MĀ‘ILI‘ILI
WATERSHED MANAGEMENT PLAN

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Appendices
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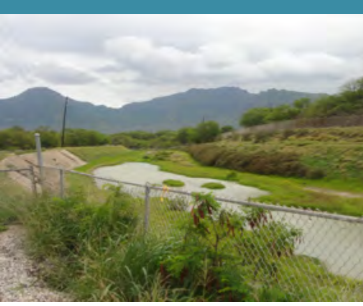


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APPENDIX A

Water Quality Standards and Testing

Note: Information in this appendix is roughly adapted from NOAA's Wahikuli-Honokōwai Watershed Management Plan [103] and supplemented with information from Ertrud and Mirza's book "Water Quality" [44]

Water Quality Standards

As mandated by the Code of Federal Regulations and the Clean Water Act, the States are required to adopt water quality standards to protect public health and welfare and enhance water quality in U.S. waters. The water quality standards for Hawai'i waters are regulated by HAR Chapter §11-54. State waters are classified as either inland waters or marine waters with specific water quality criteria for streams, estuaries, embayments, open coastal waters and oceanic waters. For the Mā'ili'ili Watershed, criteria for all except embayments are potentially applicable. "Streams" means seasonal or continuous water flowing unidirectionally down altitudinal gradients in all or part of natural or modified channels as a result of either surface water runoff or ground water influx, or both. Streams may be either perennial or intermittent and include all natural or modified watercourses. "Estuaries" means characteristically brackish coastal waters in well-defined basins with a continuous or seasonal surface connection to the ocean that allows entry of marine fauna. Estuaries may be either natural or developed. "Embayments" means land-confined and physically-protected marine waters with restricted openings to open coastal waters, defined by the ratio of total bay volume to the cross-sectional entrance area of seven hundred to one or greater. "Open coastal waters" means marine waters bounded by the 183 meter or 600 foot (100 fathom) depth contour and the shoreline, excluding bays named in subsection (a) of HAR Chapter §11-54-6. "Oceanic waters" means all other marine waters outside of the 180 meter or 600 foot (100 fathom) depth contour. Many of the water quality criteria are expressed as geometric means (average) of a whole data set, and are not intended for comparison with single sample values. The criteria also contain allowances for rainfall events in the form of less strict "10 percent" and "2 percent" criteria. The "not to exceed the given value 10% of the time" means that the standard is exceeded if greater than 10% of the samples are higher than the appropriate standard for the season of interest. A sample size of 50 to 90 to show exceedance of the corresponding "10% of the time" criterion is preferred by DOH. The "not to exceed the given value 2% of the time" means that the standard is exceeded if greater than 2% of the samples are higher than the appropriate standard for the season of interest. A sample size of 250 to 450 to show exceedance of the corresponding "2% of the time" criterion is preferred. Hawai'i's water quality standard categories are further refined by inclusion of a wet or dry criterion. The wet season is November 1 through April 30 and the dry season is May 1 through October 31. Water Quality Standard tables are found at the end of this appendix.

Understanding Water quality: Physical, chemical and biological indicators

Water quality can be separated by physical, chemical and biological parameters. Water quality impairments can come from both natural and anthropogenic inputs. Results of water quality testing are analyzed holistically because some physical, chemical, and biological pollutants have a synergistic relationship. For example, influx of agricultural runoff may introduce fertilizers into a waterbody. The increased nutrient content may result in an algal bloom which leads to a rapid increase in plant biomass, followed by a rapid plant die-off. The aerobic decomposition of the dead plant matter results in an increase in the biological oxygen demand (BOD) in the water and increased levels of suspended solids. The excessive oxygen consumption by the decomposing bacteria results in a decrease in dissolved oxygen (DO) in the water column, making it difficult for other aquatic organisms to survive. This process is known as "eutrophication".

There are various water quality indicators that are tested for water quality analyses, some of which are specifically regulated by water quality standards. Levels of these parameters may fluctuate naturally with time and space, or unnaturally due to anthropogenic pollutants [(44)]. Some of the most common indicators used in Hawai'i are listed below.

Physical Water Quality Parameters:

Temperature: Temperature varies naturally based on daytime and season. However, there are certain temperature ranges that are healthy for an aquatic ecosystem. If the temperature falls below or above that range, it affects the biological activity in that ecosystem. Wastewater effluent, runoff and other discharges can affect the temperature of a waterbody.

Total suspended solids (TSS): This is a measurement of particulate matter in the water. Water samples are filtered and the weight of the remaining particulates provides a measurement of particulate matter in the water column.

Turbidity: This parameter is linked to many things, e.g. directly to the amount of TSS in the water. Turbidity is a measure of water clarity. It is measured in "Nephelometric Turbidity Units" or NTU which is a measurement of how light is scattered by particulates in the water. Turbid waters can be caused by sediments, phytoplankton and other particulates. High turbidity reduces light penetration which affects plant photosynthesis. Settling particulates can also kill hatching larvae and clog fish gills.

Electrical conductivity: This measurement is an estimate of the total dissolved ions/minerals in the water and varies naturally depending on the geology and other factors in a watershed. Electrical conductivity measurements can help determine possible pollution problems in the water as various pollutants from wastewater, agricultural and urban runoff may cause an increase in electrical conductivity.

Clorophyll a: This measures the amount of chlorophyll, the cell component of plants that makes them green. This measurement is an indirect way of estimating plant (algae) biomass in the water.

Stream flow: Stream flow is a measure of water velocity. It is subject to seasonal variation. Stream flow has a direct effect on several water quality parameters as it affects temperature, DO and the distribution of various substances. It can also potentially alter habitat. Problems can arise during storm events when heavy rainfall causes high velocity and streambank erosion, which in turn affects the amount of TSS and turbidity. It can also physically damage habitat. Stormwater runoff is a contributor to variable flows which can negatively impact aquatic ecosystems.

Chemical Water Quality Parameters:

pH: pH is a measurement of Hydrogen ions and refers to a liquid's level of acidity or alkalinity. It is presented on a logarithmic scale of 0-14, with levels lower than 7 meaning acidic and levels higher than 7 meaning alkaline. pH has a direct effect on the solubility and biological availability of nutrients and toxic metals. Lower pH levels make toxic metals more soluble. pH is extremely important in water quality due to these synergistic effects.

Dissolved oxygen (DO): This is the amount of oxygen in the water column. In order for an aquatic ecosystem to be balanced, there are certain DO levels required to sustain aquatic organisms. If the level of DO is unusually low, this could indicate an unbalanced state such as eutrophication, where excess plant matter and its decomposition has caused a hypoxic environment.

Biological oxygen demand (BOD): BOD is an indirect measure of organic pollution. It measures the amount of DO needed for aerobic bacteria to decompose the organic material in a given water sample. If the BOD is high, this can point towards an increase in plant matter so this is an indirect indicator of eutrophication.

Salinity: Salinity measures the amount of salt in the water and is generally used in estuaries and coastal waters. There are certain salinity levels that are healthy for certain ecosystems and an influx of freshwater into estuaries or the ocean can have a negative impact on the aquatic organisms. Even treated wastewater, when directly released into the ocean, is sometimes considered pollution not just because of the nutrients and bacteria, but because of the dilution it causes in the seawater.

Nitrogen: Nitrogen is naturally present in all living and many non-living things. It makes up 78% of air. Since Nitrogen is a very important plant nutrient, it is most commonly used in chemical fertilizers. Nutrient pollution from Nitrogen and Phosphorus are one of the leading causes of water quality degradation. Through a complex Nitrogen cycle, this chemical compound can exist in and be converted into multiple different states. To assess nutrient contamination in water, testing for Nitrogen can be done for the various Nitrogen compounds created during the Nitrogen cycle. Testing parameters include Total Nitrogen, Nitrate + Nitrite, and Ammonia Nitrogen.

Phosphorus: Phosphorus is a natural mineral present in the terrestrial environment, primarily rocks and soils. It is an important plant food and along with Nitrogen is used extensively for chemical fertilization, leading to excessive aquatic plant growth when agricultural runoff enters waterbodies. The parameter tested is Total Phosphorus.

Biological Water Quality Parameters

Biological water quality refers to microbial and infectious organisms, which can come from a variety of sources within a watershed. Common causes of bacteria and other microbes in fresh and saltwater are animal fecal matter from feral ungulates, birds and livestock and human fecal matter from leaking cesspools/septic tanks or wastewater seepage from underground injection wells. Microbial contamination is an environmental health concern as different types of bacteria such as *Giardia, Cryptosporidium and Staphylococcus* can transmit disease and cause infections in humans. Transmission of waterborne diseases is through contact with contaminated water or ingestion [(94) (95)]. Pathogens are the second most common water quality impairment in the U.S. The increased interaction of humans and domestic and feral animals is also stimulating the evolution of new pathogens that have crossed the species boundary (e.g. avian flu). Testing for bacterial contamination can be difficult.

Pollutants from sewage-related sources are both an environmental issue and a public health concern, since sewage can contain harmful pathogens that cause a variety of illnesses in humans. Sewage can affect ocean and freshwater systems through point and non-point sources [(44)]. To decide whether coastal waters are safe for swimmers, Hawai‘i DOH monitors bacteria levels in ocean waters [(101)]. There are multiple disease-causing agents that can be present in sewage and it is unfeasible to test for each one. Therefore, agencies throughout the world, including the World Health Organization, EPA, and DOH, use fecal indicator bacteria to determine if sewage contamination is present. Past indicators include fecal coliform and *Escherichia coli* (*E. coli*). In 1988, the Federal standard for assessing marine water health risks officially became bacteria of the genus *Enterococcus*. Indicator bacteria are not pathogens themselves, but rather they are bacteria naturally present in the feces of warm-blooded birds and mammals. Finding high levels of *enterococci* in water is an indicator that fecal contamination may have occurred near the testing site. EPA established *enterococci* as an indicator because studies over many years have shown a positive correlation between high levels of *enterococci* and gastrointestinal illnesses caused by sewage-related bacteria and viruses. *Enterococci* is also used due to it being a good indicator in saltwater. *Enterococci* die off in the water column at about the same rate, making it a useful tool in determining when waters are swimmable. The Federal standard for *enterococci* is set at 35 CFU/100ml for marine waters and 33 CFU/100ml for fresh waters. The current standards used to determine safe swimming conditions in Hawaiʻi are: Inland waters – 33 CFU/100ml in five or more samples, single sample maximum 89 CFU/100ml; Coastal waters within 300m of the shore – 35 CFU/100 ml in five or more samples, single sample maximum 104 CFU/100ml (HAR §11-54). One important consideration is that *enterococci* have also been found to naturally occur in Hawaiian soils where they are able to survive longer than in water (up to 28 days in laboratory conditions). In the event of heavy rains, streambank erosion can cause increased levels of *enterococci* in streams and the ocean that are not from a sewage-related source. Therefore, *enterococci* is not an ideal indicator to use in Hawaiʻi and DOH is working on identifying other indicator organisms [(110)]. To address the issues of soil presence, DOH has developed a "toolbox approach" to further narrow down whether elevated levels of *enterococci* are related to sewage. To do this, they test for additional organisms (i.e. *Clostridium perfringens*) when *enterococci* levels are high. Although these organisms are not officially recognized by EPA as indicators, DOH-CWB is allowed to use them as a secondary indicator to trace human sewage [(101)]. Other modern tools used by scientists in the past few years have been DNA markers to trace contaminated waters by their fecal source, e.g. pig, human or ruminant [(100)].

Hawaiʻi State Water Quality Standard Tables:

Toxic Pollutants (micrograms per liter) - Applicable to ALL WATERS

	Freshwater		Saltwater		
Pollutant	Acute	Chronic	Acute	Chronic	Fish Consumption
Acenapthene	570	ns	320	ns	ns
Acrolein	23	ns	18	ns	250
Acrylonitrile*	2,500	ns	ns	ns	0.21
Aldrin	3	ns	1.3	ns	0.000026
Aluminum	750	260	ns	ns	ns
Antimony	3,000	ns	ns	ns	15,000
Arsenic	360	190	69	36	ns
Benzene*	1,800	ns	1,700	ns	13
Benzidine*	800	ns	ns	ns	0.00017
Beryllium*	43	ns	ns	ns	0.038
Cadmium	3+	3+	43	9.3	ns
Carbon tetrachloride*	12,000	ns	16,000	ns	2.3
Chlordane*	2.4	0.0043	0.09	0.004	0.00016
Chlorine	19	11	13	7.5	ns
Chloroethers-					
ethy (bis-2)*	ns	ns	ns	ns	0.44
isopropyl	ns	ns	ns	ns	1,400
methyl (bis)*	ns	ns	ns	ns	0.0006
Chloroform*	9,600	ns	ns	ns	5.1
Chlorophenol (2)	1,400	ns	ns	ns	ns
Chlorpyrifos	0.083	0.041	0.011	0.0056	ns
Chromium (VI)	16	11	1,100	50	ns
Copper	6+	6+	2.9	2.9	ns
Cyanide	22	5.2	1	1	ns
DDT*	1.1	0.001	0.013	0.001	0.000008
metabolite TDE*	0.03	ns	1.2	ns	ns
Demeton		0.1	ns	0.1	ns
Dichloro-					
benzenes*	370	ns	660	ns	850
benzidine*	ns	ns	ns	ns	0.007
ethane (1,2)*	39,000	ns	38,000	ns	79
ehenol (2,4)	670	ns	ns	ns	ns
propanes	7,700	ns	3,400	ns	ns
propene (1,3)	2,000	ns	260	ns	4.6
Dieldrin*	2.5	0.0019	0.71	0.0019	0.000025
Dinitro-					
o-cresol (2,4)	ns	ns	ns	ns	250
toluenes*	110	ns	200	ns	3
Dioxin	0.003	ns	ns	ns	5.0×10^{-9}
Diphenyl-hydrazine (1,2)	ns	ns	ns	ns	0.018

	Freshwater		Saltwater		
Pollutant	Acute	Chronic	Acute	Chronic	Fish Consumption
Endosulfan	0.22	0.056	0.034	0.0087	52
Endrin	0.18	0.0023	0.037	0.0023	ns
Ethylbenzene	11,000	ns	140	ns	1,070
Fluoranthene	1,300	ns	13	ns	18
Guthion	ns	0.01	ns	0.01	ns
Heptachlor*	0.52	0.0038	0.053	0.0036	0.00009
Hexachloro-					
benzene*	ns	ns	ns	ns	0.00024
butadiene*	30	ns	11	ns	16
Cyclohexane-					
alpha*	ns	ns	ns	ns	0.01
beta*	ns	ns	ns	ns	0.018
technical*	ns	ns	ns	ns	0.014
cyclopentadiene	2	ns	2	ns	ns
ethane*	330	ns	310	ns	2.9
Isophorone	39,000	ns	4,300	ns	170,000
Lead	29+	29+	140	5.6	ns
Lindane*	2	0.08	0.16	ns	0.02
Malathion	ns	0.1	ns	0.1	ns
Mercury	2.4	0.55	2.1	0.025	0.047
Methoxychlor	ns	0.03	ns	0.03	ns
Mirex	ns	0.001	ns	0.001	ns
Napthalene	770	ns	780	ns	ns
Nickel	5+	5+	75	8.3	33
Nitrobenzene	9,000	ns	2,200	ns	ns
Nitrophenols*	77	ns	1,600	ns	ns
Nitrosamines*	1,950	ns	ns	ns	0.41
Nitroso-					
dibutylamine-N*	ns	ns	ns	ns	0.19
diethylamine-N*	ns	ns	ns	ns	0.41
dimethylamine-N*	ns	ns	ns	ns	5.3
diphenylamine-N*	ns	ns	ns	ns	5.3
Pyrrolidine-N*	ns	ns	ns	ns	30
Parathion	0.065	0.013	ns	ns	ns
Pentachloro-					
ethanes	2,400	ns	130	ns	ns
benzene	ns	ns	ns	ns	28
phenol	20	13	13	ns	ns
Phenol	3,400	ns	170	ns	ns
2,4-dimethyl	700	ns	ns	ns	ns
Phthalate esters					
dibutyl	ns	ns	ns	ns	50,000
diethyl	ns	ns	ns	ns	590,000

	Freshwater		Saltwater		
Pollutant	Acute	Chronic	Acute	Chronic	Fish Consumption
di-2-ethylhexyl	ns	ns	ns	ns	16,000
dimethyl	ns	ns	ns	ns	950,000
Polychlorinated biphenyls*	2	0.014	10	0.03	0.000079
Polynuclear aromatic hydrocarbons*	ns	ns	ns	ns	0.01
Selenium	20	5	300	71	ns
Silver	1+	1+	2.3	ns	ns
Tetrachloro-					
Ethanes	3,100	ns	ns	ns	ns
benzene (1,2,4,5)	ns	ns	ns	ns	16
ethane (1,1,2,2)*	ns	ns	3,000	ns	3.5
ethylene*	1,800	ns	3,400	145	2.9
phenol (2,3,5,6)	ns	ns	ns	440	ns
Thallium	470	ns	710	ns	16
Toluene	5,800	ns	2,100	ns	140,000
Toxaphene*	0.73	0.0002	0	0.0002	0.00024
Tributylin	ns	0.026	ns	0.01	ns
Trichloro-					
ethane (1,1,1)	6,000	ns	10,400	ns	340,000
ethane (1,1,2)	6,000	ns	ns	ns	14
ethylene*	15,000	ns	700	ns	26
phenol (2,4,6)	ns	ns	ns	ns	1.2
Vinylchloride*	ns	ns	ns	ns	170
Zinc	22+	22+	95	86	Ns

ns - No standard has been developed
* - Carcinogen
\+ - The value listed is the minimum standard. Depending on hardness of receiving waters ($CaCO_3$), higher standards may be calculated using formula from EPA Water Quality Criteria (EPA 440/5-86-001)

Compounds listed in plural are mixtures of isomers. Numbers listed refer to total allowable concentration of any combination of isomers in compound.

Criteria for All Streams

Parameter	Geometric Mean not to exceed given value	Not to exceed given value more than 10% of the time	Not to exceed given value more than 2% of the time
Total Nitrogen (mg/L)			
Wet season*	0.25	0.52	0.8
Dry season*	0.18	0.38	0.6
Nitrate + Nitrite Nitrogen (mg/L)			
Wet season	0.07	0.18	0.3
Dry season	0.03	0.09	0.17
Total Phosphorus (mg/L)			
Wet season	0.05	0.1	0.15
Dry season	0.03	0.06	0.08
Total Suspended Solids (mg/L)			
Wet season	20.0	50.0	80.0
Dry season	10.0	30.0	55.0
Turbidity (N.T.U.)			
Wet season	5.0	15.0	25.0
Dry season	2.0	5.5	10.0

* - Wet season: November 1 - April 30
** - Dry season: May 1 – October 31
L - Liter
N.T.U. - Nephelometric Turbidity Units. Comparison of intensity of light scattered by sample under equal conditions. Higher intensity = higher turbidity
mg - Milligram or 0.001 grams

Additional stream water quality parameters:

Enterococci	33 CFU/100ml in 5 or more samples, 89 CFU/100ml in single sample
pH Units	Not to deviate more than 0.5 units from ambient conditions; not to be lower than 5.5 or higher than 8.0
Dissolved Oxygen	Not less than 80%, determined as a function of water temperature
Temperature	Not to vary more than one degree Celsius from ambient conditions
Specific Conductance	Not to exceed 300 micromhos/centimeter

Criteria for All Estuaries (except Pearl Harbor)

Parameter	Geometric Mean not to exceed given value	Not to exceed given value more than 10% of the time	Not to exceed given value more than 2% of the time
Total Nitrogen (mg/L)	0.2	0.35	0.5
Ammonia Nitrogen (mg/L)	0.006	0.01	0.02
Nitrate + Nitrite Nitrogen (mg/L)	0.08	0.025	0.035
Total Phosphorus (mg/L)	0.025	0.05	0.075
Chlorophyll a (mg/L)	0.002	0.005	0.001
Total Suspended Solids (mg/L)	10.00	30.00	55.00
Turbidity (N.T.U.)	1.5	3.00	5.00

L - Liter
N.T.U. - Nephelometric Turbidity Units. Comparison of intensity of light scattered by sample under equal conditions. Higher intensity = higher turbidity
mg - Milligram or 0.001 grams

Additional estuary water quality parameters:

Enterococci	33 CFU/100ml in 5 or more samples, 89 CFU/100ml in single sample
pH Units	Not to deviate more than 0.5 units from ambient conditions; not to be lower than 7.0 or higher than 8.6
Dissolved Oxygen	Not less than 75%, determined as a function of water temperature and salinity
Temperature	Not to vary more than one degree Celsius from ambient conditions
Salinity	Not to vary more than 10% from ambient conditions
Oxidation	Reduction potential (EH) – not to fall under 100 millivolts in upper 10 centimeters of sediment

Criteria for Embayments

Parameter	Geometric Mean not to exceed given value	Not to exceed given value more than 10% of the time	Not to exceed given value more than 2% of the time
Total Nitrogen (mg/L)			
Wet season*	0.2	0.35	0.5
Dry season*	0.15	0.25	0.35
Ammonia Nitrogen (mg/L)			
Wet season	0.006	0.013	0.02
Dry season	0.0035	0.008	0.015
Nitrate + Nitrite Nitrogen (mg/L)			
Wet season	0.008	0.02	0.035
Dry season	0.005	0.014	0.025
Total Phosphorus (mg/L)			
Wet season	0.025	0.05	0.075
Dry season	0.02	0.04	0.06
Chlorophyll a (mg/L)			
Wet season	0.0015	0.0045	0.0085
Dry season	0.0005	0.0015	0.003
Turbidity (N.T.U.)			
Wet season	1.50	3.00	5.00
Dry season	0.40	1.00	1.50

*	-	Wet season criteria apply when average freshwater inflow from land equals or exceeds 1% of embayment volume per day
**	-	Dry season criteria apply when average freshwater inflow from land is less than 1% of embayment volume per day
L	-	Liter
N.T.U.	-	Nephelometric Turbidity Units. Comparison of intensity of light scattered by sample under equal conditions. Higher intensity = higher turbidity
mg	-	Milligram or 0.001 grams

Additional water quality parameters:

Enterococci	35 CFU/100ml in 5 or more samples, 104 CFU/100ml in single sample
pH Units	Not to deviate more than 0.5 units from a value of 8.1, except at coastal locations where and when freshwater from stream, storm drain or groundwater discharge may decrease pH to 7.0
Dissolved Oxygen	Not less than 75%, determined as a function of water temperature and salinity
Temperature	Not to vary more than one degree Celsius from ambient conditions
Salinity	Not to vary more than 10% from natural or seasonal changes considering hydrologic input and oceanographic factors

APPENDIX B

Archaeological Report

OVERVIEW OF HISTORIC PROPERTIES IN THE MĀ‘ILI‘ILI‘I DRAINAGE OF LUALUALEI

MOKU O WAI‘ANAE, O‘AHU

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INTRODUCTION

We live in a rapidly changing world today, one that sees dramatic alterations to our landscapes. Yet in this changing world, knowing our past and seeing reminders of that past are an important part of knowing who we are and where we are going. Historic properties are visible remnants of our past. They include archaeological sites, architectural buildings, traditional cultural properties (that can even primarily be natural features), and objects. They may survive as individual properties or as part of landscapes (districts) with other properties and even with natural features of cultural significance. Only a fixed amount of these properties exist, particularly in our State with its small land area. In the face of increasing land development and alterations in the late 1960s, the federal and state historic preservation laws were created. They were created to require planners to identify important historic properties in an area and to take into account the impacts of a project on those properties. They were not intended to protect all historic properties, but to attempt to make planners protect important historic properties as best as possible within the context of the development. Planning actions enable the preservation of many of the important historic properties in an area, including the preservation of culturally important burials. But also, preservation includes gathering information from the properties to improve our knowledge of the past, and to collect relevant samples of key information from historic properties for future research (particularly from properties that might have to be destroyed), and to gather important objects from such properties. These actions are all to be done on the behalf of the public.

A key element of historic preservation planning that often does not occur is to plan well ahead of time – to be proactive and make and implement preservation and protection plans long before development or land altering activities impact an area. Another key part of preservation planning is to have as strong a knowledge base of the past for the area as possible, so one can make sound decisions. This knowledge comes from multiple sources – from archaeological research, from archival research with old records (vitally including oral histories recorded in the past), from architectural documentation, and from community knowledge passed down over the years but as yet unrecorded.

Studies such as this watershed study enable planning well ahead of time, before future actions in the watershed. This paper looks at our knowledge base of pre-European Contact and early post-contact Native Hawaiian history and historic properties in the Māʻiliʻiliʻi Watershed of Lualualei. Lualualei has gone through essentially three distinctive historical periods of use – (1) Native Hawaiian times (AD 800s/900s up to about 1840), (2) Ranch times (1850s-early 1900s), which also involved some sugarcane cultivation in mid-valley and homesteads (not Hawaiian Home Lands) created in shore areas, and (3) Modern times (1930s-present) with increasing residences along the shore and military presence in the interior. Again, this report focuses on Native Hawaiian times. At the end of the report, I will briefly make some comments related to the other periods.

The information in this paper comes from archaeology, oral history and mostly 1800s archival records. More work can be done in all areas to improve our knowledge of Lualualei's history and historic properties, and this too will be discussed at the end of the paper. The key to understanding Native Hawaiian historic properties in Lualualei and the Māʻiliʻiliʻi Watershed is to understand the natural landscape and places on this landscape over time. These places include man-made places such as temples (heiau), trails, houses and farms, but also streams, mountains, and winds. Collectively, this was the cultural landscape of the past – a vital point that planners need to understand. The Native Hawaiian cultural landscape is the natural landscape and its man-made places, and places where gods resided and famed events occurred – and the unmarked graves where deceased ancestors lie within the landscape. Also, it is important to understand Lualualei in the larger cultural landscapes of the district of Waiʻanae and the island of Oʻahu.

> I had heard of the famous places of Oʻahu … and came to see them for myself.
> [1865, Kamakau 1991:6]

The above quote from Kamakau was an introduction for his newspaper articles taking readers to famed places of Oʻahu. There were famed places on the island, famous in history for Oʻahu and the entire Hawaiian Island group. Examples include Kūkaniloko (the birthing place within the ruling center at Līhuʻe-Wahiawā), the ruling centers of Waikīkī and Kailua, the fishponds of Puʻuloa (Pearl Harbor) and Kāneʻohe, the irrigated kalo fields of Waikīkī, Nuʻuanu, and many other places, many heiau (temples) both national luakini and local, the home of Kamapuaʻa (Kaliuwaʻa) and other places associated with gods, etc. Lualualei was not really one of those famed places, although one could argue that several landforms on the borders of Lualualei were well known. Its two passes – Kolekole and Pōhākea – were indeed renowned, with Pōhākea being a famous spot in mythology where Hiʻiaka (returning from Kauaʻi with Lohiʻau) looked to Hawaiʻi Island and saw her burning lehua forests and knew that Pele had slain Hopoe. And certainly the Ulehawa coast area (outside of this project area) was famed as the birthplace of and setting for events associated with Māui (the superhero) in the Oʻahu localization of his stories. However, generally Lualualei was not as renowned as other lands on Oʻahu. Still its places, people and history were important within a regional cultural landscape on Oʻahu – the moku of Waiʻanae, the district on the west side of the island (Figs. 1-2). Within that moku, Lualualei's places on its landscape were well known, far more familiar in the 1700s than today, as much of Lualualei's landscape has been closed off to residents for the better part of a century. As will be seen, Lualualei's landscape was not the dominant economic, political or religious landscape of the moku of Waiʻanae. But it was a vital land within that moku's history.

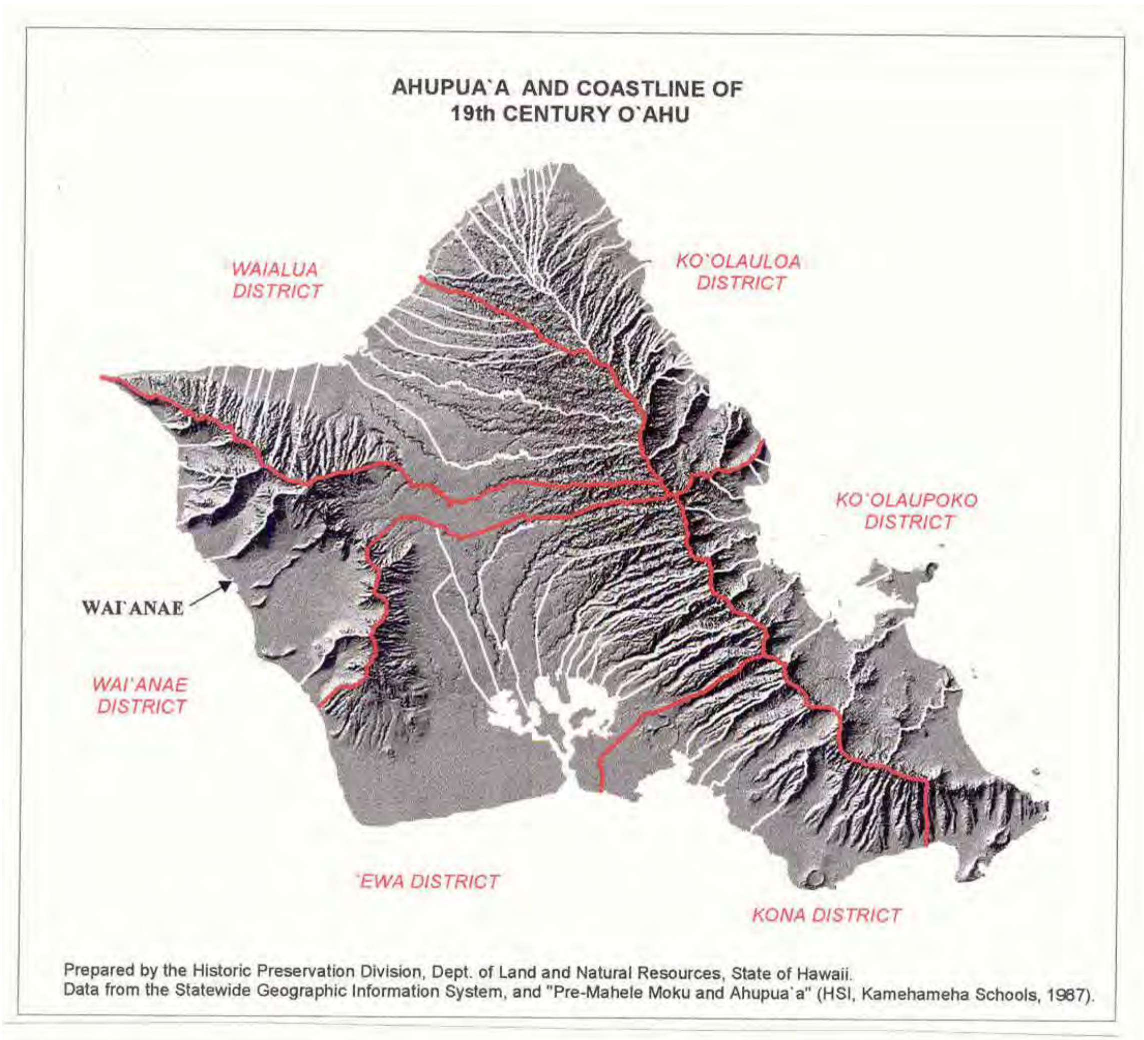


Figure 1. Island of O'ahu, showing Wai'anae district (moku) on the west coast.

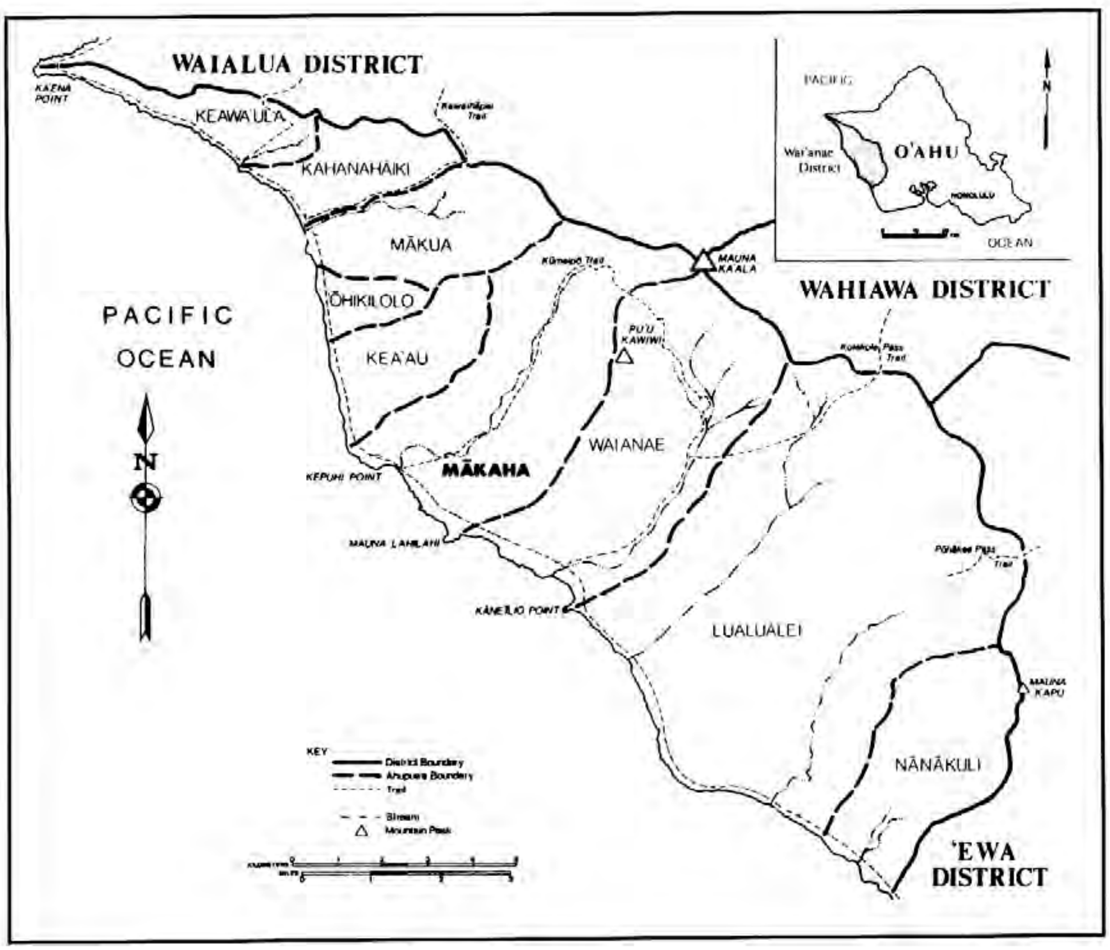


Figure 2. Map of Wai‘anae District showing the lands (ahupua‘a) within the district. (From Cordy 2002b:2; Adapted from Green 1980.)

This paper looks ultimately at the remaining cultural and historic properties in the Mā‘ili‘ili‘i watershed of Lualualei and how to manage them. This watershed as defined for this project includes all of Lualualei except (1) the Ulehawa drainage running seaward along the border with Nānākuli and reaching the shore at today’s Ulehawa Beach Park, (2) the coastal and near coastal areas between Wai’anae and Pu‘u Mā‘ili‘ili‘i (where the Wai’anae Comprehensive Health Center sits), and (3) much of the Mā‘ili shoreline and lower valley areas behind that shoreline (Fig. 3). The Mā‘ili‘ili‘i watershed, however, consists of most of Lualualei. To understand this watershed and Lualualei -- the place, the people who used it, its history, and its remaining cultural and historic properties and how to manage them – this paper includes not just the watershed as defined, but also the entire Ma'ili shore and the shore north to Wai'anae, as these areas are linked to settlement in the interior. Only Ulehawa's drainage is not covered closely. The paper looks first at the natural environment and named places of Lualualei, then briefly at the history of O'ahu and at the history of the moku o Wai'anae (Lualualei's immediate cultural region). It will then discuss what we know of Lualualei's settlement just at European Contact (late 1700s) and of its history, and patterns from Contact through the 1840s. Finally, with this knowledge base of Lualualei, attention will be given to the historic properties of Lualualei that remain today and how to manage them in the face of activities within the watershed.

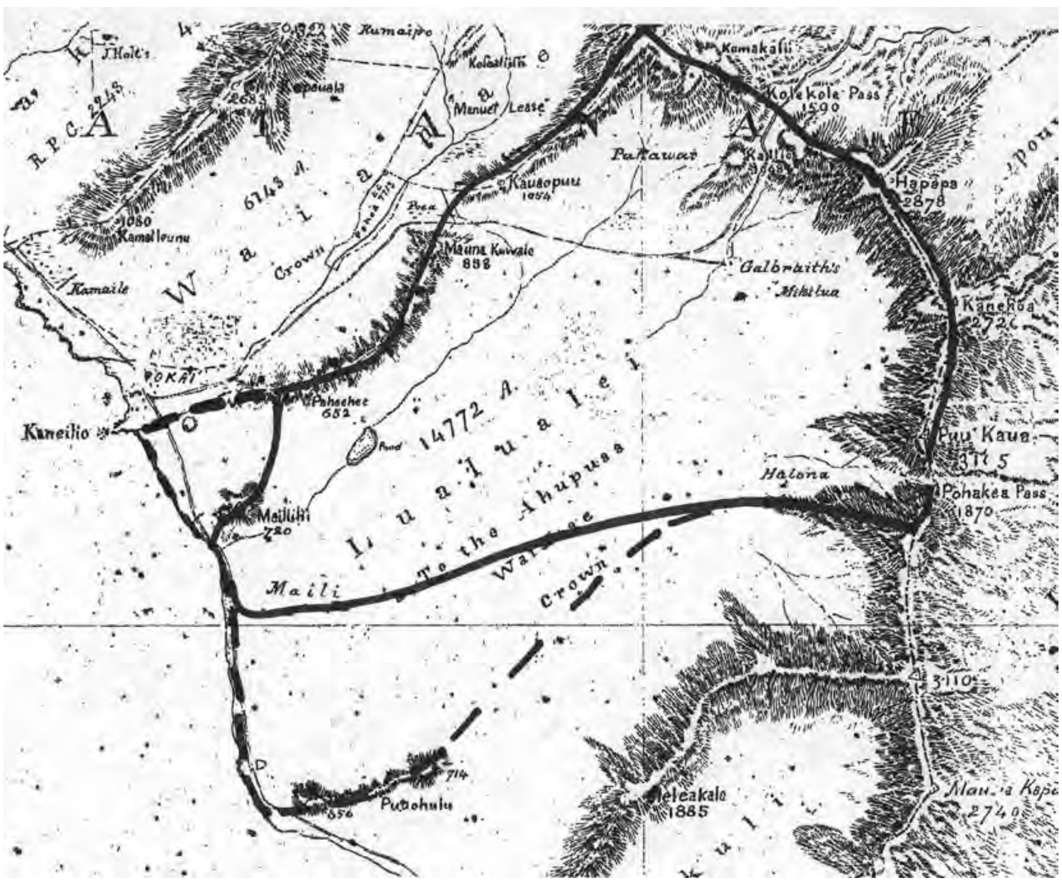


Figure 3. Map showing the watershed area bounded by solid black line. Dotted lines include Mā'ili shoreline to Pu'u o Hulu and Pu'u Mā'ili'ili'i to Kane'īlio shoreline..

THE NATURAL ENVIRONMENT OF LUALUALEI AND WAIʻANAE MOKU

> The striking feature of the Waianae Range are the great flat-floored valleys ...
> (Stearns & Vaksvik 1935:30).
>
> Bare mountain spurs run down close to the shore, where the climate is hot and quite destitute of water ...
> (O. Emerson 1928:104)

I used these quotes before in a summary of Waiʻanae's history (Cordy 1998, 2002a). They well describe much of the moku o Waiʻanae, and particularly Lualualei.

Waiʻanae district spans 20 miles of shoreline along the western shore of Oʻahu from Kaʻena Point in the north to the southern border of Nānākuli. These lands ran from nearshore waters back 5+ miles to the Waiʻanae mountains' ridgeline. One narrow extension of the district (Waiʻanae uka) went over the ridgeline at Kolekole Pass across the Central Plateau of Oʻahu and up to the ridgeline of the Koʻolau mountains.

The Waiʻanae district and mountains are the erosional remnant of the Waiʻanae shield volcano, which formed 2.5-3.3 million years ago. This volcano was older than the volcano that formed the eastern Koʻolau mountains. It eroded under heavy rains (before the Koʻolau volcano rose to block the rainfall), from huge landslides of parts of the volcano out into the sea, and from higher stands of the sea. What remains today is the lower, curving Waiʻanae mountain range, with the high point being Kaʻala at the head of Waiʻanae valley (4,025 feet), the eroded valleys, and the fringing reef.

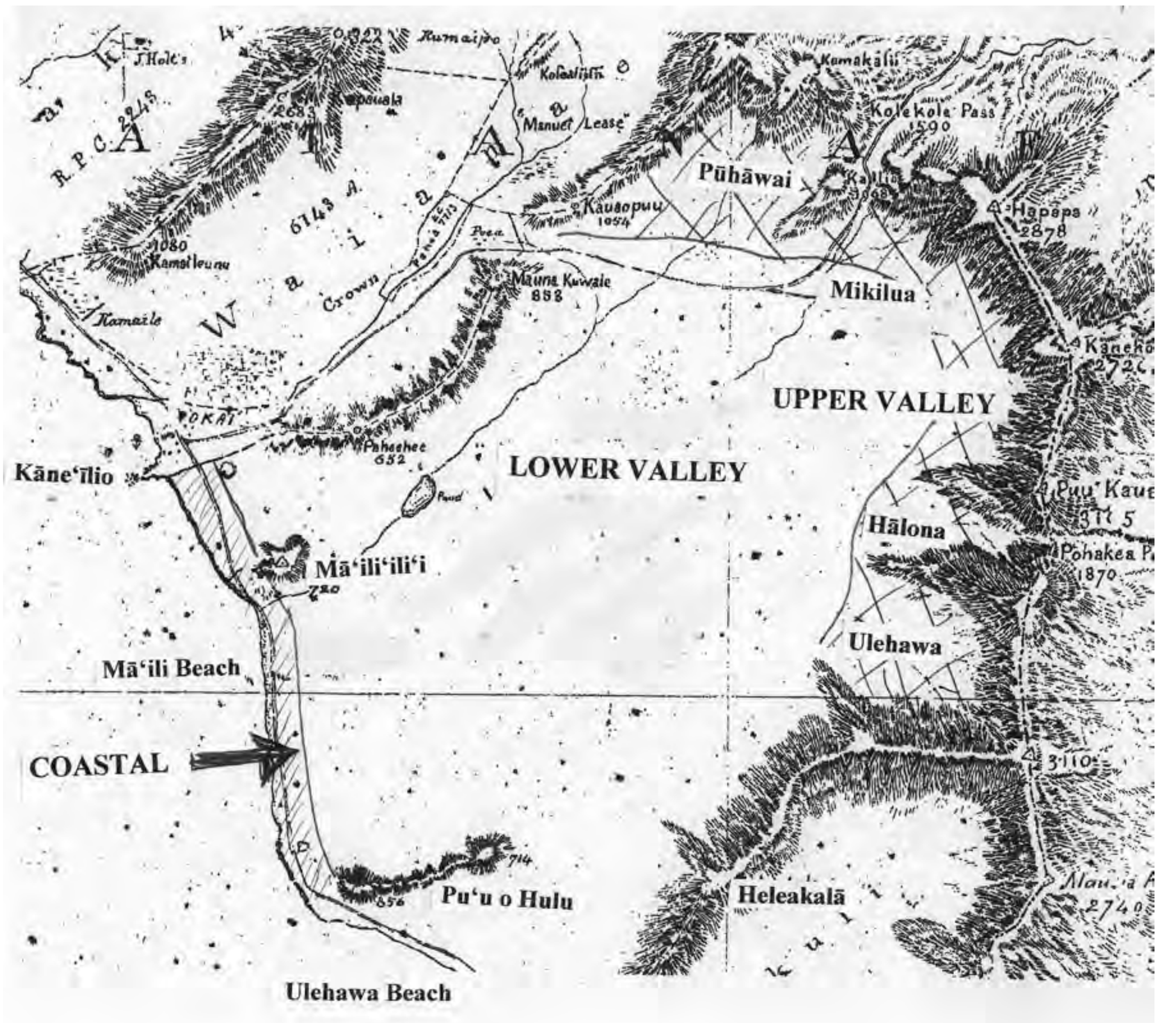
The notable features of Waiʻanae moku to many are its broad, deep valleys -- Nānākuli, Lualualei, Waiʻanae, Mākaha, Mākua and Kahanahāiki. All have steep, high valley walls and relatively flat valley floors that gradually rise back towards the mountains. Lualualei is by far the largest of these valleys, spanning 4.6 miles of shoreline and extending 5.0 miles inland. It has a complex geology. It was once a sizable part of the caldera of the Waiʻanae volcano, today's Waiʻanae ridgeline being a remnant of the eastern side of the former caldera. But on the seaward side of the caldera, several smaller valleys apparently once were present within Lualualei. Their ridges have long since eroded away, but the seaward tips remain -- Māʻiliʻiliʻi and the twin headland of Puʻu o Hulu Kai and Puʻu o Hulu Mauka. The entire area of Lualualei was massively eroded away over the millennia. Different higher stands of the sea contributed to this erosion.

A dominating trait of the environment of moku o Waiʻanae is its aridity. The coast and lower valleys usually receive 20 inches or less of rain per year. The upper valleys have 30-40 inches of rain. The longer upper valleys of Waiʻanae and Mākaha have over 40 inches of rain, and the peak of Kaʻala and adjacent ridgelines behind Mākaha and Waiʻanae have the highest rainfall, 60-100 inches of rain per year. Lualualei's upper valley areas at the base of the mountains nearest Wai‘anae valley also receive 60-80 inches of rain. As one goes south, the upper valley areas of Lualualei at the base of the ridgeline are drier, with 40-60 inches.

The Wai‘anae valleys all have three primary land zones: coastal areas, lower valleys, and upper valleys. The coastal areas typically include white sand beaches with low dunes and narrow back dunes that extend inland a ways, usually a block or less inland of Farrington Highway (a maximum inland extent of ¼ mile). Some of the coast has uplifted limestone areas (former reefs of higher sea stands). They form rocky points and in some areas flat limestone lands with thin soils behind the shore. The upper valleys are steeper and usually have one or multiple streams emerging from dike springs and run-off. These streams can flow year-round in some cases or only be intermittent (flowing during heavy rainfall). The upper valleys merge down with the much flatter and broader lower valleys, which in turn merge into the coastal dunes or raised limestone areas. The tributaries of the upper valleys tend to join into a single stream drainage (sometimes two) that runs down across the lower valley to the shore. Only Wai‘anae valley's Kaupuni Stream flowed year-round to the shore. All the other valleys had intermittent stream flow in the lower valleys.

To look more closely at Lualualei, it extends from Kāne‘īlio Point on the shore (its border with Wai‘anae valley) south to the seaward tip of Heleakalā's ridge (its border with Nānākuli) (Fig. 4). Two promontories break up the shoreline -- Mā‘ili‘ili‘i in the north and Pu‘u o Hulu Kai and its joined promontory of Pu‘u o Hulu Mauka in the south. The shore between Mā‘ili‘ili‘i and Kāne‘īlio Point has raised reef exposures in the shallow water. A sand beach (Mā‘ili Beach) runs from Mā‘ili‘ili‘i, from Mā‘ili‘ili‘i Stream mouth to near Mā‘ili Point. Raised limestone is exposed on the shore in front of Pu‘u o Hulu Kai, and then a sand beach goes from the south side of Pu‘u o Hulu Kai to the border with Nānākuli, being Ulehawa Beach. The sand areas behind Mā‘ili and Ulehawa beaches extend in behind the dunes for about 0.25 mile, a block or so inland of Farrington Highway. But behind the shore between the pu‘u Mā‘ili‘ili‘i and Kāne‘īlio Point considerable areas of raised limestone (former reefs) extended a short distance inland, and the same is true behind much of the sand shoreline of Mā‘ili nearer to Pu‘u o Hulu (today's Mā‘ili Kai subdivision). These raised limestone areas had minimal, thin soil deposits.

Behind these shore areas is the immense lower valley of Lualualei. It is flat and extends 4.2 miles inland, slowly rising to the 600 foot elevation at the base of the ridges at the back of the valley. Like the shoreline, the lower valley of Lualualei is dry and hot, with rainfall usually less than 30 inches per year. It had a thin clay soil, and is often described as a rocky soil. Much of this area has been altered over the last century. Areas not too far inland of Mā‘ili were planted in sugarcane by the Waianae Plantation, irrigated by water brought in by flume. Then the Naval Radio Transmitting Facility Lualualei (RTF LLL) covers a large portion of the mid-lower valley, evidently with the land bulldozed flat. To its north are homestead lands granted in the early 1900s. Behind the RTF and these homesteads is the Lualualei Branch of the Naval Magazine Pearl Harbor (NAVMAG LLL) with its roads and bunkers having altered the land.



DRAFT Figure 4. Map of Lualualei showing main land zones – coastal, lower valley, and upper valley (the latter above 600 feet elevation).

The upper valley of Lualualei is quite small compared to the other lands of Wai‘anae. The upper valley includes the 2,400-2,800 foot high ridgeline at the back of Lualualei and the small tributary gulleys and short ridges emerging from this ridgeline down to about the 600 foot elevation. This area receives 40-60 inches of rain per year. It has deeper clay soils as a result of the higher rainfall. Still the upper valley is 5 miles from the shore. The Ulehawa tributaries emerging from the ridge near Nānākuli joined and flowed intermittently to the shore between Pu‘u o Hulu and Nānākuli. It is not part of this study's area. However, all the other tributaries appear to have merged and flowed to the shore as Mā‘ili‘ili‘i Stream, and are the focus of this watershed study. One basin with a set of tributary streams (the Pūhāwai drainage) was nearest to Wai‘anae Valley and the higher rainfall ridge areas. The springs forming this Pūhāwai drainage flowed year-round, but the Pūhāwai tributary set became intermittent in the lower valley. An adjacent upper valley drainage (Mikilua) may have had lower year-round flow in its upper valley, but it too became intermittent on emerging into the lower valley. All the rest of Lualualei's upper valley streams were intermittent in their upper valley areas as well as in the lower valley. What this means is that the Mā‘ili‘ili‘i Stream and its branches that flowed through the lower valley and emerged at the shore was not a year-round stream in these environmental zones of Lualualei – it was an intermittently flowing stream.

One of the patterns of stream flow in many of the Wai‘anae valleys is that overflow often would back up lineally behind the dunes, forming long narrow swamplands. This may have occurred in the Mā‘ili‘ili‘i drainage near the shore. It may even have created swamplands farther inland behind and within the raised limestone areas. This is something difficult to determine today (at least with evidence I have seen) because of land alteration from sugarcane, homesteads and other activities. But a pond and fishpond are mentioned in the 1800s historical records somewhere in this area, and a drainage canal was built behind the southern part of Mā‘ili in the 20^{th} Century, perhaps related to this swampland issue.

Relevant to the intermittent flow of the streams and overflow are two quotes from from different versions of the same part of the Hi‘iaka story, when she is atop Pōhākea Pass and commenting on the upper valley (Ho‘oulumāhiehie 2006:261, English).

> When the Nāulu rains stir their fury
> The streambanks break loose, but the heart of Pūhāwai is silent…
>
> Raging against the Nāulu rains
> The streambanks are breached, the cliffs worn jagged

So, in brief, the Mā‘ili‘ili‘i watershed area includes all the upper valley areas of Lualualei, except Ulehawa next to Nānākuli. These areas saw intermittent streams and one (maybe two) permanent streams in the upper valley. As these streams emerged out onto the flat, thin-soiled lower valley beginning over 4 miles inland, they all became intermittent streams. The streams out of the far ridgeline join in mid-valley and continue toward the shore in northern Mā‘ili. They enter the shore as Mā‘ili‘ili‘i Stream just south of the Mā‘ili‘ili‘i promontory.

The stream emerges out through the dune areas at the north end of Mā'ili Beach. There it merges with coastal, nearshore waters – which could be considered yet another zone of the watershed. Essentially, the watershed's nearshore waters would be those shallower waters from Kāne'īlio Point to Pu'u o Hulu – shallow reefs off the raised limestone shore in the north and the submerged sand and reef areas off Mā'ili beach down to the raised limestone shore of Mā'ili Point.

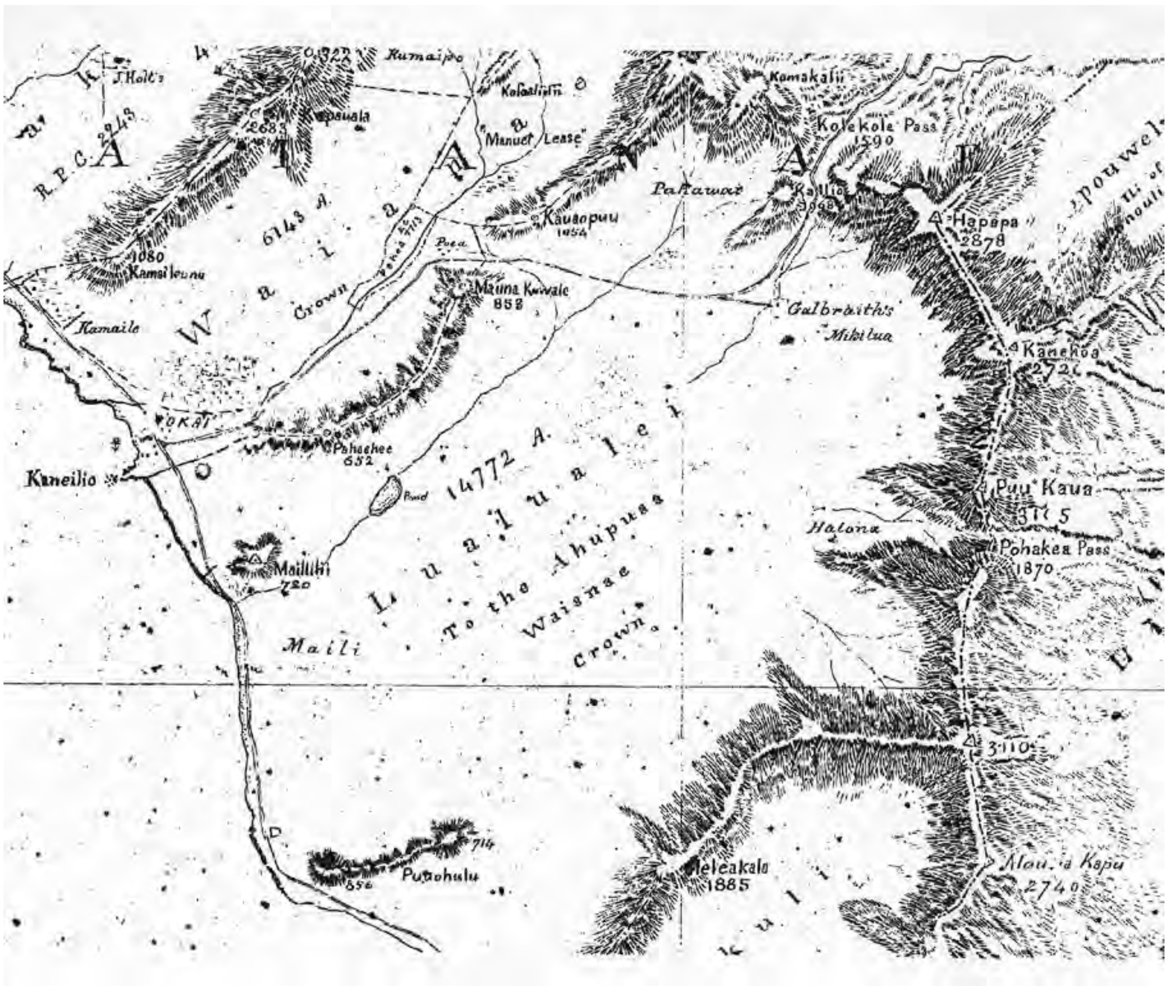


Figure 5. Blow-up of Lualualei from 1876 Kingdom Map of O'ahu.
(Kingdom Map 1876) (Reg. Map #1350)

LUALUALEI: PLACENAMES

This part of this report provides information on the older 1800s place names of Lualualei, so when reading later sections of the report, the places that are discussed can be easily located. I would argue that these place names extend at least back to the late 1700s prior to European Contact and likely much farther back, given their collection primarily in the 1800s. These places appear in some moʻolelo, oli, mele, and importantly on maps (Kingdom and early Territory maps). The Kingdom's Government Survey Office (formed in 1870) produced a map of Oahu in 1876 (with the survey work done in 1872-1875)(Kingdom Map 1876), and it is the earliest map of the Lualualei places found for this study (Fig. 5). Realize too that these places are more than just names. Like today, past place names brought forth images of how the land appeared, its winds, its smells, and how it was used. Some names evoked famous events and people.

Figure 8 locates the place names of Lualualei that are discussed here, and Table 1 lists them. Again, Lualualei was bounded on its inland side by the main Waiʻanae ridgeline; to the south by the spur ridge separating it from Nānākuli (with the high point on that ridge being Heleakalā), by the shore on the west, and by the spur ridge separating it from Waiʻanae.

<u>Mountain Peaks, Isolated Coastal Promontaries, Coastal Points, Streams</u>

Kingdom of Hawaiʻi maps and early Territorial maps consistently identify high points on the Wai'anae ridgeline at the back of Lualulalei. **Kūmakaliʻi** is near the border with Wai'anae valley, then there is a low point in the ridge that is **Kolekole** pass (1590 ft).[2] On the high point to the south of the pass is **Hāpapa** peak (2,878 ft). Hāpapa may also have been called **Kapapa**, for the oli Ka Inoa o Kūaliʻi talks about "the heights of Kapapa, at Paupauwela" (Fornander Collection 1917,4(2):384, Line 384),. and Hāpapa rises above the area on the Schofield side of the ridge known as Paupauwela. A low, very short spur ridge extends down from Kolekole Pass with a high point named **KaʻĪlio** (1968 ft). South of Hāpapa on the main ridgeline are **Kānehoa** (2,726 ft.).and **Puʻu Kaua** (3,115 ft), and then the low point on the ridge that was **Pōhākea** pass (1,870 ft.) (leading over into 'Ewa). The Pele and Hiʻiaka story cited by Emerson (1915:156-7) says the high point at this pass was called **Ka-moa-ula**. It does not appear on the older maps reviewed for this paper. Beyond the pass and below the ridgeline in Lualualei -- but outside the Māʻiliʻiliʻi drainage study area -- was Ulehawa Stream's upper tributary area, and then the cliffs of Palikea and the ridge leading to **Heleakalā** (1885 ft), the high point on the Nānākuli border.

The ridgeline between Lualualei and Waiʻanae valleys extends off the Waiʻanae ridgeline just west of Kūmakaliʻi. It runs down to a high point called **Kauaʻōpuʻu** (1054 ft.). Then there is a gap through the ridge. Beyond, the ridge begins again with **Mauna Kūwale** being a high point (858 ft) and runs down toward the sea, where some maps list two high points **Pāheʻeheʻe makai** and **Pāheʻeheʻe mauka** (652 ft), and others just list one as **Pāheʻeheʻe**.

