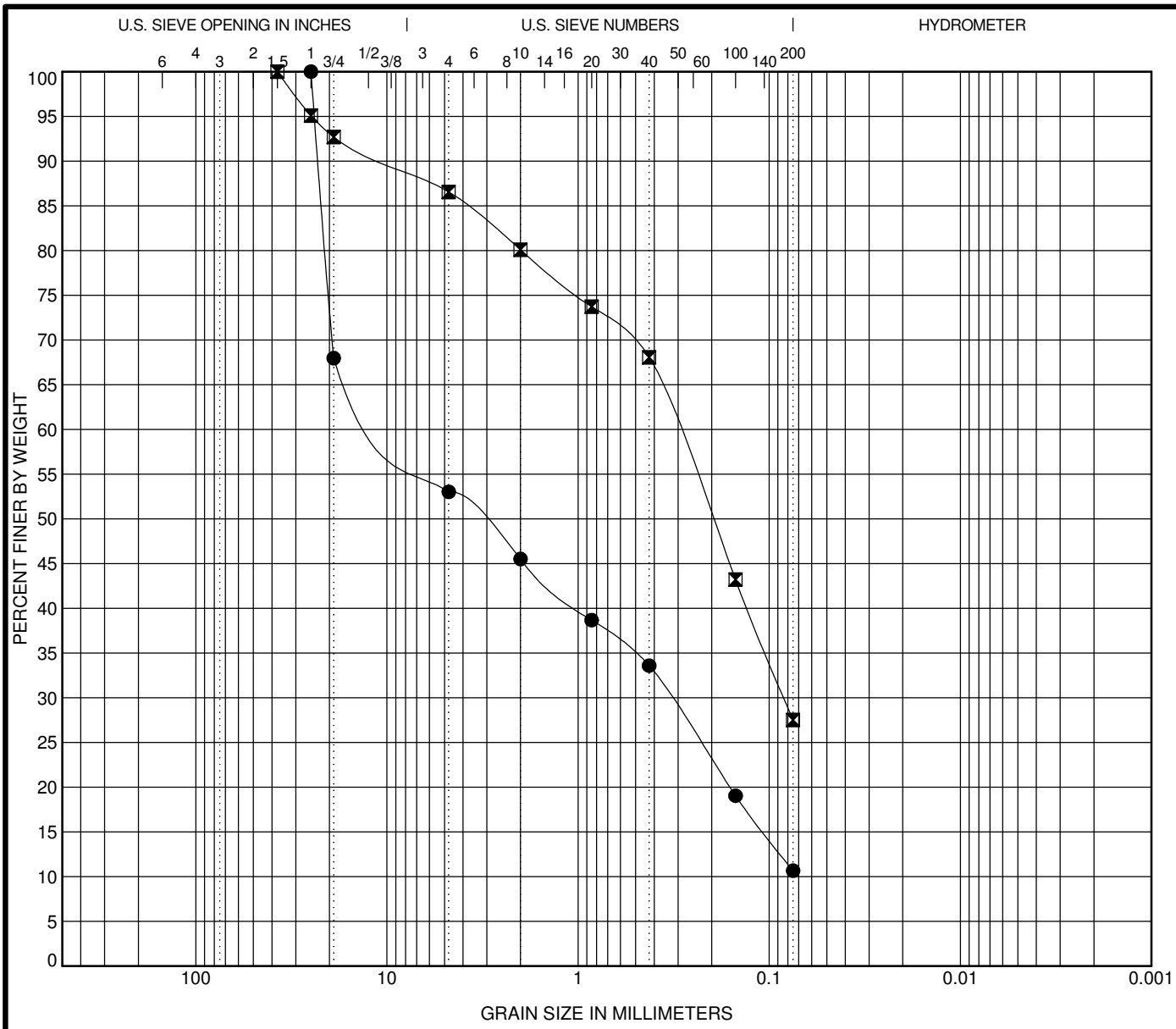
GRAIN SIZE DISTRIBUTION - ASTM C 117 & C 136

SENIOR RESIDENCE AT PIIKOI
HONOLULU, OAHU, HAWAII

Plate
B - 3

G_GRAIN_SIZE_MOD 6346-00.GPJ GEOLABS.GDT 6/13/11



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Sample	Depth (ft)	Description	LL	PL	PI	Cc	Cu
●	B-3	10.0-11.5	Light gray poorly graded gravel (GP-GM) w/ sand & some silt				0.2	127.8
⊠	B-3	21.0-22.5	Light gray silty sand (SM) w/ gravel					

	Sample	Depth (ft)	D100 (mm)	D60 (mm)	D30 (mm)	D10 (mm)	%Gravel	%Sand	%Fine
●	B-3	10.0-11.5	25	9.079	0.329		47.0	42.4	10.7
⊠	B-3	21.0-22.5	37.5	0.303	0.084		13.4	59.0	27.5

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GRAIN SIZE DISTRIBUTION - ASTM C 117 & C 136

SENIOR RESIDENCE AT PIIKOI
HONOLULU, OAHU, HAWAII

Plate
B - 4

G_GRAIN_SIZE_MOD 6346-00.GPJ GEOLABS.GDT 6/13/11

Location	Depth (feet)	Description	Date Tested	Weight of Rock (g)	Length (inches)	Diameter (inches)	Density (pcf)	Load (lb)	Length/ Diameter Ratio	Compressive Strength (psi)	Compressive Strength (ksf)
B-1	41.25 - 46	White coral	6/18/2010	1771.2	7.051	3.179	120.6	4191	2.22	528	76
B-3	37 - 41	Light tan coral	7/14/2010	1754.0	7.464	3.340	102.2	5195	2.23	593	85

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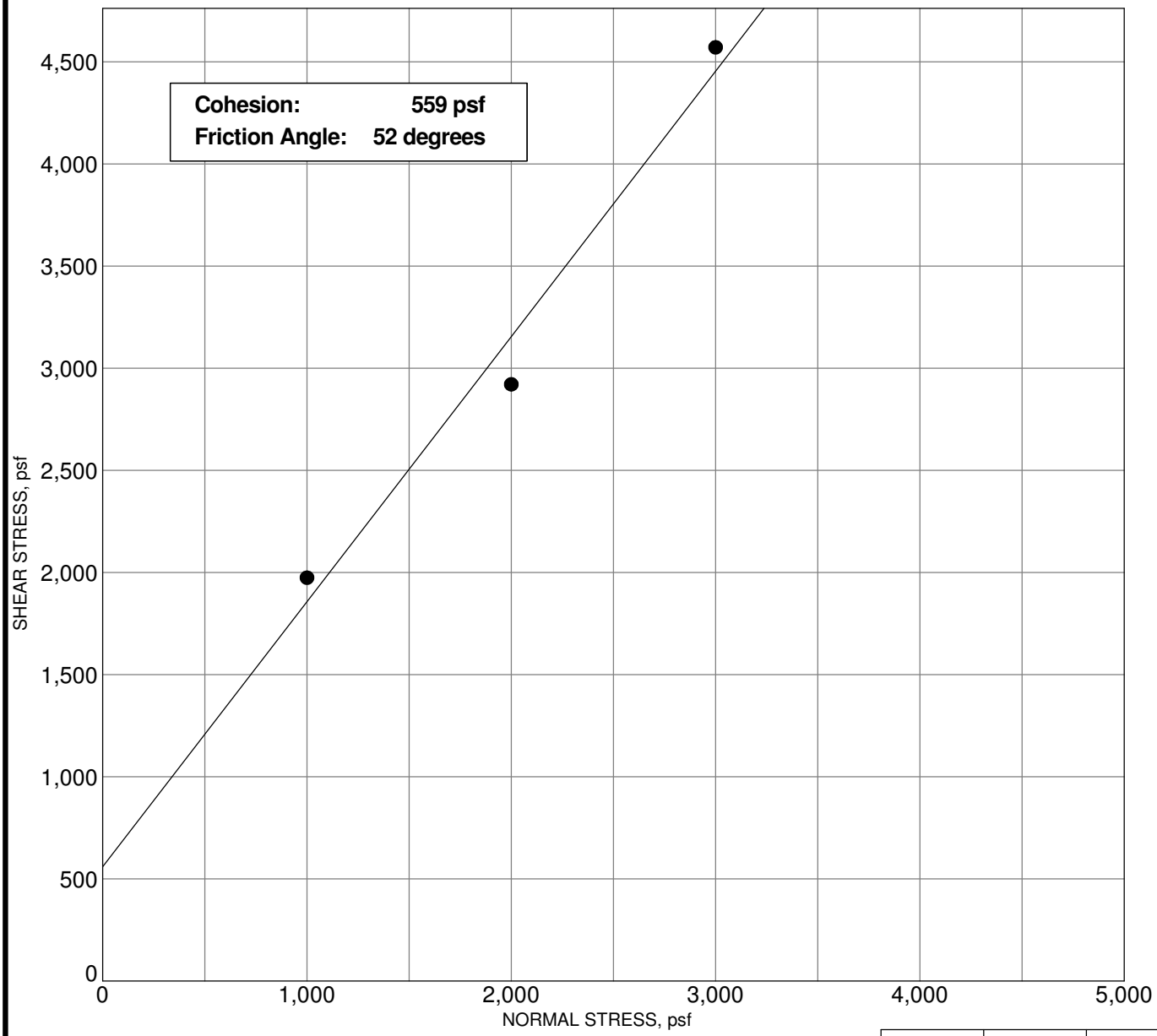
UNCONFINED COMPRESSION TEST - ASTM D 7012

SENIOR RESIDENCE AT PIIKOI
HONOLULU, OAHU, HAWAII

Plate
B - 5



		Sample #1	Sample #2	Sample #3
INITIAL	Moisture Content, %	23.9	22.0	25.0
	Dry Density, pcf	89.5	91.4	93.9
	Height, inches	1.00	1.00	1.00
FINAL	Moisture Content, %	30.5	27.2	24.1
	Dry Density, pcf	85.7	91.4	95.5
	Height, inches	1.044	1.000	0.984
	Diameter, inches	2.42	2.42	2.42
	Deformation Rate, inch/minute	0.0023	0.0022	0.0022
	Normal Stress, psf	**1000**	**2000**	**3000**
	Peak Shear Stress, psf	**1975**	**2921**	**4571**
	Shear Displacement, inches	0.38	0.31	0.20

Sample: B-1
Depth: 61.0 - 62.5 feet
Description: Light gray gravelly sand

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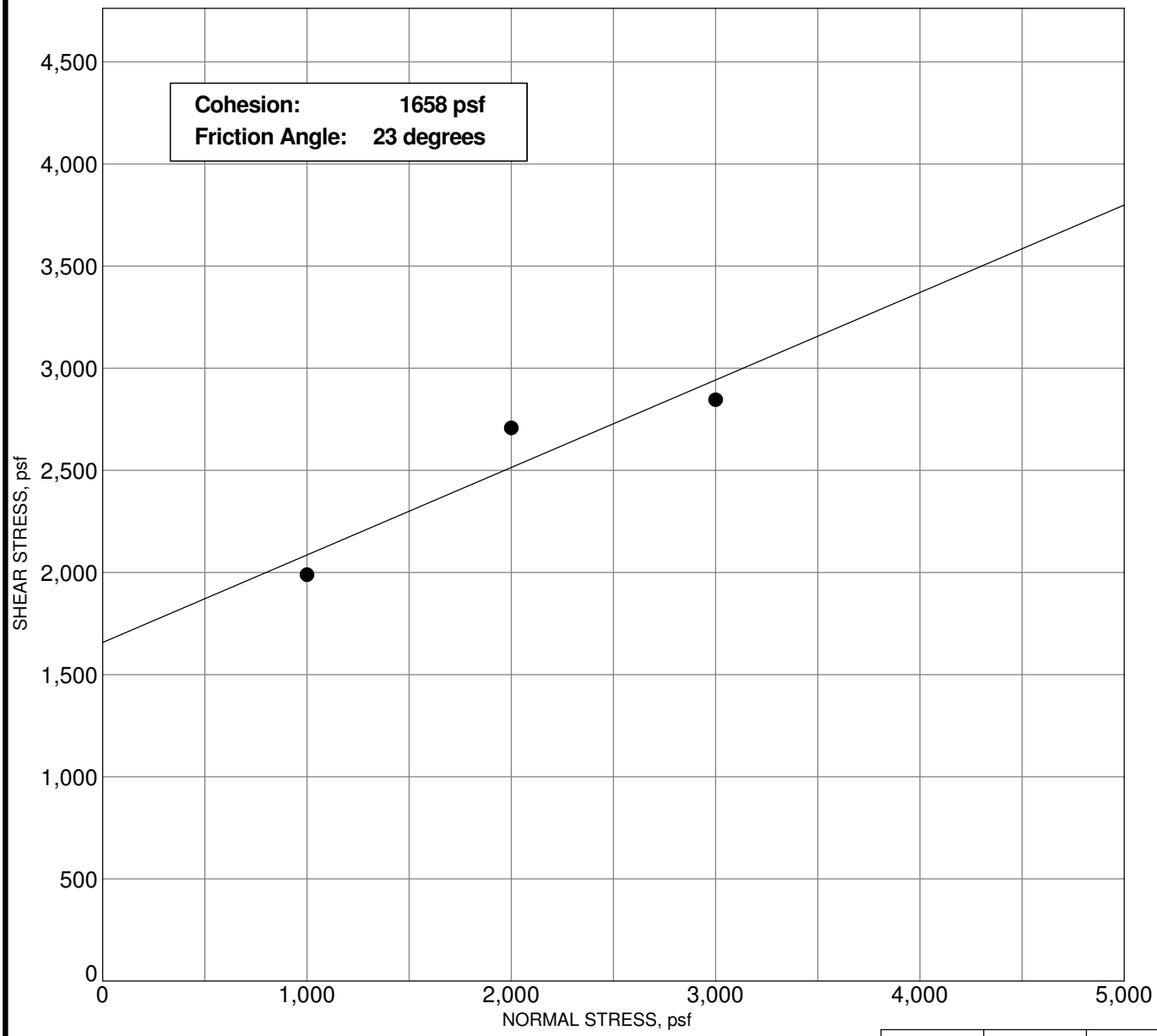
DIRECT SHEAR TEST - ASTM D 3080

SENIOR RESIDENCE AT PIIKOI
HONOLULU, OAHU, HAWAII

Plate
B - 6



		Sample #1	Sample #2	Sample #3
INITIAL	Moisture Content, %	24.0	26.4	25.6
	Dry Density, pcf	95.6	80.8	73.9
	Height, inches	1.00	1.00	1.00
FINAL	Moisture Content, %	26.0	27.6	28.8
	Dry Density, pcf	93.7	83.8	73.8
	Height, inches	1.020	0.964	1.001
	Diameter, inches	2.42	2.42	2.42
	Deformation Rate, inch/minute	0.0023	0.0023	0.0023
	Normal Stress, psf	**1000**	**2000**	**3000**
	Peak Shear Stress, psf	**1989**	**2708**	**2846**
	Shear Displacement, inches	0.33	0.41	0.42

Sample: B-1
Depth: 71.0 - 72.5 feet
Description: LIght tan sandstone

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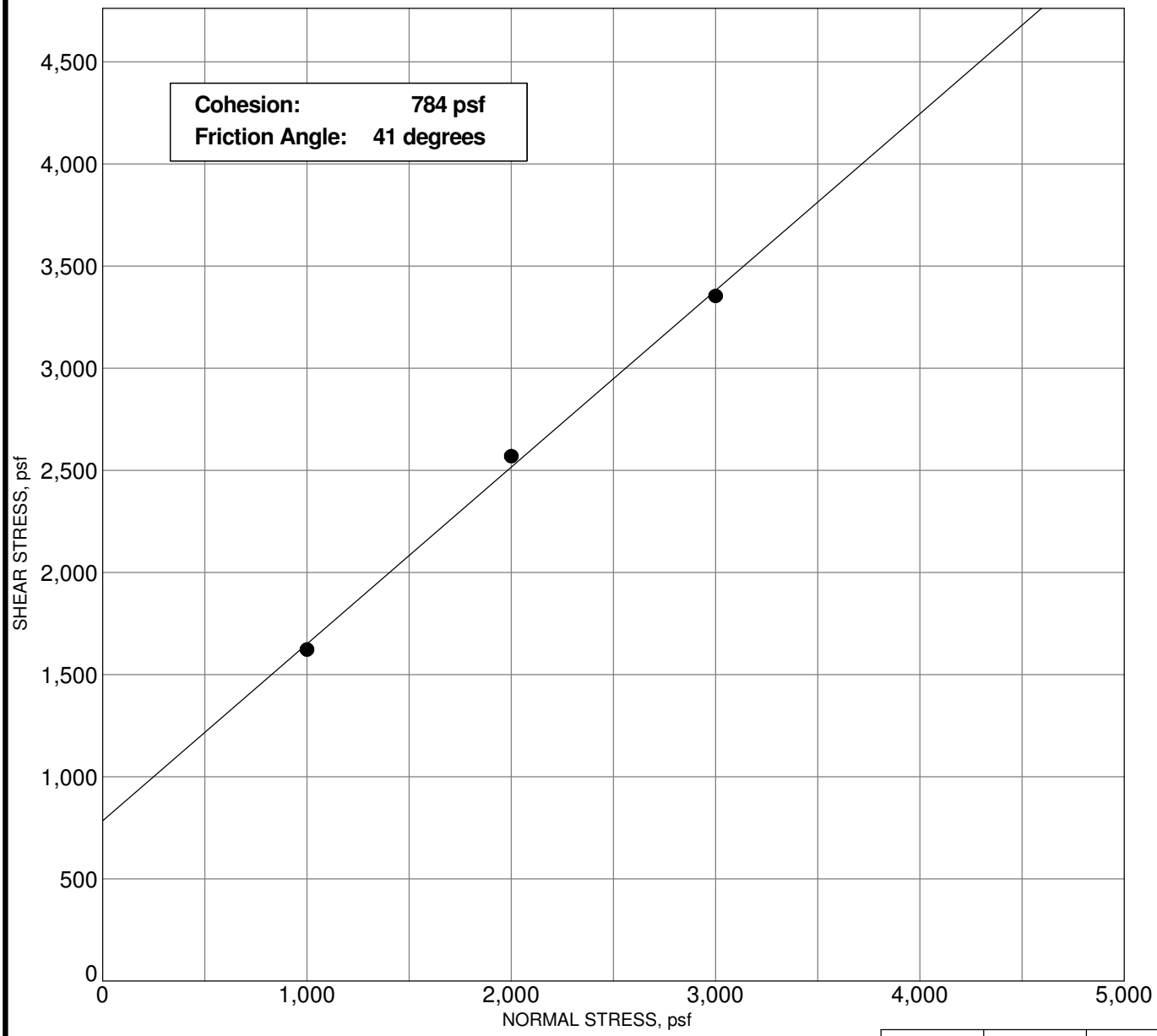
W.O. 6346-00

DIRECT SHEAR TEST - ASTM D 3080

SENIOR RESIDENCE AT PIIKOI
HONOLULU, OAHU, HAWAII

Plate
B - 7

G_DIRECT_SHEAR_6346-00.GPJ GEOLABS.GDT 6/13/11



		Sample #1	Sample #2	Sample #3
INITIAL	Moisture Content, %	25.2	27.3	24.4
	Dry Density, pcf	93.8	94.7	94.7
	Height, inches	1.00	1.00	1.00
FINAL	Moisture Content, %	25.6	27.1	23.6
	Dry Density, pcf	90.5	93.1	95.2
	Height, inches	1.036	1.016	0.995
	Diameter, inches	2.42	2.42	2.42
	Deformation Rate, inch/minute	0.0024	0.0023	0.0022
	Normal Stress, psf	**1000**	**2000**	**3000**
	Peak Shear Stress, psf	**1623**	**2570**	**3354**
	Shear Displacement, inches	0.20	0.20	0.20

Sample: B-2
Depth: 41.0 - 42.5 feet
Description: Light gray to grayish white gravel

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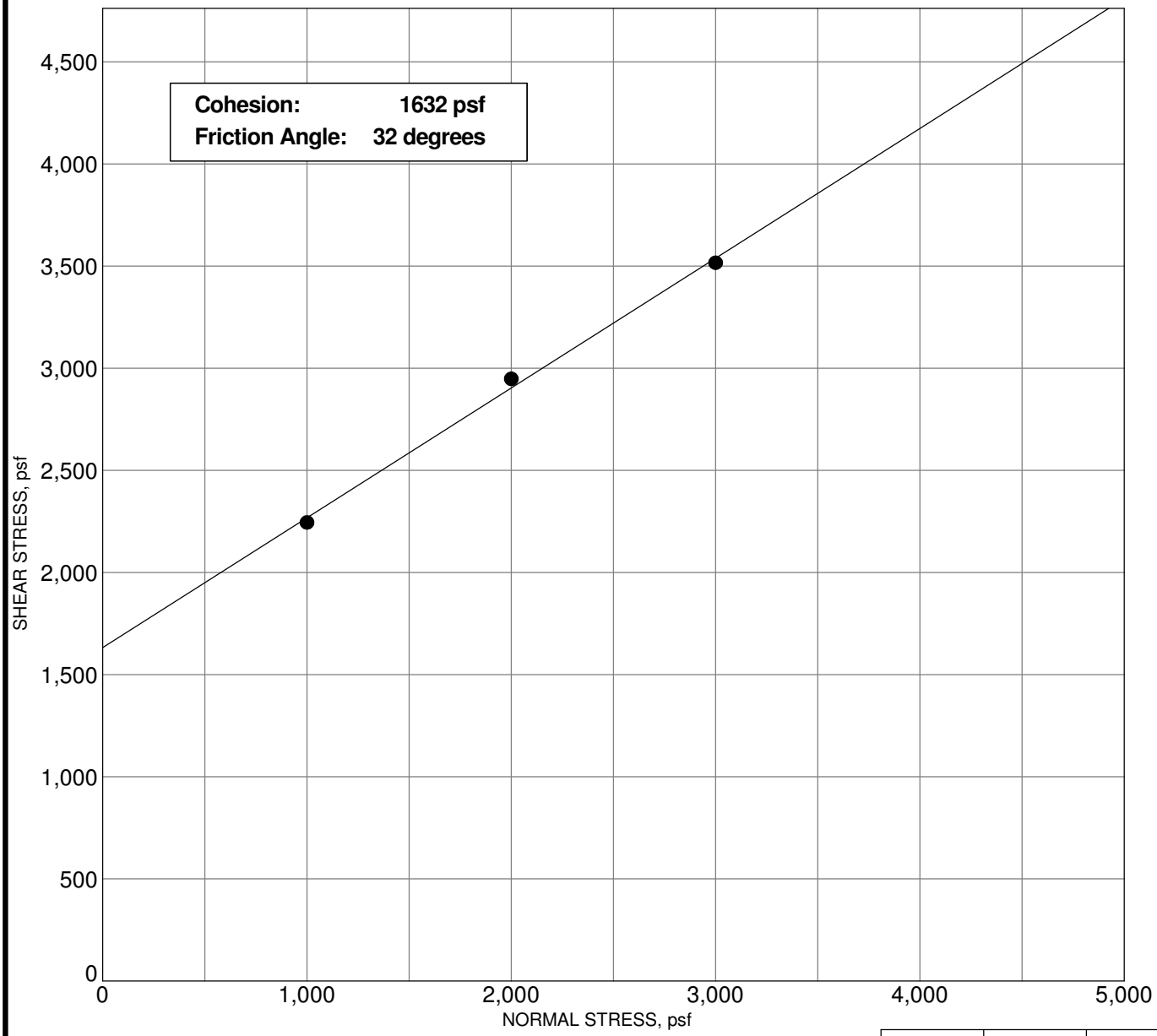
W.O. 6346-00

DIRECT SHEAR TEST - ASTM D 3080

SENIOR RESIDENCE AT PIIKOI
HONOLULU, OAHU, HAWAII

Plate
B - 8

G_DIRECT_SHEAR_6346-00.GPJ GEOLABS.GDT 6/13/11



		Sample #1	Sample #2	Sample #3
INITIAL	Moisture Content, %	33.7	29.5	33.8
	Dry Density, pcf	90.6	102.5	91.6
	Height, inches	1.00	1.00	1.00
FINAL	Moisture Content, %	39.3	30.3	33.0
	Dry Density, pcf	89.2	104.9	93.8
	Height, inches	1.016	0.977	0.976
	Diameter, inches	2.42	2.42	2.42
	Deformation Rate, inch/minute	0.0024	0.0023	0.0022
	Normal Stress, psf	**1000**	**2000**	**3000**
	Peak Shear Stress, psf	**2245**	**2948**	**3516**
	Shear Displacement, inches	0.33	0.29	0.31

Sample: B-2
Depth: 51.0 - 52.5 feet
Description: Light gray coral

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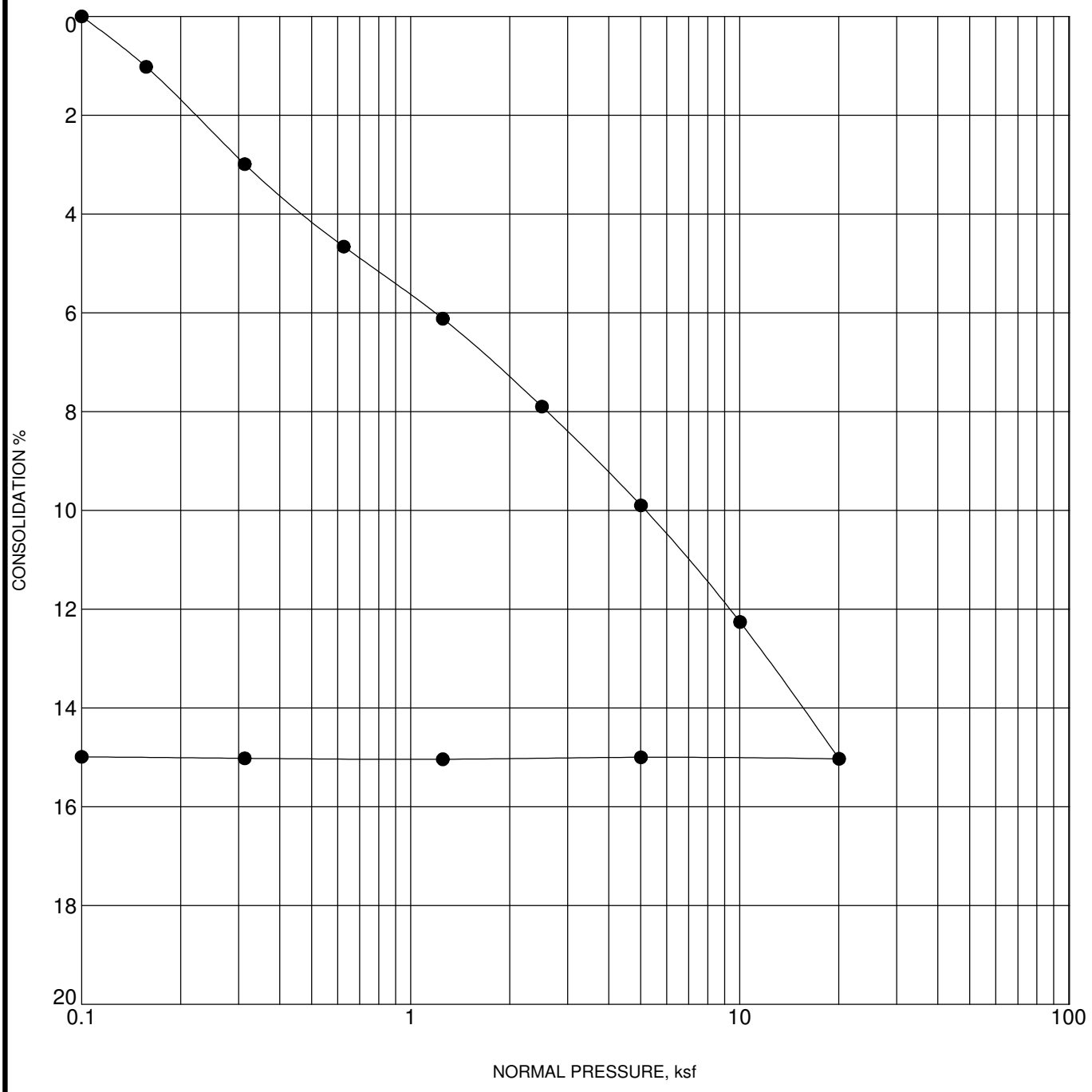
GEOTECHNICAL ENGINEERING

W.O. 6346-00

DIRECT SHEAR TEST - ASTM D 3080

SENIOR RESIDENCE AT PIIKOI
HONOLULU, OAHU, HAWAII

Plate
B - 9



Sample: B-3
Depth: 5.0 - 6.5 feet
Description: Light tan gravelly sand

Liquid Limit = N/A Plasticity Index = N/A

	Initial	Final
Water Content, %	12.9	32.0
Dry Density, pcf:	82.0	96.4
Void Ratio	1.329	0.980
Degree of Saturation, %	29.8	100.0
Sample Height, inches	1.0000	0.8357

GEOLABS, INC.
GEOTECHNICAL ENGINEERING

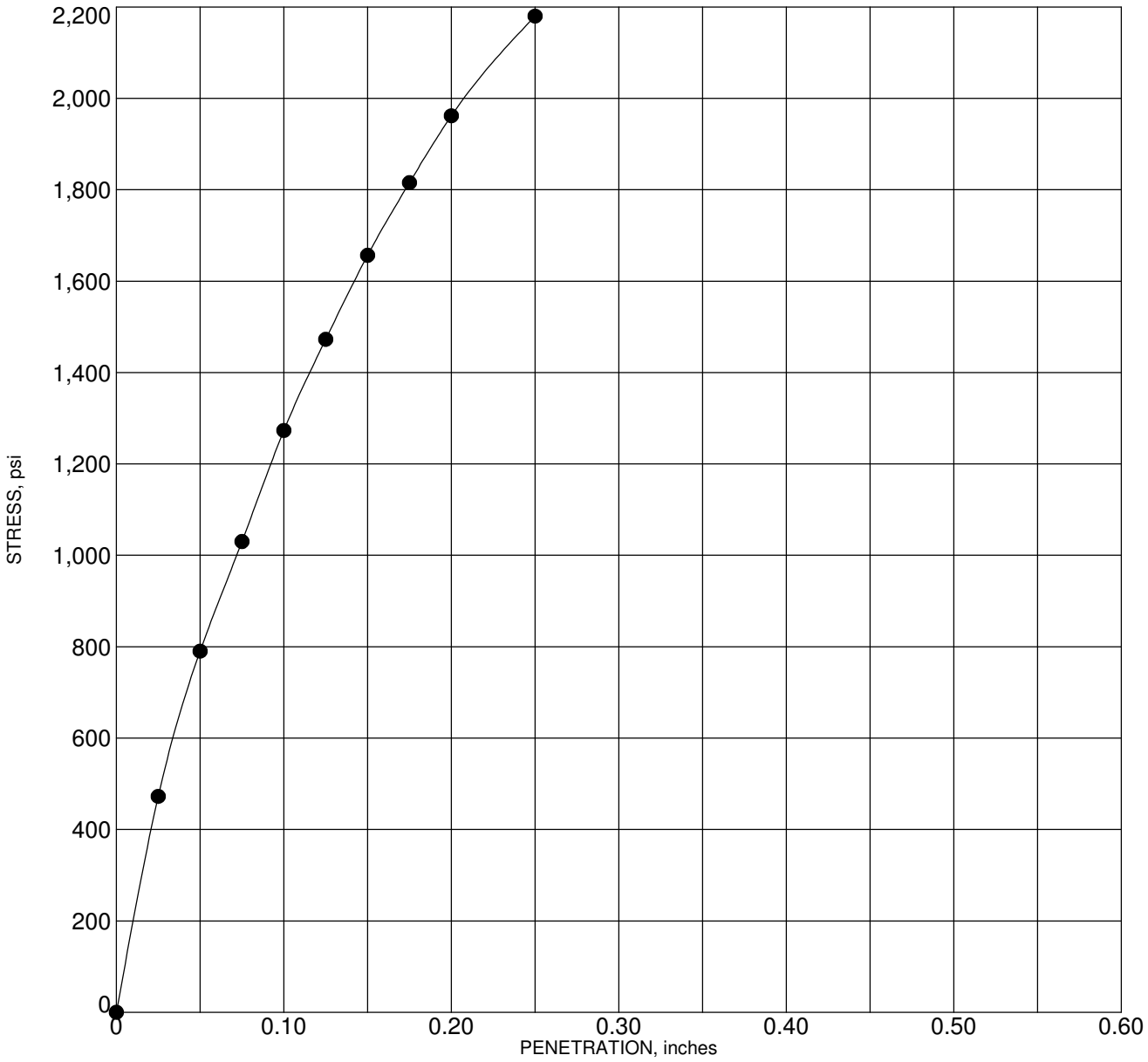
W.O. 6346-00

CONSOLIDATION TEST - ASTM D 2435

SENIOR RESIDENCE AT PIIKOI
HONOLULU, OAHU, HAWAII

Plate
B - 10

G CONSOL 6346-00.GPJ GEOLABS.GDT 6/13/11



Corr. CBR @ 0.1"	127.1
Swell (%)	0.02

Sample: Bulk-1
Depth: 0.0 - 1.0 feet
Description: Brownish gray sand and gravel (coralline) with traces of silt

Molding Dry Density (pcf)	116.9	Hammer Wt. (lbs)	10
Molding Moisture (%)	10.7	Hammer Drop (inches)	18
Days Soaked	3	No. of Blows	56
Aggregate	3/4 inch minus	No. of Layers	5

GEOLABS, INC.
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W.O. 6346-00

CALIFORNIA BEARING RATIO - ASTM D 1883

SENIOR RESIDENCE AT PIIKOI
HONOLULU, OAHU, HAWAII

Plate
B - 11

SUMMARY OF CORROSION TESTS

Senior Residence at Piikoi
Honolulu, Oahu, Hawaii

Location	Depth (feet)	pH Value	Resistivity (ohm-cm)	Chloride (mg/kg)	Sulfate (mg/kg)
B-2	2.5 – 6.5	7.68	500	160	790
Bulk-1	0 – 1.0	7.86	330	43	190

TEST METHODS

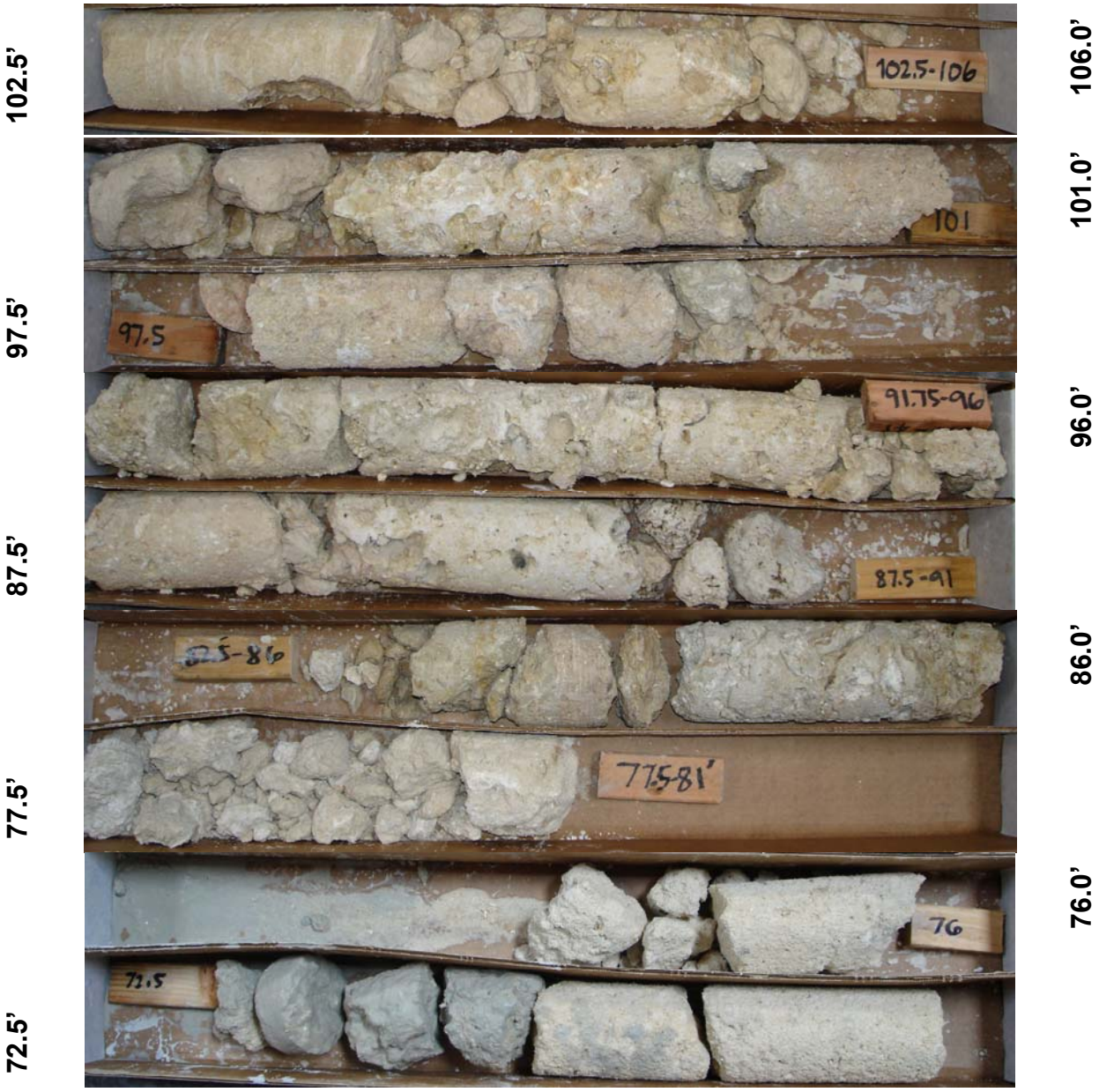
pH Value	ASTM G51
Resistivity	ASTM G57
Chloride	EPA 300.0
Soluble Sulfate	EPA 300.0

APPENDIX C

B-1 27.5’ TO 71.0’

62.5’
51.0’
46.0’
41.25’
37.5’
27.5’
71.0’
56.0’
51.0’
46.0’
41.0’
31.0’
67.5-71
62.5-66
56’
51’
51’
46.00
41.25-46
37.5-41
31.0
27.5

B-1 72.5’ TO 106.0’



B-2 22.5’ TO 56.0’

22.5’ 26.25’ 37.5’ 42.5’ 47.5’ 52.5’

26.0’ 31.0’ 41.0’ 46.0’ 51.0’ 56.0’

B-2 56.0’ TO 111.0’

B-3 17.5’ TO 66.0’

62.5
57.5
37.5
31.0’
22.5’
17.5’
17.5
22.5
26
31
36’
41
61’
66
21
66.0’
41.0’
36.0’
31.0’
21.0’

B-3 67.5’ TO 111.0’

107.5’ 96.0’ 91.25’ 82.5’ 72.5’ 67.5’

111.0’ 101.0’ 96.0’ 86.0’ 81.0’ 71.0’

ENVIRONMENTAL HAZARD EVALUATION AND ENVIRONMENTAL HAZARD MANAGEMENT PLAN

1235 Kona Street
Honolulu, Oahu, Hawaii
TMK (1) 2-3-007: Parcels 026 and 049

Prepared For:
KEWALO DEVELOPMENT, LLC
c/o: A&B Properties, Inc.
822 Bishop Street
Honolulu, Hawaii 96814

Prepared By:
ENVIROSERVICES & TRAINING CENTER, LLC
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Honolulu, Hawaii 96814
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ETC Project No. 10-2017

February 2011

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1.0 CERTIFICATIONS AND LIMITATIONS

EnviroServices & Training Center (ETC), LLC has completed this Environmental Hazard Evaluation (EHE) and Environmental Hazard Management Plan (EHMP) for the project site. ETC's findings and conclusions presented in this report are professional opinions based solely upon visual observations of the project site, government regulations, and upon interpretation of the laboratory data and field measurements available at the time and location of the study.

This report is intended for the sole use of ETC's Client, exclusively for the project site indicated. The scope of services performed in execution of this project may not be appropriate for satisfying the needs of other users, and any use or reuse of this report or the findings and conclusions presented herein is unauthorized and at the sole risk of said user.

ETC makes no guarantee or warranty; either expressed or implied, except that our services are consistent with good commercial or customary practices designed to conform to acceptable industry standards and governmental regulations. No warranty or representation, expressed or implied, is included or intended in its proposal, contracts, or reports. Opinions stated in this report apply only to the site as outlined and apply to the conditions present at the time of site sampling activities. Moreover, these opinions do not apply to site changes that occur after the site sampling activities.

Prepared By: _____
Sharla Nakashima
Project Manager

Date: Februrary 2011

2.0 INTRODUCTION AND PURPOSE

EnviroServices & Training Center (ETC), LLC was contracted by Kewalo Investments, LLC to prepare this Environmental Hazard Evaluation (EHE) and Environmental Hazard Management Plan (EHMP) for the project site identified as Tax Map Key (TMK) (1) 2-3-007: Parcels 26 and 49 and located at 1235 Kona Street in Honolulu, Hawaii.

This EHE and EHMP is based on existing environmental data for the site provided by Kewalo Investments, LLC and discussions with the Hawaii Department of Health (DOH) Hazard Evaluation and Emergency Response (HEER) Office. Previous environmental assessments and investigations at the site have indicated the presence of certain metals detected in the soil and groundwater at concentrations exceeding current, default DOH Environmental Action Levels (EALs) for sites where groundwater is not a current or potential drinking water source and where the nearest surface water body is greater than 150 meters from the site. It is suspected that the source of these metals was effluent from previous automotive repair and photograph processing operations that may have entered a drain inlet within the existing structure and flowed into two existing cesspools. Automotive repair and photograph processing operations have been ceased, the drain inlet has been sealed with concrete, and the cesspools are scheduled for cleaning/closure (Cesspool No. 1, located near Piikoi Street), and cleaning and refurbishment as an injection well (Cesspool No. 2, westernmost cesspool).

The purpose of this EHE and EHMP is to document contaminants in the soil and groundwater within the site, identify potential environmental hazards associated with these contaminants, and describe measures to be used to mitigate these hazards.

3.0 BACKGROUND

3.1 Site Description and Land Area

The Property consists of two contiguous parcels encompassing approximately 0.7 acres of improved land located at 1235 Kona Street and identified as Tax Map Key (TMK) (1) 2-3-007: Parcels 026 and 049. The Property is currently developed with one single-story structure along Waimanu Street and one two-story building along Kona Street.

The Property is relatively flat with no discernable gradient and is situated at an elevation of approximately 3 feet above mean sea level (msl). The Property is bound by Kona Street to the north, beyond which are commercial/industrial type buildings; to the east by Piikoi Street, beyond which is a retail strip mall; to the west by commercial/industrial buildings; and to the south by commercial/industrial buildings and Waimanu Street, beyond which are residential buildings. The surrounding areas generally consist of industrial and commercial properties to the north, west, and east; and residential apartment buildings to the south.

3.2 Climatologic Conditions

The main features of Oahu's climate include mild temperatures throughout the year ranging from 88˚F (31˚C) to 74˚F (23˚C) and moderate humidity of 53% during the day. The northeasterly trade winds generated by a high pressure center north of the islands are the dominant factor that governs the climate in Hawaii. Two mountain ranges on Oahu, the Koolau Mountains which extend along the northeastern side of the island and the Waianae Mountains which extend along the southwestern side of the island, influence every aspect of the climate. Both mountain ranges serve to block the trade wind moisture and as a result, showers occur almost daily on the windward side while on the leeward side showers are light. The trade winds are generally strongest during the summer (May through October) and are periodically disrupted by storms in the winter (October through April), which result in heavy rain and thunderstorms throughout the island. At the site, the average annual rainfall reported by the U.S. Department of Agriculture is between 15 to 30 inches, most of which occurs during the winter months.

3.3 Site Geology

Oahu is formed by the erosional remnants of two shield volcanoes. These are the Waianae range to the west and the Koolau range to the east. The Waianae volcano is estimated to have formed 2.4 to 3.6 million years before present. It consists of a tholeiitic lava shield with a thick cap of transitional to alkalic rock. Rejuvenation-stage volcanics of undifferentiated age occur in Kolekole Pass and on the south flank of the Waianae shield. Dike orientations define northwest and southwest rift zones (Macdonald, et al., 1983).

The Koolau volcano is estimated to have formed 1.8 to 2.6 million years before the present (Macdonald, et al., 1983). It consists of a tholeiitic lava shield and lacks an alkalic cap. It has well defined major dike complex trending northwest-southwest. A third, minor rift zone referred to as the Kaau rift trends southward from Kaau crater, near the upland crest of the Koolau Ridge. After a long dormant period and periods of deep erosion, the Koolau volcano developed abundant and scattered rejuvenation-stage vents, typically aligned on northeast-striking fissures (Macdonald, et al., 1983).

The soil at the property is mapped as mixed fill land, which consists of areas filled with material dredged from the ocean or hauled from nearby areas, garbage, and general material from other sources. Fill land occurs primarily near Pearl Harbor and in Honolulu, adjacent to the ocean. Average annual rainfall in the area is less than 200 cm per year. This land type is generally used for urban development including airports, housing areas, and industrial facilities (USDA, 1972).

Physical observations made during previous investigations and assessments indicate that the soils encountered generally consisted of reddish-brown fill and gravelly sands and clays.

3.4 Site Hydrogeology

The primary drinking water in the Hawaiian Islands is drawn from basal groundwater. Basal groundwater is formed by rainwater percolating down through the residual soils and permeable volcanic rock. The portion of the island situated below sea level, except within rift zones of the volcanoes, is saturated with ocean salt water and thus forms a basal lens called the "Ghyben-Herzberg" lens. A zone of transition between the fresh groundwater and the ocean salt water occurs due to the constant movement of the interface as a result of tidal fluctuations, seasonal fluctuations in recharge and discharge and aquifer development (Macdonald, et al., 1983).

Downward percolation of rainwater may be stopped by impermeable layers such as dense lava flows, alluvial clay layers and volcanic ash. The groundwater then forms a perched or high level aquifer, which is not in contact with salt water. Recharge of the aquifer occurs in areas of high rainfall, which are the interior mountainous areas. The groundwater flows from the recharge areas to the areas of discharge along the shoreline. Frictional resistance to groundwater flow causes it to pile up within the island until it attains sufficient hydraulic head to overcome friction. Thus, basal groundwater tends to slope toward the shoreline.

According to Mink & Lau, 1990, the site is underlain by the Nuuanu Aquifer System, which is part of the Honolulu Aquifer Sector on the island of Oahu. The aquifer is classified by Mink and Lau, 1990, with the system identification number 30102116 (13321). This system includes an unconfined basal aquifer in sedimentary (nonvolcanic) lithology. The groundwater in this aquifer is described as being currently in use and containing groundwater with a moderate salinity (1,000 to 5,000 mg/l Cl^-). The groundwater is neither a drinking water source nor ecologically important, and is also described as replaceable with a high vulnerability to contamination (Mink and Lau, 1990).

The site is further underlain by a second aquifer of the same system. The aquifer is a confined, basal aquifer in flank compartments, and is classified with the system identification number 30102121 (11113). The aquifer is described as a currently used drinking water source containing groundwater with a fresh salinity (<250 mg/l Cl^-). It is also described as irreplaceable with a low vulnerability to contamination (Mink and Lau, 1990).

According to previous environmental investigations, groundwater at the site is situated at depths of approximately 4 to 5 feet bgs.

3.5 Surface Water Bodies/Drinking Water Wells/Ecological Habitats

The nearest surface water body is the Pacific Ocean (Ala Moana Beach Park), which is located approximately 0.24-miles south-southeast of the project site. The project site is located below the Underground Injection Control (UIC) line and therefore, groundwater is not considered a drinking water resource. There are no terrestrial ecological habitats on the site or surrounding areas, all of which are used for commercial/industrial and mid- to high-density residential purposes. However, the nearby Ala Moana Beach Park, and the Pacific Ocean in general, support coral reefs, aquatic flora and fauna, and local bird populations.

3.6 Historical Land Use

According to previous documents, the Durant family has owned the property since the 1930s. Between at least 1939 and the late 1940s, the property was developed with residential structures. In 1947, the warehouse structures were developed. The portion of the warehouse along Kona Street was used as a plumbing and sheetmetal supply company that manufactured and warehoused pumping and heating systems from 1947 through approximately 1977. Other uses of the property included metal fabrication, general storage, office space, automobile undercoating sealant application, photo processing, used car sales, and miscellaneous automotive repair activities.

3.7 Current and Future Land Use

Currently, the property is vacant and short-term plans are for commercial use. Long term plans include the demolition of the current warehouse and construction of medium- to high-density residential condominium units.

3.8 Contaminants of Potential Concern

The contaminants of potential concern (COPC) identified for this site are based on review of existing data available to date. A chemical was considered an initial COPC if data indicated that the chemical was detected at a concentration exceeding the default DOH EAL. These COPC are listed in Table 1 below.

Table 1: List of Initial COPC

Soil COPC	Groundwater COPC
Acetone	Benzo(a)pyrene
Cadmium	Copper
Lead	Nickel
Thallium	Silver
Zinc	Zinc

3.9 Conceptual Site Model

A conceptual site model (CSM) provides a generalized framework regarding site-specific conditions relevant to potential contaminants, contaminant sources, migration pathways, routes of exposure, potential receptors, and environmental hazards (i.e., leaching to groundwater/ discharge to surface waters, ecological toxicity) that may be affected by the contaminants. Establishment of this framework is essential for assessing environmental hazards associated with the contaminants, determining what receptors are at risk, determining appropriate remedial strategies, and addressing unacceptable hazards.

The following environmental hazards were initially considered:

Soil

- Direct exposure threats to human health;
- Intrusion of subsurface vapors into buildings;
- Leaching and subsequent threats to groundwater resources;
- Threats to terrestrial habitats; and
- Gross contamination and general resource degradation concerns.

Groundwater

- Drinking water toxicity;
- Vapor emissions to indoor air;
- Aquatic ecotoxicity; and
- Gross contamination.

3.9.1 Receptors of Concern

When identifying potential receptors, plausible exposure under both current and future land use was evaluated. Accordingly, potential receptors were identified for both current and future use scenarios.

Future Site Users

Short-term plans identify continued commercial use of the property. Potential receptors may include workers at the commercial facilities and guests. Long-term plans may include development of the property for a medium- to high-density residential structure. Potential receptors may include future residents and guests.

Site Construction Worker

Long-term plans may include redevelopment of the existing property. As such, it is assumed that construction workers may be exposed to impacted soil and groundwater at the site during earthmoving activities.

Aquatic Ecological Receptors

Aquatic ecological receptors can be impacted when contaminant-impacted sediment or groundwater enters an aquatic habitat, through discharge from storm drainage systems or groundwater discharge zones.

Other Off-Site Receptors

Other off-site receptors can be impacted if contaminant-impacted media are not managed appropriately. As an example, for sites with contaminated soil, re-use of such soil at other sites for fill without implementing appropriate handling and management practices can create potential environmental hazards at the receiving facility.

3.9.2 Exposure Pathways

Exposure is defined as the contact of an organism with a chemical or physical agent. An exposure pathway is defined as "the course a chemical or physical agent takes from a source to an exposed organism." It describes "a unique mechanism by which an individual or population is exposed to chemicals or physical agents at or originating from a site (USEPA, 1989)." In order for an exposure pathway to be considered potentially complete, four elements must exist: 1) a source or release from a source; 2) a transport/exposure media; 3) an exposure point (point of contact with the contaminated medium); and 4) an exposure route. The potential exposure pathways present at the property are described below.

Soil Exposure Pathway

Direct contact with soil may result in incidental oral ingestion and/or dermal absorption of COPC. Although generally associated with surface soil, direct contact may also occur with subsurface soil during trenching and excavation work.

Air Exposure Pathway

Air exposure pathways become potential routes of exposure when COPC enter the air via volatilization or via adsorption to fugitive dust particles. Volatilization occurs when COPC partition to the air. Such volatilization may occur from surface soil, subsurface soil, and/or groundwater. When considering volatilization from subsurface soil or groundwater, transport of COPC occurs through void spaces in unsaturated soils, asphalt, and concrete to the outdoor air or to future indoor air through foundation cracks.

Generation of fugitive dust may occur through disturbance of affected soil, such as wind or construction activities. Dust particles may be inhaled, may settle on human skin and be ingested (hand to mouth), and/or may settle on vegetation that may be ingested by humans.

Sediment Exposure Pathway

Receptors may be exposed to COPC in sediment from the property as a result of surface runoff during storm events to nearby drainageways, which may eventually discharge to the ocean. Sediment may accumulate in the marine environment and be available for contact with various receptors. Recreational users of the marine environment (swimmers, surfers, fishermen) may come into direct contact with sediment and be exposed through oral ingestion and/or dermal absorption. Ecological receptors may live directly in the impacted sediment and may be exposed to COPC through feeding within the sediment. As a secondary transport mechanism, COPC may accumulate in ecological receptors (i.e., fish, shellfish), then be ingested by human receptors.

Groundwater Exposure Pathway

Groundwater beneath the site may have been impacted through leaching from impacted soils or direct discharge. Receptors may be exposed to COPC in the groundwater by direct contact or by inhaling volatile COPC emitted from the groundwater to air. Ecological receptors may also be affected in shallow marine environments within groundwater discharge zones or through discharge of untreated dewatering effluent to the ocean via storm drainage systems.

3.10 Project Action Levels

The action levels used for data comparison and evaluation are the DOH EALs for sites where a current or potential drinking water source is not threatened and the nearest surface water body is greater than 150 meters from the site. The default (lowest) EALs for unrestricted land use were initially utilized to identify potential environmental hazards associated with existing site soils. EALs for unrestricted land use specific to each environmental hazard were also used to further evaluate site-specific hazards.

4.0 SUMMARY OF INVESTIGATION HISTORY

In June of 1990, Unitek Environmental Consultants, Inc. (UEC) conducted an *Environmental Assessment* of the property. The purpose of the assessment was to identify recognized environmental conditions (RECs) related to asbestos containing building materials (ACM), polychlorinated biphenyl (PCB)-containing electrical equipment, hazardous chemical materials, underground storage tanks (USTs) and surface/subsurface contamination. In June of 1990, five tenants were in operation on the site: Honolulu Mini Storage, Audio Visual Company, Creative Fibers, Loomis & Pollock, Inc. and Trim Masters.

At the time of UEC's assessment, hazardous chemicals used and stored on-site were associated with photo processing performed by Loomis & Pollock, Inc. and automotive repair operations performed by Trim Masters. Based on a review of the information in the UEC report, it appeared that Loomis & Pollock, Inc. may have discharged spent photo processing solutions into an indoor drain connected to an on-site cesspool system. UEC noted that spent photo processing chemicals may contain elevated levels of silver. Based on visual observations, UEC concluded that subsurface soils could potentially be impacted by the on-site cesspool system and recommended that the spent chemicals be disposed of off-site. Since it appeared that hazardous chemicals used and stored on-site were generated in limited quantities, UEC concluded that no further recommendations were necessary (UEC, 1990).

UEC's report also noted that there was an abandoned underground storage tank located on the northwest corner of the property. UEC noted two vent pipes, two fill pipes and two dispenser pipes, indicating that there may be two USTs present on the site. UEC recommended that the tanks be registered with the DOH and the County of Honolulu Fire Prevention Bureau and that permanent closure be initiated since the tanks were abandoned and not intended for further use. In addition, UEC recommended that a limited subsurface investigation be performed in the vicinity of the USTs to assess possible soil and/or groundwater contamination due to potential leakage from the tanks (UEC, 1990). File review at the DOH SHWB and DOH HEER Office indicated that a 1,000-gallon gasoline UST and a 1,000-gallon diesel UST were removed from the north portion of the property, along Kona Street, in 1990. File review indicated that a site assessment was conducted during tank removal activities and that there was no evidence of contamination during tank removal activities; however, a closure report for the two USTs was not available.

In August of 2007, a *Phase I Environmental Site Assessment* was performed on the property by LandAmerica Assessment Corporation (LAC). At the time of LAC's assessment, the property was used for light industrial purposes. Based on LAC's environmental database review, the property was identified as having two 1,000-gallon USTs that were permanently out of service and were located on the site from 1950 to 1985. Based on LAC's site reconnaissance, it appeared that the two UST's had been removed, however documentation regarding the removal could not be found. Based on the available information, LAC concluded that the two former USTs were not considered a REC for the property (LAC, 2007).

Based on historical information obtained by LAC, it appeared that an in-ground hydraulic lift was present in the northwest portion of the property. LAC concluded that the subsurface media in the vicinity of the hydraulic lift may have been impacted by hydraulic fluid and/or PCBs (LAC, 2007). As a result, in October 2007, LAC conducted a *Phase II Limited Subsurface Investigation* to assess the RECs identified in LAC's August 2007 Phase I ESA. A total of four boreholes were advanced on the property in the vicinity of the two on-site cesspools, existing floor drain, and abandoned hydraulic lift. Analytical results indicated that one or more metals were detected in a groundwater sample collected from the site at elevated concentrations exceeding their applicable EALs. Note that document review indicated that LAC did not provide information regarding sampling techniques or handling. In addition, review indicated that the groundwater sample collected may not have been filtered prior to analysis.

As a result of LAC's questionable results, in November 2007, Bureau Veritas North America, Inc. (BV) conducted a *Limited Phase II Subsurface Investigation* on the property. A total of ten boreholes were installed at the site. Two boreholes were advanced inside the building; the first boring was advanced adjacent to the indoor floor drain and the second boring was advanced adjacent to the in-ground hydraulic lift. Four borings were advanced in the parking area along Kona Street in the vicinity of the two on-site cesspools. In addition, two borings were advanced in the northwest corner of the site within the former UST excavation area. The final two borings were installed in the paved asphalt area of the former Trim Masters area located at the southwest portion of the property. Up to two soil samples were collected from each borehole. Analytical data indicated the following:

- Elevated acetone concentration (estimated value) of 1.43 mg/kg (DOH EAL = 0.86 mg/kg) and an elevated thallium concentration (estimated value) of 1.5 mg/kg (DOH EAL = 1.0 mg/kg) were detected in boring BV-B1 near the indoor floor drain at 5 feet bgs.

- Elevated thallium concentration (estimated value) of 1.24 mg/kg (DOH EAL = 0.86 mg/kg) was detected in boring BV-B2 near the hydraulic lift at 1-foot bgs.

- Elevated lead concentration of 280 mg/kg (DOH EAL = 200 mg/kg) and elevated zinc concentration of 668 mg/kg (DOH EAL = 600 mg/kg) were detected in boring BV-B3 in the vicinity of the westernmost cesspool at 1-foot bgs.

- Elevated cadmium concentration of 16.8 mg/kg (DOH EAL = 12 mg/kg) and elevated thallium concentration (estimated value) of 1.92 mg/kg (DOH EAL = 1.0 mg/kg) were detected in boring BV-B10 in the former Trim Masters area at 5 feet bgs.

The ten boreholes were converted into temporary monitoring wells and a groundwater sample was collected from each of the ten temporary wells. Analytical data indicated the following:

- Elevated benzo(a)pyrene concentration (estimated value) of 0.0444 µg/l (DOH EAL = 0.014 µg/l) was detected in the groundwater sample collected from borehole BV-B1 near the indoor floor drain.

- Elevated copper concentration of 5.95 µg/l (DOH EAL = 2.9 µg/l), elevated nickel concentration of 7.88 µg/l (DOH EAL = 5 µg/l), elevated silver concentration (estimated value) of 3.87 µg/l (DOH EAL = 1 µg/l), elevated zinc concentration of 41.4 µg/l (DOH EAL = 22 µg/l), and elevated benzo(a)pyrene concentration (estimated value) of 0.0556 µg/l (DOH EAL = 0.014 µg/l) were detected in the groundwater sample collected from borehole BV-B2 near the hydraulic lift.

- Elevated copper concentration of 14.3 µg/l (DOH EAL = 2.9 µg/l), elevated nickel concentration of 57.4 µg/l (DOH EAL = 5 µg/l), and elevated zinc concentration of 885 µg/l (DOH EAL = 22 µg/l) were detected in the groundwater sample collected from borehole BV-B3 in the vicinity of the westernmost cesspool.

- Elevated nickel concentration of 112 µg/l (DOH EAL = 5 µg/l) was detected in the groundwater sample collected from borehole BV-B5 in the vicinity of the westernmost cesspool.

Subsequently, BV recommended that remedial options be evaluated to address the impacted soil in the vicinity of the cesspools and that the existing in-ground hydraulic lift and associated components be removed and disposed. In addition, BV recommended that permanent groundwater monitoring wells be installed in the vicinity of the in-ground hydraulic lift and on-site cesspools; and that groundwater monitoring and sampling be conducted on a quarterly basis.

As a result of BV's findings and recommendations, BV installed eight permanent monitoring wells in January 2008. Soil samples were collected from each borehole and groundwater samples were collected from each newly-installed monitoring well. Note that the placement of the new wells differed from the locations of the previous boreholes. Soil and groundwater samples were analyzed for total petroleum hydrocarbons (TPH) as gasoline (TPH-G), TPH as diesel (TPH-D), TPH as oil (TPH-O), benzene/toluene/ethylbenzene/xylenes (BTEX), polynuclear aromatic hydrocarbons (PAHs), and the metals copper, lead, nickel, silver, and zinc. Well installation activities and analytical data were documented in BV's April 15, 2008 *Monitoring Well Installation and Baseline Groundwater Sampling* report. Significant findings included the following:

- All constituent concentrations in the soil samples collected from depths of approximately 4 to 5 feet bgs were below applicable DOH EALs.

- An elevated nickel concentration of 19.3 µg/l (DOH EAL = 5 µg/l) was detected in the groundwater sample from MW-7, which was located in the vicinity of the hydraulic lift and indoor floor drain.

- All other groundwater samples had constituent concentrations below the applicable DOH EALs.

Thereafter, BV performed five groundwater monitoring events in May 2008, August 2008, November 2008, June 2009, and September 2009. Groundwater samples were typically analyzed for the metals copper, lead, nickel, silver, and zinc (lead and silver not analyzed during the May 2008 sampling event). Review of the analytical results of the quarterly groundwater monitoring events indicated that copper and nickel were detected at concentrations that exceeded the DOH EAL in four of the eight wells at least once during the four monitoring events. Copper was detected above the DOH EAL in the groundwater samples collected from the two wells (MW-1 and MW-2) located adjacent to the westernmost cesspool during the May 2008 groundwater monitoring event. Copper and nickel were detected above the DOH EALs in the groundwater sample collected from the MW-8 located adjacent to the indoor floor drain during the August 2008 groundwater monitoring event. Nickel was detected above the DOH EAL in the groundwater sample collected from MW-2 located adjacent to the westernmost cesspool during the September 2009 groundwater monitoring event. Based on these results, BV concluded that there was no specific trend related to COPC in the groundwater samples collected from wells MW-1, MW-2, MW-3, MW-4, MW-5, MW-6, and MW-8.

In all groundwater monitoring events, nickel was detected in groundwater samples collected from MW-7 (east of the in-ground hydraulic lift) at concentrations exceeding the applicable DOH EAL. Therefore, BV concluded that groundwater in the vicinity of well MW-7 had been impacted by nickel. Based on the analytical data, BV recommended that the in-ground hydraulic lift, indoor floor drain and westernmost cesspool be removed from the site.

In September 2010, ETC commenced removal of the in-ground hydraulic lift and closure of the existing drain inlet. All fluids from the hydraulic lift were drained/containerized/disposed off-site, the hydraulic lift cylinder and related components were completely removed from the ground and disposed off-site, and two soil samples were collected near the bottom of the lift at 6 feet bgs. Soil sample results indicated concentrations of TPH-D, TPH-O, and PCBs below laboratory reporting limits. In addition, ETC personnel tested the drain inlet to determine whether the drain was connected to one of the on-site cesspools. Potable water was introduced into the drain inlet via water hose and observations indicated water flow into one of the cesspools (Cesspool No. 2, located closest to the drain inlet). Thereafter, ETC personnel sealed the drain inlet with concrete to prevent future discharges into the cesspool.

5.0 MAGNITUDE AND EXTENT OF CONTAMINATION

Data for soil samples collected in 2007 (and documented in BV's November 2007 *Limited Phase II Subsurface Investigation*) indicated certain COPC exceeded current DOH EALs. These findings included:

- Acetone and thallium at 5 feet bgs in a sample collected adjacent to the indoor floor drain (BV-B1).
- Thallium at 1 foot bgs in a sample collected adjacent to the former hydraulic lift (BV-B2).
- Lead and zinc at 1 foot bgs in a sample collected in the vicinity of the westernmost cesspool (BV-B3).
- Cadmium and thallium at 5 feet bgs in a sample collected from the former Trim Masters area (BV-B10).

Subsequent soil samples collected from 4 to 5 feet bgs during installation of permanent monitoring wells in January 2008 (and documented in BV's April 15, 2008 *Monitoring Well Installation and Baseline Groundwater Sampling* report) indicated that none of the COPC were detected at concentrations exceeding current DOH EALs. Soil sampling data suggest that impacts to the soil are not widespread.

Groundwater data were collected over a series of sampling events. The first set of groundwater data was collected from temporary monitoring wells during the *Limited Phase II Subsurface Investigation*. Findings included the following:

- Benzo(a)pyrene was detected at concentrations exceeding the current DOH EAL in a temporary monitoring well adjacent to the indoor floor drain (BV-B1).
- Benzo(a)pyrene, copper, nickel, silver, and zinc were detected at concentrations exceeding the current DOH EALs in a temporary monitoring well adjacent to the former hydraulic lift (BV-B2).
- Copper, nickel, and zinc were detected at concentrations exceeding current DOH EALs in a temporary monitoring well adjacent to the westernmost cesspool (BV-B3).
- Nickel was detected at concentrations exceeding current DOH EALs in a temporary monitoring well adjacent to the westernmost cesspool (BV-B5).

Based on these findings, BV recommended that permanent monitoring wells be installed and sampled on a regular basis. Therefore, permanent wells were installed in January 2008. Although these well locations did not coincide with the previous boreholes, the general locations were based on the areas where suspected contaminants were detected in the groundwater.

Once installed, these new wells were sampled on six different occasions and results were documented in reports dated February 2008, May 2008, August 2008, November 2008, June 2009, and September 2009. The groundwater samples collected in February 2008 were analyzed for TPH-G, TPH-D, TPH-O, BTEX, PAHs, and the metals copper, lead, nickel, silver, and zinc. The analytes for subsequent groundwater monitoring events were narrowed down to just the metals copper, lead, nickel, silver, and zinc since the petroleum-related analyte concentrations during the February 2008 sampling event were below DOH EALs.

Copper and nickel were the only two COPC detected at concentrations exceeding current DOH EALs during groundwater sampling. No distinctive trend in copper and nickel detections was identified, other than nickel concentrations in monitoring well MW-7 (located east of the former hydraulic lift) consistently exceeded the DOH EAL in all sampling events.

6.0 APPLICABLE ENVIRONMENTAL ACTION LEVELS

The DOH EALs applicable to this site and considered in this EHE are the EALs associated with unrestricted land use for areas where a current or potential drinking water source is not threatened and where the nearest surface water body is greater than 150 meters from the site. In general, the following environmental hazards (each having associated EALs) were initially considered for this site:

Soil Hazards

- Direct exposure – addresses direct exposure and toxicity to humans; includes incidental ingestion, dermal contact, and inhalation of vapors or dust particles in outdoor air
- Vapor emissions to indoor air – addresses potential impacts to indoor air due to the intrusion of vapors from underlying, contaminated soil
- Terrestrial ecological impacts – addresses potential impacts to terrestrial flora and fauna
- Gross contamination – addresses odor, nuisance, generation of explosive vapors, and other, non-risk related hazards posed by heavily contaminated soils
- Leaching – addresses potential leaching of chemicals from soil and subsequent impact on shallow groundwater

Groundwater Hazards

- Drinking water toxicity – addresses potential toxicity to humans using the water as a drinking water resource; based on promulgated Primary Maximum Contaminant Limits (Primary MCLs) or equivalent
- Vapor emissions to indoor air – addresses potential impacts to indoor air due to the intrusion of vapors from underlying, contaminated groundwater
- Discharges to surface water/aquatic ecotoxicity – addresses potential chronic impacts to aquatic organisms; based on promulgated surface water quality standards or equivalent
- Gross contamination – addresses odor, nuisance, generation of explosive vapors, and other, non-risk related hazards posed by heavily contaminated groundwater; for drinking water resources, Secondary MCLs or equivalent for taste and odor concerns also considered

For this particular site, the drinking water toxicity hazard for groundwater can immediately be removed as a considered hazard since the site is located within an area where a current or potential drinking water source is not threatened.

7.0 COMPARISON OF SITE DATA TO DOH EALS

A comparison of existing data to current DOH EALs was initially performed to identify COPC. Tables 2 and 3 below summarizes all samples with constituent concentrations that exceed current, default (lowest) DOH EALs. DOH EALs specific to the various environmental hazards are also shown in the tables.

Table 2: Soil Sample Data Comparison

Sample ID	Report Date	Depth	Acetone (mg/kg)	Cadmium (mg/kg)	Lead (mg/kg)	Thallium (mg/kg)	Zinc (mg/kg)
BV-B1	11/07	5 ft	1.43 J	-	-	1.50 J	-
BV-B2	11/07	1 ft	-	-	-	1.24 J	-
BV-B3	11/07	1 ft	-	-	280	-	668
BV-B10	11/07	5 ft	-	16.8	-	1.92 J	-
Default EAL			**0.86**	**12**	**200**	**1.0**	**600**
Direct Exposure			12,000	**14**	400	**1.0**	4,700
Vapor Emissions			11,000	NS	NS	NS	NS
Terrestrial Ecotoxicity			NS	**12**	**200**	NS	**600**
Gross Contamination			500	1,000	1,000	1,000	1,000
Leaching			**0.86**	Batch test	Batch test	Batch test	Batch test

All results in mg/kg
J = estimated value, detected above method detection limit but concentration below reporting limit
- Results were either below reporting limits or below default DOH EALs
NS = no standard established for this environmental hazard and constituent
Batch test = batch test data should be used to determine whether leaching hazard exists

As shown in Table 2 above, the estimated concentration of acetone exceeded the leaching EAL, the detected cadmium concentration exceeded both the direct exposure and terrestrial ecotoxicity EALs, the detected lead concentration exceeded the terrestrial ecotoxicity EAL, the estimated concentrations of thallium exceeded the direct exposure EAL, and the detected zinc concentration exceeded the terrestrial ecotoxicity EAL.

Table 3: Groundwater Sample Data Comparison

Sample ID	Report Date	Benzo(a) pyrene (µg/l)	Copper (µg/l)	Nickel (µg/l)	Silver (µg/l)	Zinc (µg/l)
BV-B1	11/07	0.0444 J	-	-	-	-
BV-B2	11/07	0.0556 J	5.95	7.88	3.87 J	41.4
BV-B3	11/07	-	14.3	57.4	-	885
BV-B5	11/07	-	-	112	-	-
MW-1	5/08	-	11.2	-	-	-
MW-2	5/08	-	16.5	-	-	-
	9/09	-	-	5.45	-	-
MW-7	2/08	-	-	19.3	-	-
	5/08	-	-	17.5	-	-
	8/08	-	-	18.5	-	-
	11/08	-	-	17.4	-	-
	6/09	-	-	19.2	-	-
	9/09	-	-	18.5	-	-
MW-8	8/08	-	6.54	5.26	-	-
Default EAL		**0.014**	**2.9**	**5.0**	**1.0**	**22**
Vapor Emissions		NS	NS	NS	NS	NS
Aquatic Ecotoxicity		**0.014**	**2.9**	**5.0**	**1.0**	**22**
Gross Contamination		0.81	50,000	50,000	50,000	50,000

All results in µg/l
J = estimated value, detected above method detection limit but concentration below reporting limit
- Results were either below reporting limits or below default DOH EALs
NS = no standard established for this environmental hazard and constituent
Only sampling events where constituent concentrations exceeded DOH EALs listed in Table 3

As shown in Table 3 above, the various estimated and detected concentrations of COPC were detected intermittently at concentrations exceeding the aquatic ecotoxicity EALs, with the exception of nickel, which was consistently detected at concentrations exceeding the aquatic ecotoxicity EAL in MW-7 during every sampling event.

8.0 ENVIRONMENTAL HAZARDS

Based on initial comparisons of existing data with DOH EALs, the potential environmental hazards in soil include:

- Leaching to groundwater (acetone)
- Direct exposure (cadmium, thallium)
- Terrestrial ecotoxicity (cadmium, lead, zinc)

Leaching to groundwater due to the single estimated detection of acetone barely exceeding the EAL in a soil sample collected during the November 2007 investigation from a depth of 5 feet bgs was not considered to be a significant concern. Although acetone was also detected in other soil samples, none of the concentrations exceeded the default DOH EAL and acetone was not detected in the groundwater sample collected from the same borehole from which the soil sample was collected (or in any other groundwater samples). Therefore, the existence of acetone in the soil was not considered to be a widespread issue. Furthermore, it is possible that acetone may have been introduced to the soil samples during the laboratory analysis since acetone is a common laboratory chemical used in instrument preparation and clean-up. As such, leaching to groundwater due to acetone was not considered to be a significant environmental hazard and will not be retained.

The potential direct exposure hazard associated with the single detection of cadmium barely exceeding the EALs in a soil sample collected during the November 2007 investigation from a depth of 5 feet bgs was not considered a significant concern. The environmental risk associated with the slight exceedance of the EAL is not significantly greater than the environmental risk associated with concentrations just below the EAL. As such, the direct exposure hazard due to cadmium was not considered to be a significant environmental hazard and will not be retained.

The potential direct exposure hazard associated with the estimated concentrations of thallium exceeding the EAL in three soil samples collected during the November 2007 investigation from depths of both 1 and 5 feet bgs was not considered a significant concern. Review of data from two separate studies on background metal concentrations on Oahu (June 2006 *Environmental Background Analysis of Metals in Soil at Navy Oahu Facilities* prepared by Earth Tech Inc. for Department of the Navy, Naval Facilities Engineering Command, Hawaii and August 26, 2005 *Summary Draft Technical Memorandum, Base-Wide Ambient Metals Study, Hickam Air Force Base, Oahu, Hawaii* prepared by the United States Air Force, 15th Airlift Wing, Environmental Restoration Program) indicate that the thallium concentrations detected in soil at the site are well within background ranges and upper tolerance limits for various types of soils found on certain Hawaii military bases. As such, the direct exposure hazard due to thallium was not considered a significant environmental hazard and will not be retained.

The potential terrestrial ecotoxicity hazard associated with the single detection of lead and zinc exceeding their respective default EALs in a soil sample collected during the November 2007 investigation from a depth of 1 foot bgs was not considered a significant concern. Considering that the site is situated within an urban, mixed-use area, impacts to terrestrial ecological receptors are not anticipated. The area is a highly-developed portion of Honolulu characterized by commercial/industrial-type structures and medium- to high-density residential buildings that are not supportive of terrestrial flora and fauna. As such, the terrestrial ecotoxicity hazard due to lead and zinc was not considered a significant environmental hazard and will not be retained.

Based on initial comparisons of existing data with DOH EALs, the potential environmental hazard in groundwater is aquatic ecotoxicity, associated with estimated and detected concentrations of benzo(a)pyrene, copper, nickel, silver, and zinc.

Initial groundwater samples collected from the temporary monitoring wells in November 2007 indicated estimated concentrations of benzo(a)pyrene in two groundwater samples. Follow-up groundwater sampling conducted in February 2008 (after installation of permanent groundwater monitoring wells) did not identify detectable concentrations of benzo(a)pyrene, although the reporting limits used at the time were higher than the DOH EAL. Since the estimated concentrations of benzo(a)pyrene initially detected during the November 2007 sampling event were not confirmed in a subsequent sampling event and were not detected in other groundwater samples, benzo(a)pyrene impacts to the groundwater are not anticipated to be widespread. Therefore, the aquatic ecotoxicity hazard associated with benzo(a)pyrene was not considered a significant environmental hazard and will not be retained.

Copper, silver, and zinc concentrations exceeding aquatic ecotoxicity DOH EALs were intermittently detected in various wells during various sampling events. No discernible pattern in COPC concentrations could be identified and there were no identified trends. Therefore, the aquatic ecotoxicity hazard associated with copper, silver, and zinc was not considered a significant environmental hazard and will not be retained for future consideration.

The primary issue with groundwater at the site is the consistent detection of nickel in MW-7 at concentrations exceeding the aquatic ecotoxicity EAL during six sampling events. The data suggest that an aquatic ecotoxicity hazard exists for the groundwater in the vicinity of MW-7. Data for groundwater samples collected from the remaining wells indicate that the aquatic ecotoxicity hazard associated with nickel is not a widespread issue at the site since nickel was not consistently detected in groundwater samples from other wells. Based on the data, it was determined that the aquatic ecotoxicity hazard due to elevated nickel concentrations is a current environmental hazard for groundwater in the vicinity of MW-7.

9.0 MANAGEMENT OF RETAINED ENVIRONMENTAL HAZARDS

The only retained environmental hazard identified for the site was the aquatic ecotoxicity hazard associated with elevated nickel concentrations in the groundwater samples collected over the period of two years from monitoring well MW-7, located in the vicinity of the former hydraulic lift and floor drain. Considering the distance to the nearest surface water body from the site, the limited area of suspected impact, and the relatively low concentrations of nickel detected in the groundwater samples, migration of nickel through groundwater and subsequent discharge to the Pacific Ocean is unlikely. Therefore, the aquatic ecotoxicity hazard via the groundwater discharge pathway is not considered a significant concern and no long-term monitoring or other similar activities are warranted.

However, handling and management of any groundwater that may be encountered during site development (i.e., dewatering during foundation excavation, utility line installation, etc.) will need to be performed in a manner that minimizes and/or eliminates discharge of untreated effluent to surface water bodies. Since direct human contact with the nickel concentrations in groundwater is not a significant hazard, no special protection from human contact is warranted. The most common management practice to prevent direct discharge of the groundwater to the ocean would be to retain the groundwater on-site. This may be accomplished through construction of groundwater discharge trenches on site, containerizing the dewatering effluent for use as dust control, and/or other similar means. Care should be taken to ensure that surface flow of the dewatering effluent is not generated and/or is not allowed to flow off the property.

If discharge of groundwater off-site is necessary, the appropriate permits (i.e., NPDES, discharge permits, etc.) will need to be obtained prior to release. The groundwater being discharged should be sufficiently characterized and any contaminants in the groundwater must meet applicable threshold criteria (e.g., aquatic ecotoxicity EAL, surface water quality standards, etc.). Should characterization of groundwater indicate elevated contaminant concentrations, groundwater may need to be treated on-site (i.e., settling, mechanical filtration, etc.) and re-sampled prior to discharge or disposed at a government-approved facility.

10.0 REFERENCES

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APPENDIX I
Figures

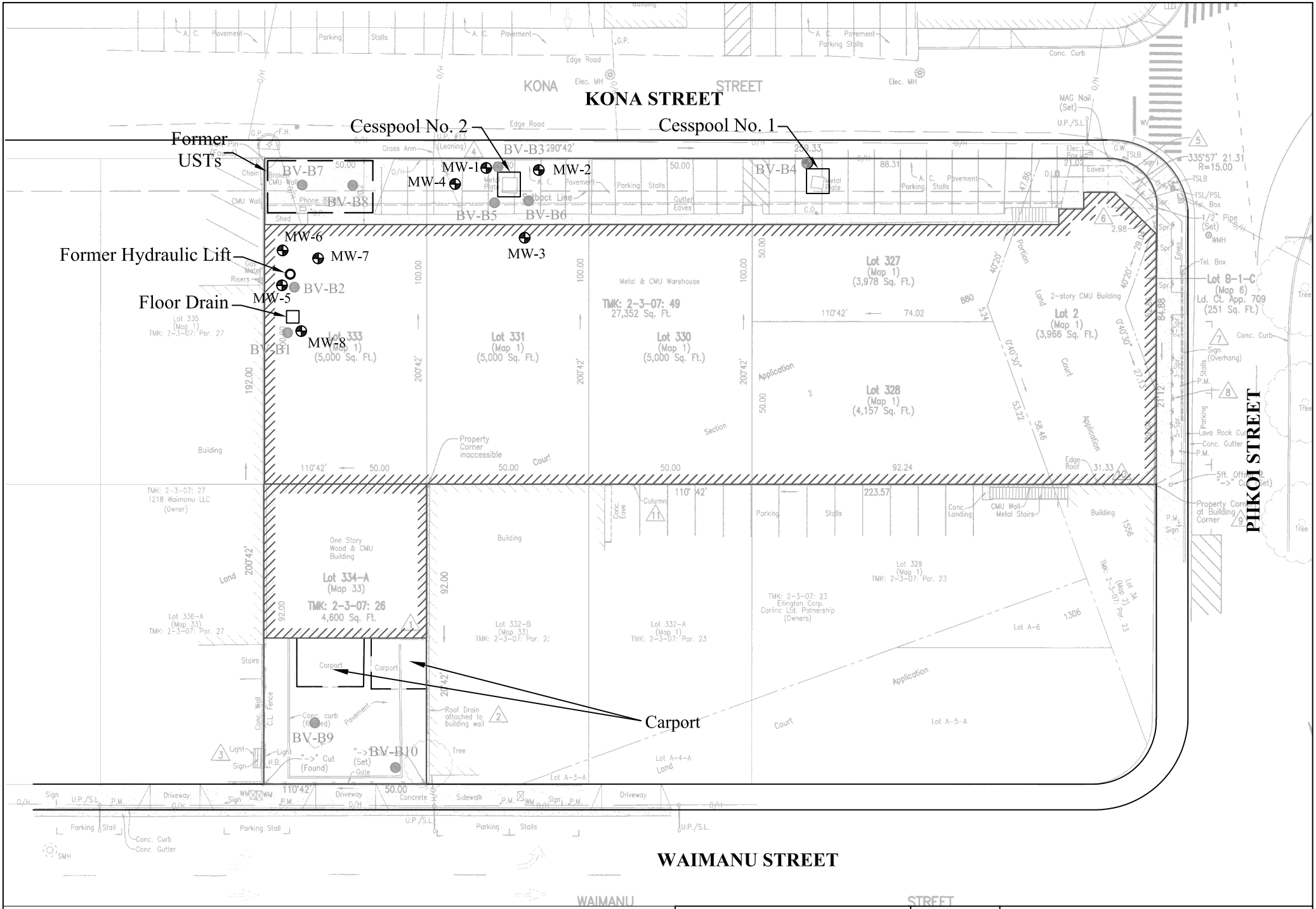
ISLAND OF OAHU
Property Vicinity
SUBJECT PROPERTY
H-1 FREEWAY
HONOLULU
MAMALA BAY
Honolulu Harbor
Honolulu Channel
Kewalo Basin
Ala Moana Regional Park
Shopping Center
Pacific Heights
Makiki Heights
Punchbowl
NATIONAL MEMORIAL CEMETERY OF THE PACIFIC
Iolani Palace State Monument
State Capitol
Aloha Tower
Foster Botanical Garden
Kawaiahao Church
Royal Mausoleum State Monument
Sacred Hearts Convent
St Theresa Sch
Kaiulani Park
Dole Park
Thomas Square
Blaisdell Center
McKinley High Sch
Washington Middle Sch
Lunalilo Sch
Punahou Sch
Makiki Park
Ala Moana Boulevard
Kapiolani Boulevard
Beretania Street
King Street
Pensacola Street
Keeaumoku
Kalakaua
Wilder
Pauoa
Nuuanu
Pacific Heights
Booth
Tantalus
Prospect
Thurston Ave
Hotel
Queen
South
Ward Avenue
Punchbowl
Coral
Reef
Wrecks
Waikiki
Kawaiahao Church
Kawaiahao Park
Kawaiahao Sq
Kawaiahao Plaza
Kawaiahao Sch
Kawaiahao Pl
Kawaiahao Pl
Kawaiahao Pl

EnviroServices & Training Center, LLC

Project No. 10-2015

February 2011

Figure 2 - Site Location Map
EHE and EHMP
1235 Kona Street
TMK (1) 2-3-007: Parcels 26 & 49
Honolulu, Oahu, Hawaii



Original Borings (2007)

Existing Wells (2008)

Basemap Source: ALTA/ALCM LAND SURVEY, Conrolpoint Surveying, Inc., September 4, 2007

EnviroServices & Training Center LLC

Project 10-2015

Approx Scale: 1" = 40'

February 2011

Figure 3 - Site Plan and Boring Locations
EHE and EHMP
1235 Kona Street
TMK (1)2-3-007: Parcels 26 and 49
Honolulu, Oahu, Hawaii

SENIOR RESIDENCE AT PI'IKOI
National Historic Preservation Act (NHPA)
Section 106 Consultation

CONCEPTUAL RENDERING

This is an artist's rendering of the project and may not accurately depict the project when actually constructed. The Developer reserves the right to make changes to the project and disclaims any warranty or promise about the location, views, size, height, layout, landscaping, specifications, and finishes of the project.