Coastal landmarks are limited on the old maps. **Kāne'īlio** Point is noted by all – the point that was the border between Lualualei and Wai'anae valleys, the south point at Pōka'ī Bay. Then the isolated promontory **Mā'ili'ili'i** (720 ft) is shown on all maps (where the Waianae Comprehensive Health Center is today). Then the isolated twin-peak promontory of **Pu'u Hulu o Kai** (856 ft) and **Pu'u Hulu o Mauka** (714 ft) (just **Puuohulu** on the 1876 map) is always labeled at the south end of this study area.

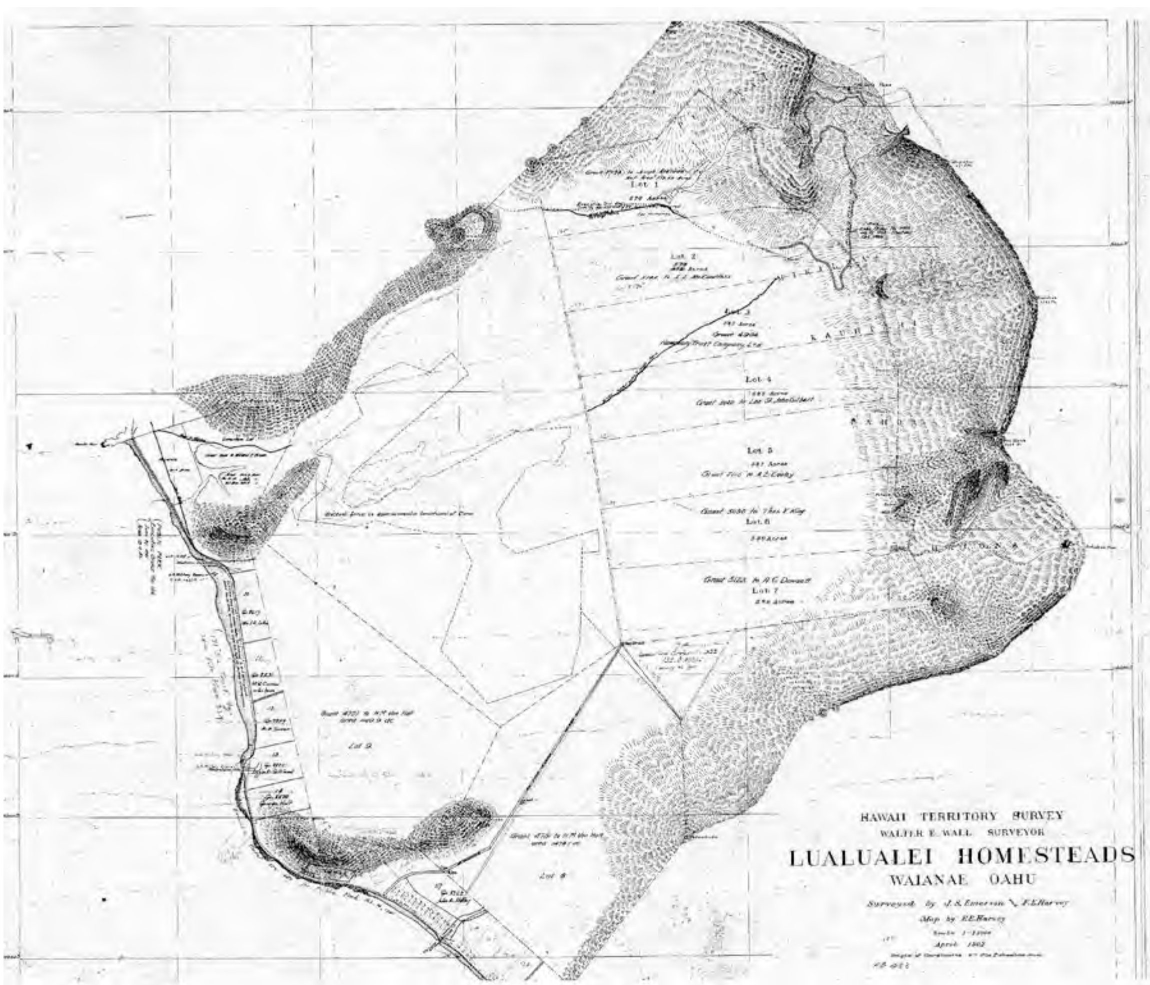


Figure 6. 1902 Hawaii Territory Survey map of Lualualei Homesteads.
(Hawaii Territorial Map 1902a)

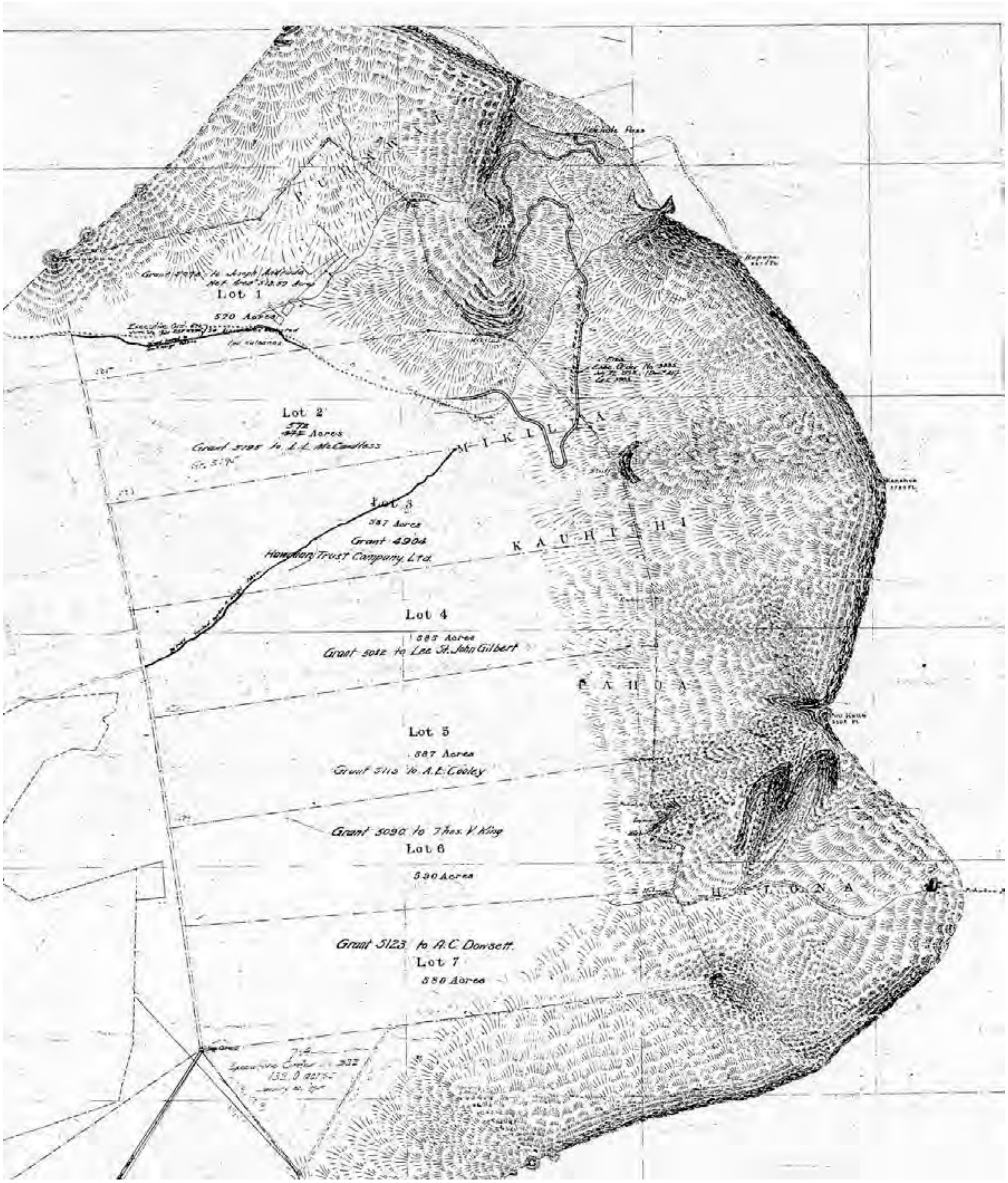


Figure 7. Close up of upper valley area of 1902 Hawaii Territory Survey map of Lualualei Homesteads, showing land names at the base of the mountains.
(Hawaii Territorial Map 1902a)

Streams are more erratically labeled. On the 1876 Kingdom map, no streams are labeled with names. The main Māʻiliʻiliʻi outlet to the sea is shown and its course back to Puhawai. A pond (labeled "Pond") is shown on the stream, back of Māʻiliʻiliʻi promontory and parallel to Pāheʻeheʻe Mauka peak. Several tributary streams are shown coming out of the Waiʻanae ridgeline in the Pūhāwai, Mikilua, Hālona, and Ulehawa areas. Except for the Pūhāwai tributaries, none of the streams are extended down towards the shore on the map. The 1881 map is the same depiction, with fewer of the upper valley tributaries shown (Kingdom Map 1881). The 1902a and 1905 maps label both Māʻiliʻiliʻi Stream and Ulehawa Stream at their mouths on the shore (Hawaii Territorial Map 1902a, 1905). No other streams are labeled, but tributary streams are shown in Pūhāwai, Mikilua and Halona. None of their connections to the stream mouths are shown. The 1905 map has roughly in the location of the "pond" the demarcation of "Lualualei Reservoir." (Hawaii Territorial Map1905).

Land Names

Four land names appear on the 1876 and 1881 maps – Māʻili near the shore behind Māʻili beach and Pūhāwai in the upper valley area with emerging streams below Kūmakaliʻi and nearest to Waiʻanae valley, Mikilua in the tributary stream area below Kolekole Pass and Hāpapa, and Hālona in the tributary area below Pōhākea Pass. Additionally, 1902a and 1905 maps, which depict new grants dividing up the upper valley (versus the former one ranchland) show these upper valley land names and two others between them – Pāhoa below Puʻu Kaua and Kaʻuhiʻuhi below Kānehoa (Hawaii Territorial Map 1902a, 1905) (Figs. 6-7).

In sum, in the upper valley and perhaps extending out onto the flats a bit in the very back of the lower valley, there are 6 land names (north to south) – Pūhāwai, Mikilua, Kaʻuhiʻuhi, Pāhoa, Hālona and Ulehawa (the last outside this study area). Thus, there are 5 named lands in the upper valley portion of the study area. Interestingly, each correlates with a set of small streams emerging out off the main ridgeline. The 1902a and 1905 maps also show names of survey points on borders of land grants, and Mikilua is the name of one such point at the base of KaʻĪlio on the opposite side of a drainage and small ridge where the land name Mikilua appears. The AMEC archaeological study emphasizes that Pūhāwai is a basin with emerging tributaries as are Mikilua, Kaʻuhʻuhi, Hālona and Ulehawa, while Pāhoa is a colluvial fan below Puʻu Kaua (Dixon et al. 2004:14). The AMEC researchers probably are more familiar with the topography of this upper valley area than anyone else as they spent 9 months working in the area. They and the old maps suggest geographic boundaries to these lands – a basin bounded by short ridgelines, several drainages below Kolekole bounded by KaʻĪlio and ridgeline, a colluvial fan bounded, and so on. These names may also have served as names for the set of streams that arose in each area. Also, as will be seen later, each named land area coincides with a cluster of house sites –with intervening unoccupied areas.

Besides Māʻili shown on the shore in the old maps, old moʻolelo about Māui the super-hero that were recorded in the 1800s have him living in a land called Ulehawa on the shore (Kamakau 1976:116-117; Thrum 1923:248-259; Sterling & Summer 1978:62) – clearly the Ulehawa coastal area. Although Ulehawa is outside the study area, there seem to have been two named coastal lands on the shore – Mā‘ili and Ulehawa. Mā‘ili on the old maps appears in the same font and type as the named upper valley lands. Thus, the mapmakers seem to be identifying them as equivalent types of lands.

This pattern of lands suggests possible ‘ili land names, particularly their correlation with fields and houses. ‘Ili were subunit lands within the ahupua‘a and minimally contained houselots and fields at the end of the 1700s. Some stretched from nearshore waters to mountain ridges, but many were just field and house areas. Māhele land records of the 1840s often clarify this issue, with claims, testimonies, and awards identifying the ‘ili and ahupua‘a described. Only 6 commoner land awards were given in Lualualei, all in Pūhāwai. The Mahele Book and/or the Foreign Testimonies (FT) refer to these awards as being “in the ili of Puhawai, Waianae” (e.g., Buke Mahele 6:234-5 for LCA 7451; FT 9:308-310 for LCAs 7436, 7452, 7454, 8005). Thus, Pūhāwai was an ‘ili. (The association with Wai‘anae where the ahupua‘a is normally listed and not Lualualei is interesting and will be returned to later in the paper.) Also, in 1855 when tax records began to be recorded, they tended to be collected by traditional ‘ili, with an ‘ili listed and individuals then listed within an ‘ili. For Lualualei, two lands are listed in 1855 – Pūhāwai and Mā‘ili – suggestive of ‘ili.

Thus, we seem to have 7 named lands, all likely ‘ili, within Lualualei. These are key names that AMEC’s archaeological report used for locating historic properties and that will also be used in this report. These lands are:

Mā‘ili – shore and kula (plain) areas of soil and raised limestone behind.
Ulehawa – shore and probably the entire Ulehawa drainage (although it might have been subdivided further)
Pūhāwai – upper valley and a small adjacent part of the uppermost lower valley.
Mikilua – ditto.
Ka‘uhi‘uhi – ditto
Pāhoa – ditto
Hālona – ditto.

One last point relevant to these lands is that we do not have clear borders for them. Because Lualualei was Crown land and was leased very early in almost its entirety to a huge ranch operation, the ‘ili borders were not relevant, unlike many other ‘ili lands that were placed on maps by the Kingdom’s Government Survey Office from the 1870s on. Elsewhere, where ‘ili were awarded to different low chiefs and where they still had resident commoners, the ‘ili borders were mapped. For Lualualei, it is apparent that these identified lands included fields and houses in the upper valley and out onto the far inland margins of the lower valley. Mā‘ili on the shore, given the location of the name on the maps, seems to have included the shore and the lower parts of the upper valley behind the shore. A huge intervening area between Mā‘ili and the inland lands is a gap. Was it included in these named lands? Did the upper valley lands extend much farther seaward into the lower valley, and did Mā‘ili extend much farther inland into the lower valley – with them meeting and sharing a border? This is almost impossible to tell at present, without new sources of archival information; for this intervening gap was in sugarcane by the late 1870s, just when the early maps were made.

Trails

All the old maps (from 1876 on) show the main coastal trail running along the shore, roughly where Farrington Highway is today.

The trail that ran over the Kolekole Pass from Līhuʻe-Wahiawā, down around KaʻĪlio, and through the gap into Waiʻanae valley is labeled "Waianae Road" on the 1876 Kingdom's Government Survey Map of Oahu (Kingdom Map 1876), with the label appearing along the trail above the pass in today's Schofield Barrack's area. The trail's path in Waiʻanae valley roughly approximates today's Waianae Valley Road. This trail and label is repeated on the 1881 and 1899 maps (Kingdom Map 1881; Beasley Map 1899). The 1902a map shows the Kolekole Pass trail labeled as "Military Road No. 280" in the Mikilua area, where part of the route had clearly been altered from the old trail (Hawaii Territorial Map 1902a). Portions of the older trail are also visible on the map.

On the 1876 map (and 1881 map) at the base of Ka'Īlio, a branch of this Kolekole trail goes to Mikilua, to a walled house (square) marked "Galbraith's" (possibly the ranch headquarters of the then Galbraith-Dowsett Mikilua Ranch covering the entire back of Lualualei). The 1899 map shows this same branch (and a square house unlabeled) and then a road that goes down across the lower valley, crossing Māʻiliʻiliʻi Stream behind the puʻu Māʻiliʻiliʻi, and then going between that puʻu and the tip of Pāheʻeheʻe Ridge to the shore in Waiʻanae. This road is labeled the "Road to Mikilua." On the 1902a map, this road is still so labeled near the shore, but the branch to Mikilua is no longer present above, as the Kolekole Pass trail has been altered as a Military Road and it loops to where this branch once went. (The 1905 map, however, shows the branch as originally depicted and the new military road.) While this may have been a road built originally for the Dowsett-Galbraith Mikilua Ranch, it might also have been an earlier trail, a branch from Kolekole Pass to the shore within Lualualei.

Clearly more modern roads appear on the 1905 map. It shows the Mikilua Road, but it also shows a branch road, breaking off near the seaward tip of Pāheʻeheʻe Ridge and running along the base of that ridge, labeled Paheehee Road. At that time, Paheehee and Mikilua roads ran on either side of new homestead lots in this area. Also, the 1905 maps shows a new road, Lualualei Road, running across the inland end of these lots and continuing all the way across the valley and down towards the shore along Ulehawa Stream (roughly the location of today's Hakimo Road). But again, these are modern roads.

Interestingly, although we know from moʻolelo, oral historical and historical records that a trail ran from ʻEwa through Pōhākea Pass and then down to the shore in one or more branches, this trail is not shown on the 1876 and later maps, suggesting perhaps that it may have gone out of use by this time.

Other Place Names within Lualualei

There are other places in Lualualei that appear in scattered sources. Many more undoubtedly existed and might be found by more intensive research in old Hawaiian newspapers and in the archival records of the Kingdom at the State Archives, as well as in journals and letters of Kingdom residents and foreign visitors. Also, careful interviews with long-time resident kūpuna of Waiʻanae could well add more names. AMEC did some interviewing of Albert Silva of today's ʻŌhikilolo Ranch (whose grandmother had been married to Link McCandless, who leased the back of Lualualei in the early 1900s – Dixon et al 2004:25), and he clearly knew some of the above land names. Anyway, here are a few of these additional names. They are less critical for following the findings reported in this study, but they are an important part of the late 1700s cultural landscape of Lualualei.

Kalimaka -- Name of a moʻo ʻāina (a set of irrigated kalo fields) claimed in LCA 7436 in Pūhāwai (Buke Mahele 6:226).
Keanaloa (Keoneloa) -- Name of a moʻo ʻāina (a set of irrigated kalo fields) claimed in LCA 8005 in Pūhāwai (Buke Mahele 6:228-9; FT 9:309-10)
Kumuohia -- Name of a moʻo ʻāina (a set of irrigated kalo fields) claimed in LCA 7452 in Pūhāwai (FT 9:309).
Pekele (?) -- Name of a moʻo ʻāina (a set of irrigated kalo fields) claimed in LCA 7454 in Pūhāwai (Buke Mahele 6:230).
Keakapili -- Name of a housing area at the mouth of Pūhāwai in the upper valley just above the Kolekole Pass road, where the houses (kahuahale or pahale) of LCA 7436 (Kahi), 7451 (Kailianu), 7452 (Kaahia), 7454 (Kanahele) and 8005 (Apiki) were located (Buke Mahele 6:226, 228-231, 234-5).
Kapūhāwai – Name of the "sacred spring" at the head of the Pūhāwai tributaries (Handy 1940:83).
Maʻipalaoa – Name of a swamp, apparently behind Māʻili's shore. It is unclear how old this name is (Sterling and Summers 1978:67).

There are several names that appear to be in Lualualei that are referred to in the famed Pele and Hiʻiaka story, when Hiʻiaka walks along the Waiʻanae shore and then walks inland through Lualualei to the top of Pōhākea Pass. At the top, several chants by Hiʻiaka refer to the terrain on both sides of the Waiʻanae ridgeline, as well as her seeing that her lehua forests on Hawaiʻi had been burnt by her sister Pele. The following names come out of the Emerson and Hoʻoulumāhiehie presentations of this story. Emerson presents two versions of her walk up to Pōhākea (Emerson 1915:156-7, 164-5), versions from different unidentified Hawaiian newspapers. Hoʻoulumāhiehie published the story in 1905, but gives several different versions of Hi'iaka's chants. One problem with Emerson's account, at least in the Waiʻanae area, is that he translates capitalized and uncapitalized place names in the Hawaiian literally into English, so it appears as prose/chant but not a name. This was true for land names within the Kamaile ʻili area of coastal Waiʻanae (Cordy 2001). It also seems true here. Hiʻiaka starts at Kāne-pu-niu, which seems to have been in Waiʻanae valley on the shore not far from the famed coconut grove near Puʻu Kāhea. This Kāne-pu-niu is also mentioned in a John Papa ʻĪʻī account describing where

Liholiho and his retinue stayed while his father and the court decided what to do about a kapu violation (ʻĪʻī 1959:23; ms quote in Sterling and Summer 1978:64). Places within Lualualei seem to be as follows:

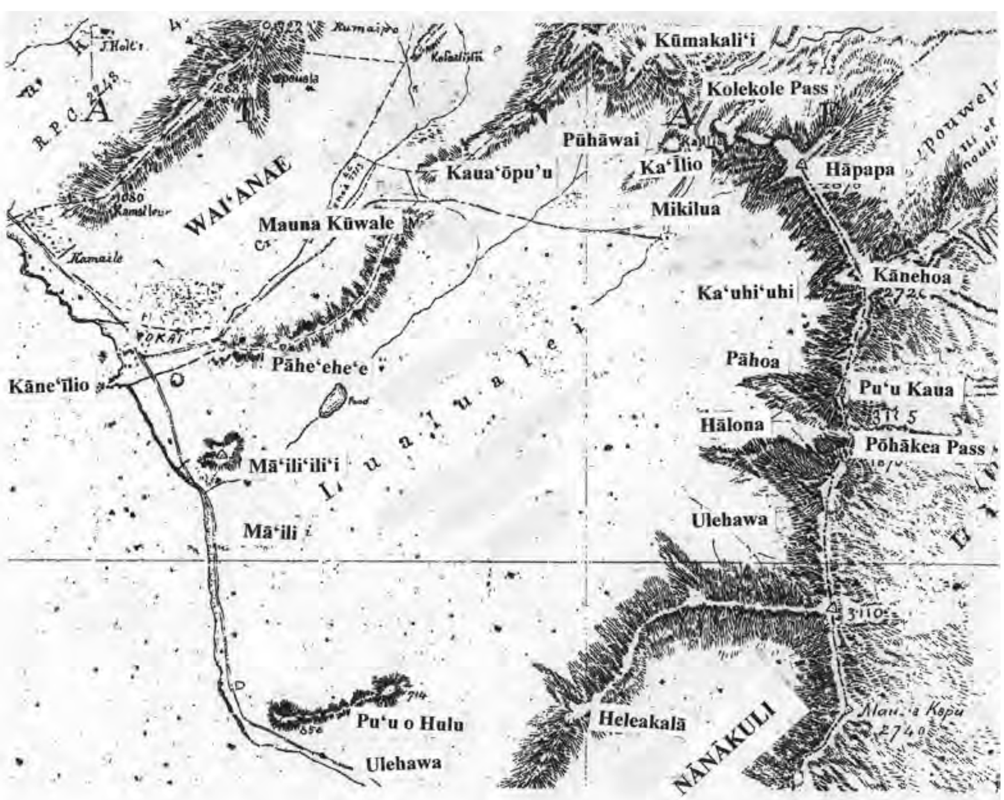
Puʻu-liʻiliʻi – clearly the promontory or puʻu Māʻiliʻiliʻi (Emerson 157; Hoʻoulumāhiehie 2006:264-5, English).
Kalawalawa – unknown, capitalized in the Hawaiian (Emerson 157)
Pahe-lona – unknown, capitalized in the Hawaiian (Emerson : 157); Paholona (Hoʻoulumāhiehie 2006:264, English)
Wai-ko-ne-ne-ne – unknown, capitalized in the Hawaiian (Emerson :157); Waikonene (Hoʻoulumāhiehie 2006:261, 264, English)
Ka-moa-ula – capitalized in the Hawaiian, the high point at Pōhākea – "Homaha aku i Ka-moa-ula; A ka luna i Poha-kea." Komoʻula (Hoʻoulumāhiehie 2006:264, English). This is the last in the series of names given, so the others are somewhere between puʻu Māʻiliʻiliʻi and Pōhākea.

The second reference has Hiʻiaka atop Pōhākea and apparently looking back into Lualualei.

Ka-ilio – This is uncapitalized from the full verse "Aluna au o Pohakea, Wehe ka ilio i kona kapa" (161), which Emerson translates as "I stand a high on Poha-kea; The dog of storm strips off his robe" (162). The first phrase seems translated satisfactorily. The second phrase is more debatable. His footnote (161) says this refers to a storm-cloud breaking up (taking off the kapa), which seems quite plausible. However, rather than the literal "The dog of storm strips off his robe", if Hiʻiaka was looking back into Lualualei, this dispersing cloud could well have been on the high point of KaʻĪlio below Kolekole Pass. Hiʻiaka's chants about features along the mountain ridge on the Schofield side often makes these kinds of statements. So perhaps the translation should be "KaʻĪlio is taking off its kapa", referring to a cloud dispersing off KaʻĪlio.
Ke kula o Miki-kala – unknown location, capitalized in Hawaiian (163), the plain (kula) of Miki-kala
Ke kula o Puha-malo – unknown location, capitalized in Hawaiian (163), the plain (kula) of Puha-malo. Pūhāmaloʻo (Hoʻoulumāhiehie 2006:261, English).

<u>Translation of Place Names</u>

No attempt is made here to translate the literal meaning of these place names, nor to interpret a link between the meaning and the place. (The reader can see the AMEC report for some of this, Dixon et al 2004:17-18, and Sites of O'ahu, Sterling and Summers 1978:63-7.) While I agree with Kepelino, who wrote in the 1860s that "to the Hawaiian the name is important", analyzing the meanings of place names is full of problems. Literal translations can often be incorrect, particularly with the fact that older spellings from the 1800s lack the ʻokina and kahakō and often utilize contractions. The rarely read appendix in Pukui, Elbert and Mookini's *Place Names of Hawaii* (1974:235-280) vastly expands on these issues. Also, over-interpretation of literal translations also can frequently occur, and do. Sometimes individuals will even suggest the Hawaiian name is not correct, and should have been something else, which they then push as the proper name. And names can change over time (notably in recent years). Rare cases exist where the original meaning is clearly retained in older records or in community knowledge directly from kūpuna (not literal translations and hypothesized meanings). If this is not the case, then all translations and interpretations need to be viewed as hypotheses. Meanings of names are complex. A name often is given in honor (in jest, or in dishonor) of a chief or god, or events or aspects of the natural environment; and sometimes these names are full of kaona and not straightforward. Pukui (1942) gives some excellent examples. Also, sometimes these names refer to events, chiefs, gods, or natural phenomena from the local area. But sometimes the names and meanings are brought from other areas and earlier times, and are not necessarily descriptive of a place, nor are the names of events, gods, chiefs, and the like necessarily associated with a place. Interpreting place names can become a very volatile and personal issue to holders of different viewpoints. I am choosing to avoid this problem here by not attempting to determine the meanings of places. I simply accept the names as places on the landscape, and will focus on looking at what can be found about how these places were used and looked like in past times. A future research project could perhaps address the meanings of these names of Lualualei – gathering rare known meanings from old sources or clearly passed down as kūpuna knowledge and analyzing hypotheses of the meanings (hypotheses both in the literature and in the community).



DRAFT Figure 8. Map Locating Main Place Names Identified in Lualualei

Table 1

LIST OF PLACE NAMES IN LUALUALEI

WAI‘ANAE RIDGELINE & ITS PEAKS

Kūmakali‘i – Kumakalii (1876, 1881)[1]
Kolekole (pass) – Kolekole Pass (1876, 1881, 1899, 1902a)
Ka‘Īlio – Kailio (1876, 1881, 1899, 1902a)(Late 1840s FT 9:309-10 for LCAs 7452 and 8005) (Emerson 1915:161-2)
Hāpapa (also possibly Kapapa) – Hapapa (1876, 1881, 1902a)
Kānehoa – Kanehoa (1876, 1881), Kanahoa (1902a)
Pu‘u Kaua – Puu Kaua (1876, 1881, 1902a)
Pōhākea (pass) – Pohakea Pass (1876, 1881, 1902a), Pohakee Pass (1899)
Ka-moa-ula – high point Pohakea pass (Emerson 1915); Komo‘ula (Ho‘oulumāhiehie 2006:264, English)

WAI‘ANAE/LUALUALEI SIDE RIDGE PEAKS

Kaua‘ōpu’u -- Kauaopuu (1876, 1881); Kauopuu (1899), Kawaopuu (1902a, 1902b)
Mauna Kūwale -- Mauna Kuwale (1876, 1881, 1899), Kuwale (1902a, 1902b)
Pāhe‘ehe‘e makai and mauka, or just Pāhe‘ehe‘e – Paheehee (1876, 1881), Paheehee makai & mauka (1902a, 1902b)

LUALUALEI/NANAKULI SIDE RIDGE PEAKS

Heleakalā – Heleakala (1876, 1881, 1899, 1902a, 1902b)

COASTAL PROMONTORIES

Mā‘ili‘ili‘i -- Mailiilii (1876, 1881, 1899, 1902a, 1902b), Pu‘u-li‘ili‘i (Emerson 1915:157; Ho‘oulumāhiehie [1905] 2006:264-5, English)
Pu‘u Hulu o Kai and Pu‘u Hulu o Mauka -- Puuohulu (1876, 1881, 1899), Puu o Hulu Makai & Mauka (1902a, 1902b)

COASTAL POINTS OF LAND

Kāne‘īlio – Kaneilio (1876, 1881, 1899)

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1. The spelling of places at the left margin uses modern orthography (‘okina and

kahakō). Older spellings are presented for each place with references for the spelling.
The dates listed here are for maps. Kingdom Maps 1876 and 1881; Beasley Map 1899, Territory of Hawaii Maps 1902a, 1902b, 1905.

Table 1
LIST OF PLACE NAMES IN LUALUALEI (contd.)

THE STREAMS & TRIBUTARIES

Māʻiliʻiliʻi Stream system

Pūhāwai
Mikilua (?)17
Pahoa (?)
Hālona (?)
Māʻiliʻiliʻi Stream – at the shore. Mailiilii Stream (1902a, 1902b)
Lualualei Creek (1899) – the drainage flowing parallel along Pāheʻeheʻe Ridge
Pond – on Māʻiliʻiliʻi Stream just back of puʻu Māʻiliʻiliʻi (1876, 1881, 1899). Possibly Lualualei Reservoir (1905)

Ulehawa Stream – at the shore (confirmed) (1902a, 1902b) and in the upper valley (?)

NAMES OF LANDS – ʻILI (?)

Pūhāwai – Puhawai (1876, 1881, 1899, 1902a), ili Puhawai (1840s land records for LCAs in Pūhāwai – FT 9:308-310; Buke Mahele 6:234-5).
Mikilua (?) – Mikilua (1876, 1881, 1899, 1902a)
Kaʻuhiʻuhi (?) – Kauhiuhi (1902a)
Pahoa (?) – Pahoa (1902a)
Hālona (?) – Halona (1876, 1881, 1899, 1902a)
Māʻili – Maili (1876, 1881, 1902b)
Ulehawa (?)

TRAILS

Coastal trail (unnamed) (1876, 1881, 1899).
Kolekole Pass
Waianae Road (1876, 1881), Road to Waianae (1899) – Kolekole pass trail, down and over through gap into Waiʻanae. Part of route altered in Mikilua as "Military Road No. 280" (1902a), and portion of trail in Wai'anae valley labeled "Trail", not road (1902a).
Road to Mikilua (1899) – from Waiʻanae on shore, through gap between tip of Pāheʻeheʻe Ridge and puʻu Māʻiliʻiliʻi, across stream and then up across the lower valley to Mikilua (connects over to Kolekole Pass road). Still visible and labeled, but

less clear in portions (1902a).
Pōhākea Pass
Pōhākea Trail – from ʻEwa, through the pass, and into Lualualei where unknown branches led to the shore (ʻĪʻī 1959:23; Emerson 1915; Hoʻoulumāhiehie 2004 [1905]).

Table 1
LIST OF PLACE NAMES IN LUALUALEI (contd.)

MISCELLANEOUS NAMES

Kalimaka -- Name of a moʻo ʻāina (a set of irrigated kalo fields) claimed in LCA 7436 in Pūhāwai (Buke Mahele 6:226).
Keanaloa (Keoneloa) -- Name of a moʻo ʻāina (a set of irrigated kalo fields) claimed in LCA 8005 in Pūhāwai (Buke Mahele 6:228-9; FT 9:309-10)
Kumuohia -- Name of a moʻo ʻāina (a set of irrigated kalo fields) claimed in LCA 7452 in Pūhāwai (FT 9:309).
Pekele (?) -- Name of a moʻo ʻāina (a set of irrigated kalo fields) claimed in LCA 7454 in Pūhāwai (Buke Mahele 6:230).
Keakapili -- Name of a housing area at the mouth of Pūhāwai in the upper valley just above the Kolekole Pass road, where the houses (kahuahale or pahale) of LCA 7436 (Kahi), 7451 (Kailianu), 7452 (Kaahia), 7454 (Kanahele) and 8005 (Apiki) were located (Buke Mahele 6:226, 228-231, 234-5).
Kapūhāwai – the "sacred spring" at the head of the Pūhāwai tributaries (Handy 1940)

Maʻipalaoa – Name of a swamp, apparently behind Māʻili's shore. Unclear how old this name is (Sterling and Summer 1978:67).

Kalawalawa – unlocated, in Hiʻiaka chant (Emerson 1915:157).
Pahe-lona – unlocated, in Hiʻiaka chant (Emerson 1915:157).
Paholona (Hoʻoulumāhiehie 2006:264, English)
Wai-ko-ne-ne-ne – unlocated, in Hiʻiaka chant (Emerson 1915:157).
Waikonene (Hoʻoulumāhiehie 2006:261, 264, English)
Ke kula o Miki-kala – unlocated, in Hiʻiaka chant (Emerson 1915:163).
Ke kula o Puha-malo – unlocated, in Hiʻiaka chant (Emerson 1915:163).
Pūhāmaloʻo (Hoʻoulumāhiehie 2006:261, English).

GENERAL HISTORICAL CONTEXT
HISTORY OF O‘AHU & OF MOKU O WAI‘ANAE

[The following summary of pre-European times is largely from Cordy 2002a, 2002b, 2012, which include more specific references.]

The Hawaiian Islands were settled between AD 300-600 or 700-900, depending on which different hypothesis is currently followed. The trend seems to be to suggest about AD 800-900 (e.g., Kirch 2012; Hommon 2008). Up to about AD 1000, permanent habitations and fields on O‘ahu were restricted to the windward sides of the islands. The leeward sides – of which Wai‘anae district is a part – were visited periodically by residents of the windward side to exploit resources (birds, fish, stone, etc.). Camp sites (used for short periods of time) are solely found on the leeward side during this period. About AD 1000, people began settling the dry sides of the island, with most lower valleys occupied with permanent houses and farms by the 1300s. This 1000-1300 period is when the lands of the Wai‘anae coast began to be permanently settled, with house sites and fields. Up to this time, it is hypothesized that countries were small and unstratified, perhaps a couple of valleys with 500 or so people under a chief with minimal power.

In the AD 1300s, the Hawaiian oral histories document the formation of large district-sized countries. Wai‘anae was part of a country that included ‘Ewa and Waialua. Two other countries on O‘ahu were Kona (the Moanalua to Kuli‘ou‘ou area, including Waikīkī and Nu‘uanu) and the Ko‘olau side (from Waimea to Waimānalo, including Kailua and Kāne‘ohe). The ‘Ewa-Wai‘anae-Waialua country was said to be the most powerful of the three countries on O‘ahu. These countries had initial forms of stratification with a ruler and local chiefs over the multiple communities, and populations of perhaps 2,000-5,000. Key institutions were begun – the kō‘ele fields that had to be cultivated for the chiefs and the hale naua/‘aha ali‘i to establish being a chief probably in relation to the king. The ‘Ewa-Wai‘anae-Waialua country’s famed ruling center was at Līhu‘e in today’s Schofield Barracks and Wahiawā area, including Kūkaniloko, the famed birthing place said to have been created in the late 1200s-early 1300s. The 1300s also saw the initial construction of larger public works projects – large fishponds and much larger temples. It would also be expected that main trails (ala loa) that linked the lands of these countries were established and worked on as public works projects by this time.

In the 1400s, the Hawaiian oral histories describe the formation of the O‘ahu Kingdom, which included all of O‘ahu. It was much more stratified, probably with the ruler and high chiefs controlling multiple lands, and local chiefs under them controlling individual communities. The oral histories also indicate stratification became greater, with the development of respect behavior that set the ruler and elite apart from the rest of the population. The oral histories indicate that Līhu‘e was the sole ruling center of this kingdom until the mid-1500s, at which point multiple ruling centers were periodically used (Waikīkī, Kailua, places around Pearl Harbor). In the 1300s-1400s, archaeology shows that commoner houses spread up into the upper valleys of the island, along with cultivated fields. The pattern of a growing population with developing stratification of the elite continued up into the 1700s. Some researchers argue (based on population models and one generated from archaeological data for the entire Hawaiian chain) that population growth dramatically leveled off, perhaps in the 1600s. Others see population still growing.

In the 1500s-1600s, there were many famed O'ahu rulers: Māʻilikūkahi, Piliwale, Kalanimanuia, Kākuhihewa, and others. There was one brief collapse of the kingdom into two kingdoms about 1620-1640, when Kaʻihikapu killed his brother Haʻo (chief over ʻEwa and Waiʻanae) and Haʻo's son Nāpūlānahu (married to his aunt Kekela and Kaʻihikapu's sister) successfully broke way forming a kingdom in Waiʻanae-Waialua and Koʻolauloa. However, the kingdom was reunified within a generation with the marriage of Kaʻihikapu's son and Nāpūlānahu's daughter, Kākuhihewa and Kaea-a-Kalona (also apparently known as Kahai-aonui-a-kaua-i-lana) (respectively) (Kamakau 1991:70; Fornander 1880:273). In the late 1600s, the king became weaker for several generations. But this changed with the famous king Kūaliʻi regaining powerful central control about 1700. In the early 1700s, the Kingdom of Oʻahu became the first "super-power" of the Islands under the rulers Kūaliʻi and his son Peleiōhōlani. Kauaʻi came under its control during Kūaliʻi's time, reputedly through inheritance, and Molokai was conquered by Peleʻiōhōlani in the mid-1700s. At this point, the kingdom possibly had 70,000 – 90,000 people.

In 1783, perhaps four years after the death of Peleʻiōhōlani, Oʻahu was conquered and became part of Kahekili's Maui Kingdom; and about a decade later, after the death of Kahekili, the Maui Kingdom was conquered by Kamehameha's Kingdom of Hawaiʻi in 1795. In 1810, Kauaʻi (which had regained its independence in the late 1700s) declared fealty to Kamehameha, and the islands were unified.

In Kamehameha's time, the Kingdom initially had about 300,000 people, and was a highly stratified society with politics, national religion, and land control centered about its elite (the king, island governors, and 20 or so high chiefs). With European contact, ports for their ships became important. Port towns accordingly grew in size. On Oʻahu, Honolulu became the sole port town by the early 1800s. Effectively, Honolulu became the sole ruling center on Oʻahu, with the king and nobility having secondary houses in places like Waikīkī. Some high chiefs had residences out in their more bountiful lands in rural O'ahu, but they seem to have rarely been in residence for long in those areas. Foreign merchant activity up to 1819 seems to have largely been focused in the Honolulu area, with some peddlers taking Euro-Asian goods into ʻEwa. But, by the end of Kamehameha's reign there was as yet no on-shore mercantile or larger foreign presence.

On Kamehameha's death, the national religion was soon abolished (1819), the missionaries arrived (1820), and by the 1830s the chiefs and their followers began to convert. In the 1820s-1830s, the king lost power to the high chiefs, who avidly participated in the sandalwood trade and then the re-supply trade to the whaling fleet to obtain new status goods from abroad. Merchants established places in Honolulu, and Honolulu became a small city of 13,000 in the 1830s, pulling in people from the rural areas for jobs, to escape the burdens of demands from their chiefs, and to see the "bright lights." Not only was settlement shifting to urban Honolulu on O'ahu, overall population was dramatically declining across the islands. The first four decades of the 1800s saw huge population drops, as a result of epidemics increasing fatalities and particularly venereal diseases causing much lower birth rates. The conservative estimate for all the islands at European contact is about 300,000 (Schmitt 1971). In 1835-36 the population was 108,579 (Schmitt 1973:8) – the latter being 36% of the Contact total. O‘ahu may have had 43,000 people at Contact (Schmitt 1971:241-2). By 1835-36, there were 27,809 (Schmitt 1973:8) – a smaller decline than on Hawai‘i and Maui islands due to the rapidly increasing size of Honolulu, but still only 65% of the Contact total, a sizable drop. By 1855 overall population was down to 70,000; 23% of the Contact estimate. As a result of overall population decline and movement of rural population to port towns, upper valleys had become largely abandoned by the 1840s. Māhele land records of the late 1840s usually dramatically show almost no commoner land claims in the upper valleys. Archaeological surveys also show this dramatic drop, with very few upper valley house sites having Euro-Asian artifacts, which began spreading into rural O’ahu in the 1840s. Essentially, the increasingly smaller population that remained in rural lands in the 1840s was strikingly contracting towards the shore.

By 1850, land became privatized in what is called today the Māhele. The Kingdom was divided into the lands of the high chiefs and king (with the king’s split into Government and personal Crown lands, and with many high chiefs giving up portions of their lands to Government lands as commutation fee payment). Within these lands, commoners then claimed their houses and fields, known today as kuleana or LCA awards (Land Commission Awards). In the 1840s, the chiefs had begun to lease lands to large ranches with free-roaming cattle. After the Māhele, the chiefs continued these leases and eventually sold lands to these ranches. The rise of these large ranches on O‘ahu is a historical story waiting to be told (but see Barrere 1970; R. Cordy & D. Cordy 2012). Many were run by foreign-born residents with high ranking Hawaiian wives and then by their children (the Robinsons, the Holts, the Dowsetts, the Manini and Meeks). In the 1870s, the sugarcane industry began to boom as a result of the reciprocity treaty with the United States ending taxes on exported Hawaiian sugar. As a result, vast lands were acquired by sugarcane companies, and masses of immigrant labor were imported. By the 1890s, Hawaiians were no longer a majority in their own land.

By the 1880s, a faction of non-Hawaiian businessmen-merchants forced King Kalākaua to alter the Constitution and require voters to have a certain amount of cash or land, essentially disenfranchising much of the Hawaiian population from voting. When Lili‘uokalani attempted to alter the Constitution and increase the ruler’s power, this faction overthrew the Kingdom of Hawai‘i’s government, ending the monarchy in 1893. Members of the largely non-Hawaiian business elite then established the Provisional Government and then a Republic (neither elected) and pushed for annexation of Hawai‘i by the United States, which occurred in 1898. The Territory of Hawaii was established in 1900. (See Osorio 2002 and Coffman 2009 for summaries of this era.)

WAI‘ANAE MOKU’S PLACE IN THIS HISTORICAL CONTEXT

[The following information largely comes from Cordy 2002b, which again includes more specific references. Contact to 1840s information comes in part from R. Cordy & D. Cordy 2012, again with more references in that paper.]

As a leeward land, the Wai‘anae coast was not occupied until after AD 1000. Prior to that time, it is suggested that residents of windward lands visited the area to hunt birds, fish, and gather resources. Camp sites are expected, and one early fire hearth at Pōka‘i Bay may come from such a camp. Camp sites could also be along the cross-mountain trails into the district (over Kolekole and Pōhākea passes).

Again, between AD 1000-1300, the leeward lands of O’ahu began to see permanent settlement and farming in their shore and lower valley areas. Wai’anae was such a leeward land, and it did indeed see settlement at this time. Because Wai‘anae valley was the only land on the coast with a stream that flowed year-round to the sea and had a large spring-fed freshwater marsh at Kamaile, it undoubtedly was an attractive land for settlement. Archaeological information shows the valley was permanently occupied in the AD 1100s-1200s. Settlement in the early years was on the shore and in the lower valley – with permanent houses and irrigated fields. A similar pattern has been hypothesized from archaeological findings in Mākaha, where dryland sweet potato fields and temporary habitation shelters have been dated to this period in the lower valley along the base of the ridges and where researchers have hypothesized that people using these fields and shelters were living in permanent housing on the shore near Mākaha Point (Green 1980). Similar early coastal settlement has been suggested for Nānākuli, based on archaeological dating of settlement movement (permanent houses and fields) into the upper valley in the 1300s and hypothesizing earlier settlement on the shore for several centuries before population expanded and some moved inland (Cordy et al. in preparation).

In the years of the ‘Ewa country (1300s) and O‘ahu Kingdom (1400s-1783), Wai‘anae district was generally a rural region. The ruling centers for the kingdom were elsewhere (Līhu‘e, around Pearl Harbor, Waikīkī, and Kailua). Again, it is likely that in the 1300s, the major trail system (ala loa) that linked the communities of the ‘Ewa-Wai’anae-Waialua country was in place and was worked on with public labor. The main coastal trail approximated Farrington Highway. Trails over the mountains included Pōhākea and Kolekole in Lualualei (the former leading towards Pearl Harbor and the latter directly into the ruling center of Līhu‘e and then north on into Waialua or south down to Pearl Harbor) and a trail out of Mākua valley and over into the Kawaihāpai area of Waialua. The two Lualualei trails would have had public access extensions down to the shore in several places in Lualualei and into the back of Wai‘anae valley through the gap in the Kaua‘ōpu‘u/Pāhe‘ehe‘e spur ridge and down to the shore (approximating Wai’anae Valley Road). (Obviously these trails could have been in use for centuries before the 1300s, but they would become key country routes requiring maintenance in the 1300s.)

Within Wai‘anae district, Wai‘anae valley was the economic center with irrigated kalo fields from the shore all the way up along Kaupuni Stream and its tributaries and in the spring-fed coastal marshlands of Kamaile. Solid dating from Nānākuli (Cordy et al. in preparation) and from Lualualei (as will be seen) indicates that in the 1300s-1400s, the upper valleys of the moku began to be permanently occupied and farmed. Intensive terraced dryland farms covered the back of the lower valley in Wai‘anae along with its widespread irrigated kalo fields in the upper valley – and when dated, it is expected permanent housing and these fields will date back to the 1300s-1400s, if not slightly earlier given the fertility of Wai‘anae valley. By European Contact (1778), fields were present across all the upper valleys of Wai’anae. It is not clear if there was more vacant land in the extreme uppermost areas that could have been put under cultivation, but it seems that if there was, this was not much land. Irrigated kalo fields were present only in Wai‘anae valley (from the mountains to the shore), in Mākaha (only in the upper valley), and as will be seen in parts of Lualualei (only in the upper valley). All of Mākaha’s lower valley, most of the valley of Lualualei, and all the rest of the moku seems to have had only cultivated rainfall fields, supplemented by some water retention features (ponds in streams, walls across drainages). In these areas, sweet potato was dominant, except perhaps in the upper valleys against the mountains where rainfall was above 40 inches per year and dryland kalo could be grown.

Linked to farming production, Wai‘anae valley was also the demographic center of the district with 1,800-2,500 people estimated at the end of the 1700s. Population seems to have grown enough by the 1300s-1400s to have permanent housing spread into upper valleys (based on the data from Nānākuli. Lualualei, and Mākaha), and then it markedly increased in numbers from the 1500s right up to European Contact (again, the dated sites from Nānākuli and, as will be seen from Lualualei). Population estimates for the late 1700s across the moku are shown in Table 2. Wai’anae valley dominates, but Lualualei also had a large population, as will be seen, but more a factor of its size. In many respects (e.g., population density), Mākaha is the number two population focus, and then Lualualei, Mākua/Kahanahāiki, and Nānākuli, and the lowest being Keawa’ula.

In the 1400s-early 1600s, it appears that the moku was governed by a high chief, who largely resided in ‘Ewa. The last of these high chiefs to clearly have control over Wai’anae as well as parts of ‘Ewa was Ha‘o, the brother of the successive rulers Kū-a-Manuia and Ka‘ihikapu, ca 1620-1640. By the 1700s Wai’anae had become a separate administrative unit, and Wai’anae valley had become the political center of the district. The first recorded high chief over the moku that has been identified in the oral histories was Kū-a-Nu‘uanu in the reign of Kūali‘i in the early 1700s (Fornander 1880:135), followed by his son Nā‘ili in the 1740 era (Kamakau 1961:71). But it is possible that Wai‘anae moku had such a high chief placed over it in Kākuhihewa’s time (1640-1660) after Nāpūlānahu split off Wai‘anae from ‘Ewa in his successful revolt against Ka‘ihikapu (Kākuhihewa’s father, who murdered Nāpūlānahu’s father Ha‘o) and when Kākuhihewa reunified the island by marrying Nāpūlānahu’s daughter (Cordy 2012:Chap. 6,note 54). The high chief that controlled Wai‘anae district resided in Wai‘anae valley at Pu‘u Kāhea behind Pōka‘i Bay, when he was in residence and not at the royal court or in his other bountiful lands. No oral histories or archaeological house site information indicates that a high chief lived elsewhere in the moku. This means that the other lands of the moku had low chiefs in residence (and Wai‘anae valley also) to manage the lands for their overlord chiefs. In the 1300s, it is suspected that the local chiefs were kin-based, the head of the senior lineage holding lands in the specific land unit. At some point, these local chiefs became appointed managers by the overlord chiefs, and were usually junior relatives of their overlord. And at some point commoner lineages lost control over land-holding, and claims by commoners to land were by past use or use granted by the local chief and always had to be validated by the local chief on behalf of his overlord.

Table 2
Population Estimates for the Lands within Waiʻanae Moku in the Late 1700s
Population Estimates for European Contact[1]

Ahupuaʻa	Taxpayer-based Estimates	Archaeological Estimates	Combined Estimates	Possible Totals
Nānākuli			420	420
Lualualei			1,532	1,532
[Inland area]	[1,100]	[846]		
Waiʻanae	*2,544	1,500-2,000		1,500-2,544
Mākaha	1,008	600		600-1,008
Keaʻau – ʻŌhikilolo	---	---		----
Mākua – Kahanahāiki	504			504
Keawaʻula	**90	50-100		50-100

1. Estimates based on 6 persons per household in pre-European times. Table from Cordy 2007.
* Another estimate for Waiʻanae, based on Māhele land records (lower valley) and archaeology (upper valley), is 1,820.
** This estimate is derived from 1820s student counts.

Last, it appears clear that Wai'anae valley was the main religious center of the district, in the sense of linkage to the kingdom's national religion. While small heiau were present at commoner houses, in fields, near the shore for fishing and in the forest, the national religion associated with the ruler and high chiefs had much larger heiau. Major heiau are said to be above 500 m^2, and the largest of these heiau were the luakini or poʻo kanaka heiau that were said to have been able to be built only with the king's permission. The luakini were used for key ceremonies of importance to the kingdom – success in war, success in cultivation for the entire kingdom, and long life of the king. Virtually every royal center had one of these luakini actively in use, but they could also be found in outlying areas built for special occasions or other reasons. Further, other major heiau could be built for other specific purposes. Strikingly, nine (9) of the 12 large heiau along the Waiʻanae coast are in Waiʻanae valley, and the main luakini temple of Kamohoaliʻi at

Pu‘u Kāhea was near Pōka‘i Bay’s shore. There is one large heiau said to be a po‘o kanaka in Lualualei (Nioi‘ula heiau), reputedly associated with Kākuhihewa. It lies along Pōhākea Trail and seems to be a luakini built for a special event or purpose. How long it was used and by which rulers besides Kākuhihewa is silent in the oral histories. Kāne‘ākī heiau in Mākaha seems to have been increased in size in the 1700s to become a luakini, again apparently for a special event or purpose. No published oral histories refer to Kāne‘ākī’s use. There was also one large heiau at Kahanahāiki on the shore (Ka‘ahihi heiau) with very little information available about its history (McAllister 1933). The key point here is that the focal presence of large heiau was in Wai’anae valley – not surprising given its place as the moku’s economic, population and political center and the spot (with sparse records, but at least in Kahahana’s time) where the king stopped during circuits of the island.

This rural context for Wai‘anae valley and the district continued under the Maui Kingdom and Kingdom of Hawai‘i until Kamehameha’s death. The royal centers were elsewhere, and the high chief would only occasionally appear and briefly stay –at Pu‘u Kāhea in Wai‘anae valley. In the late 1810s, high chief Boki was Governor of O‘ahu under Kamehameha, and he controlled Wai’anae moku (perhaps as the manager of the king’s lands). Boki occasionally resided at Pu‘u Kāhea, although his main residence was in Honolulu.

With Kamehameha’s death, Wai‘anae moku underwent many of the same changes as seen elsewhere in the islands. However, although the king’s power was diminished in the 1820s-1830s, Wai‘anae moku remained under the administration of Boki and then his wife Liliha until the early 1830s, probably managing the district on behalf of the king. The moku was fiercely loyal to Boki and Liliha and Kamehameha III. In the 1830s, the moku briefly passed into control of Kīna‘u and her husband, Governor Kekūanāo‘a, but Kamehameha III eventually claimed most of it back as his lands in the 1840s (Judd’s 1847 list of the king’s land in Kame‘eleihiwa 1992:228, 267), and sizable parts of the moku became Crown lands. Wai’anae valley and Lualualei both became Crown lands in the Māhele.

With declining island-wide population in the 1820s-1840s and with a shift in settlement on O’ahu to Honolulu, again rural populations dramatically reduced in size. Wai’anae moku also saw a reduction in overall population and considerable abandonment of its upper valleys. Archaeological surveys strikingly show this shift of settlement out of upper valleys. It appears Euro-Asian objects (bottles, ceramic plates and bowls, etc.) began to become available to commoners in rural O‘ahu in the 1840s. Sahlins notes that in Waialua in 1846 peddlers became common (selling wares out of Honolulu), and in 1849 the first retail store opened (selling cloth, clothing, plates, knives, etc.)(Sahlins 1992:163-164). (Perhaps Euro-Asian objects may have become common in the 1830s, but it does not appear that this occurred much earlier.) Although numerous house sites have been found in upper valleys in Wai‘anae moku, very few included Euro-Asian objects. Most of these houses were abandoned by the time Euro-Asian objects were becoming available, by the 1830s-1840s. This pattern can be seen in Wai‘anae and Nānākuli valleys (Cordy 2001a, 2001b; Naboa 2009; Cordy et al. in preparation). In Wai‘anae, of 48 house sites identified in the upper valley; only 6 had Euro-Asian objects indicating continued occupation into the 1830s-1840s (Cordy 2001a). Māhele land records of the late 1840s also show that most upland farms and houses were abandoned by the 1840s. There were only 5 awards in upper Wai'anae valley. As in other areas of the islands, Wai'anae's population was increasingly smaller and was contracting towards the shore.

With the Mahele of the late 1840s, large ranches also began to form in Wai‘anae moku in the 1850s – the Holt ranch in Mākaha, Frank Manini's ranch in Nānākuli, and as will be seen the Jarrett-Paul Manini ranch (later the Dowsett-Galbraith ranch) in Lualualei. The owners of these ranches tended to have houses in Honolulu, and country houses on their ranches. They were wealthy, and most were married into high ranking and wealthy Hawaiian or part-Hawaiian families. For example, the Manini ranchers of Wai‘anae were all sons of Francisco de Paula Marin (a Spaniard, who had served Kamehameha I as a translator and aide and who had married high ranking women and was noted as among the wealthiest on O‘ahu by 1830). He had acquired cattle through his contacts and had a sizable herd in the Pauoa area of Nu‘uanu by 1830. One effect of these ranches was that the free roaming cattle often damaged dryland crops of local commoners. Crops and houses often began to be walled in, but even so damage occurred. Often, this accelerated commoner abandonment of the areas in and near the ranches.

THE SETTLEMENT OF LUALUALEI

This section of the report presents what we know about Lualualei, based on old maps, mo'olelo, 1800s archival records and archaeological findings. After this section, the report will discuss the extent of archaeological coverage and the cultural and historic properties that have been identified as remaining today.

Settlement at the end of Pre-European Contact Times – the Late 1700s

As seen earlier, Lualualei's valley is by far the largest in the moku. But its lower valley was extremely arid with thin, rocky soil. It had no stream that flowed year round to the shore. Vegetation that is described in the Hi'iaka mele includes ‘ilima shrubs and pili grass, and the AMEC survey found some ‘ilima and wiliwili in gulches in the upper parts of the lower valley (Dixon et al. 2004:15). Other studies suggest that the lower valleys of the Wai'anae coast had scattered trees (likely 'a'ali'i, wiliwili; naio, loulu palms), shrubs (such as ilima, 'aheahea, ma'o), and grasses (pili, kawelu). But again, the Hi'iaka and other accounts do not mention trees in lower Lualualei. Perhaps in Lualualei the trees became more common farther back towards the mountains. It was indeed lusher and more fertile only at the back of the valley, when one entered the upper valley slopes, where rainfall was higher (30+ inches), permanent water flow came out of springs in two tributaries (Pūhāwai and Mikilua), and thicker soil was present. However, these more fertile lands were over 4 miles in from the shore.

Given this environmental pattern, not surprisingly the portrayals of the coast and lower valley of Lualualei are of a hot dry climate. Missionaries traveling along the coastal trail in the 1820s complained about the heat. Even Hi‘iaka in traveling across the lower valley from the pu‘u Mā‘ili‘ili‘i to Pōhākea Pass emphasized this point.

Ua wela i ka la ke kula o Lualualei
The heat of the sun is on the plain of Lualualei
[Hi'iaka story. *Ka Hoku o Hawaii*, 1924-28, translated by K. Maly in Jensen, 1995:7]

The Ko'olauwahine blows gently from below
Caressing the leaves of the 'ilima bushes
Hot, hot from the sun is the pili grass
Upon the breast of Pu'uli'ili'i
Overwhelming at Pāholona
Take rest at Waikonene
[Hi'iaka story. Ho'oulumāhiehie 2006:264, English]

Feisty, the Kaiaulu wind toys with people
Pounding away until faces blaze
Striking a blow at the back
Such is the sun's heat in Lualualei …
[Hi'iaka story. Ho'oulumāhiehie 2006:261, English]

The main coastal trail (ala loa) that connected the lands of O'ahu passed through Lualualei, roughly where Farrington Highway is today. Two major trails came over the Wai'anae ridgeline into Lualualei. One came through Kolekole Pass providing access from the Līhu'e-Wahiawā area, with people also coming up and over from Waialua in the north and 'Ewa in the south. Once over the pass, the trail appears to have wound down the Ka'Īlio ridge and then may have branched – one branch passing into Wai'anae valley and running down to the shore (approximating Wai'anae Valley Road) and the other leading to the shore at Mā'ili (perhaps approximating the Road to Mikilua seen on the old maps). The other pass was farther south, Pōhākea Pass. It provided more direct access from Pu'uloa (Pearl Harbor) and beyond. It came down through Hālona valley. Exactly where the Pōhākea trail reached the shore is uncertain. It may have had two branches, one descending down along Hālona stream to Mā'ili (seemingly the path that Hi'iaka took from Wai'anae to the pu'u Mā'ili'ili'i and across the lower valley up to the pass) and another directly to the shore at Ulehawa. Possibly another branch led from Hālona across the front edge of the upper valley and joined the Kolekole trail heading into Wai'anae. However, this is speculation. Further archival work might identify these branches. Interestingly, Kolekole Pass is well known today, but Pōhākea Pass was heavily used in the past also, perhaps more heavily used in the 1600s-1700s than Kolekole, for in those years all the royal centers were out beyond Pōhākea. 'I'i describes such a journey of Liholiho's followers in the pre-1819 era,

> It was at this time that the king, chiefs, and court members left Honolulu and sailed by canoe to Waianae. Liholiho, the heir to the kingdom went overland with Papa and others from Honolulu and spent the night at Kumelewai in Ewa. …

> The travelers stopped only one night and spent the following night on the other side of Pohakea. The elders and the children who went with them slept above Kunia, on this side of Pohakea. The coming of the retinue was announced in Waianae; ...
> ('I'i 1959:23)

At European contact, permanent houses seem to have been almost entirely restricted to the shoreline and to the upper valley areas. In 1818 Hunnewell (1919:13), walking the shoreline trail, noted "a number of Indian villages" were along Lualualei's shore, but this and other accounts (e.g., Chamberlain 1957[1828]:38) emphasize that these were not large. Almost no archaeology has taken place on the shore. One waterline trench in Liopolo Street in central Mā‘ili (near St. John's Road) found a habitation layer and burials (Kawachi 1990; Hammatt & Shideler 1991). Burials were also found during park renovations at Mā‘ili Point (McIntosh & Cleghorn 2006). Burials (usually in small numbers) are commonly associated with permanent housing as family cemetery plots; thus, burials and habitation deposits were likely part of the permanent housing of Mā‘ili. Archaeological survey behind the sand shoreline has been extensive and has found no permanent housing. This evidence suggests houses and associated burials were on the sand flats behind the dunes. (The same pattern was found in archaeological work at Ulehawa Beach Park – McDermott & Hammatt 2000. There, subsurface habitation deposits were found in spots within the beach park’s dune grading back toward Farrington Highway.) Almost guaranteed, archaeological remains of permanent habitations (in the form of subsurface deposits) are still present in houseyards and other parcels in the dune and back dune sand flats of Mā‘ili and Ulehawa, in parcels that have not had extensively bulldozing.

The size of the population along Lualualei's shoreline in the 1700s is far from clear. In 1855, Mā‘ili had 9 taxpayers (Green 1980:21), and each taxpayer represented a household. If Ulehawa had the same, 18 households and 90 people (5 persons/household) may have been along the shore in 1855. 1855 populations were 25% of those at European contact island-wide (using the conservative island-wide total of 300,000), so an estimate of 72 households and 360 people could be proposed for the 1700s along the shore. This would mean 36 households and 180 people in Mā‘ili, and these would be expected to be along the sandy shore probably along or near the coastal trail, not in the raised limestone or thin, rocky soil of the lower valley. But, this population estimate is only a guesstimate, at best.

It appears that the lower valley of Lualualei had no permanent housing, except perhaps a few along Mā‘ili‘ili‘i Stream. Recent archaeological survey has found one small permanent habitation along the stream (Robins & Anderson 1998 – site 5592). It is suspected that dryland agricultural fields for sweet potato cultivation may have been behind the Mā‘ili shore settlements, but little has been found, perhaps due to late 1800s-1900s land alteration. Archaeological survey of lower valley areas in the NAVMAG - Lualualei area has found temporary habitation sites (L- and C-shaped enclosures) with scattered dryland agricultural terraces and clearings in the 300-400 foot elevations (Haun 1991; Robins & Anderson 1998:32, 35). Lower valley areas between these inland-most fields and the raised limestone area behind Mā‘ili have long been altered by sugarcane, homesteading, and military activities, likely destroying much of the intervening traditional archaeological landscape. However, it has been noted that soils in the more seaward parts of the lower valley were "salt-affected and [had] poor drainage, and the limestone bedrock occurs at quite shallow levels" (Chiogioji & Hammatt 1992). One might guess that some dryland fields might have been in these areas. Dixon et al.'s (2004:32) quote may best sum up the pattern for the bulk of the lower valley:

> The vast plains behind the coast are not likely to have supported much more than seasonal planting of dryland crops in occasionally flooded soils.

Such flooded soils would likely be overflow areas along the stream and behind the coastal dunes/raised limestone areas.

ʻĪʻī, when traveling over the mountains through Pōhākea Pass between 1810-1819, did mention stopping near a fishpond in the lower valley.

> The company, ..., spent a night at Lualualei near the fish pond on the plain.
> (ʻĪʻī 1959:23)

Where this pond was located is uncertain. A pond does show on the 1876 Oahu map along Māʻiliʻiliʻi Stream inland of the puʻu Māʻiliʻiliʻi and parallel to Pāheʻeheʻe Mauka (Fig. 5). It is unclear if this was a fishpond. But it would be just inland of where the Hiʻiaka trail description and the Mikilua Road (trail?) passed by. On the 1905 map, a Lualualei Reservoir is in this location, perhaps a sugarcane era modification and then homestead modification. Alternatively, if swampy land had formed nearer the shore behind the sand dunes, or in and behind the raised limestone areas, perhaps the fishpond was there. This part of the Lualualei landscape is thoroughly altered today, likely preventing discovery of where this fishpond was. More archival work could perhaps identify its location.

Clearly, given the above patterns, it is not surprising that most foreign travelers along the shore trail in the early 1800s assumed that Lualualei was a poverty-stricken area with a low population and a heavy dependence on fishing. Indeed, a similar view existed of Nānākuli. And this perspective continues to the current day. However, any Hawaiian from the west side of Oʻahu at the end of the 1700s and in the early 1800s would have known better. They would have known that in both Lualualei and Nānākuli sizable populations lived in the upper valley along with numerous agricultural fields. The modern view of impoverishment continued until the late 1980s-early 1990s when archaeological surveys in the back of both Nānākuli and Lualualei changed this picture (Cordy et al. in preparation for Nānākuli; Haun 1991 for Lualualei.) The extremely thorough AMEC survey of Lualualei's upper valley (Dixon et al. 2004) even more dramatically changed our view of Lualualei. The following information results from their work and the earlier work by the Bishop Museum.

The upper valley of Lualualei is quite different compared to the other lands of Wai‘anae. It is a narrow band extending across the back of Lualualei, including the steep, 2,400-2,800 foot high ridges at the back of Lualualei and the small valleys or gullies and low ridges emerging from the main ridgeline, from about the 980 foot elevation down to about the 600 foot elevation. This area had 40-60/80 inches per year of rainfall, and thicker soil.

The steeper terrain (>30% slopes) had virtually no archaeological sites. It seems to have remained a dryland native forest. Vegetation can be reconstructed using remnant plant information, pollen from archaeological studies, species identification from archaeological charcoal, and comparisons to other areas. Some upper valley ridgelines along the Wai‘anae coast have remnant native dryland forest with a wide variety of species -- lama or aulu dominated with alahe‘e, kauila, naio, ‘ohe, uhiuhi, ‘ili ahi, nioi, hao and olopua trees (e.g., Judd 1931:67-69; Nature Conservancy of Hawaii 1987). Hau and kukui are still found along some stream drainages.

The more gradual upper valley terrain of tributary gulches and lower ridges was probably also once covered with this dryland forest. By European Contact (1778) parts of this forest had been cleared for farms and houselots and local religious structures. However, today this area is still noticeably cooler and more lush than the rest of the valley. Kukui and lama were identified as boundary points in the 1902 map in this area (Hawaii Territory Map 1902a). AMEC excavations in house structures of permanent housing discovered charcoal, which prior to being sent for dating underwent plant species identification – identifying wood from trees and shrubs in the area that were collected for fires. Among the tree species identified were lama, hao, kukui, hame, naio, ‘ōhi‘a, ‘ōhi‘a ‘ai, olopua, ‘ahakea,m alahe‘e, kopiko, ‘a‘ali‘i and ‘ili ahi (Murakami in Dixon et al. 2004:Appendix, see Table V-1). Shrubs were also found (ko‘oko‘olau, aheahea, ‘akoko, ma‘o, ‘ilima, ‘ulei), some likely indicative of secondary growth from clearing activities.

In 1930, a Bishop Museum archaeological project done for all O‘ahu (McAllister 1933) identified a heiau in Hālona valley (Nioi‘ula) said to be associated with Kākuhihewa, walls and terraces that might have been houses or heiau in the far back of the valley (Pāhoa), and a heiau that was no longer present but had once been adjacent to a spring in Pūhāwai valley (Kakioe heiau). No further work occurred until the mid-1980s, when the Bishop Museum did detailed archaeological reconnaissance work for the Navy (Haun 1991). PHRI did a small survey of an area within Pūhāwai (Jensen 1995). This was followed in 2000-2001 by the AMEC survey (Dixon et al. 2004).

The three recent surveys found 111 permanent house sites in this upper valley zone. These were individual structures or sets of structures with at least one structure in the 17/24-66 m^2 size range, substantive well built features, etc. (common traits used for identification of permanent houses) (Dixon et al. 2004:48). This site type is the kauhale, kahuahale or pā hale of oral historical and 1800s historical records. These sites are on the sides and tops of low ridges and on the flats at the edges of the upper valley. Strikingly, cluster analysis showed 8 groupings of permanent houses – all within the named land units of the upper valley (with two groupings each in Hālona and Ulehawa), with spatial and geographical gaps between (Fig. 9). This reinforces the conclusion that these land units were likely ʻili. In Pūhāwai is one set of 7 permanent house sites. In Mikilua there are 26 permanent habitations, in Kaʻuhiʻuhi 20, in Pāhoa 30, in Hālona 13, and in Ulehawa 52 (Dixon et al 2004:131-133). The researchers argued that these groupings were local residence groups.

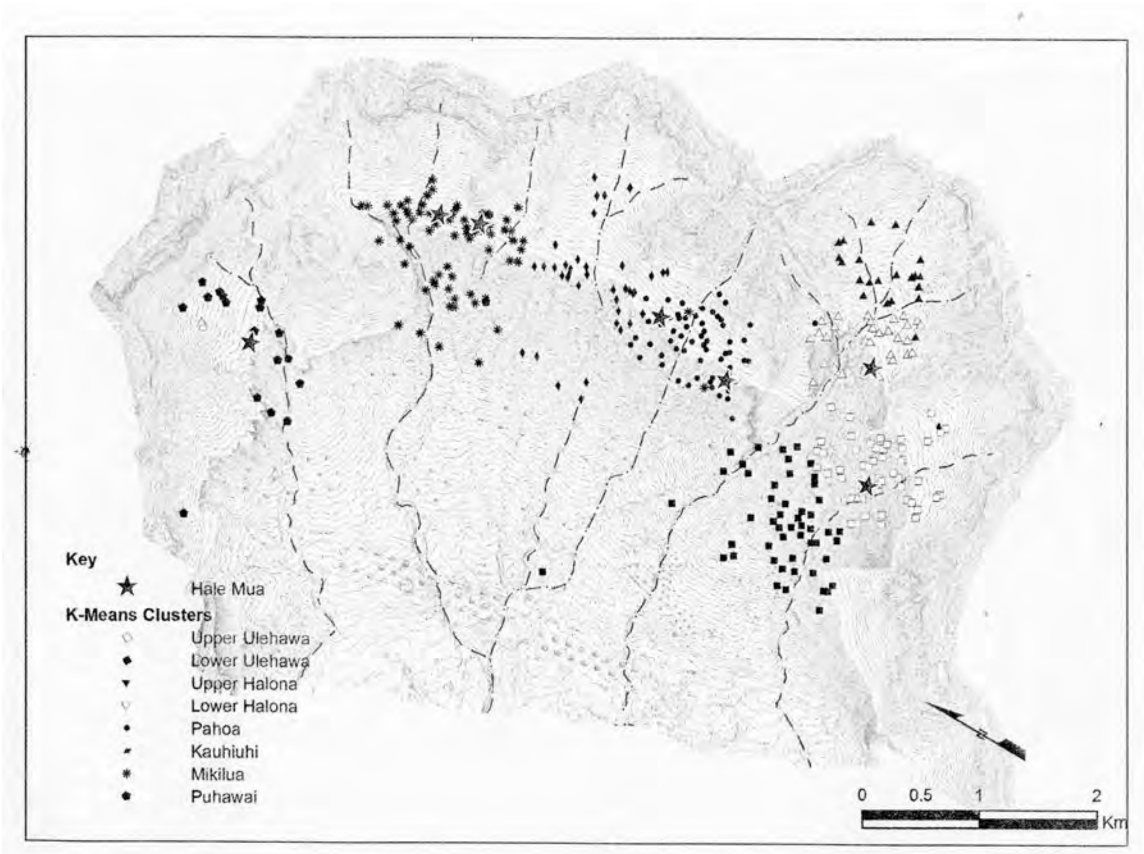


Figure 9. Map of the local residence groups in the lands across the upper valley of Lualualei. The large stars locate structures interpreted as men's houses. (Dixon, Gosser & Williams 2008:279)

Further, within each grouping, the researchers point out that there is one larger permanent habitation site with more impressive architecture and with a possible larger men's house nearby. These house sites were interpreted as residences of konohiki, "a chief's local level manager and usually the highest ranking individual (at least in a political sense) of each local residence group" (Dixon, Gosser & Williams 2008:272). The permanent house site in Hālona (site 5984) was considered of the "highest quality architecture" in the entire upper valley and thus the residence of the highest ranking individual – although based on scale of architecture not that of a high chief, but perhaps the dominant manager or local chief (Dixon et al. 2004:100-101, 136). Again, the oral historical records suggest that Lualualei likely only had a low chief in residence. Perhaps this

Hālona site is such a low chief's house, or perhaps the chief lived in Mā'ili or Ulehawa on the shore.

Small heiau were also found in each cluster, within sight of these more impressive permanent houses (Dixon et al. 2004:56-67). One of these heiau is believed to be Kakioe heiau in Pūhāwai, based on its location next to the key spring in the area (Dixon et al 2004:58). Interestingly, two larger heiau were present – in Hālona and Ulehawa. The Hālona heiau was Nioi'ula heiau, described by informants in 1930 as a luakini and found by the Bishop Museum in the 1980s to be 1,312 m^2, of luakini size (Haun 1991; Dixon et al. 2004:58). The other heiau was much smaller, but still larger than any others. The findings of more permanent houses in Hālona and Ulehawa, of the most impressive permanent house (interpreted to be a konohiki's house) in Hālona, and the presence of these two larger heiau led the researchers to conclude that Hālona and Ulehawa were probably the primary centers of population and importance in the back of Lualualei (Dixon et al. 2004:136; Dixon et al. 2008:282). Hālona is along the trail coming down from Pohākea Pass.

The AMEC study focused their work on the men's houses – "elongated masonry structures, often twice the size of nearby residential structures and of exceptional quality construction" (Dixon, Gosser & Williams 2008). They noted that all but one had a standardized architectural style. They then focused their excavation and dating on these structures, also dating a few nearby structures (often in the house site with more impressive architecture). The standardized structures all dated from AD 1650-on, essentially the period just before European Contact. The one different style of structure dated back to the AD 1400s.

There is more information available for Pūhāwai from archival records. There were 6 land claims and awards in this area in the 1840s Māhele. Each award had separate houselots (pā hale, kahuahale) at Pūhāwai, which appear to have been clustered at the front of the Pūhāwai basin, just inland from the Kolekole Trail, which passed in front of Pūhāwai on the way into Wai'anae valley. This cluster of houses could well be called a local residence group. Often commoners who did not claim lands lived in such areas, and sometimes they can be identified from names along the borders of awarded parcels. At present, 6 households can be confirmed in residence at the end of the 1840s. 1855 tax records for Pūhāwai also exist and identified 11 taxpayers (Kelly in Haun 1991:320-323), which suggests 11 permanent households here (probably more accurate than the Māhele in this case), with perhaps 55 people (5 per house). A 1700s estimate of 44 households and 220 people could be proposed for Pūhāwai (adjusting the 55 people as 25% of the contact population), but this seems high for the small Pūhāwai area.

Several population estimates can be produced for upper Lualualei. If the Pūhāwai estimate of 44 households and 220 people is accurate, one could suggest that the four other upper valley lands (Mikilua, Ka'uhi'uhi, Pāhoa and Hālona -- excluding Ulehawa) may have had similar sized populations. This would yield a total of 220 households and 1100 people. However, again, the Pūhāwai estimate seems a bit high. The AMEC findings, however, provide us actual permanent house counts, totaling 141 permanent house sites or households. Assuming all were occupied at the end of 1700s (and probably most were) and multiplying the total by 6 (an pre-

European household average), an estimate of 846 people result. As they rightly note, some additional permanent houses may be found in still unsurveyed lands at the front of the upper valleys "between 51st and 59th Street" and others may have been destroyed when the military constructed roads and bunkers (Dixon et al 2004:137). They suggest the population in the upper valley might have been "closer to 1,000." With 360 estimated on the shore, clearly Lualualei's total population could easily have exceeded 1,000, with 800+ in the upper valley.

AMEC's and the Bishop Museum's survey of the upper valley also found ruins of agricultural fields around these houses, up the tributary gulches and slightly out into the uppermost parts of the lower valley. Most of these were dryland fields, rain dependent fields -- ranging from mounds and clearings with crude terraces to field borders and regularly spaced terraces -- probably sweet potato fields, and dryland kalo possibly above the 40 inch rainfall line (although Dixon et al 2004:61 suggest the soils were too rocky and shallow to be suitable for dryland kalo). Irrigated kalo terraces were found in two locations: in Pūhāwai where year-round flowing water came from the spring called Kapūhāwai and fewer and smaller terraces in the adjacent drainage, Mikilua, tucked back beneath Hāpapa and Kolekole Pass (Dixon et al. 2004:61). AMEC suggests the Mikilua water sources had a lower flow. The Māhele records provide more information for Pūhāwai, identifying 163 lo'i (fields) in 6 kuleana awards – the six households having 17 (LCA 7346, Kahi), 23 (LCA 7451, Keilianu), 31 (LCA 7452, Kaahi), 40 (LCA 7454, Kanahele), 31 (LCA 8005, Apiki) fields each (Kelly 1991; Dixon et al 2004:24). Pūhāwai and Mikilua had the only two irrigated kalo areas in Lualualei. Both areas also had dryland fields.

Māhele information from Pūhāwai also showed that wauke and other crops were grown in that basin. Wauke (paper mulberry) was cultivated to make kapa, and it was usually grown quite close to the houses. The plant species identification of charcoal from fires and imu at the houses across the upper valley also identified several domesticated or cared for plants: coconut, ki (ti), ipu (gourd), wauke, and hala (pandanus). Hala leaves were used for making mats, and hala were often planted close about houses, as were coconuts.

The fields seem to extend out of these upper valley areas and seaward into the upper parts of the lower valley, where they were in thinner soils and lower rainfall. Here

> The majority of traditional sites were spatially dispersed, small-scale and temporarily occupied houses, usually situated near small dryland agricultural fields consisting of informal piles and rude terracing.
> [Dixon et al 2004:34]

The majority of temporary habitation sites found by the Bishop Museum (Haun 1991), PHRI (Jensen 1995), and AMEC (Dixon et al 2004) were found below the permanent habitation zone (below 650 foot elevation) "at the environmental margins of dryland agriculture" in this upper fringe of the lower valley, usually "near pockets of arable soils …, and generally next to drainages, which would have provided the only seasonal water within this more arid landscape" (Dixon et al 2004:49, 73).

Last, AMEC and others have noted the presence of adze workshops. Eighteen of these sites were located in Pūhāwai and Ulehawa where high quality adze basalt was present. These were surface scatters of stone waste flakes and preforms without habitation structures. They are on ridge tops or streambeds near outcrops of the dense basalt, and Haun found other workshops at lower elevations on the fringe of the lower valley (in Survey Parcels E and F below Pūhāwai) (Dixon et al. 2004:69).

Chronological Information – Pre-European Contact Times

The above picture is of Lualualei in the late 1700s, just prior to European Contact when it is likely that most of the sites were in use. We have one date from a burial site in sand on the shore at Māʻili Point (McIntosh & Cleghorn 2006), one date from a temporary habitation at the seaward end of the lower valley on the north edge of Puu o Hulu (Jimenez 1994), and 48 radiocarbon dates from sites in the upper valley and adjacent uppermost lower valley (10 sites of variable types with 1 date each dated by the Bishop Museum, Haun 1991; and 20 ± structures in 10 permanent habitation sites with a total of 38 dates by AMEC, Dixon et al 2004:76-81, 118-129). But habitations/burials on the shore are barely sampled as of yet. And it needs to be emphasized that the AMEC study tested and dated "a narrowly defined set of archaeological sites, which were selected to address research questions focusing on the rise of socio-political centralization. Given this intentional bias toward testing some of the most complex habitation sites in the project area, the vast majority of the site and site types remain undated" (Dixon et al 2004:129). So much more dating is needed to get a clearer picture of Lualualei's history.

It is suspected that from settlement of the Islands (let's say AD 800-900) up to AD 1000, people lived permanently and farmed on the windward side of O'ahu. Campsites would be expected on the leeward side. Thus, campsites of early age could be found anywhere in Lualualei, although perhaps most likely on the shore or along the trails coming over the mountains. Such camps have yet to be found.

We also expect initial permanent settlement of leeward Waiʻanae from AD 1000-1300, with settlement on the shore and lower valleys. Again, there is very little work in the sandy areas of Māʻili, and only one archaeological date for a burial (AD 1330-1430) (McIntosh & Cleghorn 2006). However, we would expect to see permanent settlement on the shore in the 1000s-1300s period. Farming would likely have occurred just inland, dryland farming as in Mākaha. Or perhaps, some families traveled to the lusher upper valley, even though it was far inland.

The dates from work in the upper valley show that fields and houses likely began to be established in the 1300s and 1400s (Dixon et al. 2004:129), just as in Nānākuli and apparently in Mākaha, and as in many other leeward lands on Oʻahu. The earliest dates so far (mid-1300s) seem to come from permanent houses in the Hālona area along Pōhākea Pass' trail where the largest expanse of arable land was present (the lower structure at site 5984, Dixon et al. 2004:129, 135). And an earth oven within an agricultural site (Site 1836) in lower Hālona dates back to the AD 1400s (Haun 1991:220; Dixon et al 2004:129). The Pāhoa area has a lower permanent house structure at site 8119 dating back to the early 1400s (Dixon et al 2004:129). However, more dating is needed to determine when each of the land areas in the upper valley started to see the establishment of permanent settlement and associated fields.

Population seems to have boomed across the upper valley in the 1600s-1700s. No signs of population decline are visible. By far the largest numbers of dates from permanent houses fall into the 1600s-1700s (Dixon et al 2004:76-81, 129).

In an extremely interesting hypothesis, the AMEC researchers note that the standardized men's houses associated with the large permanent habitation in each grouping all date after AD 1650. They suggest that this marks the establishment of non-local chiefly control of the populace in the upper valley – with local managers appointed by overlord high chiefs (Dixon et al 2008). This would mark the end of local chiefly or lineage control, or kin-group based leaders. This change in chiefly control is an important one in Hawaiian history, for it marks one of the important changes in land administrative control – from kin group (lineage) control to external elite chiefly control. Some argue that this occurred in the mid-1500s, based on oral stories associated with the ruler Ma'ilikukahi (Kirch 2013). However, these stories are vague at best. Others have suggested that we have yet to identify this change (Cordy 2004). The Lualualei researchers suggest it is late, at least in Lualualei (Dixon et al. 2008). This Lualualei information, thus, becomes a very important set of evidence in studying this important change.

However, these local konohiki are not considered to reflect high chiefly presence in Lualualei, or the presence of powerful central authority. Only one site reflects this presence – Nioiʻula heiau, a luakini associated with Kākuhihewa, whose reign is estimated to be about 1640-1660 AD (Dixon et al. 2004:135). It is not clear at this time when this luakini was built, or how long it was used – if other rulers besides Kākuhihewa used it. Its presence away from high chiefly residences and from abundant food resources suggests that it might have been a luakini built and used for a special purpose. This would be in contrast to Kamohoaliʻi heiau, the luakini at the high chief's residential area at Puʻu Kāhea in Waiʻanae valley, the economic, demographic, political and religious center of the district. Kamohoaliʻi probably saw continuous use over many years.

Post-European Contact Times to the 1840s

Some of the permanent habitation sites dated to post-1650 times might well date into the early 1800s. Again, work in Waiʻanae valley indicates that Euro-Asian artifacts generally do not appear in the rural west side until the 1840s (Naboa 2009; Cordy 2012), and this seems true apparently in Waialua (Sahlins 1992). Roads were not improved until after this time, enabling merchants and peddlers to get to these more remote areas. Euro-Asian artifacts of early 1800s time were found in only two upper valley Lualualei permanent habitation sites that were excavated (6119 and 6167 in Pahoa)(Dixon et al 2008:274). Clearly, some 6 or so permanent habitations were still occupied in Puhawai at this time, based on the late 1840s Mahele land records. But it is likely that most of the permanent habitations of the upper valley and their associated fields were abandoned by the 1840s. This is the pattern of upper Wai'anae valley (Naboa 2009; Cordy 2012), of Nanakuli (Cordy et al. in preparation) and of Halawa valley in ‘Ewa (Bishop Museum 1997) – and a common pattern throughout the islands.

Lualualei – An Ahupua‘a Itself or Part of Wai‘anae Ahupua‘a ?

Many of the archaeological reports on Lualualei automatically list this valley as an ahupua‘a. But a map of O‘ahu produced by UH Mānoa's Hawaiian Studies program in 1987 suggested it might be part of Wai‘anae ahupua‘a (Hawaiian Studies 1987). Kolb et al. (1995:7) evaluated this point further. The 1848 records of 6 Māhele awards in Pūhāwai all list their awards as being in "the ili Puhawai, Waianae." Usually Māhele records list and state the ‘ili and ahupua‘a. For example, ‘ili o Puhawai, Lualualei ahupua‘a. These Pūhāwai awards do not specify the ahupua‘a they are in. They simply note "Waianae" in that spot in the records – not Lualualaei. The Crown Land Survey Book (n.d.: 123) was checked and the Kingdom's letter verifying the receipt of the deed from Kamehameha IV in 1855 (Webster 1855). Both note "the lands of Lualualei" with no reference to an ahupua‘a. Kolb et al. (1995:7) indicated that while the evidence was not clear, there was "suggestive evidence [in the Māhele records for Pūhāwai] that Lualualei might be part of Wai‘anae ahupua‘a." However, this is in the era when the king was deciding what lands were his (Crown lands). It may be that discussions were lumping these adjacent Crown lands. Possibly they were ahupua‘a prior to this point. It is suggested that more archival research occur to try to clarify this question.

THE HISTORIC PROPERTIES OF LUALUALEI REMAINING TODAY – PRE-EUROPEAN TIMES TO 1840s

Historic properties are the specific legal term that is used in the federal and state historic preservation laws to refer to archaeological sites, culturally important places that can be natural places such as mountains and springs, architectural buildings, and even objects. More popularly, excluding objects, one sees these referred to as historic sites or sites. In Hawaiʻi, Native Hawaiians often refer to such sites as cultural sites or cultural places. But, for better or worse, presently historic property is the legal designation that one must deal with at certain points when coping with the bureaucracy.

The laws largely protecting historic properties are the federal and state historic preservation laws (the National Historic Preservation Act and Chapter 6E, Hawaii Revised Statutes, respectively). These laws were created to handle the impacts of development on important places, and they also apply to important places on state and federal lands. When federal undertakings (projects on federal land, permits, federal funded projects, etc.) and state undertakings (projects on State land or funded by the State, State and County permits, etc.) occur, it is necessary to identify significant (important) historic properties, so their treatment can be addressed in the face of development. Treatment can be preservation, data recovery (salvage), or no treatment at all. Importantly, the interested public in general and the interested Native Hawaiian public specifically are by law allowed to be participants in virtually every step of the historic preservation review process. The ideal purpose of the historic preservation review process was to seek "win-win solutions between historic preservation and other public interests [development]…through consultation" (King 2003:114). For any future projects within this Māʻiliʻiliʻi watershed, almost certainly historic preservation review will be required – to identify historic properties that might be impacted and attempt to appropriately treat them in the face of any impacts.

The Hawaiʻi State Historic Preservation Office (SHPO) that is housed in the State Historic Preservation Division (SHPD) within the Department of Land & Natural Resources is a key agency in both the review of federal and state undertakings. An agency might initiate a study to identify historic properties within its lands or within an associated undertaking. Many of these studies are archaeological surveys, particularly in Hawaiʻi, where 90+% of the historic properties are archaeological sites associated with 1,000 years of Native Hawaiian history in these islands. These surveys identify and describe historic properties. Eventually, as part of the review process for a project, the historic properties in a project impact area need to all be identified, and it needs to be determined which are significant (important) – eligible for inclusion on the State or Federal Registers of Historic Places. Both the federal and state historic preservation laws identify significant historic properties based on specific traits of significance (significance criteria). A significant property must be at least 50 years old, and must meet at least one of the criteria to be considered significant.

This historic preservation process can be a powerful tool for protecting important historical and cultural places. However, it is a complex process, full of bureaucratic/legal jargon.

The documentation of historic places is often done by what are called contract firms (hired under contract by developers or government agencies). These include archaeological firms, with staff that have expertise in archaeological survey work and often in archival research and increasingly in interviewing the local community. The reports of the studies done by these professionals are sometimes highly technical, and not easy for the general public to read.

This section of this paper focuses on historic properties that date from the 1840s back into pre-European times – Native Hawaiian sites.

ARCHAEOLOGICAL SURVEY COVERAGE IN THE MĀʻILIʻILIʻI WATERSHED

For planning related to historic properties within the Māʻiliʻiliʻi Watershed, it is important to understand what areas have had archaeological survey and whether that survey is archaeological inventory level survey – archaeological inventory survey being survey that has identified all (in theory) historic properties in an area, located their borders, adequately described them, interpreted their function, and established an idea of their age. This survey coverage typically is what is needed to determine if a historic property is significant (eligible for inclusion on the State and National Registers). As will be seen, for some areas of the watershed, there is a fairly complete survey coverage. However, there are some areas that have hardly any survey. Table 3 lists the previous archaeological work in the Māʻiliʻiliʻi watershed, broken down by section of the valley – shoreline, lower valley, and upper valley. Figure 10 shows the prior work areas.

TABLE 3

PREVIOUS ARCHAEOLOGICAL WORK
MĀʻILIʻILIʻI WATERSHED, LUALUALEI

Information is presented by land zone (shoreline, lower valley, upper valley) and areas within these. The project (project area) is given first, then in parenthesis the reference to the report and the firm doing the work, then (if available) the TMK, and then in brackets a summary of what was found.

FIELD SURVEYS & EXCAVATIONS

SHORELINE

Māʻiliʻiliʻi Promontory to Kāneʻīlio Point

Lualualei Beach Park, Wastewater System at Comfort Stations "A" and "B" (Thurman & Hammatt 2009 – Cultural Surveys Hawaii). (TMK: 8-6-001: por. 7) [no sites]

Wai'anae Coast Comprehensive Health Center (Flood and Dixon 1994 – Bishop Museum). [no sites found]

<u>Sand Deposits – Mā'ili</u>

Waterline on edge of Liopolo Street (Kawachi 1990 – State Historic Preservation Division; Hammatt & Shideler 1999 – Cultural Surveys Hawaii). [1 site (4244) with 9 burials, possibly associated with habitation deposits]]

<u>Mā'ili Point Area</u>

Construction at Ulehawa Beach Park (McIntosh & Cleghorn 2006 – Pacific Legacy). (TMK: 8-7-005: por. 1). [sand area -- 2 burials found in site 6711, 1 date]

Wai'anae Corporation Yard (Kennedy 1983 -- Archaeological Consultants of Hawaii.) (TMK 8-7-06:32) [thin soil area -- no sites found]

<u>LOWER VALLEY</u>

<u>Behind Shore Between Pu'u Mā'ili'ili'i and Tip of Pāhe'ehe'e Ridge</u>

Village Pokai Bay Subdivision (Sinoto & Pantaleo 1990 -- Bishop Museum). (TMK 8-6-01:04 – 118 acres). [no sites]

Proposed Wai'anae Community Transit Center (Perzinski, Shideler, & Hammatt 2002 – Cultural Surveys Hawaii) (TMK 8-6-001:29). [no sites]

Proposed Hale Wai Vista Project (Tulchin, Borthwick, & Hammatt 2007 – Cultural Surveys Hawaii) (TMK: 8-6-001:35 – 5 acres). [no sites]

Proposed Wai'anae 242 Reservoir and Access Road Project (Tulchin, O'Hare & Hammatt 2003 -- Cultural Surveys Hawaii) [on northeast side of the promontory, no sites]

<u>Behind Mā'ili Shore next to Pu'u o Hulu</u>

Mā'ili Kai Subdivision (Barrera 1975 – Chiniago Inc.; Cordy 1975, 1976 – R.H.Cordy; Mayberry & Rosendahl 1988 – PHRI; Jimenez, Joseph 1994 – PHRI). [Ca. 26 sites found, all late 1800s-1900s, except portions of 1 being pre-European. That site, 3750 a temporary habitation, tested and dated by Jimenez 1994.] [All sites are likely gone today.]

Leeward Coast Emergency Homeless Shelter Project (Tulchin & Hammatt 2008a, 2008b – Cultural Surveys Hawaii) (TMK: 8-7-10: por 7). [no sites]

Former Voice of America Facilty (Reith 2009 – IARII). (TMK: 8-7-10: 7. [no traditional era or pre-1850 sites, 2 post-1870s sites]

Along Base of Pāheʻeheʻe Ridge (DHHL Lands)

DHHL lands at base of Pāheʻeheʻe Ridge (Kolb, Conte, McFadden, Mitchell, & Cordy 1995 -- State Historic Preservation Division) (TMK: 8-6-03: por. 25) [No traditional era sites in Lualualei portion of study.]

Naval Radio Transmitting Facility Lualualei (RTF LLL)

Survey of upper portions of RTF (Haun 1991 – Bishop Museum) [No sites found.].

Survey of entire RTF (Robins & Anderson 1998 -- Ogden Environmental & Energy Service). [3 sites found. 2 traditional era: Permanent habitation (5592) and rock mound.]

Lower Two-Thirds of Naval Magazine Lualualei (NAVMAG LLL)

Survey of much of this zone (Haun 1991 – Bishop Museum) (197 sites found, but some in upper valley – see text)

Recheck of some Bishop Museum study areas and some new survey (Dixon, Gosser, Williams, Robins, O'Hare, Gilda, & Clark 2004 – AMEC survey, Pacific Consulting Services report) (Sites found, but most of work in upper valley – see text)

UPPER VALLEY

Brief visit (McAllister 1933 – Bishop Museum) [3 sites identified.]

Survey of some parts of this zone (Haun 1991 – Bishop Museum) (Sites found, but most of work in adjacent part of lower valley -- see text)

Land/Aerial Recalibration Site (Jensen 1995 – PHRI) (near gap into Waiʻanae valley in Pūhāwai -- 11 sites found, 6 traditional era)

Extensive new survey & recheck of Bishop Museum study areas (Dixon, Gosser, Williams, Robins, O'Hare, Gilda, & Clark 2004 – AMEC survey, Pacific Consulting Services report) (407 sites found, but some in adjacent part of lower valley – see text)

OVERVIEWS

Cultural Resources Overview, Naval Magazine Lualualei (Landrum, Drolet, & Bouthillier 1997 -- Ogden Environmental & Energy Services) [Review of prior work. Military building inventory.]

Cultural Resources Management Plan, Naval Magazine Lualualei (Rechtman, Bouthillier, & Denfield 1998 – PHRI) [A plan for historic property management in the NAVMAG Lualualei area.]

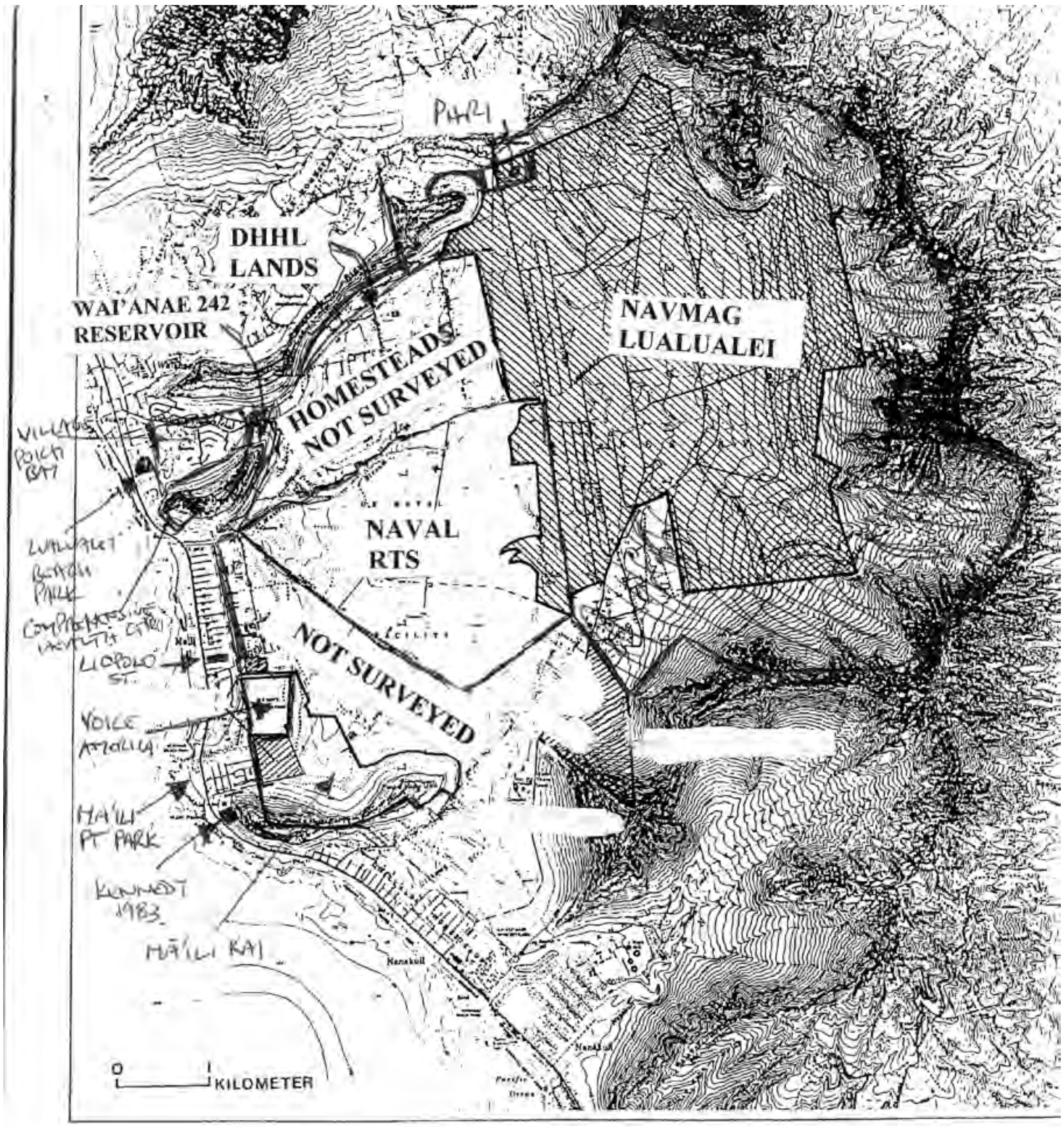
Research Paper on Waiʻanae District's Pre-European History & Settlement (Cordy 1998. State Historic Preservation Division) [Overview of Waiʻanae district's history using oral history, archaeology, and archival records. One section on Lualualei.]

Book on Waiʻanae District's Pre-European History & Settlement (Cordy 2002b) [Overview of Waiʻanae district's history using oral history, archaeology, and archival records. One section on Lualualei. Published version of 1998 ms, slightly updated.]

Research Paper on Men's Houses in the upper valley of Lualualei (Dixon, Gosser, & Williams 2009. *Journal of the Polynesian Society*, 147(3):267-296.) [Overview of findings on local residence groups, men's houses and land managers in Lualualei from the upper valley archaeological work.]

Shoreline Areas

The three shoreline areas (between the puʻu Māʻiliʻiliʻi and the seaward tip of Paheʻeheʻe ridge, Māʻili Beach, and Māʻili Point) have had very limited work in their sand areas. All were monitoring of small projects within beach parks or inadvertent finds. Thus, much of the sandy shore has yet to be investigated. Nothing was found in the first area between the puʻu Māʻiliʻiliʻi and the seaward tip of Pāheʻeheʻe ridge. However, burials were found at Ulehawa Beach Park at Māʻili Point across from Kaukama Road (just north of Puʻu o Hulu Kai) and along Liopolo Street just across Farrington Highway from Māʻili Beach. Two isolated burials were found at Ulehawa Beach Park at Māʻili Point (SHPD site 50-80-07-6771 or Oʻahu site 6771)(McIntosh & Cleghorn 2006). One was disinterred and reburied nearby; the other was left in place. A radiocarbon date was processed from the fill of the moved burial. Other burials and even habitation deposits could be present in the park, as only small construction areas were monitored. In 1990 a waterline being dug along Liopolo Street about one block inland from Farrington Highway found burials. SHPD investigated the find (Kawachi 1990; Cordy, personal observation) and Cultural Surveys Hawaii did follow-up monitoring of the waterline installation (Hammatt and Shideler 1991). Eventually 9 burials were found (Oʻahu site 4244). Five were removed and reburied nearby; the others were left in place. This historic property is likely to have included a subsurface habitation deposit associated with the burials. The lateral size of the site outside of the waterline was not determined, and no radiocarbon dates were processed from this work. Again, essentially the entire sand area of Māʻili is unstudied archaeologically. These archaeological finds indicate that while the shore is covered with beach parks, house and commercial lots, and side streets, subsurface archaeological deposits that can include habitation deposits and burials are present in this area. In some areas, deep bulldozing may have destroyed such



DRAFT Figure 10. Previous Archaeological Work.
Note unsurveyed areas in seaward half of lower valley. Also most of the shoreline is unsurveyed.

deposits. But, in other areas, such deposits are likely to still be present -- in the sand areas of Māʻili, from Māʻiliʻiliʻi Stream's mouth all the wall towards Puʻu o Hulu.

One project has taken place in the thin soil-covered areas near the base of Puʻu o Hulu Kai, just on the inland side of Farrington Highway. This was where the County's Waiʻanae Corporation Yard is located. No sites were found here.

Two studies on the slopes of the puʻu Māʻiliʻiliʻi have occurred. One was on the shoreline side at the Waiʻanae Coast Comprehensive Health Center (Flood & Dixon 1994). No sites were found here. Another study on the inland side of the pu'u, done for a proposed Waiʻanae 242 Reservoir and access road also found no sites (Tulchin et al. 2003).

The Lower Valley

The seaward two-thirds of the lower valley has had only four areas surveyed, all at the archaeological inventory survey level. One area includes the Māʻili Kai subdivision and adjacent former Voice of America parcel just north of Puʻu o Hulu (Barrera 1975; Cordy 1975, 1976; Mayberry & Rosendahl 1988; Jimenez 1994). Historic properties were found in this area, but all proved to be late 1800s-1900s in age and often lacked integrity, largely due to extensive land alteration from ranching, homesteading, limestone quarrying, and the Voice of American facilities. Two sites, however, had a few likely pre-European features. One of these features, a temporary habitation feature in site 3750, was test excavated and a radiocarbon date was processed (Jimenez 1994). All the other historic properties were recorded to adequate inventory survey levels. A second area fully surveyed is the huge Naval Radio Transmitting Facility (RTF LLL). Inland portions were surveyed by the Bishop Museum in the 1980s (Haun 1981) with no sites found, and the entire area in the late 1990s by Ogden Environmental & Energy (Robins & Anderson 1998). The latter study found 3 sites, 2 of which appeared to be pre-European in age (a rock mound and a small permanent habitation, site 5592). A third area with survey coverage includes sizable parts of the flatter lands (raised limestone with thin soil) behind the shore between puʻu Māʻiliʻiliʻi and the seaward tip of Pāheʻeheʻe ridge. This area has had several surveys in areas back from the Waianae Wastewater Treatment Plant and Waianae Mall. Collectively they cover a sizable area. They found no historic sites. These areas had been heavily disturbed in the last 100 years, notably by limestone quarrying (Tulchin et al. 2007:22-23). The fourth area surveyed is the DHHL lands at the base of Pāheʻeheʻe Ridge above Paheehee Road, which were surveyed by the State Historic Preservation Division's Interagency Survey unit in the early 1990s. No pre-European sites were found in its Lualualei portions, although two small heiau were present in the Waiʻanae Valley areas just at the gap into Lualualei (Kolb et al. 1993).

Two remaining areas of the seaward portions of the lower valley have yet to undergo archaeological survey:

(1) The early 1900s homestead area between the DHHL lands at the base of Pāheʻeheʻe Ridge and Māʻiliʻiliʻi Stream and Mikilua Stream's lower courses. It was once partly in sugarcane, and then became homestead land in the early 1900s. It may be extensively altered by ranching, sugarcane

and homesteading activities. But it could have intact pre-European sites immediately along the stream drainages in this area if the land next to the streams has not been considerably altered by late 1800s and 1900s activities.

(2) The triangular section of land behind the Māʻili shoreline between the Naval Radio Transmitting Facililty and the Māʻili Kai subdivision/Voice of America parcels to the south. Based on surveys in the Māʻili Kai area, this land area also may be extensively altered by ranching, homesteading, limestone quarrying and other late 1800s-1900s activities.

The upper one-third of the lower valley is in the NAVMAG Lualualei Facility, and two high quality, excellent surveys have taken place there (the Bishop Museum's survey primarily of lower valley areas, Haun 1991; and AMEC's survey primarily of upper valley areas, Dixon et al. 2004). It is not fully clear from reading the two extensive survey projects of parts of this facility (Haun 1991; Dixon et al. 2004) whether all areas of the facility within the lower valley have fully undergone archaeological inventory survey. However, the OGDEN overview (Landrum et al. 1997) and the PHRI Cultural Resource Management Plan study (Rechtman et al. 1998:16) reviewed the Bishop Museum survey carefully and concluded the administration and magazine areas – essentially the lower valley areas -- were adequately surveyed. The AMEC survey further checked some of these areas and verified adequate recording in the Museum study.

The Upper Valley

This area has had sites recorded by four studies (McAllister 1933; Haun 1991: Jensen 1995; Dixon et al. 2004), and apparently a fifth, an early 1900s field check of some heiau by Thrum (McAllister 1933:110). The Bishop Museum study of the early and late 1980s (Haun 1991) was thorough coverage in some areas, but only limited in others. Jensen's (1995) study was of a 60 acre area in Pūhāwai, near the gap through the Kauaʻōpuʻu-Pāheʻeheʻe ridge into Waiʻanae valley. This survey met inventory survey levels of recording and found 11 sites, 6 being traditional Native Hawaiian. The AMEC study of 2000-2001 focused on the upper valley areas and can be considered to have found all historic properties in the areas it studied (understanding that a few sites might be found later in the high steeper ridgeline or covered by vegetation in the lower upper valley – as is always common in surveys). However, it must be understood that the AMEC survey did only limited excavation and dating in 10 sites of only one functional type (permanent habitations), and the Bishop Museum in 10 sites. Thus, we are far from understanding the full range of the chronology for the full range of functional type sites in the upper valley. Nonetheless, survey coverage, site identification, description and interpretation are excellent in the upper valley.

HISTORIC PROPERTIES FOUND TO DATE – PRE-EUROPEAN TIMES TO 1840S

1. The Shoreline Areas

In the shoreline areas of Māʻili beach and Māʻili Point, two historic properties have been found (sites 4244 and 6711) – each with burials and possibly one also with habitation deposits. These properties are not fully documented. Additionally, most of these sand shoreline areas have had no archaeological survey at all.

2. The Lower Valley

In the lower valley, considerable survey has occurred in the seaward two-thirds of the lower valley. Much of the area surveyed had been extensively disturbed by late 1800s and 1900s activities (limestone quarrying, homesteading, sugarcane, ranching, etc.). Although a limited range of pre-European historic properties are expected in this area (perhaps some dryland field remains, temporary habitations, trail remnants and maybe a few permanent habitations and dryland fields along streams), the surveys indicate that the late 1800s-1900s disturbance is likely to have damaged or destroyed most of these pre-European historic properties. Only 4 historic properties of traditional Hawaiian periods have been found – a permanent habitation near Māʻiliʻili'i Stream in the Naval RTS (site 5592), a rock mound in the RTS, a C-shaped temporary habitation (site 3750) against Puʻu o Hulu in the Māʻili Kai subdivision, and possibly some features within another site in the Māʻili Kai subdivision. It is not clear if any of these historic properties survive today. Those in the Naval RTS might.

This picture of site numbers in the lower valley dramatically changes in the upper third of the lower valley, within the NAVMAG Lualualei up to ca. the 600 foot elevation. The 1980s Bishop Museum study found 200 sites (historic properties) with 1,020 features (Haun 1991) in their survey which included most of the uppermost lower valley and some areas in the upper valley. With the scale of the maps in the reports, it is difficult to determine actually how many of these sites are in the lower valley. However, the CRMP study has a map of sufficient size (Rechtman et al. 1998:Fig. 2-3), and ca. 140 of the Museum sites seem to be below the 600 foot elevation. Most are traditional Native Hawaiian sites, but a few are ranching era properties. These sites do not cover the entire upper third of the lower valley, rather they tend to extend down along stream drainages as these drainages emerge out of the upper valley.

3. The Upper Valley

The upper valley is entirely within the NAVMAG Lualualei. The 1980s Bishop Museum study found perhaps 60 of its 200 historic properties in the upper valley. The PHRI study of 60 acres in Pūhāwai found 11 historic properties; 6 were traditional Native Hawaiian properties (Jensen 1995). The AMEC survey found 407 new historic properties with 978 features (Dixon et al. 2004:37, 39), primarily in the upper valley. These historic properties again are mostly pre-European to 1840s Native Hawaiian archaeological sites, but they also include a few ranch era and later sites.

4. Summary of Identified Historic Properties of the 1840s Back into Pre-European times -- Native Hawaiian periods

Clearly, the above information indicates that very few historic properties of these time periods have been found in the shoreline and seaward two-thirds of the lower valley – only 4 to date. It seems unlikely that many more will be found in these lower valley areas, unless undisturbed landscapes exist along the stream drainages in the homestead area. However, in the shoreline sand areas of Māʻili beach and Māʻili Point, it is quite likely that subsurface habitation deposits and associated burials are present in parcels that have not been extensively bulldozed.

In contrast, large numbers of historic properties of these periods of time have been identified in NAVMAG Lualualei in the uppermost parts of the lower valley and strikingly dense in the upper valley. Approximately 600 historic properties are present here. Much of the cultural landscape seems to survive, except where military activity created roads, bunkers and the headquarters administration area. Pre-1930 ranch period activities generally are not expected to have altered much of the landscape, as this use was before extensive alteration of landscapes by bulldozers. This means that the upper valley and the areas of the uppermost lower valley with historic properties of the pre-European to 1840s time periods essentially form a cultural landscape, a landscape with alterations, but a landscape or district nonetheless.

SIGNIFICANCE EVALUATIONS OF THE HISTORIC PROPERTIES IN THE WATERSHED

1. Significance Evaluations, Generally

Significance evaluations are determinations of eligibility for inclusion on the Hawaiʻi or National Registers of Historic Places. Today, every archaeological inventory survey done for a permit or development activity that has identified historic properties typically ends with proposed significance evaluations for each property. Usually near the end of the report, one sees a table with significance criteria listed across the top and the historic properties listed down the left margin, and with "x" or checks for each criterion that applies to each property. Besides the proposal "not significant," the State has 5 criteria of significance, and the Federal process has 4 with one criterion actually having two different values. To be "significant" or "eligible for inclusion on the Register", a historic property is to be older than 50 years in age, need only meet one criterion of significance, and have integrity (be largely intact). Importantly, these are only proposed evaluations until the State Historic Preservation Division (SHPD) concurs.

Briefly, the State of Hawaiʻi significance criteria are as follows:

Criterion A. Significant for broad patterns of history.
Criterion B. Significant for association with famous persons in Hawaiian history and for specific traditional Hawaiian deities.
Criterion C. Excellent example of a type.
Criterion D. Significant for information content.
Criterion E. Traditional cultural significance.

These were summarized in a brochure printed by the Hawaiʻi SHPO in the late 1980s (SHPD 1989). They are also in today's official rules for Chapter 6E. Determining how to apply Criterion E was discussed with OHA and other Native Hawaiian groups and individuals in the late 1980s. It was decided that all Native Hawaiian burials and religious sites and major trails would automatically be considered significant under Criterion E, given a long-standing concern by Native Hawaiian communities for these types of properties. Other traditional cultural significance determinations are made on a project by project basis, based on feedback from the community and other sources.

The National Park Service established four National Register significance criteria. A historic property has to meet one or more of the criteria to be eligible for inclusion on the National Register. The criteria are as follows:

Criterion A: **(Event)** Association with events that have made significant contributions to the broad patterns of American history.
Criterion B: **(Person)** Association with the lives of persons significant to our past.
Criterion C: **(Design/Construction)** Embody the distinct characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguished entity whose components may lack individual distinction.
Criterion D: **(Information Potential)** Yield, or likely to yield, information of relevance to prehistory and history.

Also, at the federal level, a property can be considered to have traditional cultural significance under criterion A of the National Register. A separate significance criterion for traditional cultural significance was not created at the federal level.

In the early 1970s, when the federal law first began to be used in Hawaiʻi and elsewhere, the Hawaiʻi State Historic Preservation Office (SHPO) worked on submitting nomination forms for many well known historic properties that met one of the significance criteria and had integrity. In these years, the National Register was published in book form every year with properties listed by state with short descriptions and often a photograph. Problems quickly arose across the country as development accelerated in the early 1970s and federal agencies began to deal with this law. Development project archaeological surveys were finding hundreds if not thousands of archaeological properties that were technically eligible for the National Register, many that solely contained important information on prehistory (criterion D). Preparing the paperwork for every site to be nominated to the National Register and awaiting the Keeper of the National Register's decisions was taking far too long. It was dramatically threatening federal development projects, hardly a win-win situation. So in the mid-1970s, a short form was developed – a Determination of Eligibility form. It too had to be filled out for each eligible property and then be submitted to the Keeper. If approved, the property was officially determined eligible for inclusion on the National Register, but it was not published in the annual National Register book, rather it was published in the *Federal Register*. However, it also failed as an attempt to expedite the process, and all parties realized this by the end of the 1970s.

What resulted next was the U.S. Advisory Council on Historic Preservation (the federal watchdog over the National Historic Preservation Act) decided that if the SHPO and the federal agency responsible for the action agreed that historic properties identified by archeological and other surveys clearly met one or more criterion of the National Register, then the SHPO could write a letter stating that by consensus the historic property was considered eligible for the National Register. No processing of forms or paperwork through the Keeper of the National Register was required any longer. These consensus determinations allowed the review process to move on – to focus on how to treat these significant historic properties. Again, archaeological survey reports that found and documented properties had to have a significance evaluation of each property, proposing whether they met the federal significance criteria. The SHPD then needed to agree in writing for a consensus determination to be official. This process was effectively in place by the mid-1980s.

The State's historic preservation law is Chapter 6E. It was modeled after the National Historic Preservation Act, and there are several sections that require a review process for state projects or funded projects as well as for review of state and county permits. Early on the State established a Hawai'i Register of Historic Places and a Review Board of Historic Places. Much of the office's early work in the 1970s was to re-identify archaeological sites that were known (heiau, fishponds, etc.), fill out nomination forms for the State Register and have the Review Board review and eventually approve them. The criteria used were the same four from the National Register. Often properties nominated to the State Register were then passed on to the Keeper of the National Register.

However, by the late 1970s and early 1980s, the Hawai'i Historic Sites Section within State Parks was starting to review more federal projects and state/county projects and permits. Much of this review led to archaeological surveys. Many archaeological properties were found that were significant. As in the federal process, it proved too time consuming to do nomination forms for these sites. But, rather than follow the process of identifying significant sites according to significance criteria in a short form, the Section's staff often simply skipped a formal assessment of significance. Instead, they frequently approved whatever the recommendation of the archaeologists doing the survey was – such as more excavation of some sites or preservation (although very few sites were preserved).

This changed in the late 1980s when the Hawai‘i Historic Sites Section developed rigorous draft rules for a historic preservation review process. These rules followed the federal process, but with some modification to fit the Hawaiian situation. Draft rules with comments from archaeologists, government officials (state and county planners), Native Hawaiian groups and individuals (including OHA) were polished by the end of the 1980s and became operational at that time. The Section became a separate Division of the Department of Land & Natural Resources in 1990, and was fully staffed with top quality archaeologists, historians and architects up until about 2002. Although the rules were not finalized until the end of the 1990s, they were accepted and in use since 1990, if not just before. This acceptance and use for over a decade by state and county agencies led a circuit court judge to conclude that they had the effect of law (although the judge said get them finalized, which was done in 2002).

The draft rules and process that the Hawai‘i SHPO put in place from the late 1980s were again modeled on the federal historic preservation process. They required that all historic properties found have their significance evaluated to determine if they were eligible for inclusion on the Hawai‘i Register of Historic Places. As at the federal level, the Hawai‘i SHPD decided that a quicker determination of property significance was needed for State level Chapter 6-E actions, instead of the long cumbersome nomination to the Hawai‘i Register. Submittals of nomination forms were just impossible to do in a timely fashion, with over a thousand new properties recorded a year. Thus, with the adoption of the more formal process of the late 1980s, the Hawai‘i SHPO made significance determinations by consensus with the agency submitting significance evaluations. These were formally noted in written approval letters – consensus determinations. The SHPO formally began to require each project reviewed that had a survey to evaluate the significance of each historic property found according to the criteria of the State Register.

Again, all survey reports from the late 1980s on in the Hawai‘i historic preservation review process typically ended with a table evaluating each historic property’s significance, with the five criteria listed across the top of the table, with historic properties listed down the left side, and check marks (x) for each criteria that the site met. Accompanying text explained the evaluations. This is the common format that existed throughout the 1990s and early 2000s, and is still continuing today.

It is vital to emphasize one point in this process. Few Native Hawaiian historic properties in Hawai‘i are nominated to the Hawai‘i or National Registers of Historic Places. Instead, a quick consensus determination is made, and the emphasis for these hundreds, if not thousands, of properties has been placed on appropriate treatment. Properties that are placed on the Registers are often more modern architectural buildings – because placement allows dramatic reductions in property taxes or easy access to grants to restore or maintain such buildings. No such advantages exist for nearly all Native Hawaiian historic properties, so the need for nomination is minimal. Placement on the Register occasionally occurs, and it gives a property greater public visibility. However, it does not ensure any more protection than a consensus determination letter. Register nominations are vastly time consuming for SHPD staff desperately trying to ensure proper treatment of important properties. It is vital that the public and planners realize this point.

2. Significance Evaluations in Lualualei

Interestingly, for the Māʻiliʻiliʻi Watershed, it appears that very few historic properties have yet had their significance officially established.

The exception seems to be that the few historic properties found in the shoreline and seaward two-thirds of the lower valley appear to have had their significance evaluated.