Senior Residence at Pi'ikoi

Kewalo Development LLC
Pacific Housing Assistance Corporation

May 30, 2012

Design Partners Incorporated

Senior Residence at Pi‘ikoi
NHPA - Section 106 Consultation
Agenda

Refreshments	6:00 – 6:30 pm
Pule, Welcome & Introductions	6:30 pm
Purpose of Meeting	6:40 pm
Project Background	6:45 pm
– Waihonua at Kewalo	
– Senior Residence at Pi‘ikoi	
– Pacific Housing Assistance Corporation	
Overview of Identification Efforts to Date	7:00 pm
Sharing of Mana‘o	7:10 pm
Closing Remarks	7:30pm
Pule	Pau

Senior Residence at Pi‘ikoi
NHPA - Section 106 Consultation

<u>Purpose of Consultation</u>

- Review of ongoing effort to identify historic properties
- Evaluate the historic significance of any identified historic properties
- Assess adverse effects of the proposed project on any identified historic properties
- Resolve adverse effects of the proposed project on any identified historic properties

Senior Residence at Pi‘ikoi
NHPA - Section 106 Consultation

- Use of Federal funds for construction of 72 one bedroom apartments for seniors earning less than 60% of area median income
- Current plan for funding includes HOME funds, Community Development Block Grant and Federal income tax credits

Senior Residence
at Pi'ikoi
WAIHONUA
AT KEWALO
©2011 Google
Image ©2011 CyberCity 3D, Inc. / Team Vision Virtual
©2010 Google
Imagery Date: Sep 28, 2008
21°17'36.40" N 157°50'53.34" W elev 7 ft
Eye alt 1164 ft

WAIHONUA
AT KEWALO

Developer:

Kewalo Development LLC

Project Description:

1189 Waimanu Street

341 – 1, 2 & 3 bedroom residences

43 stories (400 feet)

Construction completion at end of 2014

General Contractor:

Hawaiian Dredging & Construction Company

Senior Residence at Pi‘ikoi

Developer:

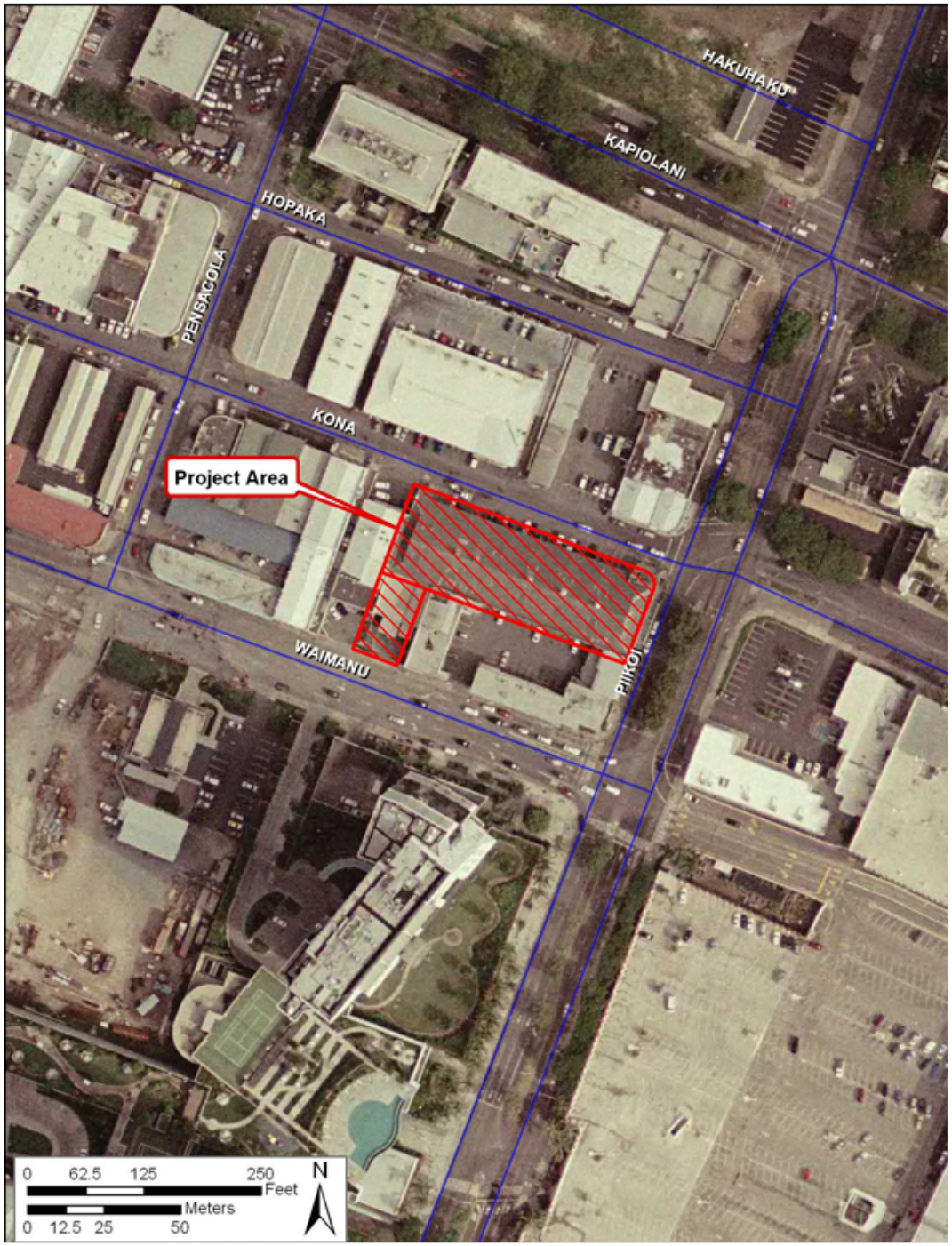
Pacific Housing Assistance Corporation (PHAC)

Project Description:

- 72 – 1 bedroom apartments
- 4 stories over ground floor lobby and parking
- Estimated rent = $850 + utilities targeted to seniors earning <60% of Area Median Income (AMI) vs. <100% of AMI required for Waihonua’s reserved housing requirement

General Contractor:

To be selected by a bid process



Senior Residence at Pi‘ikoi
NHPA - Section 106 Consultation

<u>Pacific Housing Assistance Corporation</u>

401(c)(3) corporation – allows for access to funding not available to for-profit corporations

Developer, owner and/or operator of ___ affordable housing units in the state

- ____ for sale
- ____ rentals, including ___ units for seniors

PHAC to complete

Senior Residence at Pi‘ikoi
NHPA - Section 106 Consultation

Limitations for applicants

- Age 62 and older
- Income less than $____
- Assets less than $_____

Typical application process and selection

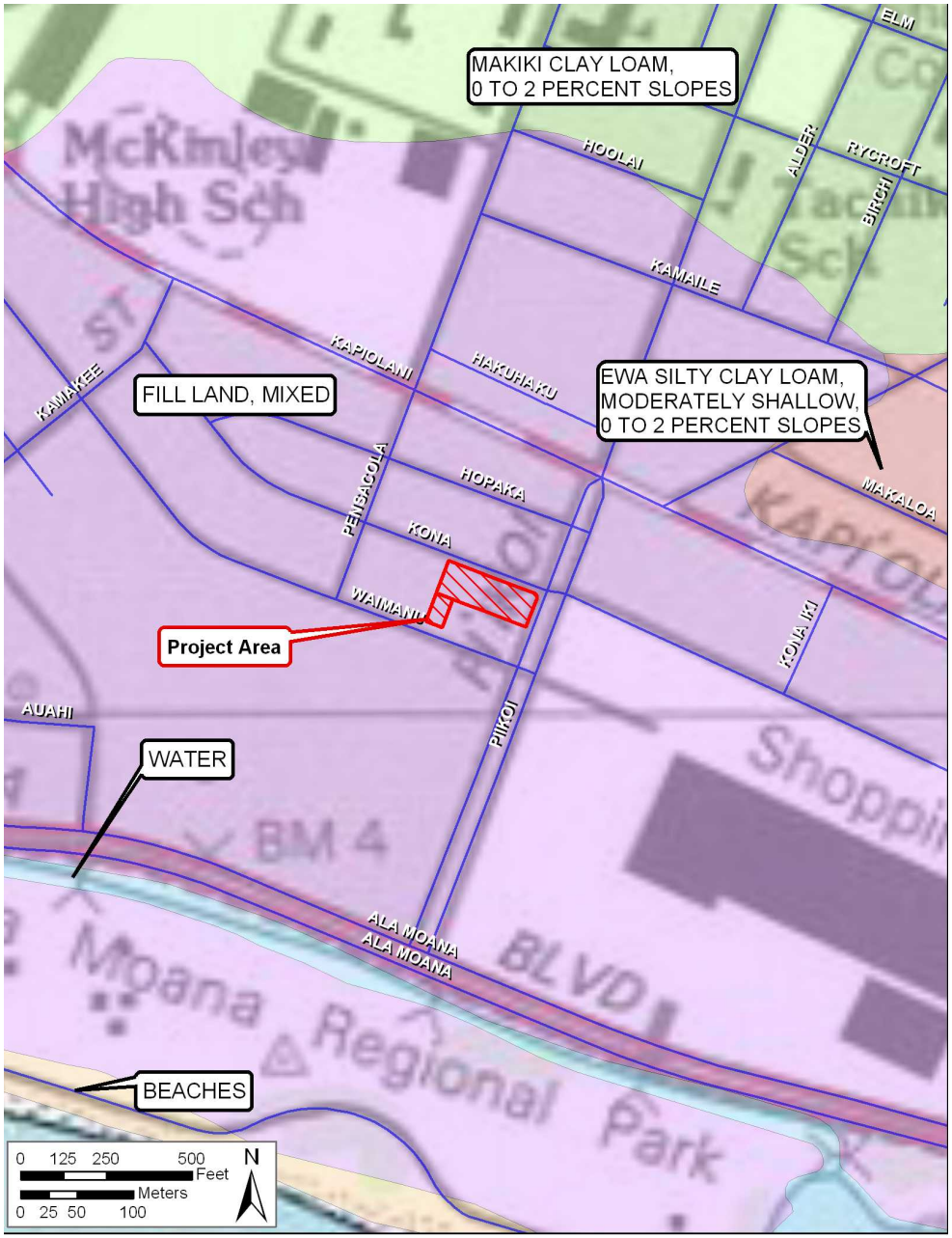
Senior Residence at Pi‘ikoi
NHPA - Section 106 Consultation

Efforts to Identify Historic Properties in Area of Potential Effect

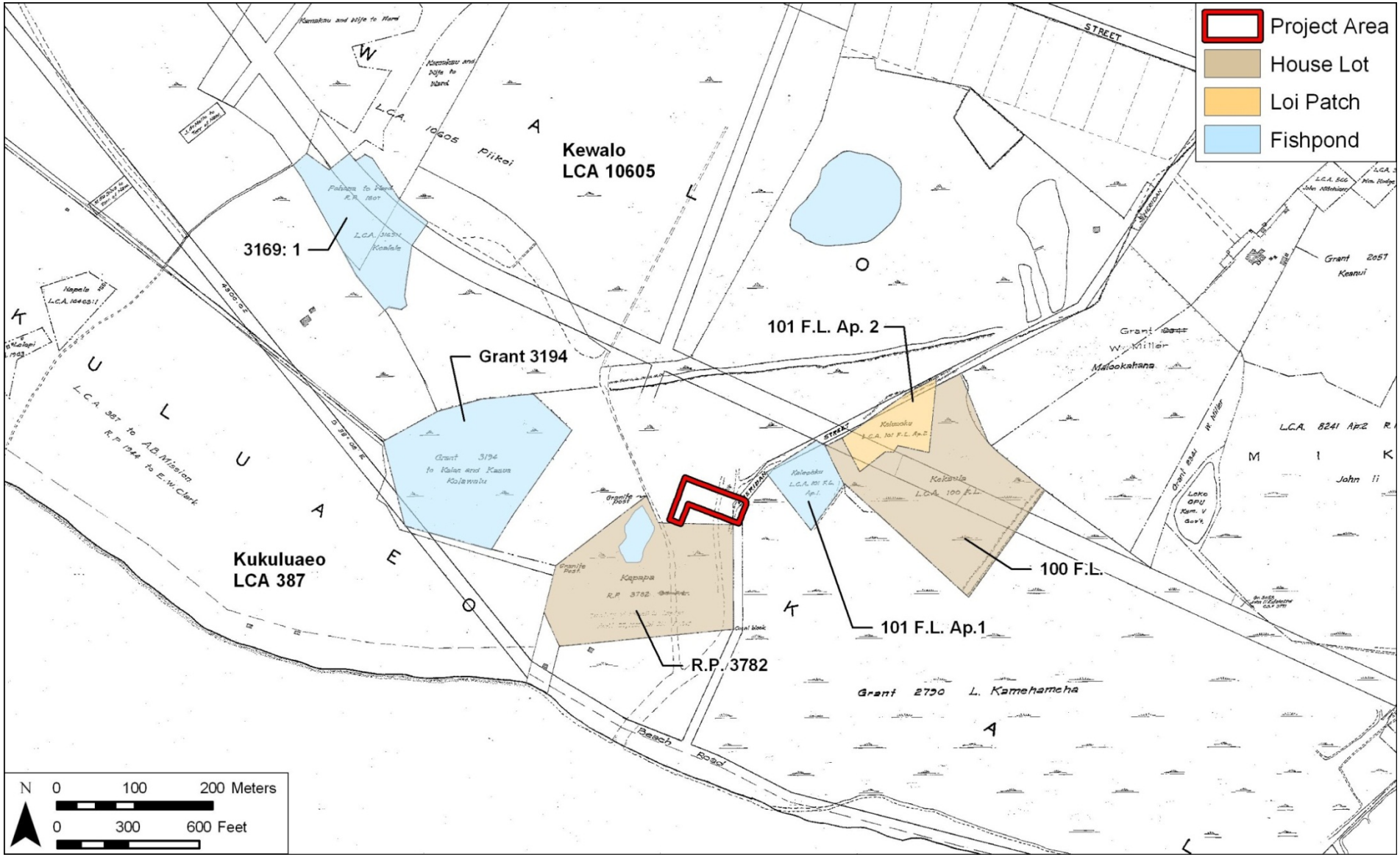
- Archaeological Inventory Survey (AIS) – acceptance by SHPD in October 2012
- ___ consultations with recognized descendants as part of Waihonua project
- Cultural impact assessment (voluntary) focusing on area surrounding both Waihonua and Senior Residence at Pi‘ikoi
- Consultations with SHPD and SHPO
- Letters sent to OHA, Colette?
- Archaeological Monitoring Plan draft – submitted to SHPD in January 2013 for review based on efforts to date

Senior Residence at Pi‘ikoi
NHPA - Section 106 Consultation

Excerpts from AIS



Senior Residence at Pi‘ikoi
NHPA - Section 106 Consultation



Senior Residence at Pi‘ikoi
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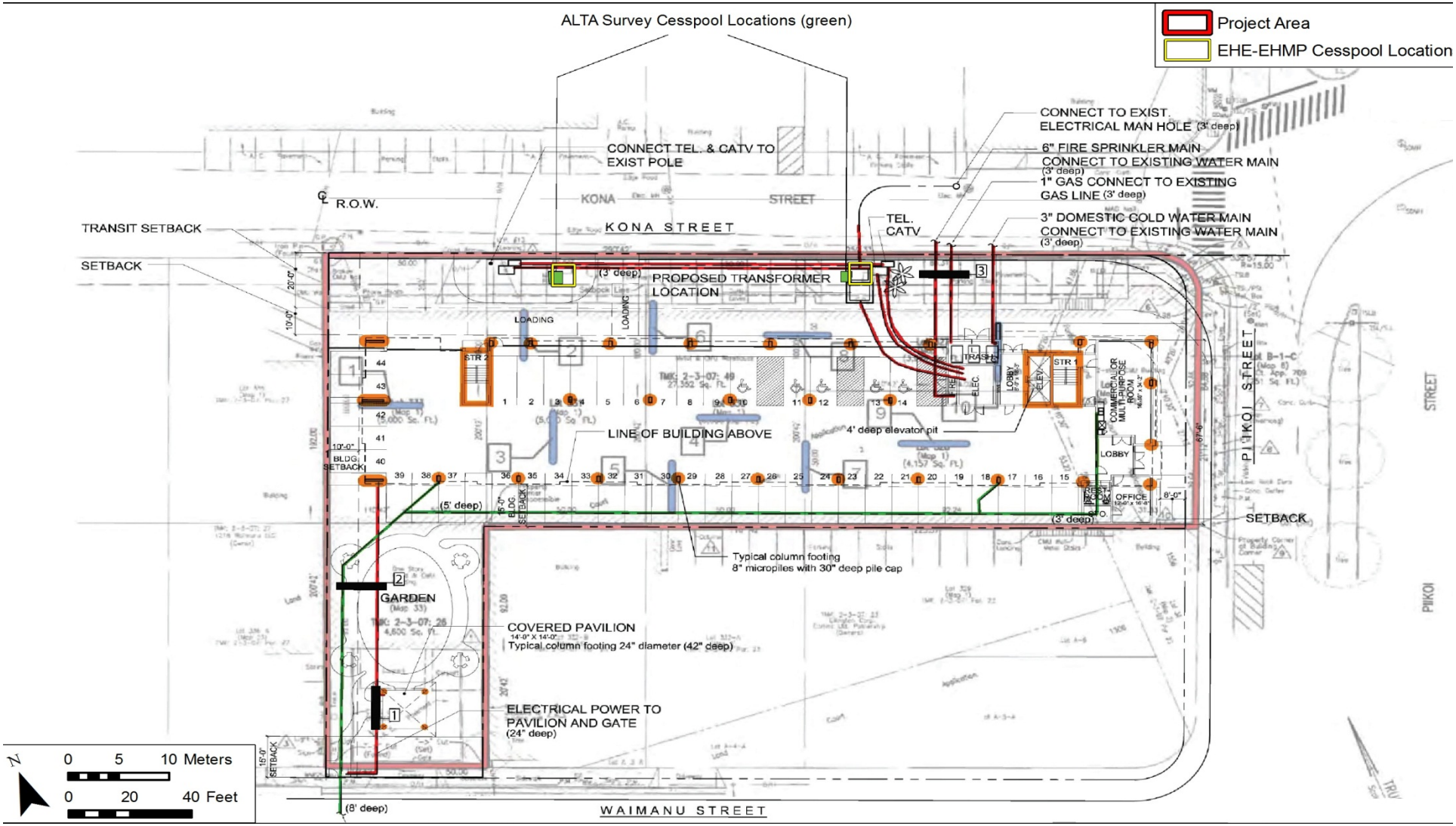

Senior Residence at Pi‘ikoi
NHPA - Section 106 Consultation

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KONA STREET ELEVATION

- Existing slab to be used to minimize ground disturbance
  - Foundation to use micro-piles
  - Additional fill needed due to flood zone
- Fourth quarter 2013 – targeted construction start; 18 month construction period
- First quarter 2015 - completion

Senior Residence at Pi‘ikoi
NHPA - Section 106 Consultation
Sharing of Mana‘o

CONCEPTUAL RENDERING

Senior Residence at Pi'ikoi

Senior Residence at Pi‘ikoi
NHPA - Section 106 Consultation

Next Steps

- Documentation of findings and determination
- Submit to SHPD; 30 days for review and acceptance or objection

Senior Residence at Pi‘ikoi
NHPA - Section 106 Consultation

Pau

Mahalo

Final
Archaeological Monitoring Plan for the Senior Residence at Pi‘ikoi, Kaka‘ako Ahupua‘a, Kona District, O‘ahu Island TMK: [1] 2-3-007:026 & 049

Prepared for

Kewalo Development LLC

Prepared by

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Management Summary

Reference	Archaeological Monitoring Plan for the Senior Residence at Pi‘ikoi, Kaka‘ako Ahupua‘a, Kona District, O‘ahu Island TMK: [1] 2-3-007:026 & 049 (Runyon, Borthwick and Hammatt 2013)
Date	May 2013
Project Number (s)	Cultural Surveys Hawai‘i job code: KAKAAKO 64
Investigation Permit Number	The archaeological monitoring program will likely be carried out under archaeological permit number 13-06, issued by the Hawai‘i State Historic Preservation Division/Department of Land and Natural Resources (SHPD/DLNR), per Hawai‘i Administrative Rules (HAR) Chapter 13-282.
Project Location	The project area is located in Kaka‘ako at 1235 Kona Street/1226 Waimanu Street/450 Pi‘ikoi Street, and is bounded on the north by Kona Street, on the south by Waimanu Street, and on the east by Pi‘ikoi Street. The project area is depicted on the USGS 7.5-Minute Series Topographic Map, Honolulu Quadrangle (1998).
Land Jurisdiction	Private; Kewalo Development LLC
Agencies	SHPD/DLNR
Project Description	The proposed project involves the construction of a new residential rental apartment building. Associated ground disturbance will include demolition of existing structures and excavation related to the project area’s development; including structural footings, utility installation, roadway and parking area installation, and landscaping. An approximately 4,600 sq. ft parcel fronting Waimanu Street will be dedicated to Hawaii Community Development Authority (HCDA) for their use, likely as a park.
Project Acreage	0.74 acres (32,234 square feet [ft^2] or 2,995 square meters [m^2])
Area of Potential Effect (APE)	For this investigation, the project's APE is defined as the 0.74 acre project footprint.
Historic Preservation Regulatory Context	In consultation with SHPD, this monitoring plan is designed to fulfill the state requirements for monitoring plans [HAR Chapter 13-279-4]. This document was prepared to support the proposed project’s historic preservation review under Hawai‘i Revised Statutes (HRS) Chapter 6E-42 and HAR Chapter 13-284. This archaeological monitoring plan describes the proposed activities, the cultural setting, and potential historic properties that could be encountered. In order to facilitate planning for the proposed reserved housing project and to support the project’s historic preservation review compliance, an archaeological field check and literature review study

	was completed (Barnes and Shideler 2007) for use by the previous landowner, K2 Investors LLC. In addition, an archaeological inventory survey (AIS) was conducted for this project. The AIS report (Runyon et al. 2012) was accepted in an SHPD Chapter 6E-42 review letter dated October 12, 2012 (Log No. 2012.2839, Doc. No. 1210SL19; included in present Appendix A). The AIS was conducted to support the proposed project's historic preservation review under HRS Chapter 6E-42 and HAR Chapter 13-13-284. In consultation with SHPD/DLNR, the AIS was designed to fulfill the State requirements per HAR Chapter 13-13-276.
Historic Properties Potentially Affected	One historic property (SIHP # 50-80-14-6636) was documented during the AIS investigation (Runyon et al. 2012). SIHP # 50-80-14-6636 consists of buried Kewalo wetland sediments. The site was determined significant based on Criteria* A and D, based on site type, contents, and associated depositional events.
Mitigation Recommendation	Based on AIS subsurface testing, the stratigraphy indicates very thick fill deposits (ranging from 1 to 2 meters in depth) exist throughout the project area. Kewalo wetland sediments (SIHP # -6636) were found approximately 1.6 meters below the ground surface. Given the presence of a documented historic property within the project area (SIHP # -6636) and based on previous archaeological studies in the vicinity which have documented buried cultural deposits and human burials, an archaeological monitoring program is recommended. The monitoring program will help alleviate the project’s impact on the documented historic property as well as facilitate the identification and treatment of any additional historic properties, including cultural deposits, artifacts, and/or human burials, that may be discovered during project construction. The monitoring program is recommended to include a combination of on-call and on-site monitoring. On-call monitoring will consist of weekly site visits to document and assess exposed project stratigraphy. On-site monitoring will consist of the monitoring of excavations which are planned to extend below 1 meter (approximately 3 feet) in depth. Any departure from this will only follow consultation with and written concurrence from the SHPD.

*Historic property significance is evaluated and expressed as eligibility for listing on the Hawai‘i Register of Historic Places (Hawai‘i Register). To be considered eligible for listing on the Hawai‘i Register a cultural resource must possess integrity of location, design, setting, materials, workmanship, feeling, and association, and meet one or more of the following broad cultural/historic significance criteria: “A” reflects major trends or events in the history of the state or nation; “B” is associated with the lives of persons significant in our past; “C” is an excellent example of a site type/work of a master; “D” has yielded or may be likely to yield information important in prehistory or history; and, “E” has traditional cultural significance to an ethnic group, includes religious structures and/or burials.

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Section 1 Introduction

1.1 Project Background

At the request of Kewalo Development LLC, Cultural Surveys Hawai‘i, Inc. (CSH) completed this archaeological monitoring plan for the proposed Senior Residence at Pi‘ikoi project in Kaka‘ako Ahupua‘a, Kona District, O‘ahu Island, TMK: [1] 2-3-007:026 & 049 (Figure 1 through Figure 4). The project area is a flag-shaped lot located in Kaka‘ako at 1235 Kona Street/1226 Waimanu Street, with an approximate 320-foot frontage along Kona Street on the north, an approximate 50-foot frontage along Waimanu Street on the south, and an approximate 100-foot frontage along Pi‘ikoi Street on the east.

The project area is comprised of TMK: [1] 2-3-007:026 & 049, totaling approximately 0.74 acres. The area of potential effect is considered to be the entire approximately 0.74 -acre project area. The project area is privately owned by Kewalo Development LLC. The proposed project involves construction for a new residential rental apartment building. Associated ground disturbance will include demolition of existing structures and excavation related to the project area’s development; including structural footings, utility installation, roadway and parking area installation, and landscaping (Figure 5 through Figure 7). An approximately 4,600 sq. ft parcel fronting Waimanu Street will be dedicated to Hawaii Community Development Authority (HCDA) for their use, likely as a park.

The proposed project is subject to Hawai‘i State environmental and historic preservation review legislation [Hawai‘i Revised Statutes (HRS) Chapter 343 and HRS 6E-42/Hawai‘i Administrative Rules (HAR) Chapter 13-284, respectively]. Prior to the current investigation, an archaeological field check and literature review study (Barnes and Shideler 2007) was completed for the previous landowner, K2 Investors LLC. The archaeological literature review and field inspection study was completed in order to support the project’s historic preservation review compliance, to determine if there were any major archaeological concerns within the project area, and to explain the State historic preservation requirements that would need to be fulfilled prior to land alteration within the project area. The study indicated an archaeological inventory survey and an archaeological monitoring program should be anticipated.

An archaeological inventory survey (AIS) was conducted by CSH between May 19, 2010 and November 16, 2011. One historic property was identified during AIS investigation, consisting of buried Kewalo wetland sediments (SIHP # 50-80-14-6636) (Runyon et al. 2012). Recommended mitigation measures included archaeological monitoring. In consultation with SHPD/DLNR, the AIS investigation was designed to fulfill the State requirements per HAR Chapter 13-13-276. The AIS report (Runyon et al. 2012) was accepted in an SHPD Chapter 6E-42 review letter dated October 12, 2012 (Log No. 2012.2839, Doc. No. 1210SL19; included in present Appendix A).

This archaeological monitoring plan was prepared to support the proposed project’s historic preservation review under Hawai‘i Revised Statutes (HRS) Chapter 6E-8 and HAR Chapter 13-275. In consultation with SHPD, this monitoring plan is designed to fulfill the state requirements for monitoring plans per HAR Chapter 13-279-4. The monitoring program will help alleviate the project’s impact on the documented historic property (SIHP # -6636) as well as facilitate the

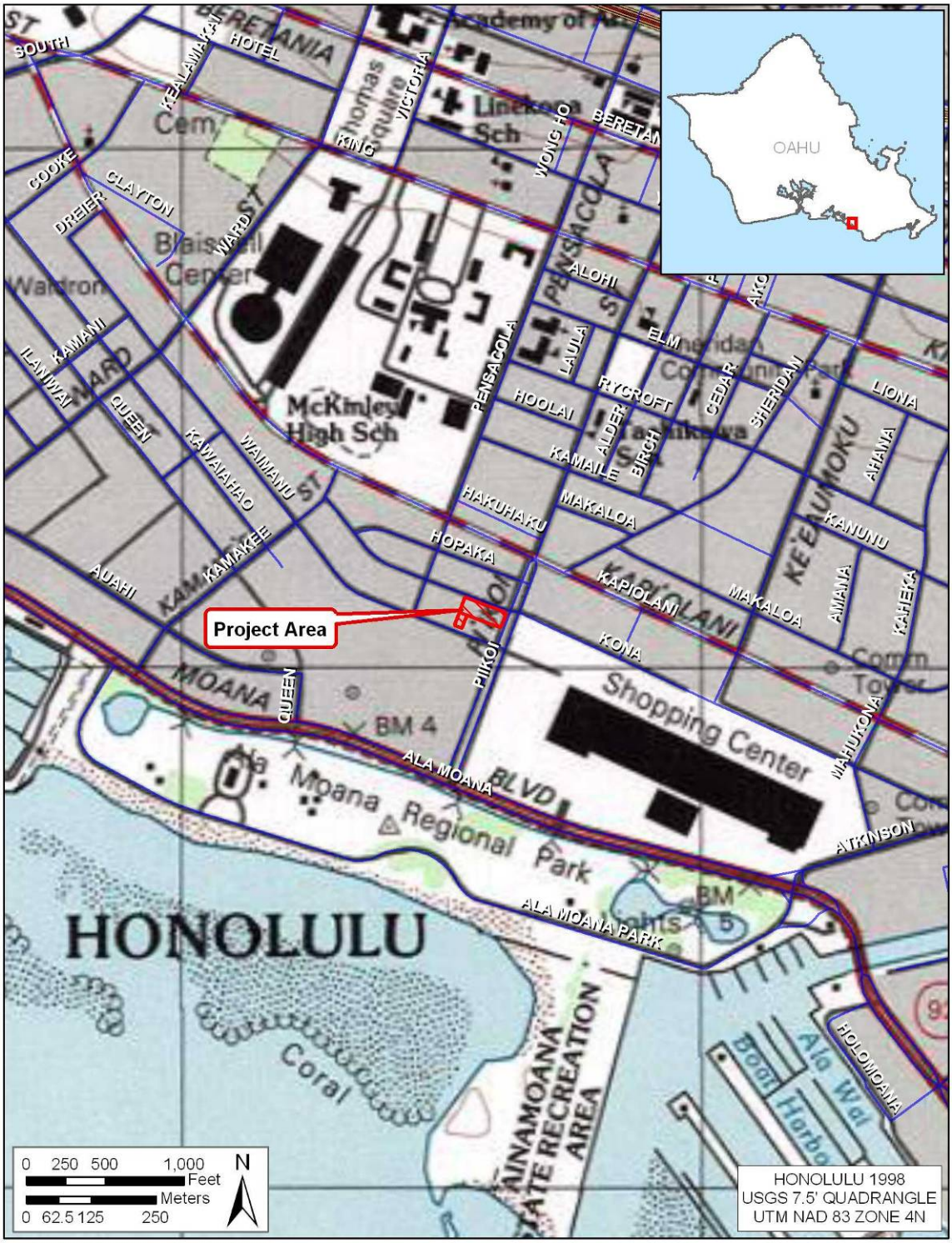

Figure 1. Portion of the U.S. Geological Survey (USGS) Honolulu Quad map (1998) showing the location of the project area

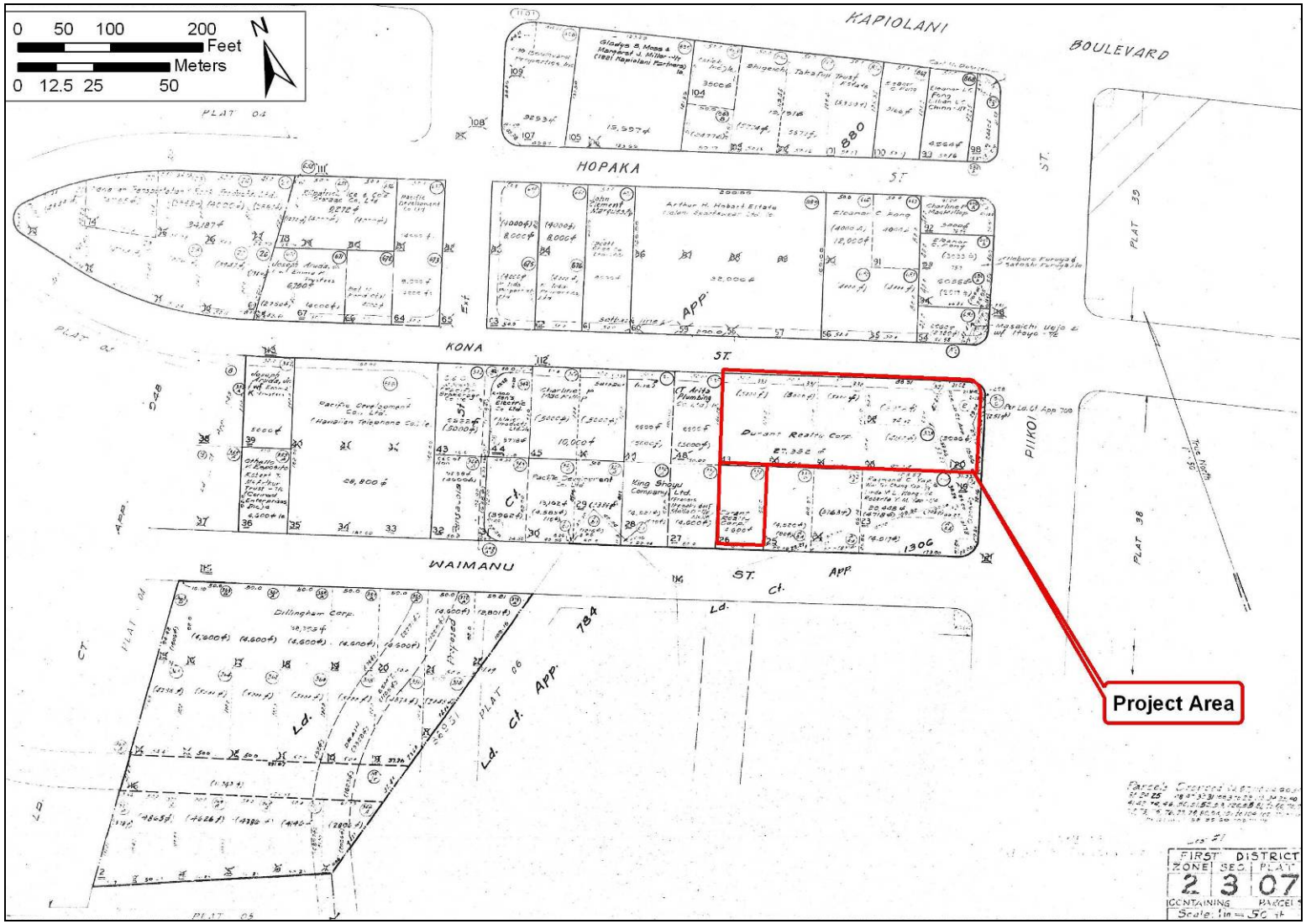

Figure 2. Tax Map Key (TMK): [1] 2-3-007 showing the location of the project area

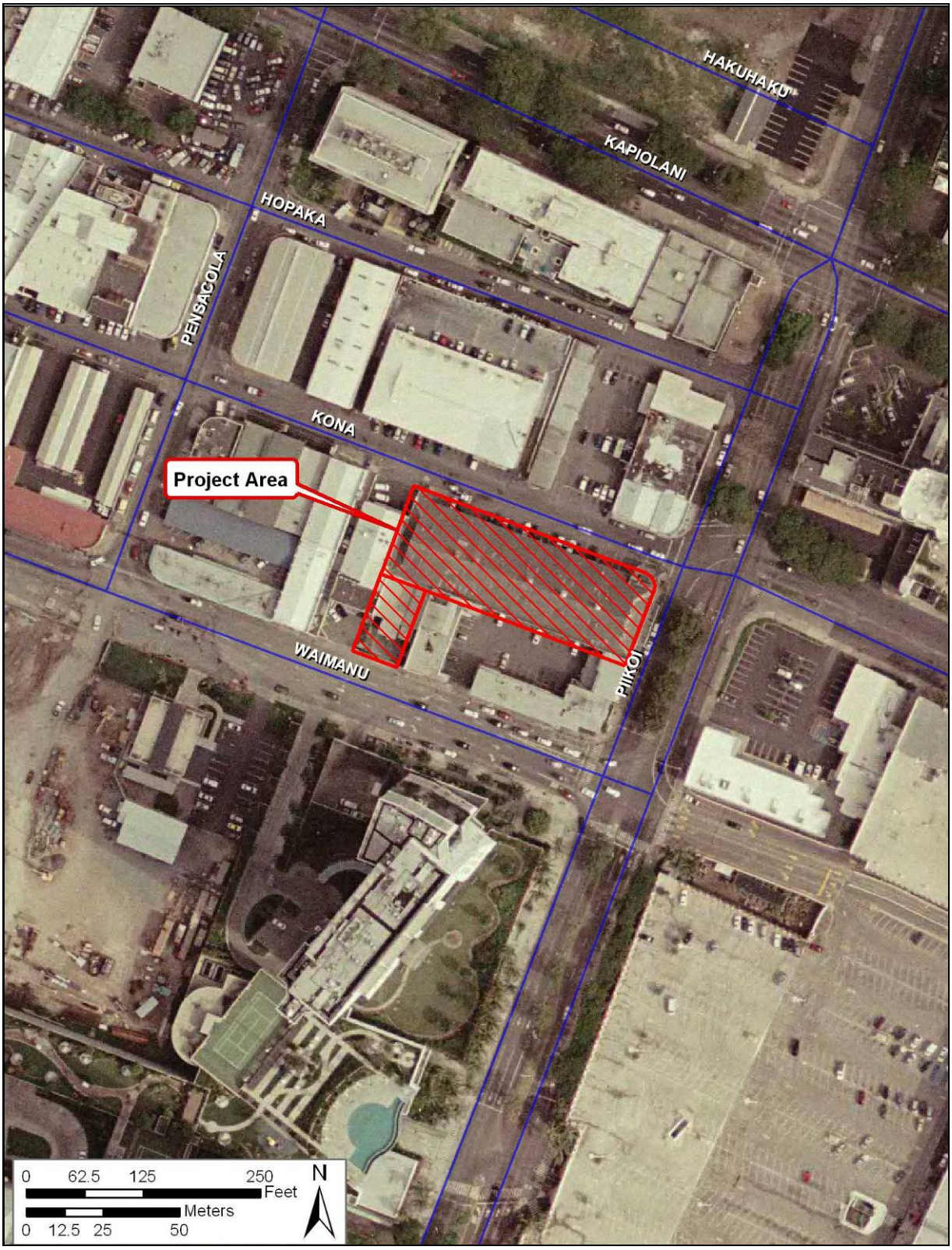

Figure 3. Aerial photograph showing project area (USGS 2005 Orthoimagery)

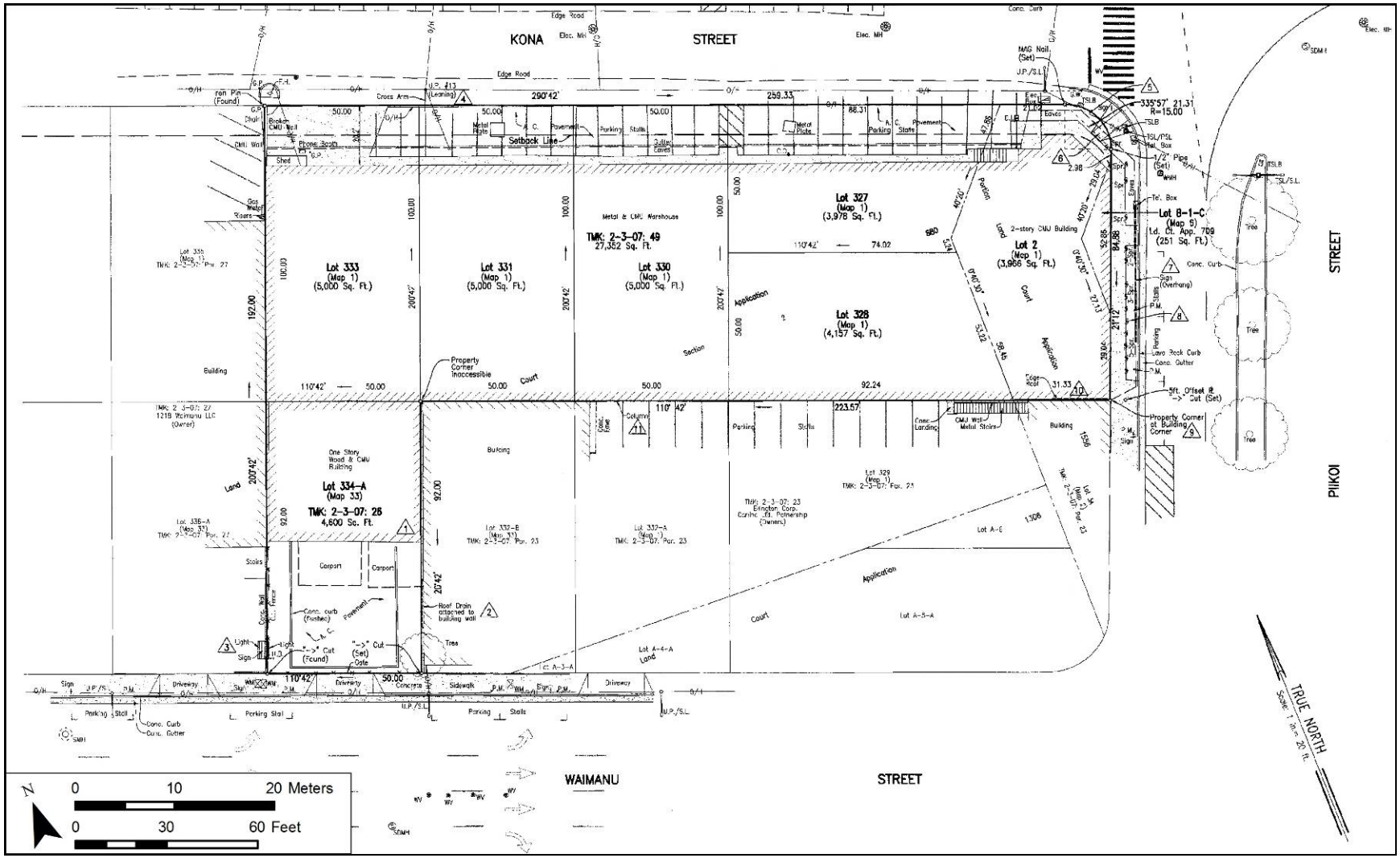

Figure 4. Portion of a 2007 ALTA Survey map showing existing conditions within the project area (provided by client)

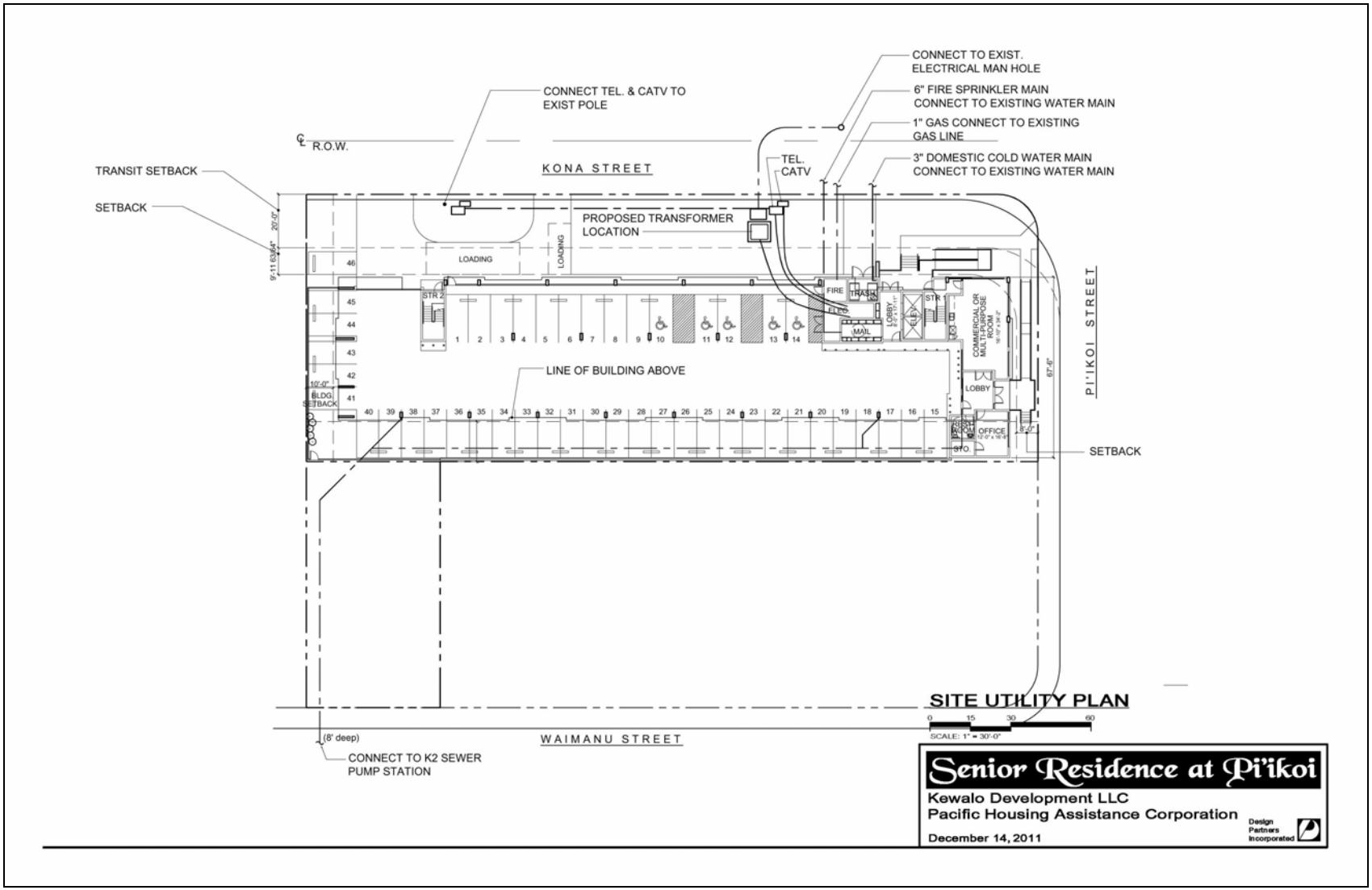

Figure 5. Conceptual construction plan showing locations of proposed project excavations (provided by client)

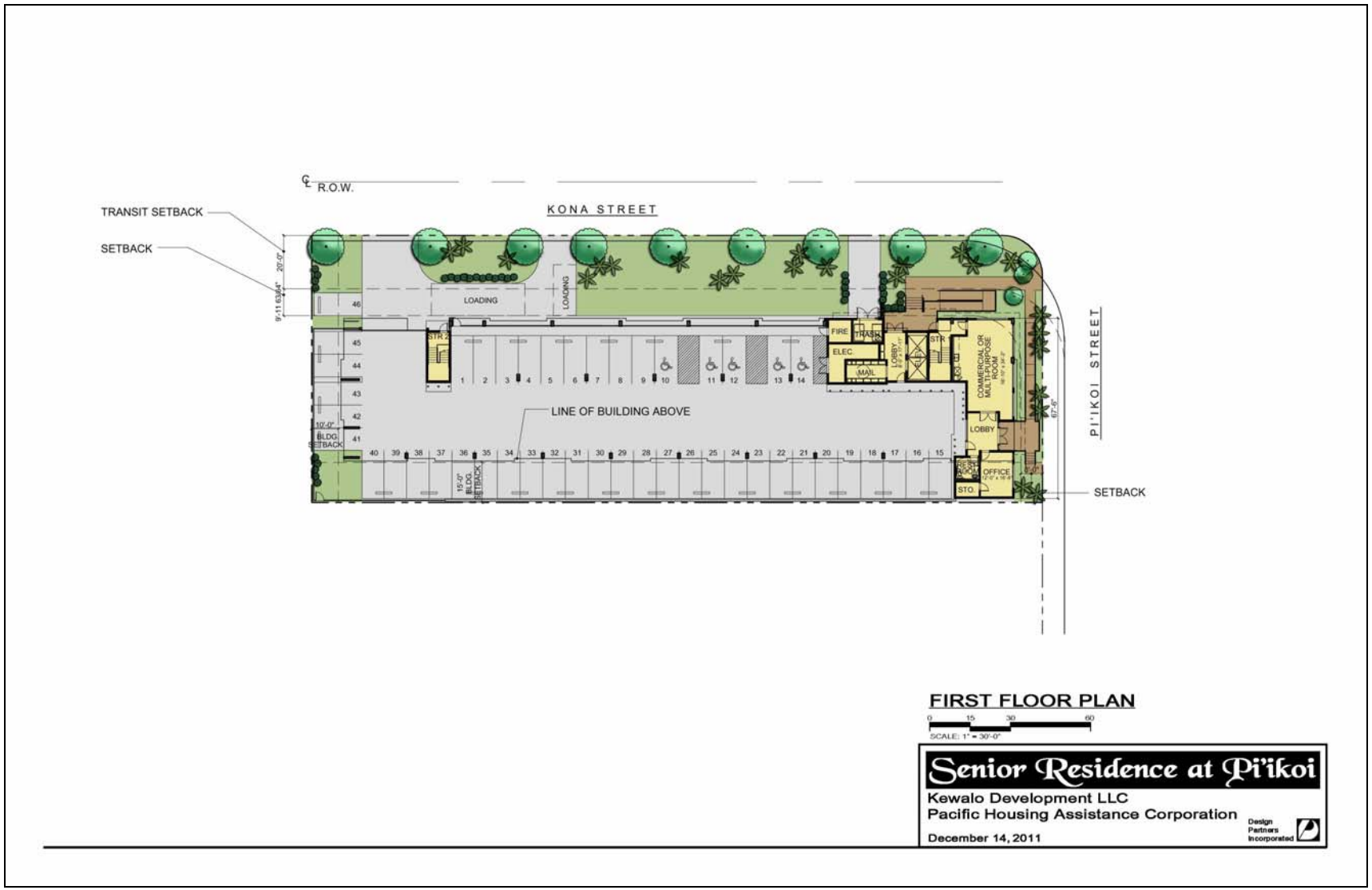

Figure 6. Conceptual plan showing first floor layout (provided by client 2012)

Figure 7. Conceptual plan showing exterior elevations (provided by client 2012)

identification and treatment of any additional historic properties, including cultural deposits, artifacts, and/or human burials, that may be discovered during project construction.

1.2 Environmental Setting

1.2.1 Natural Environment

The U. S. Department of Agriculture soil survey of the Hawaiian Islands designates the project area as Fill Lands (FL) (Figure 8). Fill Lands are described as mixed fill land used for urban development and the fill is described as “materials dredged from the ocean or hauled from nearby areas, garbage, and general material from other sources” (Foote et. al.1972). The filling-in and subsequent development of the low-lying marshes, tidal flats, fish ponds, and reef areas which constituted the undeveloped natural condition of the project area, permanently changed it into its present fully urbanized character.

Rainfall averages less than 30 inches of rain per year (Armstrong 1983:62). Northeasterly trade winds prevail throughout the year, although their frequency varies from more than 90% during the summer months to 50% in January; the average annual wind velocity is approximately 10 miles per hour (Okamoto 1998:2-1). Vegetation is largely absent within the current project area.

1.2.2 Built Environment

The project area lies in central Kaka‘ako; characterized of long-standing by mixed residential and light industry use. The project area vicinity includes industrial use warehouses, bars, shops and the Ala Moana Shopping Center across Pi‘ikoi Street. The entire project area is covered by a large warehouse that includes a two-story former retail space fronting Pi‘ikoi Street (see Figure 3).

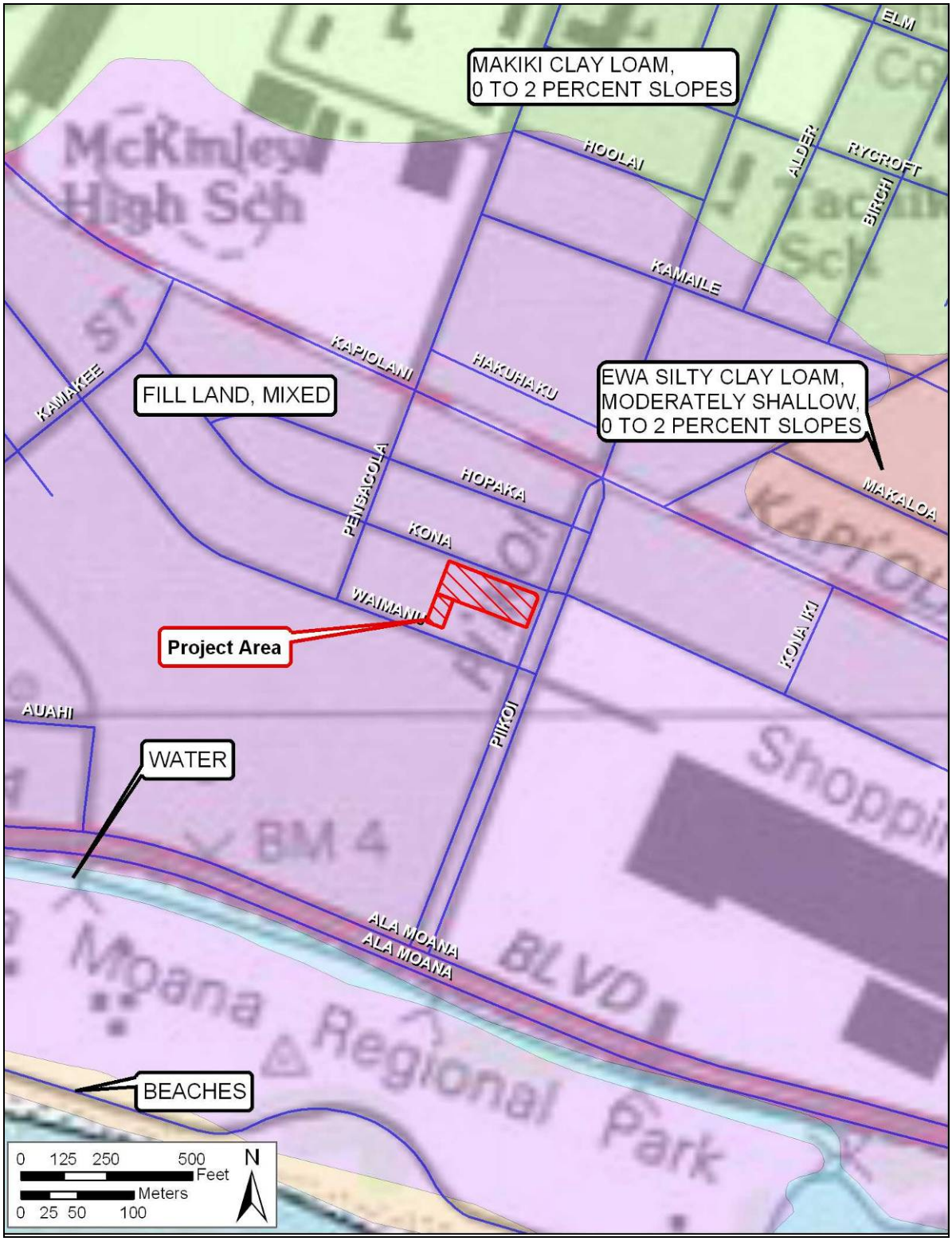

Figure 8. Portion of the USGS Honolulu Quad map (1998) with soil survey overlay, showing project area soils (Foote et al. 1972)

Section 2 Background Research

2.1 Legendary and Traditional Background

2.1.1 Overview for Kaka‘ako Ahupua‘a

The project area is within the Kaka‘ako Community Development District. However, the boundary of this modern development district is not the same as the ancient boundary of Kaka‘ako Ahupua‘a. The original location and extent of an area called Kaka‘ako is discussed by the ethnographer Henry Enoka Palenapa Kekahuna, who was born on Maui, Hawai‘i in 1881 and was a long-time resident of Honolulu. Henry placed Kaka‘ako "on the Ewa side of Kewalo to Kuloloia Stream where the Honolulu Iron Works and Fort Armstrong are now," an area now covered by One Waterfront Plaza (between South and Punchbowl Streets) (Kekahuna 1958:4). Kekahuna also related that "there were formerly scattered dunes of white sand there. Gilbert Islanders (Kilipaki) squatted there, and made a living by fishing, collecting coral for curios, and catching octopus (1958:4)." Only four 1850's Land Commission Awards list their location as within the *‘ili* (small land division) of Kaka‘ako. These are also generally located adjacent to the sea, east of Punchbowl Street between Pohukaina Street and Reed Lane. On an 1891-1902 map, F. S. Dodge placed Kaka‘ako between Punchbowl, Pohukaina, South Street and Ala Moana Blvd west of the current project area (Bishop Estate Map # 145, Registered Map 1587) (map not shown). However, on many early maps, only the area in the vicinity of the Kaka‘ako Receiving Station is labeled as Kaka‘ako. Through time Kaka‘ako became recognized as a larger land area extending from Punchbowl to Pi‘ikoi Streets. It also became recognized as a larger land area extending from Punchbowl to Pi‘ikoi Streets, *mauka* (inland) of Kapiolani Boulevard.

2.1.2 Place Names

Place name translations presented without attribution in this subsection are from *Place Names of Hawai‘i* (Pukui et al. 1974), unless indicated otherwise. The researchers for this book based their interpretations not only on literal (phonetic) translations of the words, but also on oral traditions and historic documents. In their work, the place names of geographic features and *ahupua‘a* names are translated; however, *‘ili* names (small land divisions within *ahupua‘a*) are not usually presented.

Thomas Thrum (1922) also published a short paper on place names in the 1922 edition of Lorrin Andrews *A Dictionary of the Hawaiian Language*, based only on the phonetic translations of the place names. This work does have a large number of translated *‘ili* names. Because there are no oral or written documents to confirm Thrum's interpretations, Mary Pukui (Pukui et al. 1974:136) cautioned that Thrum's translations were sometimes "unreliable." Thrums's translations will be presented here since it is our only source for many *‘ili* names, but Pukui's cautionary note for these interpretations should be kept in mind.

An 1897 map of Honolulu by M. D. Monsarrat (Figure 9) indicates that the project area is located within the southern portion of the *‘ili* (small land division within an *ahupua‘a*) of Kewalo, and situated between the two *‘ili of* Kukuluāe‘o and Kālia. The place names listed

Figure 9. 1897 map of Honolulu by M. D. Monsarrat, showing the project parcel in the land Kewalo (Hawai‘i Land Survey Division, Reg. Map No. 1910)

below are associated with specific *mo‘olelo* (oral histories) and *wahi pana* (legendary or storied places), which are presented in Section 3.3 (below).

Kaka‘ako is not translated in the definitive work, *Hawai‘i Place Name*s, by Pukui et al. (1974), but the Hawaiian word *kākā‘āko* is translated as “dull, slow” in the *Hawaiian Dictionary* (Pukui and Elbert 1986:110); it is possible that this place name refers to the abundant standing water characteristic of this once marshy place. Thrum (1922:639) translated the word as “prepare the thatching” (*kākā*=to chop, beat, or thresh; *ako*=thatch). If Thrum’s translation is correct, it could be related to the fact that salt marshes, such as areas like Kaka‘ako, were excellent places to gather tall *pili* grass, which the Hawaiians traditionally used to thatch their houses (see Legend of Kewalo, next section).

Kewalo literally means “the calling (as an echo).” Land Commission Award and other historic-era documents identify it as the area between Cooke and Sheridan Streets, *mauka* of Queen Street. According to Pukui et al. (1974:109), “outcasts (*kauwā*) intended for sacrifice were drowned here” (see *mo‘olelo* below). Kekahuna (1958:4) said that at one time, it also had a sand beach as a part of the area, where various sports, such as surfing, were engaged in. An 1866 map (Figure 10), indicates the current project area may have been located within this small thin coastal section.

Kukuluāe‘o, translates literally as the “Hawaiian stilt (bird),” *Himantopus himantopus*, and from the word *kukuluāe‘o,* which means “to walk on stilts.” Pukui et al. (1974:123) describe the area as “formerly fronting Ke-walo Basin” and “containing marshes, salt ponds, and small fishponds,” an environment well suited for this type of bird (Griffin et al. 1987:36). The ethnographer Henry Kekahuna (1958:4) described it as an area where salt was formerly made.

Kālia, meaning “waited for” (Pukui et al. 1974:77), is a name used for the central portion of Mānoa Stream and the name of the coastal area where the Pi‘inaio Stream emptied into the ocean. The exact meaning of Pi‘inaio is unknown, but *pi‘ina* means “climb or ascend” (Pukui and Elbert 1986:327). The stream’s mouth was on the western end of the Waikīkī Coast, where the Ala Moana Shopping Center is located, ‘*ewa* (west) of Duke Kahanamoku Beach and Lagoon.

Kuloloia, was a beautiful sand beach below Hale-kauila Street, extending as far as the present Bishop Street. A big pond also named Kuloloia adjoined Hale-kauila Street at a point above the former location of the Honolulu Iron Works in Kaka‘ako. A stream from it flowed down right where the old inter-island dry-dock was located (Kekahuna 1958:4).

2.1.3 Mo‘olelo Associated with Place Names

Although in modern maps the project area is within the Kaka‘ako District, only one mention of Kaka‘ako was found in Hawaiian legend. In various Hawaiian legends, there are several mentions of the areas known as Kewalo and Kālia, and Kaka‘ako and Kukuluāe‘o are mentioned in some post-Contact chants.

2.1.3.1 Kaka‘ako

Kaka‘ako is mentioned in Thrum’s (1998) version of the legend of Kū‘ula, the god presiding over the fish, and his son ‘Ai‘ai, who was the first to teach the Hawaiians how to make various fishing lines and nets, the first to set up a *ko‘a kū‘ula*, a rock shrine on which the fishermen

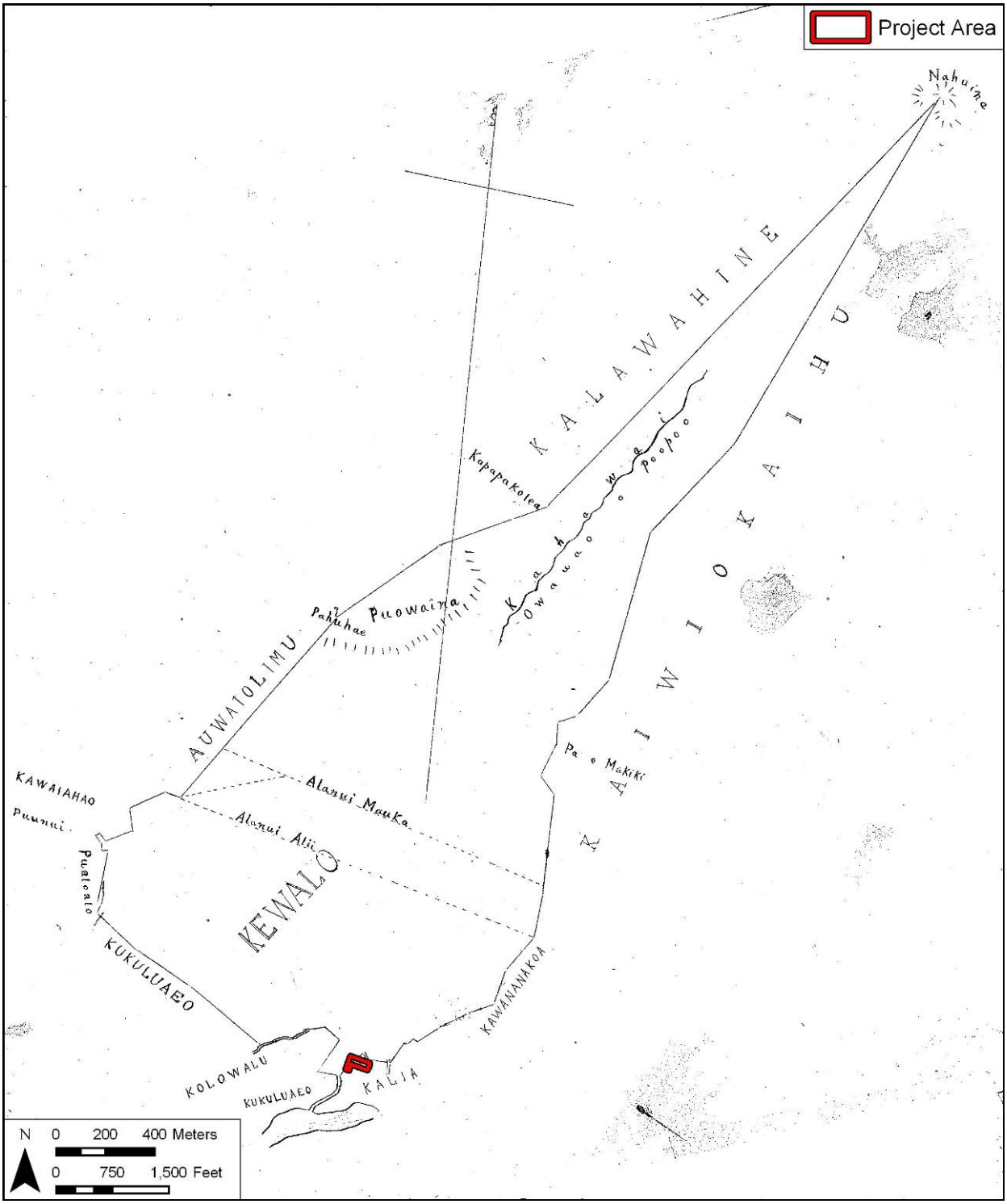

Figure 10. 1866 map of Kewalo ‘Ili by J. F. Makalena; note the relationship of Kukuluāe‘o and the small beach section of Kewalo (Hawai‘i Land Survey Division, Registered Map No. 111)

would place their first catch as an offering to Kū‘ula, and the first to set up *ko‘a ia*, fishing stations where certain fish were known to gather. Kū‘ula “lived as a man on earth on East Maui in the land called Alea-mai at a place called Leho-ula (Red cowrie)” (Beckwith1970:19). Leaving his birthplace in Maui, Kū‘ula’s son ‘Ai‘ai traveled around the islands, establishing *ko‘a kū‘ula* and *ko‘a ia*. On O‘ahu, he landed first at Makapu‘u (east tip of O‘ahu) then traveled west along the southern coast of the island.

> Aiai came to **Kālia** [Waikīkī] and so on to **Kaka‘ako**. Here he was befriended by a man named Apua, with whom he remained several days, observing and listening to the murmurs of the chief named Kou. This chief was a skilful [sic] haiku [*Katsuwonus pelamis*; bonito] fisherman, his grounds being outside of Mamala until you came to Moanalua. There was none so skilled as he, and generous withal, giving *akus* to the people throughout the district.
>
> As Aiai was dwelling with his friend Apua at Kakaako, he meandered off one day along the shore of Kulolia [Kuloloia] and so on to Pakaka and Kapapoko [Thrum 1998:242].

This story mentions several place names near the Kaka‘ako area, including the Kuloloia shore, Pākākā, an ‘*ili* or *heiau* at Honolulu Harbor, and Kapapoko, an eating house near the harbor used by Ka‘ahumanu, wife of Kamehameha I (‘Ī‘ī 1959:66). In Hawaiian legends, the names of people often point to the place where they resided. Thus, the friend Apua may have lived at ‘Āpua, a small ‘*ili* near the western boundary of the Kaka‘ako area.

2.1.3.2 Kewalo

Kewalo once had a freshwater spring in the central portion (current location unknown), as recorded in the proverb “*Ka wai huahua‘i o Kewalo*,” which translates as “The bubbling water of Kewalo.” Two springs are mentioned in a traditional story of the Waters of Ha‘o. This legend tells of two children of the chief Ha‘o who ran away from their cruel stepmother. They stayed for a time with the caretakers of Kewalo Spring, which may have been located close to the trail that connected Waikīkī and Honolulu. The children then left when they heard that the chiefess had sent men to look for them. The two children followed the moonlit trail across the plain toward Kou (Honolulu), but finally collapsed from weariness and thirst. In a dream, the boy’s mother told him to pull up a plant close to his feet. When he did, he found a spring under the plant, which was called the Water of Ha‘o, or Kawaiaha‘o. This spring is located at the western end of the trail, near Kawaiaha‘o Church (Pukui 1988:87-89).

The Kewalo area also once had a famous fishpond that was used to drown members of a pariah caste (*kauwā*) or *kapu* (taboo) breakers as the first step in a sacrificial ritual known as *Kānāwai Kaihehe‘e* (Kamakau 1991:6) or *Ke-kai-he‘ehe‘e*, which translates as “sea sliding along,” suggesting the victims were slid under the sea (Westervelt 1991:16). Kewalo is described as:

> A fishpond and surrounding land on the plains below King Street, and beyond Koula. It contains a spring rather famous in the times previous to the conversion to Christianity, as the place where victims designed for the Heiau of Kanelaau on Punchbowl slopes, was first drowned. The priest holding the victim’s head under

> water would say to her or him on any signs of struggling, “Moe malie i ke kai o ko haku.” “Lie still in the waters of your superiors.” From this it was called Kawailumalumai, “Drowning waters” [Sterling and Summers 1978: 292].

Kō‘ula (meaning “red sugar cane”) is the area around Thomas Square and the *mauka* portion of the Ward estate, suggesting that the Kawailumalumai Pond may have been east (“beyond Kō‘ula”) of the Ward estate. It may be part of the pond complex (5 ponds) awarded to Koalele as LCA 3169, north of Kolowalu (see Section 3.4).

Kewalo is mentioned in a legend as a marsh near the beach, where tall *pili* grass was growing. A man named Kapoi went to this area to get thatching for his house. While there, Kapoi found seven owls eggs and took them home to cook for his supper. An owl perched on the fence surrounding his house and cried out “O Kapoi, give me my eggs!” After several such pleas, Kapoi returned the eggs. In return, the owl became his *aumakua* (family god) and instructed him to build a *heiau* (pre-Christian place of worship) named Mānoa. Kapoi built the *heiau,* placed some bananas on the altar as a sacrifice, and set the *kapu* days for its dedication. The king of O‘ahu, Kākuhihewa, who was building his own *heiau* in Waikīkī, had made a law that if any man among his people erected a *heiau* and set the *kapu* before him, that man should die. Kapoi was seized and taken to the *heiau* of Kūpalaha, at Waikīkī. Kapoi’s ‘*aumakua* owl asked for aid from the king of the owls at Owl’s Hill (Pu‘u Pu‘eo) in Mānoa, who gathered all of the owls of the islands. They flew to Kūpalaha and battled the king’s men, who finally surrendered. From this time, the owl was considered a powerful *akua* (god). The battle area was known as Kukaeunahio-ka-pueo, which means “the confused noise of owls rising in masses” (Westervelt 1991: 135-137; Thrum 1998: 200-202).

Kewalo was the birthplace of the great chief Hua-nui-ka-la-la‘ila‘i, as mentioned in this *mele* (story) chanted by Kamakau (1991 24):

‘O Hua-a-Kamapau ke ‘li‘i	Hua-a-Kamapau the chief
O Honolulu o Waikīkī	O Honolulu, of Waikīkī
*I hanau no la i kahua la i **Kewalo**,*	Was born at **Kewalo**,
‘O Kālia la kahua	**Kālia** was the place [the site]
O Makiki la ke ēwe,	At Makiki the placenta,
I Kānelā‘au i Kahehuna ke piko,	At Kānelā‘au at Kahehuna the navel cord,
I Kalo i Pauoa ka ‘a‘a;	At Kalo at Pauoa the caul;
I uka i Kaho‘iwai i	Upland at Kaho‘iwai, at
Kanaloaho‘okau . . .	Kanaloaho‘okau . . .

2.1.3.3 Kukuluāe‘o

The chief Hua, born in Kewalo, was famous for his love of cultivation and his care for the people. His *heiau,* called Pu‘ukea, was in Kukuluāe‘o in Honolulu; it is mentioned in a traditional *wānana* (prophecy) recorded by Kamakau (1991:24-25).

[*Ka makaua ua kahi o ‘Ewa*]	[The increasing “first rain” of ‘Ewa]
Ua puni ka i‘a o Mokumoa,	Overcomes the fish of Mokumoa,
Ua kau i‘a ka nene;	Washes up fish to the nene plants;

Ua ha‘a kalo ha‘a nu;	Lays low the taro as it patters down;
Ha‘a ka i‘a o ***kewalo,***	Lays low the fish of **Kewalo**,
Ha‘a na ‘ualu o Pahua,	Lays low the sweet potatoes of Pahua,
Ha‘a ka mahiki i ***Pu‘ukea,***	Lays low the mahiki grass at **Pu‘ukea**,
Ha‘a ka unuunu i Pele‘ula,	Lays low the growing things at Pele‘ula
Ha‘a Makaaho i ke ala.	Lays low Makaaho [Makāho] in its path
E Kū e, ma ke kaha ka ua, e Kū,	O Kū, the rain goes along the edge [of the island], O Kū
[*I ‘ai ‘na ka i‘a o Maunalua*] . . .	[Eating" the fish of Maunalua] . . .

The chant mentions the *mahiki* grass of Pu‘ukea Heiau. The Hawaiian term *mahiki* means "to peel off" (Andrews 2003:369). The word was also used to describe a rite to exorcise an evil spirit, as the skilled *kahuna* (priest) "peeled" the malicious spirit from the afflicted. Used in the ritual was a shrimp called *mahiki* or a native grass called *mahiki*. *Mahiki*, or ‘*aki‘aki*, is a tufted rush (*Sporobolos* sp.) found near the seashore. The ethnologist, Mary Pukui, states that even during her youth, parents put "*tī* leaves, or *hala*, or *‘aki‘aki* grass, in a little sea-salt water and [would] have the child drink it" (Pukui et al. 1972:163) to rid them of badly-behaving spirits. The use of this grass in a ritual may explain its association with a ceremonial *heiau*, or it may simply be that the Kukuluāe‘o coast was a good habitat and thus a favored place for healers to collect this type of grass.

The literal meaning of Pu‘ukea is "white hill" (although it may have alternate meanings). Pu‘ukea is also the name of a small land division within the ‘*ili* of Kukuluāe‘o, mentioned in at least two Land Commission Awards: LCA 1502 and 1504. LCA 1504 was located near the junction of Halekauwila Street and Cooke Street. It is fairly common for a *heiau* to have the same name as the ‘*ili* it is located within, so it is possible that Pu‘ukea Heiau was also near the junction of Halekauwila and Cooke streets. The majority of the house sites in the mid-nineteenth century in Kukuluāe‘o were located near Halekauwila Street and Queen Street, *mauka* of the low-lying coastal swamplands on higher, dry ground. It is possible that the *heiau* platform or the area that it was built on was one of the few "high spots" in the flat, low-lying swamp that surrounded it, and thus gained the name *pu‘u kea* (white hill).

Thomas Thrum (1906), who made several lists and surveys for *heiau*, does not mention Pu‘ukea Heiau. In his report on the survey of O‘ahu sites conducted in the early 1930s, McAllister (1933:80) says of Honolulu: "Information regarding former sites within the present limits of Honolulu must come entirely from literary sources." He does mention Pākākā Heiau, once the main royal temple in Honolulu; this *heiau* would have been located around the foot (*makai end*) of Fort Street. He does not list Pu‘ukea Heiau, which Kamakau placed in Kukuluāe‘o, but he does note that Peter Corney, a visitor to the island in 1819, saw several *heiau* (*morai*) along the Honolulu shore:

> There are several *morais*, or churches in the village, and at new moon the priests, chiefs and *hikanees* (aikane) [counselors] enter them with offerings of hogs, plantains, and cocoanuts, which they set before the wooden images. The place is fenced in, and have pieces of white flags flying on the fences. (Corney 1896:101)

The *heiau* of Pu‘ukea and an area called Kaka‘ako are mentioned in the chant “The Battle of Nu‘uanu,” which concerns the 1795 invasion and conquest of O‘ahu by Kamehameha I. One section of the chant describes locations in Honolulu, possibly listing them from east to west:

75 Lauwili i Pūkē (**Pu‘ukea)** I Ka-imu-hai-kanaka,
76 I Kai-kua, i **Kakaako**, I Mamala,
77 I ke kai o Kuloloia, Pakaka,
78 I ka-imu-hai-kanaka, i ka-wai-apuka-Kanē
[Kala‘ikuahulu 1880:131].

2.1.3.4 Kālia

A Hawaiian saying talks about the pleasant portion of the coast of Kālia (Pukui 1983:186):

Ke kai wawalo leo le‘a o Kālia The pleasing, echoing sea of Kālia.

Kālia is also a place where *‘alamihi* crabs were once plentiful, leading to a play on the word *‘ala-mihi* (path of repentance), indicating someone who is in a repentant mood (Pukui 1983:110):

Ho‘i i Kālia ka ‘ai ‘alamihi. Gone to Kālia to eat ‘alamihi crabs.

Kālia was also known for a fishing technique used to catch schools of mullet. When a school of mullet appeared, a bag net was set and the men swam out in a row, surrounded the fish, and slapped the water together and kicked their feet, thus driving the frightened fish into the opening of their bag net. The fishermen of Kālia became known as human fishnets (Pukui 1983:150):

Ka i‘a pīkoi kānaka o Kālia; The fish caught by the men of Kālia;
he kānaka ka pīkoi, men are the floaters,
he kānaka ka pōhaku. men are the sinkers.

Kālia is also mentioned in a story about a woman who left her husband and children on Kīpahulu, Maui, to go away with a man of O‘ahu. Her husband missed her and went to see a *kahuna* who was skilled in *hana aloha* (prayer to evoke love) sorcery. The *kahuna* told the man to find a container with a lid and then speak into it of his love for his wife. The *kahuna* then uttered an incantation into the container, closed it, and threw it into the sea. The wife was fishing one morning at Kālia, O‘ahu, and saw the container. She opened the lid, and was possessed by a great longing to return to her husband. She walked until she found a canoe to take her home (Pukui 1983:158):

Ka makani kā‘ili aloha o The love-snatching wind
o Kīpahulu. of Kīpahulu

2.2 Summary of Legendary and Traditional Accounts

From the legendary accounts, it can be seen that Kewalo, Kukuluāe‘o, and Kālia were traditionally noted for their plentiful resources including fishponds, salt pans, and marsh lands where *pili* grass and other plants could be collected. The *ili* are also known for ceremonial sites such as Pu‘ukea Heiau, Kewalo Spring, and Kawailumalumai Pond at which sacrifices were made, and for the trails that allowed transport between the more populated areas of Waikīkī and

Honolulu. Important chiefs were born in the area and conducted religious rites, and commoners (*maka‘āinana*) traveled to the area to procure food and other resources. Commoners also lived in the area, adjacent to the ponds and the trails.

2.3 Early Post-Contact History and Population Centers

Kewalo/Kaka‘ako is between two centers of population, Kou and Waikīkī, on the southern shore of pre-contact O‘ahu. In Waikīkī, a system of irrigated taro *lo‘i* (irrigated fields) fed by streams descending from Makiki, Mānoa, and Pālolo valleys blanketed the plain, and networks of fishponds dotted the shoreline. Similarly, Kou - the area of downtown Honolulu surrounding the harbor - possessed shoreward fishponds and irrigated fields watered by ample streams descending from Nu‘uanu and Pauoa Valleys. The pre-Contact population and land use patterns of Kewalo and adjacent Kukuluāe‘o may have derived from its relationship to these two densely populated areas; it may have participated in some of the activities associated with them. Thus, the attempt to reconstruct the Kewalo region (and the present study area)—as it existed for the Hawaiians during the centuries before western contact and the modern urbanization that has reconfigured the landscape—must begin with accounts of Kou and Waikīkī.

Waikīkī is actually the name of a large *ahupua‘a* (traditional land division) encompassing lands stretching from Honolulu to Maunalua Bay. Within that *ahupua‘a*, by the time of the arrival of Europeans during the late eighteenth century, the area today known as Waikīkī had long been a center of population and political power on O‘ahu. According to Martha Beckwith (1940:383), by the end of the fourteenth century, Waikīkī had become “the ruling seat of the chiefs of O‘ahu.” The pre-eminence of Waikīkī continued into the eighteenth century and is confirmed by the decision of Kamehameha, in the midst of unifying control of the islands, to reside there after wresting control of O‘ahu by defeating the island’s chief, Kalanikūpule.

Chiefly residences were only one element of a complex of features sustaining a large population that characterized Waikīkī up through pre-Contact times. Beginning at least by the fifteenth century, a vast system of irrigated taro fields was constructed, extending across the littoral plain from Waikīkī to lower Mānoa and Pālolo valleys. This field system, an impressive feat of engineering, the design of which is traditionally attributed to the chief Kalamakua, took advantage of streams descending from Makiki, Mānoa, and Pālolo Valleys, which also provided ample fresh water for the Hawaiians living in the *ahupua‘a*. Water was also available from springs in nearby Mō‘ili‘ili and Punahou. Closer to the Waikīkī shoreline, coconut groves and fishponds dotted the landscape. A continuous zone of population and cultivation, from the shoreline of present day Waikīkī Beach, extended north well into Mānoa Valley. The western and eastern bounds of this zone are less clear, and there are no specific references to Waikīkī’s abundance reaching into the Kewalo region.

A basic description of Honolulu and Kou, up to western contact, is given by E. S. Craighill and Elizabeth Handy:

> What is now Honolulu was originally that flatland area between the lower ends of Nu‘uanu and Pauoa Valleys and the harbor. [W.D.] Westervelt . . . wrote that ‘Honolulu was probably a name given to a very rich district of farm land near what is now . . . the junction of Liliha and School Streets, because its chief was

> Honolulu, one of the high chiefs at the time of Kakuhihewa'. . . . It is probable that the chief referred to by Westervelt took his name from the harbor and adjoining land. The original name of the land where the town grew when the harbor became a haven for foreign ships was Kou. . . . The number of *heiau* in this area indicates that it was a place of first importance before the era of foreign contact [Handy and Handy 1972:479].

Rev. Hiram Bingham, arriving in Honolulu in 1820, described a still predominantly native Hawaiian environment - still a "village" - on the brink of western-induced transformations:

> We can anchor in the roadstead abreast of Honolulu village, on the south side of the island, about 17 miles from the eastern extremity. . . . Passing through the irregular village of some thousands of inhabitants, whose grass thatched habitations were mostly small and mean, while some were more spacious, we walked about a mile northwardly to the opening of the valley of Pauoa, then turning southeasterly, ascending to the top of Punchbowl Hill, an extinguished crater, whose base bounds the northeast part of the village or town. . . . Below us, on the south and west, spread the plain of Honolulu, having its fishponds and salt making pools along the seashore, the village and fort between us and the harbor, and the valley stretching a few miles north into the interior, which presented its scattered habitations and numerous beds of kalo (*Arum esculentum*) in its various stages of growth, with its large green leaves, beautifully embossed on the silvery water, in which it flourishes [Bingham 1847:92-93].

The Kewalo/Kaka‘ako region would have been in Bingham's view as he stood atop "Punchbowl Hill" looking toward Waikīkī to the south; it would have comprised part of the area he describes as the 'plain of Honolulu' with its "fishponds and salt making pools along the seashore."

Another visitor to Honolulu in the 1820s, Capt. Jacobus Boelen, hints at the possible pre-contact character of Honolulu and its environs, including the Kewalo area:

> It would be difficult to say much about Honoruru. On its southern side is the harbor or the basin of that name (which as a result of variations in pronunciation [*sic*] is also written as Honolulu, and on some maps, Honoonoono). The landlocked side in the northwest consists mostly of taro fields. More to the north there are some sugar plantations and a sugar mill, worked by a team of mules. From the north toward the east, where the beach forms the bight of Whytetee, the soil around the village is less fertile, or at least not greatly cultivated [Boelen 1988:62].

Boelen's description implies that the Kewalo region and the present study area are within a "not greatly cultivated" region of Honolulu, perhaps extending from Pūowaina (Punchbowl Crater) at the north through Kaka‘ako to the Kālia portion of Waikīkī in the east.

An 1855 map of Honolulu by Joseph de La Passe (Figure 11), a lieutenant aboard the French vessel, *L`Eurydice*, would place the project within a coastal marsh. The map shows fishponds and taro *lo‘i* (irrigated patches, shown as rectangles) within and surrounding the project area and

Figure 11. 1855 map of Honolulu by Lt. Joseph de La Passe of the French vessel, *L`Eurydice*; project area is situated in a heavily utilized agricultural area (squares and rectangles indicate fishponds and taro *lo‘i*) (reprinted in Fitzpatrick 1986:82-83)

houses scattered along King Street. The depicted areas of population and habitation concentration probably reflect distortions caused by the post-contact shift of Hawaiians to the area around Honolulu harbor - the only sheltered landing on O‘ahu and the center of increasing trade with visiting foreign vessels. Kamehameha himself had moved from Waikīkī to Honolulu in 1809.

A clearer picture of Kewalo and the present study area develops with accounts of other visitors to and settlers of Honolulu during the first half of the nineteenth century. Gorman D. Gilman, who arrived in Honolulu in 1841, recalled in a memoir the limits of Honolulu during the early 1840s.

> The boundaries of the old town may be said to have been, on the *makai* [seaward] side, the waters of the harbor; on the *mauka* [inland] side, Beretania street; on the Waikīkī side [i.e. the area just beyond Punchbowl Street], the barren and dusty plain, and on the Ewa [west] side, the Nu‘uanu Stream [Gilman 1904:97].

Gilman further describes the “barren and dusty plain” beyond (east of) Punchbowl Street:

> The next and last street running parallel [he had been describing the streets running *mauka-makai*, or from the mountains to the shore] was that known as Punchbowl Street. There was on the entire length of this street, from the *makai* side to the slopes of Punchbowl, but one residence, the two-story house of Mr. Henry Diamond, *mauka* of King Street. Beyond the street was the old Kawaiahao church and burying ground. A more forsaken, desolate looking place than the latter can scarcely be imagined. One, to see it in its present attractiveness of fences, trees and shrubbery, can hardly believe its former desolation, when without enclosure, horses and cattle had free access to the whole place [Gilman 1904:89].

That the environs of the missionary enclave and Kawaiaha‘o Church were indeed “forsaken” and “desolate looking” in the 1820s when the missionaries first settled there is confirmed in the memoirs of the American missionary C. S. Stewart who, arriving on Maui after living at the mission, declared Lahaina to be “like the delights of an Eden” after “four weeks residence on the dreary plain of Honoruru” (Stewart 1970:177). It is likely that these descriptions of the Honolulu plain also include - at least for western sensibilities - the Kewalo region.

The barrenness of the Kewalo region is illustrated in an 1850 sketch (Figure 12) of the coastal area *makai* and east of Kawaiaha‘o Church. Between Kawaiaha‘o Church and the sea are only a few scattered huts along the shore and huts aligned along the inland trail (now covered by King Street). The project area would be *makai* and left (east) of the church along the shore. An 1887 photograph (Figure 13 and Figure 14) of the area also shows the marshy nature of the area, with only scattered houses near the ponds or near the shore *makai* of Kawaiaha‘o Church. The missionary families grazed their cows in the lands *makai* of the mission houses, possibly on lands within the project area (*Paradise of the Pacific* 1950:21).

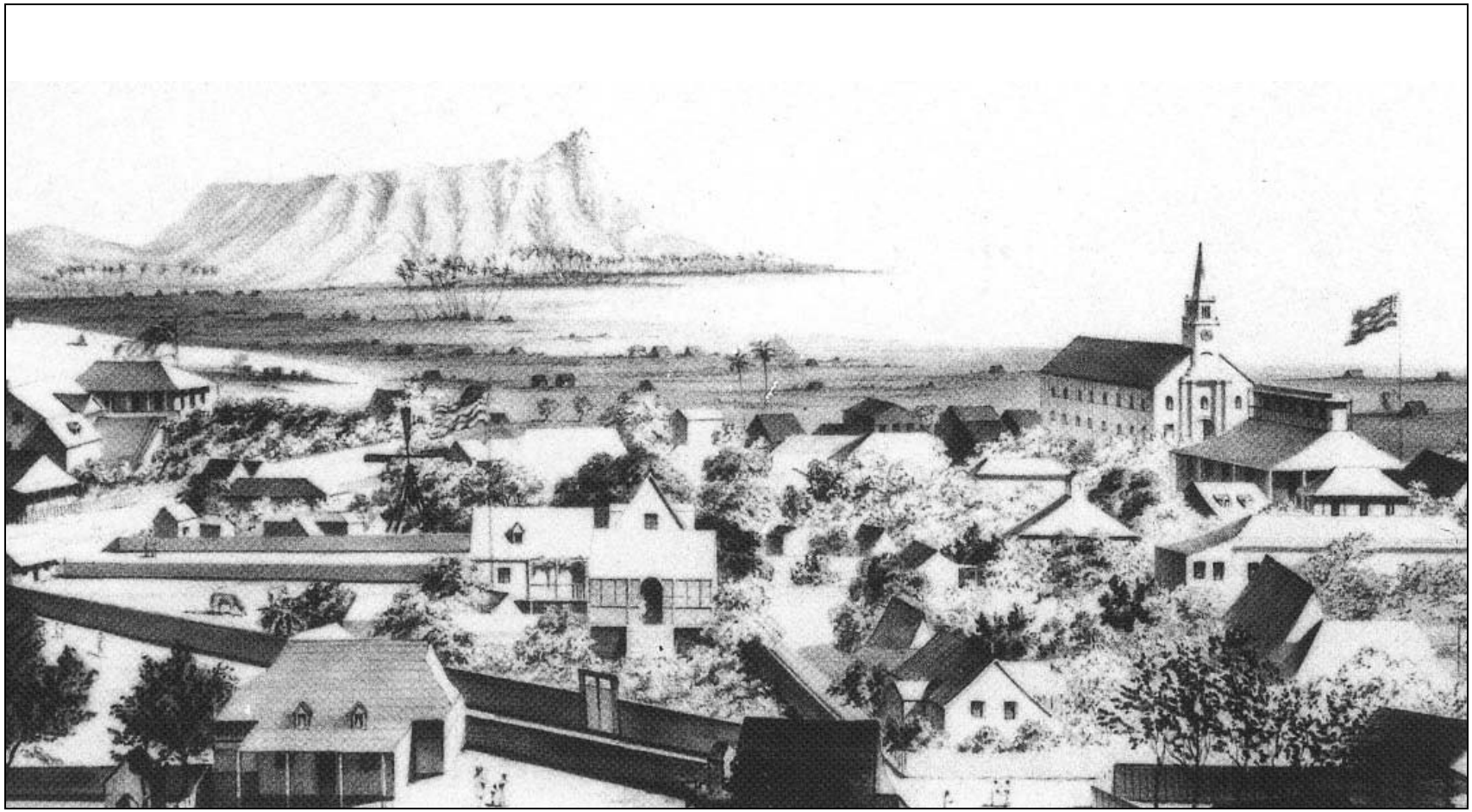

Figure 12. 1853 Sketch by Paul Emmert (original sketch at Hawaiian Historical Society; reprinted in Grant 2000:5); note marsh land *makai* and east (left) of Kawaiaha‘o Church (building with tall steeple)

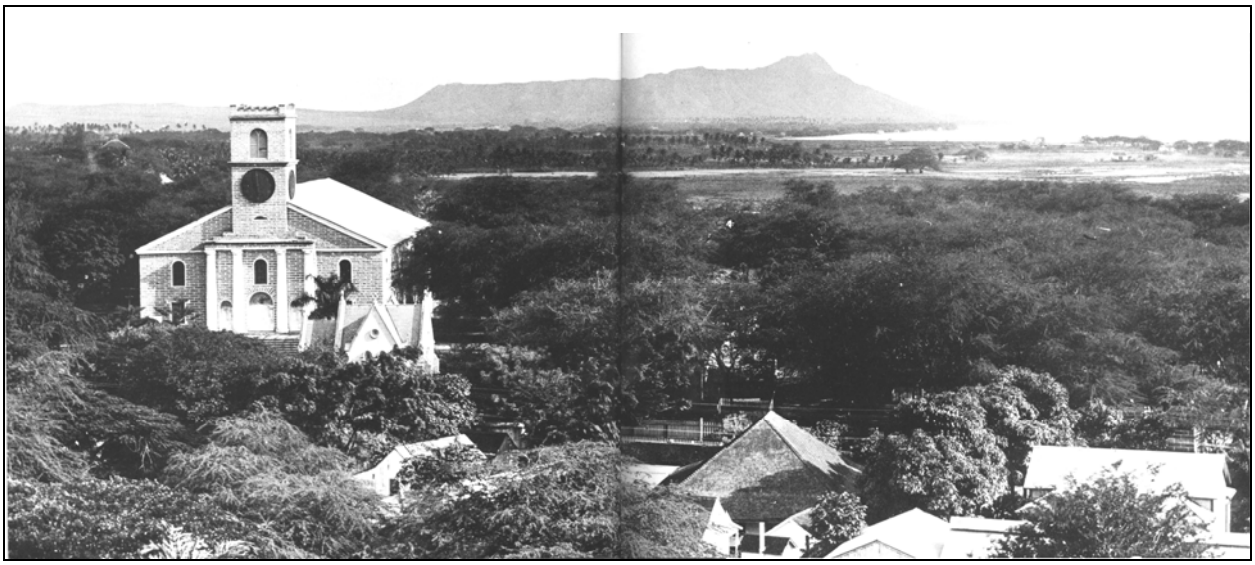

Figure 13. 1887 (circa) photograph of Honolulu and Waikīkī; Kawaiaha‘o Church in left foreground; the project area is within the marshlands seen in the right upper background (original photograph at Hawai‘i State Archives, Henry L. Chase Collection; reprinted in Stone 1983:84-85)

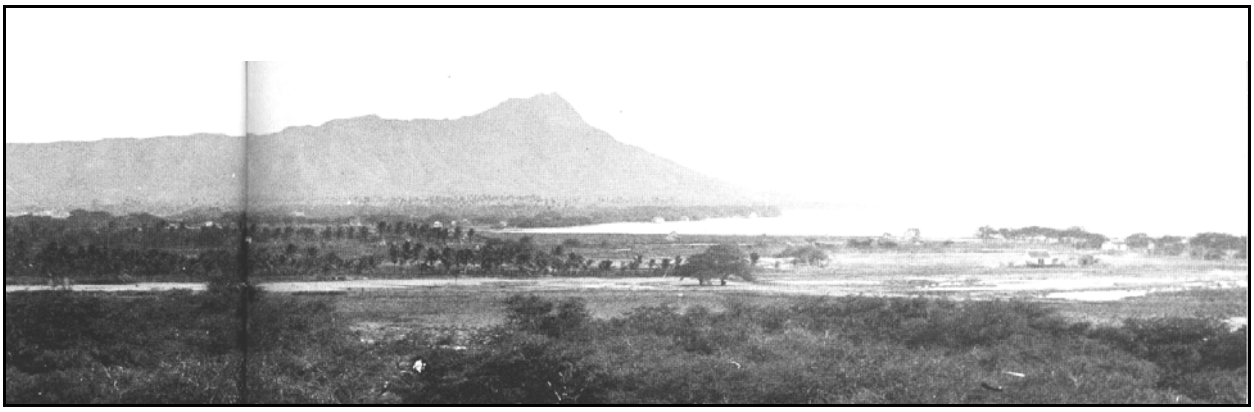

Figure 14. Enlarged inset section on 1887 (ca.) photograph (Figure 13 above) showing marshlands and scattered huts along the coast near the project area

2.4 Mid-Nineteenth Century to Early Twentieth Century

Among the first descriptions of Kewalo/Kaka‘ako by the Hawaiians themselves are the testimonies recorded during the 1840s in documents associated with Land Commission Awards (LCA) and awardees of the Māhele. The LCA records indicate that the traditional Hawaiian usage of the region and its environs may have been confined to the farming of fishponds and wetland agriculture in areas *mauka* or toward Waikīkī at the very limits of the field system descending from Makiki and Mānoa valleys. However, the testimonies do indicate that the area was lived on and was shaped by Hawaiians before the nineteenth century. The LCA records and historic maps (see Figure 11) also reveal that, midway through the nineteenth century, taro cultivation, traditional salt making, and fishpond farming activities continued within the Kewalo/Kaka‘ako area. These activities and the land features that supported them would be eliminated, or buried, during the remainder of the nineteenth century by the urbanization of Honolulu. The LCA records, historic maps, and archival photographs document traditional Hawaiian settlement and subsequent historic land usage within and in the vicinity of the present project area.

The Organic Acts of 1845 and 1846 initiated the process of the Māhele – the division of Hawaiian lands – which introduced private property into Hawaiian society. In 1848, the crown, the Hawaiian government, the *ali‘i* (chiefs), and fort land titles were granted. The common people (*maka‘āinana*) began to receive their *kuleana* awards (individual land parcels) in 1850. It is through records for Land Commission Awards (LCA) generated during the Māhele that the first specific documentation of life in Kewalo/Kaka‘ako, as it had evolved up to the mid-nineteenth century, come to light.