In the shoreline zone, the two burials found at Ulehawa Beach Park at Māʻili Point were proposed in the report to be significant under criteria D (information content) and E (traditional cultural significance)(McIntosh & Cleghorn). As action for protection was taken in consultation with the SHPD, undoubtedly the SHPD concurred with the proposed evaluation. The Liopolo Street burials (site 4244) do not seem to have a proposed evaluation in their report (Hammatt & Shideler 1991), but an evaluation would have been made with SHPD, again under criteria D and E, as protection (mitigation) actions were taken.

In the seaward two thirds of the lower valley, the 1970s studies had no significance evaluations, as this was prior to the Hawaiʻi SHPO adopting a review process that included significance evaluations. The late 1980s PHRI study did evaluate the significance of the properties that they found (albeit with a slightly different table, which occurred in the late 1980s with PHRI reports). Their report proposes that the two Native Hawaiian sites were determined significant for their information content (criterion D)(Mayberry & Rosendahl 1988). The survey report for the Naval RTS (Robins & Anderson 1998) was not found at SHPD in the research for this report. Two Native Hawaiian historic properties were found on the Naval RTS, a small permanent habitation site (5592) and a rock mound. It is possible that the report did propose a significance evaluation, following the National Register criteria as this was a federal undertaking. If so, it is likely that each was significant only for criterion D (information content). Whether this evaluation proposal was submitted to the SHPD for review and concurrence is unclear.

In the upper third of the lower valley and the upper valley that were all on NAVMAG Lualualei, again hundreds of Native Hawaiian archaeological properties (sites) were found. In the 1970s, Nioiʻula Heiau (Oʻahu site 179) was placed on the State and National Registers, probably without itemizing what significance criteria were applicable (as was common in that time period). This appears to be the only archaeological historic property that has officially had its significance evaluated in these areas. The PHRI study of the 60 acre Land/Aerial Recalibration Site did include proposed significance evaluations in its report (Jensen 1995). Four pre-European historic properties were all proposed to be significant under criterion D (information content). But the 1998 CRMP study seems to indicate that these evaluations were not submitted to the SHPD for review and concurrence. Strikingly, the 600+ historic properties (archaeological sites) found in the Bishop Museum and AMEC studies (Haun 1991; Dixon et al 2004) do not appear to have had significance evaluations officially evaluated (Rechtman et al. 1998:16; Dixon et al. 2004). It does appear as if the Museum study indicated that all these properties were at least likely to be significant for their information content (Criterion D of the State and Federal registers) (Landrum et al. 1997:159; Rechtman et al. 1998:17-20). The AMEC properties seem to have had no evaluations proposed. OGDEN's late 1990s cultural resources overview report for the Navy noted that other significance criteria likely apply to some of the Native Hawaiian archaeological properties found by the Bishop Museum in NAVMAG (Landrum et al. 1997:159), which is certainly true and also true for the AMEC properties (see below). It, thus, appears that no significance evaluations of the Native Hawaiian historic properties identified within NAVMAG have yet been officially established – except for Nioiʻula Heiau. [In part this may be because these studies were not done as federal historic preservation review process actions for proposed undertakings in NAVMAG Lualualei (Section 106), rather they were done as part of the facility's documentation of historic properties on its land (Section 110 of the National Historic Preservation Act).]

> Naval Magazine Lualualei (NavMag LLL) has some of the best preserved and most extensive archaeological remains on the island of Oʻahu.
> [Williams in Haun 1991:308]
>
> … the traditional Hawaiian settlement pattern recorded for Lualualei Branch by AMEC during 2000-2001 confirms the previous impressions that the project area is one of the richest and best preserved archaeological zones on the island of Oʻahu.
> [Dixon et al. 2004:137]
>
> Within this boundary are some of the finest examples of relatively undisturbed Traditional Hawaiian sites on Oʻahu. As a cohesive unit these archaeological sites could address important research questions for the Waiʻanae District …
> [Rechtman et al. 1998:51]

Because there are very many Native Hawaiian archaeological properties on NAVMAG Lualualei in the upper valley and the uppermost part of the lower valley and because these are well-preserved across the landscape, the Bishop Museum researchers and the AMEC researchers have noted that these properties are extremely important collectively as a cultural landscape. I walked portions of this landscape when I was Branch Chief for Archaeology of SHPD and AMEC had us field check some of their finds. This is a cultural landscape impacted by military roads and bunkers at lower valley elevations, but it is still strikingly intact particularly in the upper valley areas. One can still see most of the permanent houses of the former Hawaiian residents, and their fields and their religious structures. Undoubtedly many burials are scattered across the landscape, not readily visible on the surface.

The Bishop Museum recommended that the entire NAVMAG Lualualei be nominated to the National Register as a district, due to its strikingly intact archaeological landscape of considerable importance (Williams in Haun 1991:308). OGDEN in their overview of cultural resources made a similar recommendation (Landrum et al. 1997:166). PHRI in their Cultural

Resource Management Plan made more specific recommendations with borders based on the Museum's findings, deleting steep slopes and the headquarters buildings area where there were no archaeological properties (Rechtman et al 1998:28 51, 53). As the PHRI study noted, with additional survey of the upper valley (the eventual AMEC survey), findings would expand PHRI's proposed borders, so recommendations of the cultural landscape's or district's borders will need to be revised.

This extensive landscape in Lualualei is similar to the surviving cultural landscapes in the back of Nānākuli valley (Cordy et al. in preparation), in the back of Waiʻanae valley (e.g., Cordy 2001b, 2010), in Mākaha valley (Green 1980), and in Mākua/Kahanahāiki. The district of Waiʻanae fortunately still has almost intact surviving cultural landscapes with historic properties in many of its upper valleys. This fact is extremely rare on the island of Oʻahu. These landscapes are definitely eligible for inclusion on both the Hawaiʻi and National Registers of Historic Places as districts under multiple criteria of the Registers. For example, the following criteria clearly would apply to this cultural landscape in Lualualei:

Criterion A: Association with broad patterns of history. The archaeological properties contain key information on when fields first began to be established in upper valleys, on when permanent habitation became established in upper valleys, on the extent of fields at different points in history, on the population at different points in history, on the population in the different ʻili lands of upper Lualualei, on when appointed chiefly managers replaced kin-based managers, on when the kings of Oʻahu built national heiau such as Nioiʻula Heiau (its building stages, and which kings are likely to have used it), on when the main trails over the passes of Kolekole and Pōhākea were used, and undoubtedly other broad patterns. The Lualualei site information has already been applied to the study of some of these broad patterns of Hawaiian history, and been very important in these applications (e.g., Dixon et al. 2008; summarized in Cordy 2002b, 2004).

Criterion B: Association with famous people, and in the State Register with famous deities. Minimally, Nioiʻula Heiau as a national heiau (poʻo kanaka heiau) is associated with the Oʻahu king Kākuhihewa (McAllister 1933:110), roughly dating 1640-1660. Pōhākea Pass is associated with the deity Hiʻiaka-i-ka-poli-o-Pele, Pele's younger sister – so documented in the many versions of the famed Pele-Lohiʻau-Hiʻiaka story published in the 1800s-early 1900s newspapers and translated in at least two cases into English (Emerson 1915; Hoʻoulumāhiehie 2006). (See also Hoʻomanawanui's 2007 Ph.D. thesis on these stories.) A pivotal scene of this story occurs when Hiʻiaka stands atop the pass and looks south towards the island of Hawaiʻi. There she sees the smoke of her burning lehua forests and knows that her sister has grown impatient and broken her promise to protect those forests and Hiʻiaka's dear friend, Hopoe. Hiʻiaka had been faithfully returning Lohiʻau to her sister. But now she plans revenge and her relationship with Lohiʻau soon changes. Quite possibly, other associations with famous people or deities can be made with the Lualualei landscape. The AMEC study notes a mythological story in which a mo'o changed two women into the peaks of Pu'u o Hulu (Dixon et al. 2004:18), and the AMEC report suggests that KaʻĪlio hill might be associated with some stories of deities that have dog

(ʻīlio) kinolau (Dixon et al. 2004:17). This latter point probably needs more research, but note that such associations may mean that natural features on the landscape must be considered historic properties, even if no archaeological property is present.

Criterion C: Some of the archaeological properties will definitely be excellent examples of architectural or functional types. For example, there are numerous permanent habitation sites. Some of these will be excellent examples of types. The AMEC researchers note that some include men's houses as impressive structures. Several permanent habitation sites are noted to contain impressive architecture, possibly reflective of local konohiki, with the permanent habitation at site 5984 in Hālona considered to be the most impressive of these local managers' sites. Other permanent habitations of smaller scale will also be excellent examples of their types. The same will be true of some of the irrigated kalo sites, some of the dryland farm sites, some of the temporary habitations, some of the lithic sites, some of the local religious heiau, some of the household and smaller heiau, etc.

Criterion D: Information on prehistory and history. Collectively, nearly all these sites contain some information that will help our understanding of pre-European times. Those that date from European contact up into the 1840s will similarly contain important information on that era.

Criterion E: [Criterion A, Nat.Reg] Traditional cultural significance. Automatically, all religious sites (small and large), all sites containing burials, and all major trail corridors are considered to have traditional cultural significance under the State's historic preservation process. The possibility of other properties having traditional cultural significance needs wider coordination and consultation with the Native Hawaiian community. Evaluation of this criterion under the federal process is a more lengthy process, but again with consultation critical. It is quite possible that Native Hawaiians would view the entire landscape (district) with its intactness and wide-ranging importance to have traditional cultural significance, including natural features (mountain peaks, passes, streams, etc.).

An important note is that this cultural landscape's eligibility as a district applies only to the Native Hawaiian properties from pre-European times to the 1840s. And this landscape is in the uppermost lower valley and upper valley.

Last, it should not be forgotten that very important Native Hawaiian historic properties may be extensively present in the sand areas of the Māʻili shore – as subsurface habitation deposits and burials. Collectively, these will be significant under multiple criteria of the State and National Registers – easily A and D (information on when settlement occurred, the size of population at different points in time), C (excellent examples of these types), and E (traditional cultural significance, minimally for any burials). These could be viewed as another potential district or cultural landscape of Lualualei. Or one could anticipate one large discontinuous Native Hawaiian cultural landscape for the entire Lualualei valley.

MANAGEMENT CONCERNS

Any planned federal, state or county agency actions (including permits) in the watershed will need to undergo historic preservation review – minimally State Chapter 6E review in non-federal lands, but Federal Section 106 review in federal lands or in projects with federal involvement. Such planned projects can potentially occur even within the huge cultural landscape (district) eligible for inclusion on the State and National Registers. But several careful planning steps are needed:

1) What is the area of potential impact? Whether for planting native trees, or for flood control, or for cattle leases, or for putting irrigated kalo fields back in production, or for interpretive preservation for visitors, or for stream erosion issues, each project will need to identify the area of potential impact.

2) Next, it will need to be determined if historic properties are present within the area of impact, or nearby; and if so, adequate descriptions of each property are needed. For NAVMAG Lualualei, the Naval RTS, Lipolo Street, and spots in Ulehawa Beach Park at Māʻili Point, we do know where historic properties are located. We also know that for most of the Naval RTS, for the DHHL lands at the base of Pāheʻeheʻe ridge, and for much of the area between puʻu Māʻiliʻiliʻi and the seaward tip of Pāheʻeheʻe ridge, no historic properties seem to survive from pre-European times through the 1840s. For the Māʻili Kai parcels, parts of two properties were present, but they are likely to no longer be present. On the Voice of America parcel, no Native Hawaiian properties were present. It is likely the two major remaining unsurveyed areas of the lower valley (the homestead area inland of puʻu Māʻiliʻiliʻi and the area behind the center part of Māʻili beach) also have very few surviving Native Hawaiian historic properties based on archaeological surveys in other lower valley areas – due to extensive disturbance from sugarcane, ranching, homesteading and quarrying activities. But if landscape is intact along the stream drainages in the homestead areas, sites might be found there. For the sandy shoreline of Māʻili, virtually no archaeological work has been done, but it is highly likely that subsurface habitation deposits and associated burials are extensively present across the sand areas where extensive bulldozing has not occurred.

This information can be used to identify sensitivity areas – areas that likely have low, medium or high amounts of historic properties. (This was done for the NAVMAG area before the AMEC survey of the upper valley – e.g., Rechtman et al. 1998). Clearly, much of NAVMAG is high sensitivity. Also, the Māʻili sand shoreline areas have potentially high sensitivity. The landscapes adjacent to streams in the homestead area might have potentially medium sensitivity. Other areas have low sensitivity, or are known to contain no historic properties of these times periods. However, sensitivity areas will not be particularly useful when projects get underway. Such projects will need to know whether or not historic properties are in the area of potential impact, and survey will be needed in unsurveyed areas. To be proactive and prepare for future projects, some survey work could be done soon. It is suggested that initial archaeological reconnaissance work should occur along the streams in the homestead area to see if intact landscapes are present; and if so, to have archaeological inventory survey determine if historic properties are present. Similarly, it is suggested that in the Māʻili sand areas within the watershed, an assessment be made that identifies (1) parcels that have had extensive bulldozing and thus much less chance of subsurface habitation and burials and parcels being present and (2) parcels that have had little bulldozing and might have such deposits and burials. This would be step one towards preparing for projects in this area. Unbulldozed parcels – if included in project impact areas – will need archaeological surveys with subsurface testing. Extensively bulldozed parcels might need archaeological monitoring of land alteration. Monitoring has occurred under Farrington Highway, finding it heavily disturbed with no Native Hawaiian sites (e.g., McElroy 2008); so monitoring under the highway or its immediately adjacent shoulders should not be necessary.

Several other actions are needed related to knowing if historic properties are in a project area, and having adequate information on these properties.

1. It is vital that all the known historic properties be placed on a master planning map with their known borders clearly delineated. It is also vital that all unsurveyed areas be located on the master map.

2. Known historic properties also should also be placed on a master inventory with descriptions and maps, functional interpretations, and any chronological information. Such documentation exists. It simply needs to be collated into one inventory.

3. It needs to be realized that very little dating of the historic properties in Lualualei has occurred. The numerous AMEC dates come only from a few permanent habitation sites in the upper valley, the more impressive habitation sites. More dating is needed of the Native Hawaiian historic properties of these time periods, to be confident about general chronological placement. This will be important should some of these properties be impacted and archaeological salvage excavations (data recovery) be proposed.

4. Interviews of knowledgeable community members (notably Native Hawaiian community members) should occur to identify and document any traditional cultural properties associated with these time periods.

5. Archival research could occur to better document the trail corridors of descending trails through Kolekole and Pōhākea passes, and branches to the shore. Archival research could also attempt to clarify where the fishpond was located in the lower valley.

<u>3) Next in a project area, all historic properties will need to have their significance evaluated (proposed to SHPD and reviewed by SHPD, minimally with an eventual consensus agreement)</u>. It is best to do this as soon as possible for all known historic properties, so it will not have to be done during projects. For the cultural landscape (district) of the upper valley, the entire district needs to be identified and described (with borders), and have an official significance evaluation, again minimally a consensus determination from the SHPD. This step must be taken, because

many watershed projects (e.g., flood control, etc.) will have to involve these federal lands. Delaying the significance determination of the district will only delay future projects. Ideally, the district should have the significance of each property within the district individually determined also, to be able to handle planning for small project areas.

4) Next in a project area, proposed treatment (mitigation) will need to occur. This might be to redesign and avoid impacting all historic properties (a "no effect") or design to avoid visual and other impacts ("no adverse effect"). Or, it might involve an "effect" that necessitates a mitigation agreement. It might require special preservation planning. It might involve archaeological data recovery (salvage excavation) of small properties only significant for their information content, then enabling their destruction. Or, if a project proposes replanting an irrigated kalo site and is acceptable to all parties, then archaeological work will be needed prior to replanting (typically mapping, documenting stone architecture, excavations to recover charcoal for dating and species identification, soils for pollen studies, etc.). If a proposed project is to have more public access to certain historic properties for educational purposes, then preservation plans with paths, signs, etc. might be needed. Proposed mitigation plans need to be reviewed by SHPD, by the Native Hawaiian community, and by the general community; then be approved; and then be successfully executed (with SHPD verifying successful execution).

SOME IDEAS FOR MANAGEMENT OF NATIVE HAWAIIAN HISTORIC PROPERTIES OF PRE-EUROPEAN TO 1840s TIMES IN THE WATERSHED

It is recommended that educational plans be included for historic properties in the watershed. The public should be made aware of what is known about the history of Lualualei and its remaining historic properties related to this history. This can be done via a brochure. Also, enabling visits to historic properties that are excellent examples of types or important properties with traditional cultural significance should be considered. Many Native Hawaiians have expressed a desire to visit Nioiʻula Heiau. But just as important, it would be desirable to have some excellent examples of permanent houses, fields and small heiau accessible. Pūhāwai might be one area that could have such visits, with its irrigated kalo fields, houses and heiau. Hālona around Nioiʻula Heiau is another example. Small brochures showing key sites to be visited in each area might be prepared – for example, one for Pūhāwai and another for Hālona. A visit to the crest of Pōhākea Pass also would have merit. Some interpretive signs could be erected at key places. For Nioiʻula heiau particularly, clearing of non-native vegetation off its walls and adjacent areas would be a useful protective measure, and perhaps fencing around a buffer if cattle are still a problem. Basic clearing of paths and a few sites in Pūhāwai and Hālona might also be considered. Such clearing could be organized projects with the Native Hawaiian community. Then educational visits can be organized with appropriate Navy staff. Such educational efforts can be highly positive actions involving particularly the native Hawaiian community and schools.

It is also important to consider how to learn more about the past from the historic properties in the watershed. Many watershed projects may be planned for flood control and reforestation. If such projects require excavation or data recovery (salvage archaeology) of some sites, it is a waste of money and time to just gather information in general. The same is true for research projects that might be proposed. It is critical for such work to attempt to improve our knowledge base for Lualualei and to address island-wide, major research questions. Certain key research aims (problems) need to be framed and the information needed to address the questions must be identified, so that information can be collected. Then reports hopefully improving our knowledge on the past would be produced as a result of these projects. These research problems can periodically be revisited and revised over the years (perhaps by a small advisory group of archaeologists/historians). Here are some examples of such research problems:

1) When was Lualualei settled – with permanent house sites and fields?

   Sites relevant to this question will be subsurface habitation deposits in the Mā‘ili sand shoreline areas (and Ulehawa outside this watershed project area), for it is expected that initial settlement of Lualualei was along the shoreline sometime between AD 1000-1300.

   Relevant information will be radiocarbon dates from the basal portions of these deposits. Dates need to be obtained from a wide area of the shoreline, because early housing could have been in just one small location. Such a wide sample will also give a picture of the spread of housing along the shoreline over time.

   Agricultural field sites for early time periods are suggested to have been in adjacent lower valley areas (likely to have been destroyed by late 1800s-1900s activities) and perhaps at the seaward edge of the upper valley. Excavations and dating of such upper valley fields could contribute to this research problem. But the easiest approach is to focus on shoreline habitation deposits.

2) When was the upper valley of Lualualei permanently settled?

Findings from dated permanent habitation sites and some other site types suggests that this occurred in the AD 1300s-1400s. However, only the larger more impressive habitation sites have been dated, and very few other site types.

Sites relevant to this question will predominantly be permanent habitation sites. Of 10 dated so far, only 2 have earlier dates. There are over 100 permanent habitation sites in the upper valley and the uppermost part of the lower valley in the NAVMAG area. Clearly, our sample of dated habitation sites is as yet quite small. More sites need dating.

Relevant information will be radiocarbon dates from the basal foundations of these permanent habitation sites – locations likely to date the time of their construction.

3) What is the chronology of the fields in the upper valley of Lualualei and the adjacent inland edge of the lower valley, and how much acreage was under cultivation at different points in time?

Recall there are two basic types of fields in the upper valley – dryland fields in all areas and irrigated fields only in Pūhāwai and Mikilua. Knowing when these were established in each area is important. Also determining the acreage under cultivation at different points in time provides an idea of agricultural production. For example, field acreage might have dramatically increased in the 1600s, as a result of both local population size and chiefly demands for surpluses.

Sites relevant to this question are the agricultural sites of the upper valley and uppermost parts of the lower valley. Relevant information will be radiocarbon dates from the field sites. Fields may expand laterally over time, and may have lower earlier fields. Thus, excavation will be needed to determine if earlier fields are present. Also excavation over wide areas will be needed to recover samples for radiocarbon dates.

4) What is the picture of settlement expansion in the upper valley? Was one area (e.g., Hālona) occupied first and then others in a certain succession? Or were all areas of the upper valley occupied roughly contemporaneously?

Our dating of permanent habitation sites is so limited in the upper valley of Lualualei that little can be said about this at present. One site in Hālona has a date that might extend back into the 1300s; one in Pāhoa may date back into the 1400s. Clearly more dating of permanent habitation sites is needed.

Relevant sites are permanent habitations. Relevant information is radiocarbon dates obtained from samples recovered from the base of the architecture in these sites.

5) What are population estimates for Lualualei and its internal lands over time?

Estimating population in pre-European times seems most reliable when using counts of permanent habitations at different points in time. However, the coastal subsurface habitation deposits need to be included in the analysis of this research question somehow – perhaps looking at the areal spread of these habitation deposits at different points in time. In the upper valley and uppermost lower valley, permanent habitation sites with surface architecture are the key site type for analysis. In these sites, the relevant information are dates from the base of the architecture (when they were built) <u>and</u> dates from features on top of the architecture (reflecting periods of use). Sizable samples of dates will be needed. At least two dates will be needed to date a structure within a permanent house site – one from the base and one from the top – and ideally several from the top are needed to cover the span of use. (Note related to this research question, that the AMEC study found very many dates from the top of structures to date after AD 1650, vital for indicating when the houses were still in use.)

Also dated samples from permanent habitation sites within each internal land of upper Lualualei will be needed – from each likely ʻili. This will supply population estimates for these ʻili over time.

6) When was Nioiʻula Heiau built? Did it have multiple building stages over time, and how big was the entire heiau at each point?

Nioiʻula was again identified as a po'o kanaka heiau (a luakini or national heiau) used by Kākuhihewa, ca. 1640-1660. Often such heiau started with smaller sized structures, which were added to over time under the permission or sponsorship of different rulers.

Evaluating this research problem set requires excavations at the heiau. Such excavations would have to be approved by consultation with the local Native Hawaiian community, before any excavations could occur. However, such excavations need not be large in scale, and Maui Native Hawaiian communities approved a program of testing in major national heiau on Maui (Kolb 1991), so it might be possible to address this question. The test units would be intended to identify the size of the heiau at different points in time, by looking closing at architectural patterns (differences in style of wall facings, joins of walls or platforms, etc.) and obtaining radiocarbon dates for the construction phase of each building episode. If branch coral is present at the key points in the deposits, Uranium-Thorium dates could be processed – which have much smaller plus-and-minus ranges.

Last, a few comments on additional archival and oral historical research to improve our knowledge base for Lualualei's history in pre-European times up to 1840. There are field notebooks used by the Kingdom's Government Survey Office's surveyors, those surveyors who mapped Lualualei in the 1870s and later. Some of these notebooks may shed more light on Lualualei's places and lands. Many are in the Surveys Division office in the Kalanimoku Building. There are also numerous journals, letters, and notebooks of foreigners and native residents of the islands – some published, some not. These include records of Kingdom officials in the State Archives. These could be more extensively reviewed, and more information on

Lualualei's settlement and places in the 1800-1850 era could quite possibly be recovered. These sources might perhaps describe branch trails descending to the shore in different spots from Pōhākea Pass. There is also likely to be oral literature of different types (mele, oli, kanikau, etc.) in Hawaiian-language newspapers and manuscript material. These also could contribute to information on places. And there could quite likely be oral historical information in the newspapers and some manuscripts, besides the more commonly known Kamakau, Malo and Fornander sources. Also, sometimes post-1850 sources can provide helpful information on earlier times. For example, tax and census records might provide clues on settlements. Last, in some areas of the islands, there is old knowledge passed down from kūpuna who lived in the area – passed down in family documents, or passed down verbally to descendants. Descendants are sometimes willing to share this information. Their family genealogies could also interface with 1840s Māhele and 1850s tax and census records, providing a broader perspective into the past for the families and the entire community.

SOME COMMENTS ON THE RANCHING ERA (1850-1929)

[The following information comes primarily from Kelly in Haun 1991, Johnson in Cordy et al. in preparation, Dixon et al. 2004, and Cordy and Cordy 2012.]

The Ranching Era of Lualualei really consists of two time periods: (1) the early ranch (the Jarrett Ranch and later Dowsett/Galbraith Mikilua Ranch of 1851-1902) and (2) the ranching (notably the McCandless Ranch) of the early 1900s. Some historic properties from these ranching eras survive in Lualualei. Ranches tend to consist of walls, headquarters buildings, and corrals. Currently, although some ranch properties are identified, there is not a thorough knowledge base of either the history of the early ranch or the later ranch, or of which historic properties belong to the early ranch as opposed to the 20th Century ranch.

Some Brief Information on the Ranches

Most, if not all, of the Lualualei Crown lands was leased to William Jarrett in 1851, a 50 year lease. He operated a ranch here, which some records say was called Lualualei Ranch. He sold half his interest to Paul Manini, who apparently actually managed the ranch. Jarrett had a country home on the shore in Mā'ili, with a horse racing track nearby. Manini evidently lived at Pōka'ī Bay in Wai'anae valley. In 1854 financial squabbles between the partners arose, and Manini sold his interest to George Galbraith, and in 1869 Jarrett, having further financial difficulties, sold his remaining interest to James Dowsett. This Galbraith/Dowsett partnership ran the Lualualei ranch as the Mikilua Ranch, one of the largest and dominant ranches on O'ahu in the late 1800s. By 1896, Alex (Alika) Dowsett (James Dowsett's son) had become the sole manager of the Mikilua Ranch, eventually moving over from the Dowsett's Leilehua Ranch in the Wai'anae uka (Schofield Barracks area). George Galbraith seems to have remained in the Wahiawa area on a smaller ranch directly under his control. So essentially, the Mikilua Ranch may have become effectively Dowsett operated near the end of the Monarchy.

In 1863 the ranch had over 7,000 cattle. Until about 1870, most cattle were free-roaming. The free-roaming cattle probably resulted in the final abandonment of the upper valley soon after its establishment. The Pūhāwai houseyards and fields were walled, likely built to keep cattle out – a common pattern in the islands beginning in the 1840s (e.g., Sahlins 1992). After 1870, fencing of the ranchlands (often with stone walls) became more common, and cattle stock was improved. By 1900, Mikilua Ranch had 2,000 head of cattle as well as 110 horses and 1 stallion on 14,800 acres.

Much needs to be learned about the nature and operational history of Mikilua Ranch. The 1876 map (Kingdom Map 1876) in Figure 3 shows a house in the Mikilua area labeled Galbraith's, and this perhaps was the ranch headquarters. The ranch clearly employed a number of people – at one point 12 men (and probably their families) – who likely lived on the property. Their lifestyle and use of the land was that of the ranch-paniolo lifestyle. Again, future research needs to be focused on the history of this ranch.

It should be pointed out that the Mikilua Ranch evidently subleased part of its ranch in the central lower valley to the Waianae Plantation for sugarcane cultivation. The history of this land use and associated historic properties also needs work.

In 1902, the 50 year lease to the Dowsett's ranch expired. The Territory of Hawaii had been planning to divide up Lualualei into homesteads, for ranching and other uses. The back half of the valley and sizable parts of the seaward portion of the lower valley were divided into lots (Lots 1-9) in 1903. In 1908, they were auctioned off. Of the interior 7 lots, one was sold to Link McCandless, Lot 7 in Hālona was sold to Alika Dowsett, and the Dowsett company seem to have subleased parts of others. However, in 1915, McCandless bought most of the lots in the back of the valley, forming the large McCandless Ranch. The rise of the McCandless Ranch and its history needs research – archival <u>and</u> through interviews of elderly kūpuna. AMEC did some interviewing of Albert Silva, whose grandmother was married to McCandless (Dixon et al. 2004:27), and clearly important information survives in the community.

In 1907 smaller coastal lots were awarded to individuals as homesteads. And in 1912 a large number of lots were awarded as homesteads along Māʻiliʻiliʻi Stream just inland of puʻu Māʻiliʻiliʻi – in the former sugarcane subleased lands. These are the lots that appear on the 1905 map, with streets laid out. Thus, small scale homesteading is part of this history of Lualualei in the early 1900s. It also needs more research.

This era ends in 1929 when the military acquired most the McCandless Ranch and proceeded to turn it into an ammunition storage facility.

Some Thoughts on Historic Properties

Again, the ranch sites that have been identified need to be associated with the early ranches or 20th Century ranches. No attempt to do so is made here. But several points are suggested.

Twenty-three ranching sites were identified in the Bishop Museum and AMEC studies on NAVMAG (Dixon et al. 2004:69, 73), and probably features within other sites are ranch features. Some of these are long lineal stone walls. Probably some of these walls are parcel boundary walls, and others divided up portions of the ranches. Such walls usually were built after 1870, when cattle ranching converted from free-roaming ranching to more controlled ranching (e.g., Cordy and Cordy 2012). Thus, these walls in upper Lualualei are likely to belong to the Mikilua or later ranches.

Two properties were found that include ranch buildings and associated stone corrals – site 6315 in Mikilua (described as a semi-permanent ranch with house foundations and features and with complex walled pens – or as a "ranch house and cattle pens") and site 6342 in lower Pūhāwai at the intersection of old Kolekole Road and Waianae Road (described as a ranch with habitations or "ranch houses") (Dixon et al 2004:69, 71). These need to be more specifically interpreted – associated with a specific ranch and what they were used for and by whom. It would be interesting if 6315 coincided with "Galbraith's" on the 1876 map. If either were the main ranch headquarters, then they become much more important as historic properties.

Several ranch properties in NAVMAG had concrete features (gate posts, water troughs, a large cistern) that had names and dates etched in them – apparently associated with the McCandless Ranch. For example, one is noted with the names "Link McCandless" and "George Halemano" (Dixon et al. 2004:69). These properties' names are likely to have importance for this historical era.

In the case of the ranches, the protection of several individual historic properties may be more relevant than any consideration of a cultural landscape or district. For example, if a ranch headquarters survives, it would merit protection. Perhaps examples of walls or corrals also need protection – and the features with etched names and dates.

Historic properties related to sugarcane cultivation and the homesteading in the lower valley and shoreline also need more thought. What survives, and how do they fit in with the history of these land uses? Thoughts on which are important and which might merit preservation also should be considered.

SOME COMMENTS ON MODERN TIMES (1930-PRESENT)

[The following information comes primarily from Landrum et al. 1997 and Rechtman et al. 1998.]

This era saw military use in the interior of the valley and increasing housing along the shore. Technically, under the National Historic Preservation Act and the State's Chapter 6E, historic properties have to be 50 years or older. Thus, for purposes of managing historic properties in the watershed, this means that this period at this time extends from 1930 to 1963.

The military history of this era is summarized in Haun (1991), Dixon et al. (2004), Landrum et al. (1997) and Rechtman et al. (1998), and the latter two address different construction and facility activities in those eras. The historic buildings on NAVMAG have been recorded and inventoried, with proposed significance evaluations (Landrum et al. 1997). Recommendations for a military history district was made in the PHRI Cultural Resources Management Plan (Rechtman et al. 1998). It essentially focuses on the Administration buildings and some of the bunkers.

Interestingly, a history of increasing housing along the shore and in the homestead areas does not seem to exist. If this is a subject of interest, then some research is needed. Then the types of important historic properties associated with this history could be noted. Presumably these also will be buildings.

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APPENDIX C

Photographs

Note: Photos taken at U.S. Navy installations were approved by the Navy for public release. Photo Permit # 2325

NAVMAG:

Photo 1: Panorama view from rocket testing site looking makai

Photo 2. Panorama view from rocket testing site looking makai

Photo 3. Panorama view from rocket testing site looking towards Wai‘anae

Photo 4. Panorama view from rocket testing site looking towards Wai‘anae

Photo 5. Panorama view from rocket testing site looking mauka.

Photo 6. Drainage Structure – Herbert Street bridge.

Photo 7. Drainage Structure: Typical box culvert

Photo 8. Vegetation makai of box culvert, overgrown

Photo 9. Typical stream channel vegetation is heavy koa haole overgrowth

Photo 10. Typical stream channel vegetation upstream of large culverts on Guadalcanal Rd.

Photo 11. Close-up of Guadalcanal culvert mauka side

Photo 12. Guadalcanal culverts makai side of road

Photo 13. Large bridge on Kolekole Rd. near Puget Sound Rd. Photo shows streambed underneath the bridge.

Photo 14. Herbicide residue in blue from spraying around the bridge.

Photo 15. Bridge crossing at first sharp bend on Kolekole Rd. Stream makai of bridge is in a concrete channel.

Photo 16. Concrete channel makai of bridge

Photo 17. Aqueduct from water tunnel. A second old pipe that is no longer used was too overgrown to identify.

Photo 18. Water leakage a few feet away from the newer pipe suggests the old pipe may be leaking.

Photo 19. Last stream crossing on Kolekole Rd. before Kolekole Pass. Photo is looking mauka of road.

Photo 20. Streambed and vegetation mauka of bridge. Stream was flowing.

Photo 21. Close-up of stream flow entering the bridge.

Photo 22. Vegetation on makai side of the bridge.

Photo 23. Upstream of a large bridge on Fence Rd. This is a debris catching fence.

Photo 24. Makai side of bridge has some streambank erosion.

Photo 25. Grate covering makai side of bridge. Most likely for security purposes.

RTF:

Photo 26. Entering Niuli'i Pond Refuge.

Photo 27. Niuli'i Pond is a man-made wetland providing waterbird habitat. It is fed via septic tank effluent and supplemented with potable water.

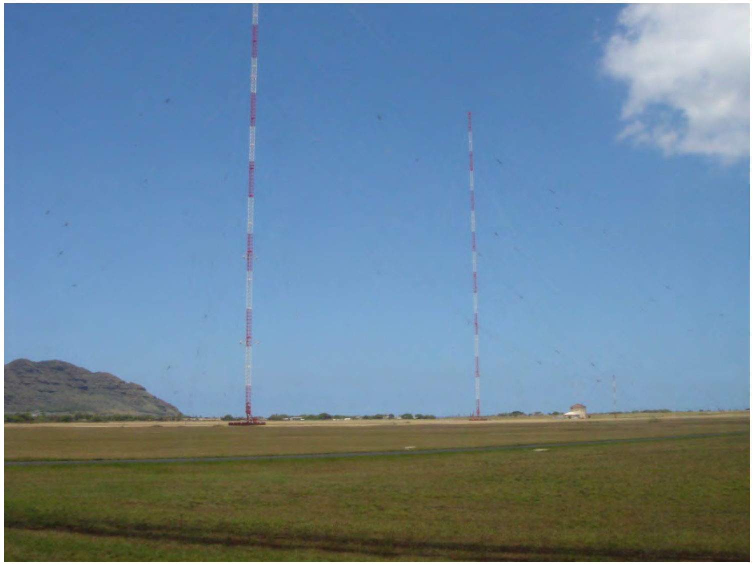

Photo 28. Radio Transmitter Towers.

Photo 29. Bridge crossing one of the grass swales that are part of the drainage system at RTF.

Photo 30. Upstream side of bridge

Photo 31. Downstream side of bridge.

Photo 32. Smaller grass swale and culverts, Hastings St.

Photo 33. Close-up of culverts

Photo 34. Intersection of two major swales on Marconi St. Banks are concrete. This picture is looking upstream of the bridge.

Photo 35. Bridge upstream side

Photo 36. Swale downstream side of bridge.

Photo 37. Culvert where water exits RTF towards Māʻiliʻili Stream.

Photo 38. View from RTF towards Lualualei Homestead Rd. Pond area described in AECOS report [(12)].

Private Land:

Photo 39. Māʻiliʻili Stream channel – C&C dumping area after restoration.

Photo 40. One of many basil farms in the neighborhood around Puhawai Rd.

Photo 41. Trash dumping on Paheʻeheʻe Rd.

Photo 42. Typical stream channel vegetation, Puhawai Stream just mauka of Puhawai Rd.

Photo 43. Concrete streambanks a few hundred feet upstream of previous photo.

Photo 44. Concrete streambank adjacent to Lindberg property. Concrete is visible in Google Earth.

Photo 45. Unstabilized eroding streambank just mauka of Lindberg property.

Photo 46. Grass overgrowth covers streambed past photo 44 before reaching "mosquito pond" seen in photo 47.

Photo 47. Berm protecting property makai of stream. Berm has failed in the past causing flooding.

Photo 48. Standing water, mosquito breeding grounds.

Photo 49. C&C trench just downstream of Puʻuhulu Rd. bridge.

Photo 50. View downstream from underneath Puʻuhulu Rd. bridge.

Photo 51. Looking makai into Puhawai Stream from Kuwale Rd. bridge

Photo 52. Exposed bank just makai of bridge on Wai'anae side of stream

Photo 53. Vegetation for first few hundred feet walking makai

Photo 54. Vegetation gets very dense walking towards Pu'uhulu bridge.

Photo 55. Several spots with streambank erosion.

Photo 56. Walking downstream on Pu'uhulu Stream from Kuwale Rd. along berm.

Photo 57. Streambed, eroding banks

Photo 58. Basil farm on Wai'anae side of Pu'uhulu Stream – no berm

Photo 59. Basil farm on Nānākuli side of Pu'uhulu Stream – with berm

Photo 60. Streambank erosion. Slight stream flow.

Photo 61. Walking past basil farms along Puʻuhulu Stream. Looking makai.

Photo 62. Looking back (mauka) from the same spot.

Photo 63. Looking makai from culvert where Puʻuhulu Stream crosses Puhawai Rd

Photo 64. Looking makai from bridge where Puʻuhulu Stream crosses Puʻuhulu Road. Concrete channel starts here.

Photo 65. Picture of one of the bridges prior to stream clean-up. Photo courtesy of State Civil Defense.

Photo 66. Picture of same bridge after stream clean-up effort was completed. Photo courtesy of State Civil Defense.

Photo 67. Photo of one of the streams prior to clean-up effort. Photo courtesy of State Civil Defense.

Photo 68. Picture of same area after stream clean-up effort was completed. Photo courtesy of State Civil Defense.

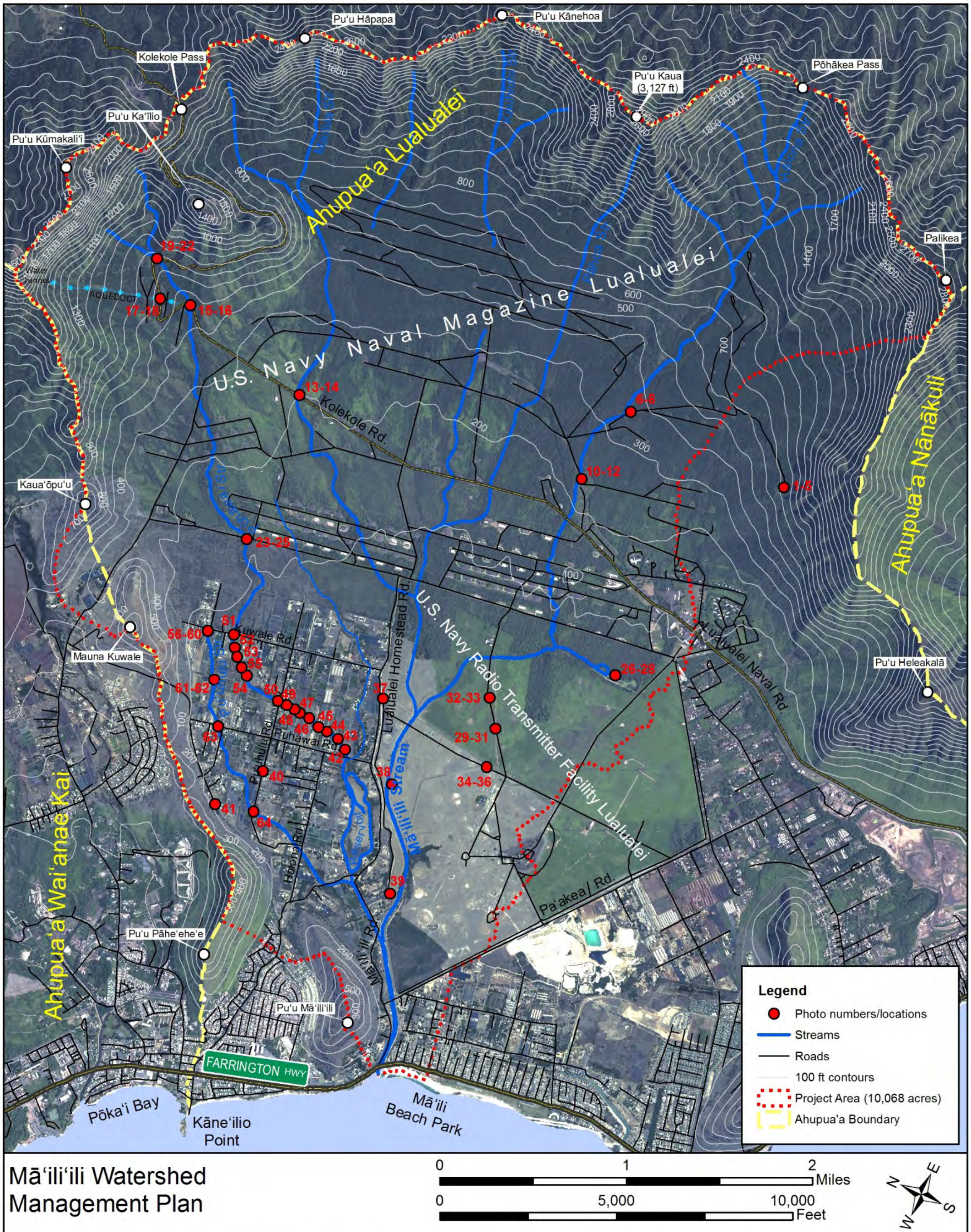

Figure C-1. Photo Locations Map

APPENDIX D

Stakeholder Interviews

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MĀʻILIʻILI WATERSHED MANAGEMENT PLAN
Interview Notes 01

Interview Date: **March 14, 2013**
Interviewees: **Walterbea Aldeguer, Lucy Gay**

Participants: Walterbea Aldeguer, Lucy Gay (Interviewees); Mohala I Ka Wai: Cynthia Rezentes; Townscape: Bruce Tsuchida, Tina Speed.

Purpose of this meeting: Interview 1 of Stakeholder Outreach Process to obtain information from community stakeholders.

Summary of discussion:

- Lucy started by talking about Niuliʻi Pond which is connected to an above-ground pipe that carries sewage. This pipe is leaking and an eye sore. It used to carry sewage from the Navy housing facilities. Now that there is no more housing on the Navy lands, this pipe should be removed. From a cultural standpoint, using these ancient ponds for sewage is not pono. The removal of the sewage pipe should be a high priority, especially since there is funding available.
- Cynthia mentioned that Janice (last name?) did studies on this issue for RAB (Restoration Advisory Board). She will forward RAB info to Townscape.
- (Note: RABs exist at all closing DoD installations and at non-closing installations where the local community expresses interest. They serve as a forum for exchange of information and partnership among citizens, the installation, EPA, and State.)
- Cynthia mentioned the same area of former military housing having PCBs. With RAB effort, soils from the Radio Transmitting Facility (RTF) were treated and sterilized. Soils and facilities are now supposed to be pesticide free.
- In terms of pollutants coming from military land, pesticides are likely still a problem. RAB is now looking at old scrap yards.
- Lucy mentioned that there is a lot of unpermitted industrial type activity in the Puhawai neighborhood, e.g. on DHHL land, "Henry's Eqipment" recycles used concrete. There is also a lot of illegal dumping of vehicles and other trash. Lucy attributes this kind of behavior to a lack of cultural understanding and respect. She thinks the industrial activities are likely of more concern than animal husbandry operations.
- After the '96 flooding, the military helped with trash removal and removed tons of vehicles and other large objects. Now it looks the same again.

- Lucy thinks that the problem will keep recurring even after cleanup unless there is clear action to educate people and clear consequences on people's pocket books. Maybe it is time for EPA to start threatening with consequences.
- Schools in the area are Leihoku and Waiʻanae Elementary schools, and Waiʻanae Highschool
- Walterbea mentioned "Riverkeeper" program in New York. This could serve as a type of model for a "Streamkeepers" program. Mohala I Ka Wai could potentially implement this kind of initiative. Citizens need to become part of the solution.
- There may be a lot of farm wells throughout the private lots, but there is no information on how many wells and whether they are being used. Mohala did a survey on farm wells with a very low response rate of 25%. She has a list of wells from the CWRM well database as well. There was speculation that people may dumping in the wells, but there is no way of knowing.
- Piggeries may still be using wells and water-based waste management systems and should be encouraged to use dry litter instead. (Note: The old hog farming methods use water to wash pig pens and store the waste in lagoons which can easily pollute surface and groundwater. Dry litter systems have been studied in Hawaii with support of a 319 grant. These systems entail using dry bedding that pushes the waste into a composting or storage pit, which is much less of a water quality threat.)
- Marine fisheries are not what they used to be. Used to get mullet, uku, eel, squid, moi, āholehole, ʻōʻio, flounder, all kinds of limu, etc.
- Māʻili Stream area (canal) used to be a wetland. With the build-up of the wetland areas, the fish-rearing areas have disappeared so there is no nursery habitat for juveniles.
- There used to be lots of crab in Māʻiliʻili Stream before it was channelized with concrete.
- The ocean is brown after storm events. In the past when the interviewees were children, stormwater would deposit kukui nuts on the beach that they could use for making lei. Now, stormwater deposits trash of unnatural (anthropogenic) sources.
- Dr. Isabella Abbott did a study in the 70s or 80s about limu along the Waiʻanae Coast.

ACTION ITEMS:

- Cynthia to send RAB studies to Townscape
- Cynthia to send CWRM well info and maps to Townscape
- Townscape to research school boundaries
- Townscape to search for Abbott study on limu

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MĀʻILIʻILI WATERSHED MANAGEMENT PLAN
Interview Notes 02

Interview Date: **April 4, 2013**
Interviewees: **Landis Ornellas, Dennis and Katherine Kamada**

Participants: Landis Ornellas, Dennis and Katherine Kamada (Interviewees); Mohala I Ka Wai: Cynthia Rezentes; Townscape: Tina Speed.

Purpose of this meeting: Interview 2 of Stakeholder Outreach Process to obtain information from community stakeholders.

Summary of discussion:

- Long discussion about project area definition and why it doesn't include all of Lualualei Valley. Landis mentioned that a lot of the mauka water from the military lands drains into Māʻili area, not our project area. Due to the flat topography, it is hard to say where exactly some of the runoff goes. There is nothing to influence the direction.
- Before the concrete channelization, the neighborhood around Māʻiliʻili Stream up to Mana Street would flood.
- A large drainage structure carries water from the RTF to Paʻakea Road quarry area.
- South of the concrete channel makai of Paʻakea Road used to be a dairy farm.
- Landis speculated about people living near the RTF and quarry being more sick than normal.
- After storm events, people have reported sickness from entering the water (ocean) and children have been observed with rashes ("red bumps") all over their skin.
- Discussion on soil vs. water sampling due to lack of rain.
- Complaints about the lack of an emergency road to evacuate neighborhood makai of Paʻakea Road during a tsunami etc. because roads connecting neighborhood to Paʻakea Road are private.
- Dennis described areas on the Navy land near the water tunnel with banana patches, rose apples and possibly taro. He also talked about missiles possibly being stored at NAVMAG being "not clean". Speculation about what kind of munitions may or may not be stored there.
- In the early 1900s, a lot of sand from the beaches here was taken to Honolulu for construction, depleting the beaches. Beach sand used to be bright white.

ACTION ITEMS:
- Cynthia to contact Dorothy Frane for interview
- Cynthia to research Puhawai Farm Association
- Townscape to contact Barry Usagawa at BWS for results of well survey

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MĀʻILIʻILI WATERSHED MANAGEMENT PLAN
Interview Notes 03

Interview Date: **April 9, 2013**
Interviewees: **West Oʻahu County Farm Bureau**

Participants: Jeanne Vana (President, WOCFB), Tom McDonald (Kahumana Farms), Gida Snyder (Cheesemaker, Naked Cow Dairy), Jennie Patton (Butter maker, Naked Cow Dairy and owner of Rainbow Eggs), Monique van der Stroom (Owner, Naked Cow Dairy), Cheryl To (Owner, Pacifikool), Sylvia Thompson (Owner, Greens & Vines) (Interviewees); Mohala I Ka Wai: Cynthia Rezentes; Townscape: Tina Speed.

Purpose of this meeting: Interview 3 of Stakeholder Outreach Process to obtain information from community stakeholders.

Summary of discussion:

- Before everyone arrived, Tom started talking about stormwater flows. After a storm, Puhawai St. becomes impassible. Stream water is thick and brown for about 2 days, then it settles. The vertisol clay soils tend to be either rock hard or muddy, depending on the amount of water. It takes a lot of input to make it into workable soil.
- Once everyone arrived, we started with self-introductions.
- Tom McDonald: He explained the social ventures of Kahumana Farms and their homeless transition program. He works with adults with developmental disabilities and autism. The organic farm has been around since 1978. They are trying to expand their produce market to different farmer's markets throughout the island, including Kailua.
- Jeanne Vana: She grows tomatoes and sells tomatoes/pizza at Kailua farmer's market. She described the West Oʻahu County Farm Bureau Chapter. It has about 120 members, 100 of whom are "regulars". Oʻahu is split up into three chapters, East County, West County, and South County. South County members tend to be more large-scale biotech (GMO) oriented farmers and organizations. The West County chapter includes Waiʻanae, Wahiawa and North Shore. The more members they have, the more of a voice/representation they have. They are stakeholders in what is happening at the legislature and it is important for them to be involved with the legislative process.
- Gida Snyder: She is a trained chef who regularly goes to France to cook. She has a background in many food-oriented ventures, providing food for the hungry and such. She is involved in getting EBT cards accepted at farmer's markets to ensure access to fresh and local produce for people on food stamps. She is very good at writing grants and getting

scholarships for her work and is currently the cheesemaker at Naked Cow Dairy. Naked Cow uses mostly milk imported from the Big Island to make their butter and cheese. This makes it economically unfeasible at the moment, but they are working hard at increasing their volume. They only have 20 cows, but many of them are pregnant or have recently given birth. When they have a large batch of mozzarella that needs to be processed quickly, woofers from Kahumana Farm assist them. There are also volunteer opportunities to help with cheesemaking.

- Tina and Cynthia then introduced themselves and partially presented the Maʻiliʻili Watershed Management Plan project. Most attendees didn't know about the stream dumping case and seemed generally very committed to environmental stewardship and using BMPs in agricultural operations.
- Jennie Patton: She makes butter at Naked Cow Dairy and is also opening "Rainbow Eggs" and a hatchery, together with Naked Cow folks. They will be breeding several varieties of chickens and selling eggs of all different colors (white, brown, pink, blue, etc.). She is also a member of the 4H Livestock Club.
- Sylvia Thompson: She owns a raw organic vegan restaurant at Ward ("Greens & Vines") and buys all her ingredients from farmer's markets. She is very interested in supporting small local farmers and is a supporter of GMO labeling.
- Cheryl To: She owns Pacifikool, which manufactures local ginger syrup to produce ginger beverages. They sell their products at stores and farmer's markets.
- Monique van der Stroom: She is the owner of Naked Cow Dairy and is very knowledgeable about BMPs for dairy farms as she has a strong background in larger-scale dairy farming.
- We then got to sample Naked Cow Cheeses, which were superb.
- Tina then continued explaining the MWMP project goals and process and what Townscape is hoping to do in terms of community outreach to farmers. She also explained the process of implementing projects with 319 and settlement funding and what kind of projects may qualify.
- Tom described the overuse of pesticides on the basil farms throughout the valley as a large problem. He guesses that up to 50% of land in the "Private landowner" area is leased by Chinese basil farmers, which use high amounts of fertilizers and pesticides to grow basil in large-scale monoculture. Their yields are extremely high and their revenue is $80,000 per acre of basil. The pesticide spraying impacts nearby farms and residents. When Naked Cow hosted a recent dinner gathering, they had to ask basil farmers to stop spraying as the pesticides were ruining their dinner party.
- In the last two years, basil farmers have been caught using illegal pesticides and CTAHR held workshops on proper pesticide use.
- Tom used to live in Taiwan and speaks Chinese, so he gets to talk to the basil farmers, who are all from China, along with the workers. One lady has been in the US less than five years and leases 40 acres of land for basil farming. Due to their high yields, he says she makes $3 million/year from her operation.
- Jeanne thinks that a lot of farmers, especially the basil farmers will be afraid to talk with Townscape for fear of being investigated.
- Tom made a suggestion for an educational project: Education for Chinese basil farmers on proper pesticide use and possibly replacing certain pesticides with alternatives. Since he

speaks Chinese and already has a relationship with some of these people, he is offering to implement or assist with implementing such a project.

- Tina gave everyone a project fact sheet and encouraged people to contact Townscape with ideas and names of people to contact.
- The meeting then continued with general talk story, dinner, and Farm Bureau business.
- Some of the farmers are only regulated by the Department of Agriculture, some also by the Department of Health (livestock farms due to runoff). People prefer dealing with DOH over DOA.

ACTION ITEMS:

- Tina to send closeup street map of Puahawai neighborhood to Jeanne so she knows whom to contact for interviews
- Tina to send 11x17 watershed map to Tom McDonald

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MĀ‘ILI‘ILI WATERSHED MANAGEMENT PLAN
Interview Notes 04

Interview Date: **April 11, 2013**
Interviewees: **John DeSoto (former City Council member)**

Participants: John DeSoto (Interviewee); Mohala I Ka Wai: Cynthia Rezentes; Townscape: Bruce Tsuchida, Tina Speed.

Purpose of this meeting: Interview # 4 of Stakeholder Outreach Process to obtain information from community stakeholders.

Summary of discussion:

- Big problem John identified: Illegal trash dumping and lack of enforcement. “If this were Hawaii Kai or Windward, all this trash would be gone”.
- John has reported dumping before, but government doesn’t do much, except give warnings.
- Private landowners are and have been dumping trash in dry streambeds and covering them with dirt. When it rains, everything comes out.
- Many older people who own land in the Puhawai neighborhood can’t work the land anymore. They live in town and lease the land to others for “storage” and other activities.
- He speculates that the soils in the valley are contaminated with pesticide and chemical residues from the military lands. Therefore, he chooses not to buy produce from any of the farms in the area.
- When John was little, there used to be many species of stream fauna present. Now no more.
- Until the 1980s, cattle were still run on the Navy lands and people could ride horses back in the valley.
- Like other interviewees, he is concerned about illegal industrial activities happening on agricultural zoned lands in Lualualei, e.g. the trucking company.
- The problem in Wai‘anae and with these types of projects is that special interests get in the way of people talking openly. Often, special interest groups will meet behind closed doors.
- Government needs to do testing of water and soils and increase enforcement!

ACTION ITEMS:
- John to notify Cynthia if he thinks of other people to contact
- Townscape to research organic farming certification requirements and whether soils require testing
- Townscape to research tire burning area and whether it was cleaned up (EPA case)

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MĀʻILIʻILI WATERSHED MANAGEMENT PLAN
Interview Notes 05

Interview Date: **April 11, 2013**
Interviewees: **Kennard Hicks (Owner, Uʻilani Farms)**

Participants: Kennard Hicks (Interviewee); Mohala I Ka Wai: Cynthia Rezentes; Townscape: Bruce Tsuchida, Tina Speed.

Purpose of this meeting: Interview # 5 of Stakeholder Outreach Process to obtain information from community stakeholders.

Summary of discussion:

- Kennard grows plumeria for local and mainland customers, as well as sweet and Thai basil. The farm is not organic and uses pesticides.
- Location of the farm is adjacent to the reservoir
- People upstream of him have blocked the stream, causing flooding when it rains. The buildup of water is mauka of the property and there is lots of rubbish.
- In the past few years, after a heavy rain, the water pools on the DHHL property (several feet deep). When this happens, he can't use it for six months as all his basil fields are under water. He had pictures to show what this looks like.
- Eggs of tilapia and other fish are in the soil and hatch when the water comes.
- His property experiences some form of flooding about twice a year and major flooding every few years.
- Nowadays, there is much less rain than there used to be. The climate has gotten even drier in the past few decades.
- On the reservoir side of the basil fields is an earthen dam that has never been overtopped.
- The fields are arranged in line with the water flow so that water crossing his property has somewhere to go. There is an outlet in the northwest corner of the property.
- Eventually, he wants to replace basil fields with orchards to grow avocado, mango and lychee. This should be more resilient to flooding than basil.
- People come to this neighborhood and dump truckloads of rubbish into streams and along the road.
- There is also a problem with trespassing and illegal dirtbiking and dumping.

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MĀʻILIʻILI WATERSHED MANAGEMENT PLAN
Interview Notes 06

Interview Date: **April 18, 2013**
Interviewees: **Karen Awana (D- State Representative 43rd House District)**

Participants: Karen Awana (Interviewee); Mohala I Ka Wai: Cynthia Rezentes; Townscape: Tina Speed.

Purpose of this meeting: Interview # 6 of Stakeholder Outreach Process to obtain information from community stakeholders.

Summary of discussion:

- Cynthia and Tina introduced the project to Rep. Awana and asked if she had any information on what activities are taking place in the area and who would be good people to speak with.
- Rep. Awana said she doesn't have much information. She mentioned a chicken farm to the right of the bridge on Puʻu Hulu Street.
- She suggested finding out more about the Puhawai Farm Association.
- She also suggested speaking with Monique of the Naked Cow Dairy and the person leasing the land to them.
- She also suggested talking to the trucking company.
- She described the boundaries of her district: Her district (43) is to the south of Lualualei Homestead Road and includes the Navy installations. Jo Jordan's district (44) is everything to the north of Lualualei Homestead Road.

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MĀʻILIʻILI WATERSHED MANAGEMENT PLAN
Interview Notes 07

Interview Date: **April 18, 2013**
Interviewees: **Maile Shimabukuro (D- State Senator 21st Senate District)**

Participants: **Maile Shimabukuro (Interviewee); Mohala I Ka Wai: Cynthia Rezentes; Townscape: Tina Speed.**

Purpose of this meeting: Interview # 7 of Stakeholder Outreach Process to obtain information from community stakeholders.