The 1884 map by Sereno Bishop (Figure 15) shows the location of the LCA parcels near the current project area. This figure is color-coded to match the description of the lands indicated in LCA testimonies: blue for fishponds, green for *lo‘i* fields, yellow for house lots. As can be seen, the area in the vicinity of the project area was used for fishponds, *lo‘i,* and house lots which are situated near established roads. The testimonies for LCA parcels within and near the project area are summarized in Table 1. The current project area is located within the *‘ili* of Kewalo which was awarded as LCA 10605 (see Section 3.4.1.1). For further information regarding LCAs within the greater Kewalo and Kukuluāe‘o regions please refer to previous nearby CSH archaeological studies which provide thorough documentation of the LCAs within these regions (O’Hare et al. 2008, Thurman et al. 2009, Hammatt 2008).

Several parcels labeled as “fort land” are documented in the near vicinity of the project area. The Act of June 7, 1848, set aside land to supply revenue for the government and specifically named certain lands as fort lands. Fort land was generally granted to high ranking Hawaiians with strong allegiances or kinship to the chief.

> In the Act of June 7, 1848, some 52 *ilis* had been set apart by name in the districts of Kalihi, Waikiki, and Honolulu proper, and classified as “Fort Lands” to supply revenue needed for the support of the garrison at Fort Honolulu. These, like other government areas, were subject to sale. On July 11, 1851, an Act was passed ordering the disposal of various government lands on each island in lots of from

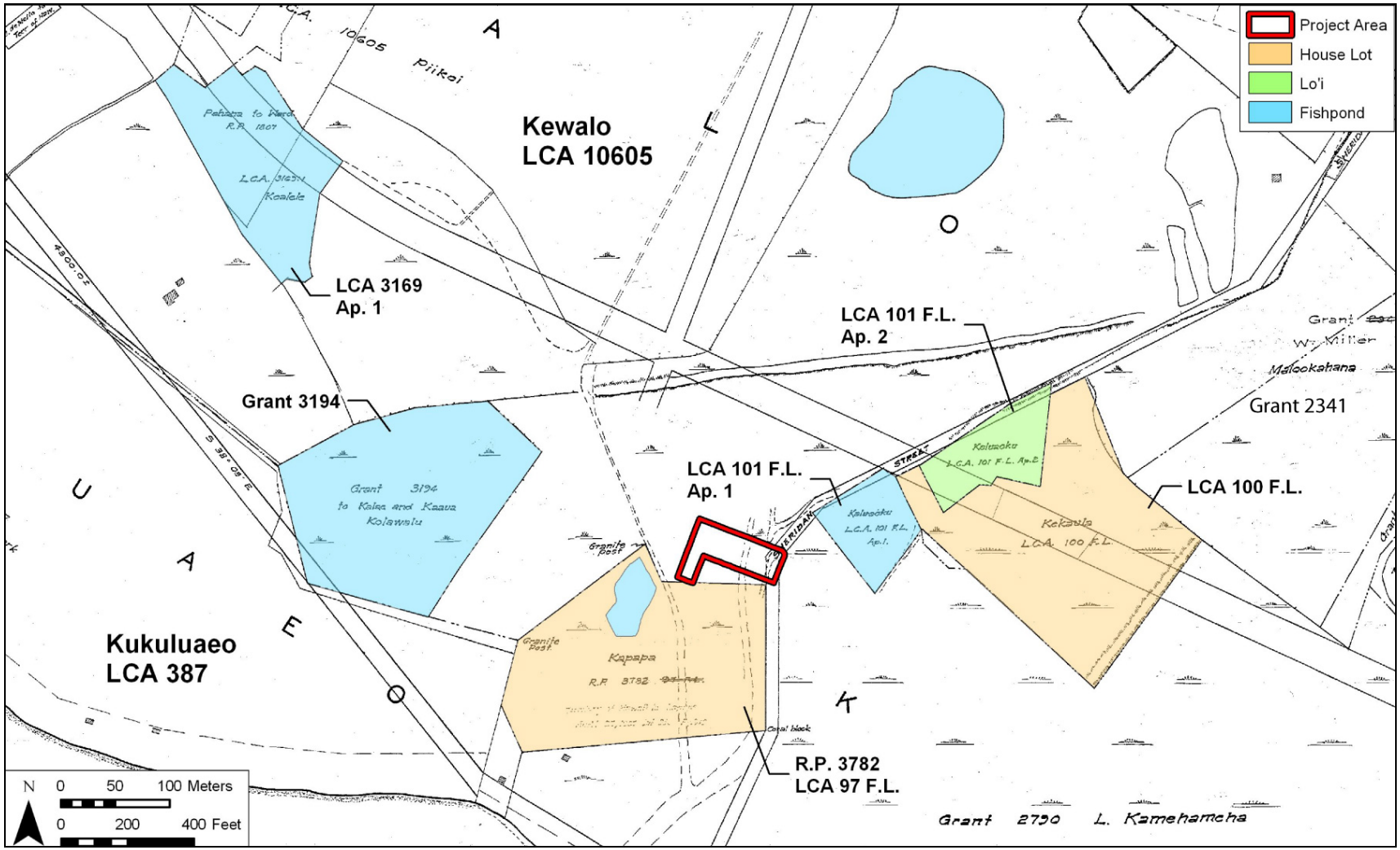

Figure 15. 1884 map of Honolulu, Kewalo Section, by S. E. Bishop, showing Land Commission Awards within and near the project area (Hawai‘i Land Survey Division, Reg. Map. No. 1090) (note: LCA’s and grants with no information or incomplete information are not color coded)

Table 1. Grants and Awards In the Vicinity of the Current Project Area (refer to Figure 15)

Grants and Awards	‘Ili	Awardee	Land Use
3194	Kolowalu	Ka‘aua and Kalae	Fishpond
3169:1	Kewalo	Koalele	Taro patches and fishponds
10605	Kewalo	K. Piikoi	No information
387	Kukuluā‘eo	ABCFM	Salt lands attached to Punahou
097 F.L.	Kālia	Kapapa	Taro ponds, ki‘opua/ponds for young fish, taro lo‘i, and a house site
100 F.L.	Kālia	Kekaula	2 taro ponds, 5 fish ponds, a patch, a pasture, and a house site
101 F.L.	Kālia	Kaluaoku	2 ponds, 3 fish ponds, and one lo‘i
2790	Kālia, Waikīkī	Lot Kamehameha	Incomplete information; LCAp 708 indicates salt pans, ponds, and house lots
2341	Kālia	William Miller	No information

> one to fifty acres. The Act restricted the sale to residents of the kingdom and specified a minimum price of fifty cents an acre.
>
> It was specifically stated that *kuleana* areas within Fort Lands should be excluded from this general sale, regardless of whether or not these had been entered with the Land Commission. A distinct series of Land Commission Awards were issued for the *kuleanas* in these areas, and they are marked “F.L.” or “Fort Lands” to distinguish them from other awards. Grants were issued on these awards. (Hobbs 1935:55)

According to Laws of 1851 relating to the Fort Lands of Honolulu:

> Whereas the reserve of lands, made by the law of the 7th June, 1848, for the use of the fort, in Honolulu, to be cultivated by soldiers, or other tenants, under the direction of the governor of Oahu, has not been productive, and consists of waste and scattered pieces, interspersed with the lands of private individuals: Therefore-- Be it enacted by the Nobles and Representatives of the Hawaiian Islands, in Legislative Council assembled..(the Act of June 7, 1848) shall be, and is, hereby, repealed. (Laws of 1851:28)

Further information regarding the sales of government fort lands was described by W. D. Alexander in 1891:

> At the same time it was ordered that the so-called “Fort Lands” should be surveyed and sold in lots at auction, after fifty acres had been reserved for the

> "Royal Agricultural Society," and after the *kuleana(s)* contained in the said lands should have been surveyed out, "whether the same had been entered at the Land Commission or not." A distinct series of L.C. Awards was issued for these *kuleana(s)* marked F.L. (Fort Land) to distinguish them from other Awards, and Royal Patents were granted for such *kuleana(s)* free of charge to the awardees. (Laws of 1851, p. 28). (Quoted from Alexander 1891:11)

Although the Fort Lands were repealed in 1851, the lands in the near vicinity of the project area appear to have continued to be cultivated and utilized as shown on the 1855 La Passe map (see Figure 11). Historic maps and LCA claims indicate the fort land parcels in the near vicinity of the current project area were handed down from successive generations of Hawaiian families.

2.4.1 The Māhele, ‘Ili and ‘Lele Lands of Honolulu

On southeastern O‘ahu, *ahupua‘a* generally extended from the Ko‘olau mountain range on the *mauka* side to the seacoast on the *makai* side. The *ahupua‘a* were divided further into smaller land divisions called *‘ili*. However, in the Honolulu/Waikīkī area, land divisions became more complicated. Because of the early development and importance of the coastal areas, several *ahupua‘a,* such as Nu‘uanu, Pauoa, Makiki, Mānoa, and Pālolo became "cut off" from the sea. In order to retain some access to all of the resources of the land, several *‘ili* had *lele* or jump lands, which were smaller contiguous or non-contiguous parcels in the uplands, in the river valleys, and along the coast, were created.

An early surveyor for the Hawaiian Government Survey office explains about *lele* in general.

> The next subject that claims attention is that of the subdivision of the *ahupua‘a*. The subdivision of the *ahupua‘a* were called *ili*. . . . each, of course, named with its own individual title and carefully marked out as to boundary. . . .
>
> There were two features of the *ili*, referred to by the terms *lele* and *ku*, which are worthy of notice. . . . the *ili* often consisted of several distinct sections of land—one, for instance, on the seashore, another on dry, open land, or *kula*, another in the regularly terraced and watered *kalo* patch or *aina loi* district, and another still in the forest, thus again carrying out the equable division system which we have seen in the *ahupua‘a*.
>
> These separate pieces were called, *lele*, i.e., "jumps," and were most common on Oahu. . . . Punahou had anciently a lot on the beach near the Kakaako Salt Works [Kukuluāe‘o]; then the large lot with the spring and *kalo* patches where is now the school, and again a forest patch on the steep sides of Manoa Valley. Kewalo meanwhile had its seacoast adjoining Waikiki, its continuous *kula* on the plain, and one-half of Punchbowl Hill and its *kalo* land in Pauoa valley. . . .
>
> These different pieces were called variously, either by their own individual name or by that of the whole *ili*, thus puzzling one sadly when attempting to obtain information with respect to them [Lyons 1894:1697].

2.4.1.1 Kewalo

The current project area is located within LCA 10605. The ‘*ili* of Kewalo was awarded to Kamake‘e Pi‘ikoi, wife of Jonah Pi‘ikoi, as part of LCA 10605, ‘*āpana* (lot) 7. Jonah Pi‘ikoi was an *ali‘i,* a retainer of Kauikeaouli, Kamehameha III, who held several government posts. The award was divided between himself and his wife (Kame‘elehiwa 1992:269). Unfortunatly no additional land use data has been found on LCA 10605.

LCA 3169 to Koalele, located northwest of the project area was described as:

> Mahoe, sworn, says he knows the land of Claimant in ‘Kewalo’. It consists of some *kalo* [taro] patches *mauka* and some *Lokos* [fishponds] *makai*. The *kalo* patches are bounded *mauka* by Kealoha; bound Waikīkī side by Kuaipaka’s, *makai* by the konohiki, ‘*Ewa* side by J. Booth. The fish ponds are bounded *mauka* by the *konohiki*.
>
> Waikīkī and *makai* side, the same. Honolulu side by J. Booth. Client received his land from Kapihi in the life time of Kinau and he has held the same without dispute till the present time [Foreign Testimony, Vol. 3:507].

The *mauka* portion of Koalele’s claim which includes the taro patches is not shown on the 1884 map (see Figure 15); it is likely somewhere immediately *mauka* of King Street. The *makai* portion - two “*Lokos*” or fish ponds - is located northwest of the project area.

2.4.1.2 Kolowalu

The Kolowalu parcel, Land Grant 3194, is located just west of the current project area in Kewalo. During the Māhele in ca 1848, a Hawaiian man named Kahue claimed seven taro patches in Kolowalu, a house lot with two houses in Kewalo, two fishponds in Kolowalu, and 7 salt beds in Kukuluāe‘o as part of LCA 1496. He stated that the two fishponds in Kolowalu were given to him by Kalei in the year 1846. The LCA testimony indicates that consultation needed to be made with several of his neighbors before awarding the land. The claim was eventually not awarded to Kahue.

The Kolowalu parcel was granted to Ka‘aua, *kāne* (man) and Kalae, *wahine* (woman) as Land Grant 3194 in the year 1878. This is some evidence that the Kolowalu parcel was not part of a Land Commission Award to an *ali‘i* or to a commoner in the mid-nineteenth century Māhele, as Land Grants recorded the sale of land set aside (or returned by the *ali‘i*) for the Hawaiian government, nor for land awarded as LCA parcels. These government lands were sold in fee simple to generate income for the kingdom. Although the land grant was not awarded until 1878, there is evidence that the awardee, Ka‘aua, had a close association with this land even before the mid-nineteenth century Māhele. Ka‘aua was a priest for the chief ‘Aikanaka, who was born around 1790. Aikanaka was the father of the Hawaiian chiefess, Analea Keohokālole (born in 1816), the mother of two future Hawaiian monarchs, Kalākaua and Lili‘uokalani. Thus if Ka‘aua was ‘Aikanaka’s contemporary, he was associated with the land in the early to mid nineteenth century, before the 1848 Māhele. Grant 3194 states that Kalākaua Kamehameha IV had:

> this day granted and given, absolutely, in Fee Simple unto Kalae (W) and Kaaua (K), his faithful and loyally disposed subject for the consideration of One hundred

> and fifty, paid into the Royal Exchequer, all that certain piece of Land situated at Kolawalu [*sic*]. . .

For a Cultural Impact Assessment for the Kaka‘ako Community Development District Mauka Area (Spearing et al. 2008), CSH contacted Paulette Kaleikini, a cultural descendant of Kaka‘ako and spokesperson for the Kaleikini family. Ms. Kaleikini's ancestors were granted the land of Kolowalu

> There were many fishponds in the Waikīkī, Honolulu, Kaka‘ako, Kewalo and Kalihi *ahupua‘a*. The genealogy and history of my *‘ohana* (family) pertains to many of these fishponds. The Ward Village project sits on part of Land Grant 3194 which belonged to my *kūpuna* Ka‘aua. On this property named Kolowalu was a fishpond. The reason why this *‘āina* (land) was given to *kūpuna* Ka‘aua was because he was *‘ohana* [family] to the king. Ka‘aua was a *kahu* (priest) of ‘Aikanaka, father of the king. Ka‘aua was a cousin to my great-great grandfather, a caretaker of the fishpond. It was the *kuleana* (responsibility) of some of my *‘ohana* to raise the fish for the *ali‘i* (royalty) who were, of course, their *pilikoko* (blood relative). It wasn't by chance that this *‘āina* was granted to Ka‘aua. It was the history of the *‘ohana* on that *‘āina* that was considered. . . . William Luther Moehonua who was the son of Aikanaka and Napua. Napua was the sister of my great-great grandfather, Ialua; the same *kūpuna* who was the *kahu* of the fishponds in Kaka‘ako and Kalihi. Aikanaka was the grandfather of King Kalākaua and Queen Lili‘uokalani. My great grandfather was G.W. Keaweamahi, the son of Ialua.

2.4.1.3 Kukuluāe‘o

The *‘ili* of Kukuluāe‘o was originally awarded to the king, but he returned it to the government. The ‘*ili* was then awarded to the American Board of Commissioners for Foreign Missions (ABCFM) as LCA 387. An 1881 map of O‘ahu (Figure 16) suggests that the project area may have been within this award, but the LCA testimony is too vague for certainty. Other historic maps suggest the project area is outside Kukuluāe‘o (refer to Figure 9, Figure 10 and Figure 15).

Initially the land of Kukuluāe‘o was associated with Punahou School in Mānoa Valley, as Chief Boki gave the Punahou lands to Hiram Bingham, pastor of Kawaiaha‘o Church in 1829 (DeLeon 1978:3), as stated in the LCA testimony:

> The boundaries of that part which lies on the sea shore we cannot define so definitely, but presume there will be no difficulty in determining them as it is commonly known as pertaining to Punahou. This part embraces fishing grounds, coral flats and salt beds [Land Commission Award 387]
>
> The above land was given by Boki to Mr. Bingham, then a member of the above named Mission and the grant was afterwards confirmed by Kaahumanu (Foreign Register, Vol. 2:33). The *Makai* part of Punahou is bounded *Mauka* by "Kewalo" and "Koula", Waititi side by "Kālia", seaward it extends out to where the surf breaks. Honolulu side by "Honolulu."

Figure 16. 1881 Hawaiian Government Survey map of O‘ahu by R. Covington (Hawai‘i Land Survey Division, Registered Map No. 1381), showing the project area within or surrounded by Kukuluāe‘o LCA 387 to the ABCFM

> This land was given to Mr. Bingham for the Sandwich Island Mission by Gov. Boki in 1829. . . . From that time to these the S. I. Mission have been the only Possessors and *Konohikis* of the Land . . .
>
> The makai part of Punahou is bounded:
>
> Mauka by Kewalo and Koula
>
> Waititi side by Kālia
>
> Seaward it extends out to where the surf breaks
>
> Honolulu side by Honolulu.
>
> The name of the *Makai* part is Kukuluaeo. There are several tenants on the land of Punahou whose rights should be respected [Foreign Testimony, Vol. 3:115].

In the Māhele, this sea land became "detached" from the Mānoa award and was instead given to the pastor of the Kawaiaha‘o Church, as noted in Punahou School history:

> There belonged in former times, as an appurtenance to the land known as Kapunahou, a valuable tract of salt-ponds, on the sea-side to the east-ward of Honolulu harbor, called Kukuluaeo, and including an area of seventy-seven acres. At the time of the settlement of land claims before the Land Commission, application was made for it by the successor of Mr. Bingham in the pastorate of Kawaiahao Church—he believing it to be a glebe land for the support of that church. His claim was resisted by the then Principal of Punahou School, but without success, and a Royal Patent was issued, severing it from the Punahou estate, and awarding it to the applicant as his private property [Punahou School and Oahu College 1866].

2.4.1.4 Kālia

The ‘*ili* of Kālia in Waikīkī was awarded to Victoria Kamāmalu, but she returned the land to the government. At least 41 *kuleana* claims were awarded in Kālia. The number of claims is uncertain because the testimony of any claim near a major road, such as King Street, lists the property by its address rather than the ‘*ili* name.

A 1921 Land Court Application map (No. 709) applied for by the Hawaiian Dredging Company, Ltd., indicates land to the east of the current project area, within Grant 2790 to Lot Kamehameha, included salt-pans and abundant ponds (Figure 17). A 1928 Land Court Application map (No. 880) applied for by the Bishop Trust Company, Ltd., indicates the project area was located within an area which had been subdivided into six lots (Figure 18), located just north of LCA 97 F.L.

To the south of the current project area is LCA 97 F.L./ Royal Patent 3782 awarded to Kapapa and recorded as being located within the *ili* of Kālia (refer to Figure 15). Testimony for LCA 97 F.L. identifies the parcel as comprising taro ponds, *ki‘opua*/ponds for young fish, and taro *lo‘i* (Native Register vol. 3, pg. 762; March 26, 1852) (Figure 19). A house lot is also mentioned in

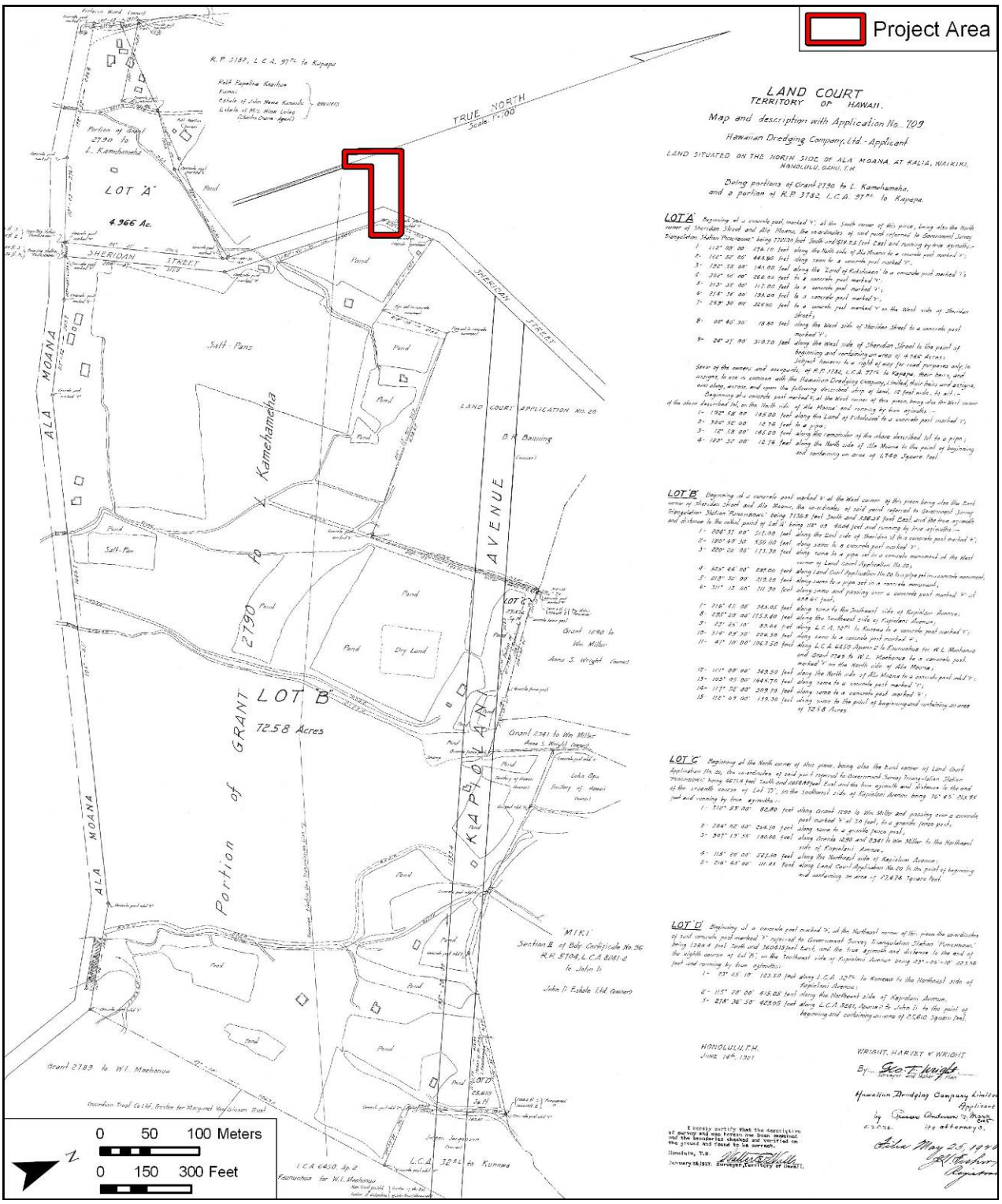

Figure 17. 1921 Land Court Application map (No. 709) showing salt-pans and ponds just southeast of the current project area

Figure 18. 1928 Land Court Application (No. 880) showing several lots within the project area (notice LCA 97 F.L./ Royal Patent 3782 to the south of the project area)

Figure 19. A compiled map using Land Court Maps from 1927 (No. 784), 1939 (No. 1250), and 1940 (No. 1306) showing land use within LCA 97 F.L. /Royal Patent 3782 , located just south of the current project area, during the early to mid twentieth century

another document (Native Testimony vol. 10, pg. 339-340; February 21, 1854).

No. 97 F.L., Kapapa, Honolulu, March 26, 1852

N.R. 762v3

See the Testimony Page 339 V.10 N.T.

Greetings to you: Here is my claim for taro ponds and three *ki‘opua* /ponds for young fish/ and a share of a taro *lo‘i* in Kalia ‘Ili in Waikiki, Oahu. It is a right from the time of Liholiho.

With thanks,
KAPAPA X, his mark
The Land Commissioners, Honolulu

N.T. 339-340v10

No. 97 [F.L.], Kapapa, 21 February 1854

Paoo, sworn, Kapapa's claim is in Kalia, Waikiki, Oahu of two ponds, three fry deposits, a patch and a house lot in three pieces probably.

Section 1 - Two ponds, three fry deposits and house lot.
Mauka, Waialae and *Makai*, Government land
Honolulu, Piikoi's land.

Section 1 - Patch.
Mauka, Government property
Waialae, Kekaula's land
Makai, Kaehuokalani's land
Honolulu, Piikoi's land.

Land received since Nu‘uanu to the present time from his parents. No objections.

S.P. Kalama (government official), I have approved this claim. It is proper. [No. 97 F.L. (no award); R.P. 3782; Kalia Honolulu Kona; 1 ‘āp.; 6.5 Acs; Patent without award]

Records for other awards - including testimonies entered for nearby fort lands- make the history and spirit of Kewalo come alive. Adjacent to the east side of Sheridan Street, LCA 100 F.L. to Kekeula is recorded as consisting of taro ponds, fish ponds, a patch, a house site, and a pasture (Native Testimony, Vol. 10: 304) (see Figure 15).

No. 100 F.L., Kekaula, Honolulu, March 26, 1852

N.R. 763-764v3

Greetings to you all: Here is my claim for taro ponds and five *ki‘opua*/ponds for raising young fish/ in the *ili* of Kalia kai in Waikiki, Oahu. It is a right from the *makuas*. I am, with thanks,

Kekaula X, his mark

Land Commissioners, Honolulu

N.T. 304v10

No. 100 FL, Kekaula, 25 July 1853

Uma, sworn, I have seen his land section in Kalia, Waikiki of 2 ponds, 5 fish ponds, 1 patch, house site and a pasture in one section of land.

Mauka, Wm. Miller's land

Waiailae, *Makai*, Honolulu, Government Land

Land from his parents at the time of Kamehameha I. I did know in the same way.

[Award 100 F.L.; R.P. 7553; Kalia Waikiki Kona; 1 ap.;8.5 Acs]

LCA 101 F.L., located east of the project area and adjacent to Sheridan Street (refer to Figure 15), included ponds, *ki‘opuaa* for young fish, and one *lo‘i* (Native Register, Vol. 3:764). LCA 101 F.L. was claimed by Kaluaoku in 1852.

No. 101 F.L., Kaluaoku
N.R. 764v3

See the Testimony Page 339 V.10 N.T.

The Land Commissioners of the Hawaiian Islands, Greetings: I hereby/ apply for/ quiet title of my land claim in Kalia kai. There are two ponds and three small *ki‘opua* ponds/for young fish/ and one *lo‘i*. This is a very old right, from the *makuas* to the present. With thanks,

KALUAOKU X, his mark

Witness: S.P. Kalama, Honolulu 24 March 1852

N.T. 339v10

No. 101 FL, Kaluaoku, 21 February 1854

Paoo, sworn, Kaluaoku's claim is in Kalia, Waikiki, Oahu of two ponds, three fry deposits (ponds), and one patch in two pieces.

Section 1 – Two ponds and three fry ponds.

Mauka, Kekaula's land

Waialae, Government land

Makai and Honolulu, Government land

Section 2 – One patch.

Mauka, Waialae, Miakai, Kekaula's land

> Honolulu, the tenant's group patch.
>
> Land received at the time of Kamehameha I from his parents, they had received it from their parents long ago.
>
> Kalauoku died in 1853 of small pox, his daughter, Pale, has this land now.
>
> Kuaio, sworn, I have seen this claim just as Paoo has related here.
>
> (Note: There are no awards for these two claims on the Books of the Commissioners, FL 101 and 97, but they have been patented in the Home Office.)
>
> [Award 101 F.L.; (no award); R.P. 3781; Kalia Waikiki Kona; 2 ap.; 3.3 Acs; Royal Patent without award]

2.4.1.4.1 Summary and Interpretation of LCA Testimony and Land Court Applications

Several LCAs, originally awarded as fort lands, were located in the near vicinity of the current project area. The LCA testimonies indicate these lands were awarded by Kamehameha I. As Grant 097 explains, the land was gifted "since Nu‘uanu", suggesting these fort lands were granted by the king after the battle of Nu‘uanu, likely to loyal warriors and their families. The LCA testimonies and Land Court Application maps indicate these lands were passed down through generations of Hawaiian families. This suggests the land in the vicinity of the project area likely continued to be utilized by Hawaiian families from the time which the land was granted as fort land (circa 1850s) through the early 1900s.

2.4.2 Kaka‘ako Salt Works and the Salt Pans of Kewalo and Kukuluāe‘o

Much of the land in the general vicinity of the current project area was used to produce salt, as shown in the 1881 Covington map (see Figure 16) and the 1921 Land Court Application map (No. 709) (see Figure 17). The Hawaiians used *pa‘akai* (salt) for a variety of purposes, to flavor food, to preserve fish by salting, for medicines, and for ceremonial purposes. David Malo described the traditional method:

> O ka paakai kekahi mea e pono ai, he mea e ono ai, ka ia, a me ke koekoe o ka paina ana, he mea hana ia ka paakai, ma kekahi aina, aole i hana a ma kekahi aina, o ke kai makai, e kii aku no ka wahine, a lawe mai ma ke poi, a ke kai hooholo ia mai kekahi ma kauwahi mai.
>
> E waiho kela kai ma kekahi poho paha, he ekaha paha, he kahe ka paha, a liu malaila, alaila lawe ana kauwahi e, a paakai iho la no ia, o ka papa laau ka mea kui poi [Malo 2006:73].
>
> Translation
>
> Pa‘akai (salt) is another beneficial item. It is used to make fish delicious and tasteless foods edible. Pa‘akai is made at a particular place, [but] it [salt] is not actually made from this spot, rather it [salt water] came from the sea. A woman

> went to get some when the sea crashed [upon the rocks] and she ran back [the salt water] to this particular spot.
>
> That salt water (kai) is placed in, perhaps, a depression (poho) or a "Bird's nest" (ēkeha) or rock basin (kāheka) and allowed to evaporate (liu). Then it is taken to another spot and is formed into pa‘akai. Wooden boards (papa lā‘au) are used to pound poi (*mashed cooked* kalo *corms*) on [Malo 2006:95].

In 1903, Nathaniel Emerson translated David Malo's articles on early Hawaiian life. In his publication, the translations are not literal, but include information that Emerson added to clarify the accounts. In Emerson's translation:

> Salt was one of the necessities and was a condiment used with fish and meat, also as a relish with fresh food. Salt was manufactured in certain places. The women brought sea-water in calabashes, or conducted it in ditches to natural holes, hollows and shallow ponds (*kekaha*) on the sea-coast, where it soon became strong brine from evaporation. Thence it was transferred to another hollow or shallow vat, where crystallization into salt was completed [Malo 1951:123].

Captain Cook was the first to note the method of making salt in prepared "saltpans."

> Amongst their arts, we must not forget that of making salt, with which we were amply supplied, during our stay at these islands, and which was perfectly good of its kind. Their saltpans are made of earth, lined with clay; being generally six or eight feet square, and about eight inches deep. They are raised upon a bank of stones near the high-water mark, from whence the salt water is conducted to the foot of them, in small trenches, out of which they are filled, and the sun quickly performs the necessary process of evaporation. . . . Besides the quantity we used in salting pork, we filled all our empty casks, amounting to sixteen puncheons, in the Resolution only [Cook 1784:151].

Captain James Cook encountered the Hawaiian Islands in 1778. In the years following, most visitors to the islands were British and American fur-traders, who stopped at Hawai‘i on their way to China. One reason for their visit was to stock up on food and water, but another concern was to buy or trade for salt, which was used to cure the seal and mammal pelts collected from the Northwest Coast. During Kotzebue's visit in 1816 and 1817, he noted that "Salt and sandalwood were the chief items of export" (in Thrum 1905:50).

> The journals of none mention the object of call other than for refreshments, though one, 3 some years later, records the scarcity and high price of salt at the several points touched at, with which to serve them in the curing of furs obtained on the coast. In all probability salt was the first article of export trade of the islands and an object, if not the object, of these pioneer fur-traders' call [Thrum 1905:45].

The missionary William Ellis, on a tour of the Hawaiian Islands in 1822 and 1823, also noted these salt pans and recorded the final step of crystallization.

> The natives of this district (Kawaihae) manufacture large quantities of salt, by evaporating the sea water. We saw a number of their pans, in the disposition of which they display great ingenuity. They have generally one large pond near the sea, into which the water flows by a channel cut through the rocks, or is carried thither by the natives in large calabashes. After remaining there for some time, it is conducted into a number of smaller pans about six or eight inches in depth, which are made with great care, and frequently lined with large evergreen leaves, in order to prevent absorption. Along the narrow banks or partitions between the different pans, we saw a number of large evergreen leaves placed. They were tied up at each end, so as to resemble a narrow dish, and filled with sea water, in which the crystals of salt were abundant [Ellis 1827:403-404].

In an article on Hawaiian salt works, Thomas Thrum discusses the large salt works at Ālia Pa‘akai (Salt Lake in Moanalua) and at Pu‘uloa on the western loch of Pearl Harbor. Kamakau (1961:409) reported “The king and Isaac of Pu‘uloa are getting rich by running the salt water into patches and trading salt with other islands.” The salt was sent to Russian settlements in the Pacific Northwest, where it was used to pack salmon (*Hawaiian Gazette,* January 29, 1897). Thrum also mentions a salt works in Kaka‘ako.

> Honolulu had another salt-making section in early days, known as the Kakaako salt works, the property of Kamehameha IV, but leased to and conducted by E. O. Hall, and subsequently E. O. Hall and Son, until comparatively recent years. This enterprise was carried on very much after the ancient method of earth saltpans as described by Cook and Ellis [Thrum 1924:116].

Four separate types of salt features were known to exist including ponds near the shore that fill with salt water at high tide (*ālia*), the drains (*ho‘oliu*) where the salt water is transferred to smaller clay-lined or leaf-lined channels, the natural depressions (or modified depressions) in the rocks along the shore where salt formed naturally, and the salt *kula*, which was waste land, land that could probably not be used for agriculture as it was impregnated with salt.

The export of salt declined in the late nineteenth century. Thrum (1924:116) states that the apex of the trade was in 1870, but by 1883, he noted that “pulu, salt and oil have disappeared entirely” from the list of yearly exports (Thrum 1884:68). By 1916, only one salt works, the Honolulu Salt Co., was still in operation. Salt continued to be manufactured for local use; the Kaka‘ako Salt Works appears on maps as late as 1891 and a page in Victoria Wards’s ledger for 1883 notes a yearly income of $651.50 received from her “Salt Lands” in Kukuluāe‘o (Hustace 2000:50).

The Chinese were involved in salt production, usually in concert with their management of fishponds. One son of a Chinese resident remembered that (ca. 1900) the Chinese form of salt production was from salt pans bordering the sea, fed continually with seawater by the tides.

> Both the natural tides and the Chinese method of peddling a wooden wheel that transported water upward, helped to keep the salt beds damp with about three inches of water. After a few months, the senior Mau would drain off the remaining water and use a wooden rake with deep prongs to break up the salt.

> When the bed was dry a flat rake was used to flatten and smooth out the salt. Later it was raked into piles, packed in cloth bags and distributed [Chong 1998:108].

The traditional method of salt production was gradually replaced by the Chinese method, as the Chinese immigrants began to take over the traditional salt and fish ponds of Honolulu in order to grow rice, to raise ducks, and to make salt. In a 1906 article, Rev. Westervelt (1906:43-46) explained the Chinese method of salt evaporation for the Honolulu salt beds. After allowing the sun to evaporate some of the water, the Chinese worker stepped into the evaporation pan and scraped the salt into a pile in the center with a simple wooden scraper. The worker then threw a large basket-shaped scoop into the brine and used a tin dipper to move the salt to the basket. Two baskets, one on each side of a pole, were then carried on the back of a worker across the thin earth dykes between the salt pans. The baskets were dumped into large drying piles, where the remaining water seeped out into the ground. The salt was then sewn into gunny sacks and sent to the market for sale.

By 1901, most of the fishponds and salt pans *makai* of the Ward "Old Plantation" area were reported as abandoned (Figure 20). In that year, the Hawai‘i First Legislature Assembly (1901:185) proposed to build a ditch to drain away the "foul and filthy water that overflows that district at the present time."

> The district makai of King St. and the Catholic Cemetery, Ewa of Mrs. Ward's (the Old Plantation), mauka of Clayton St., and Waikiki of the land from King St., leading to the Hoomananaauao Church, consists of six large abandoned fish ponds and a large number of smaller ones, all in filthy condition, fed by springs and flowing into Peck's ditches. Just makai of these ponds, at the end of Clayton street, next to Mr. Ward's, is Peck's place. An artesian well flushing the wash houses flows into two foul ditches, thence to the big pond which is Waikiki of what used to be Cyclomere and next to Mrs. Ward's line [ditch] extending down to Waimanu St. The rear portion of Mrs. Ward's property down to Waimanu St. used to be fish ponds all connecting to the sea by a ditch which is fed by an artesian well. These ponds, with the exception of three, are abandoned.

A 1902 photograph (Figure 21) shows the extensive salt beds of the Kewalo area. Just *mauka* of these salt beds is the general location of what is now Ward Street and Kapiolani Boulevard (Scott 1968:579).

Figure 20. 1887 Wall map showing the project area and the location of the C.P. Ward estate, notice a structure within the current project area

Figure 21. 1902 photograph of the Kewalo Brine (Salt) Basins (photograph reprinted in Scott 1968:579)

2.4.3 Military Works at Kukuluāe‘o

In 1887, a secret organization called the Hawaiian League was formed to push for reform in the government of King Kalākaua. The men wanted to take away much of Kalākaua’s power and form a constitutional monarchy, with the Hawaiian king a mere figurehead. The main power would reside in a new cabinet, dominated by the members of the Hawaiian League, who were mainly *haole* (non-native Hawaiian) businessmen. In 1884, a volunteer military company, called the Honolulu Rifles, was organized. In its first few years it operated mainly for drill exhibitions, often attended by Kalākaua himself, but it gradually became the military arm of the Hawaiian League. Pressured by the Hawaiian League, with the added threat of the Honolulu Rifles, in 1887 Kalākaua dismissed his cabinet, signed a new constitution, and established the Reform Government. An insurrection to the new reform government, led by Robert Wilcox, was attempted in 1889. A supporter of Queen Lili’uokalani for the throne, he organized a volunteer militia, mainly Hawaiians or part Hawaiians, called the Kamehameha Rifle Association. On July 30, they marched on ‘Iolani Palace, demanding that Kalākaua abrogate the 1887 constitution. The king was not at the palace, and Wilcox’s militia was soon boxed in on a structure in the palace yard. They came under fire when the Honolulu Rifles arrived at the palace, and eventually, they surrendered to government forces (Kuykendall 1967:347-352; 426-428).

Although the Honolulu Rifles had been officially disbanded in 1890, many of its former members became a part of the voluntary military force for the Committee of Public Safety, which was instrumental in the overthrow of the Hawaiian monarch, Queen Lili‘uokalani in 1893 (Judd 1971:160). Many members of these early volunteer militias also joined the National Guard

of Hawaii during the years of the Hawaiian Republic, which later became the U.S. National Guard after annexation.

An 1893 map of Kewalo by Walter E. Wall (Figure 22) shows a narrow section of land labeled as the “Honolulu Rifle Assoc.” This land section was probably chosen for target practice based on the absence of any habitations in the area. The narrow portion is crossed by targets with the width of the strip noted as 200 yards. This rifle range is in the Kukuluāe‘o portion of the Victoria Ward Estate, and thus west of the current study area. The Honolulu Rifle Association was organized in 1885, with J. Brodie, C. H. Nicoll, and J.H. Fisher as the officers (Thrum 1887:98). J. H. Fisher was also the commander of Company C of the Honolulu Rifles in 1887 (Adler and Barratt 1973:162). It is not clear if these are two separate organizations, or are two organizations with overlapping membership. This rifle range may have been used by the National Guard of Hawaii in 1893, as mentioned by Judd (1971:187):

> There was considerable emphasis on practice firing [in the National Guard of Hawaii]. . . . A 100 yard rifle range was constructed behind Iolani Palace Barracks which was not only convenient for use but the length of the range approximated the firing distance envisioned for the defense of the government buildings. Accuracy increased from 43% to 57% in the first two weeks of use. (The noise of rifle firing disturbed and alarmed the downtown citizenry, three months later all firing was conducted at a 200 yard range built at the Kaka‘ako Battery.)

2.4.4 The Animal Quarantine Station

The first animal quarantine station in the Hawaiian Islands was established in 1905. A veterinarian would inspect all imported animals, checking for diseases such as cholera in hogs and tuberculosis in cattle. Kennels were added in the facility in 1909 for the quarantine of all dogs brought to the islands, to be kept at the station at the owner’s expense for a minimum of 120 days. During this long period, it would be possible to assure that the animal did not have rabies, thus preventing the introduction of this disease into the islands.

The animal quarantine station is shown on a 1911 map of Kewalo in a block of land in Victoria Ward’s Kukuluāe‘o property, labeled “Animal Quarantine Station; Leased from Mrs. V. Ward” (Figure 23). This quarantine station, “on the Beach Road between Ward avenue and Sheridan street” was described in the 1913 report of the Hawaii Board of Commissioners for Forestry and Agriculture (1913:213).

> The station is located on the beach, the foundation being coral and sand, with a very scant covering of soil, which is easily removed and replaced with white sand. When the tide is high the ground water rises to within 24” of the surface, thereby providing a universal sewer under the entire station and completely obviating any smell of dog.

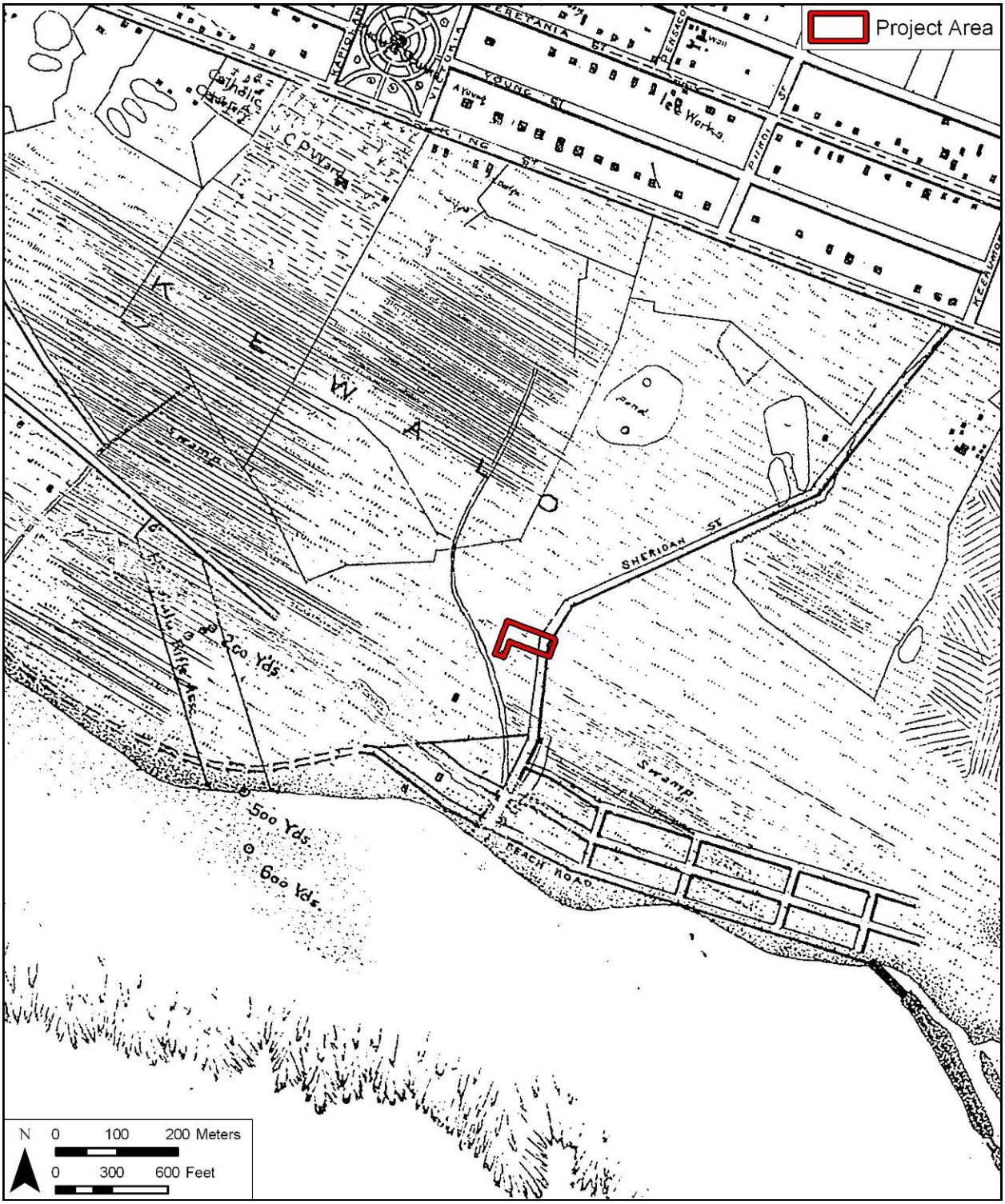

Figure 22. 1893 map of Honolulu (Hawai‘i Land Survey Division, Registered Map 1690) by W. A. Wall, showing project area (outlined in red) and “Honolulu Rifle Assoc.” 200-yard rifle range

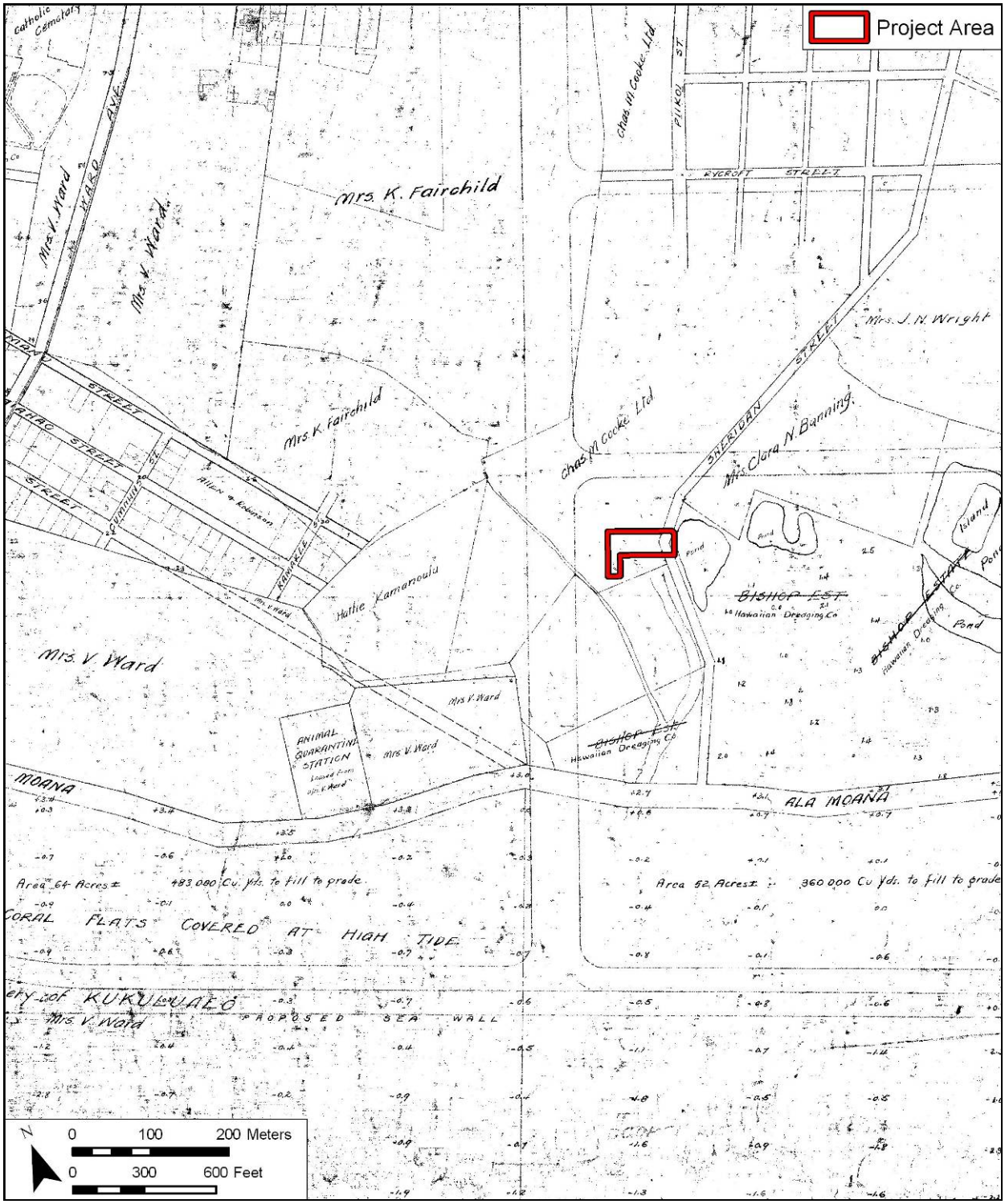

Figure 23. 1911 Podmore map of Honolulu, Kewalo, showing the location of the Animal Quarantine Station (to the west) and lands belonging to the Hawaiian Dredging Company (to the south and east of the current project area)

Besides the quarantined dogs, which were returned to their owners after 120 days, homeless dogs were also kept at the station, but for a shorter period of time. The 1913 report has a photograph of the “lethal chamber” where gas was used to euthanize “mangy and homeless” dogs (Hawaii Board of Commissioners for Forestry and Agriculture 1913:214). It is probable that the euthanized dogs were also buried at the station.

2.5 Early Twentieth Century Land Reclamation Projects

2.5.1 Kaka‘ako Reclamation

By the 1880s, filling-in of the mud flats, marshes, salt ponds in the Kaka‘ako and Kewalo area had begun. The land filling was pushed by three separate but overlapping improvement justifications. The first directive or justification was for the construction of new roads and improving older roads by raising the grade so the improvements would not be washed away by flooding during heavy rains. A report by the Hawaii Board of Health (1908:80) noted:

> I beg to call attention to the built-up section of Kewalo, “Kaka‘ako,” where extensive street improvements, filling and grading have been done. This, no doubt, is greatly appreciated and desirable to the property owners of that locality, but from a sanitary point of view is dangerous, inasmuch as no provision has been made to drain the improved section, on which have been erected neat cottages occupied for the greater part by Hawaiian and Portuguese families, now being from one to three feet below the street surface, and which will be entirely flooded during the rainy season. Unless this is remedied this locality will be susceptible to an outbreak [of cholera] such as we experienced in the past.

As mentioned in the above section, the justification most frequently cited was public health and sanitation, the desire to clean up rivers and ponds that were reservoirs for diseases such as cholera and that acted as breeding places for rats and mosquitoes. Thus as early as 1902 (Hawaii Board of Health 1902:80), it is reported that:

> The Board has paid a great deal of attention to low-lying stagnant ponds in different parts of the city, and has condemned a number of them. The Superintendent of Public Works has given great assistance to seeing that the ponds condemned by the Board are filled. In September a pond on South Street was condemned as deleterious to the public health.

The first areas to be filled were those areas closest to Honolulu town, then moving outwards to Kaka‘ako (Griffin et al. 1987:13) (Figure 24). The first fill material may have been set down for the Kaka‘ako Leper Branch Hospital (between Coral and Keawe Streets), which had been built on a salt marsh. Laborers were hired to “haul in wagonloads of rubble and earth to fill up

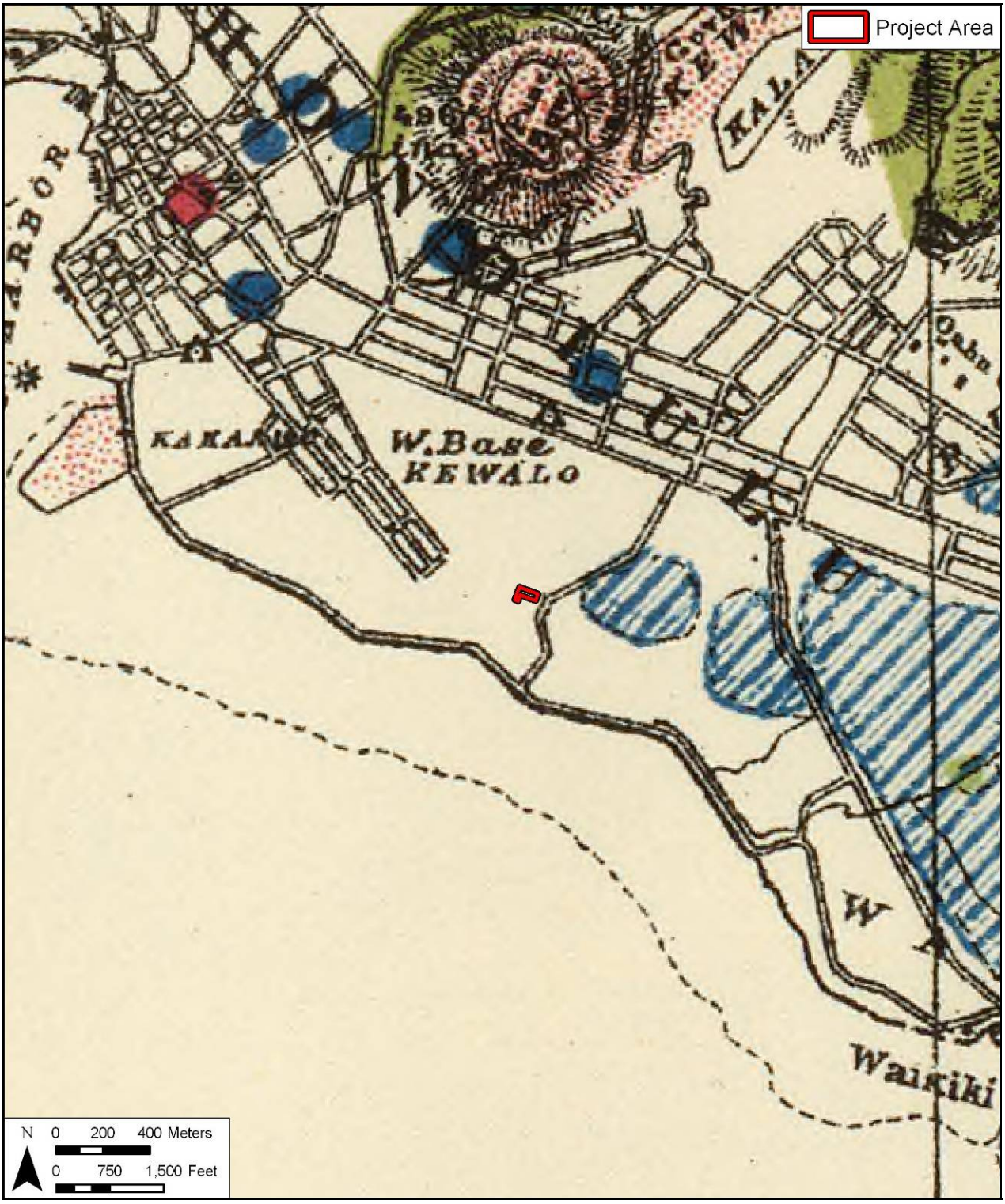

Figure 24. 1902 W.A. Wall map of Pauoa, Kewalo, showing the developing infrastructure of the Kewalo region

that end of the marsh" (Hanley and Bushnell 1980:113). In 1903, five more lots, on Laniwai, Queen, and Cooke streets, were condemned and filled (Hawaii Board of Health 1903:6).

Although public health and safety were prominently cited, according to Nakamura (1979), the main desire (and third justification) to fill in Honolulu, Kewalo, and then Waikīkī lands was to provide more room for residential subdivisions, industrial areas, and finally tourist resorts. In the early part of the twentieth century, Kaka‘ako was becoming a prime spot for large industrial complexes, such as iron works, lumber yards, and draying companies, which needed large spaces for their stables, feed lots, and wagon sheds.

In 1904, the area around South Street from King to Queen Streets was filled in. The Hawaii Department of Public Works (1904) reported "considerable filling [was] required" for the extension of Queen Street, from South Street to Ward Avenue, which would "greatly relieve the district of Kewalo in the wet season."

2.5.2 Kewalo Reclamation Project

Although the Board of Health could condemn a property and the Department of Public Works could then fill in the land, the process was rather arbitrary and piecemeal. In 1910, after an epidemic of bubonic plague, the Board of Health condemned a large section of Kewalo, consisting of 140 land parcels, (including areas once known as Kukuluāe‘o and Ka‘ākaukukui), which had numerous ponds (Hawaii Department of Public Works 1914:196).

In 1914, the entire:

> . . . locality bounded by King street, Ward avenue, Ala Moana and South street, comprising a total area of about two hundred acres, had been found by the board of health of the Territory to be deleterious to the public health in consequence of being low and below 'the established grades of the street nearest thereto' and at times covered or partly covered by water and improperly drained and incapable by reasonable expenditure of effectual drainage, and that said lands were in an insanitary and dangerous condition [Hawaii Reports 1915:329].

The superintendent then sent a letter to all of the property owners, informing them that they must fill in the lands to the grade of the street level within sixty days. Only a few of the land owners complied, and filled their land with a variety of materials. Most of the land owners did not comply with this notice, and in 1912 the bid to fill in the land was given to Lord-Young Engineering Co. to fill in the land with "sand, coral and material dredged from the harbor or reef and the depositing of the same upon the land by the hydraulic method" (Hawaii Reports 1915:331). The recalcitrant land owners sued to stop the work, and in the suit, the method of hydraulic filling is described:

> By this [hydraulic] method the material dredged is carried in suspension or by the influence of water which is forced through large pipes and laid upon the lands and intervening streets, and afterwards is distributed and leveled, the water having drained off through ditches provided for the purpose. The work is done in large sections around which bulkheads have been constructed. A section can be filled in about thirty days, the dredger working about fifteen hours per day. And in about

> two months after a section has been filled the ground will have dried out so as to be fit for use as before. . . . The character of the material varies from very fine sand to coarse bits of coral . . . It appears in evidence that though the method employed the finest of the material which is carried upon the land settles when the water which transports it becomes quiet and as the water runs off a sludge or mud remains which forms a strata more or less impervious to water. This strata, however, is covered by the coarser and more porous material. . . . it appears that by mixing in to a depth of a few inches ordinary soil small plants will grow without difficulty. . . . The character of the locality must be considered. It is not adapted to agriculture, but is suited more particularly to such business purposes as it now partly used for, such as stables, laundries, warehouses, mills, etc., and for cottages with small yards for the accommodation of laborers engaged in connection therewith. Upon the whole, we are of the opinion that the material proposed to be used in the fill-in of the lands of the complainants is not of a character as should be held to be improper for any of the reasons urged [Hawaii Reports 1914:351].

The first land to be filled in was the portion of the Ward Estate Kukuluāe‘o property west of Ward Avenue, completely filled in by June of 1913. By August, the rest of the Ward Kukuluāe‘o lands west of Ward Avenue had been completely filled and by February 1914, all of the land from South Street to Ward Street, and from Ala Moana to Queen Street had been filled.

The expense of the suit did manage to shut down operations planned for the area from Ward Street to Waikīkī (Thrum 1916:159-160), an area that would include the present project area. This land was mainly owned by the Bishop Estate, who leased the land to small farmers growing taro and rice and raising ducks in the ponds. In 1916, the Bishop Estate announced that as soon as their present tenant leases expired, they planned to fill the lands and divide them into residence and business lots (Larrison 1917:148-149). In 1919, a portion of the coastal section of the Bishop Estate lands was secured by the government in order to expand the Kewalo Basin (Thrum 1920:148).

A 1919 War Department map indicates several houses and ponds existed in areas surrounding the project area and Sheridan Street cut through the project area (Figure 25). Most of the roads to the south are depicted by dashed lines, a symbol used for proposed (but not constructed) new roads, or unimproved (dirt, not asphalt) roads. There were still many ponds surrounding the project area, including a large pond to the north of the project area filled between 1920 and 1923 to make land for McKinley High School (Figure 26). The 1927-28 USGS also shows the realignment of Sheridan Street, forming modern day Pi‘ikoi Street.

2.5.3 Kewalo Basin Dredging

In 1919, the Hawai‘i Government appropriated $130,000 to improve the small harbor of Kewalo for the aim of “harbor extension in that it will be made to serve the fishing and other small craft, to the relief of Honolulu harbor proper” (Thrum 1920:147). As the area chosen for the harbor area was adjacent to several lumber yards, such as the Lewers and Cooke yards, the basin was initially made to provide docking for lumber schooners, but by the time the wharf was completed in 1926, this import business had faded, so the harbor was used mainly by commercial

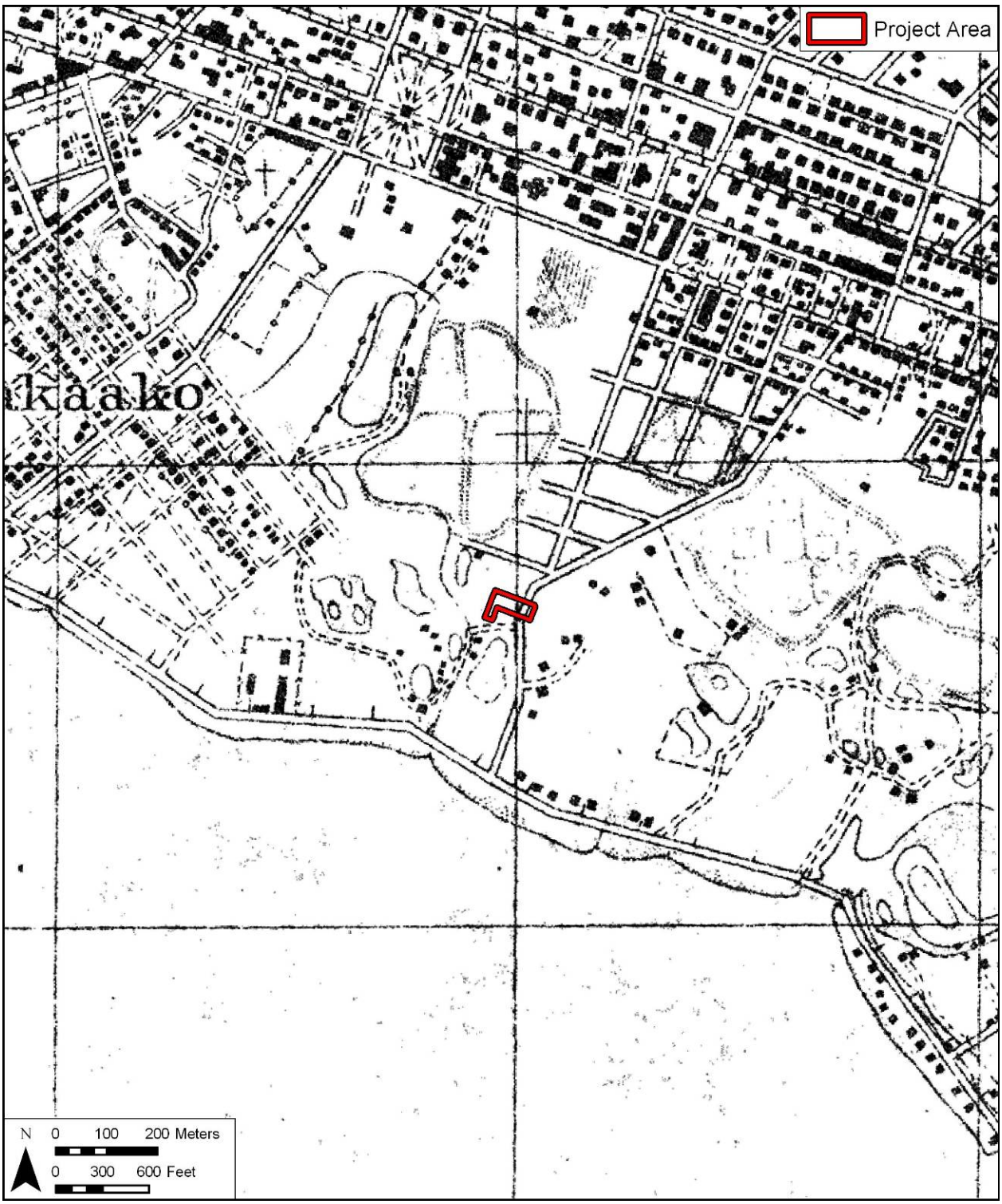

Figure 25. 1919 War Department map showing the project area

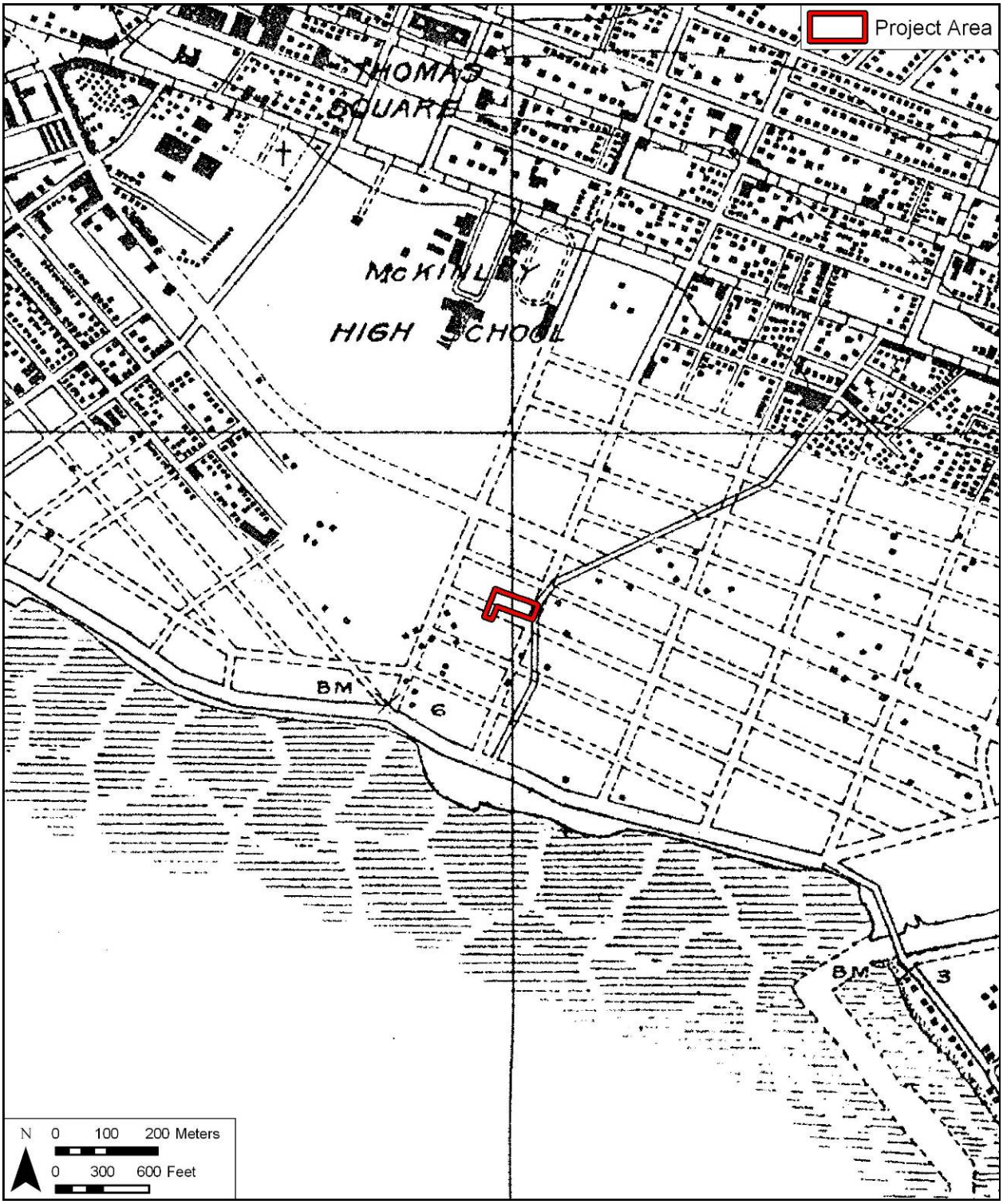

Figure 26. Portion of a 1927-28 USGS map showing the project area

fishermen. The dredged material from the basin was used to fill a portion of the Bishop Estate lands on the western edge of Waikīkī and some of the Ward Estate in the coastal area east of Ward Avenue (U.S. Department of Interior 1920:52). In 1941, the basin was dredged and expanded to its current 55 acres. In 1955, dredged material was placed along the *makai* side to form an 8-acre land section protected by a revetment.

2.5.4 Waikīkī Reclamation Project

It was during the 1920s that southeast O’ahu would be transformed when the construction of the Ala Wai Drainage Canal - begun in 1921 and completed eight years later - resulted in the draining and filling in of the remaining ponds and irrigated fields of Honolulu and Waikīkī. The canal was one element of a plan to urbanize Waikīkī and the surrounding districts, first conceived in 1906. The final result was a “canal three miles long, with an average depth of twenty-five feet and a breadth of two hundred fifty feet” (*Honolulu Advertiser*, 17 October 1928:2:16).

The first action was to dig a canal parallel to the coast of Waikīkī Beach. The dredged material was placed on adjacent properties from McCully Street to Kapi‘olani Park. This action affected several private land owners, including the Bishop Estate and the Booth Estate. The second action was to dredge a canal from the beach towards the reef. The material dredged was pumped to the new McKinley High School site, an area of former large ponds in Kewalo north of the current project area (Hawaii Governor 1922:49-50) (Figure 26). Additional dredged material was used to fill the area *makai* of the school grounds in 1930 (Hawaii Governor 1930:74).

Several claims were made against the dredging company, including compensation for destroyed crops and livestock by farmers. For instance, a Chinese tenant farmer named Chang Fow, leasing lands in Waikīkī from the Bishop Trust Company wrote a letter of complaint indicating that the salt water that leached into his lands as a result of the dredging of the canal had devastated his fishponds and stocks of ducks and chickens (letter from Chang Fow to the Bishop Trust Company, 23 May 1922, cited in Nakamura 1979:100-101). His claims, along with those of other residents of the area, give an impression of the continuing agricultural subsistence base in Waikīkī that lasted into the 1920s, and rapidly became a thing of the past.

Nakamura (1979:85) writes that the government of the Territory of Hawai‘i solicited bids, in 1920, for the dredge and fill project planned for the environs of Waikīkī. The plan was to create hundreds of acres of urban land—at the expense of wetland agriculture and aquaculture in the area. The advertisement, soliciting bids for the project put forward by Lyman H. Bigelow, masked the significance of the project by stating that “for Dredging a Drainage Canal and Filling and Reclaiming Certain Unsanitary Lands at Waikiki” (Nakamura 1979:85). He further writes that State laws were passed requiring property owners to pay for the filling in of their lands, which apparently was going to be done whether they wanted it or not. A lien would be fixed against their property and if all payment was not made on time, land would be foreclosed on. Nakamura points out that the cost was so high for some of the property owners that the bank lien could extend into a fifteen-year mortgage (Nakamura 1979:89).

Once land that the Territory of Hawai‘i government wanted filled in (for government buildings) was complete, any further dredged materials became the property of the dredging company—the Hawaiian Dredging Company—and they in turn could sell the materials to the

property owners, who in turn were forced to buy the product. Walter F Dillingham, of the Hawaiian Dredging Company died in 1963. *Time* magazine, in their article about him and his involvement in the project stated that ". . . Walter Dillingham used the muck dragged up from the sea to fill in low, marshy areas around Honolulu, over the years created 5,000 acres of solid ground that now holds a full third of the city's population" (cited in Nakamura 1979:112) (see Figure 23 and Figure 27).

The land surface of modern Honolulu and Waikīkī is the result of this decade long dredging and fill project in which the creation of the Ala Wai Canal was included. In Nakamura's (1979:113) *The Story of Waikīkī and the Reclamation Project*, he writes that this land "reclamation" program changed the ecology of Waikīkī from a once viable and important agriculture and aquaculture center . . . destroyed by profit-seeking capitalist entrepreneurs . . . under the subterfuge of "drainage" and "sanitation." Many of the original property owners lost their land or had serious damage to their property as a result of the reclamation activities and/or the costly expense for the mandatory filling in of their properties.

Dredging was not the only method for filling in the land throughout Kewalo, evidence suggests urban trash was also used, "At the beginning of the twentieth-century, the stretch of coast between Fort Armstrong and Waikīkī was the site of the Honolulu garbage dump, which burned almost continually" (Shideler 2002 quoted from Young 1994). This burnt trash was used for filling in the unwanted swamp lands.

> The residue from burned rubbish was also used to reclaim swamps. This residue provided a fill that was quite inert and solid. Thus, a rubbish dump was considered a cost-free method for a landowner to reclaim swampy land. Many property owners offered their swamps and lowlands to the City government for reclamation via open dump burning…Major landowners and estates also had a practice of allowing the use of their land for dump sites. There was no payment by the City about sharing fees that the City charged to businesses that used the dumps. The city replied that revenue sharing was not justified because the increase in the value of the land reclaimed was sufficient payment. (Young 2005)

In *The Saga of the Sandwich Islands* by Edward B. Scott, Kewalo is described as:

> 'The desert waterfront of Honolulu where there is a perpetual volcano,' described this forsaken stretch of scrub covered coral wasteland between what would become the Ala Wai and Kewalo Basin. In the center of this desolation stood a refuse dump where, day and night, columns of smoke rose into the Hawaiian sky. (Scott 1968:578)

A 1921 photo shows this "perpetual volcano," where a city employee is shown burning trash at the refuse dump (Figure 28). A 1927 aerial photo shows plumes of smoke rising into the air as an area is being burned south of the current project area (Figure 29). The 1927 photo provides a snapshot of the land before major filling events took place (see also Figure 17 and Figure 19).

In 1930 the first Kewalo Incinerator was built at the intersection of 'Ahiu and Olomehani Streets in Kaka'ako, which had a capacity to burn 80 tons of refuse a day (Shideler 2002).

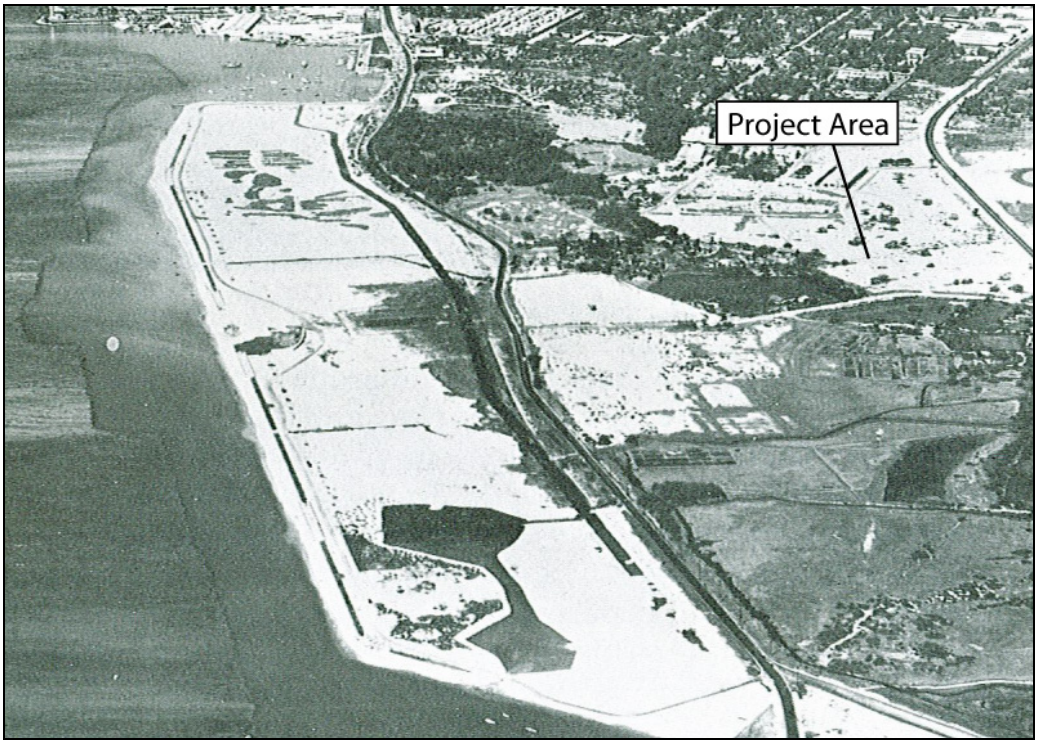

Figure 27. 1932 photo showing the filling accomplished by the Hawaiian Dredging Company (Army Air Corp. Nov 1 from 2000 feet) (Scott 1968:578)

Figure 28. 1921 photo of a city employee burning trash in Kewalo (Scott 1968:578)

Figure 29. 1927 aerial photo showing the proximity of the project area to nearby burning operations, photo taken just prior to 1930s massive filling projects (NOAA Shoreline Imagery)

2.5.5 Urban and Commercial Development in the Twentieth Century

The Kewalo Channel had been dredged in 1924 and the McFarlane Tuna Company (now Hawaiian Tuna Packers) built a shipyard there in 1929 for their fishermen’s sampan fleet (Scott 1968). A new tuna cannery was built at the basin in 1933 and operated successfully. In 1940, Kaka‘ako’s population was over 5,000 residents. Hawaiians, Portuguese, Chinese, and Japanese settled in camps based on their ethnic origins, but they came together for social and community functions.

2.6 Twentieth Century to the Present

By the 1920s, Kaka‘ako had been established as a district comprising a mix of industry, small enterprise and residence, especially in "camps" associated with immigrant groups:

> Camps were sometimes as small as the area covered by four houses, and as large as entire blocks. In the 1920's, the Ward Family Trust leased various pieces of land in Kaka‘ako to the Japanese for camps and other structures. It was here that some early, Asian immigrants developed their urban adaptations. (Griffin et al. 1987:62)

Poor people, mainly native Hawaiians, inhabited the coastal areas of Kaka‘ako. In the 1920s, on the east side of Kewalo Basin they congregated near a camp named “Blue Pond,” named after a large and deep pond near the shore. On the west side of the basin, in the Ka‘ākaukukui area (shortened to ‘Ākaukukui), they lived in shacks and sturdy houses in an area called “Squattersville,” named because they lived without authorization on government land. This camp was generally around Olomehani Street near the shore, protected from the waves by a long sea wall. There were around 700 Hawaiians and part-Hawaiians living in these two camps in the mid-1920s, but by 1926 they were all gone. The government evicted the families and razed the houses (Clark 1977:64).

> In the 1920s dredging of the Ala Wai Canal was completed and later extended along the sea front to form the Ala Wai-Kewalo Basin channel. The salt marshes and unsightly health menacing, garbage dumps of Kewalo were filled in and squatters were evicted from their jerry-built shacks of packing cases and flattened tin cans. The sampan fishing fleet could now move from its mooring at the mouth of Nu‘uanu Stream to Kewalo Basin. (Scott 1968:579)

The 1927 USGS map (see Figure 26) and the 1932 aerial photograph (see Figure 27), show the filling accomplished by the Hawaiian Dredging Company, particularly in the area which would later become Ala Moana Park. Acres of land were added to the coast to create Ala Moana Park, *makai* of the project area. A 1939-41 aerial photo (Figure 30) shows urban development just north of the current project area.

A 1943 War Department map (Figure 31) shows a grid of planned or unimproved streets situated around the project area, making evident the urbanization of the landscape of Honolulu that was taking place in the twentieth century. After World War II, Kaka‘ako became increasingly industrialized, and residents moved out to the newer subdivisions away from the Honolulu central area. The McFarlane Tuna Cannery was taken over in 1941 by the military after the attack on Pearl Harbor. The cannery was converted to military use and used to make airplane

Figure 30. 1939-41 aerial photo of Honolulu showing the approximate location of the project area (U.S. Army Air Corps)

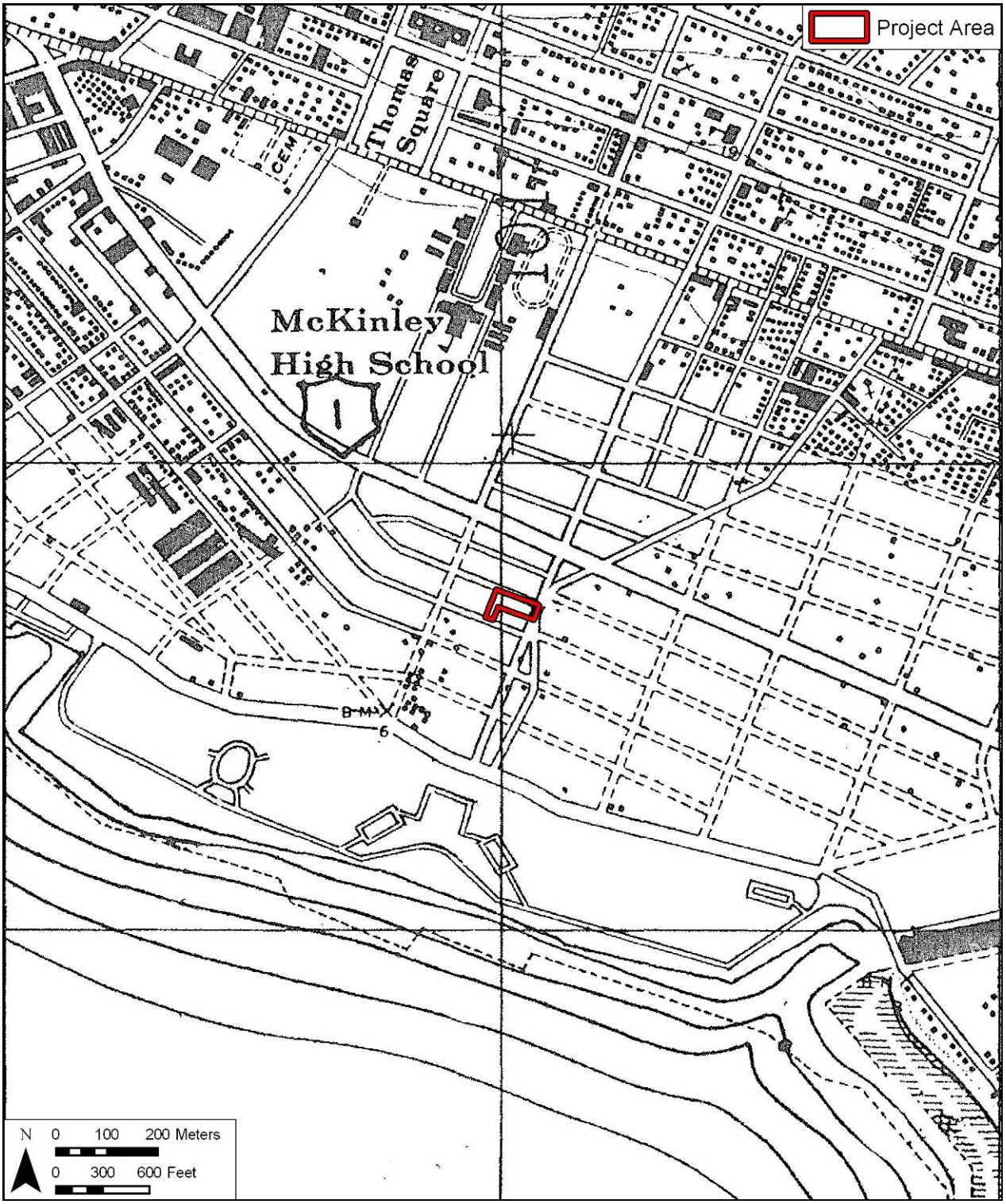

Figure 31. 1943 War Department map showing the project area

gas tanks. Land in Kaka‘ako was taken by the military and was not returned until 1946.

Aerial photographs taken in 1947 (Figure 32) and 1949 (Figure 33) taken over the top of the project area, clearly indicate the majority of the project area was covered over by the large currently existing warehouse. The surrounding landscape continues to include commercial buildings, warehouses and lumber yards.

The 1953 U.S. Army Mapping Service map (Figure 34) shows the project area situated between developed roads. A 1977-78 aerial photograph (Figure 35) shows the large warehouse structure remaining within the project area. Also of note is the roof of the parking garage for the Ala Moana Shopping Center, built in 1958, shown on the right side of the photograph. In 1975, it was estimated that there were 990 firms operating in Kaka‘ako and that approximately 30% of the neighborhood residents also worked in the area (UH 1978: A-16-117).

2.7 Background Summary

The current project area is located outside the two most intensely populated and cultivated areas during pre-contact times - Waikīkī and Honolulu (or Kou) - along this portion of O‘ahu’s southern shore. It was nonetheless well utilized by the Hawaiians for activities appropriate to the specific environment, such as salt making, farming of fishponds, and wetland agriculture. The study area was also among the last areas of urban Honolulu to be built on and developed.

The project area is located within the *‘ili* of Kewalo which was awarded as LCA 10605 to Kamake‘e Pi‘ikoi, wife of an *ali‘i* Jonah Pi‘ikoi. Unfortunatly no additional land use data on LCA 10605 has been found. Other LCAs in the near vicinity of the project area were originally awarded as fort lands. To the south of the current project area is LCA 97 F.L./ Royal Patent 3782. LCAs to the east of the project area include Royal Patent 7553 issued for LCA 100 F.L. and Royal Patent 3781 issued for LCA 101 F.L. As LCA 97 F.L. explains, the land was gifted “since Nu‘uanu”, suggesting these fort lands were granted by Kamehameha I after the battle of Nu‘uanu, likely to loyal warriors and their families. The LCA testimonies indicate these lands were passed down through generations of Hawaiian families. LCAs in the vicinity of the project area indicate these lands were used for fishponds, taro patches, salt pans, and houselots.

Historic maps and photographs indicate the land was utilized for agriculture in the mid 1800s (see Figure 11). In the early twentieth century several houses were erected adjacent to ponds in the near vicinity of the project area (see Figure 25). However, the project area does not appear to have been heavily utilized until the late 1940s when a warehouse was erected within the project area. No other land use within the project area is indicated by historic maps other than the previous alignment of Sheridan Street, subsequently straightened and re-named to Pi‘ikoi Street. The former Sheridan Street is not shown on the 1881 map (see Figure 16) but is shown on the 1884 map (see Figure 15), suggesting roads in the immediate vicinity were developing at that time. Once the land was filled (circa 1930s), it became more commercialized and became part of the system of sprawling city blocks. By the mid-twentieth century, the project area was covered over with warehouses and became heavily commercialized.

Figure 32. 1947 Bishop Museum aerial photo showing the approximate location of the project area

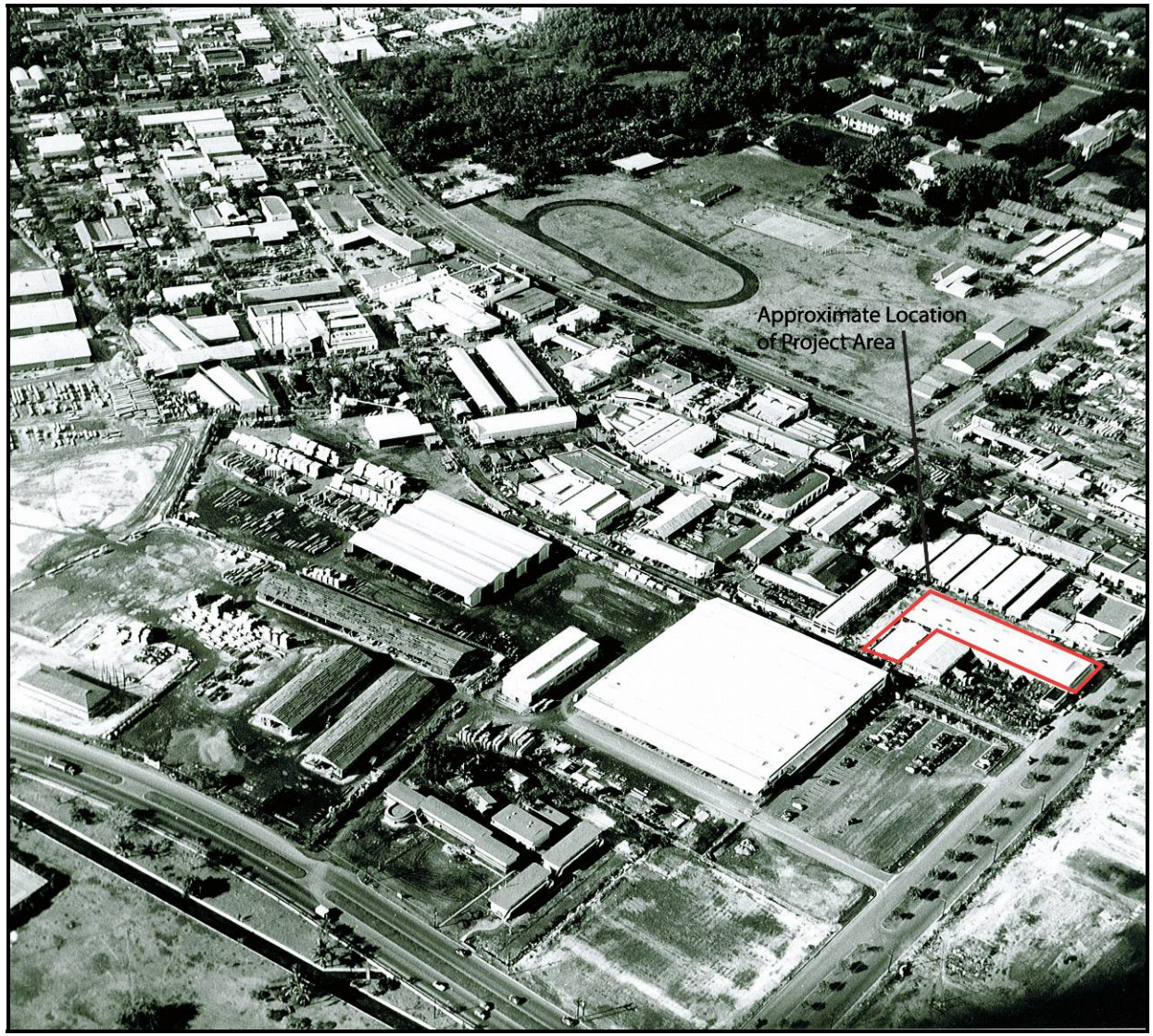

Figure 33. 1949 Bishop Museum aerial photo showing the location of the project area, notice the large newly constructed warehouse

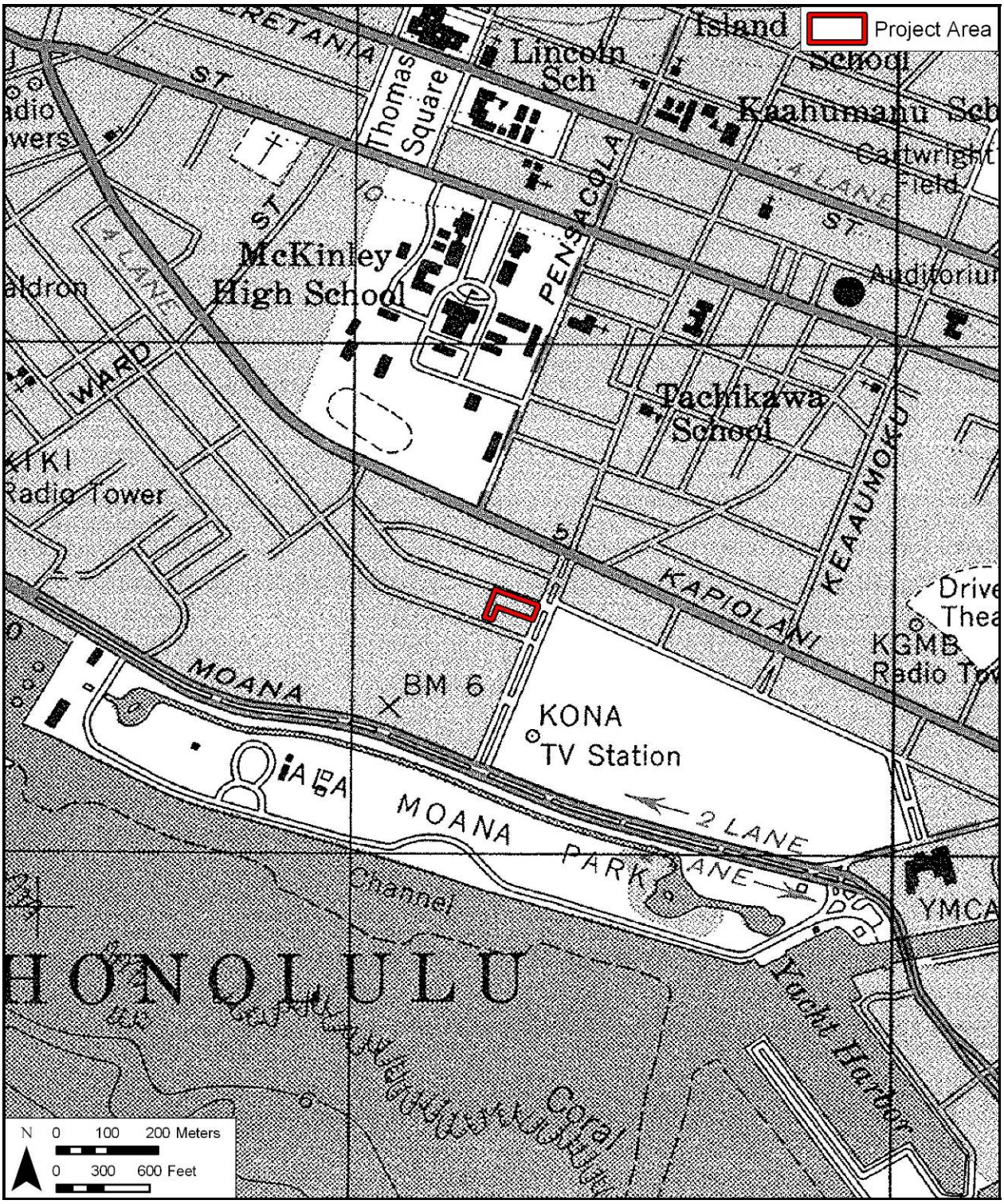

Figure 34. 1953 Army map showing the project area

Figure 35. 1977-78 USGS aerial orthophoto, showing the project area containing a large warehouse structure; notice the roof top parking of the Ala Moana Shopping Center on the bottom right

Section 3 Previous Archaeological Research

Most traditional Hawaiian surface structures had been demolished in the Kaka‘ako area by the time of the first scientific archaeological surveys (i.e. Griffin 1987). In his report on the survey of O‘ahu sites conducted in the early 1930s, McAllister (1933:80) says of Honolulu "Information regarding former sites within the present limits of Honolulu must come entirely from literary sources." He does mention Pākākā Heiau, once the main royal temple in Honolulu; this *heiau* would have been located around the foot (*makai end*) of Fort Street. He does not list Pu‘ukea Heiau (discussed in Section 2.1.2), which Kamakau (1991:24-25) placed in Kukuluāe‘o, but he does note that Peter Corney (1896:101), a visitor to the island in 1819, saw several *heiau* (*morai*) along the Honolulu shore.

Several archaeological investigations have been conducted in parcels adjacent to the project area and on road alignments near the present project area; these are summarized in Table 2. Figure 36 and Figure 37 show the location of the archaeological projects and identified sites in the vicinity of the project area.

Isolated burials have been discovered to the east and northeast of the project area (Smith 1989 and Athens et al. 1994). An in situ burial (SIHP # -4847) was found in "an unusual wetlands context" approximately 130 yards north of the current project area (Athens et al. 1994:iii). Multiple lab analyses were performed to further document the burial context, including osteological analysis, pollen analysis, land snail anlaysis, and radiocarbon anlaysis of bone collagen. The land snail analysis indicated that the area was a brackish water marsh when the burial was interred. The radiocarbon results indicate the date of death of the individual was between A.D. 1295-1473 (Athens et al. 1994:45). This date was supported through absence of European introduced pollens and land snails within the stratum associated with SIHP # -4847. Osteological analysis indicated the burial had severe and prolonged nutritional deficiencies. Based on the osteological results and as burials are not typically interred in wetland environments, the authors concluded that "the presence of skeletal remains at this location represented the last resting place for a fallen victim of disease and not an intentional burial" (Athens et al. 1994:46).

3.1.1 Kaka‘ako Improvement District 4 (ID-4) (Winieski and Hammatt 2000)

The Kaka‘ako Improvement District 4 project (Winieski and Hammatt 2000) was on the road alignment of Kamake‘e Street between Queen Street and Kapi‘olani Boulevard (TMK 2-3-02 through 05). Archaeological monitoring for the Kaka‘ako ID-4 construction project was conducted from August 1995 to August 1996. No significant cultural materials were observed during the Kaka‘ako ID-4 project, except for randomly scattered bottles and bottle fragments of modern provenance discovered within fill materials. One "Star Soda Works" bottle was dated to ca. 1900.

3.1.2 Kaka‘ako Improvement District 7 (ID-7) (Souza et al. 2002)

The Kaka‘ako Improvement District 7 (ID-7) project consisted of improvements to drainage, water, sewer, and utility systems on Kamake‘e Street between Queen Street and Ala Moana Boulevard, and also extended the drain system from Ala Moana Boulevard to Kewalo

Table 2. Previous Archaeological Work In the Immediate Vicinity of the Project Area

Authors	Project Name	Results (Sites 50-80-14-)
Smith 1989	1341 Kapi‘olani Ave.	SIHP # -4243 (isolated long bone) found in a disturbed context
Athens et al. 1994	Pi‘ikoi and Kapi‘olani Intersection	SIHP # -4847 (pre-Contact burial) found in a wetlands environment, determined to likely not have been an intentional burial location
Winieski and Hammatt 2000	Kaka‘ako ID 4 - Kamake‘e St.	SIHP # -5598 (two adjacent coffin burials) recorded; old "A" horizon noted in trenches from Queen to Waimanu St.
Souza et al. 2002	Kaka‘ako ID 7 - Kamake‘e St.	Three disturbed pre-contact burials recorded (SIHP #’s -6376, -6377, -6378*); old "A" horizon found in 7 of 10 profiles
O’Hare et al. 2003	Inventory Survey of a 6-acre lot	Original wetland surface of Kewalo (SIHP # -6636) and a trash layer (SIHP # -6637)
O’Hare et al. 2004; Tulchin and Hammatt 2005	Ko‘olani Condominium	Original wetland surface of Kewalo (SIHP # -6636), 3 historic trash pits (SIHP # -6639), and a historic fill layer (SIHP # -6641) reported during inventory survey; wetland sediments (SIHP # -6636) and historic deposits (SIHP # -6641) noted in addendum report.
O‘Leary and Hammatt 2004	Unit 9 Streets	No cultural remains found during monitoring
Bell et al. 2006	Ward Villages Shops	A cultural layer/activity area (SIHP # -6854) containing five burials and a historic privy/activity area found during inventory survey. Six burials (SIHP # -6855), and fishpond sediments (Kolowalu Pond; SIHP # -6856) recorded.
Bush and Hammatt 2006	Hokua Towers Utilities	No burials or cultural deposits found; old "A" horizon found at eastern end of Auahi St.
Esh and Hammatt 2006	Unit 5 B Streets	No cultural materials found during monitoring
O'Hare et al. 2006	Kaka‘ako ID 10	Cluster of 28 historic burials (SIHP # -6658), 2 isolated disturbed burials (SIHP # -6659) and a historic trash dump (SIHP # -6660) recorded; weak "A" horizon noted; some fishpond sediments
Carney and Hammatt 2008	Hokua Towers	One historic trash pit (SIHP # -6765), in addition an isolated human mandible fragment was found in a secondary context

Authors	Project Name	Results (Sites 50-80-14-)
Hammatt 2008	Ko‘olani Condominium Phase I project area	Two isolated burials (SIHP #’s -6910, -6912) and a cluster of 16 coffin burials (SIHP # -6911) found during monitoring project
Fong et al. 2009	Unit 9, Phase I	No sites documented
Thurman et al. 2009	Queen Street Parks	One previously documented historic fishpond remnant (SIHP # -6856), part of Grant 3194 Kolowalu fishpond was recorded
Runyon et al. 2011	Ko‘olani Condominium Phase II project area	Original wetland surface of Kewalo (SIHP # -6636), burnt trash fill layer (SIHP # -6641), cultural layer containing pre- and post- contact pit features and artifacts (SIHP # -7115), pond sediments corresponding geographically to a documented historic pond (SIHP # -7116), and a burial concentration containing 27 post-contact individuals determined to be of native Hawaiian ancestry (SIHP # -7117)

*SIHP # -6378, recovered in the Delta Co. base yard on Pensacola Avenue and Kapi‘olani Boulevard, is not shown in Figure 37 because the original location could not be determined.

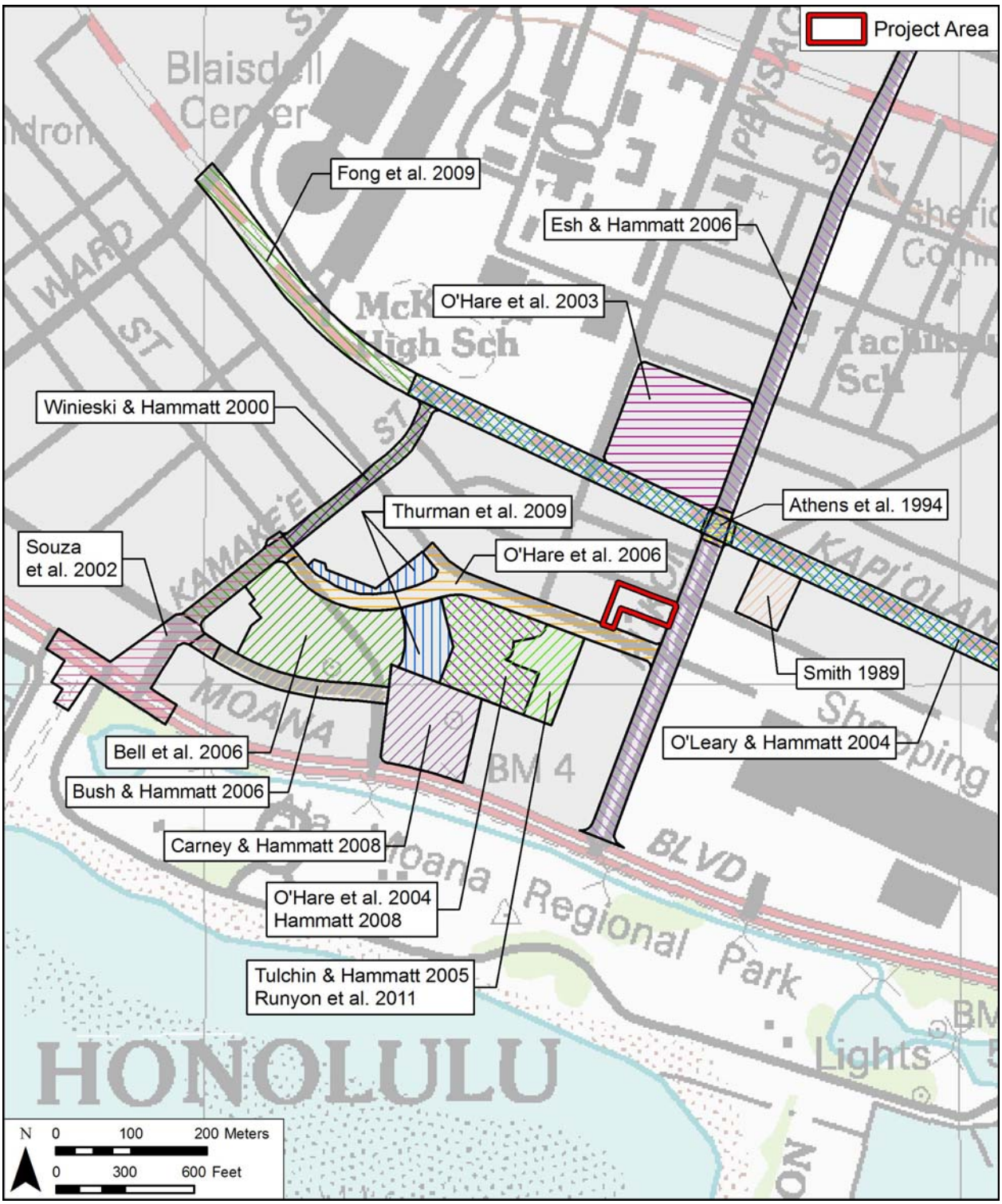

Figure 36. Portion of the 1998 USGS Honolulu 7.5 minute quadrangle map showing previous archaeological studies in the vicinity of the project area

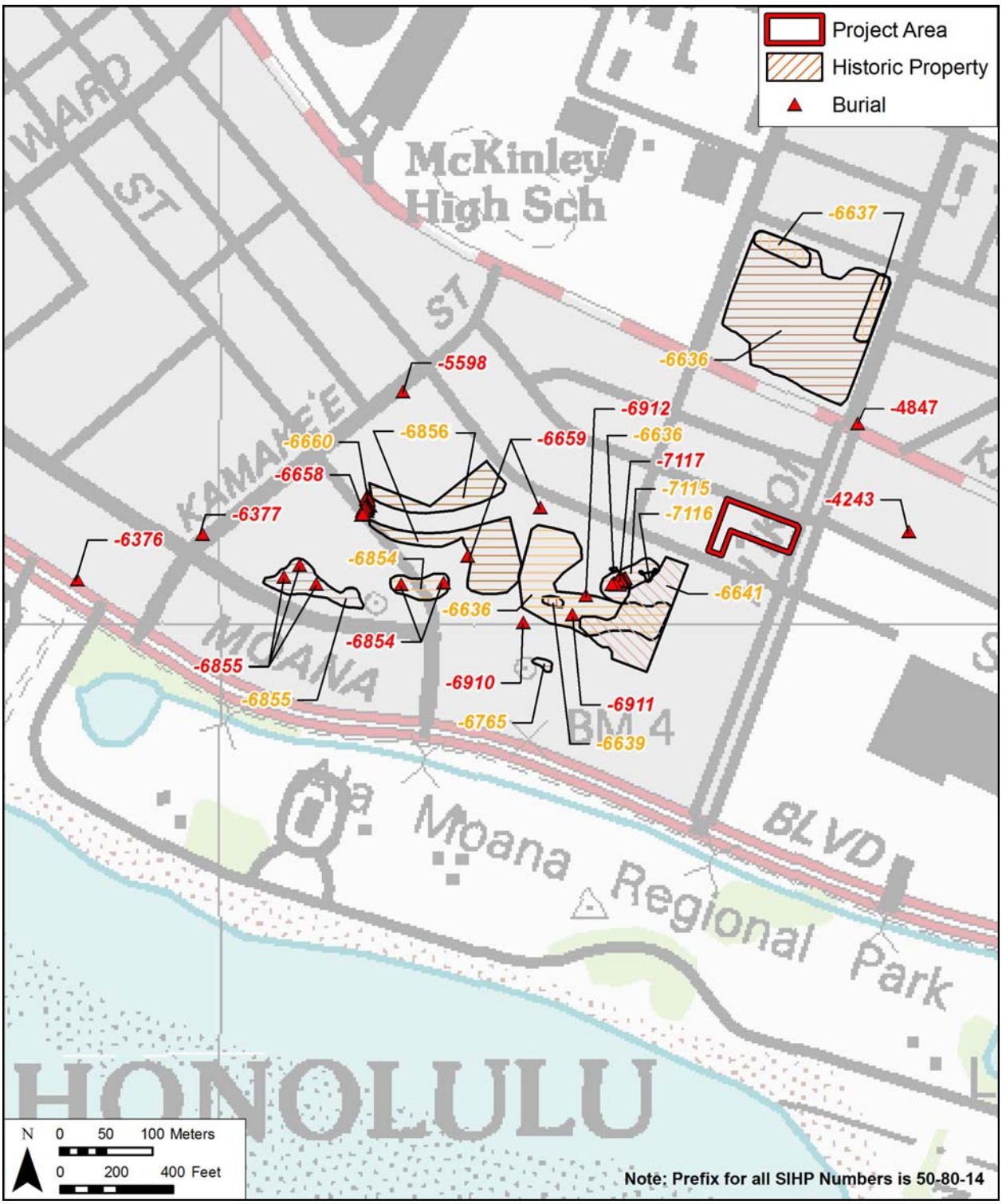

Figure 37. Portion of the 1998 USGS Honolulu quadrangle map showing locations of previously documented historic properties including burials documented near the vicinity of the current project area (note: burial locations are denoted by a red triangle)

Basin (TMK 2-1-58, 2-3, 2-3-01 thru 05) (Souza et al. 2002). The project additionally included the realignment of the existing Kamake‘e Street between Auahi Street and Ala Moana Boulevard.

During excavation activities associated with the Kaka‘ako Improvement District 7 Construction Project, three human burials were encountered. Burial 1 (SIHP # 50-80-14-6376), a single cranium, was inadvertently discovered by Delta personnel on October 13, 2000 in the base yard back dirt pile. The backdirt pile derived from a trench on Ala Moana Blvd. and Kamake‘e Street. Burial 2 (SIHP # 50-80-14-6377), an adult individual, was encountered by an archaeologist during backhoe excavations for a box drain on Kamake‘e Street. The burial was within an undisturbed sand deposit. Burial 3 (SIHP # 50-80-14-6378), consisting of a femur and several rib fragments, was recovered in the Delta Co. base yard on Pensacola Avenue and Kapi‘olani Boulevard. The original location of the burial could not be determined.

Ten profiles were described and drawn, beginning with P1 at the junction with Queen Street at the north end to P1 to P3 at the junction with Ala Moana Blvd at the southern end (see). Most of the excavations occurred in previously disturbed fill material. As expected, the land comprising Ala Moana Beach Park and the Kewalo Basin consists totally of fill material, since the areas were seaward of the shoreline in pre-contact and early historic times. Natural deposits though discontinuous, were exposed most frequently along the ‘*ewa* (west) and Diamond Head (southeast) sides of Kamake‘e Street extending down to Ala Moana Boulevard. An old “A” horizon was observed in several profiles. The stratigraphic sequence for the project area was fairly consistent throughout.

3.1.3 O’Hare et al. 2003

Cultural Surveys Hawai‘i, Inc., conducted an archaeological inventory survey for a 6-acre property from July 24- July 26, 2003. Twenty-four trenches were excavated within the project area. Two historic properties were identified (SIHP # 50-80-14-6636 and -6637). In general, observed stratigraphy included imported coral, sand, and silty clay fill layers (Strata I-II) corresponding to the early land-reclamation dredging and fill episodes of the Kewalo region which took place in the early 20th century. These fill sediments were found to overlay the original pre-contact to early 20th century wetland ground surface (Strata IIIa-IVa) (Figure 38). The original Kewalo wetland sediment (SIHP #50-80-14-6636) consisted of Stratum IIIa, a very dark brown sandy clay loam with a high percentage of platy organic material, and Stratum IIIb, a very dark grayish brown sandy loamy clay with less organic material. Strata III contained charcoal, marine invertabrates, fish scales, and rounded basalt gravel.

A trash fill layer (SIHP # 50-80-14-6637) was encountered within the northeast corner of the project area. The trash layer contained wood, brick, tires, ceramics, glass bottles and rusted metal. Many of the bottles dated from 1920s- 1940s, some specifically to the 1930s. The garbage appeared to be related to businesses in the surrounding area.

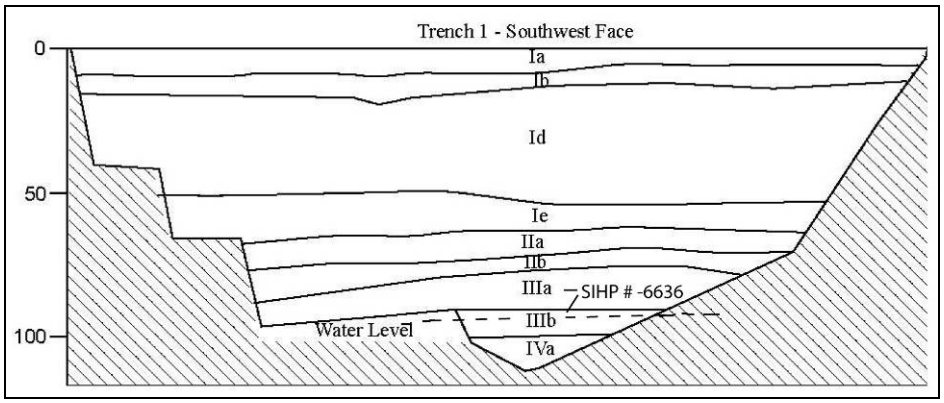

Figure 38. Profile of Trench 1 (O’Hare et al. 2003) showing representative stratigraphy

3.1.4 O’Leary and Hammatt 2004

Cultural Surveys Hawai‘i, Inc., conducted archaeological monitoring in association with the emergency sewer line repairs that occurred along Kapi‘olani Boulevard. Five 1.9-foot-deep trenches were excavated. Because these excavations took place in fill materials associated with the original placement of the sewer pipes, no historic properties were encountered (O’Leary and Hammatt 2004).

3.1.5 Victoria Ward Village Shops (Bell et al. 2006)

In 2006, Cultural Surveys Hawai‘i performed an archaeological inventory survey for the Victoria Ward Village Shops Project adjacent to Kaka‘ako ID-7 District and bounded by Auahi Street on the south and Kamake‘e Street to the east (Bell et al. 2006). A total of 86 trenches were excavated in the project area.

The common stratigraphic element within the project area is the ubiquitous historic and modern fill layers that were documented immediately below the surface in all trenches. These fill layers included: crushed coral rubble, terrigenous clays and clay loams, marine hydraulic dredge clays and silts that were pumped into the project area from dredging operations off shore of Ala Moana Beach Park and Kewalo Basin, asphalt layers, often associated with basalt gravel base courses, and, rusted metal and glass trash layers, likely from the old Kaka‘ako incinerator (e.g. at SIHP # 50-80-14-6660).

During the inventory survey, three sites were reported: SIHP # 50-80-14-6854, SIHP # 50-80-14-6855, and SIHP # 50-80-14-6856 (Bell et al. 2006). SIHP # -6854 is a subsurface cultural layer/activity area remnant with an immature pig skeleton, remnants of a historic privy, remnants of a culturally enriched A-Horizon (containing both historic and Pre-Contact cultural material), and human burials. SIHP # -6855 is an activity area remnant, comprised of a pronounced subsurface traditional Hawaiian cultural layer and human burials. SIHP # -6856 is an historic fishpond remnant, part of Land Commission Grant 3194, “Kolowalu,” awarded to Kalae and Kaaua.

A number of inadvertent finds of traditional Hawaiian burials were uncovered during construction monitoring at the site, as noted in a preliminary report (Thurman et al 2007). Of historic interest in the monitoring results, are the frequent discoveries of late nineteenth century

ammunition and animal burials. The Ward Village Shops project area correlates to areas shown on historic maps as a rifle range (1893) and an animal quarantine station (1911), which probably explains the presence of these remains.

3.1.6 Street Rehabilitation Pi‘ikoi Street and Kapi‘olani Boulevard (O’Leary and Hammatt 2004; Esh and Hammatt 2006)

Archaeological monitoring for the Emergency Phase Rehabilitation of Streets: Unit 9, Phase I Kapi‘olani Boulevard from Kalākaua Avenue to Kamake’e Street Honolulu Ahupua’a, Kona District, O‘ahu (TMK: [1] 2-3-003, 004, 007, 009, 010, 015, 016, 021, 022, 035, 039, 040 and 041) was conducted by CSH in 2004 (O’Leary and Hammatt 2004). No archaeological remains were encountered during the excavation of the five trenches and five sewer manholes during the emergency phase of sewer rehabilitation because all of the excavation was shallow and was taking place in sediments which had been excavated previously and/or were construction fill.

Archaeological monitoring for the Rehabilitation of Streets, Unit 5 B Project on Pi‘ikoi Street between Ala Moana Blvd. and Matlock Street (TMK Plats [1] 2-3-006, 007, 010, 011, 012, 014, 015, 035 and 038 and [1] 2-4-003, 004, 011 and 012) was conducted by CSH in 2004 (Esh and Hammatt 2006). Construction activities in the area primarily consisted of the resurfacing of Pi‘ikoi Street. This activity did not extend deeper than 30 cm below base course, and did not require archaeological monitoring. Construction activity requiring monitoring was limited to excavation at the intersection of Pi‘ikoi and Young Street for traffic signal improvements. No cultural materials were encountered.

3.1.7 Hokua Towers Utilities (Bush and Hammatt 2006)

In 2006, archaeological monitoring was conducted by CSH during excavations associated with Hawaiian Electric Company’s (HECO) underground electrical duct installation to be used to service the newly constructed Hokua Tower on Auahi Street (Bush and Hammatt 2006). Excavations took place using a backhoe with a 3 ft-wide bucket, as well as by hand shoveling. Excavations included 350 m of electrical line trenching and two associated manholes. No archaeological finds were encountered during monitoring.

3.1.8 Kaka‘ako Improvement District 10 (ID-10) (O’Hare et al. 2006)

In 2006, Cultural Surveys Hawai‘i completed the fieldwork pertaining to the Kaka‘ako Improvement District 10 (ID-10) project (O’Hare et al. 2006). The project concerned improvements to drainage, water, sewer, and utility systems on Queen Street and Waimanu Street beginning at Kamake‘e Street and ending at Pi‘ikoi Street (TMK 2-3-04, 06, and 07). During monitoring of the construction, 30 human burials were found and disinterred. The analysis of the distribution of the burials and the associated grave goods indicates that 28 of the burials (SIHP # 50-80-14-6658) constitute a cemetery, possibly used between the 1840s and the 1880s, located on the lip of Kolowalu Pond. Two burials (SIHP # 50-80-14-6659) were isolated finds and were not related to the main cemetery cluster. Historic trash pits (SIHP # 50-80-14-6660) were also discovered during monitoring intruding into the eastern edge of the cemetery. The human remains and associated grave goods were reburied on-site in a specially constructed vault complex.

Six stratigraphic strata were described: Stratum I consisted of a number of twentieth century fill layers (designated Ia-Ii). These strata often contained historic trash dating to the 1920s and 1930s. Sub-strata Ia-Ih were dry fills. Sub-stratum Ii was a “wet” fill material, consisting of dark reddish brown fine clay that was dredged from inshore or offshore waters and hydraulically pumped as a slurry of fine grained sediments into the wetland area during the reclamation of the Kewalo area in the 1920s and 1930s. Stratum II and III consisted of well-sorted fine sands; each had a weak “A” horizon at the top of the stratum. Stratum IV was a layer of coarse sand representing an unconsolidated reef deposit. Stratum V was a gleyed or clay layer, which represents the original pre-Contact to early post-Contact marshy environment of the area. Stratum V was subdivided into two substratum, a light greenish gray gleyed clay (Va), and a gray clay mixed with decomposing coral (Vb). Stratum V was interpreted as the result of the creation of a low-energy depositional environment, with fine silts and clays deposited by low-velocity water. Stratum VI was the coral bedrock shelf.

3.1.9 Queen Street Parks Project Area (Thurman et al. 2009)

In June 2009, CSH completed an archaeological inventory survey of the Queen Street Parks Project area (Thurman et al. 2009). A total of 29 test units encompassing 168 square meters of the Queen Street Parks project area’s surface were excavated in order to document potential subsurface cultural deposits and stratigraphy. A representative photo and profile from the Queen Street Parks project area are shown in Figure 39 and Figure 40.

One historic property was encountered during this inventory survey investigation: SIHP # 50-80-14-6856, “Kolowalu,” a historic fishpond remnant, part of Grant 3194, awarded to Kalae and Kaaua. This fish pond was previously documented in the adjacent Ward Villages project area and was recommended for the Hawai‘i Register under criterion D (for its information content).

In general, the stratigraphic sequence across both the *mauka* and *makai* sections of the proposed park included a minimum of one (1) m of fill everywhere tested (Strata Ia-Ic). The fill material ranged from terrestrial mixed soils with some historic era artifacts to primarily crushed coral fill. Below the fill layers was generally a thin organic A-Horizon (Stratum II) and pond sediments (Stratum III). In a few cases Jaucas sands were encountered (see Figure 40). In general the subsurface testing confirmed archaeological and historical background research. The bulk of the project area is within the former boundaries of Kolowalu Pond (SIHP # 50-80-14-6856). Modern construction activity has affected the subsurface condition, especially the two large dewatering basins that were located in the *makai* section of the proposed park.

Figure 39. Photo from the Queen Street Parks Project (Thurman et al. 2009) showing Test Unit 8, northeast wall; notice the bottom stratum of gleyed sediment indicating SIHP # 50-80-14-6856, Kolowalu Pond

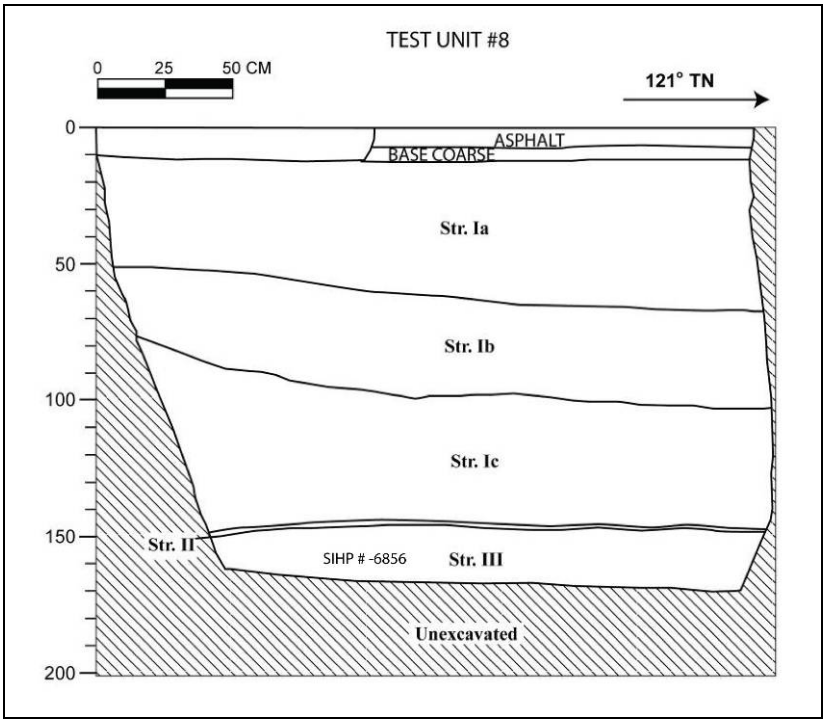

Figure 40. Profile from the Queen Street Parks Project (Thurman et al. 2009) showing Test Unit 8, northeast wall

3.1.10 Ko‘olani Condominiums Project

Phase I Project Area

3.1.10.1.1 O’Hare et al. 2004

In September of 2003, CSH completed fieldwork pertaining to the archaeological inventory survey of the proposed Ko‘olani (also called Sunset Heights) project (O’Hare et al. 2004) (Figure 42 and Figure 43). This project comprised Phase I of the Ko‘olani inventory survey program, and was conducted prior to the construction of a high-rise condominium and associated multi-level parking structure. This project area is located southwest of the current project area.

The archaeological inventory survey primarily consisted of subsurface testing as the project area had undergone previous stages of filling and surface clearing. At the time of the survey the project area contained an existing building, paved asphalt parking lots, a concrete entrance ramp to Nauru Towers and landscaped and bare-earth areas. Subsurface testing consisted of thirteen (13) trenches excavated with the use of a backhoe (Figure 41). Trench stratigraphy consisted of imported fill strata containing of asphalt, gravels, crushed coral, hydraulic pumped fill, silty loams, and silty clay loams over top of natural soil deposits including Jaucas sand and wetland sediment. Subsurface testing indicated the presence of undisturbed sand in the southwestern (*makai*) portion of the project area. The stratum that represents the original wetland surface was designated SIHP # 50-80-14-6636.

Three historic trash deposits, SIHP # 50-80-14-6639, were found with artifacts dating from the early to mid-1900s. SIHP # -6639 represents trash deposits that had been used as fill material, but were not burnt or incinerated and contained slightly more modern trash than that encountered in the designated SIHP # –6641 historic trash deposit. SIHP # -6639 contained glass bottles, ceramics and rusted metal fragments.

A historic trash fill layer, SIHP # 50-80-14-6641, representing at least two episodes of trash dumping was documented. SIHP # -6641 contained melted and crushed historic artifacts including ceramic plates, bowls, cups, stoneware bottles, and glass beverage bottles. Based on dated artifacts, the first episode of trash dumping occurred pre-1930 and the second dumping occurred during the 1930s through 1940s.

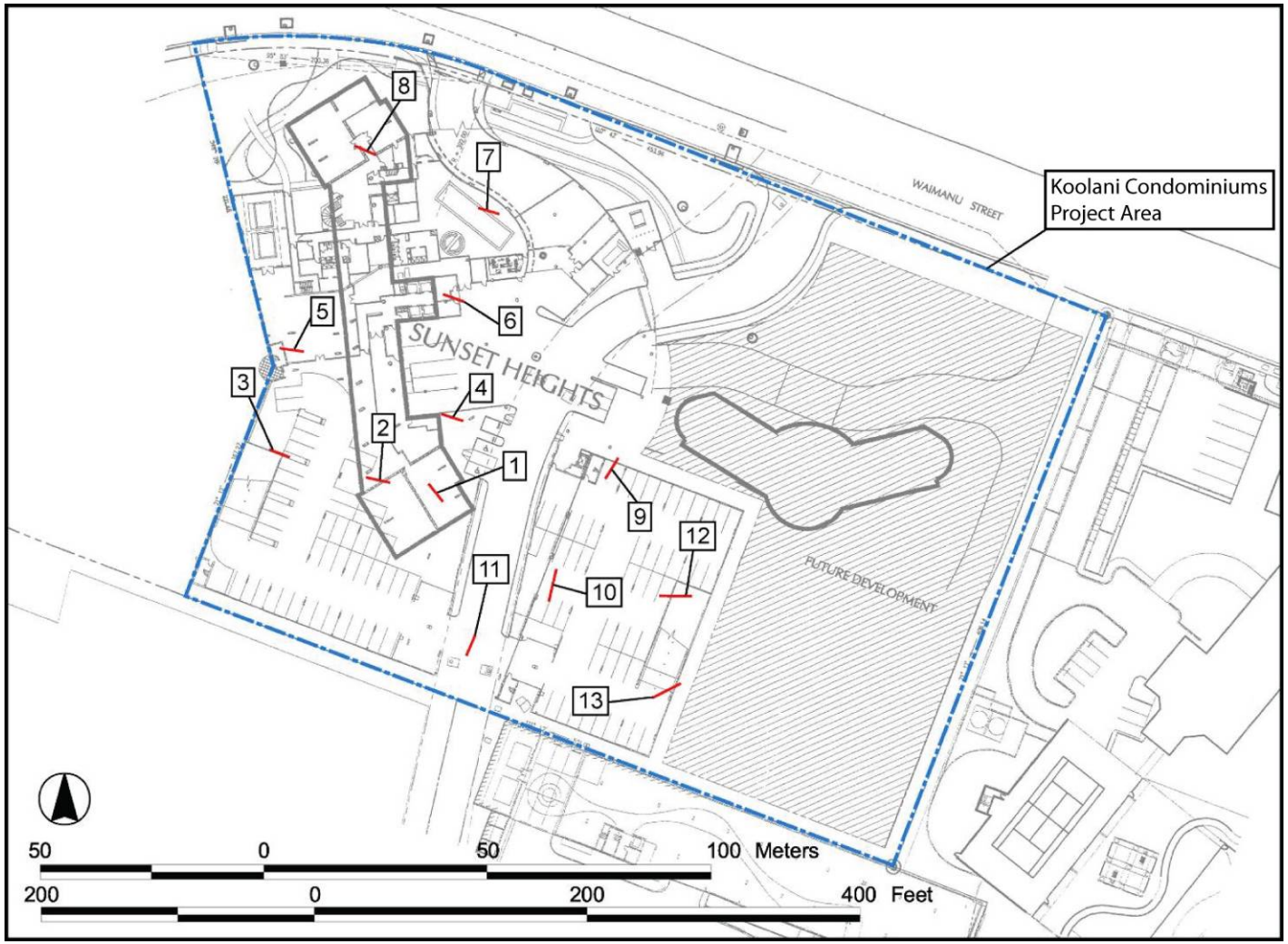

Figure 41. Plan view of the Phase I Ko‘olani Inventory Survey project (O’Hare et al. 2004) showing trench locations; notice the Phase II project area (hatched area, labeled future development) in the eastern portion of the designated project area (outlined in blue) (note: the plan was revised by the subsequent owner in 2008)

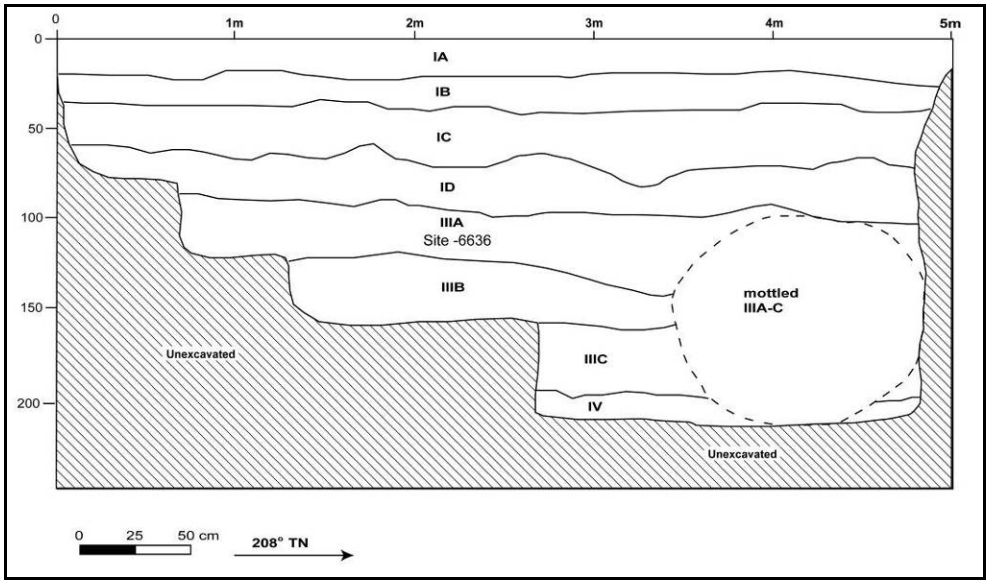

Figure 42. Profile from the Phase I Ko‘olani Inventory Survey project (O’Hare et al. 2004) showing Backhoe Trench 9, northwest wall

Stratum	(cmbs)	Sediment Description
IA	0-15	10YR 3/3 Very dark brown loamy sand; weak, medium structure; slightly hard consistency; nonplastic; weak cementation; abrupt and wavy lower boundary
IB	15-35	10YR 7/1 Light gray coarse sand; fine structure; loose consistency; nonplastic; weak cementation; abrupt and smooth lower boundary
IC	35-57/75	10YR 5/1 Gray sand; weak, fine structure; loose consistency; nonplastic; no cementation; abrupt and wavy lower boundary; coral rubble fill with sand
ID	57/75-87/95	10YR 6/3 to 6/4 Pale brown to Light yellowish brown sand; weak, medium structure; loose consistency; nonplastic; weak cementation; abrupt and wavy lower boundary; coral rubble fill with sand
IIIA	87/95-120/140	10YR 4/1 Dark Gray sandy loam; weak, medium,structure; hard consistency; nonplastic; weak cementation; abrupt and wavy lower boundary; cultural layer; disturbed, former wetland layer SIHP # -6636
IIIB	120/140-207	2.5Y 5/3 Light olive brown sandy clay; weak, structure; loose consistency; slightly plastic; weak cementation; abrupt and wavy lower boundary; pond gley
IIIC	207-223	2.5Y 6/2 Light brownish gray loamy sand; weak structure; nonsticky and nonplastic; weak cementation; abrupt and wavy lower boundary
IV	223-BOE	10Y 6/1 Greenish gray sandy clay; weak, fine structure; nonsticky consistency; nonplastic; no cementation

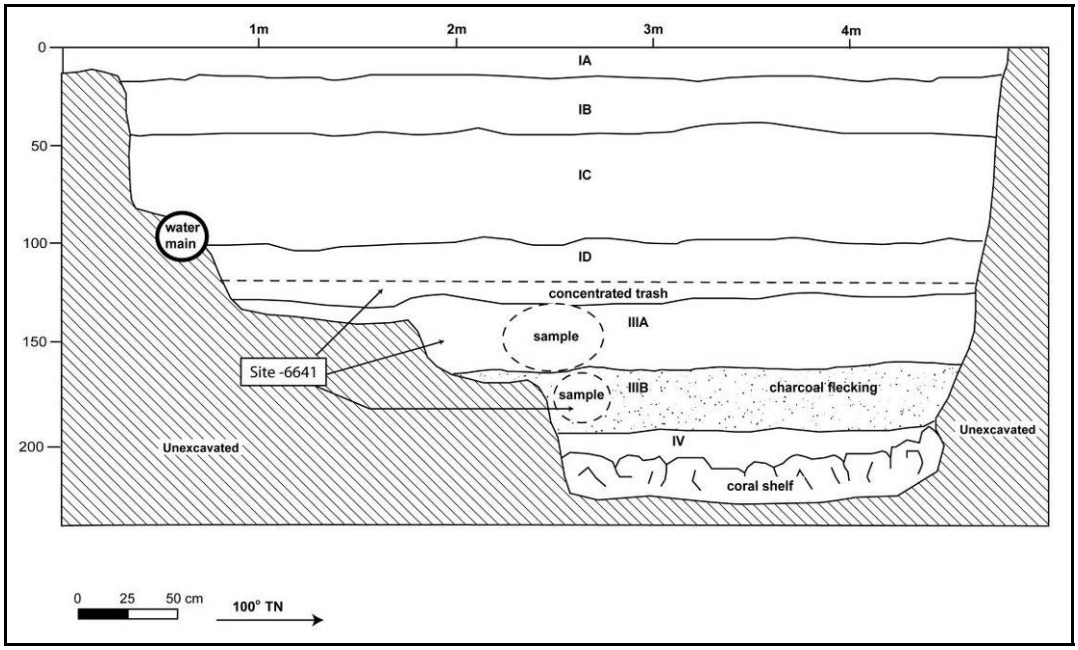

Figure 43. Profile from the Phase I Ko‘olani Inventory Survey project (O’Hare et al. 2004) showing Backhoe Trench 12, northeast wall

Stratum	(cmbs)	Sediment Description
IA	0-15	10YR 4/4 Dark yellowish brown sandy loam; weak, structure; loose consistency; nonplastic; no cementation; abrupt and smooth lower boundary; fill material
IB	15-44	10YR 5/2 Grayish brown loamy sand; weak, medium structure; loose consistency; nonplastic; no cementation; abrupt and smooth lower boundary; fill material
IC	44-101	10YR 4/3 Brown fine to medium, sandy loam; weak, medium structure; loose consistency; nonplastic; no cementation; abrupt and smooth lower boundary; fill material
ID	101-128/132	10YR 4/2 Dark grayish brown loam; weak, medium structure; loose consistency; nonplastic; no cementation; abrupt and wavy lower boundary; concentrated trash layer (part of State Site # 50-80-14-6641)
IIIA	128/132-165	10YR 6/1 Gray sandy clay; weak, fine structure; nonsticky consistency; nonplastic (part of SIHP # –6641)
IIIB	165-195	10YR 7/1 Light gray fine to medium sandy clay; weak, structure; nonsticky consistency; nonplastic; weak cementation; abrupt and smooth lower boundary; some charcoal flecking but not enough to sample (part of SIHP # –6641)
IV	195-207	10YR 7/1 Light gray sandy clay; weak structure; nonsticky consistency; nonplastic; weak cementation; abrupt and smooth lower boundary

3.1.10.1.2 Hammatt 2008

In the course of archaeological monitoring for the Phase I portion of the Ko‘olani Condominiums project in 2003 to 2004, eighteen burials were encountered (Hammatt 2008) (Figure 45 and Figure 46). Two of these burials, Burial 1 (SIHP # 50-80-14-6910) and Burial 18 (SIHP # -6912), were isolated, pre-contact burials, while the other 16 burials comprised a cluster of post-contact burials (SIHP # -6911). Historic coffin burials accounted for at least 15 of the 18 (83%) burials. Eight of the burials were left in their original locations, and the remainder were relocated closer to the burials which were left in place. One burial good, consisting of a basalt *poi* pounder, was found and re-interred with Burial 2.

Observed stratigraphy consisted of various fill layers over Jaucas sand deposits and/or wetland sediments (Figure 44 and Figure 47). The previously recorded wetland stratum (SIHP # -6636) was documented throughout the project area. Historic trash pits were encountered, however SIHP # -6641 (historic fill layer) contained only fragmented and burnt fragments that did not yield any significant data.

Figure 44. Photo from Phase I Ko‘olani Condominiums Archaeological Monitoring project (Hammatt 2008), showing representative stratigraphy near Burials 2-17; view to east

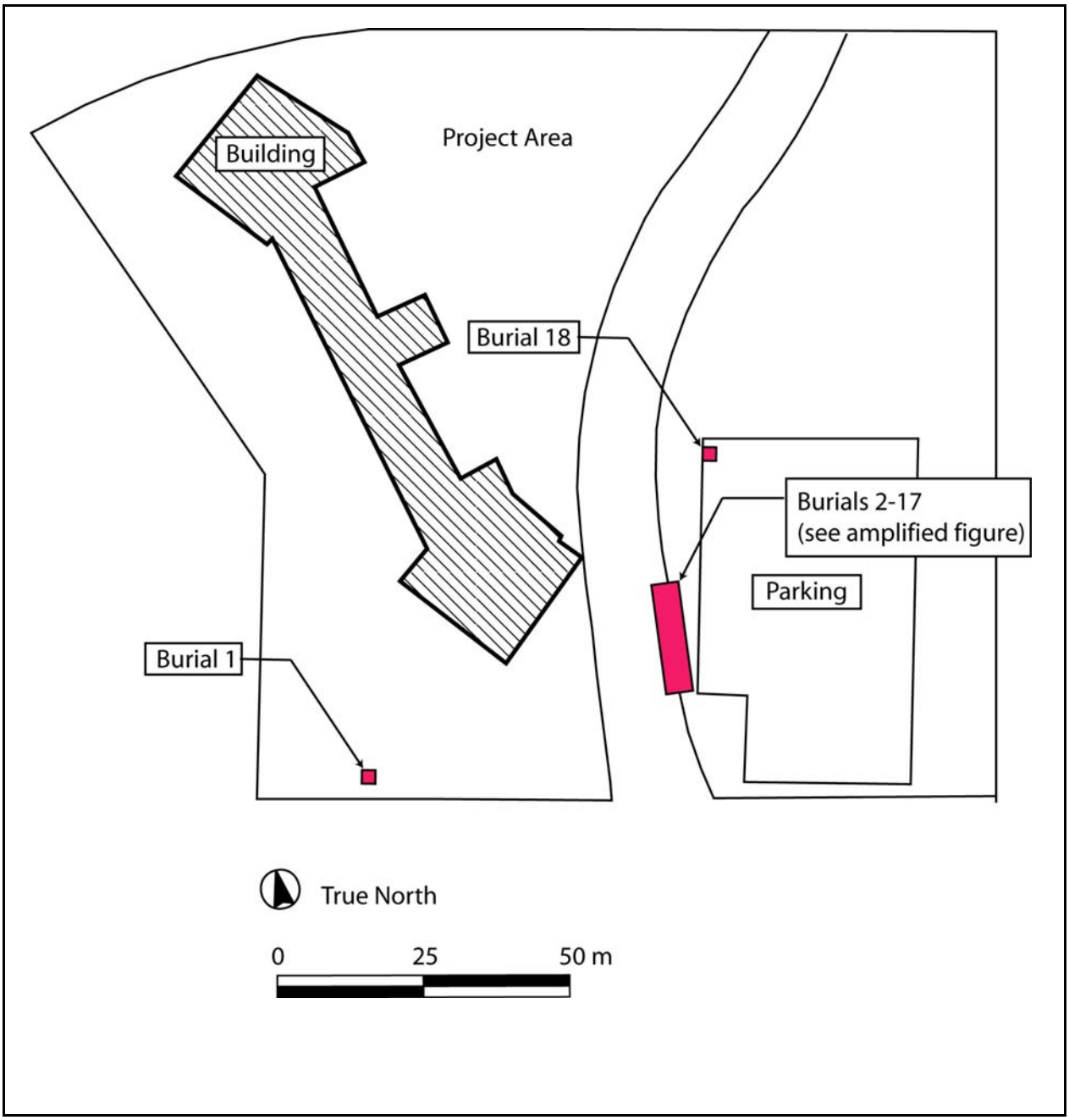

Figure 45. Plan view from Phase I Ko‘olani Condominiums Archaeological Monitoring project (Hammatt 2008), showing the locations of encountered burials

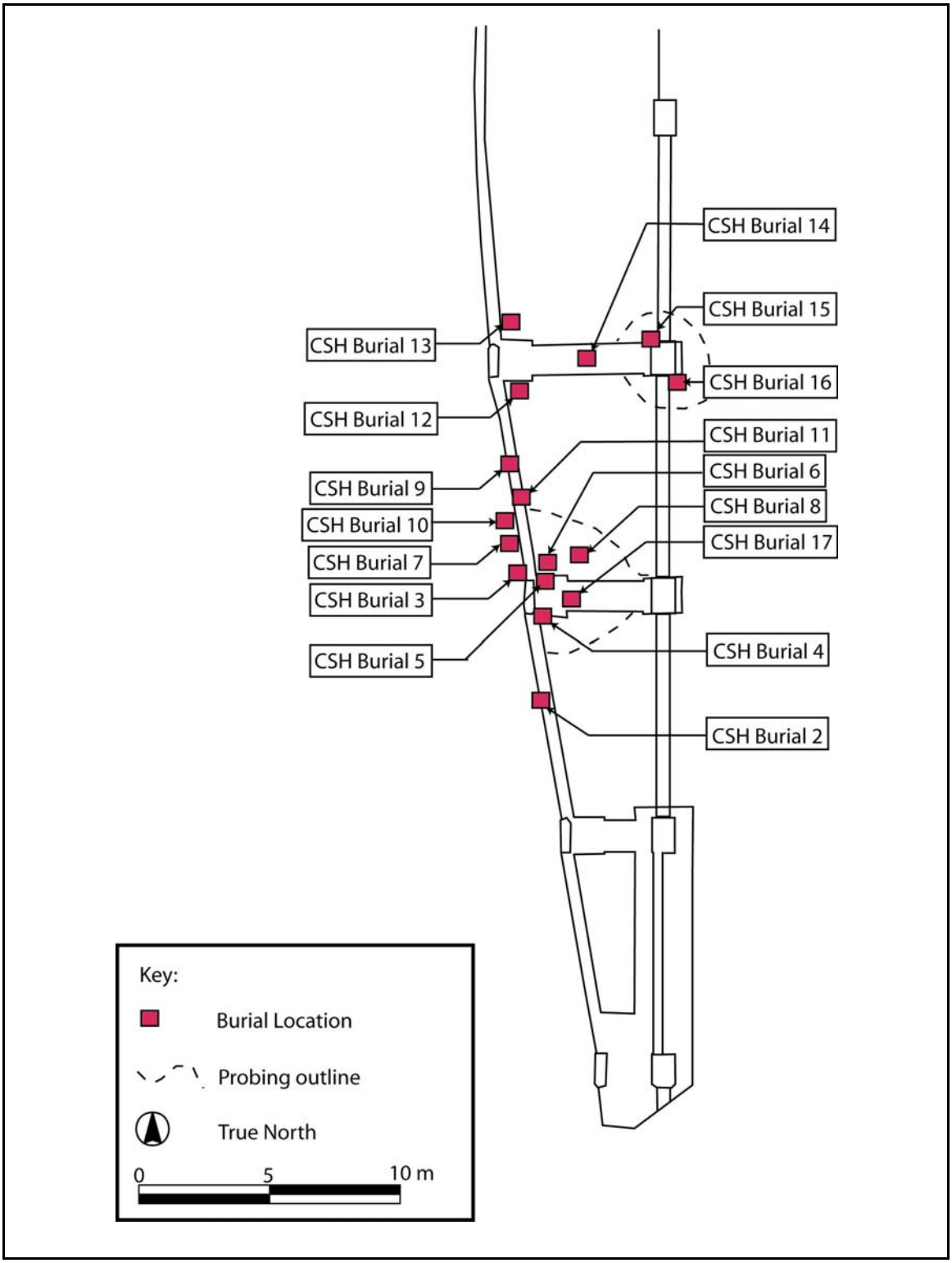

Figure 46. Amplified plan view from Phase I Ko‘olani Condominiums Archaeological Monitoring project (Hammatt 2008) showing locations of CSH burials 2-17

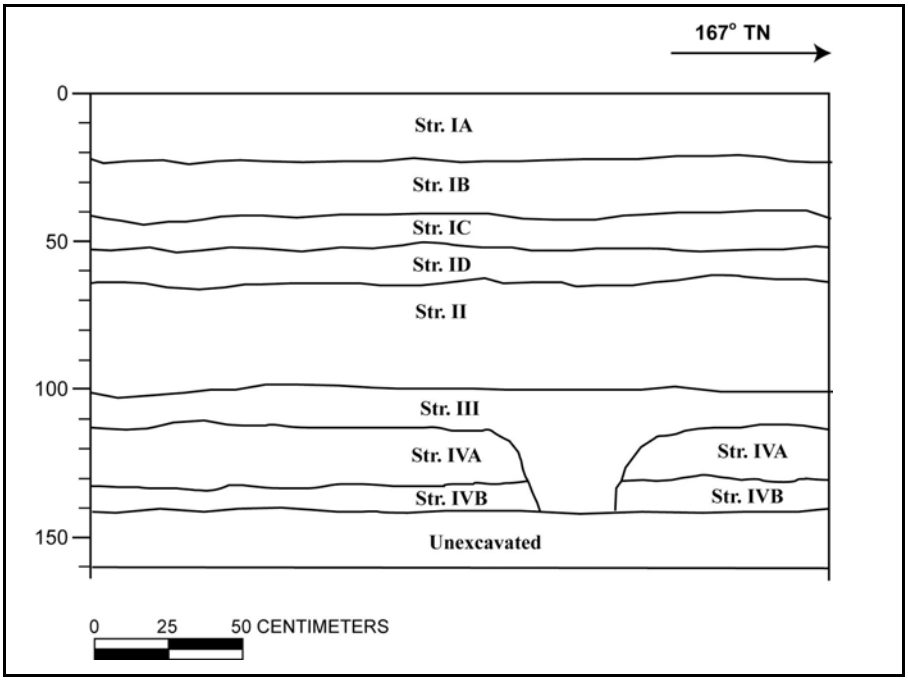

Figure 47. Profile from Phase I Ko‘olani Condominiums Archaeological Monitoring project (Hammatt 2008) showing representative stratigraphy near CSH 2-17 burial cluster

Stratum	cmbs	Sediment Description
IA	0-21 cmbs	Fill Horizon; 10 YR 4/3 brown; sandy loam; weak fine crumb structure; loose dry consistency; non-plastic; no cementation; terrestrial origin; abrupt, wavy lower boundary.
IB	21-40 cmbs	Fill Horizon; 10 YR 5/4 yellowish brown; sandy loam with 70% gravel; weak, fine crumb structure; loose dry consistency; non-plastic; no cementation; terrestrial origin; abrupt wavy boundary
IC	40-52 cmbs	Fill Horizon; 10 YR 7/3, very pale brown medium sand with 70% coral cobbles; weak, fine single grain structure; loose dry consistency; non-plastic; no cementation; mixed origin; abrupt, wavy lower boundary
ID	52-63 cmbs	Fill Horizon; 10 YR 3/3, dark brown; sandy loam with 70% gravel; weak, fine to medium, blocky structure, loose dry consistency; non-plastic; weak cementation; terrestrial origin; abrupt wavy lower boundary
II	63-100 cmbs	10 YR 5/4, yellowish brown; medium, sand; weak, fine to medium single grain structure; hard dry consistency; non-plastic; strong cementation; marine and terrestrial origin; abrupt smooth lower boundary; cemented due to compaction of former building and road
III	100-116 cmbs	A-Horizon, 10YR 3/3, dark brown; fine to medium sand; weak,

		fine single grain structure; loose dry consistency; non-plastic; no cementation; marine origin; abrupt, smooth lower boundary; contemporaneous with burial pit.
IVA	116-131 cmbs	10YR 6/2, light brownish gray, medium sand; weak, fine, single grain structure; loose moist consistency; non-plastic; no cementation; abrupt smooth lower boundary; some naturally deposited marine shell
IVB	131-BOE	10YR 5/1, gray, coarse sand; weak, medium single grain structure; wet, non-sticky; non-plastic; no cementation; marine origin; lower boundary not observed; some naturally deposited marine shell

3.1.10.2 Phase II Project Area

3.1.10.2.1 Tulchin and Hammatt 2005

In 2005, CSH completed an Addendum to the Phase I Archaeological Inventory Survey report (O'Hare et al. 2004), conducted within the southern portion of the Phase II project area (Figure 48). The inventory survey involved subsurface testing in the vicinity of a proposed high-rise condominium footprint.

The general stratigraphy consisted of four to five layers of historic and modern fill (Strata Ia-Ib in Profile 3) , including a historic trash layer (Stratum Ic in Profile 3), to approximately two meters below the ground surface overlying natural gleyed clay or sandy clay sediments (Stratum II), typical of wet, marsh-type environments (Figure 49 and Figure 50). Immediately overlying the natural marsh-type sediments was the historic trash layer containing various wood, metal, and glass refuse (SIHP # -6641).

The inventory survey documented the presence of two previously identified historic properties SIHP # -6641 (historic fill layer) and SIHP # -6636 (original wetland sediment) (O'Hare et al. 2004). Several diagnostic historic glass bottles were recovered from SIHP # -6641, dating roughly between 1910 and the 1920s. There was no evidence of pre-contact cultural materials or human remains throughout the subsurface testing area.

3.1.10.2.2 Runyon et al. 2011a

In 2011, CSH completed an Archaeological Inventory Survey for the entire 1.73-acre Phase II Ko‘olani Condominium project area (Runyon et al. 2011a). The subsurface testing program included the excavation of 29 test trenches (147 m^2) and 15 larger test units (199 m^2), comprising a total of 346 m^2 or approximately 5 % of the project area.

The project area was divided into three stratigraphic zones (Zones A-B) (Figure 51). Zone A, located in the west portion of the project area, generally consisted of imported fill material overlying a buried cultural layer (SIHP # -7115), Jaucas sand, marine sediments, and the coral shelf. Zone B, included the east half of the project area and generally consisted of imported fill material overlying a burnt trash fill layer (SIHP # -6641), buried Kewalo wetland sediment (SIHP # -6636), marine sediments, and the coral shelf. Zone C, located in the central portion of the project area, consisted of a transitional zone between Zones A and B.

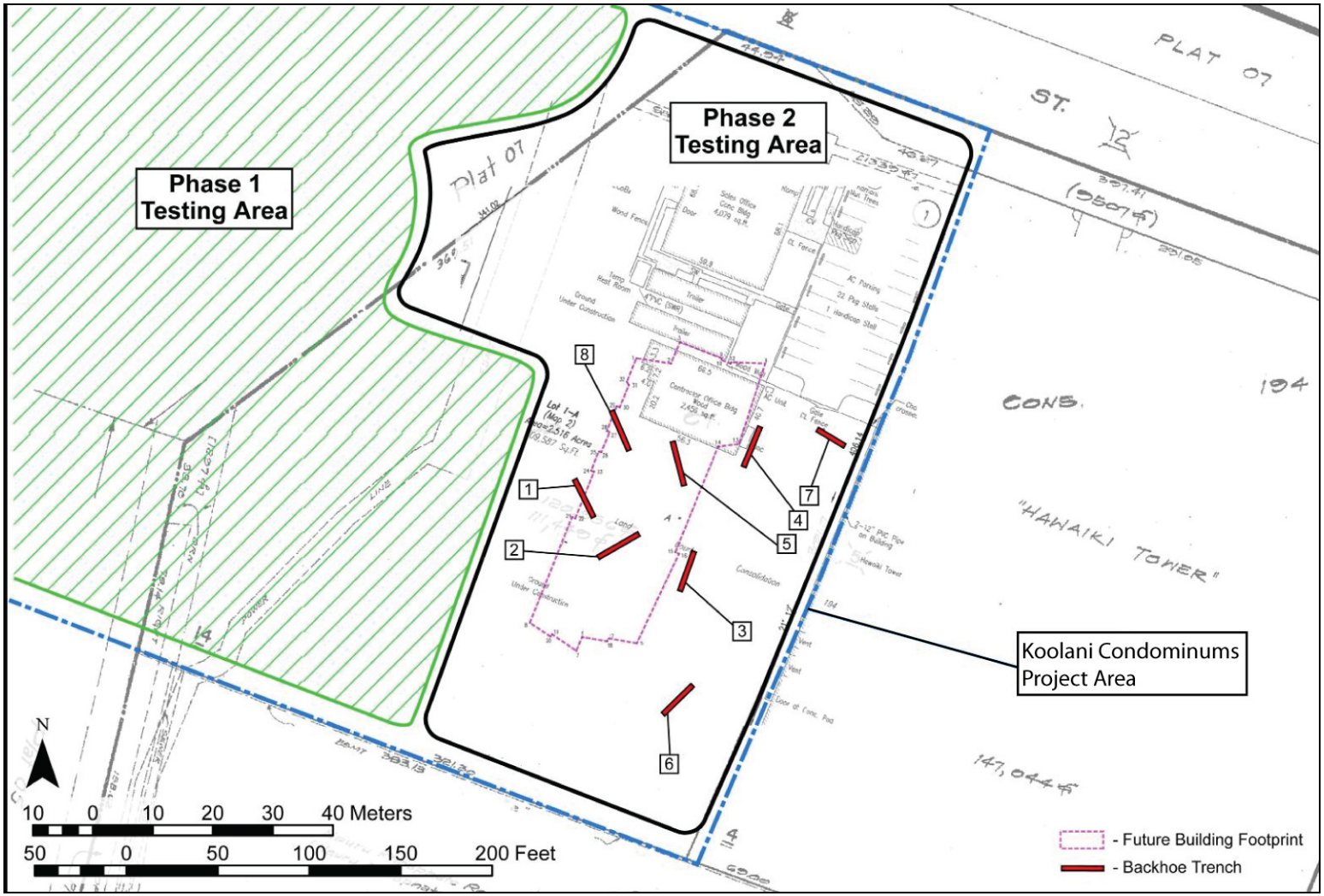

Figure 48. Plan view of the Ko‘olani Condominiums Phase II project area (Tulchin and Hammatt 2005) showing the locations of excavated trenches (note: the plan was revised by the subsequent owner in 2008)

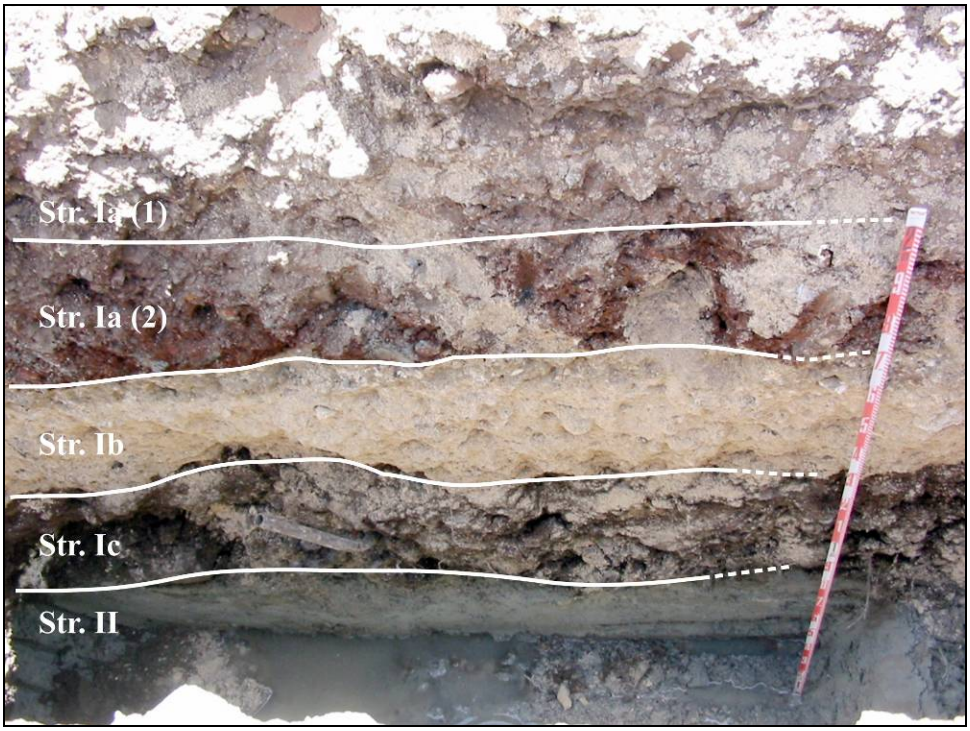

Figure 49. Photo of Trench 3, northwest wall within Addendum AIS project area (Tulchin and Hammatt 2005)

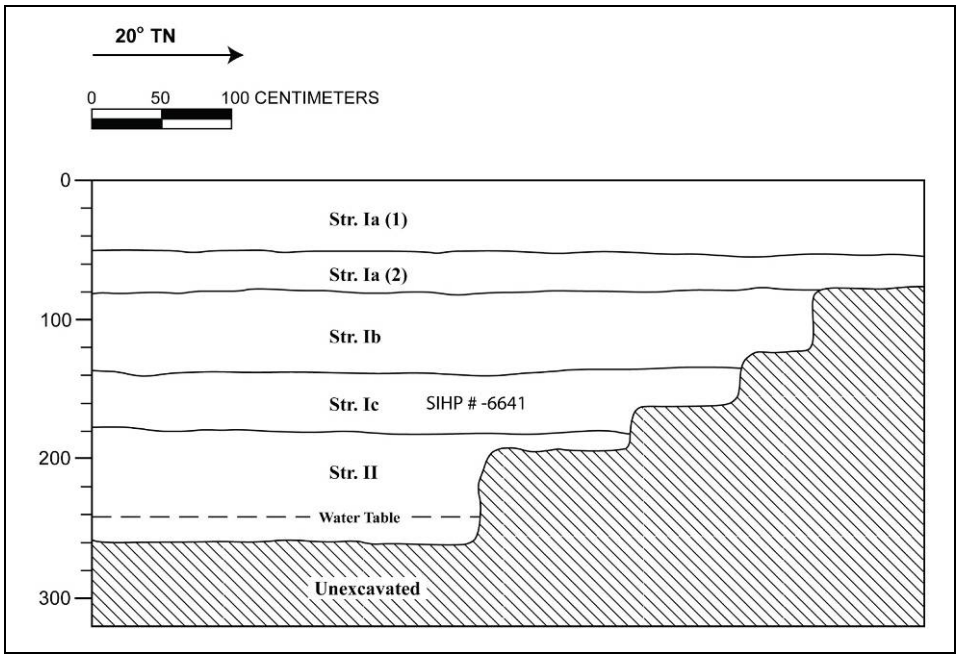

Figure 50. Profile of Trench 3, northwest wall within Addendum AIS project area (Tulchin and Hammatt 2005)

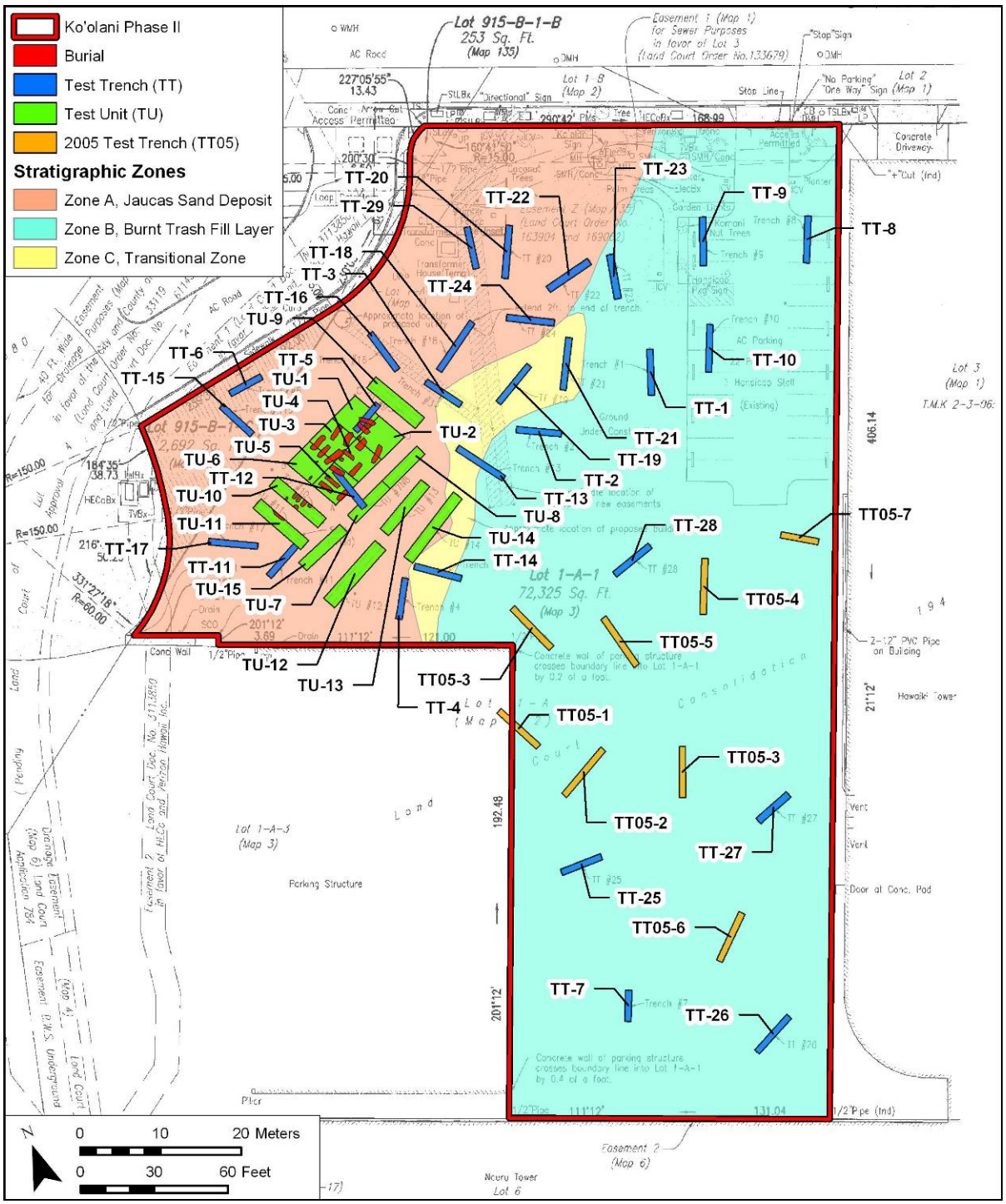

Figure 51. Survey map showing the locations of all trenches and test units excavated within the Phase II project area (Tulchin and Hammatt 2005 trenches in orange; Runyon et al. 2011a trenches in blue and test units in green), with an overlay of designated stratigraphic zones (Zones A-C) (map adapted from Engineers Surveyors Hawai‘i, Inc. 2010)

Five historic properties, including two previously documented (SIHP #'s 50-80-14-6641 and -6636) and three newly documented (SIHP #'s 50-80-14-7115, -7116, and -7117), were identified within the project area (Figure 52 through Figure 54, and refer to Figure 36 and Figure 37). A portion of the cultural layer (SIHP # -7115) was recommended for preservation (addressed in a Preservation Plan, Runyon et al. 2011b), the burial concentration (SIHP # -7117) was recommended for burial treatment and preservation in place (addressed in a Burial Treatment Plan, Runyon et al. 2011c), and sites SIHP #'s -6636, -6641, -7115, and -7116 were recommended for data recovery in the form of archaeological monitoring (addressed in a Mitigation Plan, Runyon et al. 2011d). During the monitoring program, it is also recommended to conduct a controlled data recovery component specifically relating to certain pile and pile cap locations located within SIHP # -7115 (Runyon et al. 2011d). The Burial Treatment Plan was accepted by the SHPD in 2011 (Log No. 2011.1956, Doc No. 1108pc001), the Preservation Plan was accepted by the SHPD on May 16, 2012 (Log No. 2011.3268, Doc No. 1205NN15, and the Mitigation Plan was accepted on May 16, 2012 (Log No. 2011.3267, Doc No. 1205NN14).

3.1.10.2.2.1 SIHP # 50-80-14-6636

SIHP # 50-80-14-6636 consists of portions of the former wetland surface of the Kewalo area, originally identified by O‘Hare et al. (2003) and subsequently identified within the Phase 1 portion of the Ko‘olani Condominium project (O'Hare et al. 2004) and the Addendum Inventory Survey (Tulchin and Hammatt 2005). The site consists of dark grayish brown and very dark brown peaty clay loam sediments containing decomposing organic material, snail shells and charcoal flecking, overlying marine sediments and the coral shelf.

3.1.10.2.2.2 SIHP # 50-80-14-6641

SIHP # 50-80-14-6641 consists of a historic burnt trash fill layer, originally identified within the Phase 1 portion of the Ko‘olani Condominium project (O'Hare et al. 2004) and subsequently in the Addendum Inventory Survey (Tulchin and Hammatt 2005). The site consists of a concentration of burnt trash and sediment used as fill material to raise the original ground surface.

Diagnostic artifacts collected from SIHP # -6641 provided a date range between the 1880s and 1940s. The overlapping date range for all collected diagnostic artifacts from SIHP # -6641 ranged from 1925-1927. This may indicate the time period when the burnt trash fill layer was deposited, however, it is more likely that this layer was accumulated at least in part, throughout the early twentieth century for waste disposal and land filling purposes, likely until around 1930 when the Kewalo Incinerator was built.

3.1.10.2.2.3 SIHP # 50-80-14-7115

SIHP # 50-80-14-7115 is a buried culturally-enriched sand A-Horizon (cultural layer) containing multiple pit features and pre- and post-contact artifacts, located throughout the west half of the project area. A total of 170 features were documented as associated with SIHP # -7115, including midden features, animal interments, post molds, a fire pit, a cache feature, a possible communal cesspool, among other feature types. Sixteen traditional Hawaiian artifacts, eight historic artifacts, and eleven wooden post remnants were collected from the cultural layer and associated features. The abundant features and artifacts found indicates the site function as habitation and/or activity area.

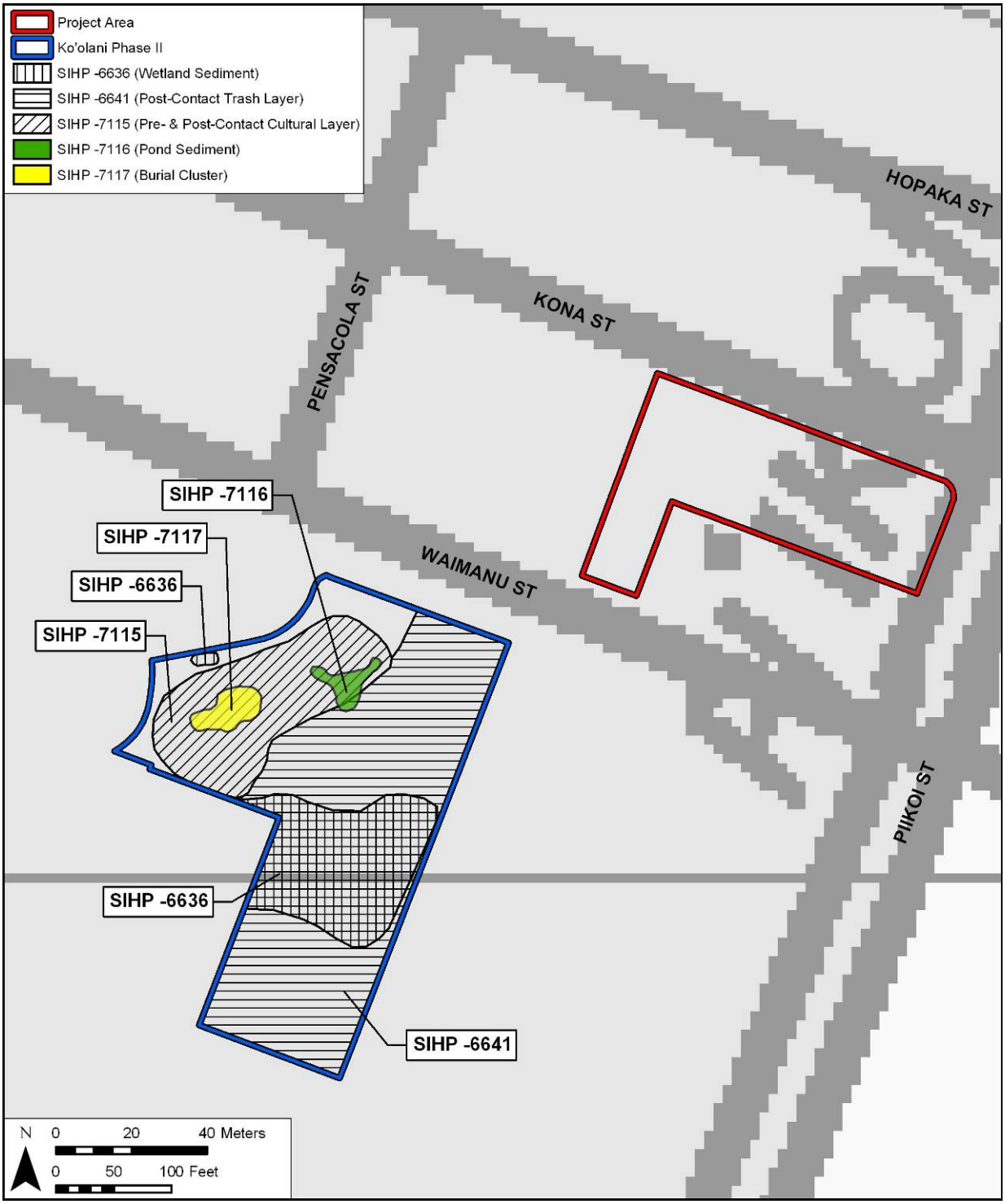

Figure 52. Portion of the 1998 USGS Honolulu 7.5 minute quadrangle map, showing locations of historic properties documented within the Phase II Ko‘olani Condominium (Runyon et al. 2011a) project area (outlined in blue) in relation to the current project area (outlined in red)

Figure 53. Photo of Trench 14, view to north (Runyon et al. 2011a)

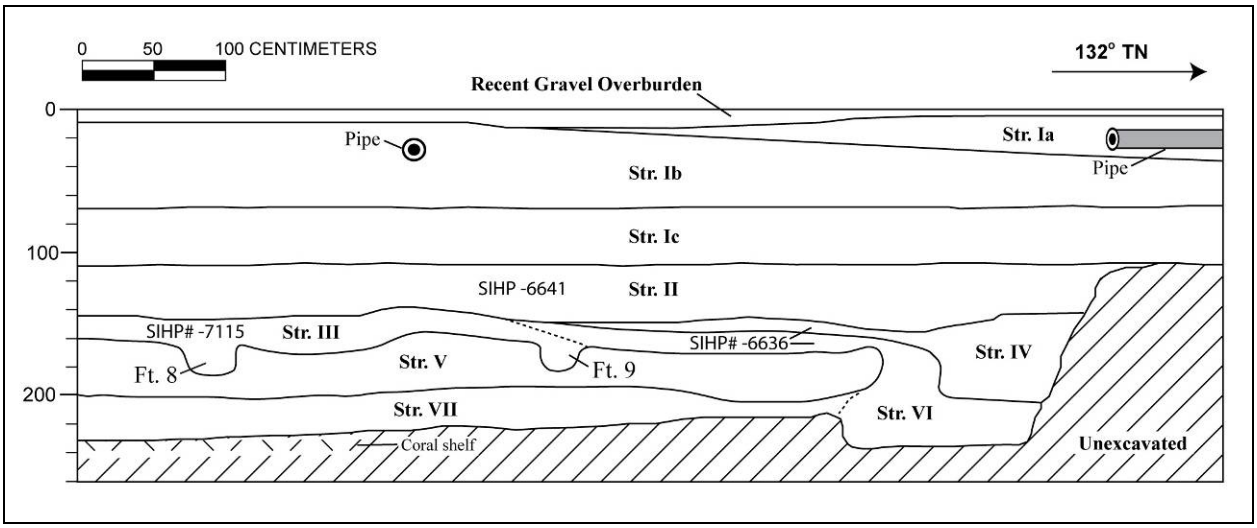

Figure 54. Profile of Trench 14, northeast wall showing SIHP #’s 50-80-14-6641, -6636, and -7115 (Runyon et al. 2011a)

Stratum	cmbs	Sediment Description
Ia	5-38	Fill Layer; 10 YR 8/1 white; crushed coral; structureless; dry hard consistency; non-plastic; no cementation; marine origin; abrupt smooth lower boundary
Ib	5-75	Fill Layer; 10 YR 5/3 brown; gravelly clay loam; structureless; dry weakly coherent; non-plastic; weak cementation; terrestrial origin; abrupt smooth lower boundary
Ic	75-110	Fill Layer 10 YR 6/3 pale brown; crushed coral; structureless; dry hard consistency; non-plastic; no cementation; marine origin; abrupt broken lower boundary
II	110-150	Historic Fill Layer; 10 YR 3/1 very dark gray; sandy clay; structureless; moist very friable; slightly plastic; no cementation; terrestrial origin; clear smooth lower boundary; burnt trash layer SIHP # 50-80-14-6641
III	142-180	Cultural Layer; 10 YR 3/1 very dark gray; sand; weak fine single grain structure; dry slightly hard consistency; non-plastic; no cementation; mixed origin; clear smooth lower boundary; buried A-Horizon old land surface; SIHP # 50-80-14-7115
IV	142-205	Wetland Sediment; 10 YR 2/2 very dark brown; peaty clay loam, moderate medium crumb structure; moist friable consistency; slightly plastic; no cementation; mixed origin; abrupt smooth lower boundary; contains snail shells, charcoal flecking, and decomposing organic material; associated with SIHP # 50-80-14-6636
V	160-210	Jaucus Sand; 10 YR 8/2 very pale brown; sand; structureless; moist loose consistency; non-plastic; no cementation; marine origin; clear smooth lower boundary
VI	142-230	Marine Sediment; Gley 1 4/10Y dark greenish gray; clay; weak medium blocky structure; moist friable consistency; slightly plastic to plastic; no cementation; mixed origin; diffuse smooth lower boundary; natural marine sediment; likely associated with SIHP # -6636
VII	200-230	Marine Sediment; Gley 1 7/5GY light greenish gray; sandy clay; weak fine single grain structure; moist friable to wet sticky consistency; slightly plastic; no cementation; marine origin; abrupt smooth lower boundary; marine sandy clay over coral shelf

Three of the collected historic artifacts had diagnostic attributes. Two of the diagnostic artifacts were associated with a communal cesspool feature and were identified as having been manufactured between 1920 and 1966. A cobalt blue bottle recovered from a sub-surface pit feature (SIHP # -7115) originating from the cultural layer was manufactured between 1901 to 1938.

Two basalt adzes found within separate features of SIHP # -7115, were sent to the University of Hawai‘i-Hilo for EDXRF analysis. The analysis determined the material originated from the Waiāhole Valley area on O‘ahu.

Three charcoal samples and two wooden post remnants collected from intact features were sent to International Archaeological Research Institute, Inc. (IARII) for taxa identification. The identified samples indicated native and introduced wood species were utilized in the project area.

One bulk sediment sample and a charcoal sample containing identified native Hawaiian taxon were sent to Beta Analytic, Inc. for radiocarbon dating. The bulk sample yielded one possible date range, with a calibrated 2-sigma date of AD 1717-AD 1891 (61.3% probability). The identified charcoal sample yielded three possible date ranges, with a calibrated 2-sigma date of AD 1724-AD 1815 (48 % probability). These dates range from the late pre-contact through early post-contact time periods which correspond with project related background and archaeological documentation of the site, which suggest the land was continually utilized by native Hawaiians for successive generations.

3.1.10.2.2.4 SIHP # 50-80-14-7116

SIHP # 50-80-14-7116 is a buried low-energy alluvial layer (gleyed sediment) typically characterized as pond sediment, located in the northern portion of the project area. The site corresponds geographically to a documented historic pond shown on historic maps. The pond sediment consisted of dark grey to dark greenish grey sandy loam and sandy clay sediments containing marine shell and decomposing organic material, overlying Jaucas sand and/or marine sediments.

3.1.10.2.2.5 SIHP # 50-80-14-7117

SIHP # 50-80-14-7117 is a burial concentration containing 27 individuals was documented within the western portion of the project area (Figure 55). Three of the burials were encountered during the initial test trenching (within Trenches 5 and 12) and 24 burials were encountered while hand excavating within the investigative test units (Test Units 1-6, 10 and 11). Figure 56 through Figure 58 shows representative stratigraphy within SIHP # -7117.

Through consultation with the SHPD, only limited exposure of the remains was conducted in order to determine burial orientation, position, and method of interment. The observed burial methods, including the extended burial positions and wooden coffins, indicated post-contact interments. Very few grave goods or artifacts were observed interred with the burials were observed. For the purposes of this project, grave goods did not include coffin remnants, which were encountered with all the documented coffin burials. All grave goods and coffin remnants were left in situ with the burials and were not collected. The burials ranged from 1 to 1.67 meters below the surface (mbs). The overlying fill averaged 1.29 mbs and the water table was encountered at an average of 2 mbs.

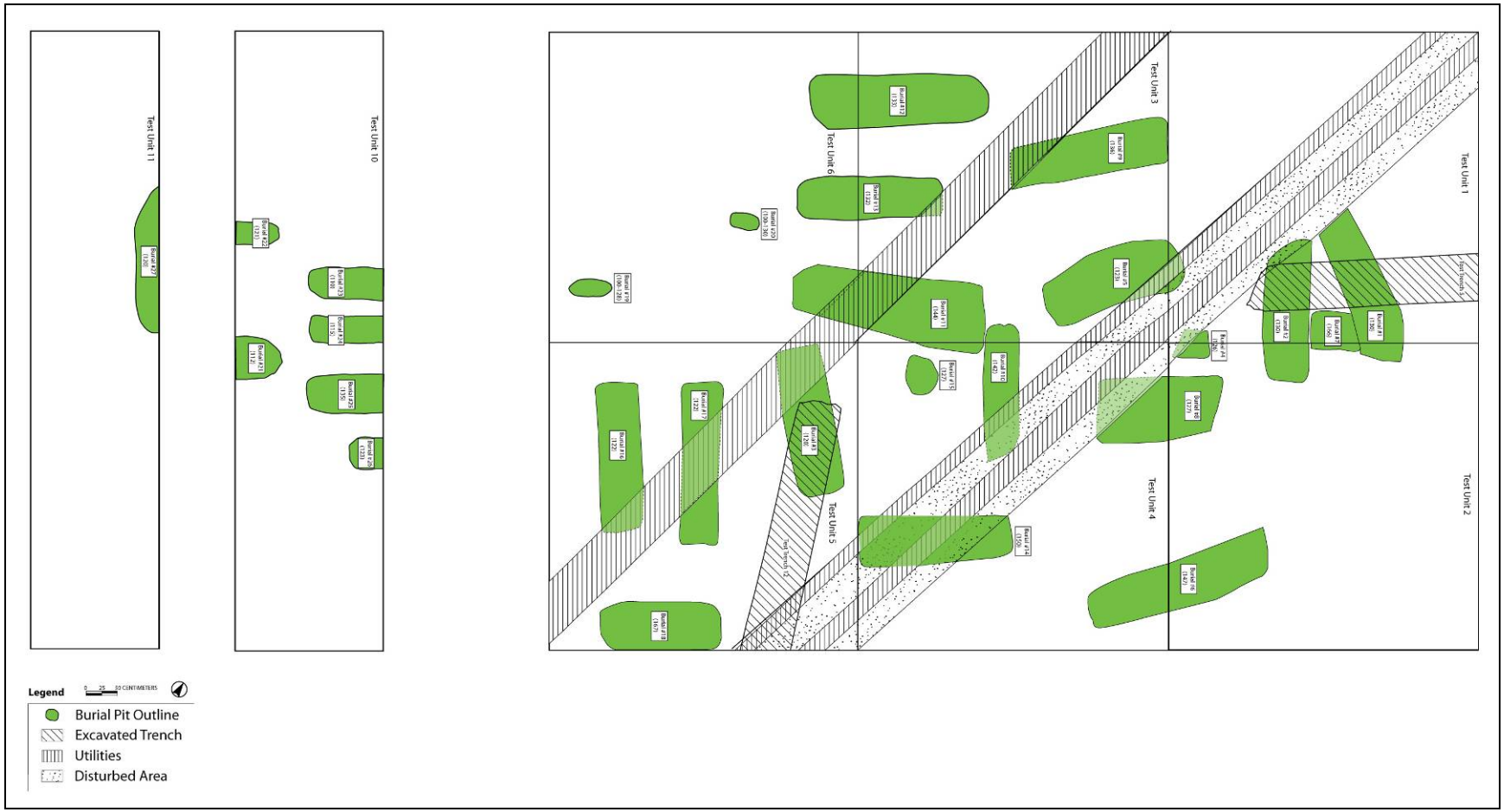

Figure 55. Plan map of Test Units 1-11 showing the locations of all burial finds from the Phase II Ko‘olani Condominiums project area (Runyon et al. 2011a)

Figure 56. Photo of Test Unit 1, west wall profile, view to west (Runyon et al. 2011a)

Figure 57. Photo of Test Unit 1, west profile wall, showing the Burial 9 pit outline, view west (Runyon et al. 2011a)

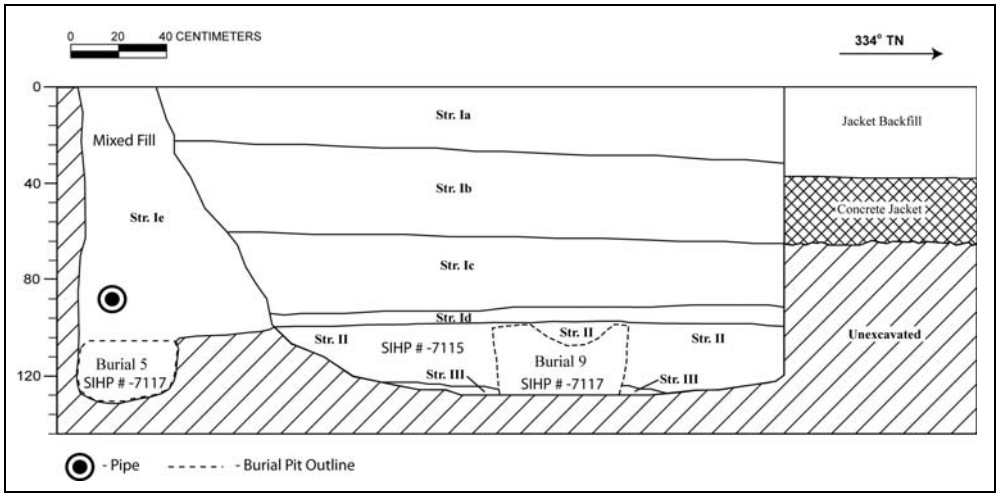

Figure 58. Profile of Test Unit 1, west wall (Runyon et al. 2011a)

Stratum	cmbs	
Ia	0-35	Fill Layer; 10 YR 8/1 white; gravel and crushed coral; structureless; dry loose consistency; non-plastic; no cementation; mixed origin; abrupt smooth lower boundary
Ib	25-65	Fill Layer; 10 YR 7/3 very pale brown; crushed coral; structureless; moist loose consistency; non-plastic; no cementation; marine origin; abrupt smooth lower boundary
Ic	65-90	Fill Layer; 5 YR 4/4 reddish brown; gravelly clay loam; weak fine crumb structure; moist friable consistency; slightly plastic; no cementation; terrestrial origin; abrupt smooth lower boundary
Id	80-90	Fill Layer; Gley 2 5/5B bluish gray; gravelly, sandy clay; hard medium crumb structure; dry hard consistency; non-plastic; strong cementation, mixed origin; abrupt smooth lower boundary; highly compacted fill
Ie	0-123	Mixed Fill; consists of Strata Ia through Id; modern utility trench cutting through upper fill strata
II	89-120	Cultural Layer; 10 YR 3/2 very dark grayish brown; sandy loam; moderate medium granular structure; moist friable consistency; slightly plastic; no cementation; mixed origin; abrupt smooth lower boundary; buried A-Horizon old land surface; SIHP # -7115
III	119-165	Jaucus Sand; 10 YR 8/3 very pale brown; sand; weak fine single grain structure; moist loose consistency; non-plastic; no cementation; marine origin; abrupt smooth lower boundary
IV	165-180	Marine Sediment; Gley 2 6/5B bluish gray; clay; moderate medium blocky structure; moist friable consistency; very plastic; no cementation; marine origin

The only diagnostic artifact observed near the burials was a historic bottle, found just above Burial 5 in a fill deposit. The bottle contained an embossed maker's mark on the base reading "C & Co" which refers to Cunninghams & Company based out of Pittsburgh, Pennsylvania from 1879-1907 (Toulouse 1971:119). This indicates that Burial 5 must pre-date circa 1908.