Summary of discussion:

- We started with lunch and introductions and Cynthia introduced the project to Maile.
- Maile described a stream walk she did in the past few years along Puhawai Stream, where there had been excessive dumping to the point where what little water was in the stream, was black.
- She described seeing large pipes close to the Navy land, where freshwater was gushing out. She is concerned about them wasting water. Also, since there are historic loʻi on the Navy lands, restoring these would require some of this water.
- She described anecdotal information about how streams in Waiʻanae used to be perennial.
- When discussing illegal dumping, Maile mentioned the organization Ka Wai Ola O Waiʻanae, a group concerned with illegal dumping and nonpoint source pollution along the Waiʻanae Coast. This nonprofit has an EPA grant for cleaning up dumping and could be a great resource for Townscape and future projects in the WMP.
- Maile also mentioned a lot of illegal activities happening on ag lands that should be reported to DPP.
- Maile then brought up the issue of the basil farms with foreign workers. She has been in touch with Kathryn Xian from the Pacific Alliance to Stop Slavery, who is looking into the situation with foreign workers (Thai, Vietnamese, Chinese) brought to some of the basil farms. Apparently, there may be issues with trafficking and/or bad worker conditions. The workers don't have required protection while spraying pesticides and are put up in very sub-standard living quarters. Also, MAʻO Farms is concerned with pesticides entering their organic farming areas.
- On a positive note, Maile said there is a great interest in natural farming and she suggested contacting a man named Keoni of the Permaculture Coalition at 554-9247.
- When asked about the Puhawai Farm Association, she said they may have disbanded, but to contact Vince Dodge (478-6492) for further information and possible contacts.

- She also suggested talking to the Choy family (Cynthia knows more) about the homeless "squatters" on their land.
- She said that tire dumping is an issue that needs to be addressed on multiple levels. The tire disposal system here is set up wrong and promotes dumping due to the fees required to legally dispose of them. There should also be a way to document illegal tire dumping.
- Maile described a situation, where a magazine was planning to come out and take pictures for an article about local farming. Naked Cow Dairy folks contacted her to let her know that the trash situation in the Puhawai neighborhood is so bad that it would not paint a nice picture for the magazine. Maile contacted the City to do some cleanup before the photos were taken and the City came out and cleaned out an entire road. Naked Cow Dairy then contacted her again because they had done the wrong road, so they had to come out again to finish the job.
- Tina mentioned the need for ongoing water quality monitoring projects that could potentially be volunteer-based because the State is allowed to use outside data to place a water body on the 303 (d) list. Maile suggested that Leeward Community College may be able to assist with this type of project.
- Maile then had a picture of us taken with the project fact sheet and posted the fact sheet as well as our article for WestSide Stories on her blog.

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MĀʻILIʻILI WATERSHED MANAGEMENT PLAN
Interview Notes 08

Interview Date: **April 18, 2013**
Interviewees: **William Aila (Director of DLNR and resident of the project area)**

Participants: William Aila (Interviewee); Mohala I Ka Wai: Cynthia Rezentes; Townscape: Bruce Tsuchida, Tina Speed.

Purpose of this meeting: Interview # 8 of Stakeholder Outreach Process to obtain information from community stakeholders.

Summary of discussion:

- Bruce and Cynthia introduced the project to William.
- The first request was to him as director of DLNR: Verify the ownership status of the roughly 500 acres of "State Land" shown on State and City map layers along the ridgeline of Lualualei Valley (TMK 88001010). Most people seem to think that this is all Navy land up to the ridge. William will verify the status with his Land Division.
- We then moved on to speaking with William as a local resident.
- He mentioned something similar to what Maile Shimabukuro had said about the Navy water pipes, which are supposedly leaking/"dumping" excess water. He wanted to know "where the Navy is dumping all the water".
- In response to what might be contributing to water quality degradation, he mentioned impervious surfaces with a special concern about arsenic and metals coming from the munitions storage areas up mauka and their old open detonation pits. Also, there are many unrecorded dump sites. For example, many post WW2 items including machines and boxes full of new linens etc. were buried in trenches on Navy lands.
- Victor H. (Hundan?) may be able to point out areas of concern.
- Victor Flynn also has information. He can be found at the harbor early on Saturday mornings.
- He suggested we research the BMPs used by the Navy for the munitions bunkers. The Navy may not be required to comply with certain requirements.
- We should get our hands on the "Ordnance Reef" study, which tested for arsenic and other contaminants. The mouth of Māʻiliʻili Stream was apparently a control used for comparison, so data should be available on contaminants coming from our project area.
- In terms of agriculture, concerns are basil and orchid farms.
- David Souza, owner of Family Topsoil, supposedly buried a lot of items under his land. William himself lives on a piece of land formerly owned by Family Topsoil and when he

moved in in 1994, he had to mitigate hundreds of old batteries and equipment. Even to this day when he digs deep enough on his land, he still finds metal and concrete buried.

- Cynthia suggested that Brownfields funding might be available to clean up these types of sites.
- Another concern is the junkyard on Puhawai Road, operated by Dicky Fredos.
- Additional old-timers he suggested talking to (but not sure if they are still alive) are Patty Poni, who once leased Navy lands for cattle and Patty Enos, who remembers the time before the valley had a Navy presence.

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MĀʻILIʻILI WATERSHED MANAGEMENT PLAN
Interview Notes 09

Interview Date: **April 18, 2013**
Interviewees: **Jo Jordan (D- State Representative 44th House District)**

Participants: Jo Jordan (Interviewee); Mohala I Ka Wai: Cynthia Rezentes; Townscape: Bruce Tsuchida, Tina Speed.

Purpose of this meeting: Interview # 9 of Stakeholder Outreach Process to obtain information from community stakeholders.

Summary of discussion:

- Bruce introduced the project to Jo and asked for pertinent information
- Jo described a complex stream clean-up she coordinated for one of the tributaries flowing into Māʻiliʻili Stream from the agricultural neighborhood. The planning for the project started in May 2011 and the clean-up happened in January of 2012.
- The stream had a lot of overgrowth and trash in it and had obviously not been cleaned in years.
- They found 200 tires, corrugated iron, concrete rubble, man-made stream blockages (asphalt/concrete), dead chickens, large trees, etc.
- Many homeowners were unaware of their responsibility to maintain the stream.
- There were some areas with streambank erosion due to man-made blockages. Puʻu Hulu Road was affected greatly by the 2008 flood.
- Jo's initiative included volunteers from various groups, including Civil Defense, Youth Challenge, faith-based groups, City & County, State, etc.
- They started focusing on some of the areas and projects mentioned in the Lualualei Flood Study, some of which may be implemented by the City (less costly projects).
- General Wong of the Hawaiʻi Air National Guard (and Director of State Civil Defense) wants to come help with future efforts like this. He can provide the manpower and expertise, but this needs to be planned a year ahead of time.
- We discussed the idea of a debris basin. Since there is no major debris or trash coming from the Navy land, such a basin would need to be on private land, which may require the government to condemn land, although easements may be possible.
- The infamous landowner David Souza, who owns several properties in Waiʻanae, was the one who blocked the stream. Due to the blockage, the landowner upstream lost 15 feet of property due to floodwater backup and erosion. The landowner later sued David Souza as well as the City & County for not taking action.

- In response to Bruce's question on the value of educational projects, Jo responded that we could definitely coordinate an effort to follow up on the stream clean-up with landowners, who responded well to the educational component of the initiative.
- The strategy was basically to send letters to landowners asking for their permission for the volunteers to enter their land and do the clean-up. In return, they offered to remove some unwanted materials or provide mulch from trees removed from the stream, etc.
- Jo has Powerpoint files showing before and after pictures.
- After the current legislative session, Townscape should be able to join Jo on a follow-up session to see if landowners have been maintaining the stream.
- We discussed the lack of enforcement by the City against violators. Jo described one case, where a farmer bulldozed a 30-foot pile of debris up against the edge of the stream. After several citations from the City, the pile is still there and enforcement has not occurred. Technically, Act 76 allows the State to put a lien on people's property after continuously failing to pay fines, but the City is not interested in taking this kind of action.
- Jo mentioned that a lot of land is leased by local landowners to foreign farmers (e.g. basil farms) and often these lessees are unaware of environmental/legal requirements in the U.S. Notices/citations should be sent to the actual landowners.
- In the past, there has been so much dumping that the streams were re-routed. The tributary was originally supposed to flow through MAʻO Farms, but it doesn't.
- A big issue with dumping is tires because there is no way to dispose of tires for free. After finding out that Jo's initiative included tire clean-up and they were storing tires and trash before hauling it away, strangers quietly deposited truckloads of tires in the clean-up area so they could be disposed of.
- Townscape would like to walk the dry streambeds. Civil Defense staff should be able to guide us on this recon.
- The current Vice Director of Civil Defense is Doug Mayne. The interim director at the time, and now the Plans & Operations Officer, is Vic Gustafson. His phone number is 733-4300.

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MĀʻILIʻILI WATERSHED MANAGEMENT PLAN
Interview Notes 10

Interview Date: **April 22, 2013**
Interviewees: **Albert Silva**

Participants: Albert Silva (Interviewee); Mohala I Ka Wai: Cynthia Rezentes; Townscape: Tina Speed.

Purpose of this meeting: Interview # 10 of Stakeholder Outreach Process to obtain information from community stakeholders.

Summary of discussion:

- Cynthia first introduced the project to Albert and asked him about historical water flow.
- Albert mentioned that the Puhawai tributary was diverted during the sugar era. According to him, all the water from the mountains used to flow through what is shown as the small, northernmost tributary on the maps. He said the water was diverted to flow into the man-made reservoir.
- He spoke of taro fields on the Navy lands near the water tunnel and sweet potato terraces in the upper (easternmost) parts of the watershed.
- He said there needs to be more planning and especially more implementation of projects to “make improvements”. He said nature has been doing everything and it works slowly, so with everything we have taken from nature, now we need to “help nature out”. He meant this specifically in regards to aquifer re-charge, which he is very concerned about. Since we withdraw groundwater to fill our residential and agricultural needs and this water eventually goes to a wastewater plant that releases it into the ocean, it is not going back into the ground (or you have to wait for nature to complete the cycle). He thinks we should do more to put the water we withdraw straight back into the ground instead of wasting it. (“Nature has been good to us. It’s time to give back.”)
- We discussed the possibility for recycled water use, which is a great way to irrigate golf courses and ornamental plants/landscaping to reduce potable water use. However, Mohala I Ka Wai has already looked into this and the problem that is hindering the possibility for recycled water use is the outdated City sewer infrastructure, including sewer mains. The porosity of the rock/soil surrounding the pipes and the fact that the pipes are old and have holes, makes the water entering the WWTP very saline. Therefore, in order to treat the wastewater to a stage past R1, there would be a need for a desalination step as well. Or to prevent this, the sewer pipes would require replacement. (If the pipes are so porous that

saline water is entering them, this begs the question whether the sewage is also exiting the pipes into the surrounding soil/water!)

- Albert suggests installing "dams" throughout the watershed to keep the water from running off and to help re-charge groundwater. He also suggests using the reservoir as a reservoir again and installing a new spillway to control water entering the ocean. This way the reservoir could be used as a sediment/debris basin. The reservoir used to produce a lot of fish as well. He said the water entering the ocean used to be clear, probably because of the reservoir filtering out sediments. He mentioned that the water entering the ocean from this stream was always clearer than from any other valley on the Waiʻanae coast.
- He believes the BWS is only pumping water, not doing much to help re-charge.
- Albert's older brother used to run cattle on the Navy land in the 1930s. As a young boy, Albert used to go with him and holoholo ("check things out, walk around"). He says that concept is not around much anymore, as people in the past used to holoholo a lot to appreciate places and share experiences with others.
- When asked about whether there is any chance that Niuliʻi was an ancient pond feature, he re-iterated that it was man-made and explained that it was part of the sugarcane irrigation system and provided water for the Mikilua flume system.
- He remembers harvesting aʻama, limu pepe, limu kala and others along the coast. There also used to be many moi and ʻoama in Māʻiliʻili Stream.
- Albert then shared a book with us, written by one of his ancestors, James Sutton McCandless ("Artesian Water", 1936). His family was in the business of drilling wells and the book is a personal historical family narrative along with a list of wells the family had drilled until 1936.
- Albert mentioned that his brother, while drilling for a well in the lower reaches of what is now RTF, came across a hot spring.

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MĀʻILIʻILI WATERSHED MANAGEMENT PLAN
Interview Notes 11

Interview Date: **April 26, 2013**
Interviewees: **Henry Aoloa**

Participants: Henry Aoloa (Interviewee); Mohala I Ka Wai: Cynthia Rezentes; Townscape: Tina Speed.

Purpose of this meeting: Interview # 11 of Stakeholder Outreach Process to obtain information from community stakeholders.

Summary of discussion:

- Cynthia first introduced the project to Henry and asked him about historical water flow.
- Henry's family has lived in Lualualei for multiple generations. He showed us on the map where each set of grandparents lived, all in the project area. Back in the 1920s and 30s, he said his grandmother and mother used to wash their clothes in Puhawai Stream because the water was always flowing at a depth of about 6 feet. When there was a storm, it turned into a torrential river that carried piles of hay from cattle operations, barrels/tanks, and other items.
- When he was a child, he used to play in the flume coming from Waiʻanae Valley to irrigate the sugar fields.
- Henry now lives off of Puhawai Road, right makai of the stream. He used to have a variety of farm animals on his land, but not anymore. He sold the rest of the family properties in the neighborhood, but sometimes he still gets phone calls with people thinking it is his land and complaining about activities there.
- His family used to raise pigs for subsistence and trade meat with the cowboys from the cattle ranches.
- He talked a lot about an area outside the project area near the quarry on Paʻakea Street. Farmers in that neighborhood started building berms which resulted in runoff heading their way being diverted towards Ulehawa Watershed.
- He was in the military for many years and went to Korea and Vietnam. They used to take Kolekole Road to get to work at Schofield.
- He identified the problems as "natural runoff and chemicals from farms". He was concerned about non English-speaking farmers being allowed to use chemicals without understanding the rules and implications.
- He talked about the reservoir and how people used to dump their aquarium fish in there, resulting in a strange variety of fish living in the reservoir, including gold fish. Once a year, the community would gather at the reservoir to catch fish.

- He spoke of World War 2 and the Japanese aircraft involved in dogfights over the Wai'anae coast. Apparently they were looking for the ammunition depots to target, but never found them.
- He said that most of the farmers farming in his neighborhood now are from Vietnam, Laos, China and Thailand and most don't speak any English. One big problem is that they burn basil leftovers and residue in big piles, smoking out the neighborhood. This is common practice in their home countries. He stressed that whoever controls the activities of farmers, needs to make sure they understand the rules and regulations concerning chemical use and other activities.
- He also shared some personal anecdotes, some disturbing Vietnam stories and he got into a discussion about the Army being blamed for ocean ammunitions dumping because the Navy was dumping Army ordnance and the Army got all the criticism.

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MĀʻILIʻILI WATERSHED MANAGEMENT PLAN
Interview Notes 12

Interview Date: **April 26, 2013**
Interviewees: **Tom McDonald and Father Phil, Kahumana Farm**

Participants: Tom McDonald and Father Phil (Interviewees); Mohala I Ka Wai: Cynthia Rezentes; Townscape: Tina Speed.

Purpose of this meeting: Interview # 12 of Stakeholder Outreach Process to obtain information from community stakeholders.

Summary of discussion:

- We started the discussion with Tom McDonald, who had already been introduced to the project during the West Oʻahu Farm Bureau meeting. Father Phil was still out and about.
- Kahumana owns their 14-acre parcel and leases another 14-acre parcel from the City for Ohana Ola, which is the homeless shelter. They are 20 years into a 65-year lease for the City parcel, with an option to purchase the parcel at some point.
- The parcel just mauka of the Kahumana parcel and adjacent to the Ohana Ola parcel (on Lualualei Homestead Road) is one of the Chinese basil farms. There are several basil farms throughout the neighborhood, which is of great concern to surrounding residents and farms not using pesticides.
- Due to the tax incentives, landowners find it a very attractive option to lease their land to basil farmers.
- Tom says 90-100% of the basil grown on the island is exported to the mainland and Canada, where it is sold at grocery stores and made into pesto. Due to the nature of basil and pesto processing, there is likely a very large amount of pesticide residue in any non-organic pesto and he himself says he would never eat non-organic pesto for that reason.
- Kahumana has had to do a lot of permitting work in order to get the permits required for them to run their farm, restaurant and housing on agricultural and City land. They have a variance on Ag land for their operations. As part of the DPP process, they had to do civil engineering work to strengthen the drainage flowing through their City parcel.
- Flooding does not really affect Kahumana, but right downstream of them, Puhawai Road is the problem area. Tom said stormwater usually carries some trash, but nothing major, mostly just brown water. He said some properties mauka of them near the Naked Cow Dairy store a ton of trash and appliances.
- Kahumana is a public charity organization and receives grant money, as well as program fees and revenue from its farm and restaurant. They also receive some small private donations. An

"angel investor" originally made it possible for them to make the $50,000 downpayment to secure the land.

- Father Phil mentioned that their neighbor ("Theo") on the property adjacent to them dumps and stores a lot of big things such as refrigerators on his property.

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MĀʻILIʻILI WATERSHED MANAGEMENT PLAN
Interview Notes 13

Interview Date: **April 29, 2013**
Interviewees: **Steven Sigler, Civil Defense**

Participants: Stephen Sigler (Interviewee); Mohala I Ka Wai: Cynthia Rezentes; Townscape: Tina Speed.

Purpose of this meeting: Interview # 13 of Stakeholder Outreach Process to obtain information from community stakeholders. This particular stakeholder representative has in-field experience in the project area.

Summary of discussion:

- Cynthia introduced the project to Steven and explained some details about implementable projects that will result from the plan.
- Steven was one of the people on the ground during the stream clean-up effort initiated by Rep. Jo Jordan. He knows the area well and can point out specific point sources for erosion.
- He mentioned erosion hotpots at the Puʻuhulu Rd. bridge as well as the stream crossing at Kuwale Rd. He showed some pictures of specific spots with heavy streambank erosion, most notably Monique DeOcampo's property near the Puʻuhulu Rd. bridge as well as Yvonne Tong (TMK 86009011) and Burgess family properties.
- He described major water quality issues from erosion (heavy sediment loads) and natural debris/vegetation overgrowth. Branches and large trees clog up the streams, resulting in flooding. He showed some pictures of the large trees they found in the streambed.
- He also reported illegal dumping, although he said he has seen much worse rubbish and dumping issues elsewhere in Hawaiʻi. He specifically mentioned the property with the rubbish/tire pile on the streambank, just mauka of the reservoir.
- Just downstream of the undersized Puʻuhulu bridge, floodwater goes straight into the DeOcampo property and then breaks the berm below every time.
- The City is getting some funds to fix drainage structures along Puhawai Rd.
- He is mostly familiar with the problems and activities on the private land neighborhood. He suspects that runoff coming from the Navy land likely carries only natural debris. We discussed the possibility of installing debris basins on Navy lands.
- He specifically talked about the David Souza property and the "blockage" of the stream. According to him, Souza essentially built a road across the stream and left a lot of concrete and other material behind. The streambank around the property (TMK 86007008) is generally "torn up".

- The Lindberg family property (TMK 86006004) received some concrete streambank stabilization to prevent erosion. This concrete can be seen in Google Earth imagery.
- He mentioned stream maintenance as a very important factor for both flooding and water quality. He described a recent maintenance effort by the City under the Puʻuhulu bridge, where the stream bottom is actually concrete-lined. The City scraped the bottom to remove debris and dredged out about 2-3 feet of sediments. Efforts like this should be ongoing to keep drainage structures clear and sediments out of the water.
- Steven will contact Tina to set up a date to take Townscape on a stream walk of the drainages in the neighborhood between 5/21-5/24 AM.
- He will also gather and email us pictures showing the condition of the stream prior to and after the clean-up.

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MĀʻILIʻILI WATERSHED MANAGEMENT PLAN
Interview Notes 14

Interview Date: **May 29, 2013**
Interviewees: **Ryan Peralta, DOFAW**

Participants: Ryan Peralta (Interviewee); Townscape: Tina Speed.

- **Purpose of this meeting: Interview # 14 of Stakeholder Outreach Process to obtain information from community stakeholders. This phone interview was conducted to obtain preliminary information from DOFAW about Executive Order 4414, which set aside roughly 700 acres of land as the Lualualei Forest Reserve.**

Summary of discussion:

- Contrary to popular belief, this was already State land, not military land. Access is either from the Navy side or the Honouliuli side, or by helicopter.
- DOFAW approached Land Division to set aside this land as a forest reserve for the purpose of managing for the benefit of the watershed. It is not considered a high priority area due to the terrain and limited access options and because BWS does not consider it a priority watershed.
- Since it is low priority for DOFAW, management measures are limited and focused on small projects, including ungulate control.
- DOFAW has spoken with Navy natural resource personnel to discuss plans for the land and collaboration opportunities, but there was a change in staff on the Navy side since. The former Navy point of contact was interested in fencing areas for endangered plants and killing goats.
- Ryan disagreed with the Navy on fencing strategies and since the staff change, no contact has been made between DOFAW and the Navy about potential collaboration.
- Ryan sees collaboration potential in the area of ungulate control/public hunting. Since the land below the reserve is all Navy land, there are access limitations for the public. Therefore, no public hunting programs have been initiated. Most hunting by DOFAW is done via helicopter. Ryan suggests that the Navy organize an opportunity for public access to allow community hunters to come help the cause.
- He emphasized that aerial hunting requires a lot of planning and any future activities in Lualualei should go along with PR initiatives to take public opinion into consideration. A typical problem with aerial hunting is that the community is opposed to wasting the meat. However, in this case, where the terrain is inaccessible on foot, there is just no way to

salvage the meat. He said that even with PR, people will always complain about what the government does.

- The one-year clause in the Executive Order is not very meaningful in this case as the land is already DLNR land. Since the purpose of this land for DOFAW is for watershed management with a focus on groundwater (BWS watershed management) and BWS does not consider this a priority watershed area, the one-year clause was explained by Ryan like this: "As long as we don't do anything to adversely affect the watershed, this clause will not go into effect".
- Ryan provided some suggestions for the Maʻiliʻili Watershed Management Plan: Goals have to be attainable and measurable. In order to achieve that, you need baseline water quality data. That way you can apply a treatment, re-measure and understand the effect of the treatment.
- He also suggested we talk to BWS and CWRM about this plan as they have expertise.
- Ryan is open to meeting with Townscape at a future date to discuss this in more detail and/or to discuss potential projects for implementation and collaboration between DOFAW and Navy.

APPENDIX E

Project Memos

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MĀʻILIʻILI WATERSHED MANAGEMENT PLAN
Memorandum No. 01

Date: **February 22, 2013**
To: **Michael Burke, DOH**
From: **Townscape, Inc.**
Re: **Project Kickoff Meeting - notes**

Participants: **Department of Health CWB: Michael Burke (Project Manager), Greg Takeshima, Matt Kurano; Mohala I Ka Wai: Cynthia Rezentes; Townscape: Bruce Tsuchida, Tina Speed.**

Purpose of this meeting: Introduction to the project and clarification of project management questions, official project name, study area and initial stakeholder outreach activities.

Summary of discussion:

- We started with general introductions of everyone and their involvement in the project. Mike Burke has a new phone number: 586-7773
- DOH expectations, deliverables and timelines are in accordance with the project scope. Follow Exhibit C from scope/NTP.
- Draft Honouliuli Plan is a good reference project. Final Plan expected mid March, will be sent to Townscape.
- Due to delay in receipt of NTP, project time may need to be adjusted at a later point. Will meet after about 8 months to discuss whether contract extension is necessary.
- There will be no regularly scheduled coordination meeting dates. Instead, Townscape is encouraged to schedule informal meetings to review material whenever necessary. Formal meetings can be scheduled as needed.
- It was agreed that the project area is defined as the basin of Māʻiliʻili Stream, not the Lualualei ahupuaʻa. Therefore the title will be "Māʻiliʻili Watershed Management Plan".
- Advance payment installment not necessary. Townscape will send a first bill at the end of February, after that monthly billing. Payment generally expected to be processed within 30 days.
- Townscape wants to meet with Navy early in the project. Maybe at different levels of authority (Commanders and on-site personnel). Possibly 1. Protocol meeting, 2. Follow-up data request meeting, 3. Tour of Navy lands in Lualualei.

- DOH has good working relationship with NAVFAC and can set up meetings with appropriate personnel.
- Pesticide and herbicide problems expected to come from Navy lands due to their vegetation.
- Navy is only releasing general information, not details about their AIS to avoid trespassing issues. Maybe DOH could obtain the AIS for project purposes.
- Cynthia suggested Vic Flynn, the community liaison, as a knowledgeable Navy source.
- Navy has NPDES permit for their MS4 and associated BMPs. DOH can forward this information to Townscape. The Navy person that signed the NPDES permit may be a good person to talk to.
- Navy has a water tunnel up mauka on the border with Waiʻanae. Community wants this water to be released back into the stream.
- DHHL is another important landowner with various activities.
- Need to determine if City owns the sewer; in Nānākuli, DHHL manages sewer.
- Townscape will work closely with Cynthia on who to contact and the Community Outreach Plan.
- Emergency Management Department may have records of '96 and '10 floods.
- This Watershed Management Plan is a 20-year plan. What matters most is what actually gets implemented. Specific projects identified should be prioritized based on what they can accomplish, not cost (although cost estimates should be included). However, there need to be enough affordable projects, not just multi-million dollar projects so that implementation can be realistic.
- Plan should be written in a non-academic way. It should be straight-forward, concise, and easy to read, even for laypeople. Any complicated content such as calculations and modeling should be in appendices. Plan will include a lot of pictures and maps.
- Workplan and schedule to be emailed to Greg and cc'd to Mike and Matt. One hard copy to be mailed. All mail should be addressed to Alec (last name?).

ACTION ITEMS:

- ~~Townscape to send two initial map files to everyone (USGS basemap and aerial)~~
- Townscape to send out workplan/schedule and start working on the Watershed Characterization/mapping
- Townscape to meet with Cynthia to map out the Community Outreach Plan
- DOH to follow up on Navy contacts and protocol meeting
- DOH to forward Navy's MS4 permit information to Townscape

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MĀʻILIʻILI WATERSHED MANAGEMENT PLAN
Memorandum No. 02

Date: **March 21, 2013**
To: **Michael Burke, DOH**
From: **Townscape, Inc.**
Re: **U.S. Navy Protocol Meeting**

Participants:

State Department of Health CWB:
Michael Burke (Project Manager)
Greg Takeshima
Matt Kurano

City & County of Honolulu:
Tonya Ketza (ENV)
Thomas Takeuchi (DFM)

Navy CNRH REC:
Patty Colemon
John Muraoka

NAVFAC Hawaiʻi:
Sara Nakasone
Jennifer Chang
Anne Hong
David Sullivan

Mohala I Ka Wai:
Cynthia Rezentes

Townscape, Inc.:
Bruce Tsuchida
Tina Speed

Purpose of this meeting: Introduction of the project to Navy environmental managers and request for data and access to Navy lands in project area.

Summary of discussion:

- We started with self introductions. Greg Takeshima and Matt Kurano then explained the watershed planning/EPA process and the background regarding the settlement agreement.
- Bruce then introduced the project and planning process in more detail and described the outreach process. He invited the Navy to be an active participant in the planning process since they are the largest landowner in the Māʻiliʻili watershed.
- Solutions for implementation will include both technical/infrastructure, as well as community/education projects.
- Matt responded to a question about the dollar amount for planning and implementation by emphasizing that this is an implementation-oriented plan. Many watershed plans in the past have been excessively lengthy and academic and DOH is moving away from that. The goal is clarity and conciseness with measurable goals and impacts.
- Funding for projects will be available both from the settlement as well as 319 funds, although with the cutbacks in federal funding, the fate of 319 funds in upcoming years is unknown.

- Greg mentioned that the pollutants DOH is required to report to EPA are sediments, Nitrogen and Phosphorus. However, other pollutants such as heavy metals and toxic substances are also of concern.
- The Wai‘anae community has been somewhat isolated from government in the past. Matt described it as a lack of “positive community/government interaction”.
- Due to the lack of interaction in the past, the mentality of careless dumping of trash has continued for a long time. Cynthia described the need for a cultural change from this lack of awareness mentality. Encouraging change will be challenging.
- During the floods of 1996 and 1998, the military was instrumental in helping clean out dumped appliances and vehicles from the project area. After less than two decades, the same buildup of trash has occurred again. This type of behavior needs to be a focus area.
- Other issues already identified in the watershed are unpermitted uses and a need for zoning enforcement in residential/agricultural areas around Puhawai Street.
- Bruce made a general DATA REQUEST: Water quality data, master plans, natural resource/land management plans, archaeological reports, stormwater/MS4 information, GIS layers.
- There is a lack of water quality data on the Navy side, but some geospatial data is available (e.g. LIDAR). A “data release form” will need to be processed to access GIS data. USACE may also have this data from the flood study.
- Less than 100 people are stationed at the base, so housing etc. is mostly abandoned.
- RECONNAISSANCE REQUEST: Initial field recon for two Townscape staff to get an overview of the two Navy installations. Follow-up site visits will be needed to see specific areas and take pictures.
- Taking pictures requires prior authorization before a site visit and review of the pictures taken. It was unknown whether taking GPS points requires authorization. Patty to follow up with appropriate personnel on this matter.
- Navy would like to review any draft material before it is made public and would like to receive several copies of the final WMP.
- It was agreed that all requests for information/site visits, etc. be made through Patty and John.
- **Note: If any data shared with Townscape is not for public consumption, Townscape treats this type of data as confidential/classified. No such data is shared in maps or documents, it would be used for internal informational purposes only.**

ACTION ITEMS:

- Patty/John to coordinate field visit request. Preferred date is THU 4/4 at 9am or 1pm. Alternative dates are WED 4/3 at 1pm OR TUE 4/9 at 1pm.
- Patty/John to coordinate with Townscape on GIS data requests
- Patty/John to follow up about GPS and photo authorizations
- Townscape to prepare for first field visit

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MĀʻILIʻILI WATERSHED MANAGEMENT PLAN
Memorandum No. 03

Date:	**April 18, 2013**
To:	**Michael Burke, DOH**
From:	**Townscape, Inc.**
Re:	**U.S. Navy Windshield field recon**

Participants:

State Department of Health CWB:
Greg Takeshima
Navy:
Patty Colemon
David Sullivan
Cory Campora
Terence Tengan
Jeff Pantaleo

AECOS:
Snookie Mello
Chad Linebaugh
Mohala I Ka Wai:
Cynthia Rezentes
Eric Enos
Townscape, Inc.:
Bruce Tsuchida
Tina Speed

Purpose of this field visit: Initial overview of the two Navy bases for introductory purposes and to determine future visit and photography needs.

Summary of recon and discussion:

- We first stopped inside the NAVMAG gate, where BAE Systems has an office. BAE is a defense manufacturer/contractor for the Navy, overseeing the munitions storage.
- We then headed up 43rd Street and stopped at the rocket testing site, where we had a great view over the whole valley.
- Maintenance of vegetation at NAVMAG is mostly done manually via cutting. Some areas, especially the gravel-covered magazines, are treated with herbicides.
- There is an archaeological map (internal only) showing the multitude of cultural sites throughout the property. There are many habitation sites and terraces and several heiau. There is a full archaeological report that Townscape can review (not for public consumption).
- Fenceline Road is the border between the two Navy installations.
- The roofed buildings close to the fence are ordnance storage facilities. Most of the munitions stored are for the Army and Marine Corps. The Navy uses mostly larger ordnance such as torpedoes and missiles. These are stored at West Loch.
- There is some data from the Navy on the fire situation, as well as on water usage.

- Vegetation on NAVMAG appeared to be mostly koa haole and non-native grasses, with abundant cactus and some kukui at the higher elevations.
- There are two sources of potable water for the installations: the pipeline from the water tunnel in the mountains and a deep well with two 750k gallon storage tanks. Since there is no one living on base anymore, water use is mostly for fire control and maintenance.
- Wastewater goes into a 50k gallon septic tank. Effluent from this tank goes into Niuliʻi Pond, a man-made wetland that is home to water birds. Since there is not much sewage anymore, they supplement the wetland with potable water.
- There is an Integrated Natural Resource Management Plan and a native plants map for the site, which can be reviewed by Townscape.
- There is a major ungulate problem in the upper reaches of the watershed. Aerial goat hunting takes place periodically and pigs are rampant throughout, causing widespread damage and erosion.
- We stopped at Nioiʻula heiau, which is estimated to be 400-500 years old, although no dating has been done. Eric mentioned that this heiau is within sight of Punanaʻula heiau in Waiʻanae Valley. People used to communicate between the sites via smoke. There is a second heiau higher up the mountain.
- We then stopped at a stream crossing with four large culverts on Guadalcanal Road.
- We continued up towards Kolekole Pass, stopping at several crossings and the aqueduct from the water tunnel. USGS has some stream gauge data for the stream here.
- We saw some low stream flow in the upper reaches of the Puhawai tributary.
- We then crossed over to the RTF site. The Navy has some data on NPDES BMPs (runoff data).
- The topography is very flat and sheet flow from rain events is channeled into swales throughout the property that transport the runoff through culverts into the Māʻiliʻili Stream Channel. Some of these swales are relatively small and not lined (grass only), others are large and have some concrete lining.
- The Coast Guard – a “tenant” organization here- has a separate communications facility.
- We stopped at the fenceline, close to the area where debris had been dumped in the stream channel by the City in 2008/2009. There was a pool/wetland area, where we observed two Hawaiian stilts.
- The gravel/dirt road along the fence leads through an endangered plant area that contains ihiʻihi lauakea, a Hawaiian clover-like fern.
- **Note: If any data shared with Townscape is not for public consumption, Townscape treats this type of data as confidential/classified. No such data is shared in maps or documents, it would be used for internal informational purposes only.**

ACTION ITEMS:

- Townscape to send consolidated list of requested reports/documents to Patty
- Patty or other responsible parties to send requested documents to Townscape
- Townscape to coordinate with Patty on photo permit for next visit

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MĀʻILIʻILI WATERSHED MANAGEMENT PLAN
Memorandum No. 04

Date: **May 23, 2013**
To: **Michael Burke, DOH**
From: **Townscape, Inc.**
Re: **Streamwalk with Civil Defense on May 20, 2013**

Participants: **Steven Sigler (State Civil Defense), Townscape, Inc: Bruce Tsuchida, Tina Speed**

Purpose of this field visit: To see some of the specific areas of concern ("hotspots") for streambank erosion, illegal dumping and other potential areas of concern for water quality.

Summary of recon and discussion:

- Note: There are numerous names people use for the streams and smaller tributaries in this watershed. For the purpose of this plan, we are following the place names identified by our archaeologist during his research on historic records and maps. These identify the northernmost tributary as "Puʻuhulu Stream" and the adjacent major drainage flowing through the private land as "Puhawai Stream". We began the walk at Puhawai Stream.
- We started our meeting at the dip on Puhawai Road that gets flooded frequently. Steven Sigler was heavily involved in the last stream clean-up done here two years ago, as well as ongoing flood mitigation efforts in the area. He is therefore very familiar with the conditions on the ground.
- We started our walk of the stream bed in Puhawai Stream, just mauka of the reservoir. The first section before reaching the Lindberg property was overgrown mostly with grasses and some koa haole. There was some minor trash. The overgrowth appeared manageable and not thick enough to block water flow. Approximately 800 feet into the streambed is a section of streambank that was concrete-reinforced by the property owner (Lindberg, TMK 86006004) to stabilize the eroding bank.
- The curve in the stream just mauka of the Lindberg property contributes to the erosion problem because flood waters hit the curve at a high velocity. The same is true for the meandering streambank at the DeOcampo property (TMK 86007014) at the Puʻuhulu St. bridge, where the water exits the bridge and impacts the streambank right after, causing severe erosion. That property has receded about 15 feet due to streambank erosion and the owners are very concerned about their house.

- Past the Lindberg property before the DeOcampo property is a pool of standing water providing a breeding ground for mosquitoes. The streambed downstream from this “pool” needs to be dredged to keep the water from pooling and to prevent mosquito/vector problems.
- Past the pool on the makai side is a berm protecting that property from flood waters. However, the berm has failed in the past, causing flood damage.
- The City & County did some dredging of the streambed under the Puʻuhulu bridge and removed approximately 2 feet of sediment. The City also dug a several hundred foot trench between the bridge and the downstream berm to see how low the natural streambed is. Property owners are complaining about the water pooling in the trench since the City abandoned the project. Ideally, the dredging should continue to allow the water to flow.
- The streambank on the mauka downstream side of the Puʻuhulu bridge (DeOcampo property) has been stabilized with rubble and debris, however this is unlikely to survive a major storm.
- USACE is currently working on a follow-up study to their 2001 Flood Study to focus on some of the mid-term flood issues that can be implemented sooner.
- Between the Puʻuhulu and Kuwale Road bridges, there is dense vegetation and some further streambank erosion. The streambank just downstream of the Kuwale bridge has several areas of concern for erosion.
- We then walked a section of the Puʻuhulu Stream, starting from Kuwale Road. According to Civil Defense staff, water enters this narrow but clear stream channel as runoff from Kuwale and Government Road, as well as general sheet flow from the slopes of Mauna Kuwale.
- The channel had some water flow in it and was surrounded by basil farms. The farm on the southern bank had a large berm, while the northern farm did not.
- The water smelled unpleasant and had some algae growth.
- We turned around and drove to the stream crossing/culvert on Puhawai Road close to MAʻO farm. The makai side culvert and area downstream is very overgrown with high grasses.
- On the mauka side, the stream is assumed to flow through underground culverts as it crosses several properties.
- We ended the tour at the Puʻuhulu Road/Puʻuhulu Stream bridge. This is where the concrete channel starts, so little vegetation or debris is in the channel.
- There was not much rubbish visible in the stream. Regular periodic stream clean-up/maintenance is recommended.

ACTION ITEMS:

- Townscape to contact USACE regarding their follow-up flood study
- Townscape to map erosion hotspots and areas of concern

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MĀʻILIʻILI WATERSHED MANAGEMENT PLAN
Memorandum No. 05

Date: **June 10, 2013**
To: **Michael Burke, DOH**
From: **Townscape, Inc.**
Re: **June 9 meeting on water quality testing/modeling**

Participants: **Greg Takeshima, Watson Okubo (CWB); Townscape, Inc: Bruce Tsuchida, Tina Speed**

Purpose of this meeting: To clarify the needs and protocols for potential water quality testing and/or modeling due to lack of data for the project watershed.

Summary of recon and discussion:

- Bruce described the lack of data and the need to clarify what the next steps are to determine what the pollutants of concern are and to quantify load reductions.
- Tina explained concern over being able to meet the EPA 9 elements without having data. Greg said that since this is not a 319-funded watershed plan, it is OK to not have data because the requirements aren't the same. Although we want to follow the nine elements for the most part, it is not a requirement for this particular plan.
- Watson suggested 4-5 sites for future sampling. Townscape will mention in the monitoring section of the report that there was no funding available for baseline testing, but that sampling could/should definitely be part of future projects.
- Watson mentioned that for now with the resources available, we could take one sample in the Māʻiliʻili channel above the estuary and test for nutrients, TSS, pesticides, and metals.
- The discussion resulted in the conclusion that instead of having AECOS do sampling, Townscape could do the sampling and send to a lab and borrow a YSI from CWB for in-stream measurements. Greg can provide sampling protocols for Heʻeia and others to prepare. If heavy rains are forecast, Townscape can contact Greg a day ahead and plan to take the YSI out the next day.
- For modeling, N-SPECT will not be needed. Greg supplied Townscape with a CD containing STEP-L, RUSLE2 and WARMF. STEP-L, which is endorsed by EPA, will be used to quantify runoff and load reductions for this watershed plan. The manual can be downloaded online.

- Initial feedback on the Draft Watershed Characterization was to include figure 25 as an 11x17 fold-out map and to elaborate a little more in the SWOT analysis.
- Greg also suggested that for projects, stream clean-ups such as the one organized by Rep. Jo Jordan would be good because they can get 319 match funding.
- Additional comments on the characterization will be received later, probably by the end of the week.

ACTION ITEMS:

- Tina to work with STEP-L and ask Greg for help if needed
- Greg to send written comments on Draft Watershed Characterization
- Greg to send some sampling protocols to Tina
- Tina and Greg to do spontaneous sampling if heavy rains are forecast

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MĀʻILIʻILI WATERSHED MANAGEMENT PLAN
Memorandum No. 06

Date: October 23, 2013
To: Cynthia Rezentes
From: Townscape, Inc.
Re: October 23 meeting on remaining stakeholder outreach activities

Participants: **Mohala I Ka Wai: Cynthia Rezentes; Townscape, Inc: Bruce Tsuchida, Tina Speed**

Purpose of this meeting: To discuss the status of stakeholder outreach activities and what else needs to be done before and after next submittal.

Summary of discussion:

- We reviewed the Stakeholder Outreach Plan (dated February 28, 2013) and crossed off items we have completed.
- We discussed the need for further interviews and timing for those. We agreed that since the agricultural neighborhood will be the focus for projects/BMPs, it would make sense to talk with Jeanne Vana of the West Oʻahu Farm Bureau again. She may have some input about BMPs and specific people who may be interested in installing projects on their property.
- In addition, the NRCS and ORC&D may have some insight on this. Cynthia will set up meetings with them, as well as MAʻO Farms.
- We will also try to meet with the appropriate person(s) of the Waiʻanae Coast Comprehensive Health Center.
- The target date for submission of the next report (Management Strategies & BMPs) is mid-December. If BMPs for Navy lands are identified, we should meet with the Navy prior to submission of the draft report to discuss feasibility/interest etc.
- After CWB has reviewed the next draft report (hopefully by end of January), we will schedule a community meeting to discuss findings and project/BMP recommendations with interested community members. Cynthia will set up the meeting and we will send out invitations to specific people of interest, in addition to publishing the date in WestSide Stories and elsewhere. The tentative date for the community meeting is February 6, 2014, but may have to be later depending on CWB review schedule.
- Bruce suspects many people will still be focused on flooding, but wants to integrate possible water quality and flood improvement projects, e.g. vetiver plantings.

- We also discussed activities on the Navy lands, including herbicide use (do they use roundup?) and whether or not we expect to see water quality problems from that. It is hard to say, but we will likely be doing some water quality sampling during the fall months to find out more details about specific pollutants of concern.
- Another issue that came up is whether or not the Navy may sell any of their Lualualei lands in the future. Before 2001, the long-term plan was phase out the magazine installation 25 years from then (ca. 2026), but at this point no one knows what the plans are. Lack of water may limit future development there, but it is prime real estate and whatever happens there in the future will have a tremendous impact on the entire valley after decades of military use.

ACTION ITEMS:

- Cynthia to set up meetings: Jeanne Vana, MAʻO Farms, NRCS, ORC&D, Waiʻanae Coast Comprehensive Health Center
- Cynthia to schedule community meeting after next submittal. Tentative date: February 6, 2014
- If BMPs are recommended for the Navy lands, Tina to set up meeting with Navy pre-submittal.
- Tina to follow up with lab re: expiration date for preservatives in testkit and possible need for replacement of bottles for upcoming water quality testing.

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MĀʻILIʻILI WATERSHED MANAGEMENT PLAN
Memorandum No. 07

Date: November 22, 2013
To: Mike Burke, DOH CWB
From: Townscape, Inc.
Re: November 22 meeting on BMP report deliverable

Participants: DOH CWB: Mike Burke, Greg Takeshima, Laurie; Townscape, Inc: Bruce Tsuchida, Tina Speed

Purpose of this meeting: To discuss the outline for the next deliverable (BMP report) and specifications for format; to provide an update on the stakeholder outreach activities; to discuss a no-cost contract extension.

Summary of discussion:

- We discussed the expected format in terms of required level of narrative versus tabular format for BMP presentation. Greg prefers tables, but sees the value in short narrative BMP descriptions for the general public. The goal is to keep it concise.
- We reviewed the format of the final Honouliuli Plan. In general, we will follow that format, but a map or maps showing proposed locations/priority of the BMPs will be included.
- Examples of maps like this were in the Hanalei Plan, however that plan in general is not the best example of what CWB is looking for.
- BMP tables should have expected load reductions from STEPL wherever possible. Since not all BMPs will be the ones used in STEPL however, ones for which load reductions cannot be quantified should have qualitative descriptions or sources describing why/how this BMP can help. The example Mike mentioned was removal of albizia, which is a Hawaiʻi-specific practice for which load reductions cannot be calculated in any model. However, plenty of evidence/research exists about the impacts of albizia and benefits of removing it.
- The Honouliuli Plan used RUSLE2 as one of their models, which shows load reductions for sediments only, but does have all the NRCS conservation practices as options. We agreed that at this point we will refrain from modeling with RUSLE2 and will supplement load reductions with qualitative estimates.

- Some BMPs are pre-manufactured devices such as baffle boxes or curb inlets. For these, the manufacturer typically supplies estimated load reductions.
- We discussed the accuracy of NRCS cost estimates, which are often not applicable to Hawaiʻi, so additional sources of cost information will be used.
- Although we have yet to complete any water quality testing and are hoping to sample at 3 different points this winter to pinpoint which land uses are contributing the most NPS pollutants, the assumption is that the Navy lands are unlikely to be a major contributor. However, some BMPs should be recommended for Navy lands in order to be "fair" and to appease the community. Navy land BMPs will likely be high-cost items such as sediment basins or constructed wetlands as these would be unfeasible on private land due to cost and land limitations. We will start developing the Navy BMPs first to give the Navy folks a heads-up before the holidays and before any recommendations are submitted. A review meeting with the Navy should be scheduled before submittal and due to the lengthy process of dealing with the Navy, it makes sense to give them enough lead time.
- We also updated CWB on the community outreach aspect of the plan. Cynthia Rezentes is scheduling some additional meetings (including MAʻO Farms and NRCS) and a community meeting will be planned for after the next submittal to discuss BMP ideas and potential pilot projects. This may help reveal landowners that are interested in installing BMPs on their land.
- Mike mentioned that there are plans to eventually construct a truck weigh station near Kahe Powerplant to regulate what materials are coming into Waiʻanae. This is likely a very longterm endeavor.
- Mike will start working on a 4-month no-cost contract extension (new due date end July), which should be processed in 4-8 weeks.

ACTION ITEMS:

- Townscape to work on draft BMPs report and consult with CWB as needed.
- Mike to process contract extension

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MĀʻILIʻILI WATERSHED MANAGEMENT PLAN
Memorandum No. 08

Date: December 3, 2013
To: Patricia Colemon, NAVFAC
From: Townscape, Inc.
Re: Preliminary BMPs for Navy lands

1.1.1. Forested Areas:

The Hawaiʻi Watershed Guidance lists ten management measures for "forestry", many of which are not applicable to the Māʻiliʻili Watershed as there is no timber extraction and the forested lands are limited to Navy and State Forest Reserve lands. The STEPL results for forested lands show very low contributions of sediments and other pollutants. However, this does not take into account the existence of invasive species that can alter the hydrology (e.g. strawberry guava) and feral ungulates, which are known to be present throughout the Navy and forest reserve lands. The Navy is already actively managing four protected areas at NAVMAG and implementing several of the NRCS conservation practices there. Table X shows the additional recommended management measures for forested lands. Restoration of native forests should be a long-term goal to restore the ecosystem and watershed to a better functioning state.

BMP	FOTG#	Flooding	Implementation	Cost
Forest Stand Improvement	666	x	Navy/DOFAW	265/acre
Riparian Forest Buffer	391	x	Navy/DOFAW	$7.40/plant
Ungulate Control	N/A		Navy/DOFAW	$50/acre

BMP definitions and details:

FOREST STAND IMPROVEMENT (# 666) refers to the manipulation of species composition, in this case specifically the selective removal of invasive species such as strawberry guava or christmasberry from a priority area like an enclosure or an area with a high density of invasives. This can have direct and indirect beneficial impacts on water quality. The Navy has four specially managed habitat areas with fenced enclosures in the upland and forest areas where this management practice can be implemented to improve the species composition.

RIPARIAN FOREST BUFFERS (# 391) are areas of selected trees and shrubs planted upgradient of a streambed to reduce excess sediments, organic material, nutrients and pesticides. This practice would be best implemented after removing invasive species from an area to restore native habitat or in areas where vegetation may be sparse. Exact locations for implementation of this management practice would have to be assessed together with Navy and DOFAW.

UNGULATE CONTROL refers to the removal of feral ungulates including pigs and goats by trapping, snaring or hunting. This can be done throughout a landscape, but is of particular importance after creating a fenced enclosure. The Navy should focus on ungulate control in and around the four special management areas. These areas are up mauka, where pig rooting and other activities can be a major NPS pollution source. There may also be potential for partnering with DOFAW to coordinate ungulate control between the Navy lands and the forest reserve as well as partnership with WMWP and the Army to connect existing and new fences. Due to access limitations, public hunting is currently not allowed. However, the Navy's Integrated Natural Resource Management Plan lists permitted/controlled public hunting with dogs and knives as a future possibility, along with aerial goat and pig hunting in partnership with DOFAW. Fees for public hunting programs could then be re-directed to fund future natural resource management activities at the NAVMAG installation.

1.1.2. Uplands:

The Hawaiʻi Watershed Guidance doesn't provide specific management measures or guidance for "uplands" as this is a term used in this document to define the mostly kiawe and haole koa dominated areas covering most of NAVMAG. Many of the forestry and *riparian BMPs can be applied on these lands as well. The Navy is already actively managing four protected areas at NAVMAG and implementing several of the NRCS conservation practices there. Table X shows the additional recommended management measures for the forested/shrubby uplands. Restoration of native forests should be a long-term goal to restore the ecosystem and watershed to a better functioning state.*

BMP	***FOTG#***	***Flooding***	***Implementation***	***Cost ****
Forest Stand Improvement	*666*	*x*	*Navy/DOFAW*	*265/acre**
Fuel Break	*383*		*Navy*	*$398/acre*
Restoration and Management of Rare or Declining Habitats	*643*		*Navy/DOFAW*	*$437/acre*
Riparian Herbaceous Cover	*390*	*x*	*Navy*	*$10/sf**
Sediment Basin	*350*	*x*	*Navy/USACE*	*$44/cy*
Ungulate Control	*N/A*		*Navy/DOFAW*	*$50/acre**

BMP definitions and details:

FOREST STAND IMPROVEMENT (# 666) refers to the manipulation of species composition, in this case specifically the selective removal of invasive species such as haole koa and christmasberry from a priority area like an enclosure or an area with a high density of invasives. This can have direct and indirect beneficial impacts on water quality. The Navy has four specially managed habitat areas with fenced enclosures in the upland and forest areas where this management practice can be implemented to improve the species composition.

A FUEL BREAK (# 383) is a strip or area of land, where vegetation has been cleared or reduced to control and reduce the spread of wildfires. This can help protect some of the fenced enclosures as well as reduce the risk of fire spreading towards Waiʻanae Valley. A situation like this occurred in 2012, when a fire originating from Lualualei NAVMAG spread into Waiʻanae Valley and caused widespread destruction.

RESTORATION AND MANAGEMENT OF RARE OR DECLINING HABITATS (# 643) applies to areas that have or are currently supporting imperiled native plants and animals. The purpose is to restore native aquatic or terrestrial habitat and improve biodiversity. This can include small or large fenced enclosures such as the ones already implemented by the Navy. An additional area the Navy could focus on is a small pocket of sandalwood trees off of Dent Street.

RIPARIAN HERBACEOUS COVER (# 390) refers to the planting of grasses, sedges and other plants in riparian zones. There are many benefits of this management practice, including improved water quality, reduced flooding, stabilization of streambanks for erosion control, etc. The exact locations of eroding streambanks at NAVMAG are unknown, but some minor areas were observed on our field visit.

A SEDIMENT BASIN (# 350) can help reduce sediment transport in stormwater runoff by capturing and detaining runoff until sediments have settled in the basin, before releasing the remaining water through an engineered outlet. According to STEPL results, sediment load is highest from subwatershed B. The most suitable location for a sediment basin would be just mauka of the private neighborhood on Kuwale Road, although it can be assumed that much of the sediment load is actually coming from the agricultural areas makai of that location. At this location, a basin would drain roughly 1,700 acres. At a cost of $44 per cubic yard, a sediment basin large enough to contain 10% of the 100-year storm would cost $14 Million. Although a sediment basin would theoretically reduce sediment runoff, as these costs are very high, it is an unlikely BMP for implementation. The NRCS FOTG describes it as a last practice in a series of erosion control and sediment capturing practices.

UNGULATE CONTROL refers to the removal of feral ungulates including pigs and goats by trapping, snaring or hunting. This can be done throughout a landscape, but is of particular importance after creating a fenced enclosure. The Navy should focus on ungulate control in and around the four special management areas. These areas are up mauka, where pig rooting and other activities can be a major NPS pollution source. There may also be potential for partnering with DOFAW to coordinate ungulate control between the Navy lands and the forest reserve as well as partnership with WMWP and the Army to connect existing and new fences. Due to access limitations, public hunting is currently not allowed. However, the Navy's Integrated Natural Resource Management Plan lists permitted/controlled public hunting with dogs and knives as a future possibility, along with aerial goat and pig hunting in partnership with DOFAW. Fees for public hunting programs could then be re-directed to fund future natural resource management activities at the NAVMAG installation.

1.1.3. Grasslands:

The grasslands covering the Naval RTF are already being actively managed with NRCS practices such as grassed waterways and wildlife habitat protection/predator control at the constructed wetland (Niuliʻi Pond). Part of RTF close to the Māʻiliʻili Stream channel contains a small area with native and endangered plants, which have already been tagged and are being monitored. ADDITIONAL IDEAS?

BMP	***FOTG#***	***Flooding***	***Implementation***	***Cost ****
Grassed Waterway	*412*	*x*	*Navy*	*$1.20/sq ft*

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MĀʻILIʻILI WATERSHED MANAGEMENT PLAN
Memorandum No. 09

Date: February 14, 2014
To: Jensen Uyeda, LIFE; Mike Burke, CWB
From: Townscape, Inc.
Re: February 14 meeting with CTAHR extension agent

Participants: CTAHR LIFE Program: Jensen Uyeda; Townscape, Inc: Tina Speed

Purpose of this meeting: To discuss opportunities for education of basil farmers and BMP installation on basil farms in Lualualei.

Summary of discussion:

- We re-visited some of the issues we had discussed via email, including what Jensen's experience has been dealing with the basil farm/pesticide issues on Oʻahu. The "Local and Immigrant Farmer Education" (LIFE) program has done a series of workshops with basil farmers in Waiʻanae Kai, ʻEwa and other areas.
- According to Jensen, the level of interest in environmental protection measures is VERY LOW among these farmers. Money is the major motivator for them and to maximize their money means to maximize their yield via whatever means necessary, including chemicals. He said that even a $5,000 fine for mis-use is just a "slap on the hand" for them and will not deter them from continuing to use and overuse whatever chemicals ensure they can bring the largest possible amount of their crop to market.
- Jensen knows some of the Lualualei basil farms. He describes them as working the following way: One person owns or operates a basil farming operation, which can include several farm parcels. This person who may speak some English (but possibly only Chinese) employs roughly 5-6 Chinese workers who go from property to property pruning, harvesting, applying chemicals etc. The workers speak no English. Sometimes the operators have children who speak English and can serve as translators, but often extension agents will rely on pointing at pictures to communicate. For educational workshops, farmers either bring their own translator or one has to be provided.

- Since the level of interest in environmental protection is so low, Jensen said it is very difficult to get basil farmers to even show up to a workshop series. Often what happens is that they may come to the first one and then realize there is nothing in it for them and then they never show up again. He stressed the need to provide some sort of incentive or motivation for these farmers since there is no one forcing them to install BMPs.
- Due to the farmers' lack of interest, Jensen sees this kind of work as low priority for their program.
- We reviewed some pictures of basil farms in Lualualei, some in close proximity to waterways. Jensen said that although it would make sense for farms to have buffer strips around them to keep their soil and chemicals from running off, and to protect them from runoff and possible diseases/pests from neighboring farms, these farmers wouldn't actually implement those kinds of BMPs without being convinced that it will improve their operation or may increase their yield.
- Jensen suggested that visiting some farms during a rain event and investigating how the water flows and drains on various farms and whether it affects other surrounding farms, would be one way to identify farms that could be convinced to install buffers.
- When discussing the concern of organic farmers in the area, he said that the non-basil and organic farmers need to take initiative to protect their lands from basil farm runoff via buffers etc.
- One of the main things that Jensen and his coworker Jari deal with is crop pests and diseases. They don't necessarily work with BMPs, but are called upon by farmers to help them identify and deal with emerging pests and diseases affecting agronomic crops. He said what the farmers want from him is basically a list of chemicals that will kill whatever pest they are dealing with at the time.
- Tina explained the situation with the settlement money available for the Māʻiliʻili Watershed and how this money could be used to fund BMPs and educational programs. Jensen is committed to helping by running additional workshops etc., but stressed that there needs to be a creative way to motivate the basil farmers. His general approach is to go through the basil distributor/exporter that buys the crops from the farmers. These people typically speak both English and Chinese and can help motivate the farmers to attend workshops.
- According to Jensen, most of the basil farms are Chinese-run. There are also some local farms employing Filipino workers. One of the problems is that the Chinese basil farmers are in competition and refuse to work together. Therefore, workshops have to be separated into groups based on who runs the farm. In Lualualei, Jensen said there are 3-4 separate groups of basil farmers, so any workshop series would have to be held 3-4 separate times because the competing groups refuse to attend the same workshop.
- One creative way to motivate attendance is to come up with an incentive that is presented at the first workshop. This could be an incentive for people who attend all workshops and especially an incentive for using BMPs and better pest management. Unfortunately Jensen thinks the only viable incentive for the basil farmers is money. He mentioned that in order to really make a difference and ensure that basil farmers are improving their practices or installing BMPs on their farms would be to provide a financial incentive. This could be in the

form of say, a “gift card” of $500 or $1,000 to be used at one of the ag/chemical companies, for the first 50 farms that implement buffer strips around their farms. Tina thought this was unlikely to happen with government money (Discuss with CWB!). Another method would be to have whoever will be implementing this watershed plan install some demonstration BMPs that would benefit the farms on their land to “prove” to the farmers that they would help them. Then they would be more likely to adopt them. The example Jensen used was to find a crop that could have dual beneficial effects as a buffer strip as well as an insect repellent. If there is an insectary crop or plant that would repel a certain insect that the farm is trying to fight, then that plant could be installed as a buffer to show the farmers how it keeps the unwanted pests away. This could then provide environmental benefits, as well as a financial benefits to the farmer by allowing them to reduce their inputs. Some of the crops discussed that have insectary properties are sunn hemp and cilantro.

- Jensen suggested that we talk to folks at NREM who can provide further insight into agricultural BMPs as well as execution of a basil farm program.
- We discussed the idea of using some of the settlement money to fund an additional short-term position in the LIFE program. Jensen was hesitant because they do not have the capacity for daily supervision of a new or inexperienced staff member. The idea he felt happiest about was funding of a research assistantship for an experienced PhD student, who could work directly with basil farmers as part of a research/extension program.
- Jensen again suggested talking to NREM and specifically his boss, Dr. Carl Evensen of CTAHR about how this kind of funding would work. Jensen said LIFE doesn’t have the capacity to deal with disseminating/reporting on how funding was used and basil farmers would not be interested in receiving funding that they have to put in work to receive. He does not know what percentage of money that would go to UH for this kind of a position would go to the actual project and what goes to UH to cover administrative costs. He suggested that we establish criteria for how the money gets used.
- Jensen sees their role as being that of organizing and holding the workshops (with input from experts at NREM), putting together announcements and getting people to come.
- We briefly talked about vetiver and how it might help with basil farm chemical remediation. He doesn’t have experience with vetiver, but suggested talking to some of the large biotech companies like Monsanto. Apparently they have a large vetiver buffer strip alongside a dry gulch off Kunia Road. That might be a place to go look at BMPs in action as they have multiple ones installed.
- Jensen said if there are any questions, just email him and he will be happy to help.

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MĀʻILIʻILI WATERSHED MANAGEMENT PLAN
Memorandum No. 10

Date: **February 21, 2014**
To: **Mike Burke, CWB**
From: **Townscape, Inc.**
Re: **February 19 focus group meeting at Kahumana Farm**

Participants: Project area farmers/representatives: Kahumana Farm, Naked Cow Dairy, Rainbow Eggs; Townscape, Inc: Bruce Tsuchida, Tina Speed

Purpose of this meeting: To discuss project ideas and BMPs for implementation and additional issues in the watershed.

Summary of discussion:

- We first re-introduced the project to some of the attendees and newcomers and explained the situation with the settlement money that will be available for BMP implementation. We described what BMPs are and that we are looking for interested farmers to implement some of these BMPs on their land etc.
- Since it had been a while since we walked the streambeds, some of the residents filled us in on new issues. The main issues brought up were the following:
- **1. New dumping issue:** According to several community members, there is a recent influx of fill material delivered by trucking companies to the basil farm just makai of Old Government/Kuwale Rd. These activities happen after hours, on nights and weekends and were described as "semi trucks and tandems bringing in fill material to dump in the stream and the basil farm". The basil farmers are allegedly accepting material to "store" on their farms and allegedly dumping this fill into the stream. The last time Townscape walked this section of the stream, we observed a berm alongside the stream, but according to the local residents, things "look a lot different there now with all the new dumping". We advised that dumping of fill material in a stream is illegal and activities like this got this whole project started in the first place. If they observe this kind of activity, it should be reported to CWB.
- **2. Frequent and disruptive pesticide spraying by basil farmers:** According to all the attendees, the basil farms spray excessive amounts of pesticide frequently, including on no-

wind days. This is disruptive to neighboring farms and causes general air quality problems in the neighborhood.

- **3. Illegal burning of trash including plastic:** According to all the attendees, the basil farms pile up their trash, including plastic and burn it, creating a thick disruptive smoke, causing health concerns for nearby farms and residents, including the transitional housing at Kahumana which houses families and children, including asthma patients. The basil farms burn trash on no-wind days as well. These farms do not have a burn permit. Kahumana and MAʻO do have burn permits and sometimes get blamed for the smoke. The attendees reported that they call DOH and DOA to complain about the burning, but it takes too long for the agencies to respond.
- Jenny from Rainbow Eggs circled the location of her Kuwale house on the map. Their house gets flooded frequently. Major floods to their home occurred in 2007 and 2011. Apparently, a property adjacent to them put up a stonewall with no drainage and Jenny suspects it is not permitted. Cynthia offered to find out more if Jenny can send us the address. We can also check the Lualualei Flood Study to see if any priority projects were identified that could help relieve the flooding.
- Rainbow Eggs is currently a small operation with 50 free range chickens at the Naked Cow Dairy. They are in need of manpower and $ to put up fencing etc. to manage the chickens.
- Naked Cow Dairy only has 12 cows and they are unsure if they will be able to expand. They would like to grow their own feed, but the water pipe serving the property is too small to irrigate and would require a $4,000 replacement. Naked Cow is also interested in leasing grazing land from the Navy, but they were denied due to the presence of an endangered native plant that would be jeopardized by cattle.
- Naked Cow as a very small-scale animal operation inquired about any BMPs they could install on their land. They currently have a small drainage pond for their wastewater. They are wondering about options for reusing some of their processing water for other things. Their butter and cheese making process produces a lot of wastewater, which contains mostly whey and skim milk. Some pig farmers along the coast have expressed interest in using it to supplement their pig feed, but would need to make more effort to pick up the buckets etc.
- Kahumana is very interested in installing BMPs and collaborating on BMPs and other implementation projects. They were very into the idea of planting rain gardens to collect surface runoff from their structures. Chris from Kahumana thinks installing rain gardens for their existing and future structures could be a great community activity and activity for their clients in transitional housing.
- Kahumana recently acquired two additional parcels in the valley just mauka of Kuwale Rd. Pūhāwai Stream runs through the property and Kahumana is very interested in incorporating BMPs and LID into their plans. Any facilities plans are very long-term and there are currently no real plans to develop facilities on the property. They want to gradually phase work for the new parcels instead of aggressively pursuing any specific plans. They do want to start growing fruit trees there asap and get started on planting vegetative barriers, stream buffers etc. They want to be good stewards of the stream running through the property and suggested a stream buffer with vetiver grass. They are also interested in creating a light

terracing system for their new farm to help reduce runoff. For now they would like to build a fence/vegetative barrier around the new parcels and look into replacing water pipes. The existing pipes are corroded metal. They need a 2” ag line meter, which could cost around $60,000. Cynthia suggested talking to SWCD about how to obtain a cheaper water line and about doing a conservation plan for their farm.

- In general, it was suggested that rainwater retention methods should be used, including barrels and storage tanks. Chris suggested 400-gallon IBC tanks.
- Kahumana asked about the process for receiving funding from this watershed plan in the future and whether they should start working on a proposal. We replied that it is too soon for that at this point and we still need to work out details of the implementation plan with ORC&D, CWB etc. We explained that the plan will be finished this summer and any implementation will begin after that. We will keep them posted on the situation.

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MĀʻILIʻILI WATERSHED MANAGEMENT PLAN
Memorandum No. 11

Date:	**February 21, 2014**
To:	**Mike Burke, CWB**
From:	**Townscape, Inc.**
Re:	**February 19 meeting with MAʻO Farm**

Participants: Gary Maunakea-Forth, MAʻO Farm; Townscape, Inc: Bruce Tsuchida, Tina Speed

Purpose of this meeting: To discuss project ideas and BMPs for implementation and additional issues in the watershed.

Summary of discussion:

- We first introduced the project to Gary and explained where in the planning process we are.
- Gary described some of the activities and BMPs used by MAʻO: When they first acquired additional property, they cleaned out the stream that runs through it. Management practices they use on their farm include cover crops (sunn hemp), an intricate crop rotation and agroforestry system, bamboo and banana as windbreaks. He explained that reducing tillage in this clay soil is very difficult, so they use a ripper-rototill-bed shaper method.
- In the future, they are interested in additional composting and mulching, using more chicken manure and possibly vermiculture (he said it was hard to use worms on such a large scale).
- They are interested in additional BMPs and collaborating with ORC&D to host workshops etc.
- Gary mentioned that there is a “mystery water pipe” suspected to be carrying runoff from the mauka basil farm (same one mentioned at focus group for stream dumping) to a spot close to Puhawai Rd. and he is interested in investigating this issue.
- MAʻO is one of the few farms that has a burn permit. Basil farmers all around them throw their trash (incl. plastic) into trenches and burn it. Sometimes people assume MAʻO is doing this because they have a burn permit and complain.
- Gary explained how the “basil system” is very profitable and relatively easy to install. The farmer next to them got evicted, but when this happens, signs go up to look for new tenants. Once the fields and irrigation systems go in, it just takes a few workers and some “typical” pesticides and fertilizers to make huge profits.

- Gary mentioned that when it rains, they have problems with water pooling.
- He also brought up the burning tire pile on the old Souza property.
- As a priority for implementation, Gary mentioned doing stream clean-ups with heavy equipment.

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MĀʻILIʻILI WATERSHED MANAGEMENT PLAN
Memorandum No. 12

Date:	**February 21, 2014**
To:	**Mike Burke, CWB**
From:	**Townscape, Inc.**
Re:	**February 19 meeting with Oʻahu RC&D**

Participants: Duane Okamoto, Amanda Camacho, ORC&D; Townscape, Inc: Bruce Tsuchida, Tina Speed

Purpose of this meeting: To discuss project ideas and BMPs for implementation and potential involvement of Oʻahu RC&D as an implementing champion for agricultural projects.

Summary of discussion:

- We introduced the project and explained where we are in the planning process, focusing on implementation of actual projects. We reviewed some maps and discussed general watershed/landowner/pollution issues and the basil farmer issues.
- We then asked ORC&D to describe what they have been doing in Waimānalo, where they are currently in the second phase of a 319 project to install BMPs on farms, as well as other projects they have been working on.
- Amanda is the one working hands on with farmers. A lot of their work has focused on the central and leeward side.
- In Waimānalo, Amanda works mostly with nurseries to install BMPs including grassed waterways, vegetative barriers with vetiver, drip irrigation, rain gardens, stream buffers etc.
- Overall, they have had a low response rate for the Waimānalo project. They have $66,000 available and require folks to submit a proposal and commit to 1/3 cost sharing. They feel that both in Waimānalo and in Māʻiliʻili, the awareness needs to be raised for landowners to become more interested.
- Duane said ORC&D is definitely able and interested in conducting an additional project in Māʻiliʻili. He suggested working together with Pacific Gateway for language barrier issues and translation for Asian basil farmers.

- We discussed the issue with basil farmers often leasing land and not owning it. Duane suggested that we find a basil farm who owns their land to do a demonstration project. Then the word may spread about its success. He also suggested getting some farmers to make an up-front commitment to installing BMPs that could benefit their farm and then providing a refund if they implement it. Basically, we need to provide incentives.
- We will be meeting with Dr. Myaing of Pacific Gateway on February 27 to discuss collaboration opportunities.

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MĀʻILIʻILI WATERSHED MANAGEMENT PLAN
Memorandum No. 13

Date: February 27, 2014
To: Mike Burke, CWB
From: Townscape, Inc.
Re: February 27 meeting with Pacific Gateway and Oʻahu RC&D

Participants: Duane Okamoto, ORC&D; Dr. Myaing, Pacific Gateway; Townscape, Inc: Bruce Tsuchida, Tina Speed

Purpose of this meeting: To discuss potential collaboration between ORC&D and Pacific Gateway to implement projects and BMPs, particularly for Chinese and Southeast Asian basil farmers.

Summary of discussion:

- We introduced the project and explained where we are in the planning process, focusing on implementation of actual projects. We reviewed some maps and discussed general watershed/landowner/pollution issues and the basil farmer issues.
- Dr. Myaing said that they have worked with many farmers and have had some good success in central Oʻahu. They typically focus on issues of self-sufficiency and try to promote land ownership. With 5 acres of farmland, someone can make a good living and send their kids to college, so they have been working with farmers to sustainably farm 5 acres.
- She mentioned that most of the farmers and workers on basil farms are very uneducated and even after having workshops with some of them, many still can't read the English language pesticide labels (I suspect the "mis-use" of pesticides basil farmers have been getting cited for may actually partially be due to this and not be an intentional mis-use?).
- Dr. Myaing said that Pacific Gateway is definitely interested in collaborating and would be able to provide translation, language interpretation and workshop services.
- However, she stressed that it will be important to provide an incentive to convince people to use BMPs. Something that "hits close to home" so to speak, like showing them the potential health impacts of pesticides (→ alligator story!)

- She suggested providing a good meal for people attending workshops because many of them may not have much time off or get time to enjoy a good meal. ORC&D believe that involving Pacific Gateway will help build trust because often, farmers that are concerned about getting in trouble for things will not let people come onto their farms.
- Dr. Myaing also described some of the human trafficking issues and Tina mentioned that there have been some reports of people being trafficked to work on Hawaiʻi basil farms.
- She also suggested using cultural tools as an incentive, including "karma" depending on what religion people are, telling the basil distributors that they are poisoning their customers and using ads on Korean television channels.
- Townscape will meet with CWB next week to discuss further details on the implementation plan and funding for this collaboration.

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MĀʻILIʻILI WATERSHED MANAGEMENT PLAN
Memorandum No. 14

Date:	**March 10, 2014**
To:	**Bruce**
From:	**Tina**
Re:	**March 7 Oʻahu RC&D Workshop in Waimānalo**

Participants: Tina Speed, Townscape Inc.

Purpose of this workshop: To experience one of the ORCD workshops and see BMPs and vetiver "in action".

Summary of workshop:

- I would say there were roughly 20 participants, plus presenters from various government agencies and representatives from biotech (Syngenta) and Irrigation supply companies (Hawaiʻi Irrigation Supply).
- Duane Okamoto, Executive Director of ORC&D gave a short introduction about ORC&D and its mission, what kind of projects they have been working on, specifically in Waimānalo with farms and nurseries, and about the 319 grant they have available for people to install conservation practices on their land.
- Next, Dorothy Mulkern, the daughter of Mulkern Nursery owner welcomed everyone to their site and talked about the success they have had with installing drip irrigation at their nursery and how much water it has saved them, as well as some of the other BMPs they have, such as grassed waterways and vetiver buffers. They grow mostly ornamental plants for their landscaping business.
- Next, Amanda Camacho of ORC&D gave a presentation about basic watershed science, explaining how after rain comes down from the mountains, it delivers runoff including chemicals and other water contaminants from agricultural and military areas to Waimānalo Bay. She described the basic concepts of using BMPs to help reduce the pollutant loading of the runoff water and how to use drip irrigation to not only save on your water bill, but reduce the total amount of runoff.

- Dr. Cynthia Stiles from NRCS gave the longest of all presentations at the workshop. She is a soil scientist and used to be a soil science professor on the mainland. She gave a really nice, straight forward soil science 101 presentation focusing on information that is specifically relevant for farmers. The main points she included were: "It is all about organic matter and pore space"; Soil surveys are not always accurate so she encourages people to dig into the soil and develop a relationship with their soil, apparently playing with dirt has therapeutic benefits for us modern-day folks who sit in offices all day because it connects us back to the earth; To put soil texture in relative terms, particles of sand would be the size of a basketball, silt the size of a baseball, and clay the size of a pinhead; Sand feels coarse, silt feels soft and smooth, clay feels sticky; Loams are a mix of sand, silt and clay; Clay holds on to water and contaminants which is why they use clay for liners; for farmers, the "available water capacity", i.e. a soil's ability to provide moisture to plants, is more important than the "water holding capacity", which depends on the aggregate size the soil creates; Higher soil organic matter means stronger, more stable aggregation and better soil structure (arrangement of particles)→ reduces amount of water needed.
- The next section of the workshop included presentations from the Department of Agriculture, the Farm Service Agency and NRCS on their various financing programs for agricultural initiatives and BMPs.
- Daryl Arai from DOA talked about the State Agricultural Loan Program and Renewable Energy Farm Loans.
- Melissa Rodrigues from FSA presented on USDA Farm Loans, Energy Loans, Youth Loans, and Microloans. Microloans are up to $35,000 and relatively easy to get.
- Rick Patterson, an NRCS conservationist (with the most extreme southern accent I have ever heard) talked about NRCS Conservation Plans and EQUIP program for farmers. He stressed that although NRCS is a federal agency, they are all voluntary (not regulatory) and they don't share any personal or other information with other federal or state agencies.
- The next section of the workshop was about irrigation systems.
- Randy Teruya from DOA described the Waimānalo water system, which is similar to the Waiāhole Ditch system in that it transfers water from one valley to another for agricultural purposes. This water system supplies water from Maunawili to agricultural operations in Waimānalo. Apparently, many farmers have not been interested in their water system because there were rumors of nematodes in the system. However, a CTAHR study from several years ago found 0 nematodes in their tanks and pipes. A follow up study is in the works. Randy encouraged farmers to explore the option of receiving water from this system at a rate of $0.50/1,000 gallons.
- Jim Kenny of Hawaiʻi Irrigation Supply Company presented some of his company's drip irrigation technology, which is much more efficient than spray irrigation. Depending on what type of plants or crops are being grown, they suggest using either drip (low rate dispensing) or micro-spray (higher rate dispensing).
- We then went on a tour to view the irrigation system, the grassed waterways and the vetiver hedges surrounding the edges of the property.

- Unfortunately Mary Wilkowski, who was supposed to give the vetiver tour and demonstration got stuck with her car and was unexpectedly unable to be there. Amanda and Dorothy Mulkern tried to fill in and do the vetiver presentation, but unfortunately they did not touch on many of the important points about vetiver and did not exactly "make the case" for it or answer questions accurately. After the official tour ended and people were allowed to walk around and explore the vetiver, I got in a discussion with some people about what I had learned about vetiver from Mary and my own research and was able to answer some of the questions people had about its benefits and inability to spread and become invasive. This ended up resulting in a small crowd of people thinking that I am some sort of vetiver expert, but I just explained that I had met Mary in the past and this is what I learned from her and some of my own research. Everyone seemed happy after.
- Overall, I would rate the workshop with a grade of B-. There could have been more scientific detail and accuracy about watersheds and vetiver. For example, I would have done the initial watershed science presentation in a very different, more laypeople-friendly way. However, unbeknownst to me before this workshop, Amanda is actually 7 months pregnant and was struggling quite a bit with the talking, walking and the heat, which I think had a noticeable effect on her performance because she was dizzy and in need of water. She thanked me for helping her answer some of the vetiver questions and said she will continue working for ORC&D after she has her baby.

Top left: Grassed waterway, a typical agricultural NRCS BMP which slows runoff water and reduces erosion.

Top right: Dorothy Mulkern describing the irrigation system for their special bamboo varieties

Bottom left: Water plants with vetiver hedge in the background

The vetiver hedges have been unmaintained and without irrigation for three years and although they don't look so pretty anymore (lack of maintenance), they are thriving and doing their job of keeping irrigation runoff from adjacent properties and streams.

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MĀʻILIʻILI WATERSHED MANAGEMENT PLAN
Memorandum No. 15

Date:	**March 12, 2014**
To:	**Mike Burke, DOH**
From:	**Townscape**
Re:	**March 6 Implementation Plan meeting with CWB**

Participants: Mike Burke, Greg Takeshima, CWB; Bruce Tsuchida, Tina Speed, Townscape Inc.

Purpose of this meeting: To discuss details about RFPs and implementation projects that will result from this watershed plan, specifically in regards to financing and the RFP process.

Summary of discussion:

- Tina first summarized the recent meetings with the farmer focus group, MAʻO, ORC&D and Pacific Gateway. A partnership between ORC&D and Pacific Gateway is promising for implementation of any basil farmer programs with a language barrier as PG provides agricultural education and translation services for Asian immigrant farmers.
- We discussed the importance of providing incentives for farmers to install BMPs as there is currently no real requirement or oversight. Mike mentioned that over the next 5 years, DOH will be enforcing NPS pollution regulations, possibly via fines to agricultural producers that aren't adequately preventing runoff. His comment: "Technically people should be doing this stuff anyways".
- Focus for buffers and similar BMPs should be on farms that are adjacent to a stream channel.
- We touched on the idea of providing funding for a "Watershed Coordinator" type position, which could be within a community organization such as Mohala I Ka Wai. Mike sort of liked the idea as this kind of person could be valuable for implementing programmatic things like educational programs and water quality monitoring. But he was hesitant to give anyone "a bucket of money".
- Some additional folks for us to potentially talk to include the SWCD, FSA, NRCS and Farm Associations (as far as we know the Puhawai Farmer's Association has been disbanded). Mike also mentioned a bill in the legislature right now to fund the Hawaiʻi Association of Conservation Districts.

- For the ag BMP program, it should be determined which farms have a Conservation Plan and which ones are in need of one.
- For the types of RFPs that will result from this plan, they won't need a match from the organization providing the service, say ORC&D. However, Mike is hesitant to "hand out free money" to farmers who aren't interested in using BMPs. So he suggested a cost-share requirement for the farmers and then maybe if there are some critical areas that need to have BMPs and farmers are being "difficult", they could still consider changing that requirement.
- Bruce suggested getting leverage for the basil farmer issues by going directly to the landowners that are leasing to basil farmers. However, in terms of enforcement, Mike found out that the violation notices/fines go to the "responsible party", i.e. the farmers, not landowners.
- We briefly discussed the currently vacant/unassigned DHHL lots along Pāheʻeheʻe Ridge. DHHL may want to consider requiring a conservation plan for new ag parcel lessees.
- Tina explained how farmers at the focus group meeting had inquired about what specifically they could obtain funding for, e.g. mulch? Since mulching was a BMP listed in the Strategies Plan, but farmers could benefit from mulch and many already use it, does it even make sense for money to be available for such a thing? Technically, the entire settlement could be spent on providing mulch for every farm, but that would probably not make sense. Mike said if anything, priority areas for mulching would be identified as part of the greater ag BMP program.
- For the ag BMP program, the implementing organization (e.g. ORC&D) should have a simple contract with the farmers to maintain BMPs over time. CWB may also monitor the status of BMPs over time.
- We talked a little about how and where the settlement money can be spent. Tina recalled that the settlement said something along the lines of "for water quality improvements on the Waiʻanae Coast". So, can the money only be spent in the Māʻiliʻili Watershed or in other watersheds as well? This was asked in specific connection with programmatic type things such as educational programs for kids-i.e. if the settlement funds a coordinator to implement an educational program for elementary school kids, should they only administer such a program in Māʻiliʻili or is it OK to be more widespread? Mike said the settlement could go to programs that include other watersheds, although for agricultural BMPs, these would only be applied in the project watershed. He also wants the settlement money to be spent first before projects that will require 319 funding come along, although he would like to retain a pot of money from the settlement to disseminate later if needed. For 319 funds, people have to front a lot of their own money and it is generally a more complicated process.
- We discussed the timeline as listed in the contract modification, which doesn't quite make sense because it leaves 3 months for the draft report. Mike and Greg said they are flexible on the dates for deliverables, as long as we are done by end of contract. For Greg, one implementation plan and a separate monitoring plan would be easiest.
- We may discuss details on the monitoring plan when it gets closer, but initial input from Greg was that monitoring can be either project-based or time-series based. This deliverable

is the smallest of them all and not super comprehensive. He said to give a general idea of what, why and when. No need to get into each project, but look at a broader scale and long-term measurable water quality benefits. This is where the measurable milestones go (not necessarily the implementation plan as stated in the project scope). The questions to ask are "how many of the projects have been implemented after x many years? And after 10 years, can they go in and see what has been done and whether the priorities still make sense.

- Going back to BMP implementation, Mike also suggested to "think bigger and list things anyway", even if they sound unrealistic. The example we discussed was replacing all cesspools. Tina mentioned that Aerobic Treatment Units (ATU) are in fact much better than septic tanks because they produce significantly cleaner effluent, but also much more expensive. Mike said that even if it is unfeasible to replace every single cesspool with an ATU, list it anyway and even if one or two get replaced, that will still make a difference. Also, provide a justification for why it may make more sense to replace fewer cesspools with ATUs, rather than more cesspools with septic tanks (if that is the case).

APPENDIX F

AECOS Water Quality Report

AECOS No. 1389

Baseline water quality assessment for Lualualei Watershed Management Plan

Prepared by:

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May 16, 2014

Baseline water quality assessment for Lualualei Watershed Management Plan

May 16, 2014 | **_DRAFT_** | AECOS No. 1389

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Introduction

This report[1] presents a summary and assessment of water quality conditions in several streams (Mā‘ili‘ili and two of its tributaries: Pu‘uhulu and Pūhāwai), drainage from basil fields towards the back of the valley, and an ocean sampling location just off the Mā‘ili‘ili Stream seawall (Fig. 1).

Methods

Water quality samples were collected at four stations (Stas. 1 through 4) on three sampling events between February 9 and March 3, 2014. Sta. 1 was located below the confluence of Ma‘ili‘ili Stream with Pu‘uhulu and Pūhāwai streams. Sta. 2 was located in the lower reach of Pu‘uhulu Stream. Sta. 3 was located in the lower reach of Pūhāwai Stream; and Sta. 4 was located near the mouth of Ma‘ili‘ili Stream, *makai* of the seawall in nearshore marine waters. A single set of water quality samples was collected on March 25, 2014 at a drainage coming off of Fat Law's basil farm (Sta. 5) and downstream in Ma‘ili‘ili Stream at a point above the confluence with Pu‘uhulu and Pūhāwai streams (Sta. 6; Fig. 1).

Temperature, salinity, pH, and dissolved oxygen (DO) were measured in the field. Samples for turbidity and total suspended solids (TSS) were collected in appropriate containers, stored on ice, and delivered to *AECOS* Inc. laboratory on windward O‘ahu for analyses. On February 19, 2014, samples were collected at

[1] Report prepared for Townscape, Inc.. The results of this report are intended for inclusion in the Lualualei Watershed Management Plan.

Stas. 1 through 4 for three metals, 25 organochlorine pesticides and PCBs, 5 organophosphorus pesticides, and 10 herbicides. These sampls were collected and stored in appropriate containers, placed on ice, and shipped to ALS Environmental Laboratory for analyses. Samples were analyzed according to the methods listed in Table 1.

Figure 1. Water quality sampling locations in Lualualei watershed.

Results

The laboratory data sheets and quality assurance/quality control (QA/QC) statements for all analyses are provided in Appendix A. Table 2 presents the averaged results of the three sampling events at Stas. 1 - 4 with the exception of metals and organic pesticide moieties that were sampled only once. Table 5 presents the results for metals and biocides at Stas. 1- 4. Note: only those metals and/or organics that were present in detectable amounts are reported in Table 2. A complete list of all water quality parameters measured is given in Appendix A.

Figure 2A (upper). Confluence of Maʻiliʻili and Puʻuhulu streams just up from Sta. 1; Figure 2B (lower) looking downstream from Sta. 1 (from *AECOS*, 2009).

Table 2. A complete list of all water quality parameters measured is given in Appendix A.

Table 1. Methods used in analyses of water sampled from Lualualei watershed.

Analysis	Method	Reference
Temperature	SM 2550 B	SM (1998)
pH	SM 4500 H+	SM (1998)
Dissolved Oxygen	YSI meter/SM 4500-O G	SM (1998)
Salinity	Refractive index	--
Turbidity	EPA 180.1 Rev 2.0	USEPA (1993)
Total Suspended Solids (TSS)	SM 2540 D	SM (1998)
Ammonia	SM4500 NH3 B/C	SM (1998)
Nitrate + Nitrite	SM 4500 NO3-E	SM (1998)
Kjeldahl Nitrogen	SM 4500 N Org B	SM (1998)
Total Nitrogen	By calculation from Kjeldahl values	
Total Phosphorus	SM 4500 P B/E	SM (1998)
Chlorophyll α	SM 10200 H(M)/0.03	SM (1998)
Metals (soluble)	EPA 200.8/0.5/0.1	USEPA (1995)
Organochlorine Pesticides	EPA 608	USEPA (1995)
Organophosphorus Pesticides	EPA 614	USEPA (1995)
Herbicides	EPA 8151A	USEPA (1995)

Stream Stas. 1 through 3 were located in concrete-lined channels (see Figs. 2A and 2B, above). Only minimal water flow was present during the three sampling events. Indeed, no water was present at Sta. 2 on the February 24 sampling event. Low flow conditions produced results of high water temperatures, especially at Stas. 2 and 3, caused by radiation effects from the solar heated concrete channels. Salinity was measureable at all stream stations, even Stas. 2 and 3 upstream of any tidal influence. Measurable salinity at these two locations likely resulted from evaporation concentrating salts in pools on the channel bottom. Temperature, salinity, pH, DO saturation and particulates (turbidity and TSS) at Sta. 4 were typical for nearshore marine waters in Hawaiʻi, showing no influence from Maʻiliʻili Stream at the times of the sampling events. Nutrient concentrations were elevated at all three stream stations, especially at Sta. 2 on Puʻuhulu Stream. Nitrate+nitrate and total N were also elevated at Sta. 4, the nearshore marine sampling station., which would be an indication of terrestrial runoff (perhaps as groundwater) enter the ocean in this locality.

Table 2. Results (means) for selected water quality parameters in Lualualei watershed.

Station	Temp. (°C)	Salinity (PSU)	pH	DO sat. (%)	Turbidity (NTU)	TSS (mg/L)
Sta. 1	28.3	2	8.97	240	7.54	38
Sta. 2.	30.7	5	8.43	150	2.64	4
Sta. 3	32.5	2	9.05	209	6.48	44
Sta. 4	25.6	35	8.06	113	2.20	8

	Ammonia (µg N/L)	Nitrate+ Nitrite (µg N/L)	Total N (µg N/L)	Total P (µg P/L)	Chl. α (µg /L)
Sta. 1	21	6620	8210	409	---
Sta. 2	110	36600	40850	2100	---
Sta. 3	69	33	4757	1275	---
Sta. 4	8	355	1860	7	0.48

Note: geometric means are given for nutrients and chlorophyll

Water quality from a single sampling event on March 25 at Fat Law's basil farm (Sta. 5) and the lower reach of Maʻiliʻili Stream (Sta. 6) are shown in Table 3. DO saturation level was noticeably low at Sta. 5, while nutrient (nitrogen and phosphorus) concentrations were very high; comparable with nutrient concentrations at Sta. 2 (see Table 2, above). Physical water quality parameters and chlorophyll α at Sta. 6 were all elevated, as were nutrient concentrations, although these were much lower than measured at Sta. 5 on the same date. The water at Sta. 6 was clearly eutrophic, a condition of excessive productivity that would apoply to all the stream stations.

Table 3. Results for selected water quality parameters in Lualualei watershed sampled on March 25, 2014.

Station	Temp. (°C)	Salinity (PSU)	pH	DO sat. (%)	Turbidity (NTU)	TSS (mg/L)
Sta. 5	22.5	4	7.69	20	0.72	2
Sta. 6	32.8	16	8.87	168	56.8	168

	Ammonia (µg N/L)	Nitrate+ Nitrite (µg N/L)	Total N (µg N/L)	Total P (µg P/L)	Chl. α (µg /L)
Sta. 5	---	37300	44100	8880	---
Sta. 6	---	52	5410	206	36.7

Table 4. Results for selected metals and biocides collected on February 19 and March 25, 2014 (n = 1).

Station	Arsenic. (µg/L)	Lead (µg/L)	Zinc (µg/L)	Organo-Chlorine Pesticides (µg/L)	Organo-Phosphorus Pesticides (µg/L)	Herbicides (µg/L)
Sta. 1	1.1	0.245	8.1	ND	ND	ND
Sta. 2	6.4	4.82	17.2	ND	ND	Dicamba 0.096
Sta. 3	3.5	1.36	9.05	ND	ND	ND
Sta. 4	2.16	0.528	0.8	ND	ND	ND
Sta. 5	4.34	0.12	13.7	Dieldrin 0.0069	ND	ND
Sta. 6	2.38	0.326	5.39	Lindane 0.0042 Heptachlor 0.0021 Aldrin 0.003 Endosulfan Sufphate 0.0063	ND	ND

The metal, pesticide and herbicide results from the February 19 sampling event at Stas. 1 – 4 are shown in Table 4 (previous page), as are results for Stas. 5 and 6 collected on March 25. All of the metal concentrations at Stas. 1 through 6 met state acute and chronic standards for dissolved metals. All of the organochlorine pesticides detected at Stas. 1 through 6 met state acute and chronic standards, with the exception of Dieldrin at Sta.5 which exceeded the chronic standard of 0.0019 µg/L. There are no state standards for the herbicide, Dicamba.

Assessment

All streams in Lualualei watershed are classified as Class 2 inland water bodies (HDOH, 2012a). None of the streams are listed on the Hawaiʻi Department of Health (HDOH) 2008/2010 list of impaired waters in Hawaiʻi, prepared under Clean Water Act §303(d) (HDOH, 2012b).

Puʻuhulu and Pūhāwai streams flow intermittently with flowing water appearing only during significant storm events. Maʻiliʻili Stream is listed as perennial in the Hawaii Stream Assessment (NPS, 1990), but this stream is actually an interrupted stream (Timbol & Maciolek, 1978), perennial perhaps only in the upper reaches. We observed very little flow in the lower reach of Maʻiliʻili Stream despite the fact that all our sampling events occurred in the wet season.

State water quality standards pertaining to streams are given in Table 5. The criteria for temperature and pH are based on deviations from ambient conditions, so they are not entirely applicable here. Criterion for DO saturation is a minimum value and conductivity is based upon a not to exceed value. Criteria for turbidity, TSS, and nutrients are based on geometric means and values not to exceed 10% and 2% of the time.

While the recorded temperatures represent ambient conditions in the stream samples, they were clearly excessive and elevated compared with what would be expected in a flowing stream. Temperatures and salinities from an earlier survey in the lower reach of Māʻiliʻili Stream (*AECOS*, 2009) also demonstrated elevated temperatures (26.3 – 29.3°C) and salinity (4 psu). pH values regularly exceeded the state criterion of 8.0. pH values were high due to algal photosynthesis removing carbon dioxide (a weak acid in solution) from water, which increases pH in the water. High DO is an indication that this is going on. While specific conductance was not measured, it would certainly exceed the state criterion (300 µmhos/cm) as measured salinity was at least 2 psu (~

4,100 µmhos/cm) at all stream stations. Turbidity and TSS exceeded the state wet season geometric mean values of 5.00 NTU and 20 mg/L, respectively at Stas. 1 and 3.

Table 5. Selected state of Hawai'i water quality criteria for streams (HAR §11-54-5.2; HDOH, 2012).

Parameter	Geometric Mean value not to exceed this value	Value not to be exceeded more than 10% of the time	Value not to be exceeded more than 2% of the time
Total Nitrogen (µg N/l)	250.0 *180.0*	520.0 *380.0*	800.0 *600.0*
Nitrate+Nitrite (µg N/l)	70.0 *30.0*	180.0 *90.0*	300.0 *170.0*
Total Phosphorus (µg P/l)	50.0 *30.0*	100.0 *60.0*	150.0 *80.0*
Total Suspended Solids (mg/l)	20.0 *10.0*	50.0 *30.0*	80.0 *55.0*
Turbidity (NTU)	5.0 *2.0*	15.0 *5.5*	25.0 *10.0*

Top value is for "wet" season - November 1 through April 30.
Bottom value is for "dry" season - May 1 through October 31.
Other "standards":
- pH units shall not deviate more than 0.5 units from ambient and not lower than 5.5 nor higher than 8.0.
- Dissolved oxygen shall not decrease below 80% of saturation.
- Temperature shall not vary more than 1C^{o} from ambient conditions.
- Specific conductance - not more than 300 µmhos/cm.

State criteria for nitrate+nitrite, total N, and total P were exceeded by a very large margin, the only exceptions being nitrate+nitrite at Sta. 3 and nutrients recorded at Sta. 4 off the shoreline (see below). There are no state criteria for ammonia concentration in streams. The source of the exceptionally high nutrient concentrations, both nitrogen and phosphorus compounds, at Sta. 2 is not known. The concrete-line channel should minimize any groundwater input; presumably these nutrients were introduced upstream, beyond the concrete-lined channel.

Water quality at Sta. 5, from a single sampling event on March 25, appears in line with state water quality criteria for temperature, pH, but not the for DO saturation or conductivity (a salinity of 4 psu being well above 300 µmhos/cm). Sta. 6 did not meet state criteria for conductivity or pH. Turbidity, nutrient, and chlorophyll results from a single sampling event cannot be compared with state criteria based on requiring geometric means. To calculate a geometric mean at least three samples must be collected, preferably over time and under varying conditions. Nevertheless, the results for Stas. 5 and 6 give insight as to conditions pertaining at the time of sampling. Nutrients were extremely high at Sta. 5 and elevated at Sta. 6. The concentration of chlorophyll α at Sta. 6 was also very high compared with typical stream values.

The coastal waters off Lualualei watershed are classified as Class A open coastal waters (HDOH, 2012a). These coastal waters are not included in the Hawaiʻi Department of Health (HDOH) 2008/2010 list of impaired waters in Hawaiʻi, prepared under Clean Water Act §303(d) (HDOH, 2012b). State water quality standards pertaining to open coastal waters are given in Table 6. "Dry season" criteria are applied here because salinity at Sta. 4 was consistently at a typical ocean water value of 35 psu; i.e., there is no indication that water at this station was diluted by groundwater intrusion or stream outflow during the sampling events.

pH and DO saturation levels at Sta. 4 were in conformance with state criteria. Turbidity did exceed the state geometric mean criterion, but this is common in nearshore coastal waters. There are no criteria for TSS in coastal waters.

All nitrogen and chlorophyll α concentrations exceeded state geometric means. The source of the elevated nitrogen concentrations at Sta. 4 is not known. While nitrogen concentrations at Sta. 1, which drains to Sta. 4 are high, there did not appear to be enough flow in the lower reach of this stream to influence nearshore waters at Sta. 4 during our sampling events. Further, the salinity at Sta. 4 represents undiluted seawater suggesting no local groundwater intrusion.

Conclusions

Water quality conditions in the concrete-lined reaches of the three streams sampled are degraded. High temperatures, pH, DO, and salinity all indicate very poor water quality. Nutrient concentrations were very high, especially at Stas. 2 and 5. While the three metals—arsenic, lead, and zinc—were present in detectable amounts at all stations, amounts were below state acute and chronic standards for these metals. In most samples of soil or water in Hawaiʻi, metals

Table 6. Selected state of Hawaiʻi water quality criteria for open coastal waters (HAR §11-54-6; HDOH, 2012).

Parameter	Geometric Mean value not to exceed this value	Value not to be exceeded more than 10% of the time	Value not to be exceeded more than 2% of the time
Total Nitrogen	150.0	250.0	350.0
(µg N/l)	*110.0*	*180.0*	*250.0*
Ammonia	3.50	8.50	15.0
(µg N/l	2.00	5.00	9.00
Nitrate+Nitrite	5.00	14.0	25.0
(µg N/l)	*3,50*	*10.0*	*20.0*
Total Phosphorus	20.0	40.0	60.0
(µg P/l)	*16.0*	*30.0*	*45.0*
Chlorophyll	0.30	0.90	1.75
(µg/L)	0.15	0.50	1.00
Turbidity	0.50	1.25	2.00
(NTU)	*0.20*	*0.50*	*1.00*

Top value is for "wet" season which appliy when open coastal waters receive more than three million gallons per day of freshwater discharge per shoreline mile.

Bottom value is for "dry" season which apply when open coastal waters receive less than three million gallons per day of fresh water discharge per shoreline mile.

Other "standards":

- pH units shall not deviate more than 0.5 units from a value of 8.1, except at coastal locations where and freshwater from stream, stormdrain or groundwater discharge may depress the pH to a minimum level of 7.0
- Dissolved oxygen shall not decrease below 75% of saturation.
- Temperature shall not vary more than 1C^{o} from ambient conditions.
- Salinity shall not vary more than 10% from natural or seasonal changes.

will be found present in low concentrations, a natural consequence of volcanic soils. Similarly, pesticides and a herbicide found in detectable concentrations in these samples were present at levels below state acute and chronic standards for the specific compounds, with the exception of Dieldrin at Sta. 5 that exceeded the chronic standard. Chronic standards are set low based upon research data that indicate a threshold concentration that may have a chronic impact on stream life: adverse as a result of long-term exposure.

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ADDENDUM: Water Quality Station Locations:

	Lat.		Long.	
Station	Deg.	Dec Min.	Deg.	Dec Min.
1	21	25.928	158	10.252
2	21	26.440	158	9.998
3	21	26.173	158	10.035
4	21	25.747	158	10.872
5	21	25.973	158	10.003
6	21	27.074	158	9.533

Appendix A

Report of Analytical Results

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FILE No.: 1389
REPORT DATE: 03/31/14

AECOS REPORT OF ANALYTICAL RESULTS

SAMPLE TYPE: Seawater **_AECOS_ LOG No.:** 29799
DATE SAMPLED: 02/19/14 **DATE RECEIVED:** 02/19/14

Mailiili Watershed Management Plan - Lualualei

SAMPLE ID ⇨ / ANALYTE ⇩	**Station 1**	**Station 2**	**Station 3**	**Station 4**	Method / Reporting Limit/ Detection Limit	Analysis Date Analyst ID
Time Sampled:	1145	1300	1227	1430		
Temperature (°C)	30.5	35.1	34.1	26.0	SM2550B / 0.1	Field (cl, jw)
Dissolved Oxygen (mg/L)	22.86	10.31	14.00	7.49	SM4500-O G / 0.01	Field
Diss.Oxygen (% saturation)	308	152	204	112	Calculated / 1	Calculated
pH	9.44	8.72	9.16	8.05	SM4500H+/0.01	Field
Salinity (ppt)	2	4	2	35	Refractive Index / 1	Field
Turbidity (NTU)	4.70	4.78	3.04	1.99	EPA 180.1 Rev 2.0 / 0.01	02/20/14 ml
Total Suspended Solids (mg/L)	60.8	5.2	30.6	6.6	SM2540D / 0.1	02/24/14 ml
Ammonia (µg N/L)	<20	83	57	<20	EPA 350.1 / 50 / 20	02/24-25/14 ALS
Nitrate+Nitrite (µg N/L)	7870	43,500	<20	<20	EPA 353.2 / 50 / 20	03/03/14 ALS
Total Nitrogen (µg N/L)	9410	48,500	4120	1300	EPA 353.2 & ASTMD1426-93B / 400 / 160	03/04/14 ALS
Total Phosphorus (µg P/L)	463	1530	787	9 [J]	EPA 365.3 / 10 / 4	02/24/14 ALS
Chlorophyll α (µg/L)	---	---	---	0.40	SM10200 H (M) / 0.03	02/19-21/14 jw

[J] – The result is an estimated value.

Jacqueline F Mello
J. Mello, Laboratory Director

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FILE No.: 1389
REPORT DATE: 03/31/14

AECOS REPORT OF ANALYTICAL RESULTS

SAMPLE TYPE: Seawater **_AECOS_ LOG No.:** 29799

DATE SAMPLED: 02/19/14 **DATE RECEIVED:** 02/19/14

Sampled By: J. Withrow, C. Linebaugh

Mailiili Watershed Management Plan - Lualualei

SAMPLE ID ⇨ / ANALYTE ⇩	Station 1	Station 2	Station 3	Station 4	Method / Reporting Limit Detection Limit	Analysis Date Analyst ID
Arsenic (µg/L)	1.1	6.4	3.5	2.16 [J]	EPA 200.8 / 0.5	02/27/14-03/03/14 ALS
Lead (µg/L)	0.245	4.820	1.360	0.528	EPA 200.8 / 0.020	02/27/14-03/03/14 ALS
Zinc (µg/L)	1.8	17.2	8.1	0.8	EPA 200.8 / 0.5	02/27/14-03/03/14 ALS
Organochlorine Pesticides and PCBs (µg/L)	ND*	ND*	ND*	ND*	EPA 608 / refer to ALS report for K1401781	02/26/14-03/12/14 ALS
Organo-phosphorus Pesticides (µg/L)	ND*	ND*	ND*	ND*	EPA 614 / refer to ALS report for K1401781	02/26/14-03/07/14 ALS
Herbicides (µg/L)	ND*	ND* except for Dicamba 0.096 [J] [J]	ND*	ND*	EPA 8151 / refer to ALS report for K1401781	02/26/14 – 03/05/14 ALS

* Not Detected at or above limit, except as noted. Refer to ALS report for Service Request Number K1401781 for specific detection/reporting limits. [J] – The result is an estimated value.

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FILE No.: 1389
REPORT DATE: 04/10/14
PAGE: 1 of 1

AECOS REPORT OF ANALYTICAL RESULTS

SAMPLE TYPE: Seawater **_AECOS_ LOG No.:** 29811
DATE SAMPLED: 02/24/14 **DATE RECEIVED:** 02/24/14

Mailiili Watershed Management Plan - Lualualei

SAMPLE ID ⇨ / ANALYTE ⇩	Station 1	Station 2	Station 3	Station 4	Method / Reporting Limit/ Detection Limit	Analysis Date Analyst ID
Time Sampled:	1246	1330 NO WATER	1305	1356		
Temperature (°C)	30.7	---	36.4	26.7	SM2550B / 0.1	Field (cl, jw)
Dissolved Oxygen (mg/L)	18.90	---	15.98	8.58	SM4500-O G / 0.01	Field
Diss.Oxygen (% saturation)	256	---	239	130	Calculated / 1	Calculated
pH	8.70	---	8.98	8.09	SM4500H+/0.01	Field
Salinity (ppt)	2	---	4	35	Refractive Index / 1	Field
Turbidity (NTU)	4.26	---	10.4	1.62	EPA 180.1 Rev 2.0 / 0.01	02/25/14 ml
Total Suspended Solids (mg/L)	12	---	56.7	5.5	SM2540D / 0.1	02/28/14 ml
Ammonia (µg N/L)	24	---	139	8 [J]	EPA 350.1 / 10 / 3	03/07/14 ALS
Nitrate+Nitrite (µg N/L)	5620	---	30 [J]	30 [J]	EPA 353.2 / 50 / 20 (#1: 100/40)	03/12/14 ALS
Total Nitrogen (µg N/L)	7270	---	10,800	900 [J]	EPA 353.2, ASTMD1426-93B / 400 / 160	03/04/14 ALS
Total Phosphorus (µg P/L)	299	---	1560	5 [J]	EPA 365.3 / 10 / 4	02/28/14 ALS
Chlorophyll α (µg/L)	---	---	---	0.41	SM10200 H (M) / 0.03	02/24/13, 03/07/14 jw

[J] – The result is an estimated value.

J. Mello, Laboratory Director

AECOS, Inc.
45-939 Kamehameha Highway, Suite 104♦Kaneohe HI 96744
Telephone: (808)234-7770♦ Fax: (808)234-7775 ♦Email: aecos@aecos.com

CLIENT: Townscapes
900 Fort Street Mall Suite 1160
Honolulu HI 96813
ATTENTION: Bruce Tsuchida / Tina Speed 808-536-6999 ext4

FILE No.: 1389
REPORT DATE: 04/10/14
PAGE: 1 of 1

AECOS REPORT OF ANALYTICAL RESULTS

SAMPLE TYPE: Seawater | ***AECOS* LOG No.:** 29829
DATE SAMPLED: 03/03/14 | **DATE RECEIVED:** 03/03/14

Mailiili Watershed Management Plan - Lualualei

SAMPLE ID ⇨ / ANALYTE ⇩	**Station 1**	**Station 2**	**Station 3**	**Station 4**	Method / Reporting Limit/ Detection Limit	Analysis Date Analyst ID
Time Sampled:	1154	1235	1215	1312		
Temperature (°C)	23.6	26.3	26.9	24.2	SM2550B / 0.1	Field (cl, jw)
Dissolved Oxygen (mg/L)	13.19	11.62	14.70	6.62	SM4500-O G / 0.01	Field
Diss.Oxygen (% saturation)	157	148	185	96	Calculated / 1	Calculated
pH	8.78	8.14	9.00	8.05	SM4500H+/0.01	Field
Salinity (ppt)	2	5	1	35	Refractive Index / 1	Field
Turbidity (NTU)	21.4	1.46	8.60	3.32	EPA 180.1 Rev 2.0 / 0.01	03/04/14 ml
Total Suspended Solids (mg/L)	74.2	3.4	48.0	11.7	SM2540D / 0.1	03/06/14 ml
Chlorophyll α (µg/L)	---	---	---	0.68	SM10200 H (M) / 0.03	03/03-07/14 jw
Ammonia (µg N/L)	18	146	41	13	EPA 350.1 / 10 / 3	03/27/14 ALS
Nitrate+Nitrite (µg N/L)	6560	30,800	37 [J]	4190	EPA 353.2 / 50 / 20	03/24/14 ALS
Total Nitrogen (µg N/L)	8090	34,400	2420	5500	EPA 353.2 & ASTMD1426-93B / 400 / 160	03/18/14 ALS
Total Phosphorus (µg P/L)	496	2880	1690	<4	EPA 365.3 / 10 / 4 (#2&#3: 50 / 20)	03/14/14 ALS

[J] – The result is an estimated value.

Jacqueline F Mello
J. Mello, Laboratory Director

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CLIENT: Townscapes
900 Fort Street Mall Suite 1160
Honolulu HI 96813
ATTENTION: Bruce Tsuchida / Tina Speed 808-536-6999 ext4

FILE No.: 1389
REPORT DATE: 04/30/14

AECOS REPORT OF ANALYTICAL RESULTS

SAMPLE TYPE: Seawater
***AECOS* LOG No.:** 29885
DATE SAMPLED: 03/25/14
DATE RECEIVED: 03/25/14

Mailiili Watershed Management Plan - Lualualei

SAMPLE ID ⇨ / ANALYTE ⇩	**Station 6** (Confluence)	**Station 5** (Basil Farm)			Method / Reporting Limit/ Detection Limit	Analysis Date Analyst ID
Time Sampled:	1400	1445				
Temperature (°C)	32.8	22.5			SM2550B / 0.1	Field (cl, rk)
Dissolved Oxygen (mg/L)	11.80	1.74			SM4500-O G / 0.01	Field
Diss.Oxygen (% saturation)	178	20			Calculated / 1	Calculated
pH	8.87	7.69			SM4500H+/0.01	Field
Salinity (ppt)	16	4			Refractive Index / 1	Field
Turbidity (NTU)	56.8	0.72			EPA 180.1 Rev 2.0 / 0.01	03/27/14 ml
Total Suspended Solids (mg/L)	168	2.0			SM2540D / 0.1	03/31/14 ml
Chlorophyll α (μg/L)	36.7	---			SM10200 H (M) / 0.03	03/25/14, 04/06/14 cl/rk, jw
Nitrate+Nitrite (μg N/L)	52	37,300			EPA 353.2 / 50 / 20	04/11/14 ALS
Total Nitrogen (μg N/L)	5410	44,100			EPA 353.2 & ASTMD1426-93B / 800 / 320	04/01/14 ALS
Total Phosphorus (μg P/L)	206	8880			EPA 365.3 / 10 / 4	04/01/14 ALS

Jacqueline F Mello
J. Mello, Laboratory Director

AECOS, Inc.

45-939 Kamehameha Highway, Suite 104♦Kaneohe HI 96744
Telephone: (808)234-7770♦ Fax: (808)234-7775 ♦Email: aecos@aecos.com

CLIENT: Townscapes
900 Fort Street Mall Suite 1160
Honolulu HI 96813
ATTENTION: Bruce Tsuchida / Tina Speed 808-536-6999 ext4

FILE No.: 1389
REPORT DATE: 04/30/14

AECOS REPORT OF ANALYTICAL RESULTS

SAMPLE TYPE: Seawater **AECOS LOG No.:** 29885
DATE SAMPLED: 03/25/14 **DATE RECEIVED:** 03/25/14
Sampled By: C. Linebaugh, R. Knapstein
Mailiili Watershed Management Plan - Lualualei

SAMPLE ID ⇨ / ANALYTE ⇩	**Station 6** (Confluence)	**Station 5** (Basil Farm)			Method / Reporting Limit / Detection Limit	Analysis Date / Analyst ID
Arsenic (µg/L)	2.38	4.34			EPA 200.8 / 0.5 / 0.05	04/01-02/14 ALS
Lead (µg/L)	0.326	0.120			EPA 200.8 / 0.020 / 0.005	04/01-02/14 ALS
Zinc (µg/L)	5.39	13.7			EPA 200.8 / 0.5 / 0.04	04/01-02/14 ALS
Organochlorine Pesticides and PCBs (µg/L)	ND* *except as noted below*	ND* *except as noted below*			EPA 3520C/ 608 refer to ALS report for K1403135	03/31/14-04/14/14 ALS
Gamma-BHC (Lindane)	0.0042 J	---				
Heptachlor	0.0021 J	---				
Aldrin	0.0028 J	---				
Endosulfan Sulfate	0.0063 J	---				
Dieldrin	---	0.0069 J				
Organo-phosphorus Pesticides (µg/L)	ND*	ND*			EPA 614 / refer to ALS report for K1403135	03/31/14-04/08/14 ALS
Herbicides (µg/L)	ND*	ND*			EPA 8151 / refer to ALS report for K1403135	04/01/14-04/03/14 ALS

* Not Detected at or above limit, except as noted. Refer to ALS report for Service Request Number K1403135 for specific detection/reporting limits. J – The result is an estimated value.

ALS Environmental
ALS Group USA, Corp.
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F: +1 360 636 1068
www.alsglobal.com

March 14, 2014 Analytical Report for Service Request No: K1401781

Ann Mello
Aecos, Incorporated
45-939 Kamehameha Highway, Suite 104
Kaneohe, HI 96744

RE: 29799

Dear Ann:

Enclosed are the results of the samples submitted to our laboratory on February 21, 2014. For your reference, these analyses have been assigned our service request number K1401781.

Analyses were performed according to our laboratory's NELAP-approved quality assurance program. The test results meet requirements of the current NELAP standards, where applicable, and except as noted in the laboratory case narrative provided. For a specific list of NELAP-accredited analytes, refer to the certifications section at www.alsglobal.com. All results are intended to be considered in their entirety, and ALS Group USA Corp. dba ALS Environmental (ALS) is not responsible for use of less than the complete report. Results apply only to the items submitted to the laboratory for analysis and individual items (samples) analyzed, as listed in the report.

Please call if you have any questions. My extension is 3275. You may also contact me via Email at Chris.Leaf@alsglobal.com.

Respectfully submitted,

ALS Group USA Corp. dba ALS Environmental

Chris Leaf
Project Manager

CL/mj

Acronyms

ASTM	American Society for Testing and Materials
A2LA	American Association for Laboratory Accreditation
CARB	California Air Resources Board
CAS Number	Chemical Abstract Service registry Number
CFC	Chlorofluorocarbon
CFU	Colony-Forming Unit
DEC	Department of Environmental Conservation
DEQ	Department of Environmental Quality
DHS	Department of Health Services
DOE	Department of Ecology
DOH	Department of Health
EPA	U. S. Environmental Protection Agency
ELAP	Environmental Laboratory Accreditation Program
GC	Gas Chromatography
GC/MS	Gas Chromatography/Mass Spectrometry
LOD	Limit of Detection
LOQ	Limit of Quantitation
LUFT	Leaking Underground Fuel Tank
M	Modified
MCL	Maximum Contaminant Level is the highest permissible concentration of a substance allowed in drinking water as established by the USEPA.
MDL	Method Detection Limit
MPN	Most Probable Number
MRL	Method Reporting Limit
NA	Not Applicable
NC	Not Calculated
NCASI	National Council of the Paper Industry for Air and Stream Improvement
ND	Not Detected
NIOSH	National Institute for Occupational Safety and Health
PQL	Practical Quantitation Limit
RCRA	Resource Conservation and Recovery Act
SIM	Selected Ion Monitoring
TPH	Total Petroleum Hydrocarbons
tr	Trace level is the concentration of an analyte that is less than the PQL but greater than or equal to the MDL.

Inorganic Data Qualifiers

*	The result is an outlier. See case narrative.
#	The control limit criteria is not applicable. See case narrative.
B	The analyte was found in the associated method blank at a level that is significant relative to the sample result as defined by the DOD or NELAC standards.
E	The result is an estimate amount because the value exceeded the instrument calibration range.
J	The result is an estimated value.
U	The analyte was analyzed for, but was not detected ("Non-detect") at or above the MRL/MDL. *DOD-QSM 4.2 definition* : Analyte was not detected and is reported as less than the LOD or as defined by the project. The detection limit is adjusted for dilution.
i	The MRL/MDL or LOQ/LOD is elevated due to a matrix interference.
X	See case narrative.
Q	See case narrative. One or more quality control criteria was outside the limits.
H	The holding time for this test is immediately following sample collection. The samples were analyzed as soon as possible after receipt by the laboratory.

Metals Data Qualifiers

#	The control limit criteria is not applicable. See case narrative.
J	The result is an estimated value.
E	The percent difference for the serial dilution was greater than 10%, indicating a possible matrix interference in the sample.
M	The duplicate injection precision was not met.
N	The Matrix Spike sample recovery is not within control limits. See case narrative.
S	The reported value was determined by the Method of Standard Additions (MSA).
U	The analyte was analyzed for, but was not detected ("Non-detect") at or above the MRL/MDL. *DOD-QSM 4.2 definition* : Analyte was not detected and is reported as less than the LOD or as defined by the project. The detection limit is adjusted for dilution.
W	The post-digestion spike for furnace AA analysis is out of control limits, while sample absorbance is less than 50% of spike absorbance.
i	The MRL/MDL or LOQ/LOD is elevated due to a matrix interference.
X	See case narrative.
+	The correlation coefficient for the MSA is less than 0.995.
Q	See case narrative. One or more quality control criteria was outside the limits.

Organic Data Qualifiers

*	The result is an outlier. See case narrative.
#	The control limit criteria is not applicable. See case narrative.
A	A tentatively identified compound, a suspected aldol-condensation product.
B	The analyte was found in the associated method blank at a level that is significant relative to the sample result as defined by the DOD or NELAC standards.
C	The analyte was qualitatively confirmed using GC/MS techniques, pattern recognition, or by comparing to historical data.
D	The reported result is from a dilution.
E	The result is an estimated value.
J	The result is an estimated value.
N	The result is presumptive. The analyte was tentatively identified, but a confirmation analysis was not performed.
P	The GC or HPLC confirmation criteria was exceeded. The relative percent difference is greater than 40% between the two analytical results.
U	The analyte was analyzed for, but was not detected ("Non-detect") at or above the MRL/MDL. *DOD-QSM 4.2 definition* : Analyte was not detected and is reported as less than the LOD or as defined by the project. The detection limit is adjusted for dilution.
i	The MRL/MDL or LOQ/LOD is elevated due to a chromatographic interference.
X	See case narrative.
Q	See case narrative. One or more quality control criteria was outside the limits.

Additional Petroleum Hydrocarbon Specific Qualifiers

F	The chromatographic fingerprint of the sample matches the elution pattern of the calibration standard.
L	The chromatographic fingerprint of the sample resembles a petroleum product, but the elution pattern indicates the presence of a greater amount of lighter molecular weight constituents than the calibration standard.
H	The chromatographic fingerprint of the sample resembles a petroleum product, but the elution pattern indicates the presence of a greater amount of heavier molecular weight constituents than the calibration standard.
O	The chromatographic fingerprint of the sample resembles an oil, but does not match the calibration standard.
Y	The chromatographic fingerprint of the sample resembles a petroleum product eluting in approximately the correct carbon range, but the elution pattern does not match the calibration standard.
Z	The chromatographic fingerprint does not resemble a petroleum product.