3.2 Previous Studies in the Project Area (Barnes and Shideler 2007)

Prior to the archaeological inventory survey for this project (Runyon, Borthwick and Hammatt 2012), an archaeological field check and literature review study was completed for the previous landowner, K2 Investors LLC (Barnes and Shideler 2007). The archaeological literature review and field inspection study was completed in order to support the project's historic preservation review compliance, to determine if there were any major archaeological concerns within the project area, and to explain the State historic preservation requirements that would need to be fulfilled prior to land alteration within the project area. The study indicated an archaeological inventory survey and an archaeological monitoring program should be anticipated. Photos were taken of the project area however, no subsurface work was conducted.

3.3 Previous Archaeology Summary and Predictive Model

Previous archaeological studies and background research suggests that the present study area is located in a region less extensively populated than the nearby centers of Waikīkī and Honolulu before the nineteenth century. However, maps and documents produced during the nineteenth century indicate that the Kewalo region had been utilized by the Hawaiians for fishpond farming, salt making, wetland agriculture, and for burial grounds. It is likely that pre-Contact cultural deposits including pit features and/or burials remain intact beneath the late nineteenth and early twentieth century fill layers covering Kewalo today.

The project area is located mostly in what was the wetland plain of Kewalo. This area provided early Hawaiians with the environment needed for the cultivation of fishponds and subsistence crops such as taro. The features expected from these cultural activities include berms, *lo‘i* (pond fields), and fish pond sediment. In the early twentieth century the land was altered more intensely by Land Reclamation projects. These dredge and fill projects destroyed what remained of traditional Hawaiian cultivation practices in the wetlands of Kewalo. Remnants of the original wetland sediment and the imported historic fill have been documented in the near vicinity of the project area and would most likely be encountered during the current project investigation.

Based on the current project area's proximity to nearby documented historic properties, a high potential exists for SIHP # -6636 (wetland sediment) and # -6641 (burned trash layer) to be encountered (Runyon et al. 2011a). In particular, these sites (SIHP #'s -6636 and -6641) may extend into the southern (*makai*) portion of the current project area (see Figure 37). SIHP # -6636 has been found in former low land areas in the surrounding Kewalo/Kaka‘ako region (O‘Hare et al. 2003, O'Hare et al. 2004, Tulchin and Hammatt 2005, and Runyon et al. 2011a). SIHP # -6636 typically contains decomposing organic materials (peat), snail shells, rootlets and charcoal flecking over gleyed sandy clay sediments and the coral shelf. The wetland sediments associated with SIHP # -6636 were covered with imported materials during the early twentieth century Land Reclamation fill events. SIHP # -6641 was originally documented just *makai* of the

current project area (O'Hare et al. 2004, Tulchin and Hammatt 2005, Runyon el al. 2011a) and consists of a concentration of burnt trash which was deposited directly over the natural coral shelf and/or wetland deposits. Historic materials contained within SIHP # -6641 range in date between the 1880s and 1940 and consist of glass bottles, ceramics, metal, and wood fragments. CSH believes the trash layer is primarily associated with localized open-air burning and dumping of urban Honolulu trash prior to the construction and use of the 1930s Kewalo Incinerator. The stratigraphy overlying SIHP # -6641 includes a thick layer of crushed coral fill and various imported fill layers.

Previous and on-going archaeological reports have documented human burials - both pre-Contact Hawaiian and historic - throughout the greater Kaka‘ako area (Kaka‘ako Improvement District), which includes the Kewalo area, and throughout Waikīkī. Eighteen burials, two pre-Contact and sixteen post-Contact, were encountered in 2008 (Hammatt 2008) during monitoring investigations of the Phase I Ko‘olani Condominium project just southwest of the current project area. During Phase II work, twenty-seven burials, all post-Contact and likely of Hawaiian ethnicity, were encountered (Runyon et al. 2011a) just south of the current project area. Isolated burials and burial clusters have been found primarily in sandy deposits, just above the water table and below historic-era fill materials.

Pre-Contact burials will likely be located within pits and be associated with pre-Contact habitation deposits. Post-Contact burials will typically be located within extended pits with possible evidence of coffin material and/or grave goods associated with the post-Contact period (metal jewelry or other Asian or European objects). Habitation deposits will frequently be evident in the stratigraphy as dark-colored sand with features such as post-molds and firepits, artifacts, and food remains (marine shell, bone, and *kukui* endocarps, etc.). Post-Contact deposits will likely contain ceramic, metal and glass. Agricultural features such as irrigation ditches, fishponds and irrigated fields, and the sand berms that were often built along the edges of ponds and fields may be found in the trench profiles.

According to background research and previous archaeological studies, construction activities in the project area have the potential to inadvertently uncover: (1) pre-Contact and post-Contact (1800s) burials; (2) pre-Contact and post-Contact wetland, agricultural, and/or aquacultural features; (3) and pre-Contact and post-Contact (1800s) habitation deposits such as trash pits and cultural deposits; (4) fill deposits associated with various with various Land Reclamation projects dating to the first half of the twentieth century.

Section 4 Archaeological Inventory Survey Results

4.1 Summary of Inventory Survey Results

4.1.1 Surface Survey

The fieldwork component of this archaeological inventory survey (AIS) was conducted between May 19, 2010 and November 16, 2011. A brief 100 percent pedestrian inspection of the project area's surface identified the existing warehouse structure covering the project area to be older than 50 years old (Figure 60 and Figure 61). On March 4, 2011, through consultation with the Architecture Branch of the SHPD, the building was determined not to merit listing on the Hawai‘i Register of Historic Places (Log No. 2011.0599, Doc No. 1103RS06) (Appendix A).

The existing warehouse structure was erected in 1948 and was completed by 1949 (refer to Figure 33). The structure was built specifically for the Durant-Irvine Company which specialized in plumbing equipment for small companies and large industries, such as plantations. More recent changes to the warehouse included a 1961 addition fronting Pi‘ikoi Street. Over time the warehouse has been used for storage and car parking and presently is being used by a single tenant for a contractor business.

4.1.2 Subsurface Testing

The subsurface testing program included the excavation of 13 test trenches, comprising a total of approximately 56 m^2 or approximately 1.8% of the project area (Figure 59 and Table 3). Ten test trenches (Trenches 1-10) were excavated within the main warehouse and three trenches (Trenches 11-13) were excavated in proposed utility corridors outside of the main warehouse.

Representative trench profiles (Trenches 3, 7, 10 and 12) and corresponding stratigraphic descriptions are presented in this report (Figure 60 through Figure 69 and Table 4 through Table 7). Observed and documented stratigraphy was relatively consistent throughout the project area. In general, project stratigraphy included a concrete or asphalt surface overlying various layers of imported historic and modern fill (Stratum I), including gravelly sandy clay, clay loam with sparse historic material (cinder, metal, and red brick), crushed coral, and hydraulic fill or pump dredge, over natural wetland (SIHP # -6636) (Stratum II), and coral shelf. Imported fill sediments extended to a minimum of 1.6 mbs (over 5 feet) in all trenches except one (Trench 7). Trench 7 was unique in that under the imported fill material (Stratum I) was a natural sandy clay deposit (Stratum II), which was not observed in any of the other trenches. The natural deposit was documented overlying natural sandy clay wetland (Stratum III) and coral shelf.

One historic property (SIHP # 50-80-14-6636) was documented during the subsurface investigation (see Figure 59). SIHP # 50-80-14-6636 consists of buried Kewalo wetland sediments. The site contains a very dark brown silty clay loam buried A-Horizon containing abundant decomposing organic materials (peat), snail shells, rootlets and charcoal flecking, overlying gleyed sandy clay sediments, over the coral shelf. In most trenches, within SIHP -6636 it was possible to discern between a very dark brown silty clay loam buried A-Horizon (Stratum IIa), and underlying gleyed sandy clay wetland sediment (Stratum IIb) (refer to the Trench 3

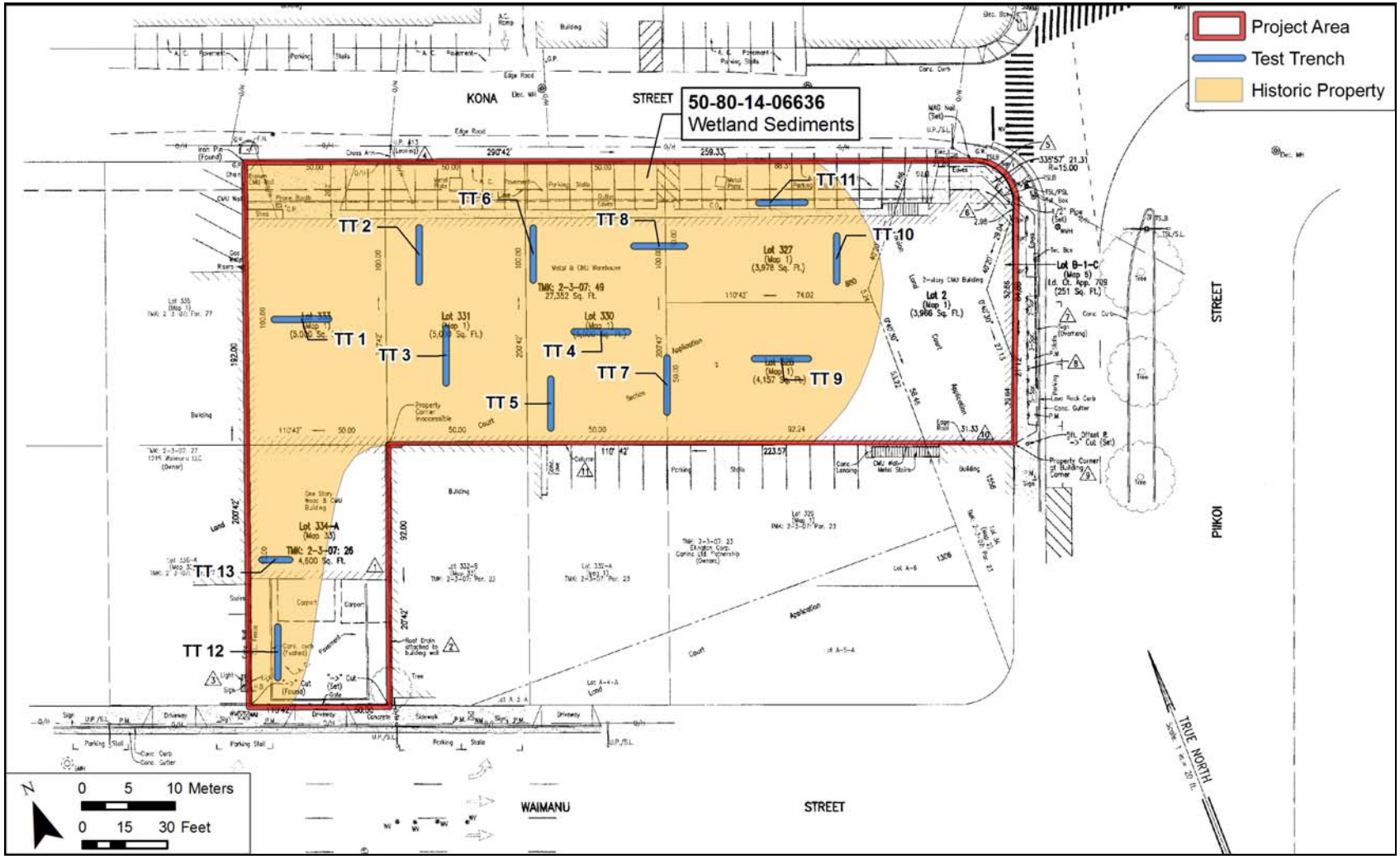

Figure 59. Construction plan showing the locations of excavated AIS trenches (in blue)

Table 3. Table Listing Trench Dimension and Orientation and Depth of SIHP # -6636 (meters below ground surface [mbs])

Trench	Length (m)	Width (m)	Orientation	Depth of Trench (mbs)	Depth of SIHP # -6636 (mbs)
1	5.9	0.8	E/W	2.2	1.6-2.2
2	5.9	0.8	N/S	2.05	1.7-2.05
3	5.9	0.8	N/S	2.05	1.75-2.05
4	5.8	0.8	E/W	2	1.7-2
5	5.3	0.8	N/S	2.05	1.7-2.05
6	5.6	0.8	NE/SW	2	1.75-2
7	5.9	0.8	N/S	2.05	1.7-2.05
8	5.5	0.8	E/W	2	1.65-2
9	5.8	0.8	SE/NW	2.5	1.8-2.5
10	4.9	0.8	N/S	2.5	2.05-2.15
11	5	0.8	E/W	2.4	1.8-2.18
12	5	0.8	N/S	1.8	1.7-1.8
13	3	0.8	E/W	1.95	1.7-1.95

profile). The buried wetland sediment (SIHP # -6636) was observed within all trenches within the project area. A photo of a bulk sample collected from SIHP # -6636 is shown in Figure 68. Historic documentation suggests the site was capped with imported fill during early 20th century Land Reclamation fill events. The site has been previously documented in nearby areas in Kaka‘ako (O’Hare et al. 2003, O’Hare et al. 2004, Tulchin and Hammatt 2005, and Runyon et al. 2011a).

A sediment sample collected from SIHP # -6636 was analyzed by Dr. Carl Christensen, professional malacologist. In general, the analysis found that the wetland site, SIHP # -6636, contains fauna typical of other similar wetland environmental sites in Hawai‘i. The analysis also notes that the snail species represented in the samples were “little changed from those present there and in similar environments in pre-Contact times” (Christensen 2011:9). Of three snail species commonly found in these wetland environments (*T. porrecta*, *M. tuberculata*, and *T. granifera*), one species (*T. porrecta*) found within SIHP # -6636 is now virtually extinct.

Figure 60. Photo of the existing warehouse (north portion) from Kona Street, view to southwest

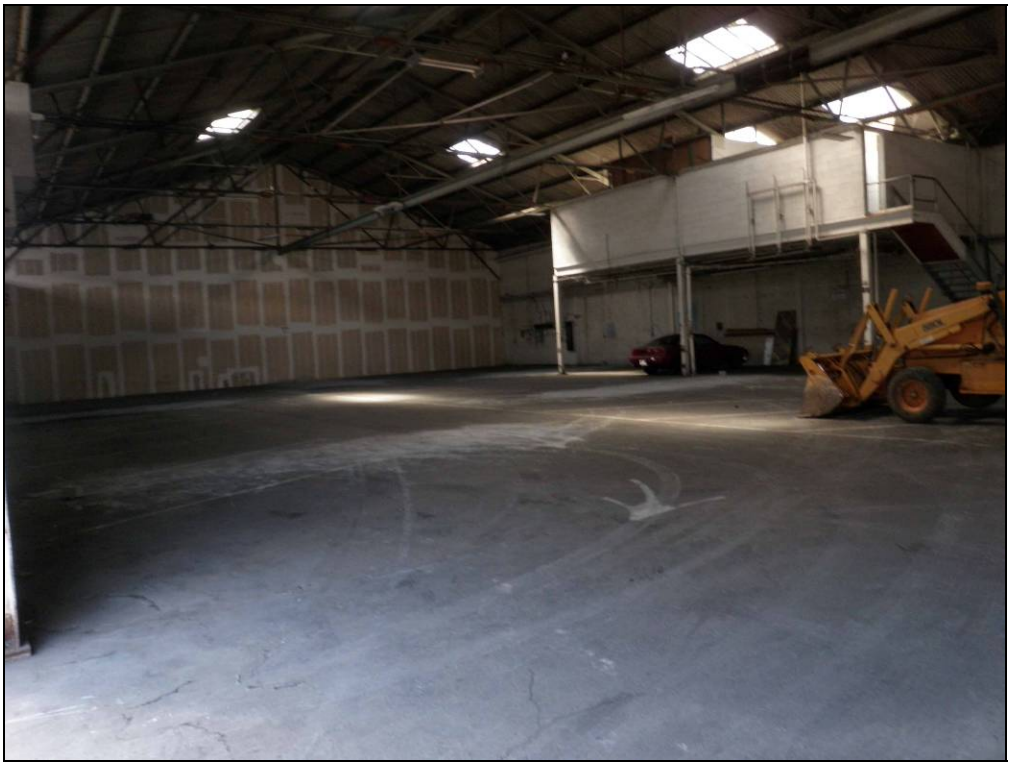

Figure 61.Photo showing the inside of the existing warehouse, view to south

4.1.3 Trench 3

Figure 62. Photo of Trench 3, showing profile wall, view to west

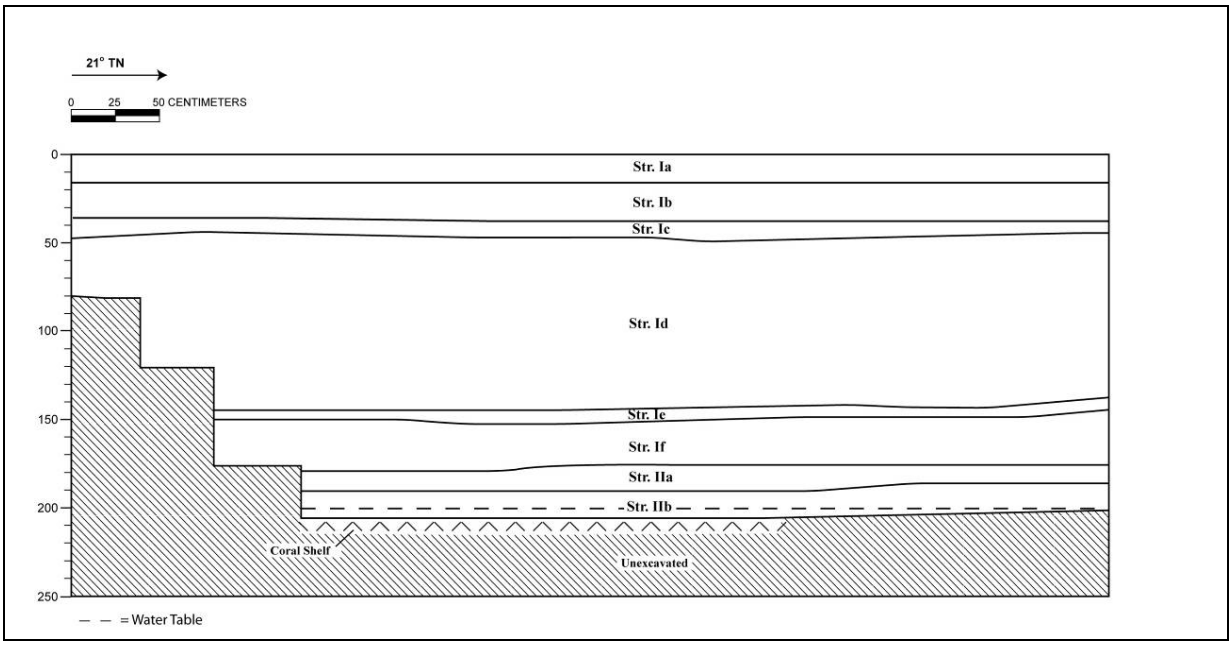

Figure 63. Profile of Trench 3, west wall

Table 4. Table Describing Stratigraphy Observed Within Trench 3

Stratum/Depth	Description
Stratum Ia (0-15 cmbs)	Concrete Surface
Stratum Ib (15-35 cmbs)	Fill; 10YR 4/3 (brown); gravelly sandy clay; structureless, fill; dry, loose consistency; non-plastic; mixed sediment; clear, smooth lower boundary; base course fill material
Stratum Ic (35-47 cmbs)	Fill; 10YR 2/2 (very dark brown) with 10YR 2/1 (black); clay loam mixed with cinder; structureless, fill; dry, slightly hard consistency; non-plastic; terrigenous; clear, smooth lower boundary; contains slag and metal fragments; possible incinerator fill
Stratum Id (47-145 cmbs)	Fill; 10YR 6/2 (light brownish gray); crushed coral; structureless, fill; dry, loose consistency; non-plastic; marine sediment; clear, smooth lower boundary; coral fill
Stratum Ie (145-150 cmbs)	Fill; 10YR 4/2 (light gray); silty clay; structureless, massive; wet, very sticky; plastic; marine sediment; diffuse, smooth lower boundary; hydraulic fill (pump dredge) material
Stratum If (150-178 cmbs)	Fill; Gley 1 7/10Y (light greenish gray); silty clay; structureless, massive; wet, very sticky consistency; very plastic; marine sediment; clear, smooth lower boundary; hydraulic fill (pump dredge) material
Stratum IIa (175-190 cmbs)	Natural; 10 YR 2/2 (very dark brown); silty clay loam; weak, medium, crumb structure; moist, very friable consistency; slightly plastic; terrigenous; clear, smooth lower boundary; many very fine to fine rootlets; natural organically-enriched A-Horizon containing thick peat, very small snails, rootlets and charcoal flecking, wetland SIHP # -6636
Stratum IIb (190-205 cmbs)	Natural; Gley 1 4/5GY (dark greenish gray); sandy clay; weak, fine, granular structure; wet, slightly sticky consistency; plastic; marine sediment; common, very fine rootlets; wetland SIHP # -6636

4.1.4 Trench 7

Figure 64. Photo of Trench 7, showing profile wall, view to northwest

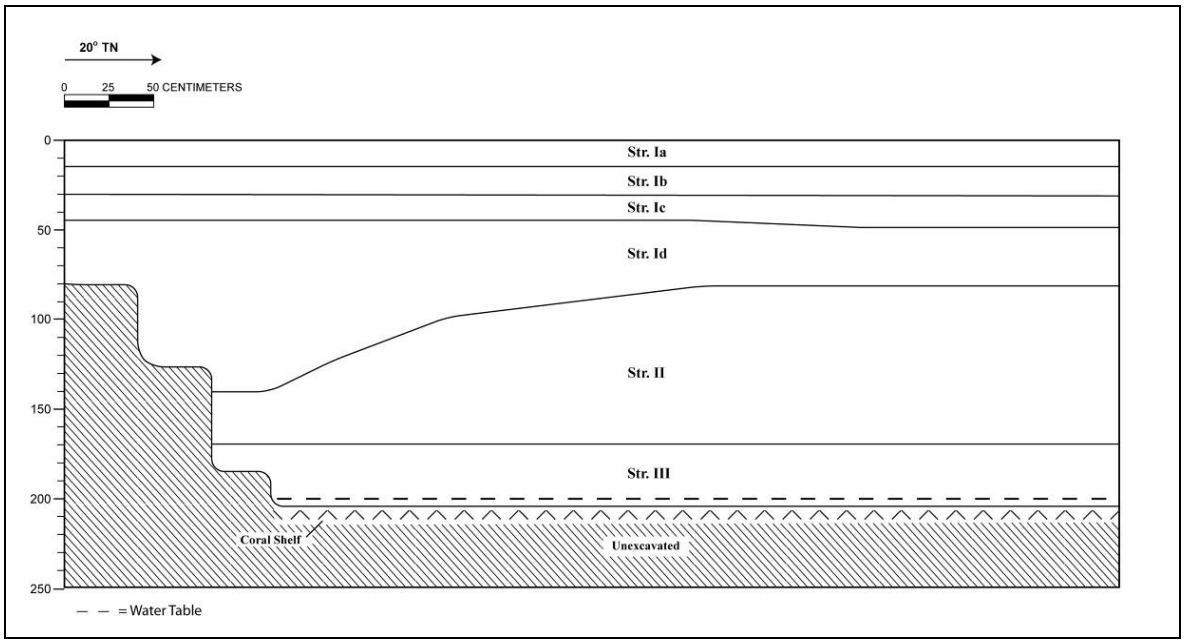

Figure 65. Profile of Trench7, west wall

Table 5. Table Describing Stratigraphy Observed Within Trench 7

Stratum/Depth	Description
Stratum Ia (0-16 cmbs)	Concrete Surface
Stratum Ib (16-30 cmbs)	Fill; 10YR 4/3 (brown); gravelly sandy clay; structureless, fill; dry, loose consistency; non-plastic; mixed sediment; clear, smooth lower boundary; base course fill material
Stratum Ic (30-50 cmbs)	Fill; 10YR 2/2 (very dark brown) with 10YR 2/1 (black); clay loam mixed with cinder; structureless, fill; dry, weakly coherent; non-plastic; terrigenous; very abrupt, smooth lower boundary; contains slag
Stratum Id (50-140 cmbs)	Fill; 10YR 6/2 (light brownish gray); crushed coral; structureless, fill; dry, loose consistency; non-plastic; marine sediment; clear, smooth lower boundary; coral fill
Stratum II (85-170 cmbs)	Natural; 10 YR 4/3 (brown); sandy clay; weak, fine, crumb structure; moist, friable consistency; plastic; mixed sediment; clear, smooth lower boundary; few, fine rootlets; contains basalt and coral cobbles (not water-worn); natural sediment
Stratum III (170-205 cmbs)	Natural; Gley 1 4/5GY (dark greenish gray); sandy clay; weak, fine, granular structure; wet, slightly sticky consistency; plastic; marine sediment; common, very fine rootlets; likely wetland sediment SIHP # -6636

4.1.5 Trench 10

Figure 66. Photo of Trench 10, showing profile wall, view to northeast

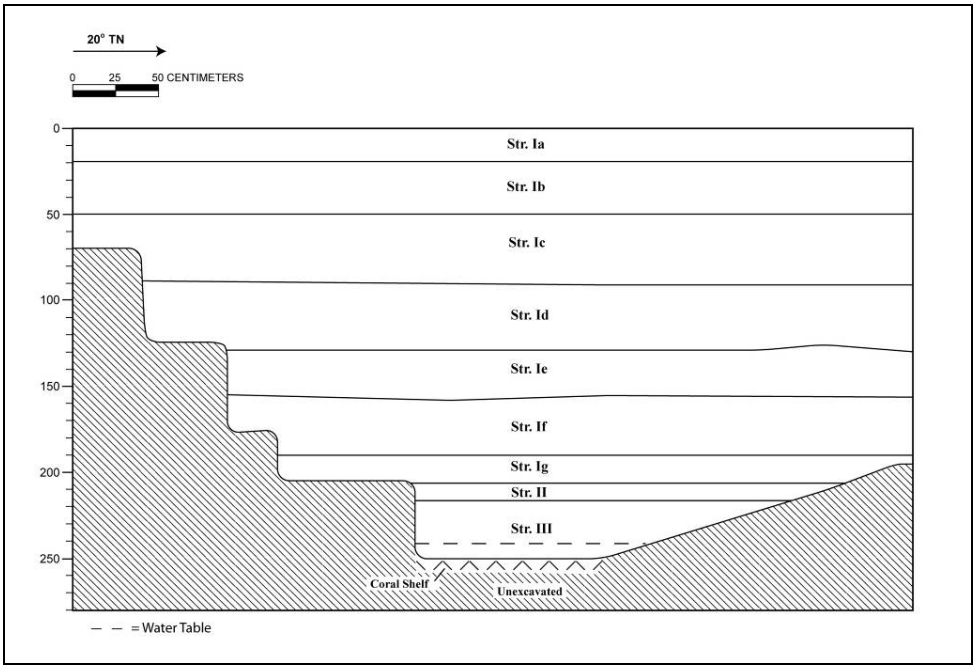

Figure 67. Profile of Trench 10, west wall

Table 6. Table Describing Stratigraphy Observed Within Trench 10

Stratum/Depth	Description
Stratum Ia (0-20 cmbs)	Concrete Surface
Stratum Ib (20-50 cmbs)	Fill; 10YR 3/2 (very dark grayish brown); gravelly sandy clay; structureless, fill; dry, loose consistency; non-plastic; mixed sediment; clear, smooth lower boundary; base course fill material
Stratum Ic (50-90 cmbs)	Fill; 10YR 2/1 (black); cinder; structureless, fill; dry, weakly coherent; non-plastic; terrigenous; very abrupt, smooth lower boundary; contains brick, coral pebbles and cobbles, and metal fragments
Stratum Id (90-130 cmbs)	Fill; 10YR 7/4 (very pale brown); crushed coral; structureless, fill; dry, loose consistency; non-plastic; marine sediment; clear, smooth lower boundary; coral fill
Stratum Ie (130-155 cmbs)	Fill; 10 YR 7/3 (very pale brown); sand; structureless, single grain; moist, loose consistency; non-plastic; marine sediment; clear and smooth lower boundary; sand fill with coral pebbles and cobbles
Stratum If (155-190 cmbs)	Fill; Gley 1 7/10Y (light greenish gray); silty clay; structureless, massive; wet, very sticky consistency; very plastic; marine sediment; clear, smooth lower boundary; hydraulic fill (pump dredge) material
Stratum Ig (190-205 cmbs)	Fill; Gley 1 7/5GY (light greenish gray); silty clay; structureless, massive; wet, very sticky consistency; very plastic; marine sediment; abrupt to clear, smooth lower boundary; hydraulic fill (pump dredge) material
Stratum II (205-215 cmbs)	Natural; 10 YR 3/1 (very dark brown); silty clay loam; moderate, medium, crumb structure; moist, friable consistency; plastic; terrigenous sediment; clear, smooth lower boundary; natural organically-enriched A-Horizon containing peat, very small snails, rootlets, and charcoal flecking, wetland SIHP # -6636
Stratum III (215-250 cmbs)	Natural; Gley 1 4/N (dark gray); loose coral shelf; moderate, coarse, angular structure, wet, non-sticky consistency; non-plastic; marine sediment; coral shelf

4.1.6 Trench 12

Figure 68. Photo of Trench 12, showing profile wall, view to south

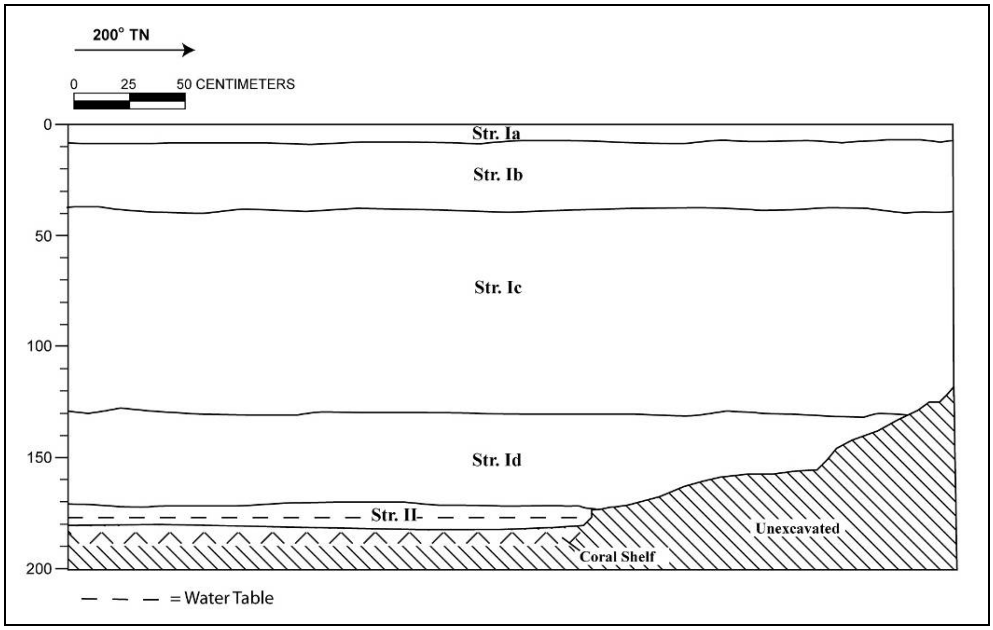

Figure 69. Profile of Trench 12, east wall

Table 7. Table Describing Stratigraphy Observed Within Trench 12

Stratum/Depth	Description
Stratum Ia (0-9 cmbs)	Asphalt Surface
Stratum Ib (6-39 cmbs)	Fill; 10YR 5/1 (gray); gravelly loam; structureless, fill; moist, loose consistency; non-plastic; mixed origin; abrupt, smooth lower boundary; no roots observed; fill containing coral and basalt gravel and concrete
Stratum Ic (36-130 cmbs)	Fill; 10YR 8/3 (very pale brown); crushed coral; structureless, fill; moist, very friable consistency; non-plastic; marine origin; clear, smooth lower boundary; common fine to medium roots; crushed coral fill
Stratum Id (130-170 cmbs)	Fill; Gley 1 7/5 GY (light greenish gray); sandy clay; structureless, massive; wet, sticky consistency; slightly plastic; marine origin; very abrupt, smooth lower boundary; no roots observed; hydraulic fill (pump dredge) material
Stratum II (170-180 cmbs)	Natural; 10YR 4/1 (dark gray); sandy clay loam; moderate, coarse, crumb structure; moist, friable consistency; plastic; mixed origin; common very fine to fine rootlets; natural organically-enriched A-Horizon containing peat, very small snails, rootlets, and charcoal flecking, wetland SIHP # -6636

Figure 70. Photo showing a sample of buried A-Horizon, wetland sediment (SIHP # -6636) (Stratum IIa) collected from Trench 13

Section 5 Historic Property Description

One historic property (SIHP # 50-80-14-6636) was documented during the project investigation. SIHP # 50-80-14-6636 consists of buried Kewalo wetland sediments.

5.1 SIHP # 50-80-14-6636

FORMAL TYPE:	Original Wetland Surface of the Kewalo area
FUNCTION:	Culturally Modified Wetland
# OF FEATURES:	0
AGE:	N/A
LOCATION:	Found throughout entire 0.74-acre project area
TAX MAP KEY:	TMK: [1] 2-3-007:026 & 049
LAND JURISDICTION:	Kewalo Development LLC

SIHP # 50-80-14-6636 consists of portions of the former wetland surface of the Kewalo area, originally identified during a study by O‘Hare et al. 2003 and also identified within the Phase 1 and Phase II portions of the Ko‘olani Condominium project (O’Hare et al. 2004, Tulchin and Hammatt 2005, and Runyon et al. 2011) (see Figure 37). The site boundary within the current project area is known only within tested portions of the project area. However, based on the distribution of SIHP # -6636 in the vicinity of the project area, this portion of SIHP # -6636 is likely discontinuous with wetland deposits documented both *mauka* (O‘Hare et al. 2003) and *makai* (O’Hare et al. 2004, Tulchin and Hammatt 2005, and Runyon et al. 2011a) of the project.

Within the current project area, SIHP # 50-80-14-6636 was found beneath thick layers of various fill materials (hydraulic fill or pump dredge and crushed coral) that were imported during early twentieth century Land Reclamation fill events. In general, the natural wetland contained two distinct strata. The upper stratum of SIHP # -6636 consisted of a silty clay loam containing abundant decomposing organic materials (peat), snail shells, rootlets and charcoal flecking representing an intact buried A-Horizon. The lower strata of SIHP # -6636 consisted of gleyed sandy clay wetland sediment containing rootlets and small snail shells. The buried wetland sediments (SIHP # -6636) were observed within all excavated trenches and were found directly overlying the coral shelf.

The stratigraphy observed during this study is similar to studies in the near vicinity which have documented SIHP # -6636. O’Hare et al. (2003) located approximately 140 meters (approximately 470 feet) north of the current project area, found Land Reclamation fill sediments overlaying original Kewalo wetland sediment (SIHP # 50-80-14-6636). The study described SIHP # -6636 as a very dark brown sandy clay loam with a high percentage of platy organic material, and an underlying very dark grayish brown sandy loamy clay with less organic material. The site was found to contain charcoal, marine invertabrates, fish scales, and rounded basalt gravel (O’Hare et al. 2003).

O’Hare et al. (2004), located approximately 100 meters (approximately 350 feet) southwest of the current project area, found Land Reclamation fill sediments overlaying original Kewalo wetland sediment (SIHP # 50-80-14-6636). The study encountered the site in 10 of 13 trenches and found it to consist of dark gray to dark grayish brown sandy loam containing charcoal flecking and marine invertebrates.

Tulchin and Hammatt (2005), conducted just across Waimanu Street from the current project area. Their study identified four to five layers of historic and modern fill which extended approximately 2 mbs. This fill overlaid natural gleyed clay or sandy clay sediments, typical of wet, marsh-type environments (SIHP # -6636). Immediately overlying the natural marsh-type sediments was a historic trash layer containing various wood, metal, and glass refuse (SIHP # -6641). Several diagnostic historic glass bottles were recovered from SIHP # -6641, dating roughly between 1910 and the 1920s. There was no evidence of pre-Contact cultural materials or human remains throughout the tested area.

The Runyon et al. (2011a), located in the same project area as Tulchin and Hammatt (2005). This more recent study identified up to five layers of imported fill overlying natural materials. The study divided the project into three stratigraphic zones (Zones A-C). Zone A contained a buried cultural layer (SIHP # -7115), Juacas sand deposits, and a small portion of wetland sediment (SIHP # -6636). Zone B consisted of a buried burnt trash fill layer (SIHP # -6641) and underlying wetland sediments (SIHP # -6636). Zone C consisted of a transitional zone and contained buried portions of the cultural layer (SIHP # -7115), pond sediments (SIHP # -7116), and a small portion of wetland sediment (SIHP # -6636). SIHP # -6636 was documented in three trenches, one in each stratigraphic zone, and was found directly overlying the coral shelf. The site consisted of dark grayish brown and very dark brown peaty clay loam sediments containing decomposing organic material, snail shells and charcoal flecking. In two trenches the peaty sediment overlaid dark gray or dark greenish gray clay wetland sediments. In Zone A, SIHP # -6636 was capped by crushed coral fill. In Zone B, SIHP # -6636 was capped by gravelly sandy clay loam and crushed coral fill. In Zone C, SIHP # -6636 was capped by a layer of burnt trash (SIHP # -6641). The trench excavated within Zone C (Trench 14) was situated on the border of a buried sand deposit containing culturally-enriched dark gray sand (SIHP # -7115) and the peripherary of the wetland (SIHP # -6636) which had been naturally accumulating over the sand deposit (refer to Figure 53). This portion of the cultural layer contained an intact midden feature (Feature 8) and an intact pig interment (Feature 9) (refer to Figure 54). Based on three radiocarbon dates, the cultural layer (SIHP # -7115) was utilized between AD 1615-1891. Due to the natural deposition of the wetland adjacent to the cultural layer, the wetland would be contemporaneous with these dates.

According to background research and previous archaeological studies, it is likely that wetland sediments very similar to those encountered during this project exists under fill deposits throughout the greater Kewalo/Kaka‘ako region. SIHP # 6636 represents the original pre-Contact to early twentieth century wetland surface of the greater Kewalo region. The site remained a natural wetland habitat, as indicated by the abundance of roots and native snail species (Christenson 2011), until the site was covered during early twentieth century Land Reclamation fill events.

Section 6 Summary and Interpretation

At the request of Kewalo Development LLC, CSH completed this archaeological monitoring plan for the approximately 0.74-acre proposed Senior Residence at Pi‘ikoi project in Kaka‘ako Ahupua‘a (TMK: [1] 2-3-007:026 & 049). Based on traditional accounts and historic background information, the current project area is located outside the two most intensely populated and cultivated areas during pre-contact times - Waikīkī and Honolulu (or Kou) - along this portion of O‘ahu’s southern shore. It was nonetheless well utilized by the Hawaiians for activities appropriate to the specific environment, such as salt making, farming of fishponds, and wetland agriculture.

The project area is located within the *‘ili* of Kewalo which was awarded as LCA 10605 to Kamake‘e Pi‘ikoi, wife of an *ali‘i* Jonah Pi‘ikoi. Unfortunately no additional land use data on LCA 10605 has been found. Other LCAs in the near vicinity of the project area were originally awarded as fort lands. To the south of the current project area is Royal Patent 3782 issued to Kapapa for Land Commission Award 97 F.L. (Fort Land). LCAs to the east of the project area include Royal Patent 7553 issued for LCA 100 F.L. and Royal Patent 3781 issued for LCA 101 F.L. As LCA 97 F.L. explains, the land was gifted “since Nu‘uanu”, suggesting these fort lands were granted by Kamehameha I after the battle of Nu‘uanu, likely to loyal warriors and their families. The LCA testimonies indicate these lands were passed down through generations of Hawaiian families. LCAs in the vicinity of the project area indicate these lands were used for fishponds, taro patches, salt pans, and house lots.

A brief 100 percent pedestrian inspection of the project area’s surface identified the existing warehouse structure covering the project area to be older than 50 years. On March 4, 2011, through consultation with the Architecture Branch of the SHPD, the warehouse was determined not to merit listing on the Hawai‘i Register of Historic Places (Log No. 2011.0599, Doc No. 1103RS06) (Appendix A).

The subsurface testing program included the excavation of 13 test trenches, comprising a total of approximately 56 m^2 or approximately 1.8% of the project area. One historic property (SIHP # 50-80-14-6636) was documented during the project investigation. SIHP # 50-80-14-6636 consists of buried Kewalo wetland sediments. SIHP # 50-80-14-6636 had been previously designated for buried wetland deposits in the vicinity of the project area. The site was originally identified approximately 140 meters (approximately 470 feet) *mauka* of the the current project area by O‘Hare et al. (2003). The site was also identified within Phase 1 and Phase II of the Ko‘olani Condominium project located across Waimanu Street from the current project area (O’Hare et al. 2004, Tulchin and Hammatt 2005, and Runyon et al. 2011a).

The site contains a very dark brown silty clay loam buried A-Horizon containing abundant decomposing organic materials (peat), snail shells, rootlets and charcoal flecking, overlying gleyed sandy clay sediments containing rootlets and small snail shells, over the coral shelf. A sample of the wetland site, SIHP # -6636, was sent to Dr. Carl Christenson for snail analysis. The analysis concluded the fauna assemblage represented in the sample was similar to what would be expected in a wetland environment in pre-contact times.

Based on the AIS results, it is unlikely that historic properties, other than the documented buried wetland sediments (SIHP # -6636), will be encountered within the project area. It is likely that if any surface structures or features had existed on the property prior to the 1930s, they would have likely been destroyed during the filling in of the area with imported sediments. However, it is possible that remnants of former agricultural and/or aquacultural features, including but not limited to irrigation ditches and/or constructed berms, may be encountered within the project area. Based on previous archaeological studies in the vicinity, potential sub-surface deposits may include pre- and/or post-Contact cultural deposits, artifacts, and/or human burials. The monitoring program will further document the wetland site, SIHP # -6636, as well as facilitate the identification and treatment of any additional historic properties that may be discovered during project construction.

Documented stratigraphy indicates very thick fill deposits exist within the project area. Therefore, the monitoring program is recommended to include a combination of on-call and on-site monitoring. On-call monitoring will consist of weekly site visits to document and assess exposed project stratigraphy. On-site monitoring will consist of the monitoring of excavations which are planned to extend below 1 meter (approximately 3 feet) in depth. Any departure from this will only occur with written concurrence from SHPD.

Section 7 Archaeological Monitoring Provisions

In consultation with SHPD, it was determined that a monitoring program was warranted as an historic preservation mitigation measure for the proposed Senior Residence at Pi‘ikoi Project. The following discussion outlines the provisions and procedures that will govern the project's archaeological monitoring program.

Under Hawai‘i State historic preservation legislation, "Archaeological monitoring may be an identification, mitigation, or post-mitigation contingency measure. Monitoring shall entail the archaeological observation of, and possible intervention with, on-going activities which may adversely affect historic properties" (HAR Chapter 13-279-3). For this project, the proposed monitoring program will serve as a mitigation measure that insures proper documentation should historic properties be encountered.

Hawai‘i State historic preservation legislation governing archeological monitoring programs requires that each monitoring plan discuss eight specific items (HAR Chapter 13-279-4). The monitoring provisions below address those eight requirements in terms of the archaeological monitoring for the construction within the project area.

1. Anticipated Historic Properties:

   The project area contains wetland sediments (SIHP # -6636) underlying thick imported fill materials. It is possible additional cultural deposits (pre- and/or post-Contact), including but not limited to former agricultural/aquacultural features (irrigation ditches, constructed berms, etc.), cultural deposits, artifacts, and/or human burials, may exist within the project area.

2. Locations of Historic Properties:

   It is likely that any encountered historic properties would be found below the thick imported fill materials ubiquitous to the project area. The wetland site (SIHP # -6636) was documented occurring at a minimum of 1.6 meters below the ground surface. However, previously disturbed but still significant finds may be present within imported fill deposits.

3. Fieldwork:

   As stated in the archaeological inventory survey report (Runyon et al. 2012) for this project, "The project development should proceed under an archaeological monitoring program to help alleviate the project's impact on the historic property documented during the current project investigation (SIHP # -6636) as well as to facilitate the identification and treatment of any additional historic properties, including cultural deposits, artifacts, and/or human burials, that may be discovered during project construction."

   The monitoring fieldwork will include standard archaeological documentation techniques. This will include drawing and recording the stratigraphy of excavation profiles where cultural features or artifacts are exposed as well as representative profiles. These exposures will be photographed, located on project area maps, and sampled. Photographs and representative profiles of excavations will be taken even if

no historically-significant sites are documented. As appropriate, sampling will include the collection of representative artifacts, bulk sediment samples, and/or the on-site screening of measured volumes of feature fill to determine feature contents.

If non-human remains are identified, SHPD will be consulted regarding appropriate mitigation measures, pursuant to HAR 13-280-3.

If human remains are identified, no further work will take place, including no screening of back dirt, no cleaning and/or excavation of the burial area, and no exploratory work of any kind unless specifically requested by the SHPD. All human skeletal remains that are encountered during construction will be handled in compliance with HRS Chapter 6E-43 and HAR Chapter 13-300 and in consultation with SHPD/DLNR.

4. Archaeologist's Role:

   The monitoring archaeologist will have the authority to stop work immediately in the area of any findings so that documentation can proceed and appropriate treatment can be determined. In addition, the archaeologist will have the authority to slow and/or suspend construction activities in order to insure that the necessary archaeological sampling and recording can take place.

5. Coordination Meeting:

   Before work commences on the project, the monitoring archaeologist shall hold a coordination meeting to orient the construction crew to the requirements of the archaeological monitoring program. At this meeting the monitor will emphasize his or her authority to temporarily halt construction and that all historic finds, including objects such as bottles, are the property of the landowner and may not be removed from the construction site.

   During the coordination meeting it will be made clear that a combination of on-call and on-site monitoring will be conducted for this project. On-call monitoring will consist of weekly site visits to document and assess exposed project stratigraphy. On-site monitoring will consist of the monitoring of excavations which are planned to extend below 1 meter (approximately 3 feet) in depth. On-site and on-call monitoring will be coordinated by CSH archaeologists with the project construction manager and construction crew. Any departure from this will only occur with written concurrence from SHPD.

6. Laboratory work:

   Laboratory work will be conducted in accordance of HAR 13-279-5-(6). Laboratory analysis of non-burial related finds will be tabulated into table form and standard artifact and midden recording will be conducted as follows: artifacts will be documented as to provenience, weight, length, width, type of material, and presumed function. Photographs of representative artifacts will be taken for inclusion into the archaeological monitoring report. Bone and shell midden materials will be sorted down to species, when possible, and then tabulated by provenience.

As appropriate, collected charcoal material obtained within intact cultural deposits will be analyzed for species identification. Subsequently, suitable identifiable samples will be sent to Beta Analytic, Inc. for radiocarbon dating. If appropriate, artifacts may be sent to the University of Hawai‘i-Hilo Geoarchaeology lab for Energy-Dispersive X-ray Fluorescence (EDXRF) analysis in order to identify and possibly geographically locate the source material. All analyzed samples, provenience information, and results will be presented in table form within the archaeological monitoring report.

7. Report Preparation:

   One of the primary objectives of the report will be to present a stratigraphic overview of the project area which will allow for predictive assessments of adjacent properties, which may be the subject of future development. The report will contain a section on stratigraphy, description of archaeological findings, monitoring methods, and results of laboratory analyses. The report will address the requirements of a monitoring report (HAR section 13-279-5). Photographs of excavations will be included in the monitoring report even if no historically-significant sites are documented. Should burial treatment be completed as part of the monitoring effort, a summary of this treatment will be included in the monitoring report. Should burials and/or human remains be identified, then other letters, memos, and/or reports may be requested by the Burial Sites Program.

8. Archiving Materials:

   Materials not associated with burials will be temporarily stored at the contracted archaeologist’s facilities until an appropriate curation facility is selected, in consultation with the landowner and SHPD. In the event that human remains are encountered and relocation is deemed appropriate by the SHPD then any interim curation of human remains and any associated grave goods is the responsibility of the landowner and will be done at the direction of the SHPD.

9. Research Focus

   Based on the AIS results, it is unlikely that historic properties, other than the documented buried wetland sediments (SIHP # -6636), will be encountered within the project area. It is likely that if any surface structures or features had existed on the property prior to the 1930s, they would have likely been destroyed during the filling in of the area with imported sediments. However, it is possible that remnants of former agricultural/aquacultural features, including but not limited to irrigation ditches and/or constructed berms, may be encountered within the project area.

   Research questions that could be answered as a result of monitoring activities related to the proposed redevelopment project include:

   a. Does SIHP # -6636 extend across the entire project area or can it be defined within the project area boundaries?
   b. Do any cultural features exist within the project area which could relate to use of the land prior to it being filled in with imported materials?

If the above questions can be addressed, then we may be able to more fully characterize the past land-use of this portion of Kaka‘ako and better predict the archaeological deposits that can be expected in the general area.

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Appendix A SHPD/DLNR Reviews

NEIL ABERCROMBIE
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KAHOOLAWE ISLAND RESERVE COMMISSION
LAND
STATE PARKS

HISTORIC PRESERVATION DIVISION
DEPARTMENT OF LAND AND NATURAL RESOURCES

601 Kamokila Boulevard, Suite 555
Kapolei, HI 96806

October 12, 2012

Mr. Douglas Borthwick, Principal Investigator
Cultural Surveys Hawai'i, Inc.
P.O. Box 1114
Kailua, Hawaii 96734
dborthwick@culturalsurveys.com

LOG NO: 2012.2839
DOC NO: 1210SL19
Archaeology

Dear Mr. Borthwick:

SUBJECT: **Chapter 6E-42 Historic Preservation Review –**
Archaeological Inventory Survey Report for the Senior Residence at Pi‘ikoi Kaka‘ako
Waikīkī Ahupua‘a, Kona District, O‘ahu Island
TMK: (1) 2-3-007:026 & 049

Thank you for the opportunity to review this revised report titled *Archaeological Inventory Survey Report for the Senior Residence at Piikoi Kakaako, Waikīkī Ahupua'a, Kona District Oahu Island TMK: [1] 2-3-007:026 & 049* (Runyon, Borthwick, and Hammatt, September 2012). The submittal was received by SHPD on October 2, 2012. According to the report, subsurface testing involved excavation of 13 backhoe trenches across the 0.74-acre project area. Two historic properties, SIHP 50-80-14-6636 (wetland sediments) and SIHP 6641 (incinerator trash fill deposits), were predicted to be encountered in the current project area based on data from nearby parcels. Subsurface testing identified only SIHP 6636, which had been previously evaluated as significant under HRHP Criteria "a" (associated with events that made a significant contribution to the broad patterns of history) and "d" (likely to yield information important to prehistory or history).

The revisions made to this document adequately address the major concerns raised in our prior correspondence (July 26, 2012; Log No. 2012.0215, Doc. No. 1206SL14). The report provides a detailed discussion of the environmental and cultural background, previous investigations in the vicinity, the methods and findings, and a synthetic historic property description for SIHP 6636. We concur with the significance assessment that the SIHP 6636 Kewalo sediment deposits are significant under HRHP Criteria "a" and "d." We also concur that archaeological monitoring should be conducted for future ground-disturbing activities because of the potential for encountering additional historic properties elsewhere within the subject property.

This archaeological inventory survey report meets the requirements of Hawaii Administrative Rule (HAR) §13-276 and is accepted by SHPD. Please send one hardcopy of the document, clearly marked FINAL, along with a copy of this review letter and a text-searchable PDF version on CD to the Kapolei SHPD office, attention SHPD Library. Please contact Susan A. Lebo at (808) 692-8019 or at Susan.A.Lebo@hawaii.gov if you have any questions or concerns regarding this letter.

Aloha,

Theresa K. Donham
Archaeology Branch Chief

NEIL ABERCROMBIE
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DEPUTY DIRECTOR - WATER

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KAHO'OLAWE ISLAND RESERVE COMMISSION
LAND
STATE PARKS

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES

HISTORIC PRESERVATION DIVISION
KAHUHIHEWA BUILDING
601 KAMOKILA BLVD, KAPOLEI HI 96706

DATE: March 4, 2011 **LOG:** 2011.0599.
DOC: 1103RS06

TO: ~~Lai~~ Land Maa Lapilio
Aukahi
1003 Bishop Street, Unit 2700
Honolulu, Hi 96813

SUBJECT: **Section 6E-42 Historic Preservation Review /** Demolition of Two Properties
Permit # (None)
Building Owner: Kewalo Development LLC
Location: 1235 Kona and 1226 Waimanu Streets, Kakaako
Tax Map Key: (1) 2-3-007:026 and :049

This letter is in response to previous conversations with SHPD and your email of February 9, 2011, re the potential demolition of structures located at 1226 Waimanu and 1235 Kona Streets in Kakaako. The Waimanu structure consists of three single story steel shed like structures, two of which have no walls. The Kona facility features a two story CMU storefront along Piikoi Street and a mostly steel warehouse structure along the Kona Street side. The Piikoi side has large picture windows (currently boarded up), concrete eyebrows sheltering the second story windows, and a flat roof. The Kona Street side has a cement stairway up to the Piikoi second floor and a beveled steel wall along much of its length. The warehouse has a gabled roof.

The area of potential effect would be the two parcels and, during work, Waimanu, Piikoi, and Kona Streets adjacent.

Honolulu City and County online records show that the Waimanu Street sheds were erected in 1948 and the Kona Street complex in 1961. Neither building has architectural features meriting listing on the Hawaii Register of Historic Places.

Our office has documentation in the forms of photographs and floor plans of both properties.

Based upon the information presented, **the project will not affect historic property.**

Any questions should be addressed to Ross W. Stephenson, SHPD Historian, at (808) 692-8028 (office), (808) 497-2233 (cell) or ross.w.stephenson@hawaii.gov.

Mahalo for the opportunity to comment.

Pua Aiu
Administrator

In the event that historic resources, including human skeletal remains, lava tubes, and lava blisters/bubbles are identified during construction activities, all work should cease in the immediate vicinity of the find, the find should be protected from additional disturbance, and the State Historic Preservation Division should be contacted immediately at (808) 692-8015.

cc: Department of Planning and Permitting, City and County of Honolulu
650 South King Street, Honolulu, HI 96813

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HISTORIC PRESERVATION
KAHOOLAWE ISLAND RESERVE COMMISSION
LAND
STATE PARKS

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES

STATE HISTORIC PRESERVATION DIVISION
601 KAMOKILA BOULEVARD, ROOM 555
KAPOLEI, HAWAII 96707

July 26, 2012

Dr. Hallett H. Hammatt, Principal Investigator
Cultural Surveys Hawai'i, Inc.
P.O. Box 1114
Kailua, Hawaii 96734

LOG NO: 2012.0215
DOC NO: 1206SL14
Archaeology

Dear Dr. Hammatt:

SUBJECT: **Chapter 6E-42 Historic Preservation Review–**
Archaeological Inventory Survey Report for the Senior Residence at Pi'ikoi Kaka'ako, Kona District, O'ahu Island TMK: [1] 2-3-007:026 & 049

Thank you for the opportunity to review this draft report titled *Archaeological Inventory Survey Report for the Senior Residence at Piikoi Kakaako, Kona District Oahu Island TMK: [1] 2-3-007:026 & 049* (Runyon, Borthwick, and Hammatt, January 2012). The submittal was received by SHPD on January 27, 2012; we apologize for the delayed review, and thank you for your patience. According to the report, an inventory survey was undertaken at the request of Kewalo Development LLC in preparation for construction of a new residential rental apartment building. Ground-disturbing activities associated with the planned project will include demolition of existing structures and excavations for structural footings, utilities, roadway and parking area, and landscaping. Subsurface testing involved excavation of 13 backhoe trenches across the entire 0.74-acre project area, totaling 56 m^2 or about 1.8% of the project area.

The report documents SIHP 50-80-14-6636, previously identified in several nearby project areas, including O'Hare et al. (2003), O'Hare et al. (2004), Tulchin and Hammatt (2005), and Runyon et al. (2022). Within the current project area, Site 6636 is identified as consisting of two stratigraphic deposits. These deposits consist of an organic-rich A-Horizon of terrestrial origin, which overlies gley sediments of marine origin. The upper portion of the A-Horizon has been truncated and is overlain by a series of twentieth-century reclamation fill deposits capped by modern road fills and asphalt. The marine wetland sediments were identified in all trenches, while the A-Horizon sediments occurred in all but Trench 7. A sample was collected for snail analysis for both the terrestrial and marine sediments in Trench 13. The results indicate a wetland environment typical of this area in the pre- to early post-contact period.

Also present in the project area is a historic artifact-rich deposit, which includes metal, brick, and slag associated with large-scale trash discard and subsequent use as fill material. This trash fill deposit was identified in Trenches 3-7 and 10-11. In Trenches 3 and 4, it is reported as "possible incinerator fill," which correlates it with SIHP 6641 (see O'Hare et al. 2004; Tulchin and Hammatt 2005; Runyon et al. 2011). Site 6641 reportedly contains at least two episodes of trash dumping, the earliest pre-1930 and the second during the 1930s and 1940s. Contents consist of melted and crushed artifacts, including ceramics and glass (O'Hare et al. 2004). In addition, wood and metal are present (Tulchin and Hammatt 2005). Runyon et al. (2011) indicate this deposit contains artifacts ranging in age from the 1880s to 1940s, and represents a burnt trash fill layer associated with waste disposal and land filling, "likely until around 1930 when the Kewalo Incinerator was built" (Runyon et al. 2011). However, the presence of 1940s material indicates accumulation continued through much of the 1940s. Runyon et al. (2011) also indicate that Site 6641 extends beyond the *mauka* limits of the 1.73-acre Phase II Koolani Condominium project area, which is less than 25 meters *makai* of the current project area. These data indicated that Site 6641 should have been anticipated as highly probable of occurring within the current project area.

The report indicates that Site 6636 has been previously evaluated as significant under HRHP Criterion "a" and Criterion "d", and indicates that monitoring is recommended to address the proposed project's effect on this historic property. It does not, however, include a historic property description, significance assessment, or mitigation recommendations for Site 6641.

We have included an attachment that identifies the issues and concerns that are in need of revision prior to the acceptance of this report pursuant to Hawaii Administrative Rule (HAR) 13-276. To aid in review of the subsequent revision please include a cover letter that specifies the changes made to this document and their page numbers. Please contact Susan A. Lebo at (808) 692-8019 or at Susan.A.Lebo@hawaii.gov if you have any questions or concerns regarding this letter.

Aloha,

Theresa K. Donham
Archaeology Branch Chief

Attachment

Comments and Questions: *Archaeological Inventory Survey Report for the Senior Residence at Piikoi Kakaako, Kona District Oahu Island TMK: [1] 2-3-007:026 & 049* (Runyon, Borthwick, and Hammatt, January 2012)

Management Summary

(1) Revise discussion of Historic Properties to include historic trash layer SIHP 6641 (ca. 1920s-1940s).

Project Background

(2) Insert Ahupua'a on cover and in introduction, management summary, etc., as appropriate.

Methods

(3) Revise 2.1.2.2 Sampling section to indicate that sampling was undertaken for the wetland sediments (SIHP 6636) but did not include the collection of artifacts from the historic trash layer (SIHP 6641).

Background Research

(4) Revise 3.4 Mid-Nineteenth Century to Early Twentieth Century section to state that common people began to receive… in 1850; Also revise Table 2 to include footnote that LCA 2341 is not shown in Fig. 13 because…

Previous Archaeological Research

(5) Revise Figures 37 & 38, and Table 4 to address inconsistencies, including: Bush & Hammatt 2006 not in Fig. 37; SIHP 6855 on Fig. 38 includes burials not mentioned for SIHP 6855 in Table 4 for Bell et al 2006, which id's SIHP 6855 only as historic privy/activity area; Fig. 37 shows burial SIHP 6377 but not SIHP 6376 or SIHP 6378 burials listed for Souza et al 2002 in Table 4; Fig. 38 shows SIHP 4847 burial not mentioned in Table 4, but which appears to correspond either with Esh & Hammatt 2006 or O'Leary & Hammat 2004 project areas.

(8) Revise Figure 47 sediment description (LB) to lower boundary.

Previous Archaeology Summary and Predictive Model

(9) Pursuant to HAR § 13-279-5 (b) (2C), revise summary to include mention that based on previous archaeological research high potential exists for Sites 6636 (wetland sediment) and 6641 (burned trash layer) to extend into southern (*makai*) portion of current project area (see Figure 52).

(10) Revise section to also include a brief summary description, known distribution, contents, and general date range for these sites.

Results of Field Work

(11) Pursuant to HAR § 13-279-5 (d and f), revise section to include discussion and map of all historic properties.

(12) Table 5 is excellent, but insert a single paragraph summary for each trench (e.g., 5.2.1 Trench 1 summary would indicate presence of SIHP 6636, which was identified in two strata - Str. IIa and Str. IIb, that IIa represents terrigenous sediments while IIb is marine in origin)...

(13) Revise figures, tables, and insert trench summary paragraphs for Trenches 3, 4, 5, 6, 7, and 11 that indicate the presence of a historic trash layer, which corresponds either with SIHP 6641, the "incinerator fill layer".

Historic Property Description

(14) Pursuant to HAR § 13-279-5 (f), revise Section 7 Historic Property Description for SIHP 6636 to include its broader distribution - it is not limited to project area, and indicate that while found in all trenches within current project area, its distribution is not continuous with SIHP 6636 in Runyon et al. 2011, or elsewhere, but that it is documented both *makai* and *mauka* of the project area. In addition, in describing it, note whether its appearance in the current project area correlates with descriptions from other project areas, e.g., presence of particular wood species, snail species, charcoal flecking, etc. As indicated in Method section, Site 6636 includes a buried A-horizon (Str. IIa), how does this correlate with the buried A-horizon recorded in vicinity (e.g., O'Hare et al. 2006; Winieski and Hammatt 2000; Souza et al. 2002; Bush and Hammatt 2006)? Are these all the same A-horizon? Are they contemporaneous?

(15) Pursuant to HAR § 13-279-5 (f), insert into Section 7 a Historic Property Description for SIHP 6641 (if you determine it is present) including a full description of its morphology, size, distribution, contents, stratigraphic location within the property's stratigraphic sequence, as well as what is known about this site from nearby project areas; include information on possible date range, correlation with known Reclamation Project(s); indicate what sampling and analyses have been conducted and findings.

Summary and Interpretation

(16) Pursuant to HAR § 13-279-5 (d and f), revise section to include discussion of all historic properties (Sites 6636 and 6641).

(17) Pursuant to HAR § 13-279-5 (d and f), also revise to include a general discussion of the project findings - i.e., multiple fill layers, most of which can be correlated with known reclamation dates - e.g., incinerator layer, hydraulic pump fill, that these fill layers overly natural wetland deposits, whether there is evidence that cultural layers were removed, etc. In addition, indicate what information this project has contributed to our understanding of this area of Kakaako; historical data indicates hydraulic fill dates 1912 (Hawaii Reports 1915).

Significance Assessments

(18) Pursuant to HAR § 13-276-8, revise Section 9 to include significance assessment for historic trash layer (SIHP 6641), including its relationship to known reclamation projects, a significant series of landscape-modifying events that took place in early 20th century.

Project Effect and Mitigation Recommendations

(19) Pursuant to HAR § 13-276-8, insert summary table listing sites and revise section to include project effect and mitigation recommendations for the historic trash layer (SIHP 6641).

References Cited

(20) Revise citations for Thrum, as needed, to reflect year published (e.g., Almanac and Annual for Year 1905 was published in 1904; for 1906 in 1905, etc).

(21) Revise inconsistencies in Hawai'i versus Hawaii for First Legislature, Dept of Public Works, Governor, Reports, etc; do a global search and replace, none of these should be spelled as Hawai'i because this is not the spelling used at the time the references were written.

(22) Revise formatting margins for Wong 1995, and Young 2005; Revise Young 2005 to match text Young 1994; Revise to address following inconsistencies or omissions: Beckwith 1970 in text, not in references; Okamoto 1998 in text versus Wilson Okamoto and Associates, Inc in references; Griffin 1987 (e.g. p76), and Griffin et al. 1987 in text, but only Griffin et al. 1987 in references; Also remove any references in References Cited that do not appear in text.

Other Minor Revisions

(23) Insert (page 15) under heading "Kuloloia" citation (Kekahuna 1958:4). Page 121: Revise from "slag peices" to "slag pieces."

DRAFT

TRAFFIC EVALUATION

Piikoi Affordable Housing

Honolulu, Oahu, Hawaii

July 2014

PARSONS BRINCKERHOFF

Over a Century of Engineering Excellence

DRAFT

TRAFFIC EVALUATION

Piikoi Affordable Housing

Honolulu, Oahu, Hawaii

July 2014

Prepared for:
Stanford Carr Development, LLC
1100 Alakea Street, 27th Floor
Honolulu, HI 96813

Prepared by:

Parsons Brinckerhoff, Inc.
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Parsons Brinckerhoff Reference Number:
16549A

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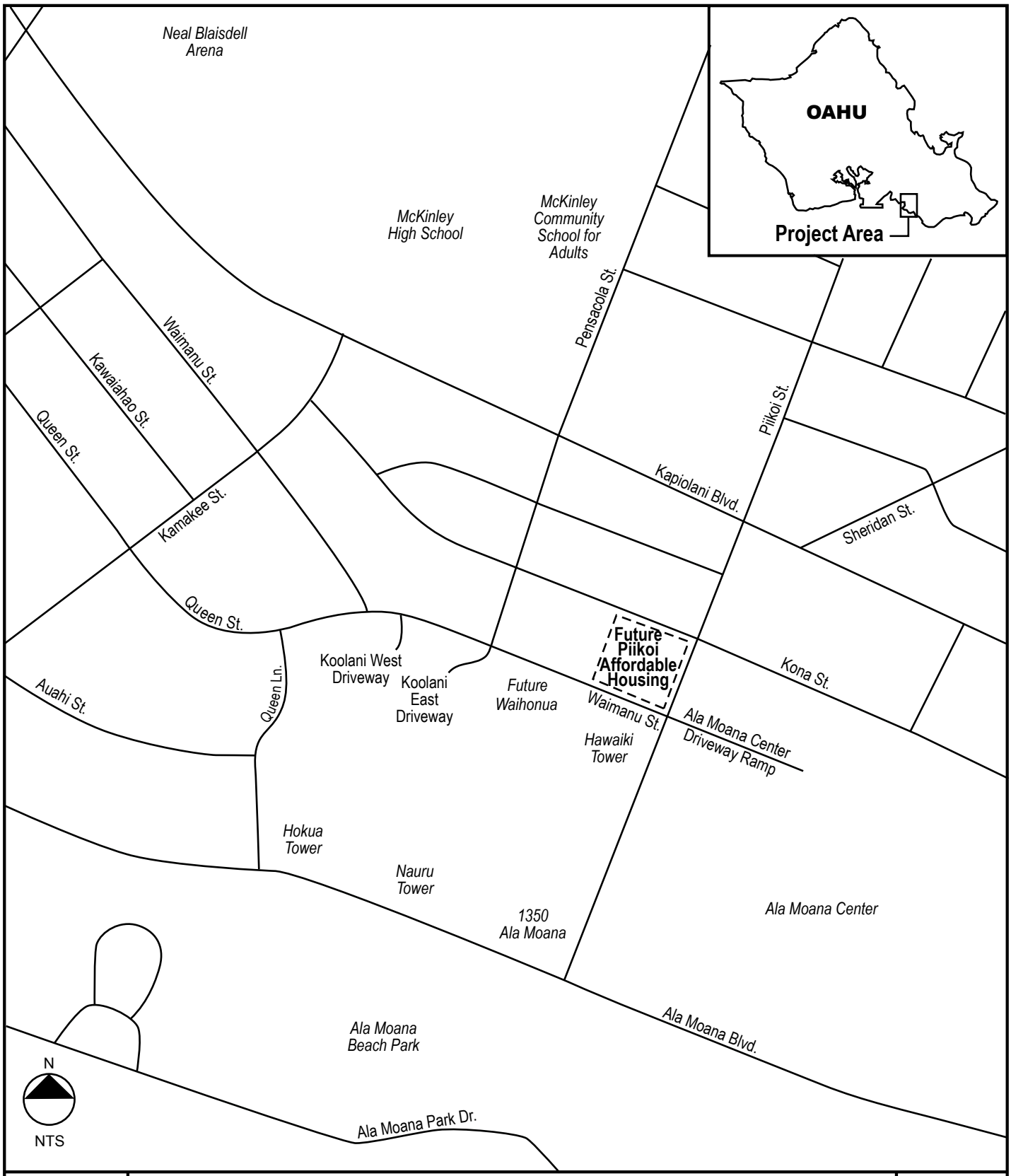
I. INTRODUCTION

The Piikoi Affordable Housing project was originally conceived as the second component of 404 Piikoi Phase IV by Alexander & Baldwin, Inc. In report dated April 2012, a senior residence was planned to be paired with Waihonua, an upscale condominium located makai of Waimanu Street next to Koolani. The senior residence lot is now being developed by Stanford Carr, LLC as affordable housing. This report is an update of the 2012 study to evaluate the impacts of the new land use.

Piikoi Affordable Housing is located adjacent to Piikoi Street makai of Kona Street across from Ala Moana Shopping Center. The vicinity map is shown in Figure 1.

The site plan is shown in Figure 2. The project consists of 128 affordable housing units and approximately 3000 square feet (SF) of commercial intended for residential use only. A total of 77 parking stalls will be provided. No parking will be provided for the commercial use. The site will be accessed from a single driveway located on Kona Street.

The Piikoi Affordable Housing project is anticipated to be built out by 2017. By 2019, the Honolulu Rail Transit Project will be operational between Kapolei and Ala Moana Shopping Center. The rail alignment will pass through Kona Street as shown.

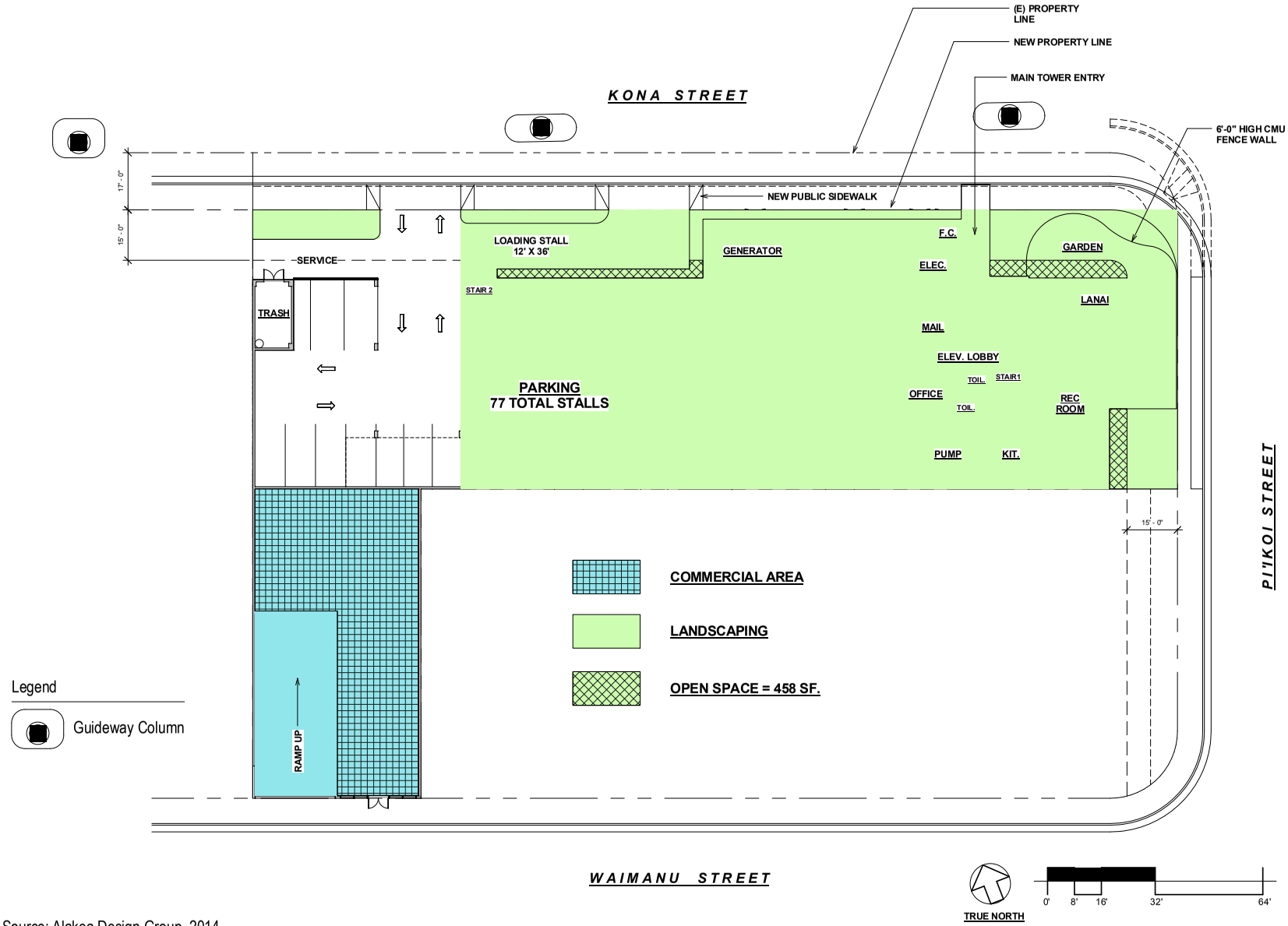


Vicinity Map

Figure 1

Parsons Brinckerhoff

Piikoi Affordable Housing
July 2014



Source: Alakea Design Group, 2014.

Piikoi Affordable Housing Site Plan

Figure 2

II. EXISTING CONDITIONS

The Piikoi Affordable Housing development is located on the makai side of Kona Street Ewa of Piikoi Street. This site is currently occupied by a mixture of restaurant and commercial and restaurant land uses.

A. Existing Roadway Network

Figure 3 illustrates the existing roadway lane configurations.

1. Waimanu Street

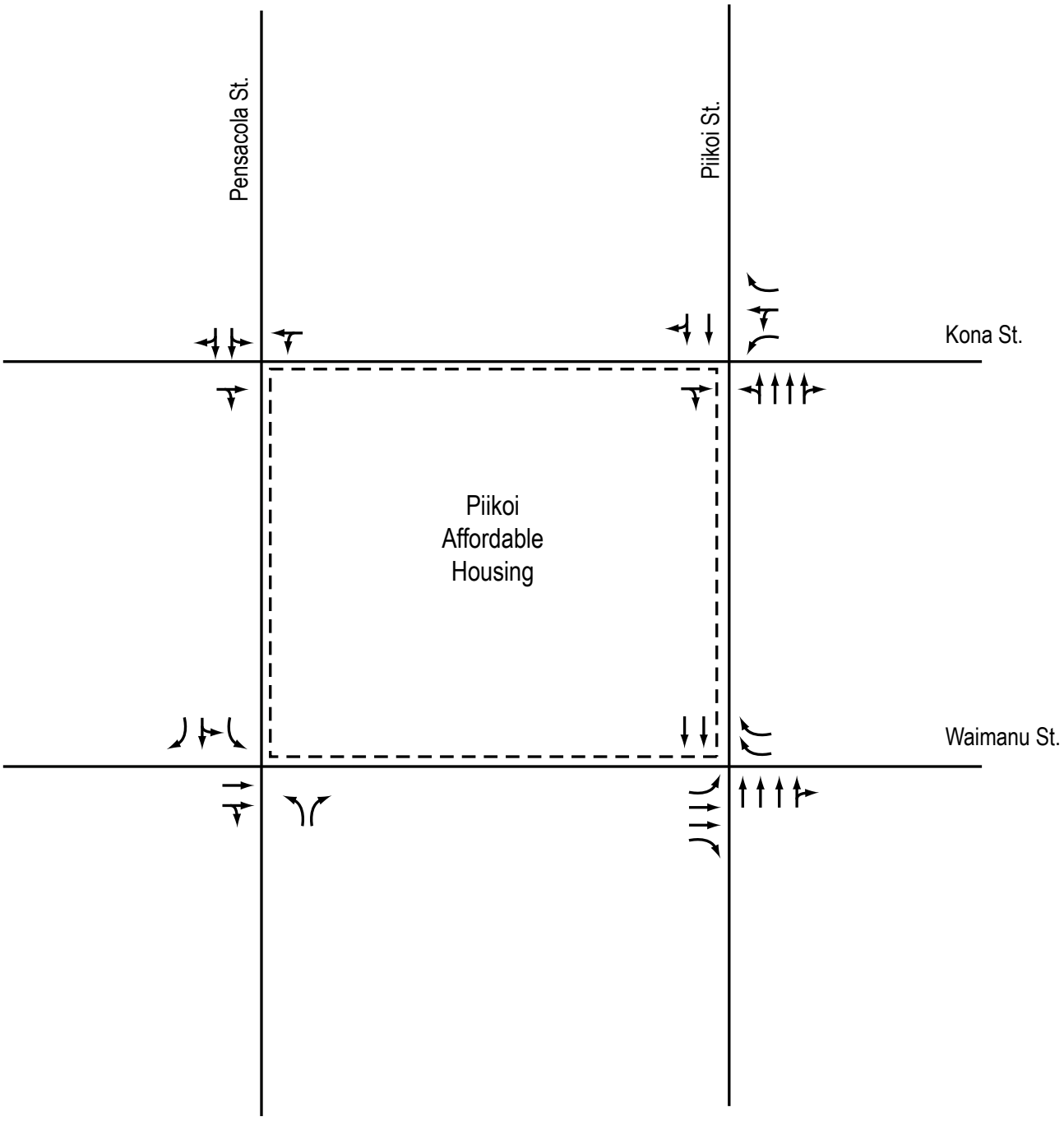
Waimanu Street is a two-lane local roadway between Dreier Street and Queen Street providing access throughout the mostly industrial area. Between Queen Street and Pensacola Street, Waimanu Street becomes a four-lane roadway. Koko Head (KKHD) of Pensacola Street becomes one-way in the KKHD-direction, providing access to Ala Moana Center via a driveway KKHD of Piikoi Street. The posted speed limit on Waimanu Street is 25 miles per hour.

2. Kona Street

Kona Street is an unstriped two-lane local roadway between Kamakee Street and Piikoi Street and a divided four-lane roadway KKHD of Piikoi Street. KKHD of Piikoi Street, Kona Street runs along the mauka side of Ala Moana Center. Ewa of Piikoi Street it provides access to industrial land uses. Within the vicinity of the project, Kona Street is signalized at Piikoi Street and unsignalized at Pensacola Street. There is no posted speed limit on Kona Street within the vicinity of the project.

3. Pensacola Street

Pensacola Street extends from Prospect Street in Makiki makai to Waimanu Street. Within the project's vicinity, Pensacola Street is a two-lane, one-way principal arterial in the makai-bound direction. Pensacola Street intersects Waimanu Street at a signalized intersection. The posted speed limit is 25 miles per hour.



N

NTS

Existing Lane Configurations

Figure

3

4. Piikoi Street

Piikoi Street is a minor arterial which extends from Ala Moana Boulevard mauka to Pensacola Street in Makiki. Within the vicinity of the project, Piikoi Street is a six-lane, divided roadway with a median. There are two makai-bound lanes and four mauka-bound lanes. Piikoi Street is signalized at Waimanu Street and Kona Street. The posted speed limit in the project vicinity is 25 miles per hour.

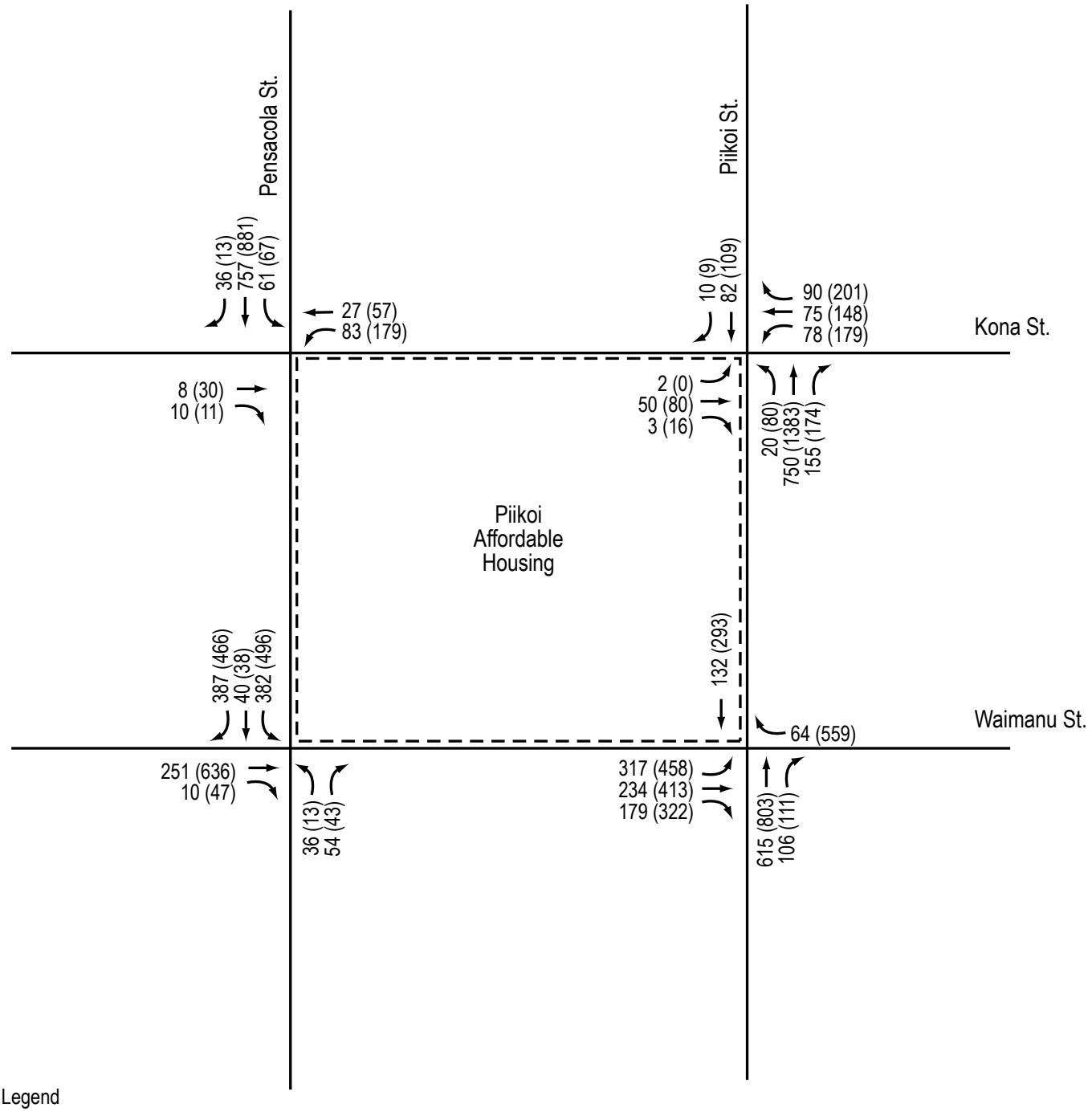
Mauka of Kapiolani Boulevard, Piikoi Street is a one-way road, forming a one-way couplet with Pensacola Street to provide mauka-makai mobility and access to H-1 Freeway on-ramps. The couplet also provides access to the primary KKHD-Ewa streets serving the urban area of Honolulu.

B. Existing Traffic Volumes

Manual traffic counts, pedestrian counts, and bicycle counts were conducted on Tuesday, January 10 and Wednesday, January 11, 2012 during the AM and PM peak periods at the following intersections:

- Pensacola Street/Waimanu Street/Koolani East Driveway
- Piikoi Street/Waimanu Street/Ala Moana Driveway
- Piikoi Street/Kona Street
- Pensacola Street/Kona Street

The traffic volumes were summarized into AM and PM peak hour volumes and a growth factor of 1% was applied to obtain existing 2014 traffic volumes shown in Figure 4. The study AM and PM peak hours were 8:00-9:00 AM and 5:00-6:00 PM, respectively.



Legend

AM: 8-9am
(PM): 5-6pm

N

NTS

Existing Traffic Volumes

Figure 4

The pedestrian counts showed that Piikoi Street saw more pedestrian activities than Pensacola Street with concentration mostly on Ala Moana Shopping Center sidewalk. At the Piikoi Street/Waimanu Street/Ala Moana Driveway intersection, 158 pedestrians used the three crosswalks during the AM peak hour and 222 pedestrians used the three crosswalks during the PM peak hour. At the Piikoi Street/Kona Street intersection, 143 pedestrians used the three crosswalks with a majority (120) using the Kona Street KKHD crosswalk. During the PM peak hour, 209 pedestrians used the three crosswalks with 119 using the Kona Street KKHD crosswalk.

At the Pensacola Street/Waimanu Street/Koolani East Driveway intersection, 16 pedestrians used the three crosswalks during the AM peak hour and 61 pedestrians used the three crosswalks during the PM peak hour. The two-way stop-controlled Pensacola Street/Kona Street intersection does not have any striped crosswalks. Still, 17 pedestrians crossed through the intersection during the AM peak hour and 27 pedestrians crossed through the intersection during the PM peak hour.

No intersection in the project vicinity attracted more than 18 bicycles in either peak hour. Appendix A contains the raw count data sheets.

C. Transit

The closest bus stop to the project vicinity is stop #4334 (Piikoi Street and Ala Moana Shopping Center ramp opposite Waimanu Street). This bus stop is serviced by bus routes #6 (Waikiki Beach & Hotels), #8 (Waikiki Beach & Hotels), #19 (Waikiki Beach & Hotels), #20 (Waikiki Beach & Hotels), #56 (Honolulu – Ala Moana Center), #57 (Honolulu – Ala Moana Center), #57A (Honolulu – Ala Moana), #65 (Honolulu – Ala Moana Center), and #88A (North Shore Express).

D. Existing Traffic Operations

The study area intersections were analyzed using the methodologies for signalized and unsignalized intersections outlined in the 2010 and 2000 Highway Capacity Manual (HCM). Operating conditions at an intersection are expressed as a qualitative measure known as Level of Service (LOS) with letter designations ranging from A through F, with LOS A representing free-flow conditions and LOS F representing over-capacity conditions. Level

of service criteria are described in Appendix B. Capacity analysis worksheets are located in Appendix C. The results of the intersection analysis are summarized in Table 1.

Table 1 Existing LOS

	Existing			
	AM		PM	
	LOS	Delay	LOS	Delay
Pensacola Street and Kona Street	**Unsignalized**		**Unsignalized**	
Kona EB Approach	C	16	C	24
Kona WB Approach	C	15	D	30
Pensacola Street and Waimanu Street	**B**	**12**	**B**	**17**
Pensacola SB Left	B	10	B	14
Pensacola SB Right	B	11	B	20
Waimanu EB Approach	B	15	B	17
Koolani East NB Left	B	17	C	25
Koolani East NB Right	B	15	C	24
Piikoi Street and Kona Street	**A**	**6**	**B**	**10**
Piikoi NB Approach	A	5	A	8
Piikoi SB Approach	A	4	A	6
Kona EB Approach	B	10	B	15
Kona WB Left	B	11	B	19
Kona WB Left-Through	B	11	B	16
Kona WB Right	B	11	B	17
Piikoi Street and Waimanu Street	**B**	**10**	**D**	**37**
Piikoi NB Through-Right	B	11	B	13
Piikoi SB Through	A	10	B	12
Waimanu EB Left	B	11	C	27
Waimanu EB Through	A	7	B	10
Waimanu EB Right	A	8	B	12
Ala Moana Driveway Approach	B	18	F	130

*Delay is expressed in seconds per vehicle

E. Summary of Existing Operations

All intersections and individual movements operate at LOS B or better overall during both peak hours with the exception of the Piikoi/Waimanu intersection. This intersection operates at LOS D during the PM peak hour largely due to the Ewa-bound right turn leaving Ala Moana which is projected to operate at LOS F.

III. PROJECTED YEAR 2017 CONDITIONS WITHOUT PROJECT

The Year 2017 represents the future conditions horizon year for the project area without the Piikoi Affordable Housing development. Queen Lane, a new roadway connection between Queen Street and Auahi Street, was opened in late 2011. No additional new roadways are projected to be constructed in the vicinity of the project by the build-out year.

A. Projected Year 2017 Roadway Network Without Project

General Growth Properties (GGP) is proposing to convert Waimanu Street to a two-way facility between Pensacola Street and Piikoi Street. The timeline of this improvement is undefined at this time, and was not considered for the year 2017 analysis. Regardless, the project is not anticipated to have a significant impact on the project's main access point.

The 2017 roadway network is assumed to be the same as the 2014 roadway network. Intersection geometry at the study area intersections and roads are expected to be the same as the 2014 scenario.

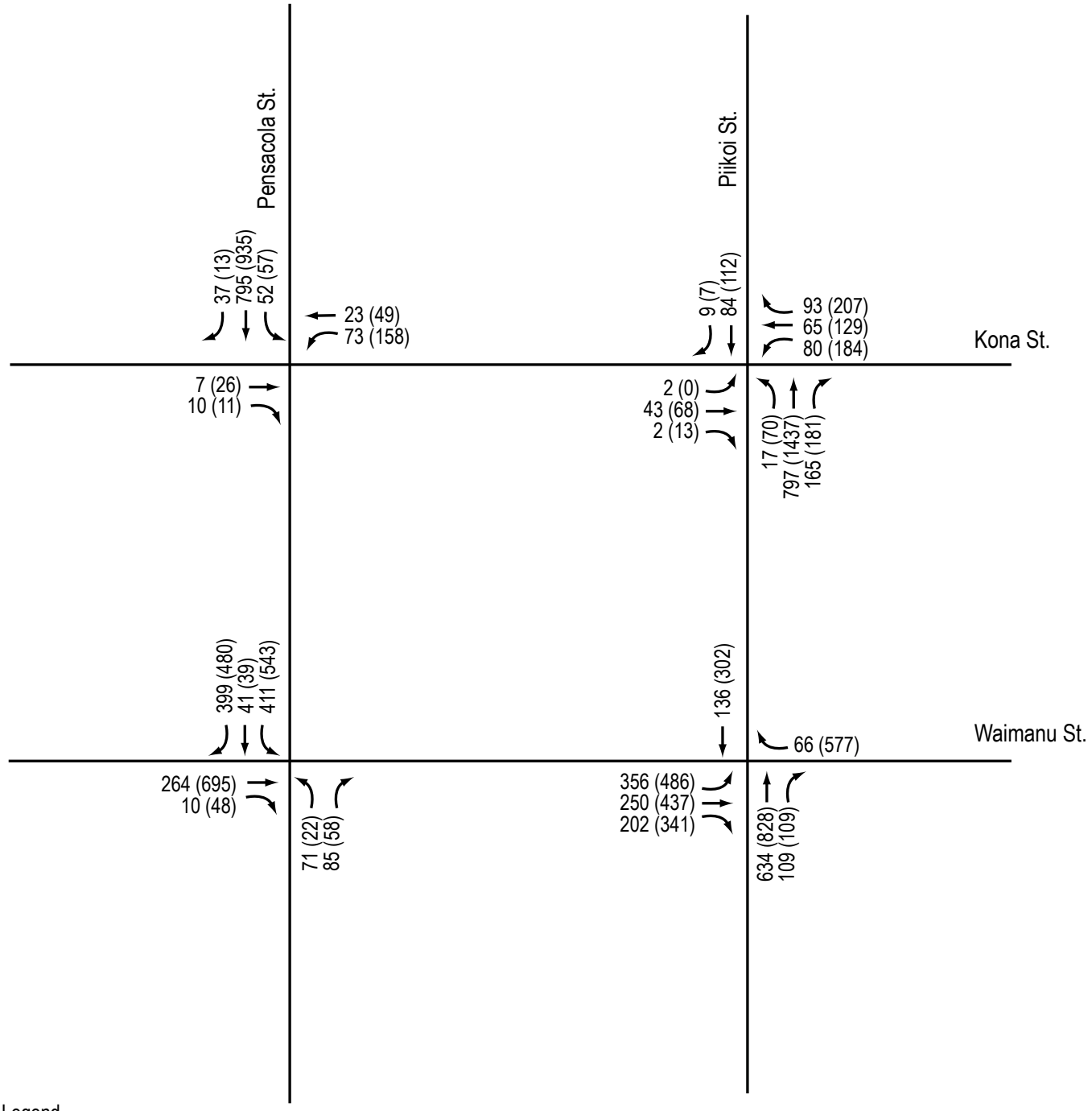
B. Projected Year 2017 Traffic Volumes Without Project

The 2017 background traffic was estimated utilizing an annual growth rate of 1%. This growth rate is based on the Oahu Metropolitan Planning Organization (MPO) Oahu Regional Transportation Plan (ORTP) 2035 model. This model takes into account all future Kakaako developments.

The projected 2017 traffic turning movement volumes without project are shown in Figure 5.

C. Projected Year 2017 Operations Without Project

The projected 2017 intersection LOS without the Piikoi Affordable Housing development is shown in Table 2.



Year 2017 Traffic Volumes without Project

Figure 5

Table 2 Projected Year 2017 LOS Without Project

	2017 Background			
	AM		PM	
	LOS	Delay	LOS	Delay
Pensacola Street and Kona Street	**Unsignalized**		**Unsignalized**	
Kona EB Approach	C	16	C	24
Kona WB Approach	B	15	D	26
Pensacola Street and Waimanu Street	**B**	**13**	**B**	**19**
Pensacola SB Left	A	10	B	15
Pensacola SB Right	B	11	C	23
Waimanu EB Approach	B	16	B	18
Koolani East NB Left	B	18	C	26
Koolani East NB Right	B	18	C	28
Piikoi Street and Kona Street	**A**	**6**	**A**	**10**
Piikoi NB Approach	A	5	A	8
Piikoi SB Approach	A	4	A	5
Kona EB Approach	B	11	B	15
Kona WB Left	B	12	B	19
Kona WB Left-Through	B	11	B	16
Kona WB Right	B	12	B	18
Piikoi Street and Waimanu Street	**B**	**11**	**D**	**42**
Piikoi NB Through-Right	B	11	B	13
Piikoi SB Through	B	10	B	12
Waimanu EB Left	B	12	D	37
Waimanu EB Through	A	7	B	11
Waimanu EB Right	A	8	B	13
Ala Moana Driveway Approach	B	18	F	153

*Delay is expressed in seconds per vehicle

D. Summary of Year 2017 Operations Without Project

All intersections and individual movements are projected to operate at LOS B or better overall during both peak hours with the exception of the Piikoi/Waimanu intersection. This intersection is projected to operate at LOS D during the PM peak hour largely due to the Ewa-bound right turn leaving Ala Moana which is projected to operate at LOS F.

IV. PROJECTED YEAR 2017 CONDITIONS WITH PROJECT

The Year 2017 "With Project" scenario represents the future conditions within the project area with the Piikoi Affordable Housing completion as shown in Figure 2.

A new access driveway is proposed to be constructed approximately 210 feet Ewa of Piikoi Street. Figure 6 illustrates the Year 2017 lane configurations with the project.

A. Year 2017 Project-Generated Traffic Volumes

Future traffic generated by the Piikoi Affordable Housing development was estimated.

1. Trip Generation

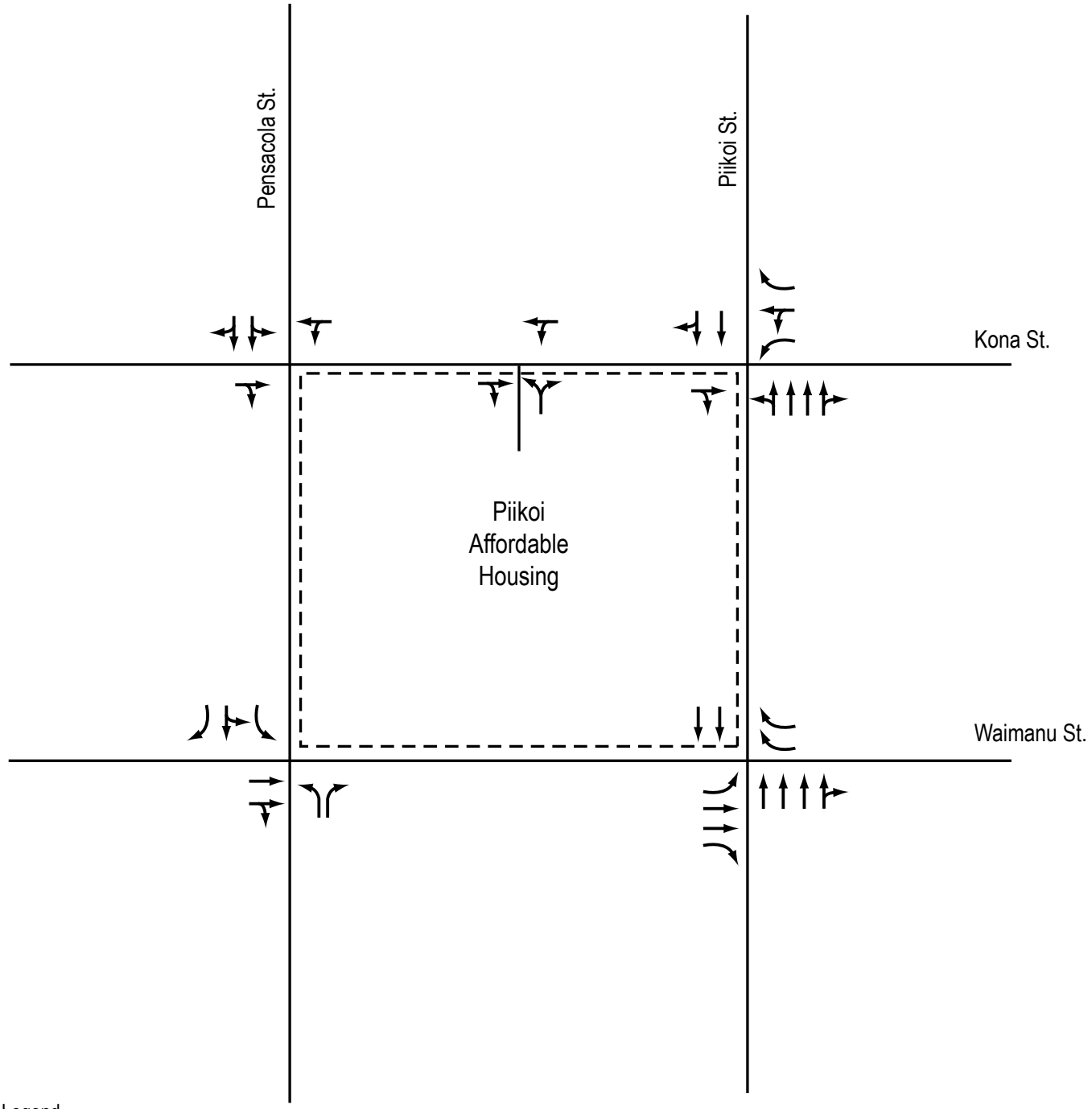
Trip generation estimates the number of vehicular trips in and out of the project based on the land use type and density. Piikoi Affordable Housing can be classified as high-rise/condominium land use. Trips were estimated using trip generation equations published by the Institute of Transportation Engineers (ITE) in Trip Generation, 8th Edition.

Table 3 shows the planned project land use and corresponding trips generated. Transit share was conservatively estimated to be 7% and pedestrian share was conservatively estimated to be 7% due to the close proximity to major shopping centers, dining, and entertainment venues.

Table 3 Piikoi Affordable Housing Trip Generation

	Land Use	Dwelling Units	AM Peak Hour			PM Peak Hour		
			Enter	Exit	Total	Enter	Exit	Total
High Rise/Condominium	High-Rise Condo	128	13	53	66	37	22	59
7% Transit Reduction			-1	-4	-5	-3	-2	-5
7% Ped Reduction			-1	-4	-5	-3	-2	-5
Total Trips			**11**	**45**	**56**	**31**	**18**	**49**

*ITE Trip Generation, 8th Edition, Land Use: High-Rise Condominium/Townhouse (232)



Legend

AM: 8-9am
(PM): 5-6pm

N

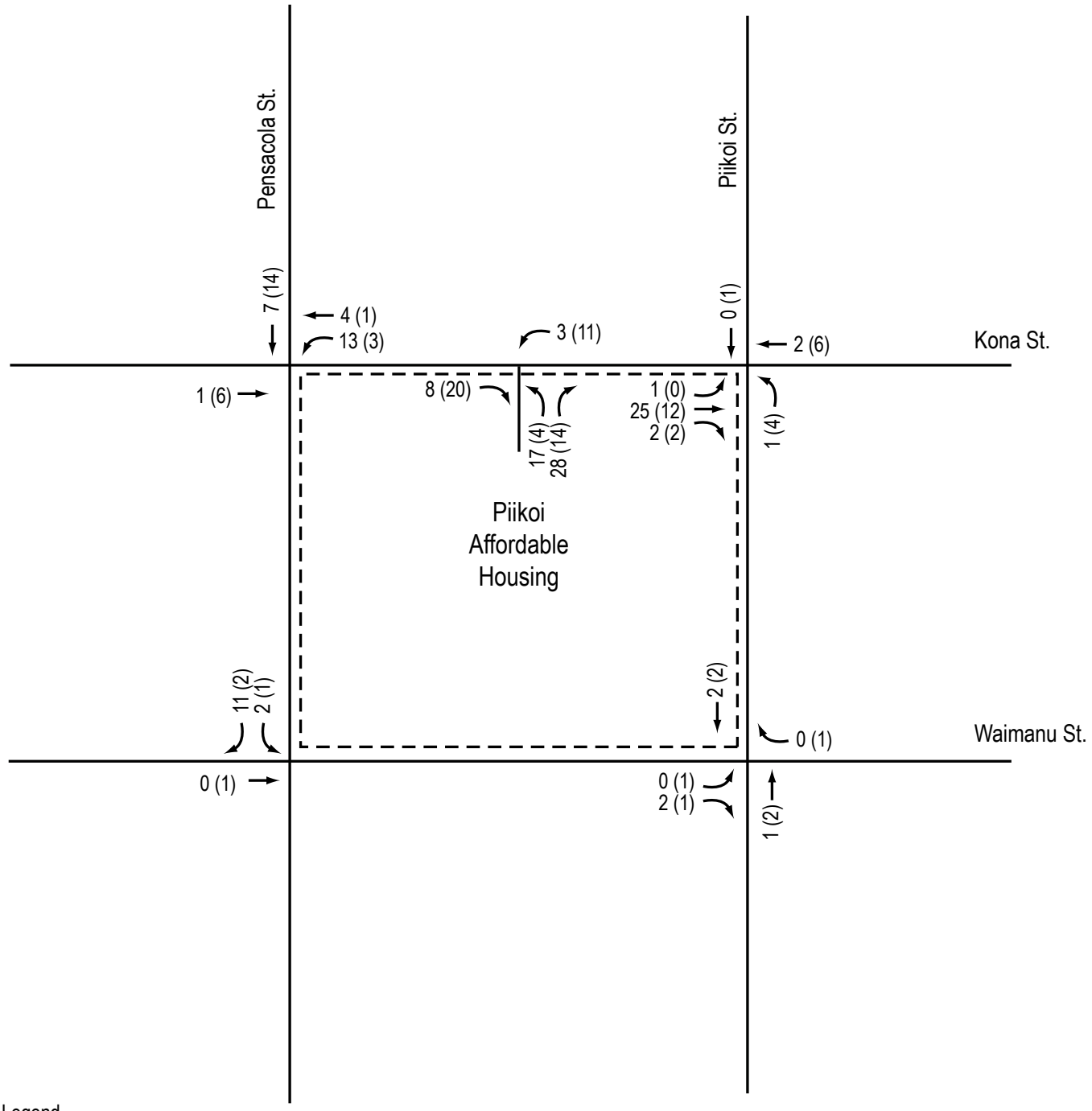
NTS

Year 2017 Lane Configurations with Project

Figure
6

2. Trip Assignment

The Oahu MPO ORTP 2035 model was referred to during the project trip distribution calculations. The existing trip distribution for the similarly-scaled Koolani condominium project was also referred to. The project-generated traffic volumes were assigned to the future network based on these two inputs. The Year 2017 project-generated trips are shown in Figure 7. The projected Year 2017 total traffic volumes are shown in Figure 8.



Legend

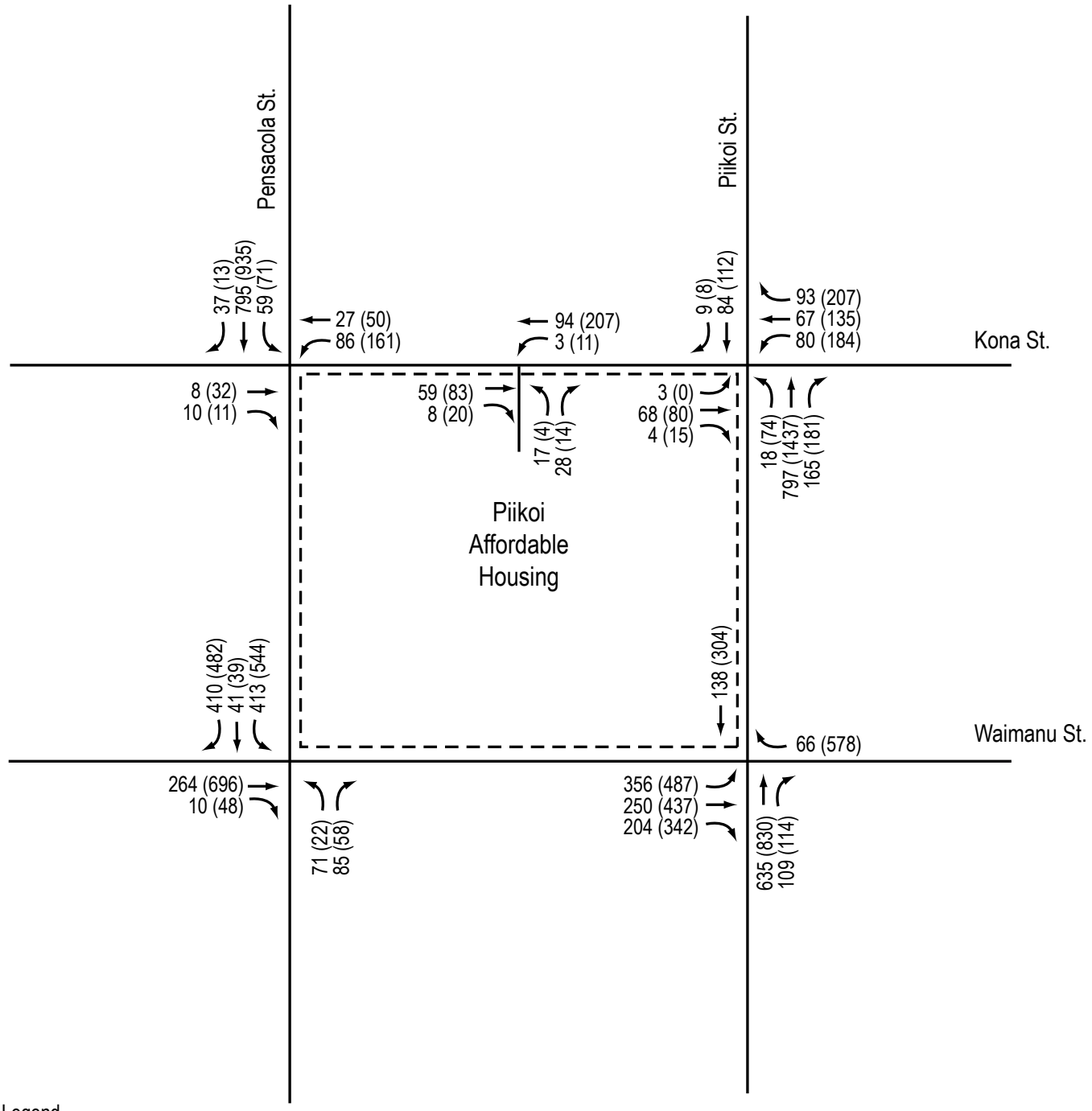
AM: 8-9am
(PM): 5-6pm

N

NTS

Year 2017 Project-Generated Traffic Volumes

Figure 7



Legend

AM: 8-9am
(PM): 5-6pm

N

NTS

Year 2017 Total Traffic Volumes

Figure 8

B. Projected Year 2017 Operations with Project

The projected Year 2017 intersection Level of service with the Piikoi Affordable Housing development is shown in Table 4.

Table 4 Projected Year 2017 LOS With Project

	2017 With Project			
	AM		PM	
	LOS	Delay	LOS	Delay
Pensacola Street and Kona Street	**Unsignalized**		**Unsignalized**	
Kona EB Approach	C	16	D	26
Kona WB Approach	C	16	D	30
Pensacola Street and Waimanu Street	**B**	**13**	**B**	**19**
Pensacola SB Left	A	10	B	15
Pensacola SB Right	B	12	C	24
Waimanu EB Approach	B	16	B	18
Koolani East NB Left	B	18	C	27
Koolani East NB Right	B	19	C	28
Piikoi Street and Kona Street	**A**	**7**	**B**	**10**
Piikoi NB Approach	A	5	A	8
Piikoi SB Approach	A	4	A	6
Kona EB Approach	B	11	B	15
Kona WB Left	B	12	B	19
Kona WB Left-Through	B	11	B	16
Kona WB Right	B	11	B	18
Piikoi Street and Waimanu Street	**B**	**11**	**D**	**43**
Piikoi NB Through-Right	B	11	B	13
Piikoi SB Through	B	10	B	12
Waimanu EB Left	B	12	D	37
Waimanu EB Through	A	8	B	11
Waimanu EB Right	A	8	B	13
Ala Moana Driveway Approach	B	18	F	155
Piikoi Affordable Housing Driveway and Kona Street	**Unsignalized**		**Unsignalized**	
Kona WB Left	A	1	A	1
Affordable Housing Driveway	A	9	A	9

*Delay is expressed in seconds per vehicle

C. Summary of Year 2017 Operations with Project

All intersections and individual movements are projected to operate at LOS B or better overall during both peak hours with the exception of the Piikoi/Waimanu intersection. This intersection is projected to operate at LOS D during the PM peak hour largely due to the Ewa-bound right turn leaving Ala Moana which is projected to operate at LOS F.

V. CONCLUSION AND RECOMMENDATIONS

The existing roadway network is sufficient to handle the additional traffic generated by the Hale Kewalo development.

Based on the operational analyses of intersections, the following are recommended to be implemented in conjunction with the proposed project:

- It is recommended that the Hale Kewalo development be accessed via a full-movement driveway on Kona Street. The driveway will be designed to meet sight distance requirements. A secondary driveway KKHD of the primary Kona Street access will be used by service trucks during limited hours only.
- The Waimanu Street driveway was analyzed as a left-in/left-out access. However, Waimanu Street is being converted to a two-way street between Pensacola Street and Piikoi Street in late 2014. In order to minimize traffic impact to Waimanu Street, it is recommended that the Waimanu Street access be configured as a right-in/right-out access.
- The City of Honolulu Department of Planning and Permitting (DPP) has requested the installation of a crosswalk across the makai leg of the intersection of Piikoi Street and Kona Street. This would be accompanied by the conversion of the middle lane of the Ewa-bound Kona Street approach from a shared left/through lane to a through lane. The Developer will continue working with GGP on an agreement to construct the crosswalk.
- The Honolulu Authority for Rapid Transportation (HART) will construct columns along Kona Street. The column location should be coordinated with the primary Kona Street driveway location.
- HART and the City & County of Honolulu will be responsible for constructing sidewalks fronting the development on Kona Street with the necessary curb ramps and curb cuts. The Developer will set aside 17' of right of way.

APPENDICES

Appendix A Traffic Count Data

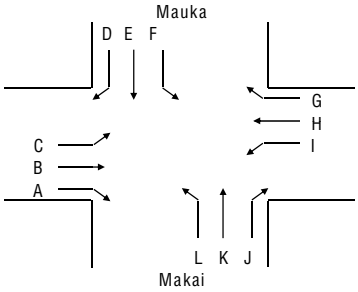
AM COUNT SHEET

Intersection: Piikoi and Waimanu

Date: 1/10/2012

By: ShengHong and David

Weather: Sunny



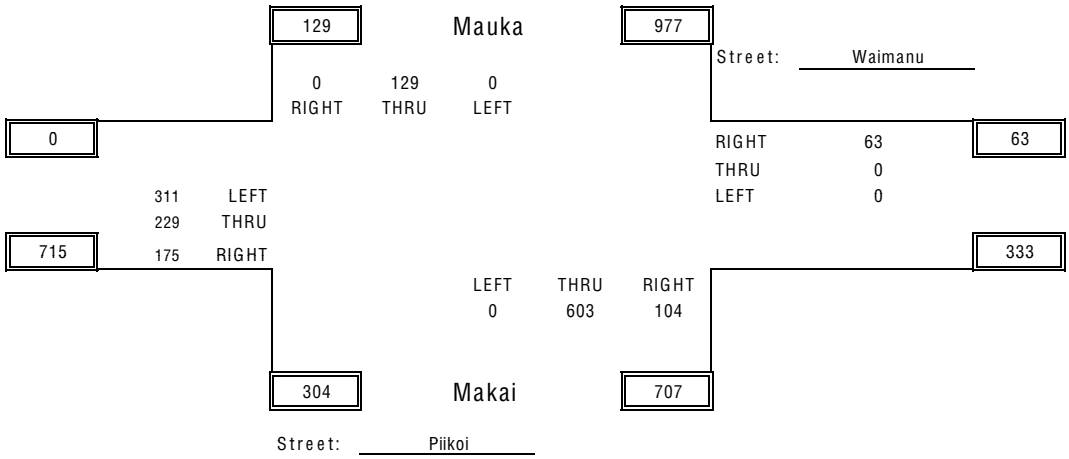
Street: Waimanu

Street: Piikoi

TIME	A	B	C	D	E	F	G	H	I	J	K	L	Total Mvmt	Total Hour
7:00 AM - 7:15 AM	29	27	54	0	20	0	0	0	0	11	150	0	291	1469
7:15 AM - 7:30 AM	45	25	83	0	24	0	5	0	0	13	180	0	375	1545
7:30 AM - 7:45 AM	42	31	98	0	27	0	5	0	0	36	181	0	420	1545
7:45 AM - 8:00 AM	40	40	76	0	45	0	9	0	0	23	150	0	383	1564
8:00 AM - 8:15 AM	46	32	82	0	25	0	8	0	0	18	156	0	367	1645
8:15 AM - 8:30 AM	47	52	52	0	34	0	13	0	0	23	154	0	375	
8:30 AM - 8:45 AM	58	71	79	0	35	0	22	0	0	25	149	0	439	
8:45 AM - 9:00 AM	55	74	98	0	35	0	20	0	0	38	144	0	464	
9:00 AM - 9:15 AM														
9:15 AM - 9:30 AM														
Phf	0.754	0.774	0.793	#DIV/0!	0.921	#DIV/0!	0.716	#DIV/0!	#DIV/0!	0.684	0.966	#DIV/0!	Peak	Phf
8:00 AM - 9:00 AM	175	229	311	0	129	0	63	0	0	104	603	0	1614	0.919

Peak Hour

8:00 AM - 9:00 AM



PARSONS
BRINCKERHOFF

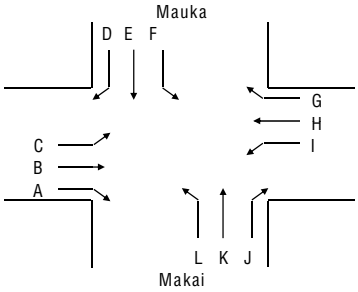
PM COUNT SHEET

Intersection: Piikoi and Waimanu

Date: 8/31/2011

By: ShengHong and David

Weather: Sunny



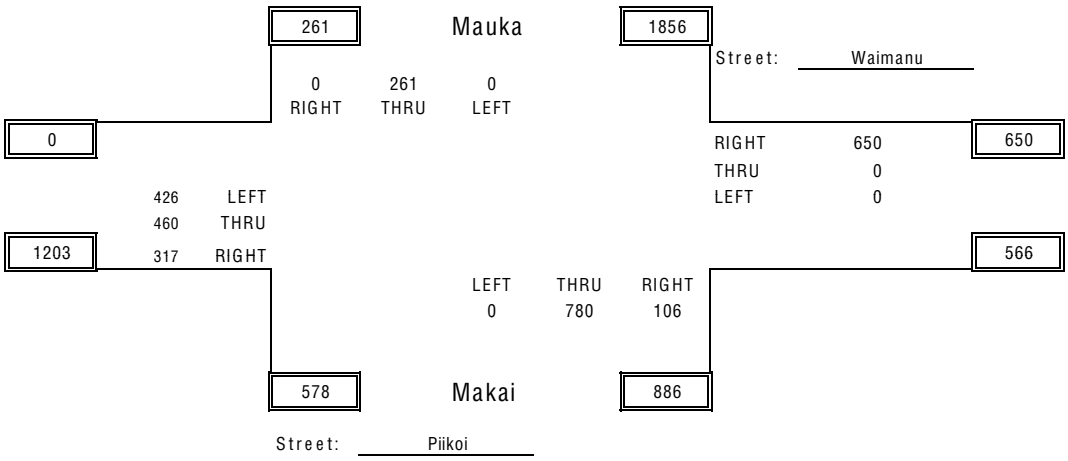
Street: Waimanu

Street: Piikoi

TIME	A	B	C	D	E	F	G	H	I	J	K	L	Total Mvmt	Total Hour
4:00 PM - 4:15 PM	77	80	98	0	68	0	85	0	0	20	171	0	599	2782
4:15 PM - 4:30 PM	96	85	99	0	73	0	109	0	0	21	178	0	661	2876
4:30 PM - 4:45 PM	66	107	128	0	71	0	131	0	0	26	184	0	713	3000
4:45 PM - 5:00 PM	87	138	93	0	65	0	207	0	0	19	200	0	809	2997
5:00 PM - 5:15 PM	69	94	116	0	53	0	126	0	0	27	208	0	693	2901
5:15 PM - 5:30 PM	95	121	89	0	72	0	186	0	0	34	188	0	785	
5:30 PM - 5:45 PM	76	98	125	0	88	0	111	0	0	25	187	0	710	
5:45 PM - 6:00 PM	76	92	119	0	74	0	125	0	0	23	204	0	713	
6:00 PM - 6:15 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	
Phf	0.834	0.833	0.832	#DIV/0!	0.906	#DIV/0!	0.785	#DIV/0!	#DIV/0!	0.779	0.938	#DIV/0!	Peak	Phf
4:30 PM - 5:30 PM	317	460	426	0	261	0	650	0	0	106	780	0	3000	0.927

Peak Hour

4:30 PM - 5:30 PM



PARSONS
BRINCKERHOFF

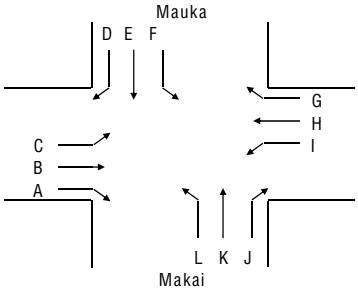
AM COUNT SHEET

Intersection: Piikoi and Kona

Date: 1/11/2012

By: ShengHong and David

Weather: Sunny



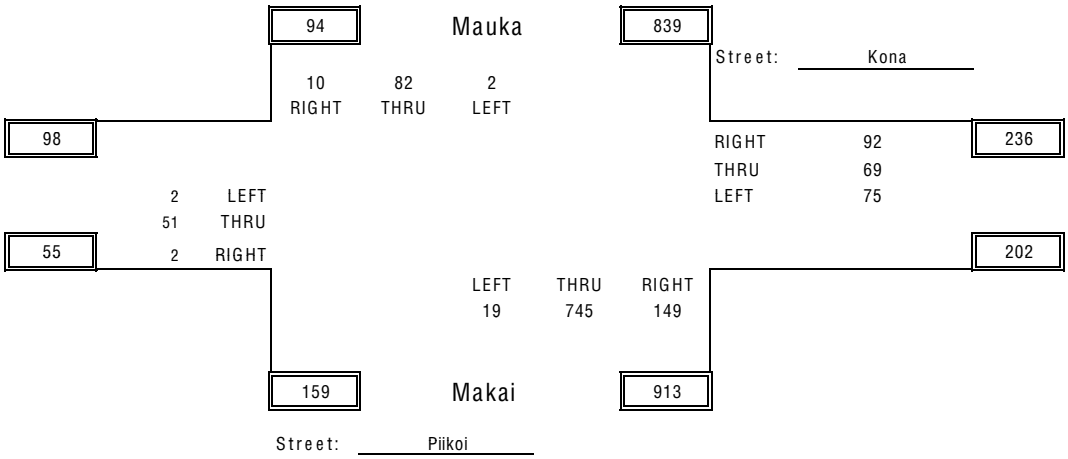
Street: Kona

Street: Piikoi

TIME	A	B	C	D	E	F	G	H	I	J	K	L	Total Mvmt	Total Hour
7:00 AM - 7:15 AM	1	5	0	1	7	1	17	12	11	34	174	9	272	1202
7:15 AM - 7:30 AM	1	7	0	4	14	0	13	15	17	33	197	8	309	1261
7:30 AM - 7:45 AM	3	4	0	4	9	0	19	14	23	44	195	3	318	1285
7:45 AM - 8:00 AM	0	12	0	3	21	0	20	10	19	37	178	3	303	1298
8:00 AM - 8:15 AM	0	9	0	2	18	2	26	27	19	43	178	7	331	1292
8:15 AM - 8:30 AM	1	16	1	5	22	0	26	13	11	30	205	3	333	
8:30 AM - 8:45 AM	1	14	1	0	21	0	20	19	26	39	184	6	331	
8:45 AM - 9:00 AM	1	10	0	3	19	1	16	15	20	40	168	4	297	
9:00 AM - 9:15 AM														
9:15 AM - 9:30 AM														
Phf	0.500	0.797	0.500	0.500	0.932	0.250	0.885	0.639	0.721	0.866	0.909	0.679	Peak	Phf
7:45 AM - 8:45 AM	2	51	2	10	82	2	92	69	75	149	745	19	1298	0.974

Peak Hour

7:45 AM - 8:45 AM



PARSONS
BRINCKERHOFF

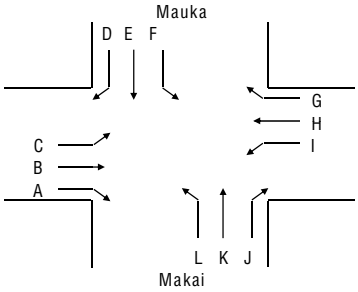
PM COUNT SHEET

Intersection: Piikoi and Kona

Date: 8/31/2011

By: ShengHong and David

Weather: Sunny



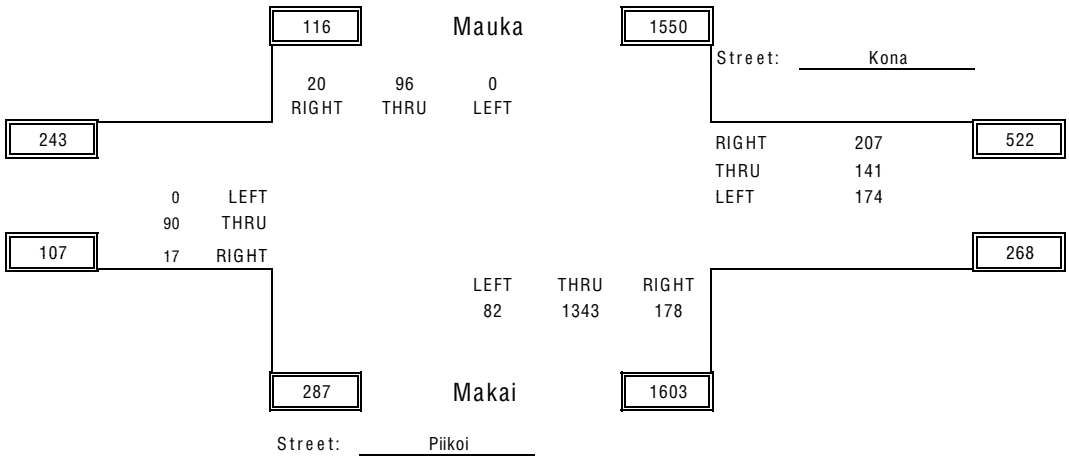
Street: Kona

Street: Piikoi

TIME	A	B	C	D	E	F	G	H	I	J	K	L	Total Mvmt	Total Hour
4:00 PM - 4:15 PM	1	21	1	2	37	2	49	33	48	30	343	17	584	2283
4:15 PM - 4:30 PM	3	23	0	11	29	3	48	25	32	30	330	23	557	2316
4:30 PM - 4:45 PM	0	22	0	4	40	0	50	28	50	37	323	19	573	2338
4:45 PM - 5:00 PM	4	30	0	12	28	0	51	28	32	40	324	20	569	2348
5:00 PM - 5:15 PM	6	22	0	7	25	0	56	34	51	74	325	17	617	2332
5:15 PM - 5:30 PM	5	19	0	0	18	0	52	37	40	30	348	30	579	
5:30 PM - 5:45 PM	2	19	0	1	25	0	48	42	51	34	346	15	583	
5:45 PM - 6:00 PM	3	18	0	1	39	0	41	32	33	33	337	16	553	
6:00 PM - 6:15 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	
Phf	0.708	0.750	#DIV/0!	0.417	0.857	#DIV/0!	0.924	0.839	0.853	0.601	0.965	0.683	Peak	Phf
4:45 PM - 5:45 PM	17	90	0	20	96	0	207	141	174	178	1343	82	2348	1.005

Peak Hour

4:45 PM - 5:45 PM



PARSONS
BRINCKERHOFF

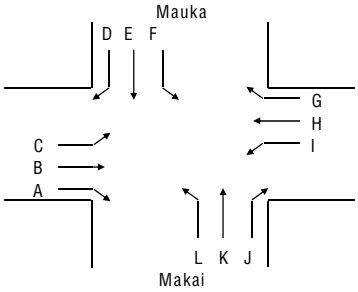
AM COUNT SHEET

Intersection: Pensacola and Waimanu

Date: 1/11/2012

By: Paula

Weather: Sunny



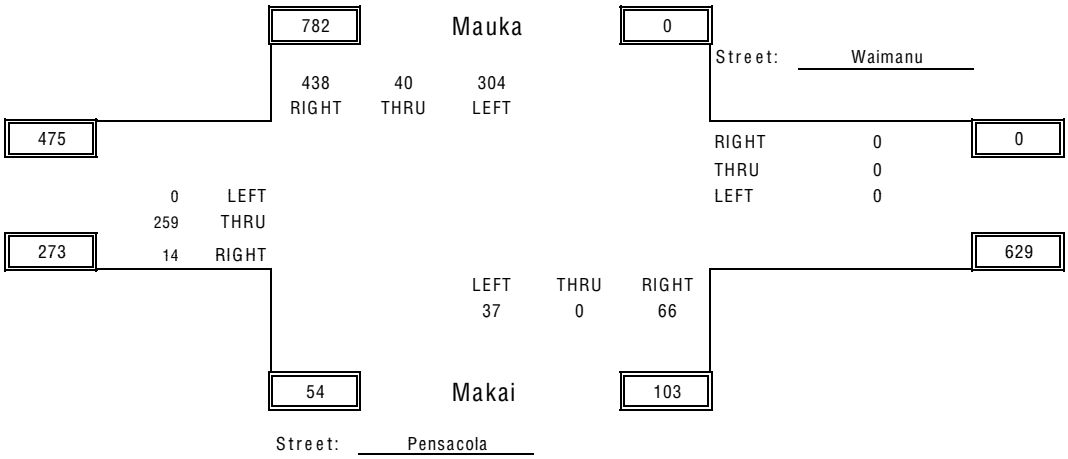
Street: Waimanu

Street: Pensacola

TIME	A	B	C	D	E	F	G	H	I	J	K	L	Total Mvmt	Total Hour
7:00 AM - 7:15 AM	0	43	0	76	2	52	0	0	0	16	0	6	195	975
7:15 AM - 7:30 AM	0	56	0	82	1	54	0	0	0	17	0	8	218	1081
7:30 AM - 7:45 AM	6	66	0	112	7	56	0	0	0	26	0	12	285	1158
7:45 AM - 8:00 AM	5	63	0	109	4	69	0	0	0	19	0	8	277	1150
8:00 AM - 8:15 AM	0	65	0	117	20	78	0	0	0	11	0	10	301	1136
8:15 AM - 8:30 AM	3	65	0	100	9	101	0	0	0	10	0	7	295	
8:30 AM - 8:45 AM	6	64	0	84	6	97	0	0	0	9	0	11	277	
8:45 AM - 9:00 AM	1	52	0	78	4	98	0	0	0	23	0	7	263	
9:00 AM - 9:15 AM														
9:15 AM - 9:30 AM														
Phf	0.583	0.981	#DIV/0!	0.936	0.500	0.752	#DIV/0!	#DIV/0!	#DIV/0!	0.635	#DIV/0!	0.771	Peak	Phf
7:30 AM - 8:30 AM	14	259	0	438	40	304	0	0	0	66	0	37	1158	0.962

Peak Hour

7:30 AM - 8:30 AM



PARSONS
BRINCKERHOFF

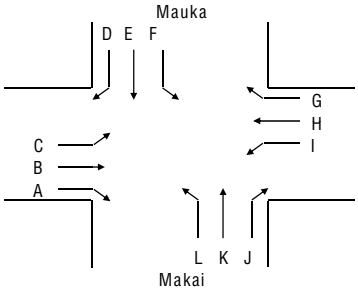
PM COUNT SHEET

Intersection: Pensacola and Waimanu

Date: 8/31/2011

By: Paula

Weather: Sunny



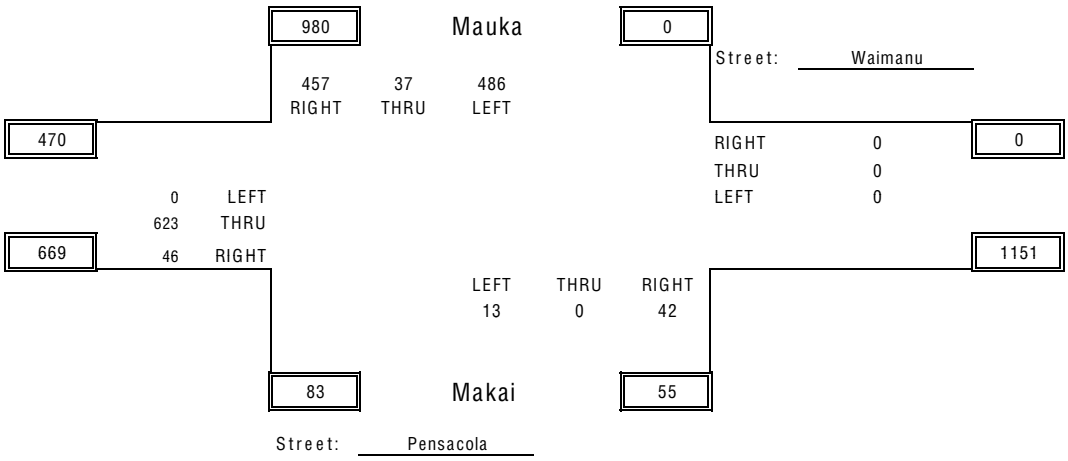
Street: Waimanu

Street: Pensacola

TIME	A	B	C	D	E	F	G	H	I	J	K	L	Total Mvmt	Total Hour
4:00 PM - 4:15 PM	8	116	0	123	15	127	0	0	0	11	0	4	404	1639
4:15 PM - 4:30 PM	4	146	0	129	6	121	0	0	0	9	0	5	420	1629
4:30 PM - 4:45 PM	6	151	0	129	10	107	0	0	0	6	0	2	411	1652
4:45 PM - 5:00 PM	32	125	0	119	9	110	0	0	0	5	0	4	404	1691
5:00 PM - 5:15 PM	9	137	0	119	7	110	0	0	0	12	0	0	394	1704
5:15 PM - 5:30 PM	12	169	0	117	12	121	0	0	0	6	0	6	443	
5:30 PM - 5:45 PM	11	168	0	115	6	135	0	0	0	10	0	5	450	
5:45 PM - 6:00 PM	14	149	0	106	12	120	0	0	0	14	0	2	417	
6:00 PM - 6:15 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	
Phf	0.821	0.922	#DIV/0!	0.960	0.771	0.900	#DIV/0!	#DIV/0!	#DIV/0!	0.750	#DIV/0!	0.542	Peak	Phf
5:00 PM - 6:00 PM	46	623	0	457	37	486	0	0	0	42	0	13	1704	1.014

Peak Hour

5:00 PM - 6:00 PM



PARSONS
BRINCKERHOFF

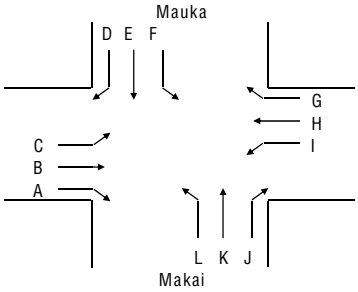
AM COUNT SHEET

Intersection: Pensacola and Kona

Date: 1/11/2012

By: Herbert

Weather: Sunny



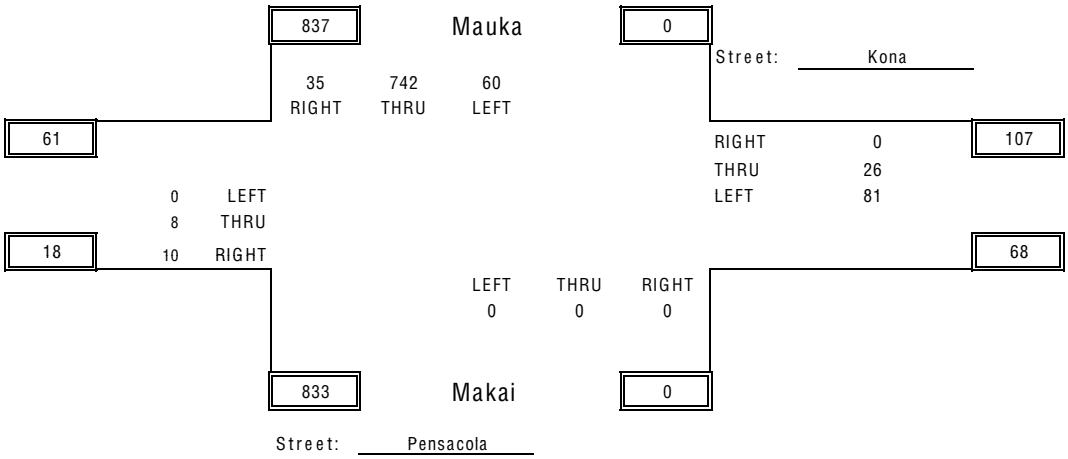
Street: Kona

Street: Pensacola

TIME	A	B	C	D	E	F	G	H	I	J	K	L	Total Mvmt	Total Hour
7:00 AM - 7:15 AM	0	3	0	0	79	6	0	2	9	0	0	0	99	656
7:15 AM - 7:30 AM	2	1	0	3	121	9	0	2	18	0	0	0	156	786
7:30 AM - 7:45 AM	1	2	0	6	143	10	0	7	10	0	0	0	179	887
7:45 AM - 8:00 AM	0	2	0	6	186	10	0	1	17	0	0	0	222	953
8:00 AM - 8:15 AM	1	1	0	15	172	12	0	7	21	0	0	0	229	962
8:15 AM - 8:30 AM	2	1	0	5	209	13	0	7	20	0	0	0	257	
8:30 AM - 8:45 AM	3	4	0	9	189	17	0	6	17	0	0	0	245	
8:45 AM - 9:00 AM	4	2	0	6	172	18	0	6	23	0	0	0	231	
9:00 AM - 9:15 AM														
9:15 AM - 9:30 AM														
Phf	0.625	0.500	#DIV/0!	0.583	0.888	0.833	#DIV/0!	0.929	0.880	#DIV/0!	#DIV/0!	#DIV/0!	Peak	Phf
8:00 AM - 9:00 AM	10	8	0	35	742	60	0	26	81	0	0	0	962	0.936

Peak Hour

8:00 AM - 9:00 AM



PARSONS
BRINCKERHOFF

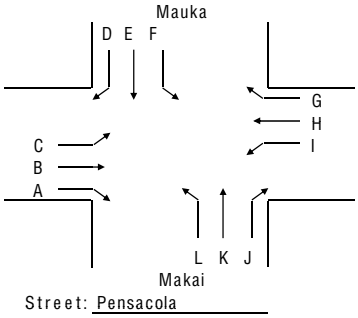
PM COUNT SHEET

Intersection: Pensacola and Kona

Date: 8/31/2011

By: Herbert

Weather: Sunny

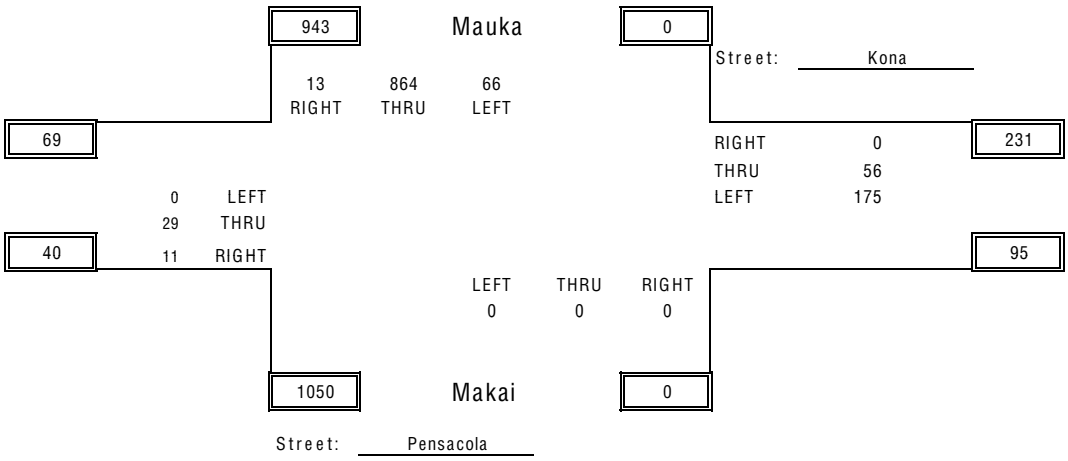


Street: Kona

TIME	A	B	C	D	E	F	G	H	I	J	K	L	Total Mvmt	Total Hour
4:00 PM - 4:15 PM	6	3	0	6	216	18	0	7	42	0	0	0	298	1154
4:15 PM - 4:30 PM	2	3	0	1	216	17	0	11	44	0	0	0	294	1147
4:30 PM - 4:45 PM	3	2	0	5	208	15	0	9	36	0	0	0	278	1141
4:45 PM - 5:00 PM	0	4	0	2	211	16	0	14	37	0	0	0	284	1174
5:00 PM - 5:15 PM	1	4	0	1	206	19	0	18	42	0	0	0	291	1214
5:15 PM - 5:30 PM	3	3	0	3	207	15	0	14	43	0	0	0	288	
5:30 PM - 5:45 PM	3	10	0	5	221	17	0	11	44	0	0	0	311	
5:45 PM - 6:00 PM	4	12	0	4	230	15	0	13	46	0	0	0	324	
6:00 PM - 6:15 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	
Phf	0.688	0.604	#DIV/0!	0.650	0.939	0.868	#DIV/0!	0.778	0.951	#DIV/0!	#DIV/0!	#DIV/0!	Peak	Phf
5:00 PM - 6:00 PM	11	29	0	13	864	66	0	56	175	0	0	0	1214	1.018

Peak Hour

5:00 PM - 6:00 PM



PARSONS
BRINCKERHOFF

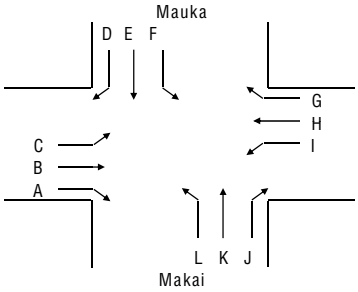
AM COUNT SHEET

Intersection: Waimanu and Koolani Dirveway

Date: 1/10/2012

By: Paula

Weather: Sunny



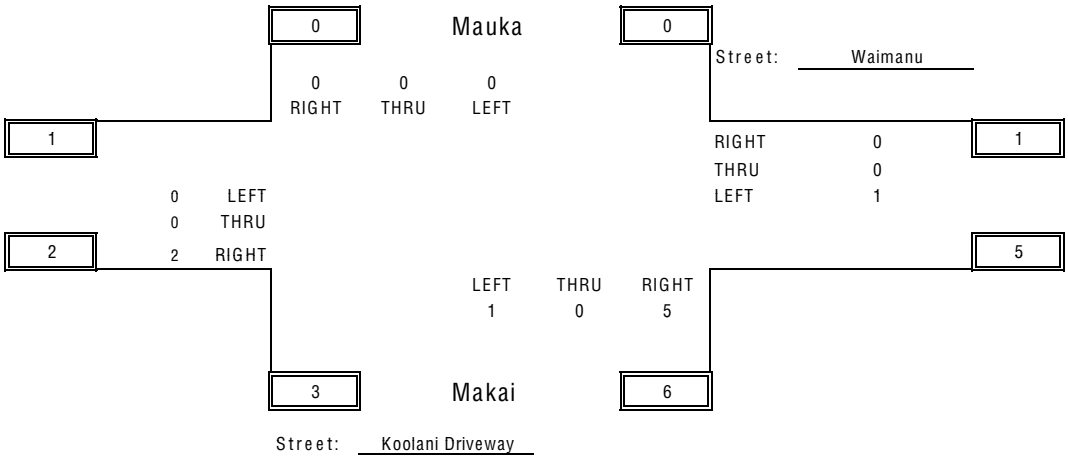
Street: Waimanu

Street: Koolani Driveway

TIME	A	B	C	D	E	F	G	H	I	J	K	L	Total Mvmt	Total Hour
7:00 AM - 7:15 AM	1	0	0	0	0	0	0	0	0	2	0	3	6	8
7:15 AM - 7:30 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	6
7:30 AM - 7:45 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	8
7:45 AM - 8:00 AM	1	0	0	0	0	0	0	0	0	1	0	0	2	9
8:00 AM - 8:15 AM	2	0	0	0	0	0	0	0	0	2	0	0	4	9
8:15 AM - 8:30 AM	0	0	0	0	0	0	0	0	1	1	0	0	2	
8:30 AM - 8:45 AM	0	0	0	0	0	0	0	0	0	0	0	1	1	
8:45 AM - 9:00 AM	0	0	0	0	0	0	0	0	0	2	0	0	2	
9:00 AM - 9:15 AM														
9:15 AM - 9:30 AM														
Phf	0.250	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0.250	0.625	#DIV/0!	0.250	Peak	Phf
8:00 AM - 9:00 AM	2	0	0	0	0	0	0	0	1	5	0	1	9	0.563

Peak Hour

8:00 AM - 9:00 AM



PARSONS
BRINCKERHOFF

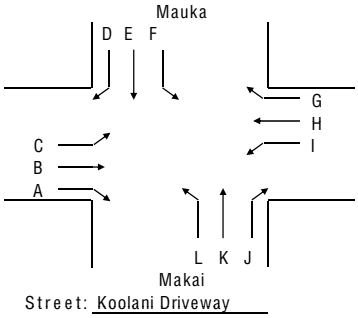
PM COUNT SHEET

Intersection: Waimanu and Koolani Dirveway

Date: 8/31/2011

By: Paula

Weather: Sunny

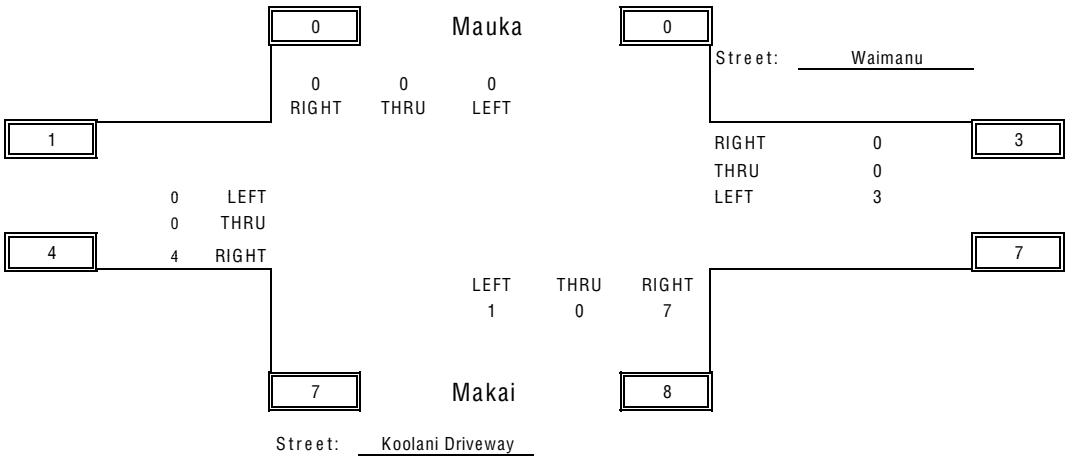


Street: Waimanu

TIME	A	B	C	D	E	F	G	H	I	J	K	L	Total Mvmt	Total Hour
4:00 PM - 4:15 PM	4	0	0	0	0	0	0	0	1	1	0	1	7	14
4:15 PM - 4:30 PM	0	0	0	0	0	0	0	0	0	1	0	1	2	11
4:30 PM - 4:45 PM	2	0	0	0	0	0	0	0	0	3	0	0	5	10
4:45 PM - 5:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	9
5:00 PM - 5:15 PM	1	0	0	0	0	0	0	0	2	0	0	1	4	15
5:15 PM - 5:30 PM	0	0	0	0	0	0	0	0	0	1	0	0	1	
5:30 PM - 5:45 PM	0	0	0	0	0	0	0	0	1	3	0	0	4	
5:45 PM - 6:00 PM	3	0	0	0	0	0	0	0	0	3	0	0	6	
6:00 PM - 6:15 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	
Phf	0.333	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0.375	0.583	#DIV/0!	0.250	Peak	Phf
5:00 PM - 6:00 PM	4	0	0	0	0	0	0	0	3	7	0	1	15	0.536

Peak Hour

5:00 PM - 6:00 PM



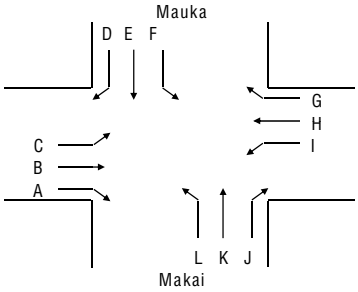
AM COUNT SHEET

Intersection: Waimanu and Queen

Date: 1/10/2012

By: Herbert

Weather: Sunny



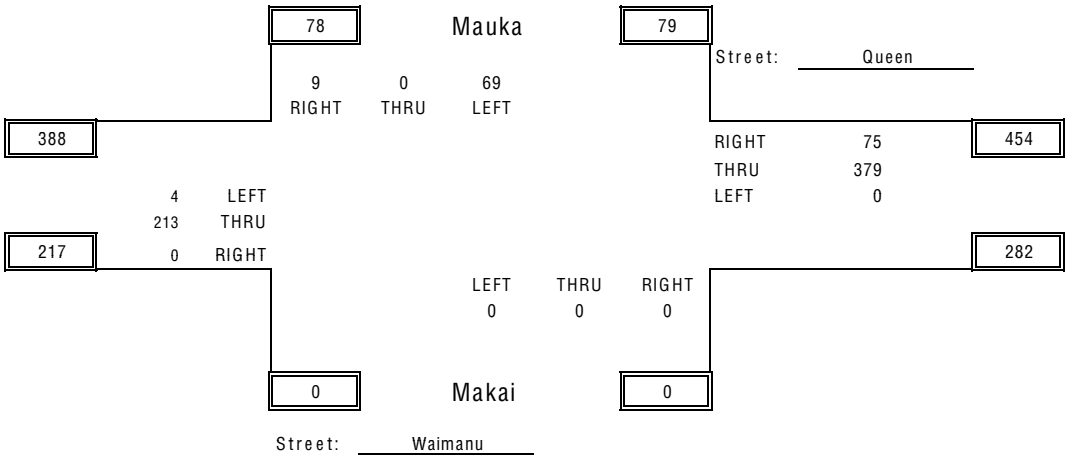
Street: Queen

Street: Waimanu

TIME	A	B	C	D	E	F	G	H	I	J	K	L	Total Mvmt	Total Hour
7:00 AM - 7:15 AM	0	30	1	1	0	16	9	58	0	0	0	0	115	631
7:15 AM - 7:30 AM	0	29	1	1	0	29	11	87	0	0	0	0	158	715
7:30 AM - 7:45 AM	0	36	1	2	0	25	22	85	0	0	0	0	171	741
7:45 AM - 8:00 AM	0	47	0	0	0	18	13	109	0	0	0	0	187	742
8:00 AM - 8:15 AM	0	57	1	2	0	9	24	106	0	0	0	0	199	749
8:15 AM - 8:30 AM	0	46	0	2	0	21	19	96	0	0	0	0	184	
8:30 AM - 8:45 AM	0	48	3	4	0	16	14	87	0	0	0	0	172	
8:45 AM - 9:00 AM	0	62	0	1	0	23	18	90	0	0	0	0	194	
9:00 AM - 9:15 AM														
9:15 AM - 9:30 AM														
Phf	#DIV/0!	0.859	0.333	0.563	#DIV/0!	0.750	0.781	0.894	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	Peak	Phf
8:00 AM - 9:00 AM	0	213	4	9	0	69	75	379	0	0	0	0	749	0.941

Peak Hour

8:00 AM - 9:00 AM



PARSONS
BRINCKERHOFF

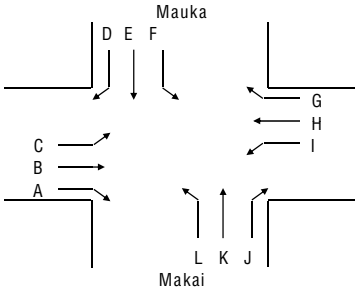
PM COUNT SHEET

Intersection: Waimanu and Queen

Date: 8/31/2011

By: Herbert

Weather: Sunny



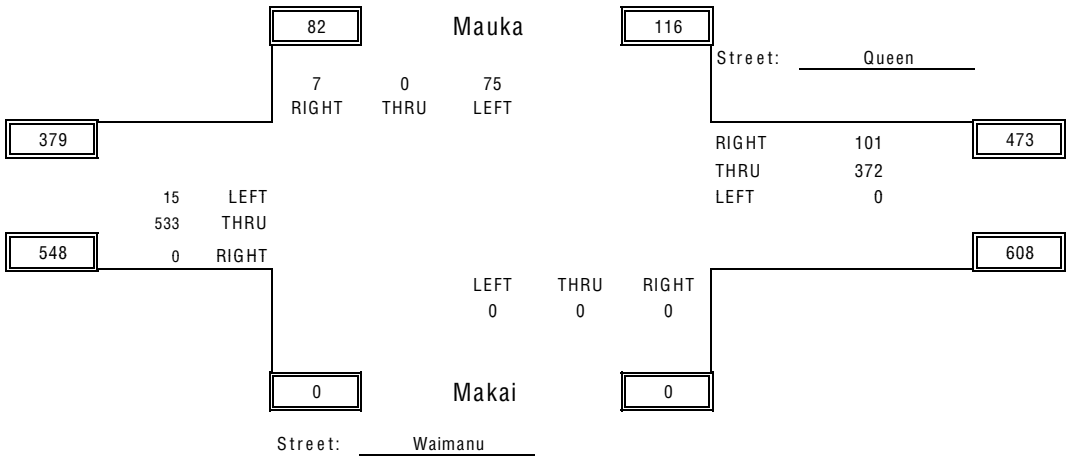
Street: Queen

Street: Waimanu

TIME	A	B	C	D	E	F	G	H	I	J	K	L	Total Mvmt	Total Hour
4:00 PM - 4:15 PM	0	105	13	2	0	18	23	118	0	0	0	0	279	1071
4:15 PM - 4:30 PM	0	107	5	2	0	19	40	95	0	0	0	0	268	1070
4:30 PM - 4:45 PM	0	121	4	5	0	26	30	83	0	0	0	0	269	1094
4:45 PM - 5:00 PM	0	104	3	4	0	17	22	105	0	0	0	0	255	1090
5:00 PM - 5:15 PM	0	130	3	2	0	24	29	90	0	0	0	0	278	1103
5:15 PM - 5:30 PM	0	130	7	5	0	14	28	108	0	0	0	0	292	
5:30 PM - 5:45 PM	0	138	4	0	0	21	23	79	0	0	0	0	265	
5:45 PM - 6:00 PM	0	135	1	0	0	16	21	95	0	0	0	0	268	
6:00 PM - 6:15 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	
Phf	#DIV/0!	0.966	0.536	0.350	#DIV/0!	0.781	0.871	0.861	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	Peak	Phf
5:00 PM - 6:00 PM	0	533	15	7	0	75	101	372	0	0	0	0	1103	0.988

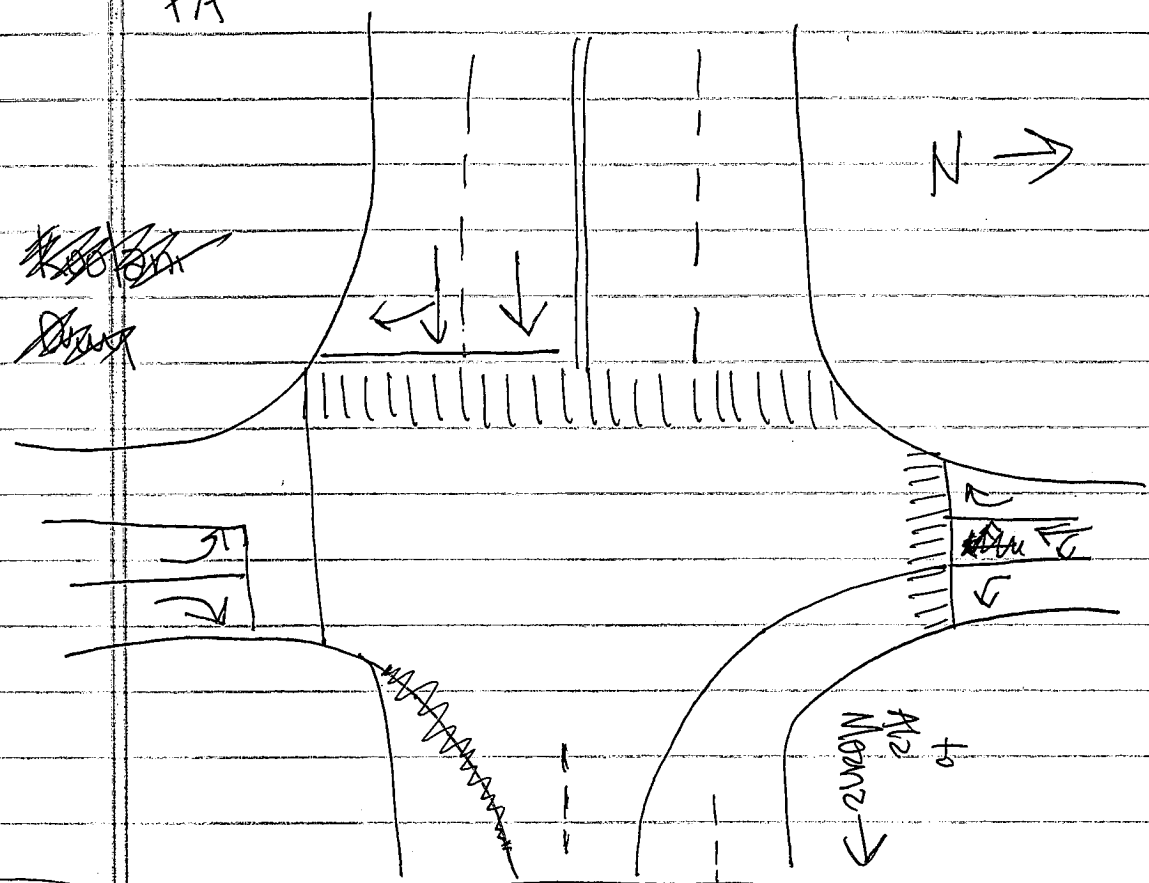
Peak Hour

5:00 PM - 6:00 PM



PARSONS
BRINCKERHOFF

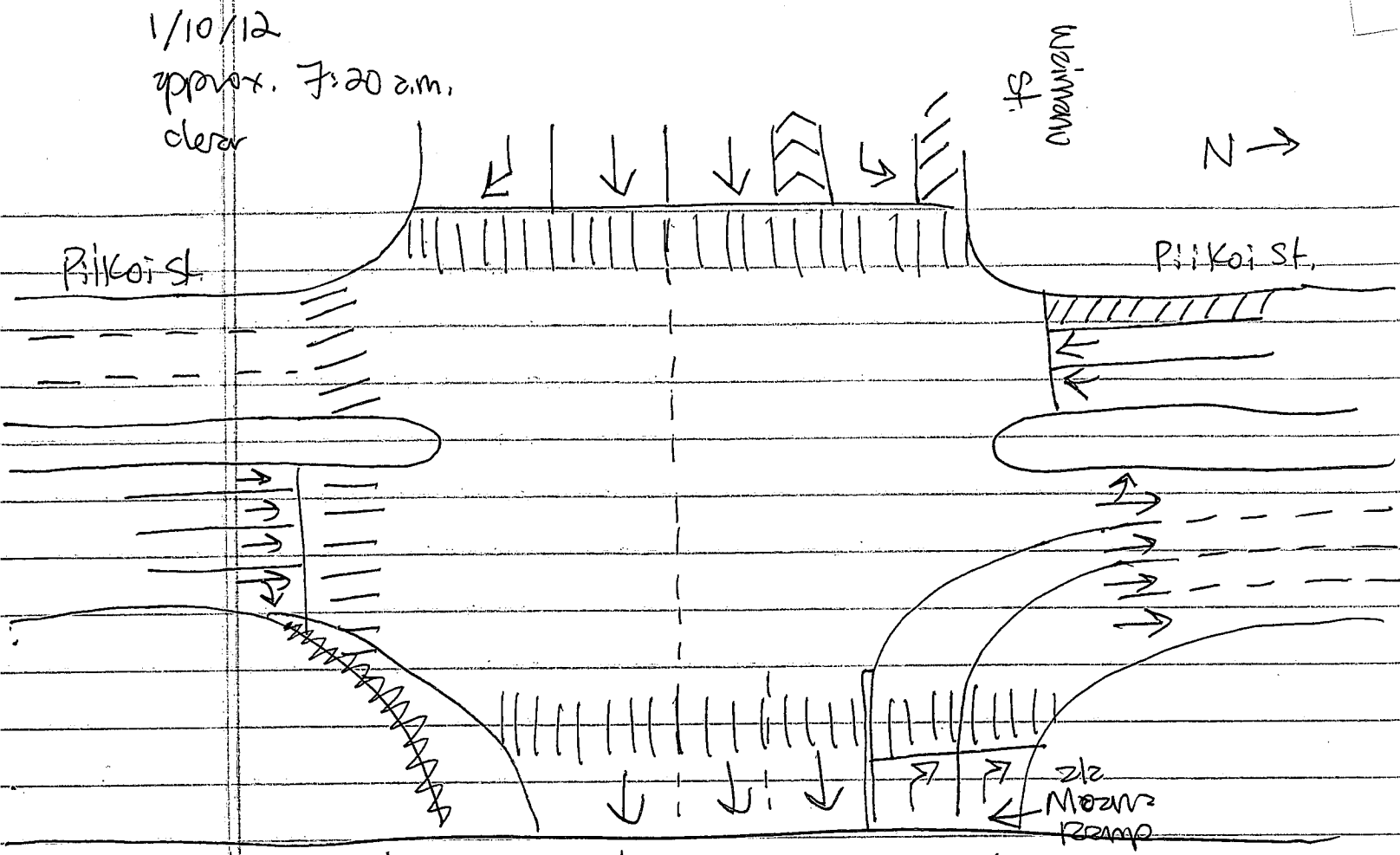
1/10/12
Walmart Street & Pensacola Street
overcast
PA



Start @ approx 7 a.m. - 7:10 a.m.

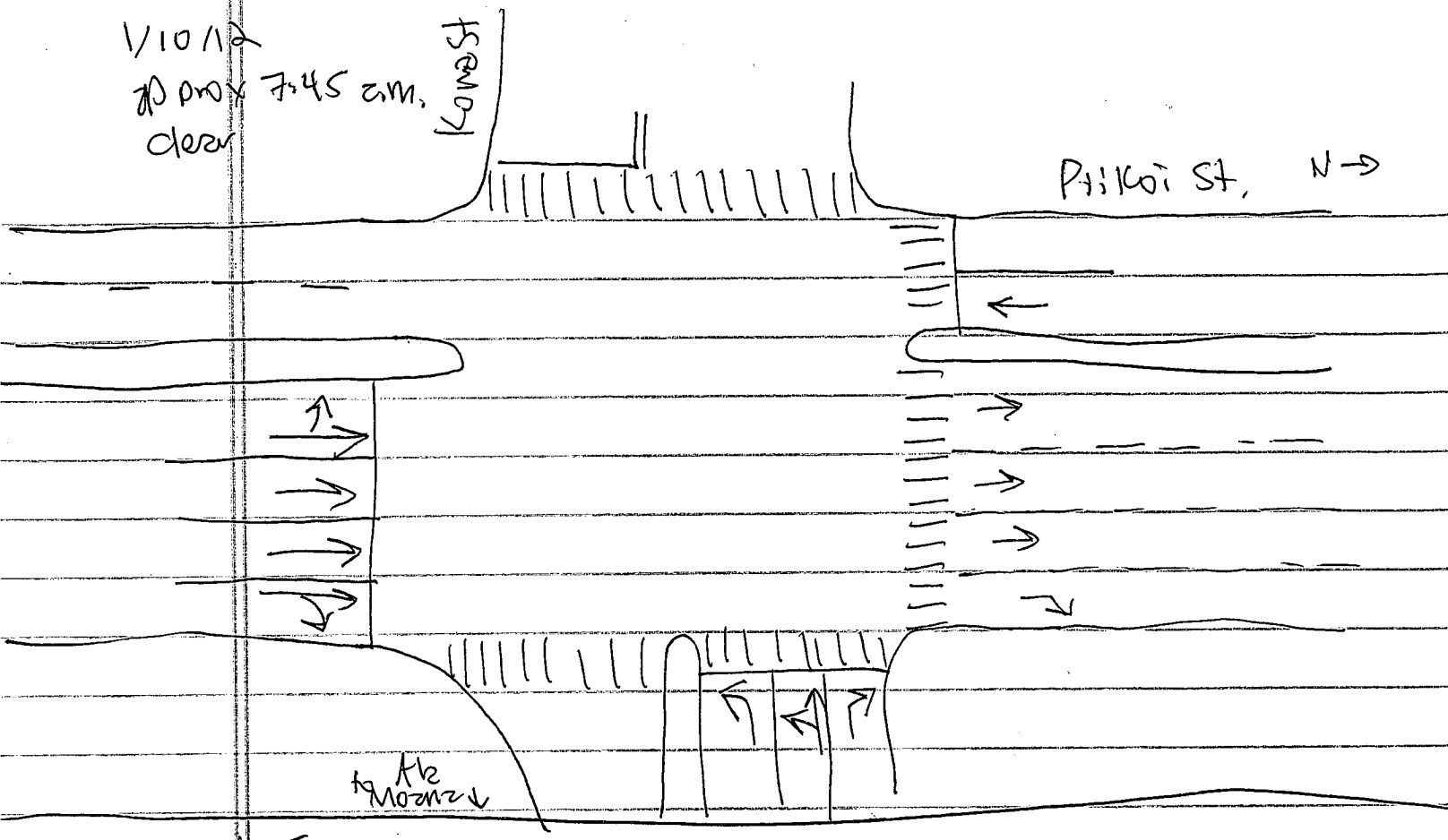
	↖ ↙ ↓	↓	↗ ↘	Total Time	yellow	all-red
1		0:26			4	1
2	1:00	1:11	only actuated upon	0:45	4	1
3	2:08	2:33	left turn	1:22		
4	3:14	3:26	queue. No	0:53		
5	4:23	4:34	left turn	1:08		
6	5:28	5:51	queue during	1:17		
			survey.			

1/10/12
approx. 7:20 a.m.
clear



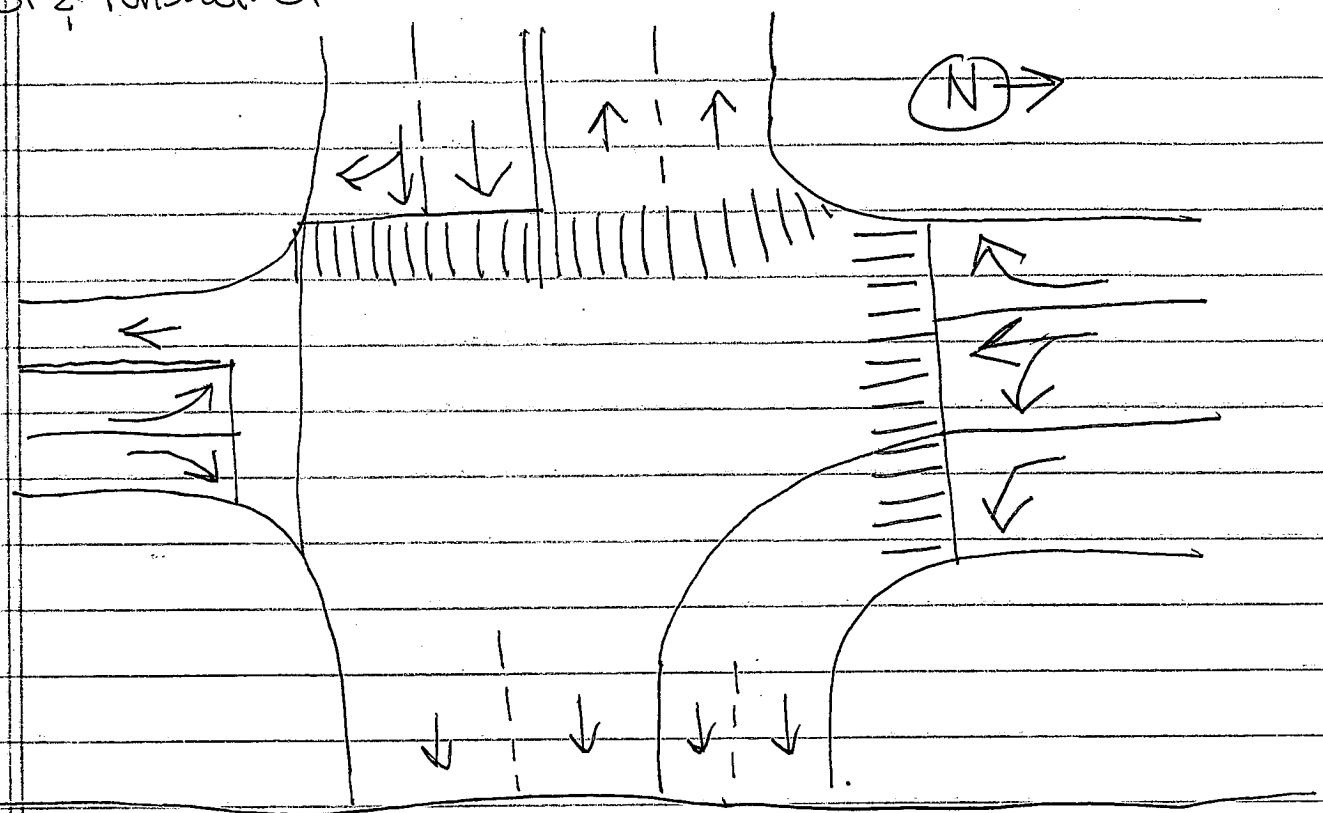
	← → ↱	↓ ↳	↱	Total time ~~red~~	yellow	all-red
1		0:32			4	1
2	1:59	2:31		1:59	4	1
3	4:00	4:32		2:01		
4	5:59	6:32		2:00		
5	7:59	8:32		2:00		
6	9:59	10:31		1:59		

1/10/12
approx 7:45 a.m.
clear



	← ↗ →	↑↑↗	yellow	all-red	Total time
1		0:35	4	1	
2	1:20	1:55	4	1	1:20
3	2:40	3:15			1:20
4	4:00	4:35			1:20
5	5:20	5:55			1:20
6	6:40	7:15			1:20

1/11/12
Wzimanu St & Pensacola St
cloudy
PA

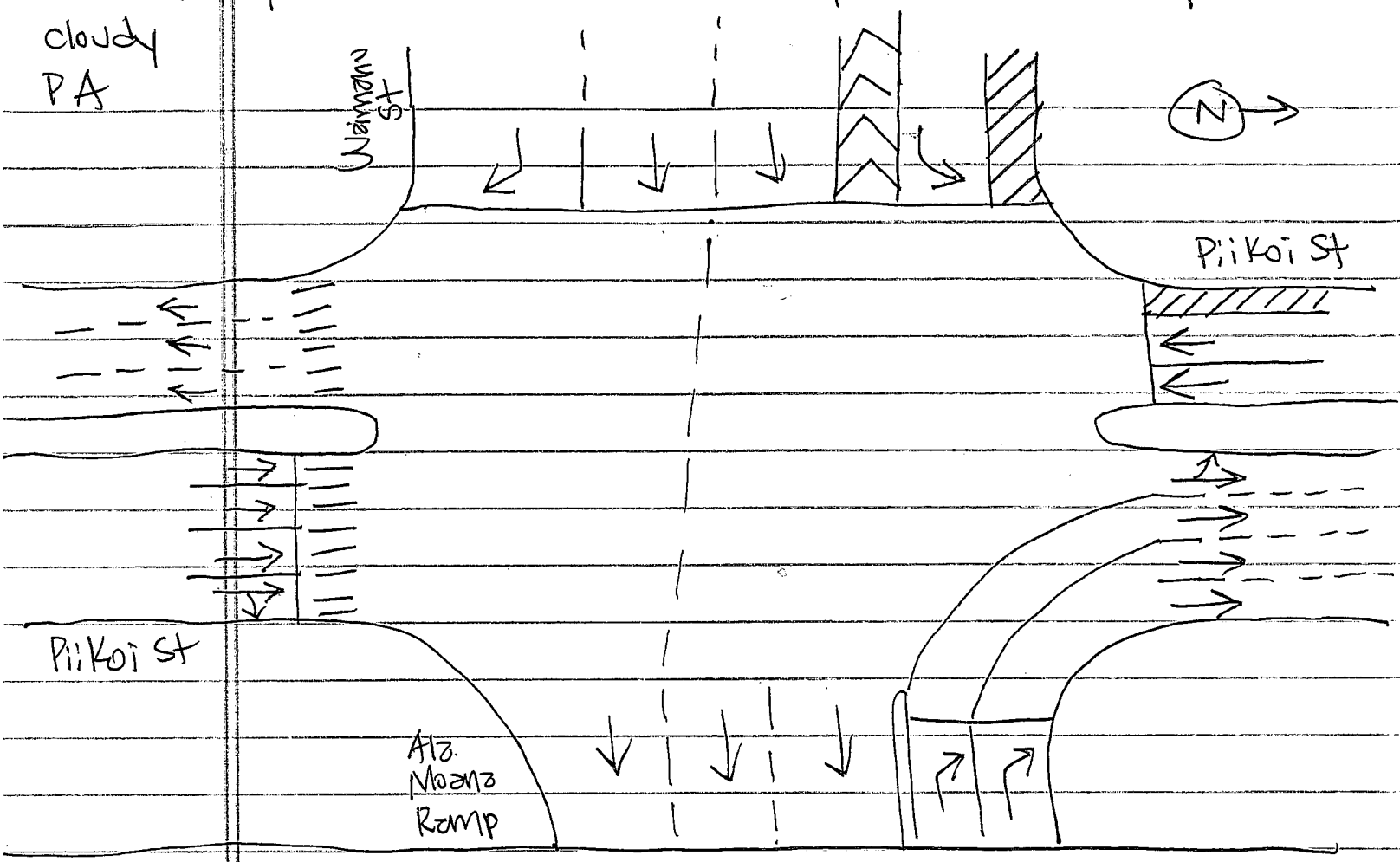


start @ approx. 4:02 p.m - 4:10 p.m.

Start time	↖ ← ↙	↙ ↓	↗ ↘	Total time	yellow	all-red
1	0:00	0:35	1:04	1:16	4	1
2	1:16	1:47		1:04	3.5	1
3	2:20	2:50		0:49	3.5	1
4	3:09	3:52	4:17	1:21		
5	4:30	5:00	5:27	1:09		
6	5:39	6:11		0:57		
7	6:36					

1/11/12
Waimanu St & Piikoi St
cloudy
PA

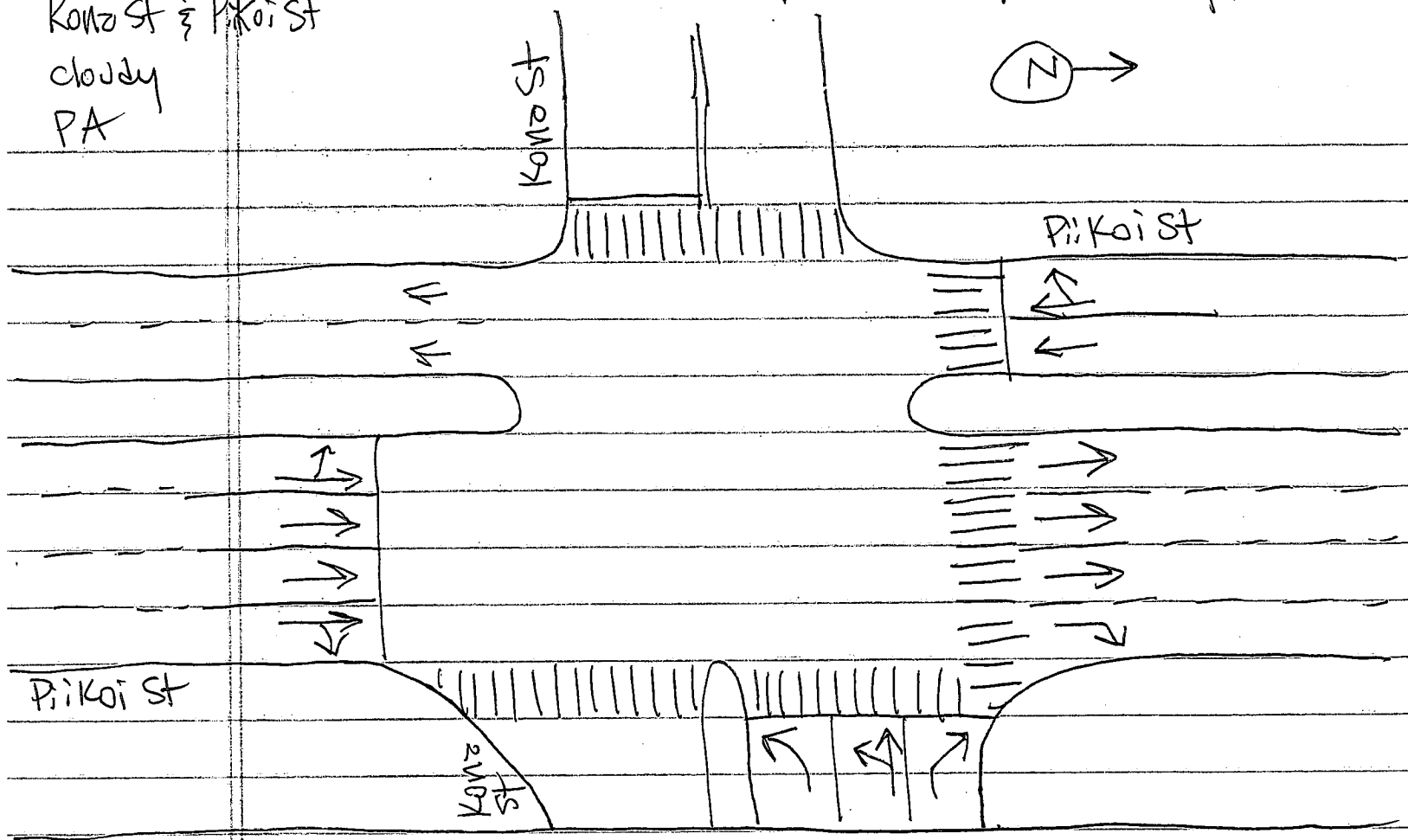
start time @ approx. 4:37 - 4:50 p.m.



	⇇ → ⇉	↓ ↳	↳ ↗	Total time	yellow	all-red
1			0:15		4	~~2~~ ?
2	0:44	1:59	2:14	1:59	4	1
3	2:44	3:59	4:14	2:00	4	1
4	4:44	5:59	6:14	2:00		
5	6:44	7:59	8:14	2:00		
6	8:44	9:59	10:14	2:00		
7	10:44					

1/11/12
Kona St & Piikoi St
cloudy
PA

start time @ approx. 4:23 p.m. – 4:30 p.m.