ALS Group USA Corp. dba ALS Environmental (ALS) - Kelso
State Certifications, Accreditations, and Licenses

Agency	Web Site	Number
Alaska DEC UST	http://dec.alaska.gov/applications/eh/ehllabreports/USTLabs.aspx	UST-040
Arizona DHS	http://www.azdhs.gov/lab/license/env.htm	AZ0339
Arkansas - DEQ	http://www.adeq.state.ar.us/techsvs/labcert.htm	88-0637
California DHS (ELAP)	http://www.cdph.ca.gov/certlic/labs/Pages/ELAP.aspx	2286
DOD ELAP	http://www.denix.osd.mil/edqw/Accreditation/AccreditedLabs.cfm	L12-28
Florida DOH	http://www.doh.state.fl.us/lab/EnvLabCert/WaterCert.htm	E87412
Georgia DNR	http://www.gaepd.org/Documents/techguide_pcb.html#cel	881
Hawaii DOH	Not available	-
Idaho DHW	http://www.healthandwelfare.idaho.gov/Health/Labs/CertificationDrinkingWaterLabs/tabid/1833/Default.aspx	-
Indiana DOH	http://www.in.gov/isdh/24859.htm	C-WA-01
ISO 17025	http://www.pjlabs.com/	L12-27
Louisiana DEQ	http://www.deq.louisiana.gov/portal/DIVISIONS/PublicParticipationandPermitSupport/LouisianaLaboratoryAccreditationProgram.aspx	3016
Maine DHS	Not available	WA0035
Michigan DEQ	http://www.michigan.gov/deq/0,1607,7-135-3307_4131_4156---,00.html	9949
Minnesota DOH	http://www.health.state.mn.us/accreditation	053-999-368
Montana DPHHS	http://www.dphhs.mt.gov/publichealth/	CERT0047
Nevada DEP	http://ndep.nv.gov/bsdw/labservice.htm	WA35
New Jersey DEP	http://www.nj.gov/dep/oqa/	WA005
North Carolina DWQ	http://www.dwqlab.org/	605
Oklahoma DEQ	http://www.deq.state.ok.us/CSDnew/labcert.htm	9801
Oregon – DEQ (NELAP)	http://public.health.oregon.gov/LaboratoryServices/EnvironmentalLaboratoryAccreditation/Pages/index.aspx	WA200001
South Carolina DHEC	http://www.scdhec.gov/environment/envserv/	61002
Texas CEQ	http://www.tceq.texas.gov/field/qa/env_lab_accreditation.html	[illegible]704427-08-TX
Washington DOE	http://www.ecy.wa.gov/programs/eap/labs/lab-accreditation.html	C1203
Wisconsin DNR	http://dnr.wi.gov/	998386840
Wyoming (EPA Region 8)	http://www.epa.gov/region8/water/dwhome/wyomingdi.html	-
Kelso Laboratory Website	www.alsglobal.com	NA

Analyses were performed according to our laboratory's NELAP-approved quality assurance program. A complete listing of specific NELAP-certified analytes, can be found in the certification section at www.caslab.com or at the accreditation bodies web site
Please refer to the certification and/or accreditation body's web site if samples are submitted for compliance purposes. The states highlighted above, require the analysis be listed on the state certification if used for compliance purposes and if the method/anlayte is offered by that state.

ALS ENVIRONMENTAL

Client:	Aecos, Incorporated	**Service Request No.:**	K1401781
Project:	29799	**Date Received:**	02/21/14
Sample Matrix:	Water and Ocean Water		

Case Narrative

All analyses were performed consistent with the quality assurance program of ALS Environmental. This report contains analytical results for samples designated for Tier II data deliverables. When appropriate to the method, method blank results have been reported with each analytical test. Surrogate recoveries have been reported for all applicable organic analyses. Additional quality control analyses reported herein include: Laboratory Duplicate (DUP), Matrix Spike (MS), Matrix/Duplicate Matrix Spike (MS/DMS), Laboratory Control Sample (LCS), and Laboratory/Duplicate Laboratory Control Sample (LCS/DLCS).

Sample Receipt

Four samples were received for analysis at ALS Environmental on 02/21/14. The samples were received in good condition and consistent with the accompanying chain of custody form, except where noted on the cooler receipt and preservation form included in this report. The samples were stored in a refrigerator at 4ºC upon receipt at the laboratory.

General Chemistry Parameters

No anomalies associated with the analysis of these samples were observed.

Total Metals

Elevated Detection Limits:
Sample 4 required a 20 fold dilution for analysis by EPA Method 200.8 do to high levels of Total Dissolved Solids (TDS). The detection limits were elevated accordingly.

No other anomalies associated with the analysis of these samples were observed.

Organochlorine Pesticides and PCBs by EPA Method 608

Elevated Detection Limits:
The detection limit was elevated for gamma-BHC (Lindane) in most sample. The chromatogram indicated the presence of non-target background components. The matrix interference prevented adequate resolution of the target compound at the normal limit. The result was flagged to indicate the matrix interference.

No other anomalies associated with the analysis of these samples were observed.

Organophosphorus Pesticides by EPA Method 614

Relative Percent Difference Exceptions:
The Relative Percent Difference (RPD) for Demeton-O,S in the replicate Laboratory Control Sample (LCS) analyses (LCS KWG1401560-1 and DLCS KWG1401560-2) was outside control criteria. All spike recoveries were within acceptance limits, indicating the analytical batch was in control. No further corrective action was appropriate.

No other anomalies associated with the analysis of these samples were observed.

Approved by______________________________

Chlorinated Herbicides by EPA Method 8151

Elevated Detection Limits:
The detection limit was elevated for a few analytes in the samples. The chromatogram indicated the presence of non-target background components. The matrix interference prevented adequate resolution of the target compounds at the normal limit. The results were flagged to indicate the matrix interference.

No other anomalies associated with the analysis of these samples were observed.

Approved by______________________________

K1401101

SUB-- CHAIN OF CUSTODY FORM

AECOS, Inc.

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Kaneohe, Oahu, HI 96744
Tel: (808) 234-7770 Fax: 234-7775

PROJECT FILE No.

LOG NUMBER [29799]

pg 1 of 2

CLIENT: AECOS INC.

ADDRESS:

CONTACT: SNOOKIE MELLO

PHONE No.: ☎ (808)234-7770

Purchase Order No.:

☐ RUSH

☐ SEE REVERSE

SPECIAL INSTRUCTIONS

	☑	SAMPLE ID	SAMPLED DATE	SAMPLED TIME	SAMPLE TYPE	CONTAINER(S)		REQUESTED ANALYSES	PRESERVATION
1		1	2/19/14	1145	stream	1	250ml poly	NO3NO2, TN, TP	H2SO4
2		↓	↓	↓	↓	1	500ml poly	Arsenic, Lead, Zinc	
3		↓	↓	↓	↓	2	1L amber glass	EPA608 (Organochlorine pesticides)	0
4		↓	↓	↓	↓	2	↓	EPA614 (organophosphorus pest.)	0
5		↓	↓	↓	↓	2	↓	Herbicides 8151	0
6		2	↓	1300	Stream	1	250ml poly	NO3NO2, TN, TP	H2SO4
7		↓	↓	↓	↓	1	500ml poly	Arsenic, Lead, Zinc	
8		↓	↓	↓	↓	2	1L amber glass	EPA608 (organochlorine Pesticides)	0
9		↓	↓	↓	↓	2	↓	EPA 614 (Organophosphorus pest.)	0
10		↓	↓	↓	↓	2	↓	Herbicides 8151	0

CLIENTS PROVIDING SAMPLES TO THE LABORATORY SHOULD COMPLETE AS MUCH OF THE ABOVE FORM AS POSSIBLE. NOTE: NAME AND DATED SIGNATURE OF PERSON COLLECTING THE SAMPLE MUST BE ENTERED BELOW ↓. INFORMATION REQUESTED IN SHADED BOXES ABOVE TO BE FILLED IN BY THE LABORATORY.

SAMPLED BY: Chad Linebaugh, Jessica Withrow DATE 2/19 2014
PRINT NAME

RELINQUISHED: DATE 2/19 2014
SIGNATURE [signature] TIME 1650

RECEIVED BY: DATE 2/19 2014
SIGNATURE [signature] TIME 1650

RELINQUISHED: DATE 2/20 2014
SIGNATURE OR INITIALS [signature] TIME NOON

RECEIVED FOR LABORATORY: DATE 2/21 2014
SIGNATURE [signature] TIME 0940

RELINQUISHED: DATE 20___
SIGNATURE OR INITIALS TIME

COMMENTS:

PRECAUTIONS:

DISPOSAL:

USE (BLACK) INK

RETURN SAMPLE TO CLIENT ☐

B1401781

AECOS, Inc.

45-939 Kamehameha Highway Suite 104
Kaneohe, Oahu, HI 96744
Tel: (808) 234-7770 Fax: 234-7775

SUB-- CHAIN OF CUSTODY FORM

PROJECT FILE No.:

LOG NUMBER [29799]

pg 2 of 2

CLIENT: AECOS INC.

ADDRESS:

CONTACT: SNOOKIE MELLO

PHONE No.: ☎ (808)234-7770

Purchase Order No.:

☐ RUSH

☐ SEE REVERSE

SPECIAL INSTRUCTIONS

	☑	SAMPLE ID	SAMPLED DATE	SAMPLED TIME	SAMPLE TYPE	CONTAINER(S)		REQUESTED ANALYSES	PRESERVATION
1		3	2/19/14	1227	Stream	1	250ml poly	NO3NO2, TN, TP	H2SO4
2		↓	↓	↓	↓	1	500ml poly	Arsenic, Lead, Zinc	
3		↓	↓	↓	↓	2	1L amber glass	EPA608 (Organochlorine pesticides)	0
4		↓	↓	↓	↓	2	↓	EPA614 (organophosphorus pest.)	0
5		↓	↓	↓	↓	2	↓	Herbicides 8151	0
6		4	↓	1430	seawater	1	250ml poly	NH3, NO3NO2, TN, TP	H2SO4
7		↓	↓	↓	↓	1	500ml poly	Arsenic, Lead, Zinc	
8		↓	↓	↓	↓	2	1L amber glass	EPA608 (organochlorine Pesticides)	0
9		↓	↓	↓	↓	2	↓	EPA 614 (Organophosphorus pest.)	0
10		↓	↓	↓	↓	2	↓	Herbicides 8151	0

CLIENTS PROVIDING SAMPLES TO THE LABORATORY SHOULD COMPLETE AS MUCH OF THE ABOVE FORM AS POSSIBLE. NOTE: NAME AND DATED SIGNATURE OF PERSON COLLECTING THE SAMPLE MUST BE ENTERED BELOW ↓. INFORMATION REQUESTED IN SHADED BOXES ABOVE TO BE FILLED IN BY THE LABORATORY.

SAMPLED BY: Chad Linebaugh, Jessica Withrow — DATE 2/19 2014
PRINT NAME

RELINQUISHED: [signature] — DATE 2/19 2014 — TIME 1650
SIGNATURE

RECEIVED BY: [signature] — DATE 2/19 2014 — TIME 1650
SIGNATURE

RELINQUISHED: [signature] — DATE 2/20 2014 — TIME Noon
SIGNATURE OR INITIALS

RECEIVED FOR LABORATORY: [signature] — DATE 2/21 2014 — TIME 0940
SIGNATURE

RELINQUISHED: — DATE — 20__ — TIME
SIGNATURE OR INITIALS

COMMENTS:

PRECAUTIONS:

DISPOSAL:

USE (BLACK) INK

RETURN SAMPLE TO CLIENT ☐

PC Ch

Cooler Receipt and Preservation Form

Client / Project: Aecos Service Request K14 01781

Received: 2/21/14 Opened: 2/21/14 By: ccc Unloaded: 2/21/14 By: ccc

1. Samples were received via? *Mail* *(Fed Ex)* *UPS* *DHL* *PDX* *Courier* *Hand Delivered*
2. Samples were received in: (circle) *(Cooler)* *Box* *Envelope* *Other* ______ *NA*
3. Were custody seals on coolers? NA Y (N) If yes, how many and where? ______
   If present, were custody seals intact? Y N If present, were they signed and dated? Y N

Raw Cooler Temp	Corrected. Cooler Temp	Raw Temp Blank	Corrected Temp Blank	Corr. Factor	Thermometer ID	Cooler/COC ID (NA)	Tracking Number	NA	Filed
5.3	5.2	—	—	-0.1	341		7979 8468 1710		
5.8	5.6	—	—	-0.2	337		7979 8468 2153		

4. Packing material: *Inserts* *Baggies* *(Bubble Wrap)* *(Gel Packs)* *Wet Ice* *Dry Ice* *Sleeves* Newspaper
5. Were custody papers properly filled out (ink, signed, etc.)? NA (Y) N
6. Did all bottles arrive in good condition (unbroken)? *Indicate in the table below.* NA (Y) N
7. Were all sample labels complete (i.e analysis, preservation, etc.)? NA (Y) N
8. Did all sample labels and tags agree with custody papers? *Indicate major discrepancies in the table on page 2.* NA (Y) N
9. Were appropriate bottles/containers and volumes received for the tests indicated? NA (Y) N
10. Were the pH-preserved bottles (*see SMO GEN SOP*) received at the appropriate pH? *Indicate in the table below* NA Y (N)
11. Were VOA vials received without headspace? *Indicate in the table below.* (NA) Y N
12. Was C12/Res negative? NA (Y) N

Sample ID on Bottle	Sample ID on COC	Identified by:

Sample ID	Bottle Count Bottle Type	Out of Temp	Head-space	Broke	pH	Reagent	Volume added	Reagent Lot Number	Initials	Time
1	1 metals				✓	HNO_3	1 ml	RE1-23 Q	ccc	1535
2	⎮				✓	⎮	⎮	⎮	⎮	⎮
3	⎮				✓	⎮	⎮	⎮	⎮	⎮
4	⎮				✓	⎮	⎮	⎮	⎮	⎮

Notes, Discrepancies, & Resolutions: ______

Page ____ *of* ____

ALS Group USA, Corp.
dba ALS Environmental

Analytical Report

Client:	Aecos, Incorporated	**Service Request:**	K1401781
Project:	29799	**Date Collected:**	02/19/14
Sample Matrix:	Water	**Date Received:**	02/21/14
Analysis Method:	350.1	**Units:**	mg/L
Prep Method:	Method	**Basis:**	NA

Ammonia as Nitrogen

Sample Name	Lab Code	Result		MRL	MDL	Dil.	Date Analyzed	Date Extracted	Q
1	K1401781-001	ND	U	0.050	0.020	1	02/24/14 15:49	2/25/14	
2	K1401781-002	**0.083**		0.050	0.020	1	02/24/14 15:49	2/25/14	
3	K1401781-003	**0.057**		0.050	0.020	1	02/24/14 15:49	2/25/14	
Method Blank	K1401781-MB	ND	U	0.050	0.020	1	02/24/14 15:49	2/25/14	

ALS Group USA, Corp.
dba ALS Environmental

Analytical Report

Client:	Aecos, Incorporated	**Service Request:**	K1401781
Project:	29799	**Date Collected:**	02/19/14
Sample Matrix:	Ocean Water	**Date Received:**	02/21/14
Analysis Method:	350.1	**Units:**	mg/L
Prep Method:	Method	**Basis:**	NA

Ammonia as Nitrogen

Sample Name	Lab Code	Result	MRL	MDL	Dil.	Date Analyzed	Date Extracted	Q
4	K1401781-004	ND U	0.050	0.020	1	02/24/14 15:49	2/25/14	

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ALS Group USA, Corp.

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QA/QC Report

Client:	Aecos, Incorporated	**Service Request:**	K1401781
Project	29799	**Date Collected:**	02/19/14
Sample Matrix:	Ocean Water	**Date Received:**	02/21/14
		Date Analyzed:	02/24/14

Replicate Sample Summary
General Chemistry Parameters

Sample Name:	4	**Units:**	mg/L
Lab Code:	K1401781-004	**Basis:**	NA

Analyte Name	Analysis Method	MRL	MDL	Sample Result	Duplicate Sample K1401781-004DUP Result	Average	RPD	RPD Limit
Ammonia as Nitrogen	350.1	0.050	0.020	ND	ND	NC	NC	20

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Percent recoveries and relative percent differences (RPD) are determined by the software using values in the calculation which have not been rounded.

ALS Group USA, Corp.
dba ALS Environmental

QA/QC Report

Client:	Aecos, Incorporated	**Service Request:**	K1401781
Project:	29799	**Date Collected:**	02/19/14
Sample Matrix:	Ocean Water	**Date Received:**	02/21/14
		Date Analyzed:	02/24/14
		Date Extracted:	02/25/14

Duplicate Matrix Spike Summary
Ammonia as Nitrogen

Sample Name:	4	**Units:**	mg/L
Lab Code:	K1401781-004	**Basis:**	NA
Analysis Method:	350.1		
Prep Method:	Method		

		Matrix Spike K1401781-004MS			Duplicate Matrix Spike K1401781-004DMS					
Analyte Name	**Sample Result**	**Result**	**Spike Amount**	**% Rec**	**Result**	**Spike Amount**	**% Rec**	**% Rec Limits**	**RPD**	**RPD Limit**
Ammonia as Nitrogen	ND U	2.08	2.00	104	2.09	2.00	105	90-110	<1	20

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Printed 3/11/2014 10:14:39 AM Superset Reference:14-0000279911 rev 00

Client:	Aecos, Incorporated	**Service Request:**	K1401781
Project:	29799	**Date Analyzed:**	02/24/14
Sample Matrix:	Water	**Date Extracted:**	02/25/14

Lab Control Sample Summary
Ammonia as Nitrogen

Analysis Method:	350.1	**Units:**	mg/L
Prep Method:	Method	**Basis:**	NA
		Analysis Lot:	381335

Sample Name	Lab Code	Result	Spike Amount	% Rec	% Rec Limits
Lab Control Sample	K1401781-LCS	10.3	10.9	94	90-110

ALS Group USA, Corp.
dba ALS Environmental

Analytical Report

Client:	Aecos, Incorporated	**Service Request:**	K1401781
Project:	29799	**Date Collected:**	02/19/14
Sample Matrix:	Water	**Date Received:**	02/21/14
Analysis Method:	353.2	**Units:**	mg/L
Prep Method:	Method	**Basis:**	NA

Nitrate+Nitrite as Nitrogen

Sample Name	Lab Code	Result	MRL	MDL	Dil.	Date Analyzed	Date Extracted	Q
1	K1401781-001	**7.87**	0.50	0.20	10	03/03/14 16:27	3/3/14	
2	K1401781-002	**43.5**	2.5	1.0	50	03/03/14 16:27	3/3/14	
3	K1401781-003	ND U	0.050	0.020	1	03/03/14 16:27	3/3/14	
Method Blank	K1401781-MB	ND U	0.050	0.020	1	03/03/14 16:27	3/3/14	

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dba ALS Environmental

Analytical Report

Client:	Aecos, Incorporated		**Service Request:**	K1401781
Project:	29799		**Date Collected:**	02/19/14
Sample Matrix:	Ocean Water		**Date Received:**	02/21/14
Analysis Method:	353.2		**Units:**	mg/L
Prep Method:	Method		**Basis:**	NA

Nitrate+Nitrite as Nitrogen

Sample Name	Lab Code	Result	MRL	MDL	Dil.	Date Analyzed	Date Extracted	Q
4	K1401781-004	ND U	0.050	0.020	1	03/03/14 16:27	3/3/14	

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QA/QC Report

Client:	Aecos, Incorporated	**Service Request:**	K1401781
Project	29799	**Date Collected:**	02/19/14
Sample Matrix:	Water	**Date Received:**	02/21/14
		Date Analyzed:	03/03/14

Replicate Sample Summary
General Chemistry Parameters

Sample Name:	3	**Units:**	mg/L
Lab Code:	K1401781-003	**Basis:**	NA

Analyte Name	Analysis Method	MRL	MDL	Sample Result	Duplicate Sample K1401781-003DUP Result	Average	RPD	RPD Limit
Nitrate+Nitrite as Nitrogen	353.2	0.050	0.020	ND	ND	NC	NC	20

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Printed 3/11/2014 10:14:40 AM Superset Reference:14-0000279911 rev 00

Client:	Aecos, Incorporated	**Service Request:**	K1401781
Project:	29799	**Date Collected:**	02/19/14
Sample Matrix:	Water	**Date Received:**	02/21/14
		Date Analyzed:	03/3/14
		Date Extracted:	03/3/14

Duplicate Matrix Spike Summary
Nitrate+Nitrite as Nitrogen

Sample Name:	3	**Units:**	mg/L
Lab Code:	K1401781-003	**Basis:**	NA
Analysis Method:	353.2		
Prep Method:	Method		

		Matrix Spike K1401781-003MS			Duplicate Matrix Spike K1401781-003DMS					
Analyte Name	**Sample Result**	**Result**	**Spike Amount**	**% Rec**	**Result**	**Spike Amount**	**% Rec**	**% Rec Limits**	**RPD**	**RPD Limit**
Nitrate+Nitrite as Nitrogen	ND U	1.02	1.00	102	1.02	1.00	102	89-114	<1	20

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ALS Group USA, Corp.
dba ALS Environmental

QA/QC Report

Client:	Aecos, Incorporated	**Service Request:**	K1401781
Project:	29799	**Date Analyzed:**	03/03/14
Sample Matrix:	Water	**Date Extracted:**	03/03/14

Lab Control Sample Summary
Nitrate+Nitrite as Nitrogen

Analysis Method:	353.2	**Units:**	mg/L
Prep Method:	Method	**Basis:**	NA
		Analysis Lot:	382237

Sample Name	Lab Code	Result	Spike Amount	% Rec	% Rec Limits
Lab Control Sample	K1401781-LCS	4.35	4.35	100	90-110

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Analytical Report

Client:	Aecos, Incorporated	**Service Request:**	K1401781
Project:	29799	**Date Collected:**	02/19/14
Sample Matrix:	Water	**Date Received:**	02/21/14
Analysis Method:	365.3	**Units:**	mg/L
Prep Method:	Method	**Basis:**	NA

Phosphorus, Total

Sample Name	Lab Code	Result	MRL	MDL	Dil.	Date Analyzed	Date Extracted	Q
1	K1401781-001	**0.463**	0.010	0.004	1	02/24/14 15:50	2/24/14	
2	K1401781-002	**1.53**	0.050	0.020	5	02/24/14 15:50	2/24/14	
3	K1401781-003	**0.787**	0.010	0.004	1	02/24/14 15:50	2/24/14	
Method Blank	K1401781-MB	ND U	0.010	0.004	1	02/24/14 15:50	2/24/14	

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Analytical Report

Client:	Aecos, Incorporated	**Service Request:**	K1401781
Project:	29799	**Date Collected:**	02/19/14
Sample Matrix:	Ocean Water	**Date Received:**	02/21/14
Analysis Method:	365.3	**Units:**	mg/L
Prep Method:	Method	**Basis:**	NA

Phosphorus, Total

Sample Name	Lab Code	Result	MRL	MDL	Dil.	Date Analyzed	Date Extracted	Q
4	K1401781-004	**0.009 J**	0.010	0.004	1	02/24/14 15:50	2/24/14	

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QA/QC Report

Client:	Aecos, Incorporated	**Service Request:**	K1401781
Project	29799	**Date Collected:**	NA
Sample Matrix:	Water	**Date Received:**	NA
		Date Analyzed:	02/24/14

Replicate Sample Summary
General Chemistry Parameters

Sample Name:	Batch QC	**Units:**	mg/L
Lab Code:	K1401716-001	**Basis:**	NA

Analyte Name	Analysis Method	MRL	MDL	Sample Result	Duplicate Sample K1401716-001DUP Result	Average	RPD	RPD Limit
Phosphorus, Total	365.3	0.010	0.004	0.275	0.299	0.287	8	20

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QA/QC Report

Client:	Aecos, Incorporated	**Service Request:**	K1401781
Project:	29799	**Date Collected:**	N/A
Sample Matrix:	Water	**Date Received:**	N/A
		Date Analyzed:	02/24/14
		Date Extracted:	02/24/14

Duplicate Matrix Spike Summary
Phosphorus, Total

Sample Name:	Batch QC	**Units:**	mg/L
Lab Code:	K1401716-001	**Basis:**	NA
Analysis Method:	365.3		
Prep Method:	Method		

		Matrix Spike K1401716-001MS			Duplicate Matrix Spike K1401716-001DMS					
Analyte Name	**Sample Result**	**Result**	**Spike Amount**	**% Rec**	**Result**	**Spike Amount**	**% Rec**	**% Rec Limits**	**RPD**	**RPD Limit**
Phosphorus, Total	0.275	0.837	0.500	112	0.827	0.500	110	60-135	2	20

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QA/QC Report

Client:	Aecos, Incorporated	**Service Request:**	K1401781
Project:	29799	**Date Analyzed:**	02/24/14
Sample Matrix:	Water	**Date Extracted:**	02/24/14

Lab Control Sample Summary
Phosphorus, Total

Analysis Method:	365.3	**Units:**	mg/L
Prep Method:	Method	**Basis:**	NA
		Analysis Lot:	381267

Sample Name	Lab Code	Result	Spike Amount	% Rec	% Rec Limits
Lab Control Sample	K1401781-LCS	3.44	3.46	99	85-115

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Analytical Report

Client:	Aecos, Incorporated	**Service Request:**	K1401781
Project:	29799	**Date Collected:**	02/19/14
Sample Matrix:	Water	**Date Received:**	02/21/14
Analysis Method:	ASTM D1426-93B	**Units:**	mg/L
Prep Method:	ASTM D3590-89B-21.1 Mod	**Basis:**	NA

Nitrogen, Total Kjeldahl (TKN)

Sample Name	Lab Code	Result	MRL	MDL	Dil.	Date Analyzed	Date Extracted	Q
1	K1401781-001	**1.54**	0.40	0.16	2	03/04/14 09:00	3/3/14	
2	K1401781-002	**4.96**	0.40	0.16	2	03/04/14 09:00	3/3/14	
3	K1401781-003	**4.12**	0.40	0.16	2	03/04/14 09:00	3/3/14	
Method Blank	K1401781-MB	ND U	0.20	0.16	2	03/04/14 09:00	3/3/14	

Client:	Aecos, Incorporated	**Service Request:**	K1401781
Project:	29799	**Date Collected:**	02/19/14
Sample Matrix:	Ocean Water	**Date Received:**	02/21/14
Analysis Method:	ASTM D1426-93B	**Units:**	mg/L
Prep Method:	ASTM D3590-89B-21.1 Mod	**Basis:**	NA

Nitrogen, Total Kjeldahl (TKN)

Sample Name	Lab Code	Result	MRL	MDL	Dil.	Date Analyzed	Date Extracted	Q
4	K1401781-004	**1.3**	1.0	0.4	2	03/04/14 09:00	3/3/14	

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QA/QC Report

Client:	Aecos, Incorporated	**Service Request:**	K1401781
Project	29799	**Date Collected:**	02/19/14
Sample Matrix:	Water	**Date Received:**	02/21/14
		Date Analyzed:	03/04/14

Replicate Sample Summary
General Chemistry Parameters

Sample Name:	1	**Units:**	mg/L
Lab Code:	K1401781-001	**Basis:**	NA

Analyte Name	Analysis Method	MRL	MDL	Sample Result	Duplicate Sample K1401781-001DUP Result	Average	RPD	RPD Limit
Nitrogen, Total Kjeldahl (TKN)	ASTM D1426-93B	0.40	0.16	1.54	1.60	1.57	4	20

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Client:	Aecos, Incorporated	**Service Request:**	K1401781
Project:	29799	**Date Collected:**	02/19/14
Sample Matrix:	Water	**Date Received:**	02/21/14
		Date Analyzed:	03/4/14
		Date Extracted:	03/3/14

Duplicate Matrix Spike Summary
Nitrogen, Total Kjeldahl (TKN)

Sample Name:	1	**Units:**	mg/L
Lab Code:	K1401781-001	**Basis:**	NA
Analysis Method:	ASTM D1426-93B		
Prep Method:	ASTM D 3590-89B-21.1		

		Matrix Spike K1401781-001MS			**Duplicate Matrix Spike** K1401781-001DMS					
Analyte Name	**Sample Result**	**Result**	**Spike Amount**	**% Rec**	**Result**	**Spike Amount**	**% Rec**	**% Rec Limits**	**RPD**	**RPD Limit**
Nitrogen, Total Kjeldahl (TKN)	1.54	18.6	20.0	86	37.0	40.0	89	53-160	3	20

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Client:	Aecos, Incorporated	**Service Request:**	K1401781
Project:	29799	**Date Analyzed:**	03/04/14
Sample Matrix:	Water	**Date Extracted:**	03/03/14

Lab Control Sample Summary
Nitrogen, Total Kjeldahl (TKN)

Analysis Method:	ASTM D1426-93B	**Units:**	mg/L
Prep Method:	ASTM D 3590-89B-21.1	**Basis:**	NA
		Analysis Lot:	382332

Sample Name	Lab Code	Result	Spike Amount	% Rec	% Rec Limits
Lab Control Sample	K1401781-LCS	8.48	9.08	93	72-129

ALS Group USA, Corp.
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Analytical Report

Client:	Aecos, Incorporated		**Service Request:**	K1401781
Project:	29799		**Date Collected:**	2/19/2014
Sample Matrix:	Water		**Date Received:**	2/21/2014

Nitrogen, Total as Nitrogen

Prep Method:	NONE		Units:	mg/L
Analysis Method:	353.2/ASTM D1426-93B		Basis:	NA
Test Notes:				

Sample Name	Lab Code	MRL	MDL	Dilution Factor	Date Extracted	Date Analyzed	Result	Result Notes
1	K1401781-001	0.40	0.16	2	NA	3/4/2014	9.41	
2	K1401781-002	0.40	0.16	2	NA	3/4/2014	48.5	
3	K1401781-003	0.40	0.16	2	NA	3/4/2014	4.12	

ALS Group USA, Corp.
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Analytical Report

Client:	Aecos, Incorporated	**Service Request:**	K1401781
Project:	29799	**Date Collected:**	2/19/2014
Sample Matrix:	Ocean water	**Date Received:**	2/21/2014

Nitrogen, Total as Nitrogen

Prep Method:	NONE	Units:	mg/L
Analysis Method:	353.2/ASTM D1426-93B	Basis:	NA
Test Notes:			

Sample Name	Lab Code	MRL	MDL	Dilution Factor	Date Extracted	Date Analyzed	Result	Result Notes
4	K1401781-004	1.0	0.4	2	NA	3/4/2014	1.3	

ALS Group USA, Corp.
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Analytical Report

Client:	Aecos, Incorporated	**Service Request:**	K1401781
Project:	29799	**Date Collected:**	02/19/14
Sample Matrix:	Water	**Date Received:**	02/21/14
Analysis Method:	NCASI TNTP-W10900	**Units:**	mg/L
Prep Method:	Method	**Basis:**	NA

Nitrogen, Total as Nitrogen

Sample Name	Lab Code	Result	MRL	MDL	Dil.	Date Analyzed	Date Extracted	Q
1	K1401781-001	**8.0**	1.0	0.4	2	03/10/14 13:00	3/4/14	
2	K1401781-002	**43**	13	5	25	03/10/14 13:00	3/4/14	
3	K1401781-003	**4.85**	0.50	0.20	1	03/10/14 13:00	3/4/14	
Method Blank	K1401781-MB	ND U	0.50	0.20	1	03/10/14 13:00	3/4/14	

Analytical Report

Client:	Aecos, Incorporated	**Service Request:**	K1401781
Project:	29799	**Date Collected:**	02/19/14
Sample Matrix:	Ocean Water	**Date Received:**	02/21/14
Analysis Method:	NCASI TNTP-W10900	**Units:**	mg/L
Prep Method:	Method	**Basis:**	NA

Nitrogen, Total as Nitrogen

Sample Name	Lab Code	Result	MRL	MDL	Dil.	Date Analyzed	Date Extracted	Q
4	K1401781-004	**0.55**	0.50	0.20	1	03/10/14 13:00	3/4/14	

ALS Group USA, Corp.
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QA/QC Report

Client:	Aecos, Incorporated	**Service Request:**	K1401781
Project	29799	**Date Collected:**	NA
Sample Matrix:	Water	**Date Received:**	NA
		Date Analyzed:	03/10/14

Replicate Sample Summary
General Chemistry Parameters

Sample Name:	Batch QC	**Units:**	mg/L
Lab Code:	K1401491-001	**Basis:**	NA

Analyte Name	Analysis Method	MRL	MDL	Sample Result	Duplicate Sample K1401491-001DUP Result	Average	RPD	RPD Limit
Nitrogen, Total as Nitrogen	NCASI TNTP-W10900	0.50	0.20	ND	ND	NC	NC	20

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ALS Group USA, Corp.
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QA/QC Report

Client:	Aecos, Incorporated	**Service Request:**	K1401781
Project:	29799	**Date Collected:**	N/A
Sample Matrix:	Water	**Date Received:**	N/A
		Date Analyzed:	03/10/14
		Date Extracted:	03/4/14

Duplicate Matrix Spike Summary
Nitrogen, Total as Nitrogen

Sample Name:	Batch QC	**Units:**	mg/L
Lab Code:	K1401491-001	**Basis:**	NA
Analysis Method:	NCASI TNTP-W10900		
Prep Method:	Method		

		Matrix Spike			**Duplicate Matrix Spike**					
		K1401491-001MS			K1401491-001DMS					
Analyte Name	**Sample Result**	**Result**	**Spike Amount**	**% Rec**	**Result**	**Spike Amount**	**% Rec**	**% Rec Limits**	**RPD**	**RPD Limit**
Nitrogen, Total as Nitrogen	ND U	1.85	2.00	93	1.88	2.00	94	75-125	1	20

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ALS Group USA, Corp.
dba ALS Environmental

QA/QC Report

Client:	Aecos, Incorporated	**Service Request:**	K1401781
Project:	29799	**Date Analyzed:**	03/10/14
Sample Matrix:	Water	**Date Extracted:**	03/04/14

Lab Control Sample Summary
Nitrogen, Total as Nitrogen

Analysis Method:	NCASI TNTP-W10900	**Units:**	mg/L
Prep Method:	Method	**Basis:**	NA
		Analysis Lot:	383032

Sample Name	Lab Code	Result	Spike Amount	% Rec	% Rec Limits
Lab Control Sample	K1401781-LCS	4.86	5.00	97	85-115

ALS Group USA, Corp.
dba ALS Environmental

- Cover Page -
INORGANIC ANALYSIS DATA PACKAGE

Client: Aecos, Incorporated
Project Name: 29799
Project No.:

Service Request: K1401781

Sample Name:	Lab Code:
1	K1401781-001
2	K1401781-002
3	K1401781-003
4	K1401781-004
Method Blank	K1401781-MB
Batch QC1D	K1401786-002D
Batch QC1S	K1401786-002S

Comments:

Metals

- 1 -

INORGANIC ANALYSIS DATA PACKAGE

Client: Aecos, Incorporated
Service Request: K1401781
Project No.: NA
Date Collected: 02/19/14
Project Name: 29799
Date Received: 02/21/14
Matrix: WATER
Units: ug/L
Basis: NA

Sample Name: **1**
Lab Code: **K1401781-001**

Analyte	Analysis Method	MRL	MDL	Dilution Factor	Date Extracted	Date Analyzed	Result	C	Q
Arsenic	200.8	0.5	0.1	1.0	02/27/14	03/03/14	1.1		
Lead	200.8	0.020	0.005	1.0	02/27/14	03/03/14	0.245		
Zinc	200.8	0.5	0.2	1.0	02/27/14	03/03/14	1.8		

Comments:

Metals

- 1 -

INORGANIC ANALYSIS DATA PACKAGE

Client: Aecos, Incorporated
Project No.: NA
Project Name: 29799
Matrix: WATER

Service Request: K1401781
Date Collected: 02/19/14
Date Received: 02/21/14
Units: ug/L
Basis: NA

Sample Name: **2** **Lab Code:** **K1401781-002**

Analyte	Analysis Method	MRL	MDL	Dilution Factor	Date Extracted	Date Analyzed	Result	C	Q
Arsenic	200.8	0.5	0.1	1.0	02/27/14	03/03/14	6.4		
Lead	200.8	0.020	0.005	1.0	02/27/14	03/03/14	4.820		
Zinc	200.8	0.5	0.2	1.0	02/27/14	03/03/14	17.2		

Comments:

Metals

- 1 -

INORGANIC ANALYSIS DATA PACKAGE

Client: Aecos, Incorporated
Project No.: NA
Project Name: 29799
Matrix: WATER

Service Request: K1401781
Date Collected: 02/19/14
Date Received: 02/21/14
Units: ug/L
Basis: NA

Sample Name: 3 **Lab Code:** K1401781-003

Analyte	Analysis Method	MRL	MDL	Dilution Factor	Date Extracted	Date Analyzed	Result	C	Q
Arsenic	200.8	0.5	0.1	1.0	02/27/14	03/03/14	3.5		
Lead	200.8	0.020	0.005	1.0	02/27/14	03/03/14	1.360		
Zinc	200.8	0.5	0.2	1.0	02/27/14	03/03/14	8.1		

Comments:

Metals

- 1 -

INORGANIC ANALYSIS DATA PACKAGE

Client: Aecos, Incorporated

Project No.: NA

Project Name: 29799

Matrix: WATER

Service Request: K1401781

Date Collected: 02/19/14

Date Received: 02/21/14

Units: ug/L

Basis: NA

Sample Name: 4

Lab Code: K1401781-004

Analyte	Analysis Method	MRL	MDL	Dilution Factor	Date Extracted	Date Analyzed	Result	C	Q
Arsenic	200.8	10.0	1.0	20.0	02/27/14	03/04/14	2.16	J	
Lead	200.8	0.4	0.1	20.0	02/27/14	03/04/14	0.528		
Zinc	200.8	10.0	0.8	20.0	02/27/14	03/04/14	0.8	U	

Comments:

Metals

- 1 -

INORGANIC ANALYSIS DATA PACKAGE

Client:	Aecos, Incorporated	**Service Request:**	K1401781
Project No.:	NA	**Date Collected:**	
Project Name:	29799	**Date Received:**	
Matrix:	WATER	**Units:**	ug/L
		Basis:	NA

Sample Name: **Method Blank** **Lab Code:** **K1401781-MB**

Analyte	Analysis Method	MRL	MDL	Dilution Factor	Date Extracted	Date Analyzed	Result	C	Q
Arsenic	200.8	0.5	0.1	1.0	02/27/14	03/03/14	0.1	U	
Lead	200.8	0.020	0.005	1.0	02/27/14	03/03/14	0.005	U	
Zinc	200.8	0.5	0.2	1.0	02/27/14	03/03/14	0.2	U	

Comments:

ALS Group USA, Corp.
dba ALS Environmental

Metals
- 5A -
SPIKE SAMPLE RECOVERY

Client: Aecos, Incorporated

Service Request: K1401781

Project No.: NA

Units: UG/L

Project Name: 29799

Basis: NA

Matrix: WATER

Sample Name: Batch QC1S

Lab Code: K1401786-002S

Analyte	Control Limit %R	Spike Result	C	Sample Result	C	Spike Added	%R	Q	Method
Arsenic	70 - 130	55.5		0.3	J	50.00	110.4		200.8
Lead	70 - 130	50.8		0.238		50.00	101.1		200.8
Zinc	70 - 130	45.9		20.1		25.00	103.2		200.8

An empty field in the Control Limit column indicates the control limit is not applicable

Metals
- 6 -
DUPLICATES

Client: Aecos, Incorporated
Service Request: K1401781
Project No.: NA
Units: UG/L
Project Name: 29799
Basis: NA
Matrix: WATER

Sample Name: Batch QC1D
Lab Code: K1401786-002D

Analyte	Control Limit	Sample (S)	C	Duplicate (D)	C	RPD	Q	Method
Arsenic		0.3	J	0.3	J	0.0		200.8
Lead	20	0.238		0.233		2.1		200.8
Zinc	20	20.1		20.6		2.5		200.8

An empty field in the Control Limit column indicates the control limit is not applicable.

ALS Group USA, Corp.
dba ALS Environmental

Metals
-7-
LABORATORY CONTROL SAMPLE

Client: Aecos, Incorporated **Service Request:** K1401781

Project No.: NA

Project Name: 29799

Aqueous LCS Source: **CAS MIXED** **Solid LCS Source:**

Analyte	Aqueous (ug/L)			Solid (mg/kg)				
	True	Found	%R	True	Found	C	Limits	%R
Arsenic	50	53.4	106.8					
Lead	50	51.2	102.4					
Zinc	25	27.3	109.2					

Analytical Results

Client:	Aecos, Incorporated	**Service Request:**	K1401781
Project:	29799	**Date Collected:**	02/19/2014
Sample Matrix:	Water	**Date Received:**	02/21/2014

Organochlorine Pesticides and Polychlorinated Biphenyls

Sample Name:	1	**Units:**	ug/L
Lab Code:	K1401781-001	**Basis:**	NA
Extraction Method:	EPA 3520C	**Level:**	Low
Analysis Method:	608		

Analyte Name	Result	Q	MRL	MDL	Dilution Factor	Date Extracted	Date Analyzed	Extraction Lot	Note
alpha-BHC	ND	U	0.020	0.0013	1	02/26/14	03/12/14	KWG1401738	
beta-BHC	ND	U	0.020	0.0016	1	02/26/14	03/12/14	KWG1401738	
gamma-BHC (Lindane)	ND	Ui	0.020	0.0057	1	02/26/14	03/12/14	KWG1401738	
delta-BHC	ND	U	0.020	0.0068	1	02/26/14	03/12/14	KWG1401738	
Heptachlor	ND	U	0.020	0.0020	1	02/26/14	03/12/14	KWG1401738	
Aldrin	ND	U	0.020	0.0033	1	02/26/14	03/12/14	KWG1401738	
Heptachlor Epoxide	ND	U	0.020	0.0020	1	02/26/14	03/12/14	KWG1401738	
Endosulfan I	ND	U	0.020	0.0026	1	02/26/14	03/12/14	KWG1401738	
Dieldrin	ND	U	0.020	0.0017	1	02/26/14	03/12/14	KWG1401738	
4,4'-DDE	ND	U	0.020	0.0022	1	02/26/14	03/12/14	KWG1401738	
Endrin	ND	U	0.020	0.0026	1	02/26/14	03/12/14	KWG1401738	
Endosulfan II	ND	U	0.020	0.0020	1	02/26/14	03/12/14	KWG1401738	
4,4'-DDD	ND	U	0.020	0.0029	1	02/26/14	03/12/14	KWG1401738	
Endrin Aldehyde	ND	U	0.020	0.0033	1	02/26/14	03/12/14	KWG1401738	
Endosulfan Sulfate	ND	U	0.020	0.0024	1	02/26/14	03/12/14	KWG1401738	
4,4'-DDT	ND	U	0.020	0.0035	1	02/26/14	03/12/14	KWG1401738	
Toxaphene	ND	U	0.97	0.16	1	02/26/14	03/12/14	KWG1401738	
Chlordane	ND	U	0.39	0.041	1	02/26/14	03/12/14	KWG1401738	
Aroclor 1016	ND	U	0.097	0.083	1	02/26/14	03/12/14	KWG1401738	
Aroclor 1221	ND	U	0.20	0.12	1	02/26/14	03/12/14	KWG1401738	
Aroclor 1232	ND	U	0.20	0.095	1	02/26/14	03/12/14	KWG1401738	
Aroclor 1242	ND	U	0.20	0.035	1	02/26/14	03/12/14	KWG1401738	
Aroclor 1248	ND	U	0.20	0.068	1	02/26/14	03/12/14	KWG1401738	
Aroclor 1254	ND	U	0.20	0.056	1	02/26/14	03/12/14	KWG1401738	
Aroclor 1260	ND	U	0.20	0.11	1	02/26/14	03/12/14	KWG1401738	

Surrogate Name	%Rec	Control Limits	Date Analyzed	Note
Decachlorobiphenyl	67	10-134	03/12/14	Acceptable

Comments:

Analytical Results

Client:	Aecos, Incorporated	**Service Request:**	K1401781
Project:	29799	**Date Collected:**	02/19/2014
Sample Matrix:	Water	**Date Received:**	02/21/2014

Organochlorine Pesticides and Polychlorinated Biphenyls

Sample Name:	2	**Units:**	ug/L
Lab Code:	K1401781-002	**Basis:**	NA
Extraction Method:	EPA 3520C	**Level:**	Low
Analysis Method:	608		

Analyte Name	Result	Q	MRL	MDL	Dilution Factor	Date Extracted	Date Analyzed	Extraction Lot	Note
alpha-BHC	ND	U	0.013	0.00080	1	02/26/14	03/12/14	KWG1401738	
beta-BHC	ND	U	0.013	0.00097	1	02/26/14	03/12/14	KWG1401738	
gamma-BHC (Lindane)	ND	Ui	0.013	0.0036	1	02/26/14	03/12/14	KWG1401738	
delta-BHC	ND	U	0.013	0.0043	1	02/26/14	03/12/14	KWG1401738	
Heptachlor	ND	U	0.013	0.0013	1	02/26/14	03/12/14	KWG1401738	
Aldrin	ND	U	0.013	0.0021	1	02/26/14	03/12/14	KWG1401738	
Heptachlor Epoxide	ND	U	0.013	0.0013	1	02/26/14	03/12/14	KWG1401738	
Endosulfan I	ND	U	0.013	0.0016	1	02/26/14	03/12/14	KWG1401738	
Dieldrin	ND	U	0.013	0.0011	1	02/26/14	03/12/14	KWG1401738	
4,4'-DDE	ND	U	0.013	0.0014	1	02/26/14	03/12/14	KWG1401738	
Endrin	ND	U	0.013	0.0016	1	02/26/14	03/12/14	KWG1401738	
Endosulfan II	ND	U	0.013	0.0013	1	02/26/14	03/12/14	KWG1401738	
4,4'-DDD	ND	U	0.013	0.0019	1	02/26/14	03/12/14	KWG1401738	
Endrin Aldehyde	ND	U	0.013	0.0021	1	02/26/14	03/12/14	KWG1401738	
Endosulfan Sulfate	ND	U	0.013	0.0015	1	02/26/14	03/12/14	KWG1401738	
4,4'-DDT	ND	U	0.013	0.0023	1	02/26/14	03/12/14	KWG1401738	
Toxaphene	ND	U	0.62	0.11	1	02/26/14	03/12/14	KWG1401738	
Chlordane	ND	U	0.25	0.026	1	02/26/14	03/12/14	KWG1401738	
Aroclor 1016	ND	U	0.062	0.053	1	02/26/14	03/12/14	KWG1401738	
Aroclor 1221	ND	U	0.13	0.072	1	02/26/14	03/12/14	KWG1401738	
Aroclor 1232	ND	U	0.13	0.061	1	02/26/14	03/12/14	KWG1401738	
Aroclor 1242	ND	U	0.13	0.023	1	02/26/14	03/12/14	KWG1401738	
Aroclor 1248	ND	U	0.13	0.043	1	02/26/14	03/12/14	KWG1401738	
Aroclor 1254	ND	U	0.13	0.036	1	02/26/14	03/12/14	KWG1401738	
Aroclor 1260	ND	U	0.13	0.066	1	02/26/14	03/12/14	KWG1401738	

Surrogate Name	%Rec	Control Limits	Date Analyzed	Note
Decachlorobiphenyl	35	10-134	03/12/14	Acceptable

Comments:

Analytical Results

Client: Aecos, Incorporated
Project: 29799
Sample Matrix: Water

Service Request: K1401781
Date Collected: 02/19/2014
Date Received: 02/21/2014

Organochlorine Pesticides and Polychlorinated Biphenyls

Sample Name: 3
Lab Code: K1401781-003

Units: ug/L
Basis: NA

Extraction Method: EPA 3520C
Analysis Method: 608

Level: Low

Analyte Name	Result	Q	MRL	MDL	Dilution Factor	Date Extracted	Date Analyzed	Extraction Lot	Note
alpha-BHC	ND	U	0.013	0.00085	1	02/26/14	03/12/14	KWG1401738	
beta-BHC	ND	U	0.013	0.0011	1	02/26/14	03/12/14	KWG1401738	
gamma-BHC (Lindane)	ND	Ui	0.013	0.0050	1	02/26/14	03/12/14	KWG1401738	
delta-BHC	ND	U	0.013	0.0046	1	02/26/14	03/12/14	KWG1401738	
Heptachlor	ND	U	0.013	0.0013	1	02/26/14	03/12/14	KWG1401738	
Aldrin	ND	U	0.013	0.0023	1	02/26/14	03/12/14	KWG1401738	
Heptachlor Epoxide	ND	U	0.013	0.0013	1	02/26/14	03/12/14	KWG1401738	
Endosulfan I	ND	U	0.013	0.0017	1	02/26/14	03/12/14	KWG1401738	
Dieldrin	ND	U	0.013	0.0012	1	02/26/14	03/12/14	KWG1401738	
4,4'-DDE	ND	U	0.013	0.0015	1	02/26/14	03/12/14	KWG1401738	
Endrin	ND	U	0.013	0.0017	1	02/26/14	03/12/14	KWG1401738	
Endosulfan II	ND	U	0.013	0.0013	1	02/26/14	03/12/14	KWG1401738	
4,4'-DDD	ND	U	0.013	0.0020	1	02/26/14	03/12/14	KWG1401738	
Endrin Aldehyde	ND	U	0.013	0.0023	1	02/26/14	03/12/14	KWG1401738	
Endosulfan Sulfate	ND	U	0.013	0.0016	1	02/26/14	03/12/14	KWG1401738	
4,4'-DDT	ND	U	0.013	0.0024	1	02/26/14	03/12/14	KWG1401738	
Toxaphene	ND	U	0.65	0.11	1	02/26/14	03/12/14	KWG1401738	
Chlordane	ND	U	0.26	0.028	1	02/26/14	03/12/14	KWG1401738	
Aroclor 1016	ND	U	0.065	0.056	1	02/26/14	03/12/14	KWG1401738	
Aroclor 1221	ND	U	0.13	0.076	1	02/26/14	03/12/14	KWG1401738	
Aroclor 1232	ND	U	0.13	0.064	1	02/26/14	03/12/14	KWG1401738	
Aroclor 1242	ND	U	0.13	0.024	1	02/26/14	03/12/14	KWG1401738	
Aroclor 1248	ND	U	0.13	0.046	1	02/26/14	03/12/14	KWG1401738	
Aroclor 1254	ND	U	0.13	0.038	1	02/26/14	03/12/14	KWG1401738	
Aroclor 1260	ND	U	0.13	0.069	1	02/26/14	03/12/14	KWG1401738	

Surrogate Name	%Rec	Control Limits	Date Analyzed	Note
Decachlorobiphenyl	38	10-134	03/12/14	Acceptable

Comments:

Analytical Results

Client:	Aecos, Incorporated	**Service Request:**	K1401781
Project:	29799	**Date Collected:**	02/19/2014
Sample Matrix:	Ocean water	**Date Received:**	02/21/2014

Organochlorine Pesticides and Polychlorinated Biphenyls

Sample Name:	4	**Units:**	ug/L
Lab Code:	K1401781-004	**Basis:**	NA
Extraction Method:	EPA 3520C	**Level:**	Low
Analysis Method:	608		

Analyte Name	Result	Q	MRL	MDL	Dilution Factor	Date Extracted	Date Analyzed	Extraction Lot	Note
alpha-BHC	ND	U	0.0098	0.00065	1	02/26/14	03/12/14	KWG1401738	
beta-BHC	ND	U	0.0098	0.00079	1	02/26/14	03/12/14	KWG1401738	
gamma-BHC (Lindane)	ND	U	0.0098	0.0020	1	02/26/14	03/12/14	KWG1401738	
delta-BHC	ND	U	0.0098	0.0035	1	02/26/14	03/12/14	KWG1401738	
Heptachlor	ND	U	0.0098	0.0010	1	02/26/14	03/12/14	KWG1401738	
Aldrin	ND	U	0.0098	0.0017	1	02/26/14	03/12/14	KWG1401738	
Heptachlor Epoxide	ND	U	0.0098	0.0010	1	02/26/14	03/12/14	KWG1401738	
Endosulfan I	ND	U	0.0098	0.0013	1	02/26/14	03/12/14	KWG1401738	
Dieldrin	ND	U	0.0098	0.00085	1	02/26/14	03/12/14	KWG1401738	
4,4'-DDE	ND	U	0.0098	0.0011	1	02/26/14	03/12/14	KWG1401738	
Endrin	ND	U	0.0098	0.0013	1	02/26/14	03/12/14	KWG1401738	
Endosulfan II	ND	U	0.0098	0.0010	1	02/26/14	03/12/14	KWG1401738	
4,4'-DDD	ND	U	0.0098	0.0015	1	02/26/14	03/12/14	KWG1401738	
Endrin Aldehyde	ND	U	0.0098	0.0017	1	02/26/14	03/12/14	KWG1401738	
Endosulfan Sulfate	ND	U	0.0098	0.0012	1	02/26/14	03/12/14	KWG1401738	
4,4'-DDT	ND	U	0.0098	0.0018	1	02/26/14	03/12/14	KWG1401738	
Toxaphene	ND	U	0.49	0.083	1	02/26/14	03/12/14	KWG1401738	
Chlordane	ND	U	0.20	0.021	1	02/26/14	03/12/14	KWG1401738	
Aroclor 1016	ND	U	0.049	0.043	1	02/26/14	03/12/14	KWG1401738	
Aroclor 1221	ND	U	0.098	0.058	1	02/26/14	03/12/14	KWG1401738	
Aroclor 1232	ND	U	0.098	0.049	1	02/26/14	03/12/14	KWG1401738	
Aroclor 1242	ND	U	0.098	0.018	1	02/26/14	03/12/14	KWG1401738	
Aroclor 1248	ND	U	0.098	0.035	1	02/26/14	03/12/14	KWG1401738	
Aroclor 1254	ND	U	0.098	0.029	1	02/26/14	03/12/14	KWG1401738	
Aroclor 1260	ND	U	0.098	0.053	1	02/26/14	03/12/14	KWG1401738	

Surrogate Name	%Rec	Control Limits	Date Analyzed	Note
Decachlorobiphenyl	88	10-134	03/12/14	Acceptable

Comments:

Analytical Results

Client:	Aecos, Incorporated	**Service Request:**	K1401781
Project:	29799	**Date Collected:**	NA
Sample Matrix:	Water	**Date Received:**	NA

Organochlorine Pesticides and Polychlorinated Biphenyls

Sample Name:	Method Blank	**Units:**	ug/L
Lab Code:	KWG1401738-5	**Basis:**	NA
Extraction Method:	EPA 3520C	**Level:**	Low
Analysis Method:	608		

Analyte Name	Result	Q	MRL	MDL	Dilution Factor	Date Extracted	Date Analyzed	Extraction Lot	Note
alpha-BHC	ND	U	0.0098	0.00065	1	02/26/14	03/12/14	KWG1401738	
beta-BHC	ND	U	0.0098	0.00079	1	02/26/14	03/12/14	KWG1401738	
gamma-BHC (Lindane)	ND	U	0.0098	0.0020	1	02/26/14	03/12/14	KWG1401738	
delta-BHC	ND	U	0.0098	0.0035	1	02/26/14	03/12/14	KWG1401738	
Heptachlor	ND	U	0.0098	0.0010	1	02/26/14	03/12/14	KWG1401738	
Aldrin	ND	U	0.0098	0.0017	1	02/26/14	03/12/14	KWG1401738	
Heptachlor Epoxide	ND	U	0.0098	0.0010	1	02/26/14	03/12/14	KWG1401738	
Endosulfan I	ND	U	0.0098	0.0013	1	02/26/14	03/12/14	KWG1401738	
Dieldrin	ND	U	0.0098	0.00085	1	02/26/14	03/12/14	KWG1401738	
4,4'-DDE	ND	U	0.0098	0.0011	1	02/26/14	03/12/14	KWG1401738	
Endrin	ND	U	0.0098	0.0013	1	02/26/14	03/12/14	KWG1401738	
Endosulfan II	ND	U	0.0098	0.0010	1	02/26/14	03/12/14	KWG1401738	
4,4'-DDD	ND	U	0.0098	0.0015	1	02/26/14	03/12/14	KWG1401738	
Endrin Aldehyde	ND	U	0.0098	0.0017	1	02/26/14	03/12/14	KWG1401738	
Endosulfan Sulfate	ND	U	0.0098	0.0012	1	02/26/14	03/12/14	KWG1401738	
4,4'-DDT	ND	U	0.0098	0.0018	1	02/26/14	03/12/14	KWG1401738	
Toxaphene	ND	U	0.49	0.083	1	02/26/14	03/12/14	KWG1401738	
Chlordane	ND	U	0.20	0.021	1	02/26/14	03/12/14	KWG1401738	
Aroclor 1016	ND	U	0.049	0.043	1	02/26/14	03/12/14	KWG1401738	
Aroclor 1221	ND	U	0.098	0.058	1	02/26/14	03/12/14	KWG1401738	
Aroclor 1232	ND	U	0.098	0.049	1	02/26/14	03/12/14	KWG1401738	
Aroclor 1242	ND	U	0.098	0.018	1	02/26/14	03/12/14	KWG1401738	
Aroclor 1248	ND	U	0.098	0.035	1	02/26/14	03/12/14	KWG1401738	
Aroclor 1254	ND	U	0.098	0.029	1	02/26/14	03/12/14	KWG1401738	
Aroclor 1260	ND	U	0.098	0.053	1	02/26/14	03/12/14	KWG1401738	

Surrogate Name	%Rec	Control Limits	Date Analyzed	Note
Decachlorobiphenyl	78	10-134	03/12/14	Acceptable

Comments:

ALS Group USA, Corp. dba ALS Environmental

QA/QC Report

Client:	Aecos, Incorporated	**Service Request:**	K1401781
Project:	29799		
Sample Matrix:	Water		

Surrogate Recovery Summary
Organochlorine Pesticides and Polychlorinated Biphenyls

Extraction Method:	EPA 3520C	**Units:**	Percent
Analysis Method:	608	**Level:**	Low

Sample Name	Lab Code	Sur1
1	K1401781-001	67
2	K1401781-002	35
3	K1401781-003	38
4	K1401781-004	88
Method Blank	KWG1401738-5	78
Lab Control Sample	KWG1401738-1	83
Duplicate Lab Control Sample	KWG1401738-2	65

Surrogate Recovery Control Limits (%)

Sur1 = Decachlorobiphenyl 10-134

Results flagged with an asterisk (*) indicate values outside control criteria.

Results flagged with a pound (#) indicate the control criteria is not applicable.

QA/QC Report

Client:	Aecos, Incorporated	**Service Request:**	K1401781
Project:	29799	**Date Extracted:**	02/26/2014
Sample Matrix:	Water	**Date Analyzed:**	03/12/2014

Lab Control Spike/Duplicate Lab Control Spike Summary
Organochlorine Pesticides and Polychlorinated Biphenyls

Extraction Method:	EPA 3520C	**Units:**	ug/L
Analysis Method:	608	**Basis:**	NA
		Level:	Low
		Extraction Lot:	KWG1401738

	Lab Control Sample KWG1401738-1 **Lab Control Spike**			Duplicate Lab Control Sample KWG1401738-2 **Duplicate Lab Control Spike**					
Analyte Name	**Result**	**Spike Amount**	**%Rec**	**Result**	**Spike Amount**	**%Rec**	**%Rec Limits**	**RPD**	**RPD Limit**
alpha-BHC	0.0871	0.100	87	0.0841	0.100	84	37-134	3	30
beta-BHC	0.0847	0.100	85	0.0807	0.100	81	17-147	5	30
gamma-BHC (Lindane)	0.0965	0.100	97	0.0935	0.100	94	32-127	3	30
delta-BHC	0.0860	0.100	86	0.0832	0.100	83	19-140	3	30
Heptachlor	0.0829	0.100	83	0.0810	0.100	81	34-111	2	30
Aldrin	0.0833	0.100	83	0.0804	0.100	80	42-122	4	30
Heptachlor Epoxide	0.0990	0.100	99	0.0945	0.100	94	37-142	5	30
Endosulfan I	0.0971	0.100	97	0.0931	0.100	93	45-153	4	30
Dieldrin	0.104	0.100	104	0.0983	0.100	98	36-146	6	30
4,4'-DDE	0.102	0.100	102	0.0972	0.100	97	30-145	4	30
Endrin	0.101	0.100	101	0.0962	0.100	96	30-147	5	30
Endosulfan II	0.0977	0.100	98	0.0925	0.100	93	10-202	5	30
4,4'-DDD	0.104	0.100	104	0.0981	0.100	98	31-141	6	30
Endrin Aldehyde	0.0804	0.100	80	0.0784	0.100	78	43-125	2	30
Endosulfan Sulfate	0.0936	0.100	94	0.0890	0.100	89	26-144	5	30
4,4'-DDT	0.105	0.100	105	0.0990	0.100	99	25-160	6	30

Results flagged with an asterisk (*) indicate values outside control criteria.