	← ↱ →	↙ ↓ ↖ ↑ ↗	Total time	yellow	all-red
1		0:35 35		4	1
2	1:19 44	1:54 35	1:19	4	1
3	2:39 44	3:14 35	1:20		
4	3:59 44	4:34 35	1:20		
5	5:19 44	5:54 35	1:20		
6	6:39 44	7:14 35	1:20		
7	7:59 44				

Data Collection Worksheet

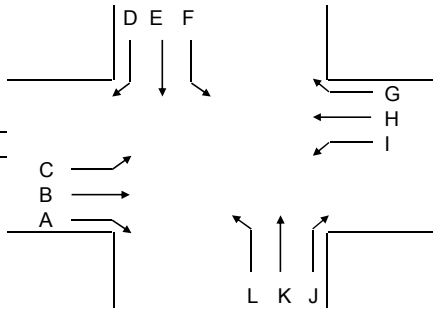
Intersection: Queen St & Waimau St

Date: 1/10/2012

By: Herbert

Weather: Sunny

Street: **Waimanu Street**
Sp. Lim:
Slope:



Street: **Queen Street**
Slope:

Street: **Queen Street**
Sp. Lim:
Slope:

Street:
Slope:

AM Peak Count

TIME	A	B	C	D	E	F	G	H	I	J	K	L
7:00 AM - 7:15 AM	Bike	Bike 1	Bike	Bike	Bike	Bike 1	Bike 1	Bike 4	Bike	Bike	Bike	Bike
	Ped	Ped	Ped	Ped	Ped 7	Ped	Ped	Ped 1	Ped	Ped	Ped	Ped
7:15 AM - 7:30 AM	Bike	Bike 1	Bike	Bike	Bike	Bike	Bike	Bike 3	Bike	Bike	Bike	Bike
	Ped	Ped	Ped	Ped	Ped 9	Ped	Ped	Ped 1	Ped	Ped	Ped	Ped
7:30 AM - 7:45 AM	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike 2	Bike	Bike	Bike	Bike
	Ped	Ped	Ped	Ped	Ped 9	Ped	Ped	Ped 4	Ped	Ped	Ped	Ped
7:45 AM - 8:00 AM	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike
	Ped	Ped	Ped	Ped	Ped 5	Ped	Ped	Ped	Ped	Ped	Ped	Ped
8:00 AM - 8:15 AM	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike
	Ped	Ped	Ped	Ped	Ped 7	Ped	Ped	Ped 5	Ped	Ped	Ped	Ped
8:15 AM - 8:30 AM	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike
	Ped	Ped	Ped	Ped	Ped 7	Ped	Ped	Ped 4	Ped	Ped	Ped	Ped
8:30 AM - 8:45 AM	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike
	Ped	Ped	Ped	Ped	Ped 11	Ped	Ped	Ped 4	Ped	Ped	Ped	Ped
8:45 AM - 9:00 AM	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike
	Ped	Ped	Ped	Ped	Ped 10	Ped	Ped	Ped 14	Ped	Ped	Ped	Ped

Sketch of Intersection's Lane Configuration

Data Collection Worksheet

Intersection: Queen St & Waimau St

Date: 1/10/2012

By: Herbert

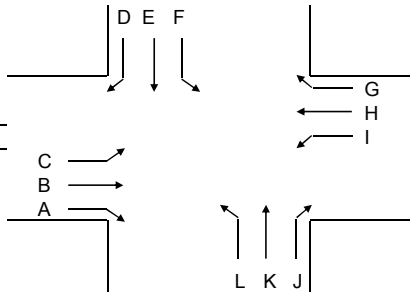
Weather: Sunny

Street: **Waimanu Street**
Sp. Lim:
Slope:

Street: **Queen Street**
Slope:

Street: **Queen Street**
Sp. Lim:
Slope:

Street: **0**
Slope:



PM Peak Count

TIME	A	B	C	D	E	F	G	H	I	J	K	L
4:00 PM - 4:15 PM	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped 17	Bike Ped	Bike Ped	Bike Ped 4	Bike Ped	Bike Ped	Bike Ped	Bike Ped
4:15 PM - 4:30 PM	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped 19	Bike Ped	Bike Ped	Bike Ped 5	Bike Ped	Bike Ped	Bike Ped	Bike Ped
4:30 PM - 4:45 PM	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped 2	Bike Ped	Bike Ped	Bike Ped 3	Bike Ped	Bike Ped	Bike Ped	Bike Ped
4:45 PM - 5:00 PM	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped 6	Bike Ped	Bike Ped	Bike Ped 2	Bike Ped	Bike Ped	Bike Ped	Bike Ped
5:00 PM - 5:15 PM	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped 3	Bike Ped	Bike Ped	Bike Ped 1	Bike Ped	Bike Ped	Bike Ped	Bike Ped
5:15 PM - 5:30 PM	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped 18	Bike Ped	Bike Ped	Bike Ped 4	Bike Ped	Bike Ped	Bike Ped	Bike Ped
5:30 PM - 5:45 PM	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped 12	Bike Ped	Bike Ped	Bike Ped 1	Bike Ped	Bike Ped	Bike Ped	Bike Ped
5:45 PM - 6:00 PM	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped 15	Bike Ped	Bike Ped	Bike Ped 3	Bike Ped	Bike Ped	Bike Ped	Bike Ped

Sketch of Intersection's Lane Configuration

Data Collection Worksheet

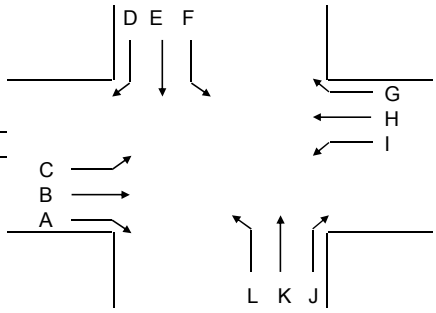
Intersection: Waimanu St & Koolani West

Date: 1/10/2012

By: Paula

Weather: Sunny

Street:
Sp. Lim:
Slope:



Street: **Waimanu Street**
Slope:

Street: **Waimanu Street**
Sp. Lim:
Slope:

Street: **Koolani West Driveway**
Slope:

AM Peak Count

TIME	A	B	C	D	E	F	G	H	I	J	K	L
7:00 AM - 7:15 AM	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped
7:15 AM - 7:30 AM	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped 1	Bike Ped	Bike Ped
7:30 AM - 7:45 AM	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped
7:45 AM - 8:00 AM	Bike Ped	Bike Ped	Bike 1 Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike 1 Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped
8:00 AM - 8:15 AM	Bike Ped	Bike Ped	Bike 1 Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike 2 Ped	Bike Ped	Bike 2 Ped	Bike Ped	Bike Ped
8:15 AM - 8:30 AM	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike 3 Ped	Bike Ped	Bike 1 Ped	Bike Ped	Bike Ped
8:30 AM - 8:45 AM	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike 1 Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped
8:45 AM - 9:30 AM	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike 1 Ped	Bike Ped	Bike Ped

Sketch of Intersection's Lane Configuration

Data Collection Worksheet

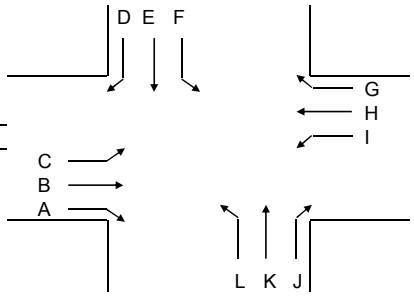
Intersection: Waimanu St & Koolani West

Date: 1/10/2012

By: Paula

Weather: Sunny

Street: **0**
Sp. Lim:
Slope:



Street: **Waimanu Street**
Slope:

Street: **Waimanu Street**
Sp. Lim:
Slope:

Street: **Koolani West Driveway**
Slope:

PM Peak Count

TIME	A	B	C	D	E	F	G	H	I	J	K	L
4:00 PM - 4:15 PM	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped 2	Bike Ped	Bike Ped
4:15 PM - 4:30 PM	Bike Ped	Bike 1 Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped 1	Bike Ped	Bike Ped
4:30 PM - 4:45 PM	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped
4:45 PM - 5:00 PM	Bike Ped	Bike 1 Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped
5:00 PM - 5:15 PM	Bike Ped	Bike 2 Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped 8	Bike Ped	Bike Ped
5:15 PM - 5:30 PM	Bike Ped	Bike 4 Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped
5:30 PM - 5:45 PM	Bike Ped	Bike 1 Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike 1 Ped	Bike Ped	Bike Ped 1	Bike Ped	Bike Ped
5:45 PM - 6:00 PM	Bike Ped	Bike 2 Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike 1 Ped	Bike Ped	Bike Ped 4	Bike Ped	Bike Ped

Sketch of Intersection's Lane Configuration

Data Collection Worksheet

Intersection: Pensacola St & Waimanu St

Date: 1/11/2012

By: Paula

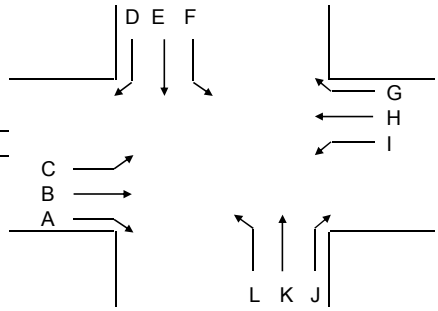
Weather: Sunny

Street: **Pensacola Street**
Sp. Lim:
Slope:

Street: **Kona Street**
Slope:

Street: **Kona Street**
Sp. Lim:
Slope:

Street: **Koolani East Driveway**
Slope:



AM Peak Count

TIME	A	B	C	D	E	F	G	H	I	J	K	L
7:00 AM - 7:15 AM	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike 1 Ped	Bike Ped	Bike 1 Ped	Bike Ped 1	Bike Ped	Bike Ped	Bike 1 Ped 2	Bike Ped
7:15 AM - 7:30 AM	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike 2 Ped	Bike Ped	Bike 1 Ped	Bike Ped 1	Bike 1 Ped	Bike Ped	Bike Ped 1	Bike Ped
7:30 AM - 7:45 AM	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike 1 Ped	Bike Ped 4	Bike Ped	Bike Ped	Bike 1 Ped 6	Bike Ped
7:45 AM - 8:00 AM	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike 3 Ped	Bike Ped	Bike Ped	Bike Ped 7	Bike Ped	Bike Ped	Bike 1 Ped 1	Bike Ped
8:00 AM - 8:15 AM	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped 1	Bike Ped	Bike Ped	Bike Ped	Bike Ped
8:15 AM - 8:30 AM	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike 1 Ped	Bike Ped 3	Bike Ped	Bike Ped	Bike Ped 1	Bike Ped
8:30 AM - 8:45 AM	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike 3 Ped	Bike Ped 6	Bike 1 Ped	Bike Ped	Bike Ped	Bike Ped
8:45 AM - 9:30 AM	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike 2 Ped	Bike Ped 4	Bike Ped	Bike Ped	Bike Ped 1	Bike Ped

Sketch of Intersection's Lane Configuration

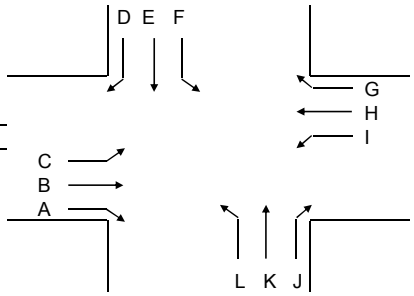
Data Collection Worksheet

Intersection: Pensacola St & Waimanu St

Date: 1/11/2012

By: Paula

Weather: Sunny



Street: **Pensacola Street**
Sp. Lim:
Slope:

Street: **Kona Street**
Slope:

Street: **Kona Street**
Sp. Lim:
Slope:

Street: **Koolani East Driveway**
Slope:

PM Peak Count

TIME	A	B	C	D	E	F	G	H	I	J	K	L
4:00 PM - 4:15 PM	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped 8	Bike Ped	Bike Ped	Bike Ped 11	Bike Ped
4:15 PM - 4:30 PM	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped 5	Bike Ped	Bike Ped	Bike Ped 9	Bike Ped
4:30 PM - 4:45 PM	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped 15	Bike Ped	Bike Ped	Bike Ped 6	Bike Ped
4:45 PM - 5:00 PM	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped 5	Bike Ped	Bike Ped	Bike Ped 5	Bike Ped
5:00 PM - 5:15 PM	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped 4	Bike Ped	Bike Ped	Bike Ped 12	Bike Ped
5:15 PM - 5:30 PM	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped 8	Bike Ped	Bike Ped	Bike Ped 6	Bike Ped
5:30 PM - 5:45 PM	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped 6	Bike Ped	Bike Ped	Bike Ped 10	Bike Ped
5:45 PM - 6:00 PM	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped 1	Bike Ped	Bike Ped	Bike Ped 14	Bike Ped
TOTAL BIKE					15		7	1		3	1	

Data Collection Worksheet

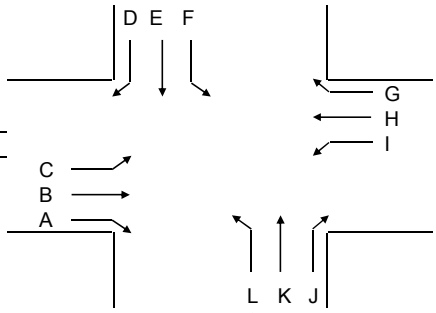
Intersection: Pensacola St & Kona St

Date: 1/11/2012

By: Herbert

Weather: Sunny

Street: **Pensacola Street**
Sp. Lim:
Slope:



Street: **Kona Street**
Slope:

Street: **Kona Street**
Sp. Lim:
Slope:

Street: **Pensacola Street**
Slope:

AM Peak Count

TIME	A	B	C	D	E	F	G	H	I	J	K	L
7:00 AM - 7:15 AM	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped
7:15 AM - 7:30 AM	Bike Ped	Bike Ped 1	Bike Ped	Bike Ped	Bike 1 Ped 1	Bike Ped	Bike Ped	Bike Ped 1	Bike 1 Ped	Bike Ped	Bike Ped	Bike Ped
7:30 AM - 7:45 AM	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped 4	Bike Ped	Bike Ped	Bike 1 Ped 1	Bike Ped	Bike Ped	Bike Ped	Bike Ped
7:45 AM - 8:00 AM	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped 5	Bike Ped	Bike Ped	Bike Ped 1	Bike Ped	Bike Ped	Bike Ped	Bike Ped
8:00 AM - 8:15 AM	Bike Ped	Bike Ped 1	Bike Ped	Bike Ped	Bike 1 Ped 2	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped
8:15 AM - 8:30 AM	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped 3	Bike Ped	Bike Ped	Bike 1 Ped	Bike 2 Ped	Bike 1 Ped	Bike Ped	Bike Ped
8:30 AM - 8:45 AM	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike 2 Ped 2	Bike 1 Ped	Bike Ped	Bike 3 Ped 1	Bike 2 Ped	Bike Ped	Bike Ped	Bike Ped
8:45 AM - 9:00 AM	Bike Ped	Bike 1 Ped	Bike Ped	Bike Ped	Bike 3 Ped 4	Bike Ped	Bike Ped	Bike Ped 2	Bike 1 Ped	Bike Ped	Bike Ped 2	Bike Ped

Sketch of Intersection's Lane Configuration

Data Collection Worksheet

Intersection: Pensacola St & Kona St

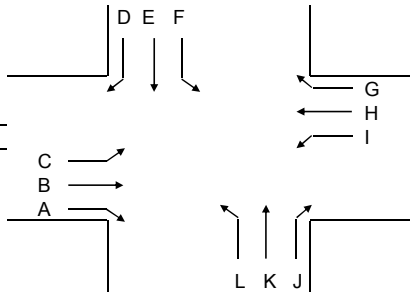
Date: 1/11/2012

By: Herbert

Weather: Sunny

Street: **Pensacola Street**
Sp. Lim:
Slope:

Street: **Kona Street**
Slope:



Street: **Kona Street**
Sp. Lim:
Slope:

Street: **Pensacola Street**
Slope:

PM Peak Count

TIME	A	B	C	D	E	F	G	H	I	J	K	L
4:00 PM - 4:15 PM	Bike Ped	Bike Ped 2	Bike Ped	Bike Ped	Bike 1 Ped 8	Bike Ped	Bike Ped	Bike Ped 2	Bike Ped	Bike Ped	Bike Ped 2	Bike Ped
4:15 PM - 4:30 PM	Bike Ped	Bike Ped 1	Bike Ped	Bike Ped	Bike Ped 4	Bike Ped	Bike Ped	Bike Ped 1	Bike Ped	Bike Ped	Bike Ped	Bike Ped
4:30 PM - 4:45 PM	Bike Ped	Bike Ped 1	Bike Ped	Bike Ped	Bike 2 Ped 4	Bike Ped	Bike Ped	Bike 1 Ped 6	Bike Ped	Bike Ped	Bike Ped	Bike Ped
4:45 PM - 5:00 PM	Bike Ped	Bike Ped 1	Bike Ped	Bike Ped	Bike 3 Ped 3	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped 1	Bike Ped
5:00 PM - 5:15 PM	Bike Ped	Bike 2 Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped 4	Bike Ped	Bike Ped	Bike 1 Ped	Bike Ped
5:15 PM - 5:30 PM	Bike Ped	Bike Ped 1	Bike Ped	Bike Ped	Bike Ped 3	Bike Ped	Bike Ped	Bike Ped	Bike 1 Ped 1	Bike Ped	Bike Ped 4	Bike Ped
5:30 PM - 5:45 PM	Bike Ped	Bike Ped 1	Bike Ped	Bike Ped	Bike 4 Ped 7	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped 3	Bike Ped
5:45 PM - 6:00 PM	Bike Ped	Bike Ped 1	Bike Ped	Bike Ped	Bike 4 Ped 1	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped	Bike Ped 1	Bike Ped

Sketch of Intersection's Lane Configuration

Data Collection Worksheet

Intersection: Piikoi St & Waimau St

Date: 1/10/2012

By: ShengHong and David

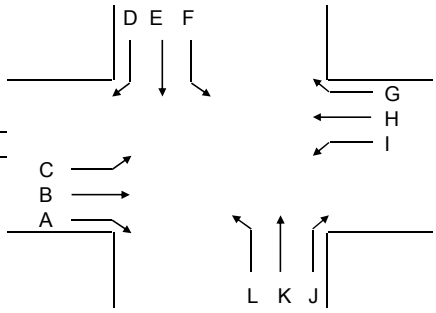
Weather: Sunny

Street: **Piikoi Street**
Sp. Lim:
Slope:

Street: **Waimanu Street**
Slope:

Street: **Ala Moana Entrance**
Sp. Lim:
Slope:

Street: **Piikoi Street**
Slope:



AM Peak Count

TIME	A	B	C	D	E	F	G	H	I	J	K	L
7:00 AM - 7:15 AM	Bike	Bike	Bike	Bike	Bike 1	Bike	Bike	Bike	Bike	Bike	Bike	Bike
	Ped	Ped 27	Ped	Ped	Ped 7	Ped	Ped	Ped	Ped	Ped	Ped 2	Ped
7:15 AM - 7:30 AM	Bike	Bike 1	Bike	Bike	Bike 1	Bike	Bike	Bike	Bike	Bike	Bike	Bike
	Ped	Ped 11	Ped	Ped	Ped 6	Ped	Ped	Ped	Ped	Ped	Ped	Ped
7:30 AM - 7:45 AM	Bike	Bike 1	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike
	Ped	Ped 14	Ped	Ped	Ped 8	Ped	Ped	Ped	Ped	Ped	Ped 1	Ped
7:45 AM - 8:00 AM	Bike	Bike 1	Bike	Bike	Bike 1	Bike	Bike	Bike	Bike	Bike	Bike	Bike
	Ped	Ped 11	Ped	Ped	Ped 5	Ped	Ped	Ped	Ped	Ped	Ped 3	Ped
8:00 AM - 8:15 AM	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike
	Ped	Ped 7	Ped	Ped	Ped 4	Ped	Ped	Ped	Ped	Ped	Ped 6	Ped
8:15 AM - 8:30 AM	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike
	Ped	Ped 9	Ped	Ped	Ped 6	Ped	Ped	Ped	Ped	Ped	Ped 4	Ped
8:30 AM - 8:45 AM	Bike	Bike	Bike	Bike	Bike 1	Bike	Bike	Bike	Bike	Bike	Bike	Bike
	Ped	Ped 16	Ped	Ped	Ped 18	Ped	Ped	Ped	Ped	Ped	Ped 42	Ped
8:45 AM - 9:00 AM	Bike	Bike 3	Bike	Bike	Bike 1	Bike	Bike	Bike	Bike	Bike	Bike	Bike
	Ped	Ped 15	Ped	Ped	Ped 7	Ped	Ped	Ped	Ped	Ped	Ped 24	Ped

Sketch of Intersection's Lane Configuration

Data Collection Worksheet

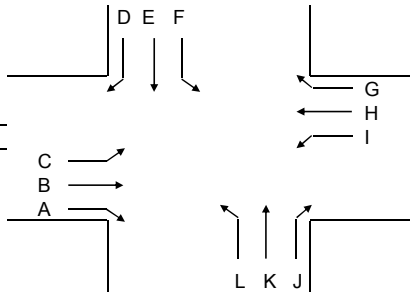
Intersection: Piikoi St & Waimau St

Date: 1/10/2012

By: ShengHong and David

Weather: Sunny

Street: **Piikoi Street**
Sp. Lim:
Slope:



Street: **Waimanu Street**
Slope:

Street: **Ala Moana Entrance**
Sp. Lim:
Slope:

Street: **Piikoi Street**
Slope:

PM Peak Count

TIME	A	B	C	D	E	F	G	H	I	J	K	L
4:00 PM - 4:15 PM	Bike	Bike 2	Bike	Bike	Bike 2	Bike	Bike	Bike	Bike	Bike	Bike 3	Bike
	Ped	Ped 20	Ped	Ped	Ped 12	Ped	Ped	Ped	Ped	Ped	Ped 15	Ped
4:15 PM - 4:30 PM	Bike	Bike 3	Bike	Bike	Bike 13	Bike	Bike	Bike	Bike	Bike	Bike 4	Bike
	Ped	Ped 36	Ped	Ped	Ped 13	Ped	Ped	Ped	Ped	Ped	Ped 21	Ped
4:30 PM - 4:45 PM	Bike	Bike 2	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike 1	Bike
	Ped	Ped 21	Ped	Ped	Ped 8	Ped	Ped	Ped	Ped	Ped	Ped 11	Ped
4:45 PM - 5:00 PM	Bike	Bike 7	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike 1	Bike
	Ped	Ped 18	Ped	Ped	Ped 8	Ped	Ped	Ped	Ped	Ped	Ped 35	Ped
5:00 PM - 5:15 PM	Bike	Bike 2	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike 1	Bike
	Ped	Ped 15	Ped	Ped	Ped 12	Ped	Ped	Ped	Ped	Ped	Ped 10	Ped
5:15 PM - 5:30 PM	Bike	Bike 3	Bike	Bike	Bike 1	Bike	Bike	Bike	Bike	Bike	Bike	Bike
	Ped	Ped 10	Ped	Ped	Ped 21	Ped	Ped	Ped	Ped	Ped	Ped 33	Ped
5:30 PM - 5:45 PM	Bike	Bike 1	Bike	Bike	Bike 2	Bike	Bike	Bike	Bike	Bike	Bike 1	Bike
	Ped	Ped 25	Ped	Ped	Ped 14	Ped	Ped	Ped	Ped	Ped	Ped 26	Ped
5:45 PM - 6:00 PM	Bike	Bike	Bike	Bike	Bike 3	Bike	Bike	Bike	Bike	Bike	Bike 1	Bike
	Ped	Ped 23	Ped	Ped	Ped 21	Ped	Ped	Ped	Ped	Ped	Ped 12	Ped

Sketch of Intersection's Lane Configuration

Data Collection Worksheet

Intersection: Piikoi St & Kona St

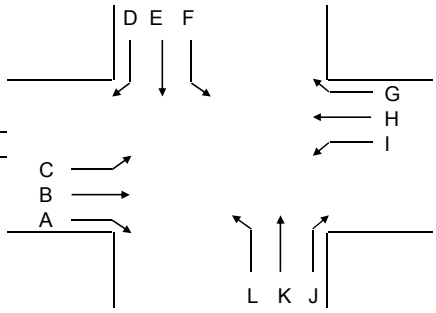
Date: 1/11/2012

By: ShengHong and David

Weather: Sunny

Street: **Piikoi Street**
Sp. Lim:
Slope:

Street: **Kona Street**
Slope:



Street: **Kona Street**
Sp. Lim:
Slope:

Street: **Piikoi Street**
Slope:

AM Peak Count

TIME	A	B	C	D	E	F	G	H	I	J	K	L
7:00 AM - 7:15 AM	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike 1	Bike	Bike	Bike 3	Bike
	Ped	Ped	Ped	Ped	Ped 3	Ped	Ped	Ped	Ped	Ped	Ped 3	Ped
7:15 AM - 7:30 AM	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike 2	Bike	Bike	Bike	Bike
	Ped	Ped	Ped	Ped	Ped 2	Ped	Ped	Ped 2	Ped	Ped	Ped 4	Ped
7:30 AM - 7:45 AM	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike 1	Bike	Bike	Bike 1	Bike
	Ped	Ped	Ped	Ped	Ped 4	Ped	Ped	Ped 1	Ped	Ped	Ped 6	Ped
7:45 AM - 8:00 AM	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike
	Ped	Ped	Ped	Ped	Ped 1	Ped	Ped	Ped 2	Ped	Ped	Ped 6	Ped
8:00 AM - 8:15 AM	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike 1	Bike	Bike	Bike 1	Bike
	Ped	Ped	Ped	Ped	Ped 2	Ped	Ped	Ped 4	Ped	Ped	Ped 8	Ped
8:15 AM - 8:30 AM	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike 4	Bike
	Ped	Ped	Ped	Ped	Ped 1	Ped	Ped	Ped 1	Ped	Ped	Ped 23	Ped
8:30 AM - 8:45 AM	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike 1	Bike	Bike	Bike 4	Bike
	Ped	Ped	Ped	Ped	Ped 3	Ped	Ped	Ped 2	Ped	Ped	Ped 32	Ped
8:45 AM - 9:00 AM	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike 1	Bike	Bike	Bike 3	Bike
	Ped	Ped	Ped	Ped	Ped 3	Ped	Ped	Ped 8	Ped	Ped	Ped 57	Ped

Sketch of Intersection's Lane Configuration

Data Collection Worksheet

Intersection: Piikoi St & Kona St

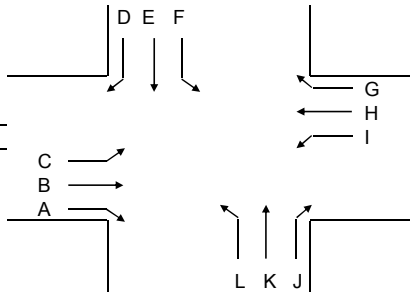
Date: 1/11/2012

By: ShengHong and David

Weather: Sunny

Street: **Piikoi Street**
Sp. Lim:
Slope:

Street: **Kona Street**
Slope:



Street: **Kona Street**
Sp. Lim:
Slope:

Street: **Piikoi Street**
Slope:

PM Peak Count

TIME	A	B	C	D	E	F	G	H	I	J	K	L
4:00 PM - 4:15 PM	Bike	Bike	Bike	Bike	Bike 1	Bike	Bike	Bike 1	Bike	Bike	Bike	Bike
	Ped	Ped	Ped	Ped	Ped 3	Ped	Ped	Ped 5	Ped	Ped	Ped 20	Ped
4:15 PM - 4:30 PM	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike 3	Bike	Bike	Bike 2	Bike
	Ped	Ped	Ped	Ped	Ped 6	Ped	Ped	Ped 11	Ped	Ped	Ped 22	Ped
4:30 PM - 4:45 PM	Bike	Bike	Bike	Bike	Bike 1	Bike	Bike	Bike 3	Bike	Bike	Bike 3	Bike
	Ped	Ped	Ped	Ped	Ped 1	Ped	Ped	Ped 18	Ped	Ped	Ped 14	Ped
4:45 PM - 5:00 PM	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike 1	Bike	Bike	Bike 2	Bike
	Ped	Ped	Ped	Ped	Ped	Ped	Ped	Ped 29	Ped	Ped	Ped 64	Ped
5:00 PM - 5:15 PM	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike 2	Bike	Bike	Bike 3	Bike
	Ped	Ped	Ped	Ped	Ped 29	Ped	Ped	Ped 8	Ped	Ped	Ped 17	Ped
5:15 PM - 5:30 PM	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike 5	Bike	Bike	Bike 2	Bike
	Ped	Ped	Ped	Ped	Ped 5	Ped	Ped	Ped 11	Ped	Ped	Ped 33	Ped
5:30 PM - 5:45 PM	Bike	Bike	Bike	Bike	Bike 1	Bike	Bike	Bike	Bike	Bike	Bike	Bike
	Ped	Ped	Ped	Ped	Ped 4	Ped	Ped	Ped 16	Ped	Ped	Ped 37	Ped
5:45 PM - 6:00 PM	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike	Bike 1	Bike
	Ped	Ped	Ped	Ped	Ped 1	Ped	Ped	Ped 16	Ped	Ped	Ped 32	Ped

Sketch of Intersection's Lane Configuration

Appendix B Level of Service Definitions

The 2000 Highway Capacity Manual defines six Intersection Levels of Service (LOS), labeled A through F, from free flow to congested conditions.

Levels of Service for signalized intersections is defined in terms of control delay, which is a measure of driver discomfort, frustration, fuel consumption, and increased travel time. The delay experienced by a motorist is made up of a number of factors that relate to control, geometrics, traffic, and incidents. Total delay is the difference between the travel time actually experienced and the reference travel time that would result during base conditions: in the absence of traffic control, geometric delay, any incidents, and any other vehicles. Specifically, LOS criteria for traffic signals are stated in terms of the average control delay per vehicle, typically for a 15-minute analysis period. Delay is a complex measure and depends on a number of variables, including the quality of progression, the cycle length, the green ratio, and the v/c ratio for the lane group.

LEVEL OF SERVICE A: Low control delay, up to 10 s/veh. This LOS occurs when progression is extremely favorable and most vehicles arrive during the green phase. Many vehicles do not stop at all. Short cycle lengths may tend to contribute to low delay values.

LEVEL OF SERVICE B: Control delay greater than 10 and up to 20 s/veh. This level generally occurs with good progression, short cycle lengths, or both. More vehicles stop than with LOS A, causing higher levels of delay.

LEVEL OF SERVICE C: Control delay greater than 20 and up to 35 s/veh. These higher delays may result from only fair progression, longer cycle lengths, or both. Individual cycle failures may begin to appear at this level. Cycle failure occurs when a given green phase does not serve queued vehicles, and overflows occur. The number of vehicles stopping is significant at this level, though many still pass through the intersection without stopping.

LEVEL OF SERVICE D: Control delay greater than 35 and up to 55 s/veh. At LOS D, the influence of congestion becomes more noticeable. Longer delays may result from some combination of unfavorable progression, long cycle lengths, and high v/c ratios. Many vehicles stop, and the proportion of vehicles not stopping declines. Individual cycle failures are noticeable.

LEVEL OF SERVICE E: Control delay greater than 55 and up to 80 s/veh. These high delay values generally indicate poor progression, long cycle lengths, and high v/c ratios. Individual cycle failures are frequent.

LEVEL OF SERVICE F: Control delay in excess of 80 s/veh. This level, considered unacceptable to most drivers, often occurs with oversaturation, that is when arrival flow rates exceed the capacity of lane groups. It may also occur at high v/c ratios with many individual cycle failures. Poor progression and long cycle lengths may also contribute significantly to high delay levels.

For unsignalized intersections, the Highway Capacity Manual evaluates gaps in the major street traffic flow and calculates available gaps for left-turns across oncoming traffic and for the left and right-turns onto the major roadway from the minor street. Average control delay, based on these factors, is still used to define the levels of service.

LEVEL OF SERVICE A: Low control delay, up to 10 s/veh.

LEVEL OF SERVICE B: Control delay greater than 10 and up to 15 s/veh.

LEVEL OF SERVICE C: Control delay greater than 15 and up to 25 s/veh.

LEVEL OF SERVICE D: Control delay greater than 25 and up to 35 s/veh.

LEVEL OF SERVICE E: Control delay greater than 35 and up to 50 s/veh.

LEVEL OF SERVICE F: Control delay in excess of 50 s/veh.

Levels of Service for arterial roadways is defined by the average through-vehicle speed. The LOS is influenced by the number of signals per mile and by the intersection control delay. The arterial LOS criteria is based on the free-flow speed (FFS). The street classification and LOS for each class is summarized in the following table.

Arterial Class	I	II	III	IV
Range of FFS	55-45 mph	45-35 mph	35-30 mph	35-25mph
Typical FFS	50 mph	40 mph	35 mph	30 mph
LOS	Average Travel Speed (mph)			
A	> 42	> 35	> 30	> 25
B	> 34-42	> 28-35	> 24-30	> 19-25
C	> 27-34	> 22-28	> 18-24	> 13-19
D	> 21-27	> 17-22	> 14-18	> 9-13
E	> 16-21	> 13-17	> 10-14	> 7-9
F	≤ 16	≤ 13	≤ 10	≤ 7

Queen Kaahumanu Highway was analyzed as Arterial Class I.

Appendix C Intersection Capacity Analysis Worksheets

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	317	234	179	0	0	64	0	615	106	0	132	0
Number	7	4	14	3	8	18	5	2	12	1	6	16
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1863	1863	1863	0	1909	1909	0	1863	1900	0	1863	0
Adj Flow Rate, veh/h	345	254	195	0	0	70	0	668	115	0	143	0
Adj No. of Lanes	1	2	1	0	1	2	0	4	0	0	2	0
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Percent Heavy Veh, %	2	2	2	0	2	2	0	2	2	0	2	0
Cap, veh/h	679	1529	684	0	202	303	0	1835	307	0	1166	0
Arrive On Green	0.21	0.43	0.43	0.00	0.00	0.11	0.00	0.33	0.33	0.00	0.33	0.00
Sat Flow, veh/h	1774	3539	1583	0	1909	2856	0	5832	933	0	3725	0
Grp Volume(v), veh/h	345	254	195	0	0	70	0	574	209	0	143	0
Grp Sat Flow(s),veh/h/ln	1774	1770	1583	0	1909	1428	0	1602	1698	0	1770	0
Q Serve(g_s), s	6.5	1.8	3.3	0.0	0.0	0.9	0.0	3.8	4.0	0.0	1.2	0.0
Cycle Q Clear(g_c), s	6.5	1.8	3.3	0.0	0.0	0.9	0.0	3.8	4.0	0.0	1.2	0.0
Prop In Lane	1.00		1.00	0.00		1.00	0.00		0.55	0.00		0.00
Lane Grp Cap(c), veh/h	679	1529	684	0	202	303	0	1583	559	0	1166	0
V/C Ratio(X)	0.51	0.17	0.29	0.00	0.00	0.23	0.00	0.36	0.37	0.00	0.12	0.00
Avail Cap(c_a), veh/h	736	2112	945	0	456	682	0	9749	3445	0	7179	0
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	1.00	0.00	0.00	1.00	0.00	1.00	1.00	0.00	1.00	0.00
Uniform Delay (d), s/veh	10.7	7.3	7.7	0.0	0.0	17.2	0.0	10.7	10.7	0.0	9.8	0.0
Incr Delay (d2), s/veh	0.6	0.1	0.2	0.0	0.0	0.4	0.0	0.1	0.4	0.0	0.0	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	3.2	0.9	1.5	0.0	0.0	0.4	0.0	1.7	1.9	0.0	0.6	0.0
LnGrp Delay(d),s/veh	11.3	7.3	7.9	0.0	0.0	17.5	0.0	10.8	11.2	0.0	9.9	0.0
LnGrp LOS	B	A	A			B		B	B		A	
Approach Vol, veh/h		794			70			783			143	
Approach Delay, s/veh		9.2			17.5			10.9			9.9	
Approach LOS		A			B			B			A	

Timer	1	2	3	4	5	6	7	8
Assigned Phs		2		4		6	7	8
Phs Duration (G+Y+Rc), s		18.8		23.1		18.8	13.7	9.4
Change Period (Y+Rc), s		5.0		5.0		5.0	5.0	5.0
Max Green Setting (Gmax), s		85.0		25.0		85.0	10.0	10.0
Max Q Clear Time (g_c+I1), s		6.0		5.3		3.2	8.5	2.9
Green Ext Time (p_c), s		7.8		2.5		7.9	0.2	1.5

Intersection Summary	
HCM 2010 Ctrl Delay	10.3
HCM 2010 LOS	B

Notes

User approved pedestrian interval to be less than phase max green.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	2	50	3	78	75	90	20	750	155	0	80	10
Number	7	4	14	3	8	18	5	2	12	1	6	16
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1900	1863	1900	1863	1863	1863	1900	1863	1900	0	1863	1900
Adj Flow Rate, veh/h	2	54	3	84	84	98	22	815	168	0	87	11
Adj No. of Lanes	0	1	0	1	1	1	0	4	0	0	2	0
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Percent Heavy Veh, %	2	2	2	2	2	2	2	2	2	0	2	2
Cap, veh/h	133	316	17	460	344	292	157	2442	486	0	1492	185
Arrive On Green	0.18	0.18	0.18	0.18	0.18	0.18	0.47	0.47	0.47	0.00	0.47	0.47
Sat Flow, veh/h	27	1712	93	1341	1863	1583	50	5187	1032	0	3262	394
Grp Volume(v), veh/h	59	0	0	84	84	98	296	463	246	0	48	50
Grp Sat Flow(s),veh/h/ln	1831	0	0	1341	1863	1583	1841	1458	1513	0	1770	1793
Q Serve(g_s), s	0.0	0.0	0.0	1.6	1.1	1.6	0.0	2.9	3.0	0.0	0.4	0.4
Cycle Q Clear(g_c), s	0.8	0.0	0.0	2.4	1.1	1.6	2.9	2.9	3.0	0.0	0.4	0.4
Prop In Lane	0.03		0.05	1.00		1.00	0.07		0.68	0.00		0.22
Lane Grp Cap(c), veh/h	466	0	0	460	344	292	1000	1372	712	0	833	844
V/C Ratio(X)	0.13	0.00	0.00	0.18	0.24	0.34	0.30	0.34	0.35	0.00	0.06	0.06
Avail Cap(c_a), veh/h	2007	0	0	1599	1927	1638	2638	4021	2087	0	2441	2473
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00
Uniform Delay (d), s/veh	10.0	0.0	0.0	11.0	10.1	10.3	4.8	4.8	4.9	0.0	4.2	4.2
Incr Delay (d2), s/veh	0.1	0.0	0.0	0.2	0.4	0.7	0.2	0.1	0.3	0.0	0.0	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.4	0.0	0.0	0.6	0.6	0.7	1.5	1.2	1.3	0.0	0.2	0.2
LnGrp Delay(d),s/veh	10.1	0.0	0.0	11.2	10.5	11.0	5.0	5.0	5.1	0.0	4.2	4.2
LnGrp LOS	B			B	B	B	A	A	A		A	A
Approach Vol, veh/h		59			266			1005			98	
Approach Delay, s/veh		10.1			10.9			5.0			4.2	
Approach LOS		B			B			A			A	

Timer	1	2	3	4	5	6	7	8
Assigned Phs		2		4		6		8
Phs Duration (G+Y+Rc), s		18.7		10.3		18.7		10.3
Change Period (Y+Rc), s		5.0		5.0		5.0		5.0
Max Green Setting (Gmax), s		40.0		30.0		40.0		30.0
Max Q Clear Time (g_c+I1), s		5.0		2.8		2.4		4.4
Green Ext Time (p_c), s		8.7		1.4		8.8		1.4

Intersection Summary	
HCM 2010 Ctrl Delay	6.3
HCM 2010 LOS	A

Notes

User approved volume balancing among the lanes for turning movement.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	0	251	10	0	0	0	36	0	54	382	40	387
Number	5	2	12	1	6	16	7	4	14	3	8	18
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	0	1863	1900	0	1863	0	1863	1863	1863	1863	1863	1863
Adj Flow Rate, veh/h	0	273	11	0	0	0	39	0	59	446	0	421
Adj No. of Lanes	0	2	0	0	1	0	1	1	1	2	0	1
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Percent Heavy Veh, %	0	2	2	0	2	0	2	2	2	2	2	2
Cap, veh/h	0	546	22	0	293	0	269	211	179	1075	0	601
Arrive On Green	0.00	0.16	0.16	0.00	0.00	0.00	0.04	0.00	0.11	0.30	0.00	0.38
Sat Flow, veh/h	0	3562	139	0	1863	0	1774	1863	1583	3548	0	1583
Grp Volume(v), veh/h	0	139	145	0	0	0	39	0	59	446	0	421
Grp Sat Flow(s),veh/h/ln	0	1770	1838	0	1863	0	1774	1863	1583	1774	0	1583
Q Serve(g_s), s	0.0	2.5	2.5	0.0	0.0	0.0	0.8	0.0	1.2	3.5	0.0	7.9
Cycle Q Clear(g_c), s	0.0	2.5	2.5	0.0	0.0	0.0	0.8	0.0	1.2	3.5	0.0	7.9
Prop In Lane	0.00		0.08	0.00		0.00	1.00		1.00	1.00		1.00
Lane Grp Cap(c), veh/h	0	279	289	0	293	0	269	211	179	1075	0	601
V/C Ratio(X)	0.00	0.50	0.50	0.00	0.00	0.00	0.15	0.00	0.33	0.42	0.00	0.70
Avail Cap(c_a), veh/h	0	1007	1046	0	1060	0	709	530	450	5550	0	2477
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	0.00	1.00	1.00	0.00	0.00	0.00	1.00	0.00	1.00	1.00	0.00	1.00
Uniform Delay (d), s/veh	0.0	13.5	13.5	0.0	0.0	0.0	16.6	0.0	14.4	9.8	0.0	9.2
Incr Delay (d2), s/veh	0.0	1.4	1.3	0.0	0.0	0.0	0.2	0.0	1.1	0.3	0.0	1.5
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.0	1.3	1.4	0.0	0.0	0.0	0.4	0.0	0.6	1.7	0.0	3.6
LnGrp Delay(d),s/veh	0.0	14.9	14.9	0.0	0.0	0.0	16.8	0.0	15.4	10.0	0.0	10.7
LnGrp LOS		B	B				B		B	B		B
Approach Vol, veh/h		284			0			98			867	
Approach Delay, s/veh		14.9			0.0			16.0			10.4	
Approach LOS		B						B			B	

Timer	1	2	3	4	5	6	7	8
Assigned Phs		2	3	4		6	7	8
Phs Duration (G+Y+Rc), s		10.5	15.6	9.0		10.5	6.3	18.4
Change Period (Y+Rc), s		5.0	5.0	5.0		5.0	5.0	5.0
Max Green Setting (Gmax), s		20.0	55.0	10.0		20.0	10.0	55.0
Max Q Clear Time (g_c+I1), s		4.5	5.5	3.2		0.0	2.8	9.9
Green Ext Time (p_c), s		1.4	3.5	0.1		0.0	0.0	3.5

Intersection Summary	
HCM 2010 Ctrl Delay	11.8
HCM 2010 LOS	B

Notes

User approved pedestrian interval to be less than phase max green.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	0	8	10	83	27	0	0	1	0	61	757	36
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	9	11	90	29	0	0	1	0	66	823	39
Pedestrians												
Lane Width (ft)												
Walking Speed (ft/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (ft)								246				
pX, platoon unblocked												
vC, conflicting volume	991	976	431	560	996	1	862			1		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	991	976	431	560	996	1	862			1		
tC, single (s)	7.5	6.5	6.9	*5.0	*5.5	6.9	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	100	96	98	84	91	100	100			96		
cM capacity (veh/h)	180	239	573	564	311	1083	776			1620		

Direction, Lane #	EB 1	WB 1	NB 1	SB 1	SB 2
Volume Total	20	120	1	478	451
Volume Left	0	90	0	66	0
Volume Right	11	0	0	0	39
cSH	354	470	1700	1620	1700
Volume to Capacity	0.06	0.25	0.00	0.04	0.27
Queue Length 95th (ft)	4	25	0	3	0
Control Delay (s)	15.8	15.3	0.0	1.4	0.0
Lane LOS	C	C		A	
Approach Delay (s)	15.8	15.3	0.0	0.7	
Approach LOS	C	C			

Intersection Summary			
Average Delay	2.6		
Intersection Capacity Utilization	46.5%	ICU Level of Service	A
Analysis Period (min)	15		

* User Entered Value

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	458	413	322	0	0	559	0	803	111	0	293	0
Number	7	4	14	3	8	18	5	2	12	1	6	16
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1863	1863	1863	0	1909	1909	0	1863	1900	0	1863	0
Adj Flow Rate, veh/h	498	449	350	0	0	608	0	873	121	0	318	0
Adj No. of Lanes	1	2	1	0	1	2	0	4	0	0	2	0
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Percent Heavy Veh, %	2	2	2	0	2	2	0	2	2	0	2	0
Cap, veh/h	587	1573	704	0	339	508	0	2170	296	0	1337	0
Arrive On Green	0.18	0.44	0.44	0.00	0.00	0.18	0.00	0.38	0.38	0.00	0.38	0.00
Sat Flow, veh/h	1774	3539	1583	0	1909	2856	0	6006	785	0	3725	0
Grp Volume(v), veh/h	498	449	350	0	0	608	0	728	266	0	318	0
Grp Sat Flow(s),veh/h/ln	1774	1770	1583	0	1909	1428	0	1602	1724	0	1770	0
Q Serve(g_s), s	10.0	4.5	8.9	0.0	0.0	10.0	0.0	6.2	6.4	0.0	3.5	0.0
Cycle Q Clear(g_c), s	10.0	4.5	8.9	0.0	0.0	10.0	0.0	6.2	6.4	0.0	3.5	0.0
Prop In Lane	1.00		1.00	0.00		1.00	0.00		0.45	0.00		0.00
Lane Grp Cap(c), veh/h	587	1573	704	0	339	508	0	1815	651	0	1337	0
V/C Ratio(X)	0.85	0.29	0.50	0.00	0.00	1.20	0.00	0.40	0.41	0.00	0.24	0.00
Avail Cap(c_a), veh/h	587	1573	704	0	339	508	0	7264	2606	0	5349	0
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	1.00	0.00	0.00	1.00	0.00	1.00	1.00	0.00	1.00	0.00
Uniform Delay (d), s/veh	15.9	9.9	11.1	0.0	0.0	23.1	0.0	12.8	12.9	0.0	12.0	0.0
Incr Delay (d2), s/veh	11.2	0.1	0.5	0.0	0.0	106.6	0.0	0.1	0.4	0.0	0.1	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	4.7	2.2	3.9	0.0	0.0	11.4	0.0	2.8	3.1	0.0	1.7	0.0
LnGrp Delay(d),s/veh	27.1	10.0	11.7	0.0	0.0	129.7	0.0	13.0	13.3	0.0	12.1	0.0
LnGrp LOS	C	B	B			F		B	B		B	
Approach Vol, veh/h		1297			608			994			318	
Approach Delay, s/veh		17.0			129.7			13.1			12.1	
Approach LOS		B			F			B			B	

Timer	1	2	3	4	5	6	7	8
Assigned Phs		2		4		6	7	8
Phs Duration (G+Y+Rc), s		26.2		30.0		26.2	15.0	15.0
Change Period (Y+Rc), s		5.0		5.0		5.0	5.0	5.0
Max Green Setting (Gmax), s		85.0		25.0		85.0	10.0	10.0
Max Q Clear Time (g_c+I1), s		8.4		10.9		5.5	12.0	12.0
Green Ext Time (p_c), s		12.9		6.1		12.9	0.0	0.0

Intersection Summary	
HCM 2010 Ctrl Delay	36.6
HCM 2010 LOS	D

Notes

User approved pedestrian interval to be less than phase max green.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	0	80	16	179	148	201	80	1383	174	0	109	9
Number	7	4	14	3	8	18	5	2	12	1	6	16
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1900	1863	1900	1863	1863	1863	1900	1863	1900	0	1863	1900
Adj Flow Rate, veh/h	0	87	17	178	185	218	87	1503	189	0	118	10
Adj No. of Lanes	0	1	0	1	1	1	0	4	0	0	2	0
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Percent Heavy Veh, %	2	2	2	2	2	2	2	2	2	0	2	2
Cap, veh/h	0	403	79	425	496	421	196	2899	360	0	1783	150
Arrive On Green	0.00	0.27	0.27	0.27	0.27	0.27	0.54	0.54	0.54	0.00	0.54	0.54
Sat Flow, veh/h	0	1515	296	1285	1863	1583	211	5375	667	0	3399	277
Grp Volume(v), veh/h	0	0	104	178	185	218	506	826	447	0	63	65
Grp Sat Flow(s),veh/h/ln	0	0	1811	1285	1863	1583	1761	1458	1577	0	1770	1814
Q Serve(g_s), s	0.0	0.0	2.3	6.4	4.2	6.0	1.1	9.4	9.4	0.0	0.9	0.9
Cycle Q Clear(g_c), s	0.0	0.0	2.3	8.7	4.2	6.0	8.9	9.4	9.4	0.0	0.9	0.9
Prop In Lane	0.00		0.16	1.00		1.00	0.17		0.42	0.00		0.15
Lane Grp Cap(c), veh/h	0	0	482	425	496	421	1032	1572	851	0	954	978
V/C Ratio(X)	0.00	0.00	0.22	0.42	0.37	0.52	0.49	0.53	0.53	0.00	0.07	0.07
Avail Cap(c_a), veh/h	0	0	1057	833	1087	924	1443	2269	1228	0	1377	1412
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00
Uniform Delay (d), s/veh	0.0	0.0	14.7	18.1	15.4	16.1	7.5	7.6	7.6	0.0	5.7	5.7
Incr Delay (d2), s/veh	0.0	0.0	0.2	0.7	0.5	1.0	0.4	0.3	0.5	0.0	0.0	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.0	0.0	1.2	2.4	2.2	2.7	4.6	3.7	4.1	0.0	0.4	0.4
LnGrp Delay(d),s/veh	0.0	0.0	14.9	18.7	15.8	17.0	7.9	7.9	8.1	0.0	5.7	5.7
LnGrp LOS			B	B	B	B	A	A	A		A	A
Approach Vol, veh/h		104			581			1779			128	
Approach Delay, s/veh		14.9			17.2			7.9			5.7	
Approach LOS		B			B			A			A	

Timer	1	2	3	4	5	6	7	8
Assigned Phs		2		4		6		8
Phs Duration (G+Y+Rc), s		32.7		18.7		32.7		18.7
Change Period (Y+Rc), s		5.0		5.0		5.0		5.0
Max Green Setting (Gmax), s		40.0		30.0		40.0		30.0
Max Q Clear Time (g_c+I1), s		11.4		4.3		2.9		10.7
Green Ext Time (p_c), s		16.4		3.1		18.8		2.9

Intersection Summary	
HCM 2010 Ctrl Delay	10.2
HCM 2010 LOS	B

Notes

User approved volume balancing among the lanes for turning movement.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	0	636	47	0	0	0	13	0	43	496	38	466
Number	5	2	12	1	6	16	7	4	14	3	8	18
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	0	1863	1900	0	1863	0	1863	1863	1863	1863	1863	1863
Adj Flow Rate, veh/h	0	691	51	0	0	0	14	0	47	568	0	507
Adj No. of Lanes	0	2	0	0	1	0	1	1	1	2	0	1
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Percent Heavy Veh, %	0	2	2	0	2	0	2	2	2	2	2	2
Cap, veh/h	0	1006	74	0	561	0	168	148	126	1140	0	612
Arrive On Green	0.00	0.30	0.30	0.00	0.00	0.00	0.01	0.00	0.08	0.32	0.00	0.39
Sat Flow, veh/h	0	3435	247	0	1863	0	1774	1863	1583	3548	0	1583
Grp Volume(v), veh/h	0	366	376	0	0	0	14	0	47	568	0	507
Grp Sat Flow(s),veh/h/ln	0	1770	1819	0	1863	0	1774	1863	1583	1774	0	1583
Q Serve(g_s), s	0.0	9.2	9.2	0.0	0.0	0.0	0.4	0.0	1.4	6.5	0.0	14.5
Cycle Q Clear(g_c), s	0.0	9.2	9.2	0.0	0.0	0.0	0.4	0.0	1.4	6.5	0.0	14.5
Prop In Lane	0.00		0.14	0.00		0.00	1.00		1.00	1.00		1.00
Lane Grp Cap(c), veh/h	0	533	548	0	561	0	168	148	126	1140	0	612
V/C Ratio(X)	0.00	0.69	0.69	0.00	0.00	0.00	0.08	0.00	0.37	0.50	0.00	0.83
Avail Cap(c_a), veh/h	0	880	904	0	926	0	496	370	315	1763	0	787
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	0.00	1.00	1.00	0.00	0.00	0.00	1.00	0.00	1.00	1.00	0.00	1.00
Uniform Delay (d), s/veh	0.0	15.5	15.5	0.0	0.0	0.0	24.4	0.0	22.0	13.8	0.0	13.9
Incr Delay (d2), s/veh	0.0	1.6	1.5	0.0	0.0	0.0	0.2	0.0	1.8	0.3	0.0	5.8
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.0	4.7	4.8	0.0	0.0	0.0	0.2	0.0	0.7	3.2	0.0	7.2
LnGrp Delay(d),s/veh	0.0	17.1	17.0	0.0	0.0	0.0	24.6	0.0	23.8	14.1	0.0	19.8
LnGrp LOS		B	B				C		C	B		B
Approach Vol, veh/h		742			0			61			1075	
Approach Delay, s/veh		17.0			0.0			24.0			16.8	
Approach LOS		B						C			B	

Timer	1	2	3	4	5	6	7	8
Assigned Phs		2	3	4		6	7	8
Phs Duration (G+Y+Rc), s		20.1	21.2	9.0		20.1	5.7	24.4
Change Period (Y+Rc), s		5.0	5.0	5.0		5.0	5.0	5.0
Max Green Setting (Gmax), s		25.0	25.0	10.0		25.0	10.0	25.0
Max Q Clear Time (g_c+I1), s		11.2	8.5	3.4		0.0	2.4	16.5
Green Ext Time (p_c), s		4.0	3.9	0.0		0.0	0.0	2.9

Intersection Summary	
HCM 2010 Ctrl Delay	17.1
HCM 2010 LOS	B

Notes

User approved pedestrian interval to be less than phase max green.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	0	30	11	179	57	0	0	1	0	67	881	13
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	33	12	195	62	0	0	1	0	73	958	14
Pedestrians												
Lane Width (ft)												
Walking Speed (ft/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (ft)								246				
pX, platoon unblocked												
vC, conflicting volume	1142	1111	486	654	1118	1	972			1		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	1142	1111	486	654	1118	1	972			1		
tC, single (s)	7.5	6.5	6.9	*5.0	*5.5	6.9	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	100	84	98	58	77	100	100			96		
cM capacity (veh/h)	124	198	527	461	271	1083	705			1620		

Direction, Lane #	EB 1	WB 1	NB 1	SB 1	SB 2
Volume Total	45	257	1	552	493
Volume Left	0	195	0	73	0
Volume Right	12	0	0	0	14
cSH	238	394	1700	1620	1700
Volume to Capacity	0.19	0.65	0.00	0.04	0.29
Queue Length 95th (ft)	17	111	0	4	0
Control Delay (s)	23.6	29.6	0.0	1.4	0.0
Lane LOS	C	D		A	
Approach Delay (s)	23.6	29.6	0.0	0.7	
Approach LOS	C	D			

Intersection Summary			
Average Delay	7.0		
Intersection Capacity Utilization	56.3%	ICU Level of Service	B
Analysis Period (min)	15		

* User Entered Value

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	356	250	202	0	0	66	0	634	109	0	136	0
Number	7	4	14	3	8	18	5	2	12	1	6	16
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1863	1863	1863	0	1909	1909	0	1863	1900	0	1863	0
Adj Flow Rate, veh/h	387	272	220	0	0	72	0	689	118	0	148	0
Adj No. of Lanes	1	2	1	0	1	2	0	4	0	0	2	0
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Percent Heavy Veh, %	2	2	2	0	2	2	0	2	2	0	2	0
Cap, veh/h	698	1564	700	0	203	303	0	1838	307	0	1167	0
Arrive On Green	0.22	0.44	0.44	0.00	0.00	0.11	0.00	0.33	0.33	0.00	0.33	0.00
Sat Flow, veh/h	1774	3539	1583	0	1909	2856	0	5835	930	0	3725	0
Grp Volume(v), veh/h	387	272	220	0	0	72	0	591	216	0	148	0
Grp Sat Flow(s),veh/h/ln	1774	1770	1583	0	1909	1428	0	1602	1699	0	1770	0
Q Serve(g_s), s	7.7	2.0	3.9	0.0	0.0	1.0	0.0	4.1	4.3	0.0	1.3	0.0
Cycle Q Clear(g_c), s	7.7	2.0	3.9	0.0	0.0	1.0	0.0	4.1	4.3	0.0	1.3	0.0
Prop In Lane	1.00		1.00	0.00		1.00	0.00		0.55	0.00		0.00
Lane Grp Cap(c), veh/h	698	1564	700	0	203	303	0	1585	560	0	1167	0
V/C Ratio(X)	0.55	0.17	0.31	0.00	0.00	0.24	0.00	0.37	0.38	0.00	0.13	0.00
Avail Cap(c_a), veh/h	710	2020	904	0	436	652	0	9325	3296	0	6867	0
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	1.00	0.00	0.00	1.00	0.00	1.00	1.00	0.00	1.00	0.00
Uniform Delay (d), s/veh	11.1	7.4	7.9	0.0	0.0	18.0	0.0	11.2	11.3	0.0	10.3	0.0
Incr Delay (d2), s/veh	0.9	0.1	0.3	0.0	0.0	0.4	0.0	0.1	0.4	0.0	0.0	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	3.8	1.0	1.8	0.0	0.0	0.4	0.0	1.8	2.0	0.0	0.6	0.0
LnGrp Delay(d),s/veh	12.0	7.4	8.2	0.0	0.0	18.4	0.0	11.4	11.7	0.0	10.3	0.0
LnGrp LOS	B	A	A			B		B	B		B	
Approach Vol, veh/h		879			72			807			148	
Approach Delay, s/veh		9.6			18.4			11.5			10.3	
Approach LOS		A			B			B			B	

Timer	1	2	3	4	5	6	7	8
Assigned Phs		2		4		6	7	8
Phs Duration (G+Y+Rc), s		19.4		24.4		19.4	14.7	9.7
Change Period (Y+Rc), s		5.0		5.0		5.0	5.0	5.0
Max Green Setting (Gmax), s		85.0		25.0		85.0	10.0	10.0
Max Q Clear Time (g_c+I1), s		6.3		5.9		3.3	9.7	3.0
Green Ext Time (p_c), s		8.2		2.7		8.2	0.1	1.6

Intersection Summary	
HCM 2010 Ctrl Delay	10.8
HCM 2010 LOS	B

Notes

User approved pedestrian interval to be less than phase max green.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	2	43	3	80	65	93	17	797	165	0	84	9
Number	7	4	14	3	8	18	5	2	12	1	6	16
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1900	1863	1900	1863	1863	1863	1900	1863	1900	0	1863	1900
Adj Flow Rate, veh/h	2	47	3	79	82	101	18	866	179	0	91	10
Adj No. of Lanes	0	1	0	1	1	1	0	4	0	0	2	0
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Percent Heavy Veh, %	2	2	2	2	2	2	2	2	2	0	2	2
Cap, veh/h	132	294	18	446	324	275	146	2536	508	0	1572	170
Arrive On Green	0.17	0.17	0.17	0.17	0.17	0.17	0.49	0.49	0.49	0.00	0.49	0.49
Sat Flow, veh/h	31	1690	105	1349	1863	1583	35	5197	1042	0	3315	349
Grp Volume(v), veh/h	52	0	0	79	82	101	313	490	260	0	49	52
Grp Sat Flow(s),veh/h/ln	1827	0	0	1349	1863	1583	1847	1458	1511	0	1770	1801
Q Serve(g_s), s	0.0	0.0	0.0	1.6	1.1	1.7	0.0	3.1	3.1	0.0	0.4	0.4
Cycle Q Clear(g_c), s	0.7	0.0	0.0	2.3	1.1	1.7	3.1	3.1	3.1	0.0	0.4	0.4
Prop In Lane	0.04		0.06	1.00		1.00	0.06		0.69	0.00		0.19
Lane Grp Cap(c), veh/h	444	0	0	446	324	275	1030	1423	738	0	864	879
V/C Ratio(X)	0.12	0.00	0.00	0.18	0.25	0.37	0.30	0.34	0.35	0.00	0.06	0.06
Avail Cap(c_a), veh/h	1961	0	0	1579	1889	1605	2599	3942	2043	0	2392	2435
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00
Uniform Delay (d), s/veh	10.4	0.0	0.0	11.4	10.6	10.8	4.7	4.7	4.7	0.0	4.0	4.0
Incr Delay (d2), s/veh	0.1	0.0	0.0	0.2	0.4	0.8	0.2	0.1	0.3	0.0	0.0	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.4	0.0	0.0	0.6	0.6	0.8	1.6	1.3	1.4	0.0	0.2	0.2
LnGrp Delay(d),s/veh	10.5	0.0	0.0	11.5	11.0	11.6	4.8	4.8	5.0	0.0	4.0	4.0
LnGrp LOS	B			B	B	B	A	A	A		A	A
Approach Vol, veh/h		52			262			1063			101	
Approach Delay, s/veh		10.5			11.4			4.9			4.0	
Approach LOS		B			B			A			A	

Timer	1	2	3	4	5	6	7	8
Assigned Phs		2		4		6		8
Phs Duration (G+Y+Rc), s		19.4		10.1		19.4		10.1
Change Period (Y+Rc), s		5.0		5.0		5.0		5.0
Max Green Setting (Gmax), s		40.0		30.0		40.0		30.0
Max Q Clear Time (g_c+I1), s		5.1		2.7		2.4		4.3
Green Ext Time (p_c), s		9.3		1.3		9.4		1.3

Intersection Summary	
HCM 2010 Ctrl Delay	6.2
HCM 2010 LOS	A

Notes

User approved volume balancing among the lanes for turning movement.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	0	264	10	0	0	0	71	0	85	411	41	399
Number	5	2	12	1	6	16	7	4	14	3	8	18
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	0	1863	1900	0	1863	0	1863	1863	1863	1863	1863	1863
Adj Flow Rate, veh/h	0	287	11	0	0	0	77	0	92	479	0	434
Adj No. of Lanes	0	2	0	0	1	0	1	1	1	2	0	1
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Percent Heavy Veh, %	0	2	2	0	2	0	2	2	2	2	2	2
Cap, veh/h	0	555	21	0	297	0	295	206	175	1178	0	607
Arrive On Green	0.00	0.16	0.16	0.00	0.00	0.00	0.06	0.00	0.11	0.33	0.00	0.38
Sat Flow, veh/h	0	3569	133	0	1863	0	1774	1863	1583	3548	0	1583
Grp Volume(v), veh/h	0	146	152	0	0	0	77	0	92	479	0	434
Grp Sat Flow(s),veh/h/ln	0	1770	1839	0	1863	0	1774	1863	1583	1774	0	1583
Q Serve(g_s), s	0.0	2.8	2.9	0.0	0.0	0.0	1.6	0.0	2.1	3.9	0.0	8.8
Cycle Q Clear(g_c), s	0.0	2.8	2.9	0.0	0.0	0.0	1.6	0.0	2.1	3.9	0.0	8.8
Prop In Lane	0.00		0.07	0.00		0.00	1.00		1.00	1.00		1.00
Lane Grp Cap(c), veh/h	0	282	294	0	297	0	295	206	175	1178	0	607
V/C Ratio(X)	0.00	0.52	0.52	0.00	0.00	0.00	0.26	0.00	0.53	0.41	0.00	0.71
Avail Cap(c_a), veh/h	0	939	976	0	989	0	662	494	420	5179	0	2311
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	0.00	1.00	1.00	0.00	0.00	0.00	1.00	0.00	1.00	1.00	0.00	1.00
Uniform Delay (d), s/veh	0.0	14.5	14.5	0.0	0.0	0.0	17.4	0.0	15.8	9.7	0.0	9.9
Incr Delay (d2), s/veh	0.0	1.5	1.4	0.0	0.0	0.0	0.5	0.0	2.4	0.2	0.0	1.6
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.0	1.5	1.6	0.0	0.0	0.0	0.8	0.0	1.0	1.9	0.0	4.0
LnGrp Delay(d),s/veh	0.0	16.0	15.9	0.0	0.0	0.0	17.8	0.0	18.3	9.9	0.0	11.4
LnGrp LOS		B	B				B		B	A		B
Approach Vol, veh/h		298			0			169			913	
Approach Delay, s/veh		15.9			0.0			18.1			10.7	
Approach LOS		B						B			B	

Timer	1	2	3	4	5	6	7	8
Assigned Phs		2	3	4		6	7	8
Phs Duration (G+Y+Rc), s		11.0	17.5	9.2		11.0	7.2	19.5
Change Period (Y+Rc), s		5.0	5.0	5.0		5.0	5.0	5.0
Max Green Setting (Gmax), s		20.0	55.0	10.0		20.0	10.0	55.0
Max Q Clear Time (g_c+I1), s		4.9	5.9	4.1		0.0	3.6	10.8
Green Ext Time (p_c), s		1.4	3.7	0.1		0.0	0.1	3.7

Intersection Summary	
HCM 2010 Ctrl Delay	12.7
HCM 2010 LOS	B

Notes

User approved pedestrian interval to be less than phase max green.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	0	8	10	73	23	0	0	1	0	52	795	37
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	9	11	79	25	0	0	1	0	57	864	40
Pedestrians												
Lane Width (ft)												
Walking Speed (ft/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (ft)								246				
pX, platoon unblocked												
vC, conflicting volume	1011	998	452	561	1018	1	904			1		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	1011	998	452	561	1018	1	904			1		
tC, single (s)	7.5	6.5	6.9	*5.0	*5.5	6.9	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	100	96	98	86	92	100	100			97		
cM capacity (veh/h)	177	234	555	565	305	1083	748			1620		

Direction, Lane #	EB 1	WB 1	NB 1	SB 1	SB 2
Volume Total	20	104	1	489	472
Volume Left	0	79	0	57	0
Volume Right	11	0	0	0	40
cSH	344	469	1700	1620	1700
Volume to Capacity	0.06	0.22	0.00	0.03	0.28
Queue Length 95th (ft)	4	21	0	3	0
Control Delay (s)	16.1	14.8	0.0	1.1	0.0
Lane LOS	C	B		A	
Approach Delay (s)	16.1	14.8	0.0	0.6	
Approach LOS	C	B			

Intersection Summary			
Average Delay	2.2		
Intersection Capacity Utilization	46.6%	ICU Level of Service	A
Analysis Period (min)	15		

* User Entered Value

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	486	437	341	0	0	577	0	828	114	0	302	0
Number	7	4	14	3	8	18	5	2	12	1	6	16
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1863	1863	1863	0	1909	1909	0	1863	1900	0	1863	0
Adj Flow Rate, veh/h	528	475	371	0	0	627	0	900	124	0	328	0
Adj No. of Lanes	1	2	1	0	1	2	0	4	0	0	2	0
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Percent Heavy Veh, %	2	2	2	0	2	2	0	2	2	0	2	0
Cap, veh/h	576	1550	693	0	334	500	0	2225	302	0	1369	0
Arrive On Green	0.18	0.44	0.44	0.00	0.00	0.18	0.00	0.39	0.39	0.00	0.39	0.00
Sat Flow, veh/h	1774	3539	1583	0	1909	2856	0	6010	781	0	3725	0
Grp Volume(v), veh/h	528	475	371	0	0	627	0	750	274	0	328	0
Grp Sat Flow(s),veh/h/ln	1774	1770	1583	0	1909	1428	0	1602	1725	0	1770	0
Q Serve(g_s), s	10.0	5.0	9.8	0.0	0.0	10.0	0.0	6.5	6.6	0.0	3.6	0.0
Cycle Q Clear(g_c), s	10.0	5.0	9.8	0.0	0.0	10.0	0.0	6.5	6.6	0.0	3.6	0.0
Prop In Lane	1.00		1.00	0.00		1.00	0.00		0.45	0.00		0.00
Lane Grp Cap(c), veh/h	576	1550	693	0	334	500	0	1860	667	0	1369	0
V/C Ratio(X)	0.92	0.31	0.54	0.00	0.00	1.25	0.00	0.40	0.41	0.00	0.24	0.00
Avail Cap(c_a), veh/h	576	1550	693	0	334	500	0	7155	2568	0	5269	0
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	1.00	0.00	0.00	1.00	0.00	1.00	1.00	0.00	1.00	0.00
Uniform Delay (d), s/veh	17.2	10.4	11.8	0.0	0.0	23.5	0.0	12.7	12.8	0.0	11.8	0.0
Incr Delay (d2), s/veh	19.6	0.1	0.8	0.0	0.0	129.6	0.0	0.1	0.4	0.0	0.1	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	9.4	2.4	4.4	0.0	0.0	12.9	0.0	2.9	3.2	0.0	1.7	0.0
LnGrp Delay(d),s/veh	36.8	10.5	12.6	0.0	0.0	153.1	0.0	12.9	13.2	0.0	11.9	0.0
LnGrp LOS	D	B	B			F		B	B		B	
Approach Vol, veh/h		1374			627			1024			328	
Approach Delay, s/veh		21.2			153.1			12.9			11.9	
Approach LOS		C			F			B			B	

Timer	1	2	3	4	5	6	7	8
Assigned Phs		2		4		6	7	8
Phs Duration (G+Y+Rc), s		27.1		30.0		27.1	15.0	15.0
Change Period (Y+Rc), s		5.0		5.0		5.0	5.0	5.0
Max Green Setting (Gmax), s		85.0		25.0		85.0	10.0	10.0
Max Q Clear Time (g_c+I1), s		8.6		11.8		5.6	12.0	12.0
Green Ext Time (p_c), s		13.5		6.2		13.5	0.0	0.0

Intersection Summary	
HCM 2010 Ctrl Delay	42.4
HCM 2010 LOS	D

Notes

User approved pedestrian interval to be less than phase max green.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	0	68	16	184	129	207	70	1437	181	0	112	7
Number	7	4	14	3	8	18	5	2	12	1	6	16
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1900	1863	1900	1863	1863	1863	1900	1863	1900	0	1863	1900
Adj Flow Rate, veh/h	0	74	17	170	182	225	76	1562	197	0	122	8
Adj No. of Lanes	0	1	0	1	1	1	0	4	0	0	2	0
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Percent Heavy Veh, %	2	2	2	2	2	2	2	2	2	0	2	2
Cap, veh/h	0	371	85	417	471	400	175	2998	373	0	1864	121
Arrive On Green	0.00	0.25	0.25	0.25	0.25	0.25	0.55	0.55	0.55	0.00	0.55	0.55
Sat Flow, veh/h	0	1466	337	1300	1863	1583	171	5425	675	0	3467	219
Grp Volume(v), veh/h	0	0	91	170	182	225	525	850	460	0	64	66
Grp Sat Flow(s),veh/h/ln	0	0	1803	1300	1863	1583	1780	1458	1576	0	1770	1824
Q Serve(g_s), s	0.0	0.0	2.0	6.1	4.2	6.4	0.0	9.5	9.5	0.0	0.9	0.9
Cycle Q Clear(g_c), s	0.0	0.0	2.0	8.1	4.2	6.4	9.0	9.5	9.5	0.0	0.9	0.9
Prop In Lane	0.00		0.19	1.00		1.00	0.14		0.43	0.00		0.12
Lane Grp Cap(c), veh/h	0	0	456	417	471	400	1064	1611	871	0	978	1008
V/C Ratio(X)	0.00	0.00	0.20	0.41	0.39	0.56	0.49	0.53	0.53	0.00	0.06	0.07
Avail Cap(c_a), veh/h	0	0	1054	848	1089	925	1458	2272	1228	0	1379	1421
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00
Uniform Delay (d), s/veh	0.0	0.0	15.1	18.3	15.9	16.7	7.2	7.3	7.3	0.0	5.3	5.3
Incr Delay (d2), s/veh	0.0	0.0	0.2	0.6	0.5	1.2	0.4	0.3	0.5	0.0	0.0	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.0	0.0	1.0	2.2	2.2	2.9	4.6	3.8	4.2	0.0	0.4	0.4
LnGrp Delay(d),s/veh	0.0	0.0	15.3	18.9	16.4	17.9	7.5	7.5	7.8	0.0	5.4	5.4
LnGrp LOS			B	B	B	B	A	A	A		A	A
Approach Vol, veh/h		91			577			1835			130	
Approach Delay, s/veh		15.3			17.8			7.6			5.4	
Approach LOS		B			B			A			A	

Timer	1	2	3	4	5	6	7	8
Assigned Phs		2		4		6		8
Phs Duration (G+Y+Rc), s		33.4		18.0		33.4		18.0
Change Period (Y+Rc), s		5.0		5.0		5.0		5.0
Max Green Setting (Gmax), s		40.0		30.0		40.0		30.0
Max Q Clear Time (g_c+I1), s		11.5		4.0		2.9		10.1
Green Ext Time (p_c), s		16.9		3.0		19.6		2.9

Intersection Summary	
HCM 2010 Ctrl Delay	10.0
HCM 2010 LOS	A

Notes

User approved volume balancing among the lanes for turning movement.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	0	695	48	0	0	0	22	0	58	543	39	480
Number	5	2	12	1	6	16	7	4	14	3	8	18
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	0	1863	1900	0	1863	0	1863	1863	1863	1863	1863	1863
Adj Flow Rate, veh/h	0	755	52	0	0	0	24	0	63	620	0	522
Adj No. of Lanes	0	2	0	0	1	0	1	1	1	2	0	1
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Percent Heavy Veh, %	0	2	2	0	2	0	2	2	2	2	2	2
Cap, veh/h	0	1049	72	0	582	0	173	142	121	1185	0	614
Arrive On Green	0.00	0.31	0.31	0.00	0.00	0.00	0.02	0.00	0.08	0.33	0.00	0.39
Sat Flow, veh/h	0	3453	231	0	1863	0	1774	1863	1583	3548	0	1583
Grp Volume(v), veh/h	0	397	410	0	0	0	24	0	63	620	0	522
Grp Sat Flow(s),veh/h/ln	0	1770	1822	0	1863	0	1774	1863	1583	1774	0	1583
Q Serve(g_s), s	0.0	10.8	10.8	0.0	0.0	0.0	0.7	0.0	2.1	7.6	0.0	16.3
Cycle Q Clear(g_c), s	0.0	10.8	10.8	0.0	0.0	0.0	0.7	0.0	2.1	7.6	0.0	16.3
Prop In Lane	0.00		0.13	0.00		0.00	1.00		1.00	1.00		1.00
Lane Grp Cap(c), veh/h	0	552	569	0	582	0	173	142	121	1185	0	614
V/C Ratio(X)	0.00	0.72	0.72	0.00	0.00	0.00	0.14	0.00	0.52	0.52	0.00	0.85
Avail Cap(c_a), veh/h	0	819	843	0	862	0	462	345	293	1641	0	732
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	0.00	1.00	1.00	0.00	0.00	0.00	1.00	0.00	1.00	1.00	0.00	1.00
Uniform Delay (d), s/veh	0.0	16.5	16.5	0.0	0.0	0.0	26.1	0.0	24.0	14.5	0.0	15.1
Incr Delay (d2), s/veh	0.0	1.8	1.7	0.0	0.0	0.0	0.4	0.0	3.5	0.4	0.0	8.1
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.0	5.5	5.6	0.0	0.0	0.0	0.4	0.0	1.0	3.8	0.0	8.3
LnGrp Delay(d),s/veh	0.0	18.3	18.2	0.0	0.0	0.0	26.4	0.0	27.5	14.9	0.0	23.2
LnGrp LOS		B	B				C		C	B		C
Approach Vol, veh/h		807			0			87			1142	
Approach Delay, s/veh		18.2			0.0			27.2			18.7	
Approach LOS		B						C			B	

Timer	1	2	3	4	5	6	7	8
Assigned Phs		2	3	4		6	7	8
Phs Duration (G+Y+Rc), s		21.9	23.0	9.1		21.9	6.2	26.0
Change Period (Y+Rc), s		5.0	5.0	5.0		5.0	5.0	5.0
Max Green Setting (Gmax), s		25.0	25.0	10.0		25.0	10.0	25.0
Max Q Clear Time (g_c+I1), s		12.8	9.6	4.1		0.0	2.7	18.3
Green Ext Time (p_c), s		4.1	4.1	0.1		0.0	0.0	2.7

Intersection Summary	
HCM 2010 Ctrl Delay	18.9
HCM 2010 LOS	B

Notes

User approved pedestrian interval to be less than phase max green.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	0	26	11	158	49	0	0	1	0	57	935	13
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	28	12	172	53	0	0	1	0	62	1016	14
Pedestrians												
Lane Width (ft)												
Walking Speed (ft/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (ft)								246				
pX, platoon unblocked												
vC, conflicting volume	1175	1148	515	659	1155	1	1030			1		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	1175	1148	515	659	1155	1	1030			1		
tC, single (s)	7.5	6.5	6.9	*5.0	*5.5	6.9	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	100	85	98	63	80	100	100			96		
cM capacity (veh/h)	120	190	505	467	262	1083	670			1620		

Direction, Lane #	EB 1	WB 1	NB 1	SB 1	SB 2
Volume Total	40	225	1	570	522
Volume Left	0	172	0	62	0
Volume Right	12	0	0	0	14
cSH	233	394	1700	1620	1700
Volume to Capacity	0.17	0.57	0.00	0.04	0.31
Queue Length 95th (ft)	15	86	0	3	0
Control Delay (s)	23.6	25.6	0.0	1.1	0.0
Lane LOS	C	D		A	
Approach Delay (s)	23.6	25.6	0.0	0.6	
Approach LOS	C	D			

Intersection Summary			
Average Delay	5.4		
Intersection Capacity Utilization	55.9%	ICU Level of Service	B
Analysis Period (min)	15		

* User Entered Value

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	356	250	204	0	0	66	0	635	109	0	138	0
Number	7	4	14	3	8	18	5	2	12	1	6	16
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1863	1863	1863	0	1909	1909	0	1863	1900	0	1863	0
Adj Flow Rate, veh/h	387	272	222	0	0	72	0	690	118	0	150	0
Adj No. of Lanes	1	2	1	0	1	2	0	4	0	0	2	0
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Percent Heavy Veh, %	2	2	2	0	2	2	0	2	2	0	2	0
Cap, veh/h	698	1564	699	0	203	303	0	1842	307	0	1169	0
Arrive On Green	0.22	0.44	0.44	0.00	0.00	0.11	0.00	0.33	0.33	0.00	0.33	0.00
Sat Flow, veh/h	1774	3539	1583	0	1909	2856	0	5837	929	0	3725	0
Grp Volume(v), veh/h	387	272	222	0	0	72	0	592	216	0	150	0
Grp Sat Flow(s),veh/h/ln	1774	1770	1583	0	1909	1428	0	1602	1699	0	1770	0
Q Serve(g_s), s	7.7	2.0	4.0	0.0	0.0	1.0	0.0	4.1	4.3	0.0	1.3	0.0
Cycle Q Clear(g_c), s	7.7	2.0	4.0	0.0	0.0	1.0	0.0	4.1	4.3	0.0	1.3	0.0
Prop In Lane	1.00		1.00	0.00		1.00	0.00		0.55	0.00		0.00
Lane Grp Cap(c), veh/h	698	1564	699	0	203	303	0	1587	561	0	1169	0
V/C Ratio(X)	0.55	0.17	0.32	0.00	0.00	0.24	0.00	0.37	0.38	0.00	0.13	0.00
Avail Cap(c_a), veh/h	709	2017	902	0	435	651	0	9312	3292	0	6858	0
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	1.00	0.00	0.00	1.00	0.00	1.00	1.00	0.00	1.00	0.00
Uniform Delay (d), s/veh	11.1	7.4	7.9	0.0	0.0	18.0	0.0	11.2	11.3	0.0	10.3	0.0
Incr Delay (d2), s/veh	0.9	0.1	0.3	0.0	0.0	0.4	0.0	0.1	0.4	0.0	0.0	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	3.8	1.0	1.8	0.0	0.0	0.4	0.0	1.8	2.0	0.0	0.6	0.0
LnGrp Delay(d),s/veh	12.0	7.5	8.2	0.0	0.0	18.4	0.0	11.4	11.7	0.0	10.3	0.0
LnGrp LOS	B	A	A			B		B	B		B	
Approach Vol, veh/h		881			72			808			150	
Approach Delay, s/veh		9.6			18.4			11.5			10.3	
Approach LOS		A			B			B			B	

Timer	1	2	3	4	5	6	7	8
Assigned Phs		2		4		6	7	8
Phs Duration (G+Y+Rc), s		19.5		24.4		19.5	14.7	9.7
Change Period (Y+Rc), s		5.0		5.0		5.0	5.0	5.0
Max Green Setting (Gmax), s		85.0		25.0		85.0	10.0	10.0
Max Q Clear Time (g_c+I1), s		6.3		6.0		3.3	9.7	3.0
Green Ext Time (p_c), s		8.2		2.7		8.2	0.1	1.6

Intersection Summary	
HCM 2010 Ctrl Delay	10.8
HCM 2010 LOS	B

Notes

User approved pedestrian interval to be less than phase max green.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	3	68	5	80	67	93	22	797	165	0	84	9
Number	7	4	14	3	8	18	5	2	12	1	6	16
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1900	1863	1900	1863	1863	1863	1900	1863	1900	0	1863	1900
Adj Flow Rate, veh/h	3	74	5	80	83	101	24	866	179	0	91	10
Adj No. of Lanes	0	1	0	1	1	1	0	4	0	0	2	0
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Percent Heavy Veh, %	2	2	2	2	2	2	2	2	2	0	2	2
Cap, veh/h	127	330	22	442	364	309	151	2480	496	0	1543	167
Arrive On Green	0.20	0.20	0.20	0.20	0.20	0.20	0.48	0.48	0.48	0.00	0.48	0.48
Sat Flow, veh/h	28	1689	111	1314	1863	1583	52	5179	1036	0	3315	349
Grp Volume(v), veh/h	82	0	0	80	83	101	315	493	261	0	49	52
Grp Sat Flow(s),veh/h/ln	1828	0	0	1314	1863	1583	1839	1458	1512	0	1770	1801
Q Serve(g_s), s	0.0	0.0	0.0	1.7	1.2	1.7	0.0	3.3	3.3	0.0	0.5	0.5
Cycle Q Clear(g_c), s	1.1	0.0	0.0	2.8	1.2	1.7	3.3	3.3	3.3	0.0	0.5	0.5
Prop In Lane	0.04		0.06	1.00		1.00	0.08		0.69	0.00		0.19
Lane Grp Cap(c), veh/h	478	0	0	442	364	309	1007	1396	724	0	847	863
V/C Ratio(X)	0.17	0.00	0.00	0.18	0.23	0.33	0.31	0.35	0.36	0.00	0.06	0.06
Avail Cap(c_a), veh/h	1892	0	0	1471	1822	1548	2493	3802	1972	0	2307	2349
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00
Uniform Delay (d), s/veh	10.4	0.0	0.0	11.6	10.4	10.6	5.0	5.0	5.0	0.0	4.3	4.3
Incr Delay (d2), s/veh	0.2	0.0	0.0	0.2	0.3	0.6	0.2	0.2	0.3	0.0	0.0	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.6	0.0	0.0	0.6	0.6	0.8	1.7	1.3	1.4	0.0	0.2	0.2
LnGrp Delay(d),s/veh	10.6	0.0	0.0	11.8	10.7	11.2	5.2	5.2	5.3	0.0	4.3	4.3
LnGrp LOS	B			B	B	B	A	A	A		A	A
Approach Vol, veh/h		82			264			1069			101	
Approach Delay, s/veh		10.6			11.2			5.2			4.3	
Approach LOS		B			B			A			A	

Timer	1	2	3	4	5	6	7	8
Assigned Phs		2		4		6		8
Phs Duration (G+Y+Rc), s		19.7		11.0		19.7		11.0
Change Period (Y+Rc), s		5.0		5.0		5.0		5.0
Max Green Setting (Gmax), s		40.0		30.0		40.0		30.0
Max Q Clear Time (g_c+I1), s		5.3		3.1		2.5		4.8
Green Ext Time (p_c), s		9.4		1.5		9.5		1.5

Intersection Summary	
HCM 2010 Ctrl Delay	6.5
HCM 2010 LOS	A

Notes

User approved volume balancing among the lanes for turning movement.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	0	264	10	0	0	0	71	0	85	413	41	410
Number	5	2	12	1	6	16	7	4	14	3	8	18
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	0	1863	1900	0	1863	0	1863	1863	1863	1863	1863	1863
Adj Flow Rate, veh/h	0	287	11	0	0	0	77	0	92	481	0	446
Adj No. of Lanes	0	2	0	0	1	0	1	1	1	2	0	1
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Percent Heavy Veh, %	0	2	2	0	2	0	2	2	2	2	2	2
Cap, veh/h	0	552	21	0	296	0	292	204	174	1202	0	618
Arrive On Green	0.00	0.16	0.16	0.00	0.00	0.00	0.06	0.00	0.11	0.34	0.00	0.39
Sat Flow, veh/h	0	3569	133	0	1863	0	1774	1863	1583	3548	0	1583
Grp Volume(v), veh/h	0	146	152	0	0	0	77	0	92	481	0	446
Grp Sat Flow(s),veh/h/ln	0	1770	1839	0	1863	0	1774	1863	1583	1774	0	1583
Q Serve(g_s), s	0.0	2.9	2.9	0.0	0.0	0.0	1.6	0.0	2.1	4.0	0.0	9.1
Cycle Q Clear(g_c), s	0.0	2.9	2.9	0.0	0.0	0.0	1.6	0.0	2.1	4.0	0.0	9.1
Prop In Lane	0.00		0.07	0.00		0.00	1.00		1.00	1.00		1.00
Lane Grp Cap(c), veh/h	0	281	292	0	296	0	292	204	174	1202	0	618
V/C Ratio(X)	0.00	0.52	0.52	0.00	0.00	0.00	0.26	0.00	0.53	0.40	0.00	0.72
Avail Cap(c_a), veh/h	0	927	963	0	976	0	653	488	415	5110	0	2280
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	0.00	1.00	1.00	0.00	0.00	0.00	1.00	0.00	1.00	1.00	0.00	1.00
Uniform Delay (d), s/veh	0.0	14.7	14.7	0.0	0.0	0.0	17.6	0.0	16.1	9.7	0.0	9.9
Incr Delay (d2), s/veh	0.0	1.5	1.4	0.0	0.0	0.0	0.5	0.0	2.5	0.2	0.0	1.6
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.0	1.5	1.6	0.0	0.0	0.0	0.8	0.0	1.0	2.0	0.0	4.2
LnGrp Delay(d),s/veh	0.0	16.2	16.2	0.0	0.0	0.0	18.1	0.0	18.6	9.9	0.0	11.5
LnGrp LOS		B	B				B		B	A		B
Approach Vol, veh/h		298			0			169			927	
Approach Delay, s/veh		16.2			0.0			18.3			10.7	
Approach LOS		B						B			B	

Timer	1	2	3	4	5	6	7	8
Assigned Phs		2	3	4		6	7	8
Phs Duration (G+Y+Rc), s		11.1	17.9	9.2		11.1	7.2	19.9
Change Period (Y+Rc), s		5.0	5.0	5.0		5.0	5.0	5.0
Max Green Setting (Gmax), s		20.0	55.0	10.0		20.0	10.0	55.0
Max Q Clear Time (g_c+I1), s		4.9	6.0	4.1		0.0	3.6	11.1
Green Ext Time (p_c), s		1.4	3.8	0.1		0.0	0.1	3.8

Intersection Summary	
HCM 2010 Ctrl Delay	12.8
HCM 2010 LOS	B

Notes

User approved pedestrian interval to be less than phase max green.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	0	8	10	86	27	0	0	1	0	59	795	37
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	9	11	93	29	0	0	1	0	64	864	40
Pedestrians												
Lane Width (ft)												
Walking Speed (ft/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (ft)								246				
pX, platoon unblocked												
vC, conflicting volume	1028	1014	452	577	1034	1	904			1		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	1028	1014	452	577	1034	1	904			1		
tC, single (s)	7.5	6.5	6.9	*5.0	*5.5	6.9	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	100	96	98	83	90	100	100			96		
cM capacity (veh/h)	169	228	555	555	299	1083	748			1620		

Direction, Lane #	EB 1	WB 1	NB 1	SB 1	SB 2
Volume Total	20	123	1	496	472
Volume Left	0	93	0	64	0
Volume Right	11	0	0	0	40
cSH	339	460	1700	1620	1700
Volume to Capacity	0.06	0.27	0.00	0.04	0.28
Queue Length 95th (ft)	5	27	0	3	0
Control Delay (s)	16.3	15.6	0.0	1.3	0.0
Lane LOS	C	C		A	
Approach Delay (s)	16.3	15.6	0.0	0.7	
Approach LOS	C	C			

Intersection Summary			
Average Delay	2.6		
Intersection Capacity Utilization	47.7%	ICU Level of Service	A
Analysis Period (min)	15		

* User Entered Value

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	59	8	3	94	17	28
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	64	9	3	102	18	30
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)				319		
pX, platoon unblocked						
vC, conflicting volume			73		177	68
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			73		177	68
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			100		98	97
cM capacity (veh/h)			1527		811	995

Direction, Lane #	EB 1	WB 1	NB 1
Volume Total	73	105	49
Volume Left	0	3	18
Volume Right	9	0	30
cSH	1700	1527	916
Volume to Capacity	0.04	0.00	0.05
Queue Length 95th (ft)	0	0	4
Control Delay (s)	0.0	0.2	9.2
Lane LOS		A	A
Approach Delay (s)	0.0	0.2	9.2
Approach LOS			A

Intersection Summary			
Average Delay	2.1		
Intersection Capacity Utilization	17.4%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	487	437	342	0	0	578	0	830	114	0	304	0
Number	7	4	14	3	8	18	5	2	12	1	6	16
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1863	1863	1863	0	1909	1909	0	1863	1900	0	1863	0
Adj Flow Rate, veh/h	529	475	372	0	0	628	0	902	124	0	330	0
Adj No. of Lanes	1	2	1	0	1	2	0	4	0	0	2	0
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Percent Heavy Veh, %	2	2	2	0	2	2	0	2	2	0	2	0
Cap, veh/h	575	1548	692	0	334	500	0	2230	302	0	1372	0
Arrive On Green	0.17	0.44	0.44	0.00	0.00	0.17	0.00	0.39	0.39	0.00	0.39	0.00
Sat Flow, veh/h	1774	3539	1583	0	1909	2856	0	6012	780	0	3725	0
Grp Volume(v), veh/h	529	475	372	0	0	628	0	752	274	0	330	0
Grp Sat Flow(s),veh/h/ln	1774	1770	1583	0	1909	1428	0	1602	1725	0	1770	0
Q Serve(g_s), s	10.0	5.0	9.9	0.0	0.0	10.0	0.0	6.5	6.6	0.0	3.6	0.0
Cycle Q Clear(g_c), s	10.0	5.0	9.9	0.0	0.0	10.0	0.0	6.5	6.6	0.0	3.6	0.0
Prop In Lane	1.00		1.00	0.00		1.00	0.00		0.45	0.00		0.00
Lane Grp Cap(c), veh/h	575	1548	692	0	334	500	0	1864	669	0	1372	0
V/C Ratio(X)	0.92	0.31	0.54	0.00	0.00	1.26	0.00	0.40	0.41	0.00	0.24	0.00
Avail Cap(c_a), veh/h	575	1548	692	0	334	500	0	7146	2565	0	5262	0
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	1.00	0.00	0.00	1.00	0.00	1.00	1.00	0.00	1.00	0.00
Uniform Delay (d), s/veh	17.3	10.5	11.8	0.0	0.0	23.6	0.0	12.7	12.7	0.0	11.8	0.0
Incr Delay (d2), s/veh	20.1	0.1	0.8	0.0	0.0	131.2	0.0	0.1	0.4	0.0	0.1	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	6.7	2.5	4.4	0.0	0.0	13.0	0.0	2.9	3.2	0.0	1.8	0.0
LnGrp Delay(d),s/veh	37.4	10.6	12.7	0.0	0.0	154.7	0.0	12.8	13.1	0.0	11.9	0.0
LnGrp LOS	D	B	B			F		B	B		B	
Approach Vol, veh/h		1376			628			1026			330	
Approach Delay, s/veh		21.4			154.7			12.9			11.9	
Approach LOS		C			F			B			B	

Timer	1	2	3	4	5	6	7	8
Assigned Phs		2		4		6	7	8
Phs Duration (G+Y+Rc), s		27.2		30.0		27.2	15.0	15.0
Change Period (Y+Rc), s		5.0		5.0		5.0	5.0	5.0
Max Green Setting (Gmax), s		85.0		25.0		85.0	10.0	10.0
Max Q Clear Time (g_c+I1), s		8.6		11.9		5.6	12.0	12.0
Green Ext Time (p_c), s		13.6		6.2		13.6	0.0	0.0

Intersection Summary	
HCM 2010 Ctrl Delay	42.8
HCM 2010 LOS	D

Notes

User approved pedestrian interval to be less than phase max green.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	0	80	18	184	135	207	74	1437	181	0	112	8
Number	7	4	14	3	8	18	5	2	12	1	6	16
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1900	1863	1900	1863	1863	1863	1900	1863	1900	0	1863	1900
Adj Flow Rate, veh/h	0	87	20	174	184	225	80	1562	197	0	122	9
Adj No. of Lanes	0	1	0	1	1	1	0	4	0	0	2	0
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Percent Heavy Veh, %	2	2	2	2	2	2	2	2	2	0	2	2
Cap, veh/h	0	387	89	416	492	418	179	2951	368	0	1825	133
Arrive On Green	0.00	0.26	0.26	0.26	0.26	0.26	0.55	0.55	0.55	0.00	0.55	0.55
Sat Flow, veh/h	0	1466	337	1281	1863	1583	184	5408	673	0	3438	244
Grp Volume(v), veh/h	0	0	107	174	184	225	525	853	461	0	64	67
Grp Sat Flow(s),veh/h/ln	0	0	1803	1281	1863	1583	1773	1458	1576	0	1770	1820
Q Serve(g_s), s	0.0	0.0	2.4	6.5	4.2	6.4	0.7	9.9	9.9	0.0	0.9	0.9
Cycle Q Clear(g_c), s	0.0	0.0	2.4	8.9	4.2	6.4	9.4	9.9	9.9	0.0	0.9	0.9
Prop In Lane	0.00		0.19	1.00		1.00	0.15		0.43	0.00		0.13
Lane Grp Cap(c), veh/h	0	0	476	416	492	418	1047	1591	860	0	966	993
V/C Ratio(X)	0.00	0.00	0.22	0.42	0.37	0.54	0.50	0.54	0.54	0.00	0.07	0.07
Avail Cap(c_a), veh/h	0	0	1030	809	1064	904	1421	2220	1200	0	1347	1385
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00
Uniform Delay (d), s/veh	0.0	0.0	15.1	18.6	15.8	16.6	7.5	7.7	7.7	0.0	5.6	5.6
Incr Delay (d2), s/veh	0.0	0.0	0.2	0.7	0.5	1.1	0.4	0.3	0.5	0.0	0.0	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.0	0.0	1.2	2.3	2.2	2.9	4.8	4.0	4.4	0.0	0.4	0.5
LnGrp Delay(d),s/veh	0.0	0.0	15.4	19.3	16.3	17.7	7.9	7.9	8.2	0.0	5.7	5.7
LnGrp LOS			B	B	B	B	A	A	A		A	A
Approach Vol, veh/h		107			583			1839			131	
Approach Delay, s/veh		15.4			17.7			8.0			5.7	
Approach LOS		B			B			A			A	

Timer	1	2	3	4	5	6	7	8
Assigned Phs		2		4		6		8
Phs Duration (G+Y+Rc), s		33.7		18.9		33.7		18.9
Change Period (Y+Rc), s		5.0		5.0		5.0		5.0
Max Green Setting (Gmax), s		40.0		30.0		40.0		30.0
Max Q Clear Time (g_c+I1), s		11.9		4.4		2.9		10.9
Green Ext Time (p_c), s		16.8		3.2		19.6		3.0

Intersection Summary	
HCM 2010 Ctrl Delay	10.3
HCM 2010 LOS	B

Notes

User approved volume balancing among the lanes for turning movement.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	0	696	48	0	0	0	22	0	58	544	39	482
Number	5	2	12	1	6	16	7	4	14	3	8	18
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	0	1863	1900	0	1863	0	1863	1863	1863	1863	1863	1863
Adj Flow Rate, veh/h	0	757	52	0	0	0	24	0	63	621	0	524
Adj No. of Lanes	0	2	0	0	1	0	1	1	1	2	0	1
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Percent Heavy Veh, %	0	2	2	0	2	0	2	2	2	2	2	2
Cap, veh/h	0	1050	72	0	582	0	173	142	121	1188	0	615
Arrive On Green	0.00	0.31	0.31	0.00	0.00	0.00	0.02	0.00	0.08	0.33	0.00	0.39
Sat Flow, veh/h	0	3454	231	0	1863	0	1774	1863	1583	3548	0	1583
Grp Volume(v), veh/h	0	398	411	0	0	0	24	0	63	621	0	524
Grp Sat Flow(s),veh/h/ln	0	1770	1822	0	1863	0	1774	1863	1583	1774	0	1583
Q Serve(g_s), s	0.0	10.8	10.8	0.0	0.0	0.0	0.7	0.0	2.1	7.7	0.0	16.4
Cycle Q Clear(g_c), s	0.0	10.8	10.8	0.0	0.0	0.0	0.7	0.0	2.1	7.7	0.0	16.4
Prop In Lane	0.00		0.13	0.00		0.00	1.00		1.00	1.00		1.00
Lane Grp Cap(c), veh/h	0	553	569	0	582	0	173	142	121	1188	0	615
V/C Ratio(X)	0.00	0.72	0.72	0.00	0.00	0.00	0.14	0.00	0.52	0.52	0.00	0.85
Avail Cap(c_a), veh/h	0	816	840	0	859	0	460	344	292	1636	0	730
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	0.00	1.00	1.00	0.00	0.00	0.00	1.00	0.00	1.00	1.00	0.00	1.00
Uniform Delay (d), s/veh	0.0	16.5	16.5	0.0	0.0	0.0	26.2	0.0	24.1	14.5	0.0	15.1
Incr Delay (d2), s/veh	0.0	1.8	1.7	0.0	0.0	0.0	0.4	0.0	3.5	0.4	0.0	8.3
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.0	5.5	5.6	0.0	0.0	0.0	0.4	0.0	1.0	3.8	0.0	8.6
LnGrp Delay(d),s/veh	0.0	18.3	18.3	0.0	0.0	0.0	26.5	0.0	27.6	14.9	0.0	23.5
LnGrp LOS		B	B				C		C	B		C
Approach Vol, veh/h		809			0			87			1145	
Approach Delay, s/veh		18.3			0.0			27.3			18.8	
Approach LOS		B						C			B	

Timer	1	2	3	4	5	6	7	8
Assigned Phs		2	3	4		6	7	8
Phs Duration (G+Y+Rc), s		21.9	23.1	9.1		21.9	6.2	26.1
Change Period (Y+Rc), s		5.0	5.0	5.0		5.0	5.0	5.0
Max Green Setting (Gmax), s		25.0	25.0	10.0		25.0	10.0	25.0
Max Q Clear Time (g_c+I1), s		12.8	9.7	4.1		0.0	2.7	18.4
Green Ext Time (p_c), s		4.1	4.1	0.1		0.0	0.0	2.7

Intersection Summary	
HCM 2010 Ctrl Delay	19.0
HCM 2010 LOS	B

Notes

User approved pedestrian interval to be less than phase max green.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	0	32	11	161	50	0	0	1	0	71	935	13
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	35	12	175	54	0	0	1	0	77	1016	14
Pedestrians												
Lane Width (ft)												
Walking Speed (ft/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (ft)								246				
pX, platoon unblocked												
vC, conflicting volume	1206	1179	515	693	1186	1	1030			1		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	1206	1179	515	693	1186	1	1030			1		
tC, single (s)	7.5	6.5	6.9	*5.0	*5.5	6.9	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	100	81	98	59	78	100	100			95		
cM capacity (veh/h)	112	180	505	431	251	1083	670			1620		

Direction, Lane #	EB 1	WB 1	NB 1	SB 1	SB 2
Volume Total	47	229	1	585	522
Volume Left	0	175	0	77	0
Volume Right	12	0	0	0	14
cSH	216	369	1700	1620	1700
Volume to Capacity	0.22	0.62	0.00	0.05	0.31
Queue Length 95th (ft)	20	100	0	4	0
Control Delay (s)	26.3	29.5	0.0	1.4	0.0
Lane LOS	D	D		A	
Approach Delay (s)	26.3	29.5	0.0	0.7	
Approach LOS	D	D			

Intersection Summary			
Average Delay	6.4		
Intersection Capacity Utilization	56.5%	ICU Level of Service	B
Analysis Period (min)	15		

* User Entered Value

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	83	20	11	207	4	14
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	90	22	12	225	4	15
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)				319		
pX, platoon unblocked					0.96	
vC, conflicting volume			112		350	101
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			112		296	101
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			99		99	98
cM capacity (veh/h)			1478		659	954

Direction, Lane #	EB 1	WB 1	NB 1
Volume Total	112	237	20
Volume Left	0	12	4
Volume Right	22	0	15
cSH	1700	1478	868
Volume to Capacity	0.07	0.01	0.02
Queue Length 95th (ft)	0	1	2
Control Delay (s)	0.0	0.4	9.2
Lane LOS		A	A
Approach Delay (s)	0.0	0.4	9.2
Approach LOS			A

Intersection Summary			
Average Delay	0.8		
Intersection Capacity Utilization	28.2%	ICU Level of Service	A
Analysis Period (min)	15		

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Environmental Noise Assessment Report
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Honolulu, Hawaii

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DLAA Project No. 14-34

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1.0 EXECUTIVE SUMMARY

1.1 The Hale Kewalo project is located in the Ala Moana district in Honolulu, Hawaii. The proposed 11 story residential project includes approximately 176 residential units, 77 parking stalls, and ground-floor commercial space on this 11 story structure. The project site is currently occupied by an unoccupied, vacant warehouse structure, and is zoned as commercial property.

1.2 The project area is currently exposed to varying daytime and nighttime ambient noise levels, typical of an urban environment. Noise measurements taken on the existing project property show a day-night level (L_{dn}) of 67 dBA. This noise level is above the threshold of the HUD exterior noise design criteria of L_{dn} < 65 dBA, therefore it is recommended that the design of the residential units incorporate increased sound attenuating construction at the exterior of the building. Peak hour equivalent sound levels (L_{eq}(h)) at the ground floor commercial / retail space are below the FHWA noise abatement criteria for this land use of 72 dBA.

1.3 During the project construction, the dominant noise sources will likely be earth moving equipment, such as bulldozers and diesel powered trucks. Noise from construction activities should be short term and must comply with State Department of Health noise regulations, and a construction noise permit.

1.4 After construction is complete, noise generated from any stationary mechanical equipment on the project site must comply with the Hawaii Department of Health property line noise regulations. Noise mitigation for stationary mechanical equipment should be considered during the design of the project.

1.5 Noise from the planned parking garage may be audible at the neighboring buildings. The design of the garage should incorporate noise control measures.

1.6 The results of the vehicular traffic noise analysis show a negligible increase in traffic noise to the project site and to the surround community due to the project.

1.7 The Honolulu Rail Transit Project (HART), expected to begin operation after the Hale Kewalo project is complete, will have a significant noise impact on the project site. High STC rated windows should be provided for the residential units facing Kona Street to reduce noise levels on the Unit interior.

2.0 PROJECT DESCRIPTION

2.1 Project Design

The Hale Kewalo project is located in the Ala Moana district in Honolulu, Hawaii. The proposed 11 story residential project includes approximately 176 residential units, 77 parking stalls, and ground-floor commercial space on this 11 story structure. The project site is currently occupied by an unoccupied, vacant warehouse structure, and is zoned as commercial property.

2.2 Future Honolulu Rail Transit Project (HART)

The future elevated HART rail guideway will run near the mauka face of the property along Kona Street, adjacent to the 5th floor of the building. A 3 foot tall parapet barrier wall is planned along the edge of the guideway to reduce wheel noise, however noise will still be a significant factor in the design of the Hale Kewalo project. The rail guideway is expected to be constructed after completion of the Hale Kewalo project, and begin operation in 2019.

3.0 NOISE STANDARDS

Various local and federal agencies have established guidelines and standards for assessing environmental noise impacts and set noise limits as a function of land use. A brief description of common acoustic terminology used in these guidelines and standards is presented in Appendix A.

3.1 State of Hawaii, Community Noise Control (HDOH)

The State of Hawaii Community Noise Control Rule [Reference 1] defines three classes of zoning districts and specifies corresponding maximum permissible sound levels due to *stationary* noise sources such as air-conditioning units, exhaust systems, generators, compressors, pumps, etc. The Community Noise Control Rule does not address most *moving* sources, such as vehicular traffic noise, aircraft noise, or rail transit noise. However, the Community Noise Control Rule does regulate noise related to agricultural, construction, and industrial activities, which may not be stationary.

The maximum permissible noise levels for stationary mechanical equipment are enforced by the Hawaii Department of Health (HDOH) for any location at or beyond the property line and shall not be exceeded for more than 10% of the time during any 20-minute period. The specified noise limits which apply are a function of the zoning and time of day as shown in Figure 1. With respect to mixed zoning districts, the rule specifies that the primary land use designation shall be used to determine the applicable zoning district class and the maximum permissible sound level. In determining the maximum permissible sound level, the background noise level is taken into account by HDOH.

The criteria for *impulse* or impact noise is separate from stationary noise due to the nature of the sound. HDOH defines impulse noise as " any sound with a rapid rise and decay of sound pressure level, lasting less than one second, caused by sudden contact between two or more surfaces ". Noise from pile driving is considered impulse noise and the maximum permissible noise level is 10 dB above the specified noise limits for stationary sources, as shown in Figure 1.

3.2 U.S. Federal Highway Administration (FHWA)

The FHWA regulation 23 CFR 772 contains highway traffic noise abatement criteria (NAC) for seven land use activity categories and assigns corresponding maximum hourly equivalent sound levels (L_{eq}(h)) for traffic noise exposure [Reference 2, 3]. The Noise Abatement Criteria (NAC) for all seven categories are listed in Figure 2. The commercial portion of this project is classified under “Category E”, which has a maximum L_{eq}(h) of 72dBA. The residential portions of this project are evaluated under separate noise standards within this report. These limits are viewed as design goals, and all projects meeting these limits are deemed in conformance with FHWA noise standards.

3.3 State of Hawaii Department of Transportation (HDOT)

The HDOT has implemented the requirements of the FHWA's design goals for traffic noise exposure in its noise analysis and abatement policy [Reference 4]. According to the policy, a traffic noise impact occurs when the predicted traffic noise levels "approach" or exceed FHWA's NAC or when the predicted traffic noise levels "substantially exceed the existing noise levels." The policy also states that "approach" is defined as 1 dB less than FHWA's NAC and "substantially exceed" is defined as an increase of at least 15 dB.

3.4 U.S. Department of Housing and Urban Development (HUD)

HUD's environmental noise criteria and standards in 24 CFR 51 [Reference 5] were established for determining housing project site acceptability. These standards are based on day-night equivalent sound levels, L_{dn}, and are not limited to traffic noise exposure.

3.4.1 Exterior Noise Design Criteria

The HUD Site Acceptability Standards for exterior sound levels are summarized in Table 1. HUD also recommends L_{dn} 55 dBA as a future goal for outdoors in residential areas, however this is rarely achievable in urban environments.

Table 1. HUD Site Acceptability Standards

Category	Site L_{dn}	Comments
Acceptable	≤ 65 dBA	No special acoustical design consideration necessary
Normally Unacceptable	> 65 dBA, ≤ 70 dBA	5 dB additional attenuation required through use of barriers or in design to ensure interior noise levels are acceptable
	> 70 dBA, ≤ 75 dBA	10 dB addition attenuation required through the use of barriers or in design to ensure interior noise levels are acceptable
Unacceptable	> 75 dBA	Attenuation measures must be submitted on a case-by-case basis

3.4.2 Interior Noise Design Criteria

The intent of the above exterior noise criteria is to achieve an interior L_{dn} of 45 dBA, however, the standard also applies to locations where quiet outdoor space is required. HUD will sometimes allow upgrades to the building shell to meet an interior L_{dn} of 45 dBA in Normally Unacceptable or Unacceptable areas. This can be accomplished by specifying building facades, windows, and doors with a higher STC rating than normal construction.

3.5 Federal Transit Administration Noise Criteria (FTA)

The FTA guidance manual "Transit Noise and Vibration Impact Assessment" [Reference 7] classifies land uses into 3 categories. Multi-Family areas of the Hale Kewalo project and surrounding properties are classified as Category 2, while commercial / retail areas are classified as Category 3. Noise impacts are rated as either "no impact", "moderate impact", or "severe impact", as shown Figure 2, and are a factor of existing noise exposure and project transit noise exposure.

3.6 Community Response to Change in Noise Level

Human sensitivity to changes in sound pressure level is highly individualized. Sensitivity to sound depends on frequency content, time of occurrence, duration, and psychological factors such as emotions and expectations. However, the average ability of an individual to perceive changes in noise levels is well documented and has been summarized in Table 2 [Reference 6]. These guidelines permit direct estimation of an individual's probable perception of changes in noise levels.

Table 2. Average Ability to Perceive Changes in Noise Level

Sound Level Change (dB)	Human Perception of Sound
0	Imperceptible
3	Just barely perceptible
6	Clearly noticeable
10	Two times (or 1/2) as loud
20	Four times (or 1/4) as loud

4.0 EXISTING ACOUSTICAL ENVIRONMENT

Noise measurements consisted of continuous long-term ambient noise level measurements, as described in the sections below. The noise measurements were conducted between August 1, 2014 and August 5, 2014.

The methodology, location, and results for each of the measurements are described below and the measurement locations are illustrated in Figure 4. Photographs of the measurements locations are provided in Appendix B.

4.1 Long Term Noise Measurements

Continuous long-term ambient noise level measurements were conducted to assess the existing acoustical environment in the vicinity of the project site. Long-term measurements (taken continuously over the course of multiple days) offer a baseline for establishing existing ambient noise levels in the area and are used for estimating future noise levels by adding the ambient levels to other noise levels generated from the proposed project.

4.1.1 Long-Term Noise Measurement Procedure

Hourly equivalent sound levels (L_{eq}(h)) were recorded for approximately 4 days. The measurements were taken using a Larson-Davis, Model 831, Type 1 Sound Level Meter together with a Larson Davis, PRM831 Type 1 Microphone. Calibration was checked before and after the measurements with a Larson-Davis Model CAL200 calibrator. Both the sound level meter and the calibrator have been certified by the manufacturer within the recommended 2-year calibration period. The microphone was mounted a tripod at approximately 20 feet above grade. A windscreen covered the microphone during the entire measurement period. The sound level meter was secured in a weather-resistant case.

4.1.2 Long-Term Noise Measurement Locations

Location: The sound level meter was located on the rooftop of the existing building overlooking Piikoi Street at the project site location, between Waimanu and Kona Streets. The dominant noise source was vehicular traffic from the roadway. Secondary noise sources included birds, wind, and construction equipment.

4.1.3 Long-Term Noise Measurement Results

The measured L_{eq}(h) and the 90 percent exceedance level (L_{90}) in dBA are graphically presented in Figure 5. The ambient sound levels were dynamic and depended significantly on the vehicular traffic patterns along Piikoi Avenue. The range of L_{eq}(h) during the day (7:00 AM to 10:00 PM) and during the night (10:00

PM to 7:00 AM) and average calculated day-night level are summarized for each location in Table 3 below.

Table 3. Summary of Noise Measurement Results (dBA)

Measurement Location	7 AM-10 PM $L_{eq(h)}$ Range	10 PM-7 AM $L_{eq(h)}$ Range	Average L_{dn}
Project Site	68-70	63-64	71

5.0 POTENTIAL NOISE IMPACTS

5.1 Project Construction Noise and Compliance with HDOH Community Noise Control Rule

The various construction phases of the project will generate significant amounts of noise. Depending on when construction occurs, the 450 Piikoi project may impact existing adjacent properties, such as the high-rise condominium tower across Waimanu Street (Hawaiki Tower) and single-story retail strip malls across Piikoi Avenue and Kona Street.

Development of the project areas will involve excavation, grading, and other typical construction activities during construction. The use of impact equipment is not anticipated, as the foundation will be pre-drilled to avoid any need for pile driving. The actual noise levels produced during construction will be a function of the methods employed during each stage of the construction process. Typical ranges of construction equipment noise are shown in Figure 6. Earthmoving equipment, e.g., bulldozers and diesel-powered trucks, will probably be the loudest equipment used during construction. In cases where construction noise is expected to exceed the HDOH "maximum permissible" property line noise levels, a permit must be obtained to allow the operation of construction equipment.

5.2 Project Generated Stationary Mechanical Noise and Compliance with HDOH Community Noise Control Rule

The Hale Kewalo Development is proposed to be a multi-family development, which will likely incorporate stationary mechanical equipment. Expected mechanical equipment may include HVAC equipment, emergency generators, etc. Noise from this mechanical equipment and other equipment must meet the State noise rules, which stipulate maximum permissible noise limits at the property line. For multi-family dwellings, business, and commercial areas, the noise limits are 60 dBA during the day and 50 dBA during the night, as shown in Figure 1. Mitigation of mechanical noise to meet the HDOH noise rules should be incorporated into the project design.

5.3 Transportation Noise Analysis

A transportation noise analysis was completed using the DataKustik CadnaA (version 4.4) software program [Reference 8] for the existing conditions, future year 2017 including the “with project” and “without project” conditions, and future year 2019 after the Honolulu Rail Transit Project (HART) is expected to start operation near the project site.

Two noise metrics were used to evaluate traffic noise impact, based on the intended land or space use, as described below. These metrics are based FTA guidelines, discussed later in this report, but also apply to HUD and FHWA criteria for residential and commercial areas, respectively.

5.3.1 Commercial / Retail Area Noise Evaluation

Commercial / retail areas were evaluated based on the $L_{eq}(h)$ for worst-case peak-hour traffic volumes, which was determined to be PM hour as traffic volumes during this hour exceeded AM traffic volumes in all cases. This metric is used in areas that are typically only occupied during daytime hours.

5.3.2 Multi-Family Area Noise Evaluation

Multi-family areas were evaluated based on L_{dn} noise levels, which takes into account noise levels from both daytime (15-hour average) and nighttime (9-hour average) traffic volumes. Traffic volume data was not available for off-peak hours, and was estimated from the long term noise measurement data discussed above. Traffic volumes for future conditions were based on percentage increases shown in the Traffic Report. The L_{dn} metric is used in areas that are typically occupied during both daytime and nighttime hours, and where people are intended to sleep.

5.3.3 Traffic Noise

The traffic noise analysis was based on the peak hour AM and PM traffic volumes for existing, future without project, and future with project conditions shown in the Traffic Report [Reference 9]. Intersection geometric configurations were also in this report.

5.3.4 Rail Noise

The elevated HART guideway will be routed along Kona Street, and adjacent to the 5th floor of the proposed Hale Kewalo building. To evaluate future rail noise into the residential units, the FTA's "Transit Noise and Vibration Impact Assessment" methodology was used. Additionally, the "Noise and Vibration Technical Report – Honolulu High-Capacity Transit Corridor Project" report [Reference 10] and Addendum 1 of the report [Reference 11] were used in the noise analysis of the building shell for the Hale Kewalo project.

The HART EIS states that no noise impact is expected along the Kona Street / Kapiolani Blvd. residential high-rises adjacent to the project site, and therefore no acoustically absorptive material is planned along the surface of the rail tracks. However, this project was not under design during the noise evaluation for the HART EIS so was not evaluated. Automatic track lubrication system will be not installed near the project site, as this section of track is generally straight and does not contain any significant turns which could result in tire squeal. Lastly, no crossover tracks are expected near the site.

5.3.5 Overall Transportation Noise Impacts on the Surrounding Community

Vehicular traffic noise levels were calculated throughout the surrounding community. In general, traffic noise increases along Waimanu, Piikoi, and Kona Streets due to the project range from 0 dB to 1 dB change, which is not noticeable to the average person. A 3 dB increase is typically the minimum increase required to be perceptible by most listeners

Existing and future traffic noise level projections at the façade of the nearby commercial properties currently approach the FHWA's noise abatement criteria of 72 dBA, but these noise levels will not increase significantly due to the project.

Existing and future traffic noise level projections at adjacent multi-family properties will not increase significantly due to the project.

Existing and future predicted noise levels are shown on Figures 7 and 8.

5.3.6 Overall Transportation Noise Impacts on the Project Site

Existing and future traffic noise level projections at the façade of the project's ground-floor commercial façade are less than the FHWA maximum noise limit of 72 dBA, so typical construction methods will be adequate.

Existing and future noise level projections, including traffic and transit noise, at the multi-family areas range from “acceptable” to “unacceptable” per HUD’s exterior noise design criteria. Based on the existing noise environment and future rail noise projections, rail noise is expected to have a severe impact on the project site. Therefore, upgraded exterior façade elements such as glazing may be required in select areas to comply with the L_{dn} 45 dBA noise criteria inside the units.

Existing and future predicted noise levels are shown in Figures 9 and 10.

5.4 Compliance with HUD Noise Guidelines

The results from the long-term noise measurements conducted at the project site and the transportation noise analysis indicate that the day-night level will be higher than the HUD 65 dBA site acceptability criteria, so a higher STC building shell will be required at the multi-family areas of the project.

It is important to note that the HUD noise guidelines are design goals and not enforceable regulations, although the HUD site acceptability standards must be satisfied for projects involving HUD or federal financing. However, these guidelines and design goals are useful tools for assessing the noise environment.

6.0 NOISE IMPACT MITIGATION

6.1 HDOH Noise Permit

In cases where construction noise exceeds, or is expected to exceed the State’s "maximum permissible" property line noise levels [Reference 1], a permit must be obtained from HDOH to allow the operation of vehicles, cranes, construction equipment, power tools, etc., which emit noise levels in excess of the "maximum permissible" levels.

In order for HDOH to issue a construction noise permit, the contractor must submit a noise permit application to HDOH, which describes the construction activities for the project. Prior to issuing the noise permit, HDOH may require action by the contractor to incorporate noise mitigation into the construction plan. HDOH may also require the contractor to conduct noise monitoring or community meetings inviting the neighboring residents and business owners to discuss construction noise. The contractor should use reasonable and standard practices to mitigate noise, such as using mufflers on diesel and gasoline engines, using properly tuned and balanced machines, etc. However, HDOH may require additional noise mitigation, such as temporary noise barriers, or time of day usage limits for certain kinds of construction activities.

Specific permit restrictions for construction activities [Reference 1] are:

> "No permit shall allow any construction activities which emit noise in excess of the maximum permissible sound levels ... before 7:00 AM and after 6:00 PM of the same day, Monday through Friday."
>
> “No permit shall allow any construction activities which emit noise in excess of the maximum permissible sound levels... before 9:00 AM and after 6:00 PM on Saturday."
>
> “No permit shall allow any construction activities which emit noise in excess of the maximum permissible sound levels on Sundays and on holidays."

Although not anticipated during construction of the housing development, the use of pile drivers, hoe rams and jack hammers 25 pounds (lbs.) or larger, high pressure sprayers, and chain saws are restricted to 9:00 AM to 5:30 PM, Monday through Friday. In addition, construction equipment and on-site vehicles or devices whose operations involve the

exhausting of gas or air, excluding pile hammers and pneumatic hand tools weighing less than 15 pounds (lbs.), must be equipped with mufflers [Reference 1].

The HDOH noise permit does not limit the noise level generated at the construction site, but rather the times at which noisy construction can take place. However, when considering a noise permit application, consideration is also given to any proposed noise mitigation for the project. Therefore, noise mitigation for construction activities should be addressed using project management and the source and path noise control measures discussed in Section 6.3 below.

6.2 HDOH Noise Variance

In cases where nighttime construction is expected, a variance must be obtained from the HDOH to allow the operation of a noise source which emits noise levels in excess of the maximum permissible levels and which operation does not conform to the requirements of the noise permit (i.e., nighttime construction activities which occur between 6:00 p.m. and 7:00 a.m., Monday through Friday). However, nighttime construction is not anticipated for this project so a variance will not be required.

6.3 Mitigation of Project Construction Noise

6.3.1 Mitigation of Noise Source

Mitigating construction noise at the source is the most effective form of noise control. The source control methods listed in Table 5 below can be applied to most construction equipment.

Table 4. Construction Noise Source Control Methods

Scheduling	Limit activities that generate the most noise to less sensitive time periods (e.g. daytime hours).
Substitution	Use quieter methods/equipment when possible (e.g. low noise generators, smaller excavators, etc.).
Exhaust Mufflers	Install quality mufflers on equipment.
Reduced Power Options	Use smallest size and/or lowest power as required.
Quieter Backup Alarms	Install manual adjustable or ambient sensitive alarms. Do not use backup alarms during night work.
Motors	Insulate or enclose motors
Equipment Selection	Electric equipment is quieter than pneumatic equipment
Equipment Retrofit	Rubber chucks in jackhammers
Equipment Maintenance	Sharpen and balance tools, repair silencing equipment, replace worn parts and open airways
Staging Area	Maximize the distance between the construction staging areas and nearby receptors to the greatest extent possible

In general, a majority of the construction noise mitigation is in the form of scheduling, specifically, limiting the construction hours to the time frame specified by the HDOH. The jackhammer is expected to be the most disruptive piece of equipment used during the construction process so the allowable hours of operation are even more restrictive, as described in Section 6.1.

6.3.2 Mitigation of Noise Path

When source control measures are not sufficient to avoid a noise impact, path control measures must be considered. Non-permanent noise barriers or curtains and equipment enclosures could be installed at the construction site to reduce construction noise in noise sensitive locations. The general contractor could also

conduct noise monitoring of construction during noisy or extensive activities at locations close to residential properties.

6.4 Mitigation of HART Construction Noise

HART construction is expected to occur after the Hale Kewalo project is completed and occupied. For details regarding HART construction noise, refer to “Noise and Vibration Technical Report – Honolulu High-Capacity Transit Corridor Project” report [Reference 11].

6.5 Mitigation of Development Noise

6.5.1 Stationary Mechanical Equipment Noise

The design of the Hale Kewalo building should give consideration to controlling the noise emanating from all stationary mechanical equipment such as air-cooled chillers, cooling towers, air-handling units, condensing units, emergency generators, etc. so as to comply with the State of Hawaii Community Noise Control rules [Reference 1]. Noisy equipment should be located away from neighboring properties and residential units as much as possible. Enclosed mechanical rooms may be required for some equipment.

6.5.2 Parking Garage Noise

Noise emanating from the parking garage to the neighboring buildings may be audible and cause complaints. Noise reduction measures such as rough, non-painted driving surfaces and acoustical absorption on the ceiling should be considered during the project’s design phase.

6.6 Mitigation of Transportation Noise on the Development

Units overlooking Kona Street and the future HART guideway will experience relatively high noise levels once the rail begins operation. High STC rated windows in the range of STC 40 – 45 should be considered to comply with the HUD interior noise design criteria, as shown in Figure 11. Smaller window sizes may reduce these STC requirements, assuming that the exterior wall is sufficiently massive.

For unit glazing overlooking Waimanu Street away from the rail guideway, typical 1” IGU glazing will be sufficient to mitigate exterior noise to comply with the HUD interior noise design criteria.

REFERENCES

1. Chapter 46, *Community Noise Control*, Department of Health, State of Hawaii, Administrative Rules, Title 11, September 23, 1996.

2. *Department of Transportation, Federal Highway Administration Procedures for Abatement of Highway Traffic Noise*, Title 23, CFR, Chapter 1, Subchapter J, Part 772, 38 FR 15953, June 19, 1973; Revised at 75 FR 32820, July 13, 2010.

3. *Highway Traffic Noise: Analysis and Abatement Guidance*, U.S. Department of Transportation, Federal Highways Administration, December 2011.

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5. *Department of Housing and Urban Development Environmental Criteria and Standards*, Title 24, CFR, Part 51, 44 FR 40860, July 12, 1979; Amended by 49 FR 880, January 6, 1984.

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9. *Piikoi Affordable Housing – Draft Traffic Evaluation,* Parsons Brinckerhoff, July 2014

10. *Noise and Vibration Technical Report – Honolulu High-Capacity Transit Corridor Project,* Parsons Brinckerhoff, October 2008

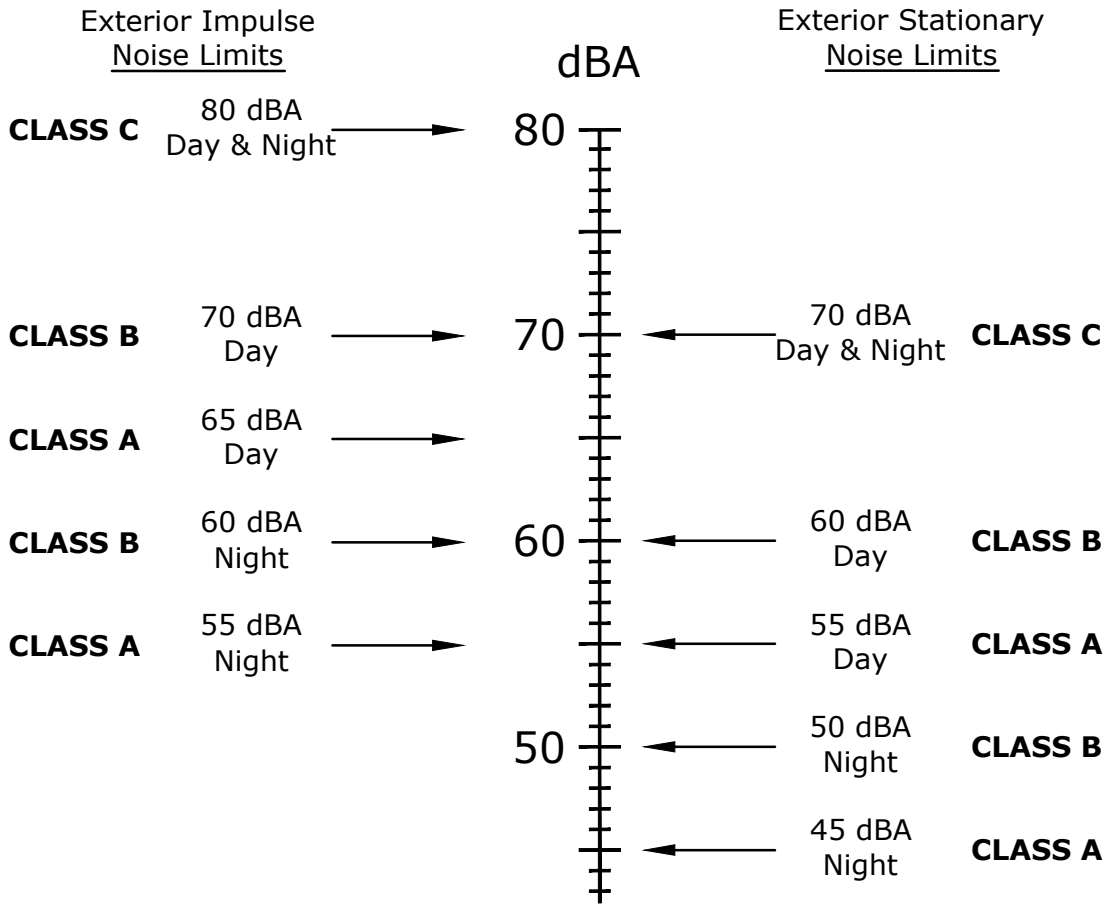
11. *Addendum 01 to the Noise and Vibration Technical Report – Honolulu High-Capacity Corridor Project*, Parsons Brinckerhoff, June 1, 2010

HAWAII DEPARTMENT OF HEALTH MAXIMUM PERMISSIBLE SOUND LEVELS FOR VARIOUS ZONING DISTRICTS

Zoning District	**Day Hours** (7 AM to 10 PM)	**Night Hours** (10 PM to 7 AM)
CLASS A Residential, Conservation, Preservation, Public Space, Open Space	55 dBA (Exterior)	45 dBA (Exterior)
CLASS B Multi-Family Dwellings, Apartments, Business, Commercial, Hotel, Resort	60 dBA (Exterior)	50 dBA (Exterior)
CLASS C Agriculture, Country, Industrial	70 dBA (Exterior)	70 dBA (Exterior)

IMPULSE NOISE:

The maximum permissible noise limit for impulse noise is 10 dBA above the stationary noise limits.



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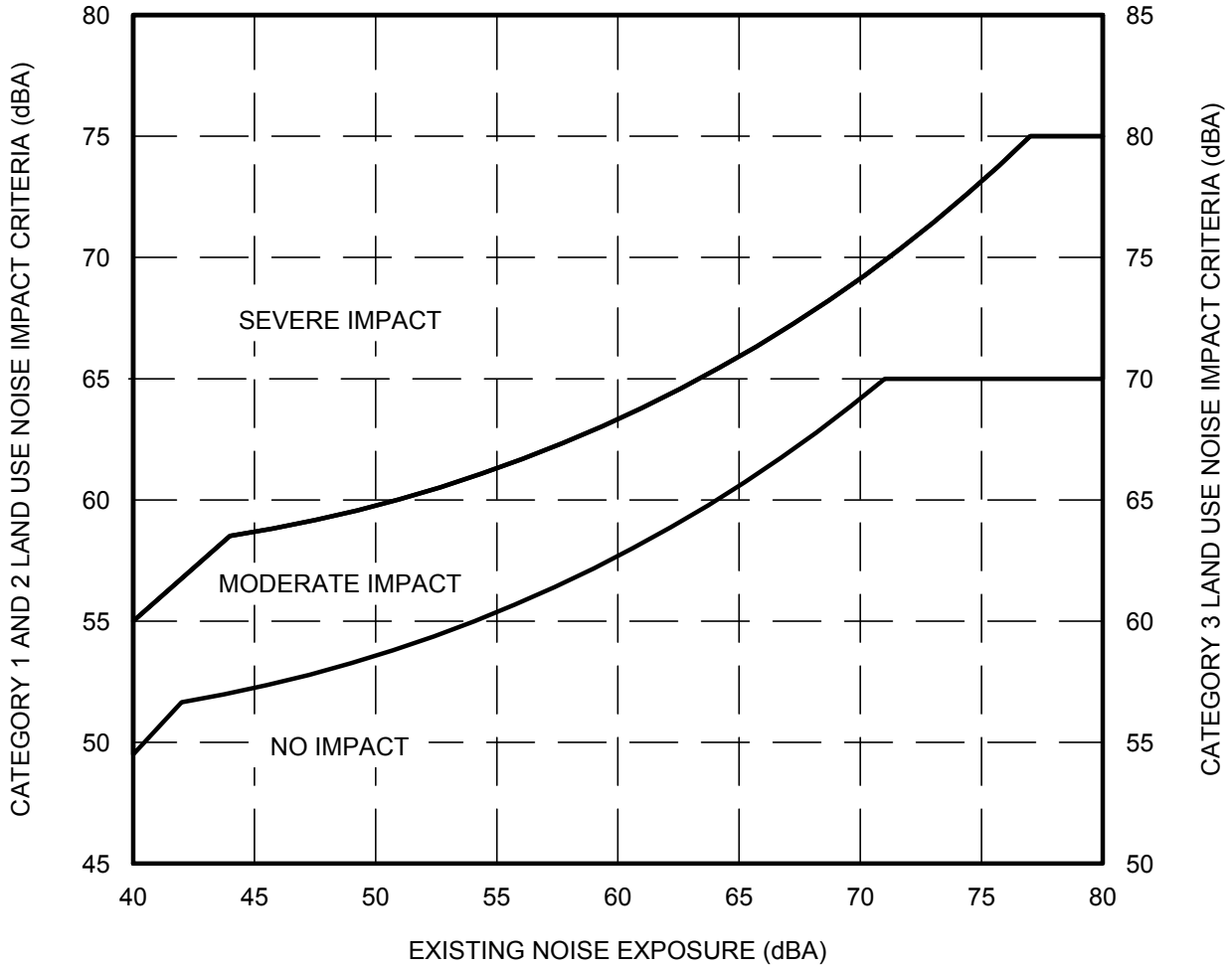
PROJECT:		
Hale Kewalo		
PROJECT NO: 14-34	DATE: October 2014	FIGURE: 1

FEDERAL TRANSIT AUTHORITY (FTA) NOISE IMPACT CRITERIA

LAND USE CATEGORY	Noise Metric (dBA)
CATEGORY 1 Outdoor land areas where a quiet environment is essential to their intended use (e.g. outdoor amphitheaters, historical landmarks, etc.)	Outdoor $L_{eq}(h)$, Daytime Peak Hour
CATEGORY 2 Residences and other buildings where people typically sleep (e.g. hospitals, hotels, etc.)	Outdoor L_{dn}, 24 Hour Avg.
CATEGORY 3 Institutional land uses with primarily daytime and evening uses (e.g. schools, libraries, churches, etc.)	Outdoor $L_{eq}(h)$, Daytime Peak Hour



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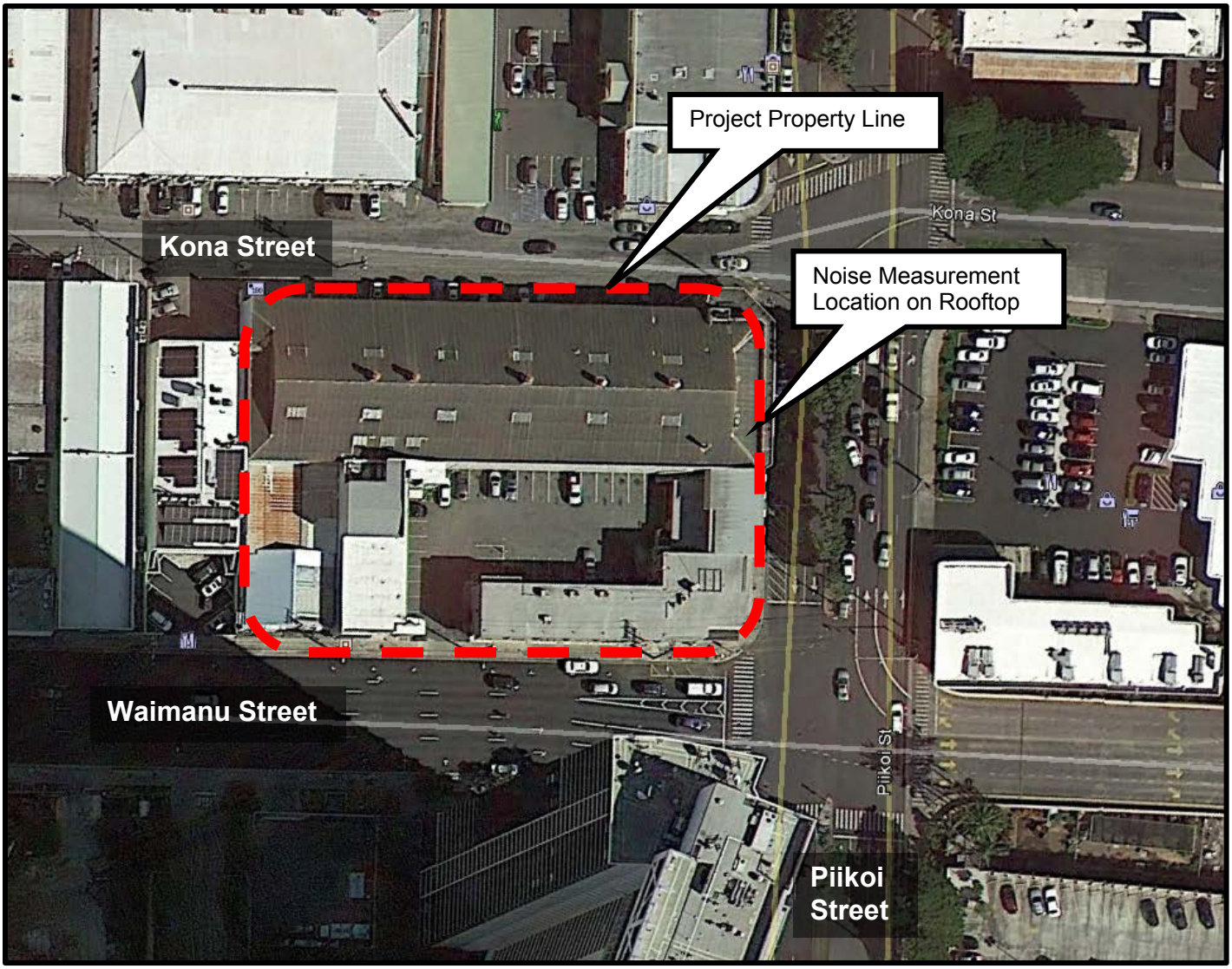
PROJECT:		
Hale Kewalo		
PROJECT NO: 14-34	DATE: October 2014	FIGURE: 2

FEDERAL HIGHWAY ADMINISTRATION NOISE ABATEMENT CRITERIA FOR HIGHWAY NOISE

ACTIVITY CATEGORY	ACTIVITY CATEGORY DESCRIPTION	HOURLY EQUIVALENT SOUND LEVEL L_{eq}
A	LANDS ON WHICH SERENITY AND QUIET ARE OF EXTRAORDINARY SIGNIFICANCE AND SERVE AN IMPORTANT PUBLIC NEED AND WHERE THE PRESERVATION OF THOSE QUALITIES IS ESSENTIAL IF THE AREA IS TO CONTINUE TO SERVE ITS INTENDED PURPOSE.	57 dBA (EXTERIOR)
B	RESIDENTIAL	67 dBA (EXTERIOR)
C	ACTIVE SPORT AREAS, AMPHITHEATERS, AUDITORIUMS, CAMPGROUNDS, CEMETERIES, DAY CARE CENTERS, HOSPITALS, LIBRARIES, MEDICAL FACILITIES, PARKS, PICNIC AREAS, PLACES OF WORSHIP, PLAYGROUNDS, PUBLIC MEETING ROOMS, PUBLIC OR NONPROFIT INSTITUTIONAL STRUCTURES, RADIO STUDIOS, RECORDING STUDIOS, RECREATION AREAS, SECTION 4(F) SITES, SCHOOLS, TELEVISION STUDIOS, TRAILS, AND TRAIL CROSSINGS	67 dBA (EXTERIOR)
D	AUDITORIUMS, DAY CARE CENTERS, HOSPITALS, LIBRARIES, MEDICAL FACILITIES, PLACES OF WORSHIP, PUBLIC MEETING ROOMS, PUBLIC OR NONPROFIT INSTITUTIONAL STRUCTURES, RADIO STUDIOS, RECORDING STUDIOS, SCHOOLS, AND TELEVISION STUDIOS .	52 dBA (INTERIOR)
E	HOTELS, MOTELS, OFFICES, RESTAURANTS/BARS, AND OTHER DEVELOPED LANDS, PROPERTIES OR ACTIVITIES NOT INCLUDED IN A-D OR F.	72 dBA (EXTERIOR)
F	AGRICULTURE, AIRPORTS, BUS YARDS, EMERGENCY SERVICES, INDUSTRIAL, LOGGING, MAINTENANCE FACILITIES, MANUFACTURING, MINING, RAIL YARDS, RETAIL FACILITIES, SHIPYARDS, UTILITIES (WATER RESOURCES, WATER TREATMENT, ELECTRICAL), AND WAREHOUSING	N/A
G	UNDEVELOPED LANDS THAT ARE NOT PREMITTED	N/A

PROJECT SITE OVERVIEW AND NOISE MEASUREMENT LOCATION



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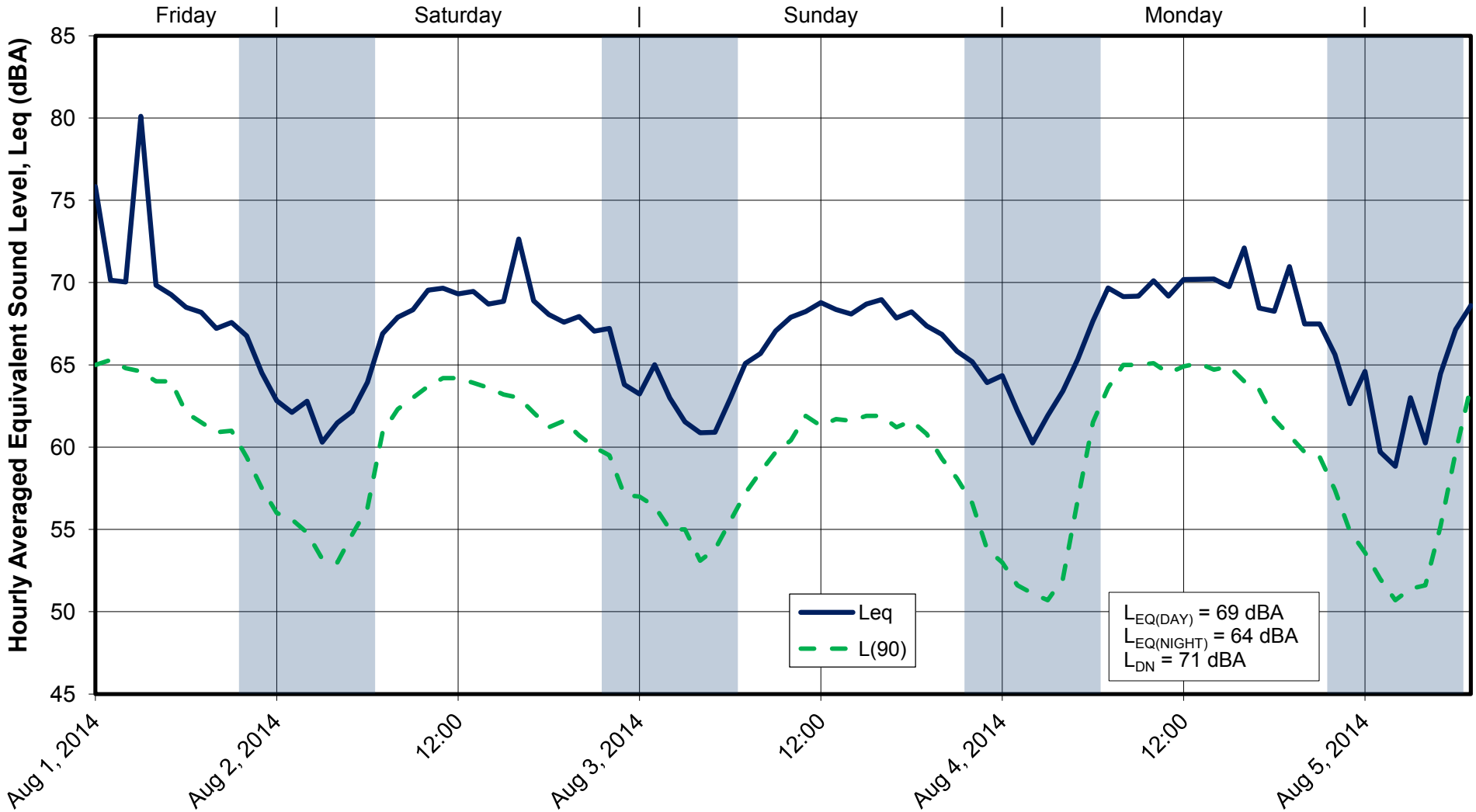
	PROJECT NO: 14-34	DATE: October 2014	FIGURE: 4

Project Site Noise Measurement



Date & Time of Measurement

L_{eq}: Equivalent Sound Level - Logrithmic average of sound levels of time.
L_{90}: Ambient Noise Level: Highest noise level exceeded 90% of each hourly recording.

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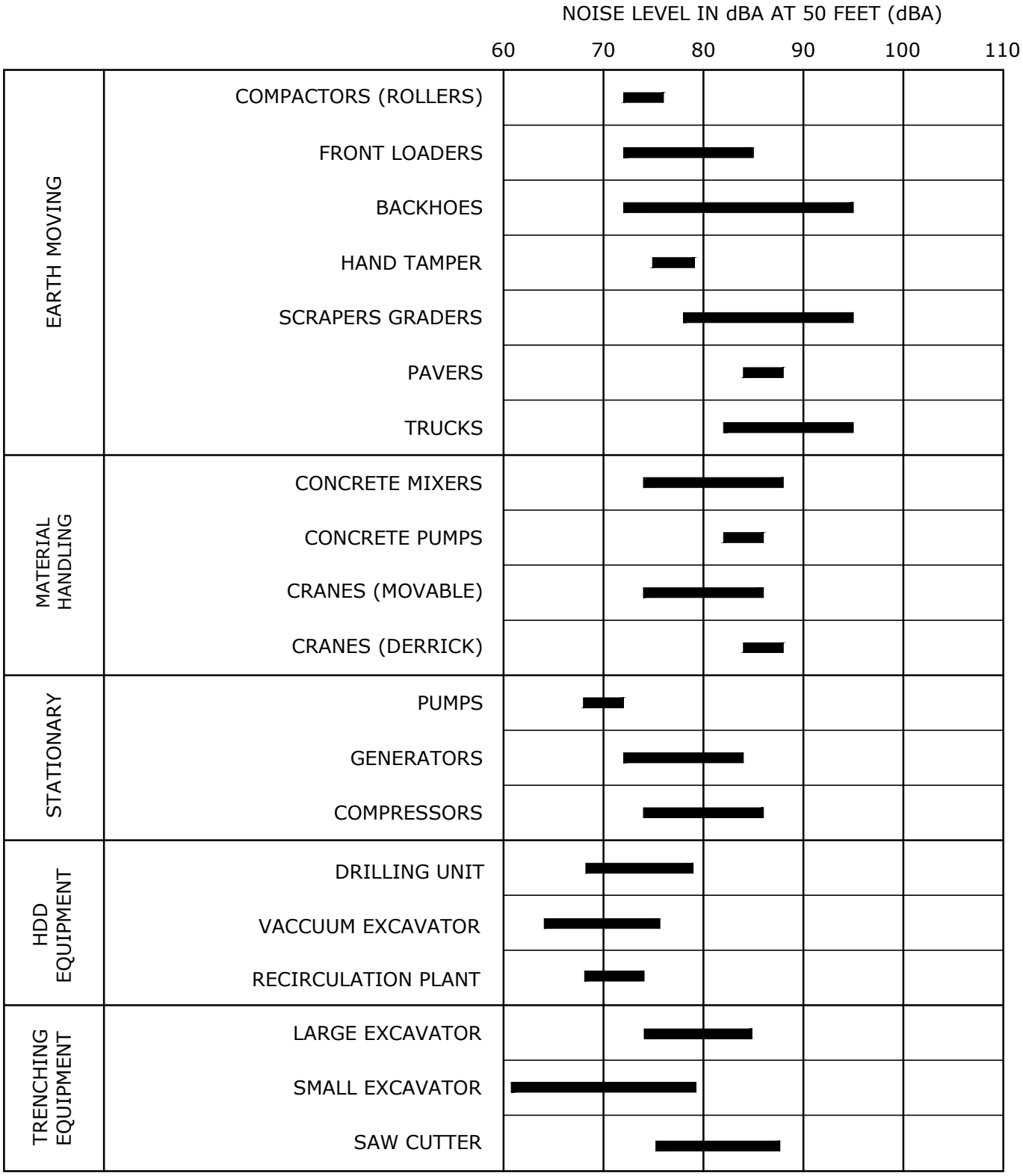
TYPICAL NOISE LEVELS FROM CONSTRUCTION EQUIPMENT



NOTE: BASED ON LIMITED AVAILABLE DATA SAMPLES

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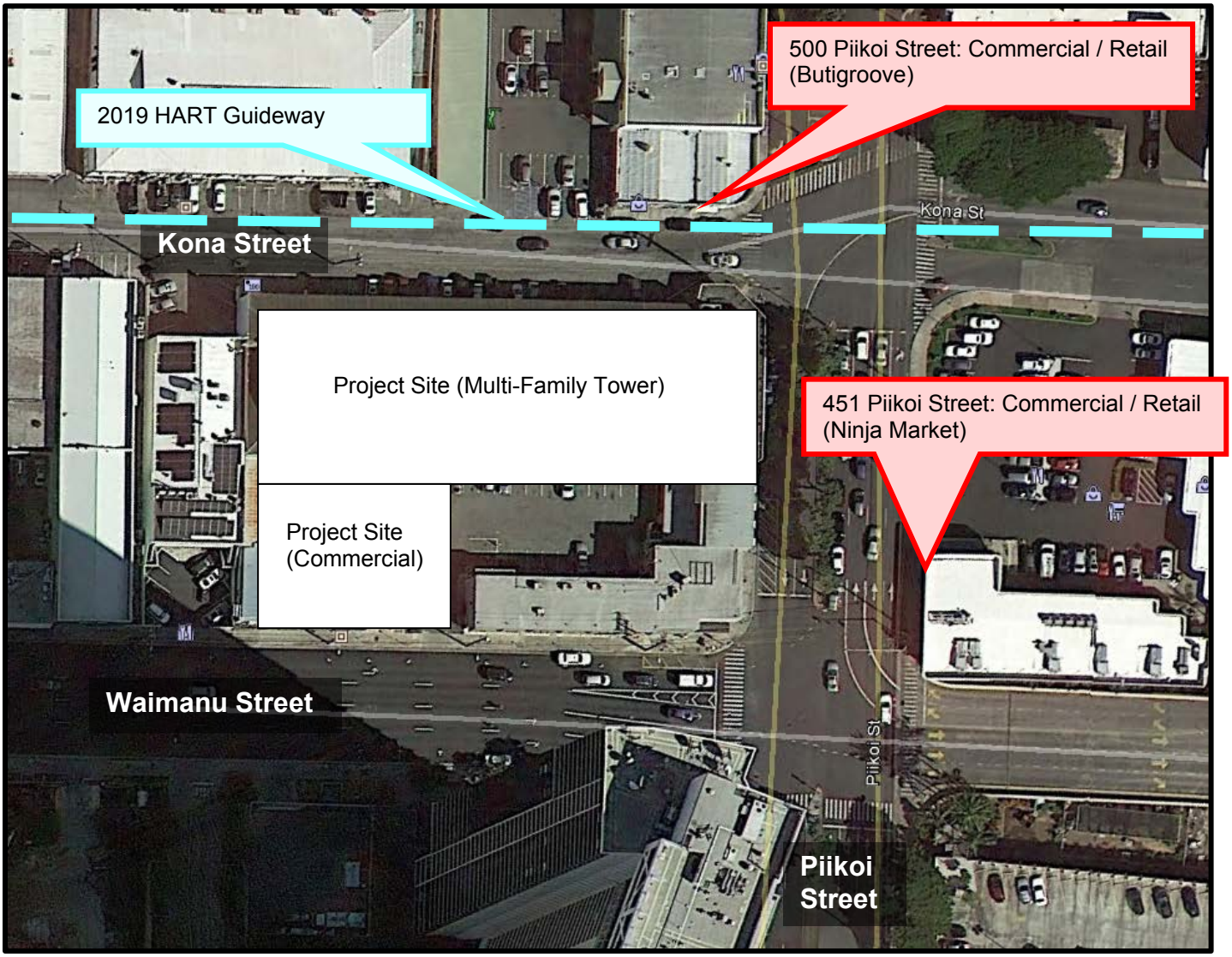
PROJECT:		
Hale Kewalo		
PROJECT NO: 14-34	DATE: October 2014	FIGURE: 6

TRANSPORTATION NOISE IMPACT ON SURROUDING COMMERCIAL PROPERTIES (PEAK HOUR L_{EQ})



Year	w/ Project	500 Piikoi Street, Ground Level	451 Piikoi Street, Ground Level
Existing		65 dBA	71 dBA
2017		64 dBA	71 dBA
2017	X	65 dBA	71 dBA
2017 Change Due to Project		1 dB	0 dB

Note: Noise predictions for 2017 include traffic noise only. HART is expected to start operation on this section of guideway in 2019.

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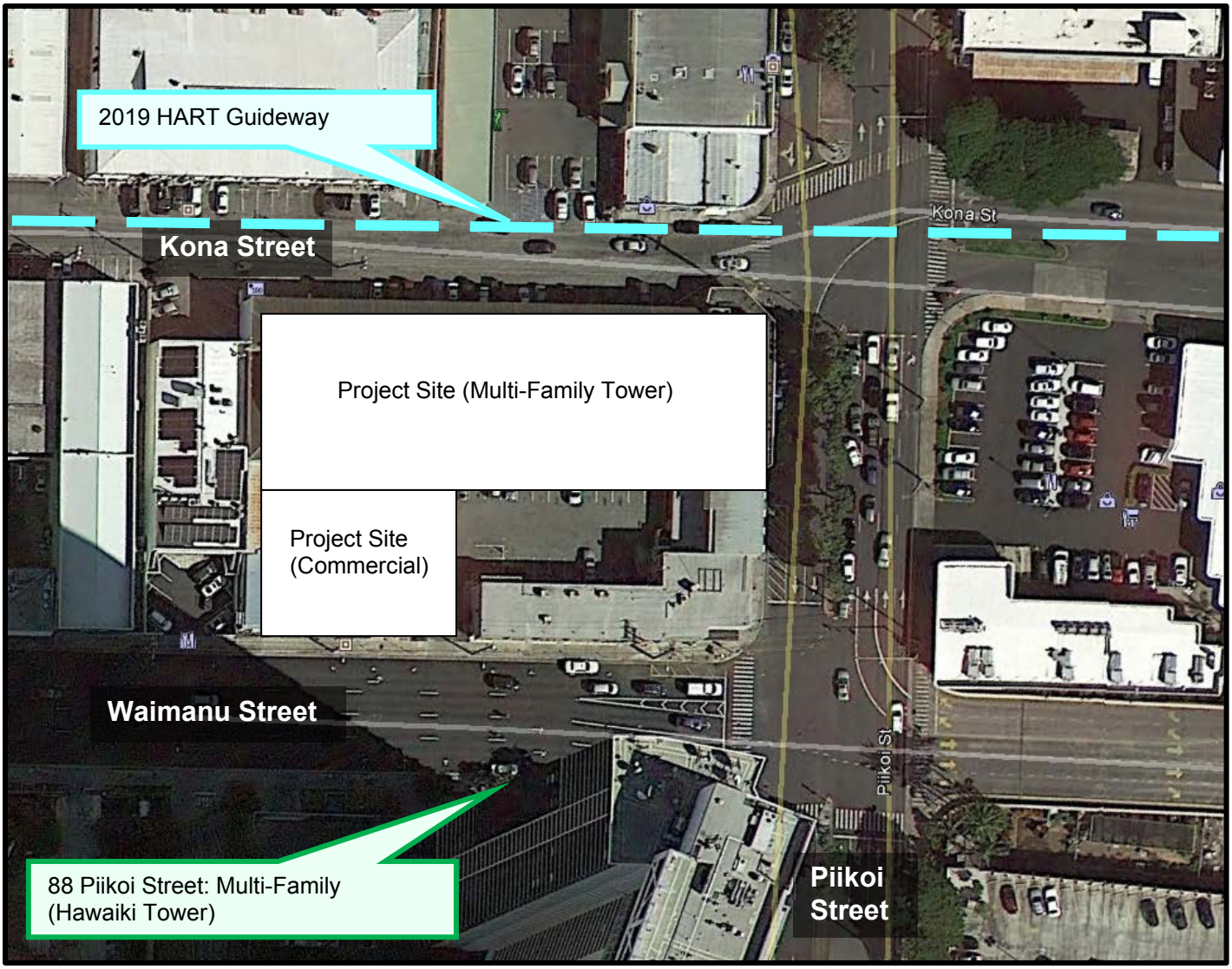
TRANSPORTATION NOISE IMPACT ON SURROUDING MULTI-FAMILY PROPERTIES (24-HOUR L_{DN})



Year	w/ Project	88 Piikoi Street, 2nd Level	88 Piikoi Street, Penthouse Level
Existing		66 dBA	55 dBA
2017		66 dBA	55 dBA
2017	X	67 dBA	55 dBA
2017 Change Due to Project		1 dB	0 dB

Note: Noise predictions for 2017 include traffic noise only. The Honolulu Rail is expected to start operation on this section of guideway in 2019.

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PROJECT:		
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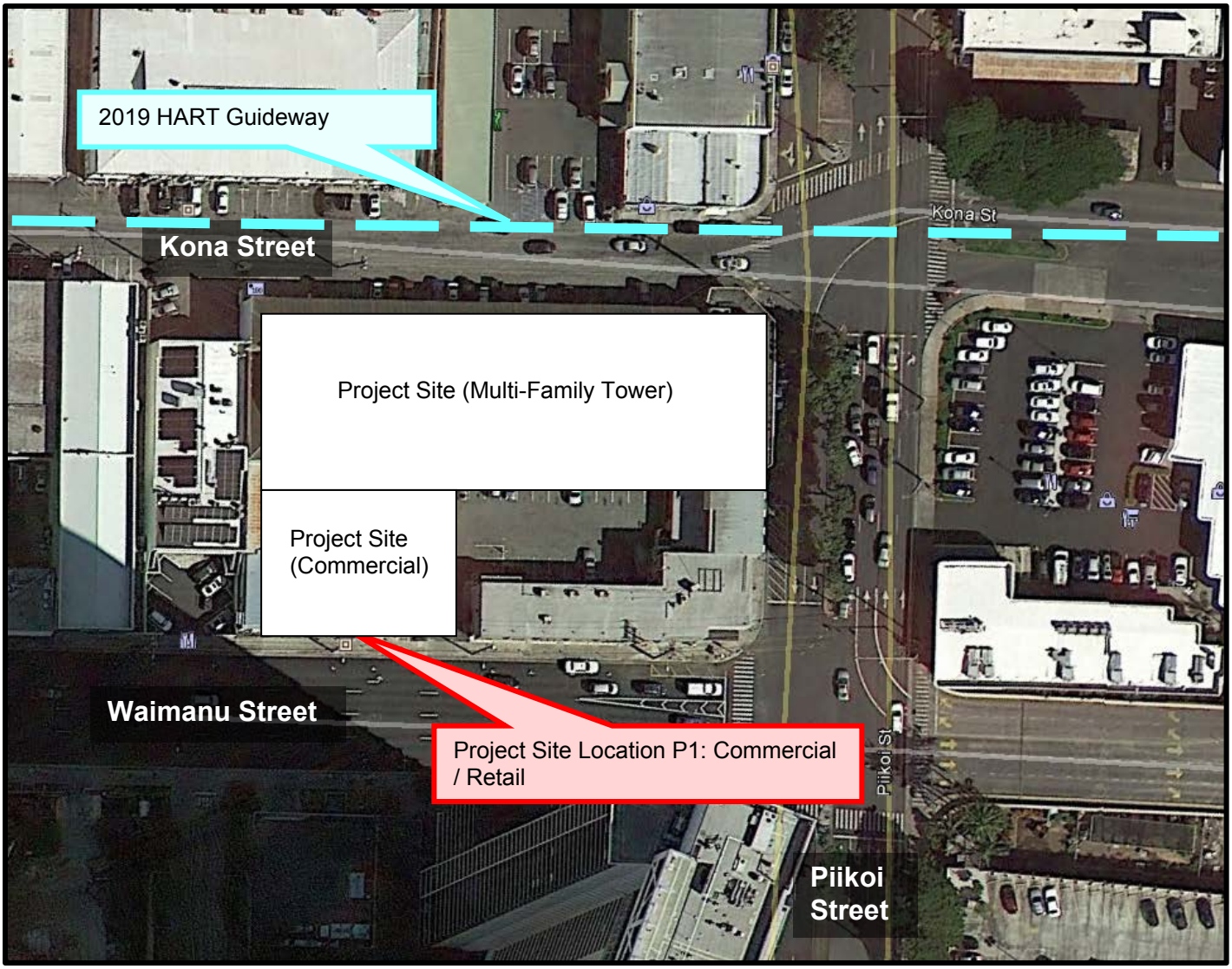
TRANSPORTATION NOISE IMPACT ON PROJECT COMMERCIAL AREAS (PEAK HOUR L_{EQ})



Year	w/ Project	w/ Rail	Project Site Location P1, Ground Level
Existing			69 dBA
2017	X		70 dBA
2019	X	X	70 dBA

Note: Noise predictions for 2017 include traffic noise only. HART is expected to start operation on this section of guideway in 2019.

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PROJECT:		
Hale Kewalo		
PROJECT NO:	DATE:	FIGURE:
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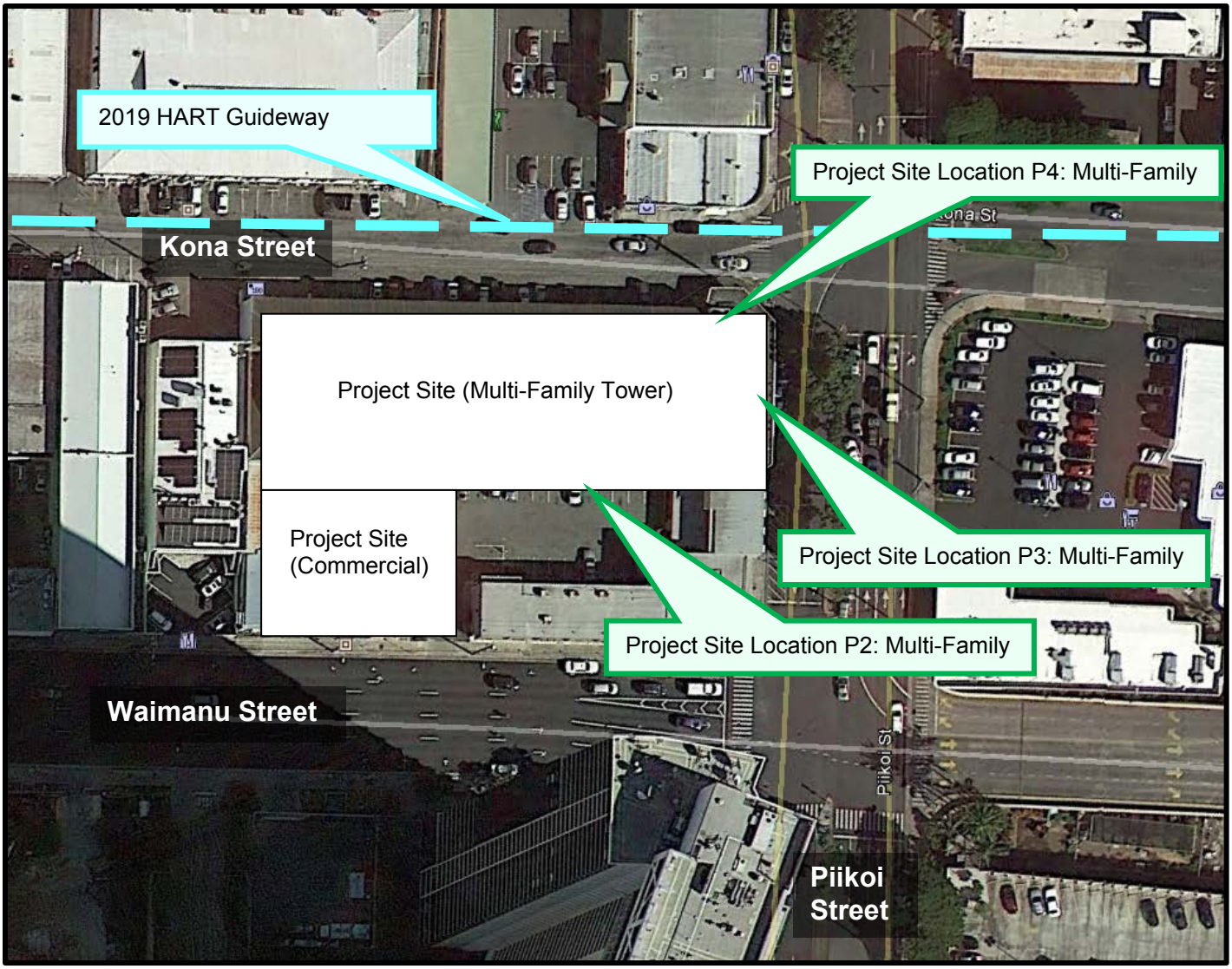
TRANSPORTATION NOISE IMPACT ON PROJECT MULTI-FAMILY AREAS (24-HOUR L_{DN})



Year	w/ Project	w/ Rail	Project Site Location P2, 3rd Level	Project Site Location P3, 2nd Level	Project Site Location P4, 5th Level
Existing			59 dBA	67 dBA	64 dBA
2017	X		60 dBA	67 dBA	64 dBA
2019	X	X	60 dBA	73 dBA	77 dBA

Note: Noise predictions for 2017 include traffic noise only. HART is expected to start operation on this section of guideway in 2019.

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PROJECT:		
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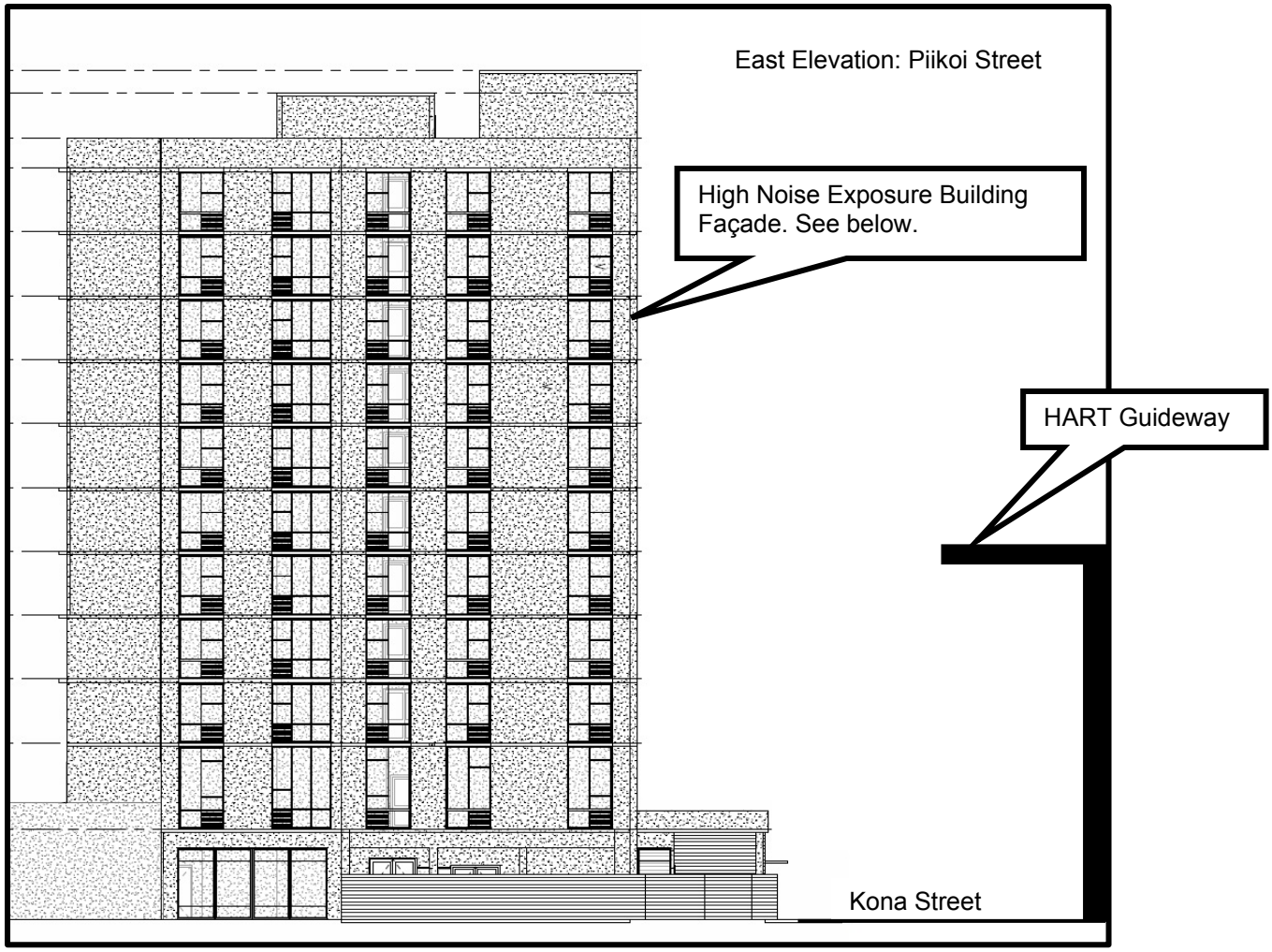
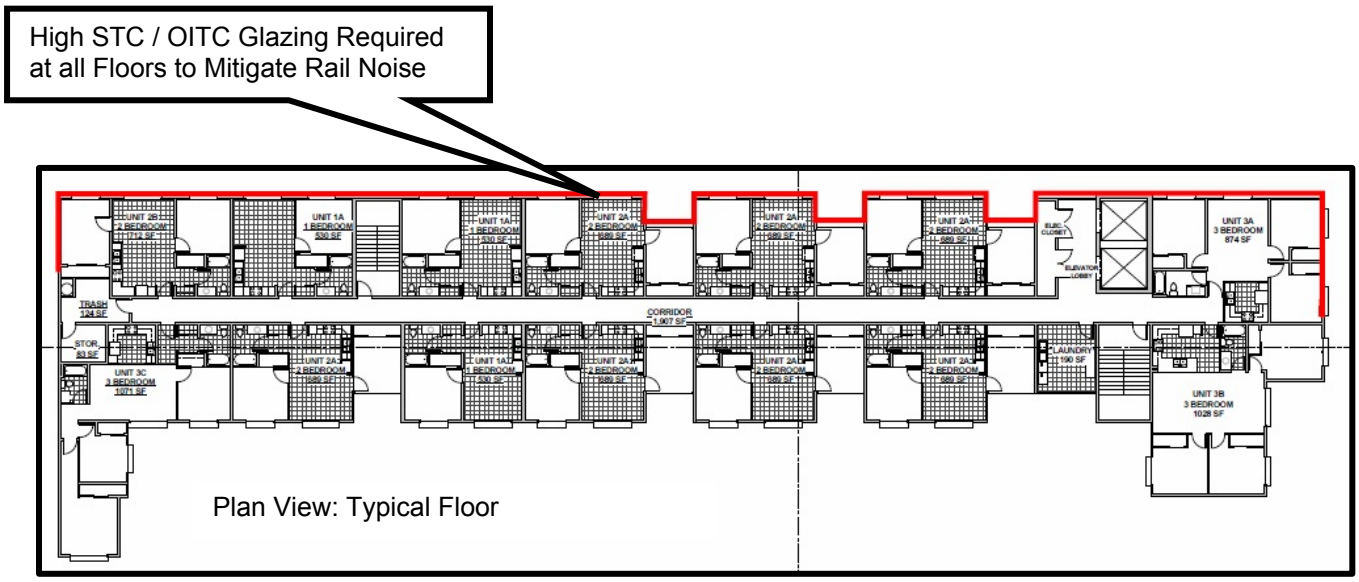
MITIGATION OF RESIDENTIAL UNITS EXPOSED TO RAIL NOISE





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	PROJECT NO: 14-34	DATE: October 2014	FIGURE: 11

APPENDIX A

Acoustic Terminology

Acoustic Terminology

Sound Pressure Level

Sound, or noise, is the term given to variations in air pressure that are capable of being detected by the human ear. Small fluctuations in atmospheric pressure (sound pressure) constitute the physical property measured with a sound pressure level meter. Because the human ear can detect variations in atmospheric pressure over such a large range of magnitudes, sound pressure is expressed on a logarithmic scale in units called decibels (dB). Noise is defined as Aunwanted@ sound.

Technically, sound pressure level (SPL) is defined as:

$$SPL = 20 \log (P/P_{ref}) \text{ dB}$$

where P is the sound pressure fluctuation (above or below atmospheric pressure) and P_{ref} is the reference pressure, 20 µPa, which is approximately the lowest sound pressure that can be detected by the human ear. For example:

If P = 20 µPa, then SPL = 0 dB
If P = 200 µPa, then SPL = 20 dB
If P = 2000 µPa, then SPL = 40 dB

The sound pressure level that results from a combination of noise sources is not the arithmetic sum of the individual sound sources, but rather the logarithmic sum. For example, two sound levels of 50 dB produce a combined sound level of 53 dB, not 100 dB. Two sound levels of 40 and 50 dB produce a combined level of 50.4 dB.

Human sensitivity to changes in sound pressure level is highly individualized. Sensitivity to sound depends on frequency content, time of occurrence, duration, and psychological factors such as emotions and expectations. However, in general, a change of 1 or 2 dB in the level of sound is difficult for most people to detect. A 3 dB change is commonly taken as the smallest perceptible change and a 6 dB change corresponds to a noticeable change in loudness. A 10 dB increase or decrease in sound level corresponds to an approximate doubling or halving of loudness, respectively.

A-Weighted Sound Level

Studies have shown conclusively that at equal sound pressure levels, people are generally more sensitive to certain higher frequency sounds (such as made by speech, horns, and whistles) than most lower frequency sounds (such as made by motors and engines)[1] at the same level. To address this preferential response to frequency, the A-weighted scale was developed. The A-weighted scale adjusts the sound level in each frequency band in much the same manner that the human auditory system does. Thus the A-weighted sound level (read as "dBA") becomes a single number that defines the level of a sound and has some correlation with the sensitivity of the human ear to that sound. Different sounds with the same A-weighted sound level are perceived as being equally loud. The A-weighted noise level is commonly used today in environmental noise analysis and in noise regulations. Typical values of the A-weighted sound level of various noise sources are shown in Figure A-1.

[1] D.W. Robinson and R.S. Dadson, AA Re-Determination of the Equal-Loudness Relations for Pure Tones,@ *British Journal of Applied Physics*, vol. 7, pp. 166 - 181, 1956. (Adopted by the International Standards Organization as Recommendation R-226.

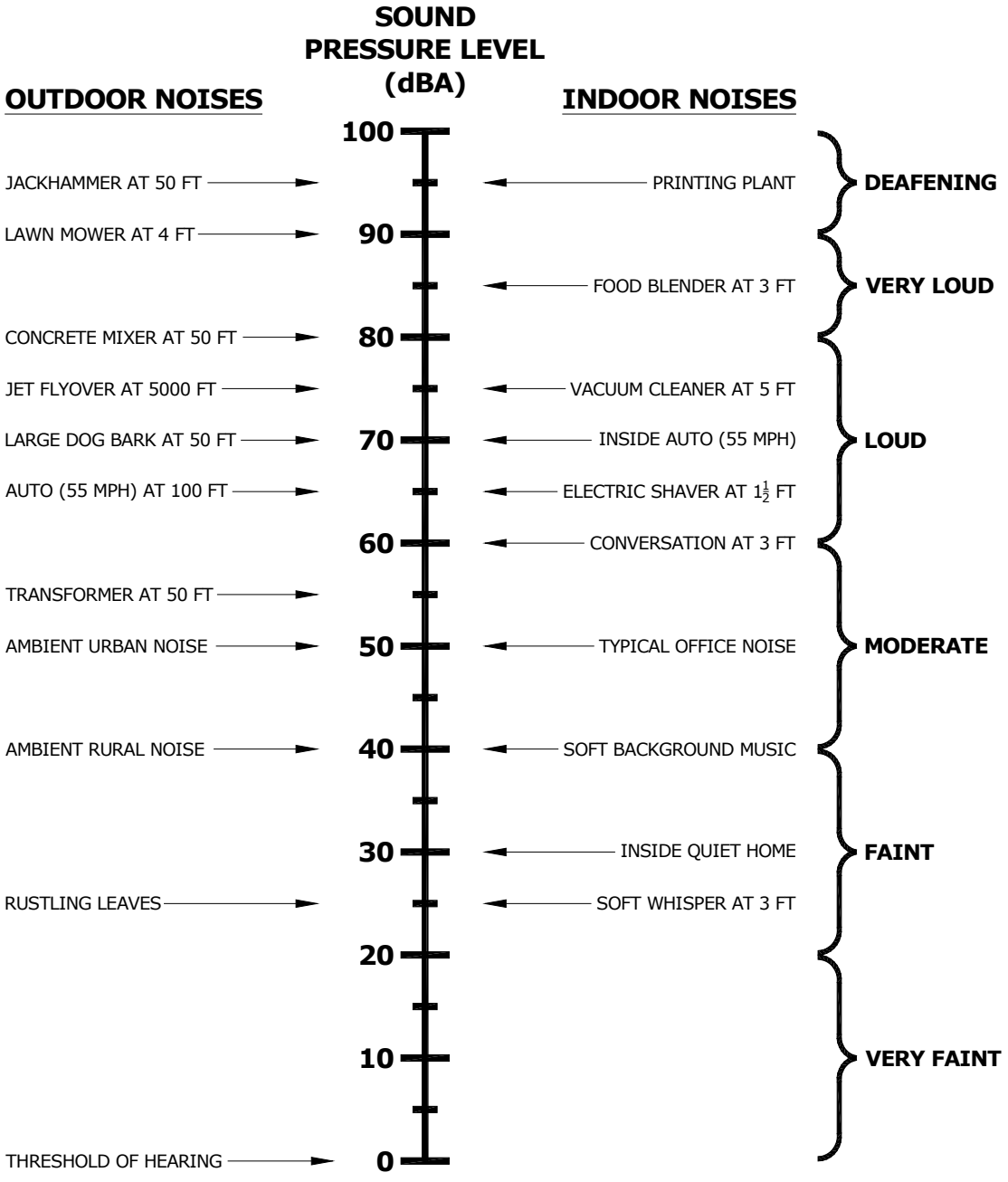


Figure A-1. Common Outdoor/Indoor Sound Levels

Equivalent Sound Level

The Equivalent Sound Level (L_{eq}) is a type of average which represents the steady level that, integrated over a time period, would produce the same energy as the actual signal. The actual *instantaneous* noise levels typically fluctuate above and below the measured L_{eq} during the measurement period. The A-weighted L_{eq} is a common index for measuring environmental noise. A graphical description of the equivalent sound level is shown in Figure A-2.

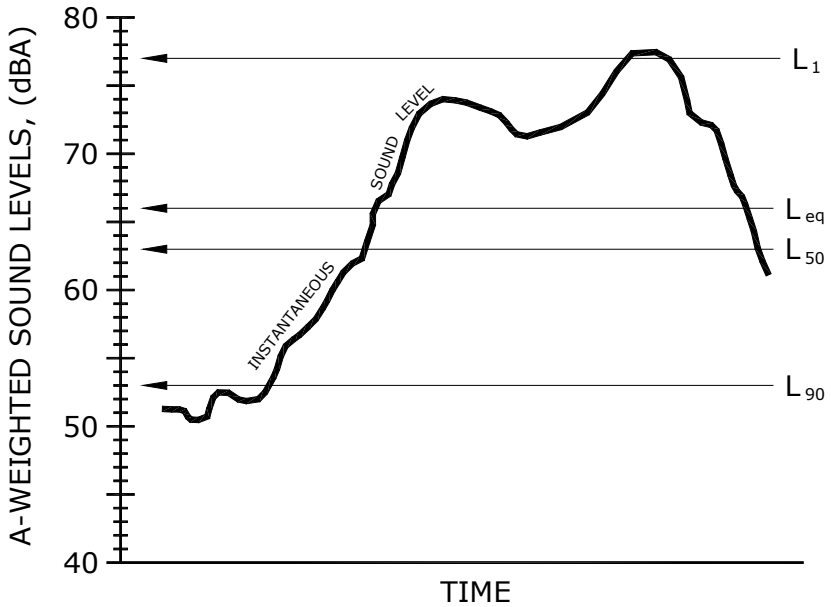


Figure A-2. Example Graph of Equivalent and Statistical Sound Levels

Statistical Sound Level

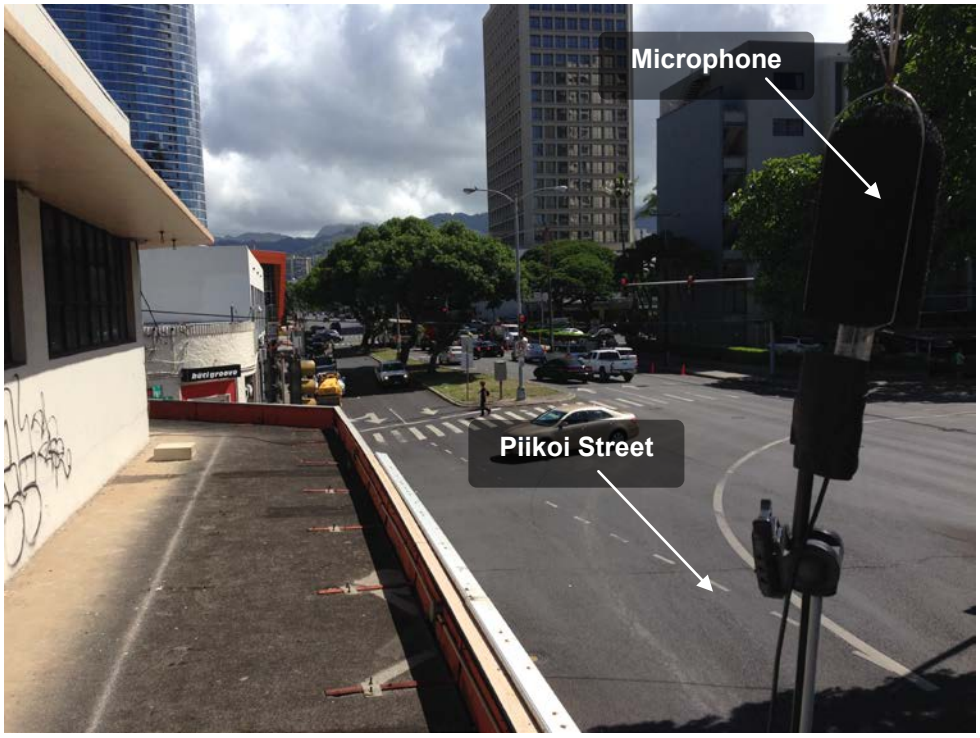
The sound levels of long-term noise producing activities such as traffic movement, aircraft operations, etc., can vary considerably with time. In order to obtain a single number rating of such a noise source, a statistically-based method of expressing sound or noise levels has been developed. It is known as the Exceedence Level, L_n. The L_n represents the sound level that is exceeded for n% of the measurement time period. For example, L_{10} = 60 dBA indicates that for the duration of the measurement period, the sound level exceeded 60 dBA 10% of the time. Typically, in noise regulations and standards, the specified time period is one hour. Commonly used Exceedence Levels include L_{01}, L_{10}, L_{50}, and L_{90}, which are widely used to assess community and environmental noise. A graphical description of the equivalent sound level is shown in Figure A-2.

Day-Night Equivalent Sound Level

The Day-Night Equivalent Sound Level, L_{dn}, is the Equivalent Sound Level, L_{eq}, measured over a 24-hour period. However, a 10 dB penalty is added to the noise levels recorded between 10 p.m. and 7 a.m. to account for people's higher sensitivity to noise at night when the background noise level is typically lower. The L_{dn} is a commonly used noise descriptor in assessing land use compatibility, and is widely used by federal and local agencies and standards organizations.

APPENDIX B

Photographs at Project Site

Location L1

Microphone mounted on tripod on building rooftop, approximately 20-feet above grade.