Percent recoveries and relative percent differences (RPD) are determined by the software using values in the calculation which have not been rounded.

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Analytical Results

Client:	Aecos, Incorporated	**Service Request:**	K1401781
Project:	29799	**Date Collected:**	02/19/2014
Sample Matrix:	Water	**Date Received:**	02/21/2014

Organophosphorus Pesticides

Sample Name:	1	**Units:**	ug/L
Lab Code:	K1401781-001	**Basis:**	NA
Extraction Method:	EPA 3535A	**Level:**	Low
Analysis Method:	614M		

Analyte Name	Result	Q	MRL	MDL	Dilution Factor	Date Extracted	Date Analyzed	Extraction Lot	Note
Demeton-O,S	ND	U	1.7	0.067	1	02/26/14	03/07/14	KWG1401560	
Chlorpyrifos	ND	U	1.7	0.067	1	02/26/14	03/07/14	KWG1401560	
Malathion	ND	U	1.7	0.067	1	02/26/14	03/07/14	KWG1401560	
Ethyl Parathion	ND	U	1.7	0.067	1	02/26/14	03/07/14	KWG1401560	
Azinphos-methyl (Guthion)	ND	U	1.7	0.067	1	02/26/14	03/07/14	KWG1401560	

Surrogate Name	%Rec	Control Limits	Date Analyzed	Note
Triphenyl Phosphate	106	57-112	03/07/14	Acceptable
Tributyl Phosphate	96	54-115	03/07/14	Acceptable

Comments:

Client:	Aecos, Incorporated	**Service Request:**	K1401781
Project:	29799	**Date Collected:**	02/19/2014
Sample Matrix:	Water	**Date Received:**	02/21/2014

Organophosphorus Pesticides

Sample Name:	2	**Units:**	ug/L
Lab Code:	K1401781-002	**Basis:**	NA
Extraction Method:	EPA 3535A	**Level:**	Low
Analysis Method:	614M		

Analyte Name	Result	Q	MRL	MDL	Dilution Factor	Date Extracted	Date Analyzed	Extraction Lot	Note
Demeton-O,S	ND	U	1.3	0.052	1	02/26/14	03/07/14	KWG1401560	
Chlorpyrifos	ND	U	1.3	0.052	1	02/26/14	03/07/14	KWG1401560	
Malathion	ND	U	1.3	0.052	1	02/26/14	03/07/14	KWG1401560	
Ethyl Parathion	ND	U	1.3	0.052	1	02/26/14	03/07/14	KWG1401560	
Azinphos-methyl (Guthion)	ND	U	1.3	0.052	1	02/26/14	03/07/14	KWG1401560	

Surrogate Name	%Rec	Control Limits	Date Analyzed	Note
Triphenyl Phosphate	101	57-112	03/07/14	Acceptable
Tributyl Phosphate	94	54-115	03/07/14	Acceptable

Comments:

Analytical Results

Client:	Aecos, Incorporated	**Service Request:**	K1401781
Project:	29799	**Date Collected:**	02/19/2014
Sample Matrix:	Water	**Date Received:**	02/21/2014

Organophosphorus Pesticides

Sample Name:	3	**Units:**	ug/L
Lab Code:	K1401781-003	**Basis:**	NA
Extraction Method:	EPA 3535A	**Level:**	Low
Analysis Method:	614M		

Analyte Name	Result	Q	MRL	MDL	Dilution Factor	Date Extracted	Date Analyzed	Extraction Lot	Note
Demeton-O,S	ND	U	1.2	0.048	1	02/26/14	03/07/14	KWG1401560	
Chlorpyrifos	ND	U	1.2	0.048	1	02/26/14	03/07/14	KWG1401560	
Malathion	ND	U	1.2	0.048	1	02/26/14	03/07/14	KWG1401560	
Ethyl Parathion	ND	U	1.2	0.048	1	02/26/14	03/07/14	KWG1401560	
Azinphos-methyl (Guthion)	ND	U	1.2	0.048	1	02/26/14	03/07/14	KWG1401560	

Surrogate Name	%Rec	Control Limits	Date Analyzed	Note
Triphenyl Phosphate	104	57-112	03/07/14	Acceptable
Tributyl Phosphate	99	54-115	03/07/14	Acceptable

Comments:

Client:	Aecos, Incorporated	**Service Request:**	K1401781
Project:	29799	**Date Collected:**	02/19/2014
Sample Matrix:	Ocean water	**Date Received:**	02/21/2014

Organophosphorus Pesticides

Sample Name:	4	**Units:**	ug/L
Lab Code:	K1401781-004	**Basis:**	NA
Extraction Method:	EPA 3535A	**Level:**	Low
Analysis Method:	614M		

Analyte Name	Result	Q	MRL	MDL	Dilution Factor	Date Extracted	Date Analyzed	Extraction Lot	Note
Demeton-O,S	ND	U	0.97	0.040	1	02/26/14	03/07/14	KWG1401560	
Chlorpyrifos	ND	U	0.97	0.040	1	02/26/14	03/07/14	KWG1401560	
Malathion	ND	U	0.97	0.040	1	02/26/14	03/07/14	KWG1401560	
Ethyl Parathion	ND	U	0.97	0.040	1	02/26/14	03/07/14	KWG1401560	
Azinphos-methyl (Guthion)	ND	U	0.97	0.040	1	02/26/14	03/07/14	KWG1401560	

Surrogate Name	%Rec	Control Limits	Date Analyzed	Note
Triphenyl Phosphate	100	57-112	03/07/14	Acceptable
Tributyl Phosphate	95	54-115	03/07/14	Acceptable

Comments:

Analytical Results

Client:	Aecos, Incorporated	**Service Request:**	K1401781
Project:	29799	**Date Collected:**	NA
Sample Matrix:	Water	**Date Received:**	NA

Organophosphorus Pesticides

Sample Name:	Method Blank	**Units:**	ug/L
Lab Code:	KWG1401560-5	**Basis:**	NA
Extraction Method:	EPA 3535A	**Level:**	Low
Analysis Method:	614M		

Analyte Name	Result	Q	MRL	MDL	Dilution Factor	Date Extracted	Date Analyzed	Extraction Lot	Note
Demeton-O,S	ND	U	0.97	0.040	1	02/26/14	03/07/14	KWG1401560	
Chlorpyrifos	ND	U	0.97	0.040	1	02/26/14	03/07/14	KWG1401560	
Malathion	ND	U	0.97	0.040	1	02/26/14	03/07/14	KWG1401560	
Ethyl Parathion	ND	U	0.97	0.040	1	02/26/14	03/07/14	KWG1401560	
Azinphos-methyl (Guthion)	ND	U	0.97	0.040	1	02/26/14	03/07/14	KWG1401560	

Surrogate Name	%Rec	Control Limits	Date Analyzed	Note
Triphenyl Phosphate	104	57-112	03/07/14	Acceptable
Tributyl Phosphate	98	54-115	03/07/14	Acceptable

Comments:

Client:	Aecos, Incorporated	**Service Request:**	K1401781
Project:	29799		
Sample Matrix:	Water		

Surrogate Recovery Summary
Organophosphorus Pesticides

Extraction Method:	EPA 3535A	**Units:**	Percent
Analysis Method:	614M	**Level:**	Low

Sample Name	Lab Code	Sur1	Sur2
1	K1401781-001	106	96
2	K1401781-002	101	94
3	K1401781-003	104	99
4	K1401781-004	100	95
Method Blank	KWG1401560-5	104	98
Lab Control Sample	KWG1401560-1	102	98
Duplicate Lab Control Sample	KWG1401560-2	106	102

Surrogate Recovery Control Limits (%)

Sur1	=	Triphenyl Phosphate	57-112
Sur2	=	Tributyl Phosphate	54-115

Results flagged with an asterisk (*) indicate values outside control criteria.

Results flagged with a pound (#) indicate the control criteria is not applicable.

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QA/QC Report

Client:	Aecos, Incorporated	**Service Request:**	K1401781
Project:	29799	**Date Extracted:**	02/26/2014
Sample Matrix:	Water	**Date Analyzed:**	03/07/2014

Lab Control Spike/Duplicate Lab Control Spike Summary
Organophosphorus Pesticides

Extraction Method:	EPA 3535A	**Units:**	ug/L
Analysis Method:	614M	**Basis:**	NA
		Level:	Low
		Extraction Lot:	KWG1401560

	Lab Control Sample KWG1401560-1 **Lab Control Spike**			Duplicate Lab Control Sample KWG1401560-2 **Duplicate Lab Control Spike**						
Analyte Name	**Result**	**Spike Amount**	**%Rec**	**Result**	**Spike Amount**	**%Rec**	**%Rec Limits**	**RPD**		**RPD Limit**
Demeton-O,S	0.709	2.00	35	0.502	2.00	25	16-100	34	*	30
Chlorpyrifos	1.99	2.00	100	1.89	2.00	95	44-119	5		30
Malathion	1.67	2.00	83	1.59	2.00	80	43-116	5		30
Ethyl Parathion	1.64	2.00	82	1.61	2.00	81	46-127	2		30
Azinphos-methyl (Guthion)	2.51	2.00	126	2.41	2.00	120	30-151	4		30

Results flagged with an asterisk (*) indicate values outside control criteria.

Percent recoveries and relative percent differences (RPD) are determined by the software using values in the calculation which have not been rounded.

Analytical Results

Client:	Aecos, Incorporated	**Service Request:**	K1401781
Project:	29799	**Date Collected:**	02/19/2014
Sample Matrix:	Water	**Date Received:**	02/21/2014

Chlorinated Herbicides

Sample Name:	1	**Units:**	ug/L
Lab Code:	K1401781-001	**Basis:**	NA
Extraction Method:	Method	**Level:**	Low
Analysis Method:	8151A		

Analyte Name	Result	Q	MRL	MDL	Dilution Factor	Date Extracted	Date Analyzed	Extraction Lot	Note
Dalapon	ND	U	0.68	0.34	1	02/26/14	03/05/14	KWG1401633	
Dicamba	ND	U	0.34	0.043	1	02/26/14	03/05/14	KWG1401633	
MCPP	ND	U	170	24	1	02/26/14	03/05/14	KWG1401633	
MCPA	ND	U	170	15	1	02/26/14	03/05/14	KWG1401633	
Dichlorprop	ND	U	0.68	0.051	1	02/26/14	03/05/14	KWG1401633	
2,4-D	ND	U	0.68	0.062	1	02/26/14	03/05/14	KWG1401633	
2,4,5-TP (Silvex)	ND	U	0.34	0.077	1	02/26/14	03/05/14	KWG1401633	
2,4,5-T	ND	U	0.34	0.056	1	02/26/14	03/05/14	KWG1401633	
2,4-DB	ND	U	0.68	0.17	1	02/26/14	03/05/14	KWG1401633	
Dinoseb	ND	U	0.34	0.026	1	02/26/14	03/05/14	KWG1401633	

Surrogate Name	%Rec	Control Limits	Date Analyzed	Note
2,4-Dichlorophenylacetic Acid	45	17-113	03/05/14	Acceptable

Comments:

Client:	Aecos, Incorporated	**Service Request:**	K1401781
Project:	29799	**Date Collected:**	02/19/2014
Sample Matrix:	Water	**Date Received:**	02/21/2014

Chlorinated Herbicides

Sample Name:	2	**Units:**	ug/L
Lab Code:	K1401781-002	**Basis:**	NA
Extraction Method:	Method	**Level:**	Low
Analysis Method:	8151A		

Analyte Name	Result	Q	MRL	MDL	Dilution Factor	Date Extracted	Date Analyzed	Extraction Lot	Note
Dalapon	ND	U	0.59	0.30	1	02/26/14	03/05/14	KWG1401633	
Dicamba	**0.096**	JP	0.30	0.037	1	02/26/14	03/05/14	KWG1401633	
MCPP	ND	U	150	21	1	02/26/14	03/05/14	KWG1401633	
MCPA	ND	Ui	150	20	1	02/26/14	03/05/14	KWG1401633	
Dichlorprop	ND	U	0.59	0.045	1	02/26/14	03/05/14	KWG1401633	
2,4-D	ND	Ui	0.59	0.078	1	02/26/14	03/05/14	KWG1401633	
2,4,5-TP (Silvex)	ND	U	0.30	0.067	1	02/26/14	03/05/14	KWG1401633	
2,4,5-T	ND	U	0.30	0.049	1	02/26/14	03/05/14	KWG1401633	
2,4-DB	ND	Ui	0.84	0.84	1	02/26/14	03/05/14	KWG1401633	
Dinoseb	ND	Ui	0.30	0.11	1	02/26/14	03/05/14	KWG1401633	

Surrogate Name	%Rec	Control Limits	Date Analyzed	Note
2,4-Dichlorophenylacetic Acid	74	17-113	03/05/14	Acceptable

Comments:

Client:	Aecos, Incorporated	**Service Request:**	K1401781
Project:	29799	**Date Collected:**	02/19/2014
Sample Matrix:	Water	**Date Received:**	02/21/2014

Chlorinated Herbicides

Sample Name:	3	**Units:**	ug/L
Lab Code:	K1401781-003	**Basis:**	NA
Extraction Method:	Method	**Level:**	Low
Analysis Method:	8151A		

Analyte Name	Result	Q	MRL	MDL	Dilution Factor	Date Extracted	Date Analyzed	Extraction Lot	Note
Dalapon	ND	U	0.46	0.23	1	02/26/14	03/05/14	KWG1401633	
Dicamba	ND	U	0.23	0.029	1	02/26/14	03/05/14	KWG1401633	
MCPP	ND	U	120	16	1	02/26/14	03/05/14	KWG1401633	
MCPA	ND	U	120	9.9	1	02/26/14	03/05/14	KWG1401633	
Dichlorprop	ND	U	0.46	0.035	1	02/26/14	03/05/14	KWG1401633	
2,4-D	ND	U	0.46	0.041	1	02/26/14	03/05/14	KWG1401633	
2,4,5-TP (Silvex)	ND	U	0.23	0.052	1	02/26/14	03/05/14	KWG1401633	
2,4,5-T	ND	U	0.23	0.038	1	02/26/14	03/05/14	KWG1401633	
2,4-DB	ND	Ui	0.93	0.93	1	02/26/14	03/05/14	KWG1401633	
Dinoseb	ND	Ui	0.23	0.069	1	02/26/14	03/05/14	KWG1401633	

Surrogate Name	%Rec	Control Limits	Date Analyzed	Note
2,4-Dichlorophenylacetic Acid	76	17-113	03/05/14	Acceptable

Comments:

Client:	Aecos, Incorporated	**Service Request:**	K1401781
Project:	29799	**Date Collected:**	02/19/2014
Sample Matrix:	Ocean water	**Date Received:**	02/21/2014

Chlorinated Herbicides

Sample Name:	4	**Units:**	ug/L
Lab Code:	K1401781-004	**Basis:**	NA
Extraction Method:	Method	**Level:**	Low
Analysis Method:	8151A		

Analyte Name	Result	Q	MRL	MDL	Dilution Factor	Date Extracted	Date Analyzed	Extraction Lot	Note
Dalapon	ND	U	0.40	0.20	1	02/26/14	03/05/14	KWG1401633	
Dicamba	ND	U	0.20	0.025	1	02/26/14	03/05/14	KWG1401633	
MCPP	ND	U	100	14	1	02/26/14	03/05/14	KWG1401633	
MCPA	ND	U	100	8.7	1	02/26/14	03/05/14	KWG1401633	
Dichlorprop	ND	U	0.40	0.030	1	02/26/14	03/05/14	KWG1401633	
2,4-D	ND	U	0.40	0.036	1	02/26/14	03/05/14	KWG1401633	
2,4,5-TP (Silvex)	ND	U	0.20	0.045	1	02/26/14	03/05/14	KWG1401633	
2,4,5-T	ND	U	0.20	0.033	1	02/26/14	03/05/14	KWG1401633	
2,4-DB	ND	U	0.40	0.10	1	02/26/14	03/05/14	KWG1401633	
Dinoseb	ND	U	0.20	0.015	1	02/26/14	03/05/14	KWG1401633	

Surrogate Name	%Rec	Control Limits	Date Analyzed	Note
2,4-Dichlorophenylacetic Acid	47	17-113	03/05/14	Acceptable

Comments:

ALS Group USA, Corp. dba ALS Environmental

Analytical Results

Client:	Aecos, Incorporated	**Service Request:**	K1401781
Project:	29799	**Date Collected:**	NA
Sample Matrix:	Ocean water	**Date Received:**	NA

Chlorinated Herbicides

Sample Name:	Method Blank	**Units:**	ug/L
Lab Code:	KWG1401633-3	**Basis:**	NA
Extraction Method:	Method	**Level:**	Low
Analysis Method:	8151A		

Analyte Name	Result	Q	MRL	MDL	Dilution Factor	Date Extracted	Date Analyzed	Extraction Lot	Note
Dalapon	ND	U	0.39	0.20	1	02/26/14	03/03/14	KWG1401633	
Dicamba	ND	U	0.20	0.025	1	02/26/14	03/03/14	KWG1401633	
MCPP	ND	U	96	14	1	02/26/14	03/03/14	KWG1401633	
MCPA	ND	U	96	8.7	1	02/26/14	03/03/14	KWG1401633	
Dichlorprop	ND	U	0.39	0.030	1	02/26/14	03/03/14	KWG1401633	
2,4-D	ND	U	0.39	0.036	1	02/26/14	03/03/14	KWG1401633	
2,4,5-TP (Silvex)	ND	U	0.20	0.045	1	02/26/14	03/03/14	KWG1401633	
2,4,5-T	ND	U	0.20	0.033	1	02/26/14	03/03/14	KWG1401633	
2,4-DB	ND	U	0.39	0.10	1	02/26/14	03/03/14	KWG1401633	
Dinoseb	ND	U	0.20	0.015	1	02/26/14	03/03/14	KWG1401633	

Surrogate Name	%Rec	Control Limits	Date Analyzed	Note
2,4-Dichlorophenylacetic Acid	42	17-113	03/03/14	Acceptable

Comments:

Client: Aecos, Incorporated
Project: 29799
Sample Matrix: Water

Service Request: K1401781

Surrogate Recovery Summary
Chlorinated Herbicides

Extraction Method: Method
Analysis Method: 8151A

Units: Percent
Level: Low

Sample Name	Lab Code	Sur1
1	K1401781-001	45
2	K1401781-002	74
3	K1401781-003	76
4	K1401781-004	47
Method Blank	KWG1401633-3	42
Lab Control Sample	KWG1401633-1	69
Duplicate Lab Control Sample	KWG1401633-2	76

Surrogate Recovery Control Limits (%)

Sur1 =	2,4-Dichlorophenylacetic Acid	17-113

Results flagged with an asterisk (*) indicate values outside control criteria.

Results flagged with a pound (#) indicate the control criteria is not applicable.

QA/QC Report

Client:	Aecos, Incorporated	**Service Request:**	K1401781
Project:	29799	**Date Extracted:**	02/26/2014
Sample Matrix:	Ocean water	**Date Analyzed:**	03/03/2014

Lab Control Spike/Duplicate Lab Control Spike Summary
Chlorinated Herbicides

Extraction Method:	Method	**Units:**	ug/L
Analysis Method:	8151A	**Basis:**	NA
		Level:	Low
		Extraction Lot:	KWG1401633

	Lab Control Sample KWG1401633-1 **Lab Control Spike**			Duplicate Lab Control Sample KWG1401633-2 **Duplicate Lab Control Spike**					
Analyte Name	**Result**	**Spike Amount**	**%Rec**	**Result**	**Spike Amount**	**%Rec**	**%Rec Limits**	**RPD**	**RPD Limit**
Dalapon	1.71	2.50	68	2.10	2.50	84	14-110	20	30
Dicamba	1.84	2.50	74	1.84	2.50	74	30-108	0	30
MCPP	205	250	82	191	250	76	16-141	7	30
MCPA	194	250	78	176	250	71	21-117	10	30
Dichlorprop	1.97	2.50	79	1.83	2.50	73	29-104	7	30
2,4-D	2.32	2.50	93	2.13	2.50	85	35-110	8	30
2,4,5-TP (Silvex)	2.18	2.50	87	2.09	2.50	84	37-114	4	30
2,4,5-T	2.37	2.50	95	2.23	2.50	89	30-120	6	30
2,4-DB	1.72	2.50	69	1.94	2.50	77	10-134	11	30
Dinoseb	1.75	2.50	70	1.69	2.50	67	11-105	3	30

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May 6, 2014

Analytical Report for Service Request No: K1403135
Revised Service Request Number: K1403135.01

Snookie Mello
Aecos, Incorporated
45-939 Kamehameha Highway, Suite 104
Kaneohe, HI 96744

RE: Lualualei/29885

Dear Snookie:

Enclosed is the revised report for the samples submitted to our laboratory on March 28, 2014. For your reference, these analyses have been assigned our service request number K1403135.01.

The Total Nitrogen determined by calculation is included in this revision.

Analyses were performed according to our laboratory's NELAP-approved quality assurance program. The test results meet requirements of the current NELAP standards, where applicable, and except as noted in the laboratory case narrative provided. For a specific list of NELAP-accredited analytes, refer to the certifications section at www.alsglobal.com. All results are intended to be considered in their entirety, and ALS Group USA Corp. dba ALS Environmental (ALS) is not responsible for use of less than the complete report. Results apply only to the items submitted to the laboratory for analysis and individual items (samples) analyzed, as listed in the report.

We apologize for any inconvenience this may have created.

Please call if you have any questions. My extension is 3275. You may also contact me via Email at Chris.Leaf@alsglobal.com.

Respectfully submitted,

ALS Group USA Corp. dba ALS Environmental

Chris Leaf
Project Manager

CL/aj

REVISED
12:59 pm, May 06, 2014

Acronyms

ASTM	American Society for Testing and Materials
A2LA	American Association for Laboratory Accreditation
CARB	California Air Resources Board
CAS Number	Chemical Abstract Service registry Number
CFC	Chlorofluorocarbon
CFU	Colony-Forming Unit
DEC	Department of Environmental Conservation
DEQ	Department of Environmental Quality
DHS	Department of Health Services
DOE	Department of Ecology
DOH	Department of Health
EPA	U. S. Environmental Protection Agency
ELAP	Environmental Laboratory Accreditation Program
GC	Gas Chromatography
GC/MS	Gas Chromatography/Mass Spectrometry
LOD	Limit of Detection
LOQ	Limit of Quantitation
LUFT	Leaking Underground Fuel Tank
M	Modified
MCL	Maximum Contaminant Level is the highest permissible concentration of a substance allowed in drinking water as established by the USEPA.
MDL	Method Detection Limit
MPN	Most Probable Number
MRL	Method Reporting Limit
NA	Not Applicable
NC	Not Calculated
NCASI	National Council of the Paper Industry for Air and Stream Improvement
ND	Not Detected
NIOSH	National Institute for Occupational Safety and Health
PQL	Practical Quantitation Limit
RCRA	Resource Conservation and Recovery Act
SIM	Selected Ion Monitoring
TPH	Total Petroleum Hydrocarbons
tr	Trace level is the concentration of an analyte that is less than the PQL but greater than or equal to the MDL.

Inorganic Data Qualifiers

*	The result is an outlier. See case narrative.
#	The control limit criteria is not applicable. See case narrative.
B	The analyte was found in the associated method blank at a level that is significant relative to the sample result as defined by the DOD or NELAC standards.
E	The result is an estimate amount because the value exceeded the instrument calibration range.
J	The result is an estimated value.
U	The analyte was analyzed for, but was not detected ("Non-detect") at or above the MRL/MDL. *DOD-QSM 4.2 definition* : Analyte was not detected and is reported as less than the LOD or as defined by the project. The detection limit is adjusted for dilution.
i	The MRL/MDL or LOQ/LOD is elevated due to a matrix interference.
X	See case narrative.
Q	See case narrative. One or more quality control criteria was outside the limits.
H	The holding time for this test is immediately following sample collection. The samples were analyzed as soon as possible after receipt by the laboratory.

Metals Data Qualifiers

#	The control limit criteria is not applicable. See case narrative.
J	The result is an estimated value.
E	The percent difference for the serial dilution was greater than 10%, indicating a possible matrix interference in the sample.
M	The duplicate injection precision was not met.
N	The Matrix Spike sample recovery is not within control limits. See case narrative.
S	The reported value was determined by the Method of Standard Additions (MSA).
U	The analyte was analyzed for, but was not detected ("Non-detect") at or above the MRL/MDL. *DOD-QSM 4.2 definition* : Analyte was not detected and is reported as less than the LOD or as defined by the project. The detection limit is adjusted for dilution.
W	The post-digestion spike for furnace AA analysis is out of control limits, while sample absorbance is less than 50% of spike absorbance.
i	The MRL/MDL or LOQ/LOD is elevated due to a matrix interference.
X	See case narrative.
+	The correlation coefficient for the MSA is less than 0.995.
Q	See case narrative. One or more quality control criteria was outside the limits.

Organic Data Qualifiers

*	The result is an outlier. See case narrative.
#	The control limit criteria is not applicable. See case narrative.
A	A tentatively identified compound, a suspected aldol-condensation product.
B	The analyte was found in the associated method blank at a level that is significant relative to the sample result as defined by the DOD or NELAC standards.
C	The analyte was qualitatively confirmed using GC/MS techniques, pattern recognition, or by comparing to historical data.
D	The reported result is from a dilution.
E	The result is an estimated value.
J	The result is an estimated value.
N	The result is presumptive. The analyte was tentatively identified, but a confirmation analysis was not performed.
P	The GC or HPLC confirmation criteria was exceeded. The relative percent difference is greater than 40% between the two analytical results.
U	The analyte was analyzed for, but was not detected ("Non-detect") at or above the MRL/MDL. *DOD-QSM 4.2 definition* : Analyte was not detected and is reported as less than the LOD or as defined by the project. The detection limit is adjusted for dilution.
i	The MRL/MDL or LOQ/LOD is elevated due to a chromatographic interference.
X	See case narrative.
Q	See case narrative. One or more quality control criteria was outside the limits.

Additional Petroleum Hydrocarbon Specific Qualifiers

F	The chromatographic fingerprint of the sample matches the elution pattern of the calibration standard.
L	The chromatographic fingerprint of the sample resembles a petroleum product, but the elution pattern indicates the presence of a greater amount of lighter molecular weight constituents than the calibration standard.
H	The chromatographic fingerprint of the sample resembles a petroleum product, but the elution pattern indicates the presence of a greater amount of heavier molecular weight constituents than the calibration standard.
O	The chromatographic fingerprint of the sample resembles an oil, but does not match the calibration standard.
Y	The chromatographic fingerprint of the sample resembles a petroleum product eluting in approximately the correct carbon range, but the elution pattern does not match the calibration standard.
Z	The chromatographic fingerprint does not resemble a petroleum product.

ALS Group USA Corp. dba ALS Environmental (ALS) - Kelso
State Certifications, Accreditations, and Licenses

Agency	Web Site	Number
Alaska DEC UST	http://dec.alaska.gov/applications/eh/ehllabreports/USTLabs.aspx	UST-040
Arizona DHS	http://www.azdhs.gov/lab/license/env.htm	AZ0339
Arkansas - DEQ	http://www.adeq.state.ar.us/techsvs/labcert.htm	88-0637
California DHS (ELAP)	http://www.cdph.ca.gov/certlic/labs/Pages/ELAP.aspx	2286
DOD ELAP	http://www.denix.osd.mil/edqw/Accreditation/AccreditedLabs.cfm	L12-28
Florida DOH	http://www.doh.state.fl.us/lab/EnvLabCert/WaterCert.htm	E87412
Georgia DNR	http://www.gaepd.org/Documents/techguide_pcb.html#cel	881
Hawaii DOH	Not available	-
Idaho DHW	http://www.healthandwelfare.idaho.gov/Health/Labs/CertificationDrinkingWaterLabs/tabid/1833/Default.aspx	-
Indiana DOH	http://www.in.gov/isdh/24859.htm	C-WA-01
ISO 17025	http://www.pjlabs.com/	L12-27
Louisiana DEQ	http://www.deq.louisiana.gov/portal/DIVISIONS/PublicParticipationandPermitSupport/LouisianaLaboratoryAccreditationProgram.aspx	3016
Maine DHS	Not available	WA0035
Michigan DEQ	http://www.michigan.gov/deq/0,1607,7-135-3307_4131_4156---,00.html	9949
Minnesota DOH	http://www.health.state.mn.us/accreditation	053-999-457
Montana DPHHS	http://www.dphhs.mt.gov/publichealth/	CERT0047
Nevada DEP	http://ndep.nv.gov/bsdw/labservice.htm	WA35
New Jersey DEP	http://www.nj.gov/dep/oqa/	WA005
North Carolina DWQ	http://www.dwqlab.org/	605
Oklahoma DEQ	http://www.deq.state.ok.us/CSDnew/labcert.htm	9801
Oregon – DEQ (NELAP)	http://public.health.oregon.gov/LaboratoryServices/EnvironmentalLaboratoryAccreditation/Pages/index.aspx	WA200001
South Carolina DHEC	http://www.scdhec.gov/environment/envserv/	61002
Texas CEQ	http://www.tceq.texas.gov/field/qa/env_lab_accreditation.html	T104704427-08-TX
Washington DOE	http://www.ecy.wa.gov/programs/eap/labs/lab-accreditation.html	C1203
Wisconsin DNR	http://dnr.wi.gov/	998386840
Wyoming (EPA Region 8)	http://www.epa.gov/region8/water/dwhome/wyomingdi.html	-
Kelso Laboratory Website	www.alsglobal.com	NA

Analyses were performed according to our laboratory's NELAP-approved quality assurance program. A complete listing of specific NELAP-certified analytes, can be found in the certification section at www.caslab.com or at the accreditation bodies web site

Please refer to the certification and/or accreditation body's web site if samples are submitted for compliance purposes. The states highlighted above, require the analysis be listed on the state certification if used for compliance purposes and if the method/anlayte is offered by that state.

ALS ENVIRONMENTAL

Client:	Aecos, Incoporated	**Service Request No.:**	K1403135
Project:	Lualualei/ 29885	**Date Received:**	03/28/14
Sample Matrix:	Water		

Case Narrative

All analyses were performed consistent with the quality assurance program of ALS Environmental. This report contains analytical results for samples designated for Tier II data deliverables. When appropriate to the method, method blank results have been reported with each analytical test. Surrogate recoveries have been reported for all applicable organic analyses. Additional quality control analyses reported herein include: Laboratory Duplicate (DUP), Matrix Spike (MS), Matrix/Duplicate Matrix Spike (MS/DMS), Laboratory Control Sample (LCS), and Laboratory/Duplicate Laboratory Control Sample (LCS/DLCS).

Sample Receipt

Two water samples were received for analysis at ALS Environmental on 03/28/14. The samples were received in good condition and consistent with the accompanying chain of custody form. The samples were stored in a refrigerator at 4ºC upon receipt at the laboratory.

General Chemistry Parameters

No anomalies associated with the analysis of these samples were observed.

Total Metals

No anomalies associated with the analysis of these samples were observed.

Organochlorine Pesticides and PCBs by EPA Method 608

Calibration Verification Exceptions:
The analysis of Chlorinated Pesticides and PCB Aroclors by EPA 608 requires the use of dual column confirmation. When the Continuing Calibration Verification (CCV) criterion is met for both columns, the lower of the two sample results is generally reported. The primary evaluation criteria were not met on the confirmation column for a number of analytes. The results were reported from the column with an acceptable CCV. The data quality was not affected. No further corrective action was necessary.

Elevated Detection Limits:
The detection limit was elevated for beta-BHC in sample Confluence. The chromatogram indicated the presence of non-target background components. The matrix interference prevented adequate resolution of the target compound at the normal limit. The result was flagged to indicate the matrix interference.

No other anomalies associated with the analysis of these samples were observed.

Approved by____

Organophosphorus Pesticides by EPA Method 614

Calibration Verification Exceptions:
The upper control criterion was exceeded for a few analytes in associated Continuing Calibration Verifications (CCV). The field samples analyzed in this sequence did not contain hits for any target analytes. Since the apparent problem indicated a potential high bias, the data quality was not affected. No further corrective action was required.

Internal Standard Exceptions:
The analysis of method EPA 8141A requires the use of dual column confirmation. When the internal standard criterion is met for both columns, the lower of the two sample results is generally reported. The internal standard criteria were not met on the confirmation column. This would cause a bias for any detection on the confirmation column. Therefore, all results for all analytes and surrogates were taken from the column with the fully resolved internal standard. No further corrective action was necessary.

Matrix Spike Recovery Exceptions:
Insufficient sample volume was received to perform a Matrix Spike/Matrix Spike Duplicate (MS/MSD). A Laboratory Control Sample/Duplicate Laboratory Control Sample (LCS/DLCS) was analyzed and reported in lieu of the MS/MSD for these samples.

Surrogate Exceptions:
The lower control criteria were exceeded for Tributyl and Triphenyl Phosphate in sample Confluence due to suspected matrix interference. A less than optimal sample was extracted due to the high particulate content of this field sample. No further corrective action was appropriate.

The upper control criterion was exceeded for Triphenyl Phosphate in sample Basil Farm. No target analytes were detected in the sample. The error associated with an elevated recovery equated to a high bias. The quality of the sample data was not significantly affected. No further corrective action was appropriate.

Elevated Detection Limits:
The detection limit for all analytes for sample Confluence was elevated due to less than optimal sample volume used for analysis.

No other anomalies associated with the analysis of these samples were observed.

Chlorinated Herbicides by EPA Method 8151

Calibration Verification Exceptions:
The analysis of EPA 8151 requires the use of dual column confirmation. When the Continuing Calibration Verification (CCV) criterion is met for both columns, the lower of the two sample results is generally reported. The primary evaluation criteria were not met on the confirmation column for 2,4,5-T, 2,4-DB and Dinoseb in an associated closing CCV. The results were reported from the column with an acceptable CCV. The data quality was not affected. No further corrective action was necessary.

Elevated Detection Limits:
The detection limit was elevated for at least one analyte in both field samples. The chromatogram indicated the presence of non-target background components. The matrix interference prevented adequate resolution of the target compounds at the normal limit. The results were flagged to indicate the matrix interference.

The detection limit was elevated for 2,4-DB in samples Confluence and Basil Farm. The chromatogram indicated the presence of non-target background components. The original analysis of the sample extracts resulted in failure of the closing Continuing Calibration Verification (CCV) to meet control criteria on both primary and confirmation columns. The extracts were reanalyzed at a dilution to prevent further detriment to the analytical system and to achieve accurate quantitation of the target analytes. The results from the reanalysis were reported. No further corrective action was feasible.

Approved by____________________________________

Relative Percent Difference Exceptions:
The Relative Percent Difference (RPD) for Dinoseb in the replicate Laboratory Control Sample (LCS) analyses (KWG1402902-1 and KWG1402902-2) was outside control criteria. The data was flagged to indicate the problem.

Matrix Spike Recovery Exceptions:
Insufficient sample volume was received to perform a Matrix Spike/Matrix Spike Duplicate (MS/MSD). A Laboratory Control Sample/Duplicate Laboratory Control Sample (LCS/DLCS) was analyzed and reported in lieu of the MS/MSD for these samples.

No other anomalies associated with the analysis of these samples were observed.

Approved by____

AECOS, Inc.

45-939 Kamehameha Highway Suite 104
Kaneohe, Oahu, HI 96744
Tel: (808) 234-7770 Fax: 234-7775

SUB-- CHAIN OF CUSTODY FORM

H1403135

PROJECT: Lualualei
FILE No.:
LOG NUMBER [29885]

CLIENT: AECOS INC.
ADDRESS:

CONTACT: SNOOKIE MELLO
PHONE No.: (808)234-7770
Purchase Order No.:

☐ RUSH
☐ SEE REVERSE
SPECIAL INSTRUCTIONS

	☑	SAMPLE ID	SAMPLED DATE	SAMPLED TIME	SAMPLE TYPE	CONTAINER(S)		REQUESTED ANALYSES	PRESERVATION
1		Confluence	3/25/14	1400	stream/estuary (brackish)	1	250ml P	NO3NO2, TN, TP	H2SO4
2		(sal ≈ 16ppt) ↓	↓	↓	↓	1	500ml P	Arsenic, Lead, Zinc	none
3						2	1L G	EPA 608 Organochlorine Pests	none
4						2	1L G	EPA 614 Organophos. Pesticides	none
5						2	1L G	EPA 615 (or 8151A?) Herbicides	none
6		Basil Farm	3/25/14	1445		1	250ml P	NO3NO2, TN, TP	H2SO4
7		(sal ≈ 4 ppt) ↓	↓	↓		1	500ml P	Arsenic, Lead, Zinc	none
8						2	1L G	EPA 608 Organochlorine Pests	none
9						2	1L G	EPA ~~615~~ 614 OP Pesticides	none
10					↓	2	1L G	EPA 615/8151? Herb	none

CLIENTS PROVIDING SAMPLES TO THE LABORATORY SHOULD COMPLETE AS MUCH OF THE ABOVE FORM AS POSSIBLE. NOTE: NAME AND DATED SIGNATURE OF PERSON COLLECTING THE SAMPLE MUST BE ENTERED BELOW ↓. INFORMATION REQUESTED IN SHADED BOXES ABOVE TO BE FILLED IN BY THE LABORATORY.

SAMPLED BY: AECOS CL, RK (PRINT NAME) DATE 3/25 2014	RECEIVED BY: AECOS [signature] (SIGNATURE) DATE 3/25 2014 TIME	RECEIVED FOR LABORATORY: [signature] (SIGNATURE) DATE 3-28 2014 TIME 10:00
RELINQUISHED: CL, RK [signature] (SIGNATURE) DATE 3/25 2014 TIME 1415	RELINQUISHED: AECOS [signature] (SIGNATURE OR INITIALS) DATE 3/~~25~~ 27 2014 TIME 1100	RELINQUISHED: (SIGNATURE OR INITIALS) DATE 20__ TIME

COMMENTS:

PRECAUTIONS:

DISPOSAL:

USE (BLACK) INK

RETURN SAMPLE TO CLIENT ☐

PC ___CL___

Cooler Receipt and Preservation Form

Client / Project: Aecos Service Request **K14** 3185

Received: 3-28-14 Opened: 3-28-14 By: GH Unloaded: 3-28-14 By: GH

1. Samples were received via? *Mail* *(Fed Ex)* *UPS* *DHL* *PDX* *Courier* *Hand Delivered*
2. Samples were received in: (circle) *(Cooler)* *Box* *Envelope* *Other* ______ *NA*
3. Were custody seals on coolers? (NA) Y N If yes, how many and where? ______
   If present, were custody seals intact? Y N If present, were they signed and dated? Y N

Raw Cooler Temp	Corrected. Cooler Temp	Raw Temp Blank	Corrected Temp Blank	Corr. Factor	Thermometer ID	Cooler/COC ID (NA)	Tracking Number NA	Filed
5.5	5.6	—	—	+0.1	282		7983 5146 1640	

4. Packing material: *Inserts* *(Baggies)* *(Bubble Wrap)* *(Gel Packs)* *Wet Ice* *Dry Ice* *Sleeves* ______
5. Were custody papers properly filled out (ink, signed, etc.)? NA (Y) N
6. Did all bottles arrive in good condition (unbroken)? *Indicate in the table below.* NA (Y) N
7. Were all sample labels complete (i.e analysis, preservation, etc.)? NA (Y) N
8. Did all sample labels and tags agree with custody papers? *Indicate major discrepancies in the table on page 2.* NA (Y) N
9. Were appropriate bottles/containers and volumes received for the tests indicated? NA (Y) N
10. Were the pH-preserved bottles (*see SMO GEN SOP*) received at the appropriate pH? *Indicate in the table below* NA Y (N)
11. Were VOA vials received without headspace? *Indicate in the table below.* (NA) Y N
12. Was C12/Res negative? NA (Y) N

Sample ID on Bottle	Sample ID on COC	Identified by:

Sample ID	Bottle Count Bottle Type	Out of Temp	Head-space	Broke	pH	Reagent	Volume added	Reagent Lot Number	Initials	Time
Confluence 29855	250cc Pl				X	HNO3	1mL	0000021587	GH	13:50 *
Basil Farm 29855	250ccPL				X	HNO3	1mL	0000021587	GH	13:50 *
Confluence	500ml				X	HNO3	1ml	0000021587	KO	1640
Basil Farm	↓				X	HNO3	1ml	↓	KO	1640

Notes, Discrepancies, & Resolutions: * Error acid preservative for the 250ml NO2/NO3 bottle; aliquotted from the 500ml unpreserved bottle and preserved with H_2SO_4 @ 1640

Page ____ ***of*** ____

ALS Group USA, Corp.
dba ALS Environmental

Analytical Report

Client: Aecos, Incorporated
Project: Lualualei/29885
Sample Matrix: Water

Service Request: K1403135
Date Collected: 03/25/14
Date Received: 03/28/14

Analysis Method: 353.2
Prep Method: Method

Units: mg/L
Basis: NA

Nitrate+Nitrite as Nitrogen

Sample Name	Lab Code	Result	MRL	MDL	Dil.	Date Analyzed	Date Extracted	Q
Confluence	K1403135-001	**0.052**	0.050	0.020	1	04/11/14 10:24	4/11/14	
Basil Farm	K1403135-002	**37.3**	0.50	0.20	10	04/11/14 10:24	4/11/14	
Method Blank	K1403135-MB	**0.024 J**	0.050	0.020	1	04/11/14 10:24	4/11/14	

ALS Group USA, Corp.

dba ALS Environmental

QA/QC Report

Client:	Aecos, Incorporated	**Service Request:**	K1403135
Project	Lualualei/29885	**Date Collected:**	NA
Sample Matrix:	Water	**Date Received:**	NA
		Date Analyzed:	04/11/14

Replicate Sample Summary
General Chemistry Parameters

Sample Name:	Batch QC	**Units:**	mg/L
Lab Code:	K1403123-005	**Basis:**	NA

Analyte Name	Analysis Method	MRL	MDL	Sample Result	Duplicate Sample K1403123-005DUP Result	Average	RPD	RPD Limit
Nitrate+Nitrite as Nitrogen	353.2	0.050	0.020	2.92	2.95	2.94	1	20

Results flagged with an asterisk (*) indicate values outside control criteria.

Results flagged with a pound (#) indicate the control criteria is not applicable.

Percent recoveries and relative percent differences (RPD) are determined by the software using values in the calculation which have not been rounded.

Printed 4/14/2014 10:41:52 AM   Superset Reference:14-0000284070 rev 00

ALS Group USA, Corp.
dba ALS Environmental

QA/QC Report

Client:	Aecos, Incorporated	**Service Request:**	K1403135
Project:	Lualualei/29885	**Date Collected:**	N/A
Sample Matrix:	Water	**Date Received:**	N/A
		Date Analyzed:	04/11/14
		Date Extracted:	04/11/14

Duplicate Matrix Spike Summary
Nitrate+Nitrite as Nitrogen

Sample Name:	Batch QC	**Units:**	mg/L
Lab Code:	K1403123-005	**Basis:**	NA
Analysis Method:	353.2		
Prep Method:	Method		

		Matrix Spike K1403123-005MS			Duplicate Matrix Spike K1403123-005DMS					
Analyte Name	**Sample Result**	**Result**	**Spike Amount**	**% Rec**	**Result**	**Spike Amount**	**% Rec**	**% Rec Limits**	**RPD**	**RPD Limit**
Nitrate+Nitrite as Nitrogen	2.92	4.97	2.00	103	4.91	2.00	100	89-114	1	20

Results flagged with an asterisk (*) indicate values outside control criteria.

Results flagged with a pound (#) indicate the control criteria is not applicable.

Percent recoveries and relative percent differences (RPD) are determined by the software using values in the calculation which have not been rounded.

Printed 4/14/2014 10:41:53 AM Superset Reference:14-0000284070 rev 00

ALS Group USA, Corp.
dba ALS Environmental

QA/QC Report

Client:	Aecos, Incorporated	**Service Request:**	K1403135
Project:	Lualualei/29885	**Date Analyzed:**	04/11/14
Sample Matrix:	Water	**Date Extracted:**	04/11/14

Lab Control Sample Summary
Nitrate+Nitrite as Nitrogen

Analysis Method:	353.2	**Units:**	mg/L
Prep Method:	Method	**Basis:**	NA
		Analysis Lot:	387871

Sample Name	Lab Code	Result	Spike Amount	% Rec	% Rec Limits
Lab Control Sample	K1403135-LCS	4.37	4.35	101	90-110

ALS Group USA, Corp.
dba ALS Environmental

Analytical Report

Client: Aecos, Incorporated
Project: Lualualei/29885
Sample Matrix: Water
Analysis Method: 365.3
Prep Method: Method

Service Request: K1403135
Date Collected: 03/25/14
Date Received: 03/28/14
Units: mg/L
Basis: NA

Phosphorus, Total

Sample Name	Lab Code	Result	MRL	MDL	Dil.	Date Analyzed	Date Extracted	Q
Confluence	K1403135-001	**0.206**	0.010	0.004	1	04/01/14 18:55	4/1/14	
Basil Farm	K1403135-002	**8.88**	0.10	0.04	10	04/01/14 18:55	4/1/14	
Method Blank	K1403135-MB	**0.010 J**	0.010	0.004	1	04/01/14 18:55	4/1/14	

ALS Group USA, Corp.
dba ALS Environmental

QA/QC Report

Client:	Aecos, Incorporated	**Service Request:**	K1403135
Project	Lualualei/29885	**Date Collected:**	NA
Sample Matrix:	Water	**Date Received:**	NA
		Date Analyzed:	04/01/14

Replicate Sample Summary
General Chemistry Parameters

Sample Name:	Batch QC	**Units:**	mg/L
Lab Code:	K1403074-001	**Basis:**	NA

Analyte Name	Analysis Method	MRL	MDL	Sample Result	Duplicate Sample K1403074-001DUP Result	Average	RPD	RPD Limit
Phosphorus, Total	365.3	0.010	0.004	0.124	0.125	0.125	<1	20

Results flagged with an asterisk (*) indicate values outside control criteria.

Results flagged with a pound (#) indicate the control criteria is not applicable.

Percent recoveries and relative percent differences (RPD) are determined by the software using values in the calculation which have not been rounded.

Client:	Aecos, Incorporated	**Service Request:**	K1403135
Project:	Lualualei/29885	**Date Collected:**	N/A
Sample Matrix:	Water	**Date Received:**	N/A
		Date Analyzed:	04/1/14
		Date Extracted:	04/1/14

Duplicate Matrix Spike Summary
Phosphorus, Total

Sample Name:	Batch QC	**Units:**	mg/L
Lab Code:	K1403074-001	**Basis:**	NA
Analysis Method:	365.3		
Prep Method:	Method		

		Matrix Spike K1403074-001MS			Duplicate Matrix Spike K1403074-001DMS					
Analyte Name	**Sample Result**	**Result**	**Spike Amount**	**% Rec**	**Result**	**Spike Amount**	**% Rec**	**% Rec Limits**	**RPD**	**RPD Limit**
Phosphorus, Total	0.124	0.676	0.500	110	0.665	0.500	108	60-135	2	20

Results flagged with an asterisk (*) indicate values outside control criteria.

Results flagged with a pound (#) indicate the control criteria is not applicable.

Percent recoveries and relative percent differences (RPD) are determined by the software using values in the calculation which have not been rounded.

ALS Group USA, Corp.
dba ALS Environmental

QA/QC Report

Client:	Aecos, Incorporated	**Service Request:**	K1403135
Project:	Lualualei/29885	**Date Analyzed:**	04/01/14
Sample Matrix:	Water	**Date Extracted:**	04/01/14

Lab Control Sample Summary
Phosphorus, Total

Analysis Method:	365.3	**Units:**	mg/L
Prep Method:	Method	**Basis:**	NA
		Analysis Lot:	386328

Sample Name	Lab Code	Result	Spike Amount	% Rec	% Rec Limits
Lab Control Sample	K1403135-LCS	3.67	3.46	106	85-115

ALS Group USA, Corp.
dba ALS Environmental

Analytical Report

Client:	Aecos, Incorporated	**Service Request:**	K1403135
Project:	Lualualei/29885	**Date Collected:**	03/25/14
Sample Matrix:	Water	**Date Received:**	03/28/14
Analysis Method:	ASTM D1426-93B	**Units:**	mg/L
Prep Method:	ASTM D3590-89B-21.1 Mod	**Basis:**	NA

Nitrogen, Total Kjeldahl (TKN)

Sample Name	Lab Code	Result	MRL	MDL	Dil.	Date Analyzed	Date Extracted	Q
Confluence	K1403135-001	**5.36**	0.80	0.32	4	04/01/14 14:15	3/31/14	
Basil Farm	K1403135-002	**6.79**	0.80	0.32	4	04/01/14 14:15	3/31/14	
Method Blank	K1403135-MB	ND U	0.20	0.16	2	04/01/14 14:15	3/31/14	

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QA/QC Report

Client:	Aecos, Incorporated	**Service Request:**	K1403135
Project	Lualualei/29885	**Date Collected:**	NA
Sample Matrix:	Water	**Date Received:**	NA
		Date Analyzed:	04/01/14

Replicate Sample Summary
General Chemistry Parameters

Sample Name:	Batch QC	**Units:**	mg/L
Lab Code:	K1403091-001	**Basis:**	NA

Analyte Name	Analysis Method	MRL	MDL	Sample Result	Duplicate Sample K1403091-001DUP Result	Average	RPD	RPD Limit
Nitrogen, Total Kjeldahl (TKN)	ASTM D1426-93B	0.40	0.16	19.8	19.7	19.7	<1	20

Results flagged with an asterisk (*) indicate values outside control criteria.

Results flagged with a pound (#) indicate the control criteria is not applicable.

Percent recoveries and relative percent differences (RPD) are determined by the software using values in the calculation which have not been rounded.

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QA/QC Report

Client:	Aecos, Incorporated	**Service Request:**	K1403135
Project:	Lualualei/29885	**Date Collected:**	N/A
Sample Matrix:	Water	**Date Received:**	N/A
		Date Analyzed:	04/1/14
		Date Extracted:	03/31/14

Duplicate Matrix Spike Summary
Nitrogen, Total Kjeldahl (TKN)

Sample Name:	Batch QC	**Units:**	mg/L
Lab Code:	K1403091-001	**Basis:**	NA
Analysis Method:	ASTM D1426-93B		
Prep Method:	ASTM D 3590-89B-21.1		

		Matrix Spike K1403091-001MS			Duplicate Matrix Spike K1403091-001DMS					
Analyte Name	**Sample Result**	**Result**	**Spike Amount**	**% Rec**	**Result**	**Spike Amount**	**% Rec**	**% Rec Limits**	**RPD**	**RPD Limit**
Nitrogen, Total Kjeldahl (TKN)	19.8	41.6	20.0	109	50.0	40.0	76	53-160	36*	20

Results flagged with an asterisk (*) indicate values outside control criteria.

Results flagged with a pound (#) indicate the control criteria is not applicable.

Percent recoveries and relative percent differences (RPD) are determined by the software using values in the calculation which have not been rounded.

Client:	Aecos, Incorporated	**Service Request:**	K1403135
Project:	Lualualei/29885	**Date Analyzed:**	04/01/14
Sample Matrix:	Water	**Date Extracted:**	03/31/14

Lab Control Sample Summary
Nitrogen, Total Kjeldahl (TKN)

Analysis Method:	ASTM D1426-93B	**Units:**	mg/L
Prep Method:	ASTM D 3590-89B-21.1	**Basis:**	NA
		Analysis Lot:	386318

Sample Name	Lab Code	Result	Spike Amount	% Rec	% Rec Limits
Lab Control Sample	K1403135-LCS	8.80	9.08	97	72-129

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Analytical Report

Client:	Aecos, Incorporated	**Service Request:**	K1403135
Project:	Lualualei/29885	**Date Collected:**	03/25/14
Sample Matrix:	Water	**Date Received:**	03/28/14
Analysis Method:	NCASI TNTP-W10900	**Units:**	mg/L
Prep Method:	Method	**Basis:**	NA

Nitrogen, Total as Nitrogen

Sample Name	Lab Code	Result	MRL	MDL	Dil.	Date Analyzed	Date Extracted	Q
Confluence	K1403135-001	**3.53**	0.50	0.20	1	04/04/14 08:47	4/2/14	
Basil Farm	K1403135-002	**40.0**	5.0	2.0	10	04/04/14 08:47	4/2/14	
Method Blank	K1403135-MB	ND U	0.50	0.20	1	04/04/14 08:47	4/2/14	

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QA/QC Report

Client:	Aecos, Incorporated	**Service Request:**	K1403135
Project	Lualualei/29885	**Date Collected:**	03/25/14
Sample Matrix:	Water	**Date Received:**	03/28/14
		Date Analyzed:	04/04/14

Replicate Sample Summary
General Chemistry Parameters

Sample Name:	Confluence	**Units:**	mg/L
Lab Code:	K1403135-001	**Basis:**	NA

Analyte Name	Analysis Method	MRL	MDL	Sample Result	Duplicate Sample K1403135-001DUP Result	Average	RPD	RPD Limit
Nitrogen, Total as Nitrogen	NCASI TNTP-W10900	0.50	0.20	3.53	2.97	3.25	17	20

Results flagged with an asterisk (*) indicate values outside control criteria.

Results flagged with a pound (#) indicate the control criteria is not applicable.

Percent recoveries and relative percent differences (RPD) are determined by the software using values in the calculation which have not been rounded.

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QA/QC Report

Client:	Aecos, Incorporated	**Service Request:**	K1403135
Project:	Lualualei/29885	**Date Collected:**	03/25/14
Sample Matrix:	Water	**Date Received:**	03/28/14
		Date Analyzed:	04/4/14
		Date Extracted:	04/2/14

Duplicate Matrix Spike Summary
Nitrogen, Total as Nitrogen

Sample Name:	Confluence	**Units:**	mg/L
Lab Code:	K1403135-001	**Basis:**	NA
Analysis Method:	NCASI TNTP-W10900		
Prep Method:	Method		

		Matrix Spike K1403135-001MS			Duplicate Matrix Spike K1403135-001DMS					
Analyte Name	**Sample Result**	**Result**	**Spike Amount**	**% Rec**	**Result**	**Spike Amount**	**% Rec**	**% Rec Limits**	**RPD**	**RPD Limit**
Nitrogen, Total as Nitrogen	3.53	5.8	2.0	113	5.9	2.0	119	75-125	2	20

Results flagged with an asterisk (*) indicate values outside control criteria.

Results flagged with a pound (#) indicate the control criteria is not applicable.

Percent recoveries and relative percent differences (RPD) are determined by the software using values in the calculation which have not been rounded.

Client:	Aecos, Incorporated	**Service Request:**	K1403135
Project:	Lualualei/29885	**Date Analyzed:**	04/04/14
Sample Matrix:	Water	**Date Extracted:**	04/02/14

Lab Control Sample Summary
Nitrogen, Total as Nitrogen

Analysis Method:	NCASI TNTP-W10900	**Units:**	mg/L
Prep Method:	Method	**Basis:**	NA
		Analysis Lot:	386858

Sample Name	Lab Code	Result	Spike Amount	% Rec	% Rec Limits
Lab Control Sample	K1403135-LCS	5.06	5.00	101	85-115

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Analytical Report

Client:	Aecos, Incorporated	**Service Request:**	K1403135
Project:	Lualualei/29885	**Date Collected:**	3/25/2014
Sample Matrix:	Water	**Date Received:**	3/28/2014

Nitrogen, Total as Nitrogen

Prep Method:	NONE	Units:	mg/L
Analysis Method:	353.2/ASTM D1426-93B	Basis:	NA
Test Notes:			

Sample Name	Lab Code	MRL	MDL	Dilution Factor	Date Extracted	Date Analyzed	Result	Result Notes
Confluence	K1403135-001	0.80	0.32	4	NA	4/1/2014	5.41	
Basil Farm	K1403135-002	0.80	0.32	4	NA	4/1/2014	44.1	

REVISED
12:59 pm, May 06, 2014

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- Cover Page -
INORGANIC ANALYSIS DATA PACKAGE

Client: Aecos, Incorporated
Project Name: Lualualei
Project No.: 29885

Service Request: K1403135

Sample Name:	Lab Code:
Batch QC1D	K1403029-001D
Batch QC1S	K1403029-001S
Confluence	K1403135-001
Basil Farm	K1403135-002
Method Blank	K1403135-MB

Comments:

ALS Group USA, Corp.
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Metals

- 1 -

INORGANIC ANALYSIS DATA PACKAGE

Client: Aecos, Incorporated
Project No.: 29885
Project Name: Lualualei
Matrix: WATER

Service Request: K1403135
Date Collected: 03/25/14
Date Received: 03/28/14
Units: ug/L
Basis: NA

Sample Name: **Confluence** **Lab Code:** **K1403135-001**

Analyte	Analysis Method	MRL	MDL	Dilution Factor	Date Extracted	Date Analyzed	Result	C	Q
Arsenic	200.8	1.00	0.10	2.0	04/01/14	04/02/14	2.38		
Lead	200.8	0.040	0.010	2.0	04/01/14	04/02/14	0.326		
Zinc	200.8	1.00	0.08	2.0	04/01/14	04/02/14	5.39		

Comments:

Metals

- 1 -

INORGANIC ANALYSIS DATA PACKAGE

Client:	Aecos, Incorporated	**Service Request:**	K1403135
Project No.:	29885	**Date Collected:**	03/25/14
Project Name:	Lualualei	**Date Received:**	03/28/14
Matrix:	WATER	**Units:**	ug/L
		Basis:	NA

Sample Name: **Basil Farm** **Lab Code:** **K1403135-002**

Analyte	Analysis Method	MRL	MDL	Dilution Factor	Date Extracted	Date Analyzed	Result	C	Q
Arsenic	200.8	0.50	0.05	1.0	04/01/14	04/02/14	4.34		
Lead	200.8	0.020	0.005	1.0	04/01/14	04/02/14	0.120		
Zinc	200.8	0.50	0.04	1.0	04/01/14	04/02/14	13.7		

Comments:

Metals
- 1 -
INORGANIC ANALYSIS DATA PACKAGE

Client: Aecos, Incorporated
Service Request: K1403135
Project No.: 29885
Date Collected:
Project Name: Lualualei
Date Received:
Matrix: WATER
Units: ug/L
Basis: NA

Sample Name: **Method Blank**
Lab Code: **K1403135-MB**

Analyte	Analysis Method	MRL	MDL	Dilution Factor	Date Extracted	Date Analyzed	Result	C	Q
Arsenic	200.8	0.50	0.05	1.0	04/01/14	04/02/14	0.05	U	
Lead	200.8	0.020	0.005	1.0	04/01/14	04/02/14	0.008	J	
Zinc	200.8	0.50	0.04	1.0	04/01/14	04/02/14	0.10	J	

Comments:

Metals
- 5A -
SPIKE SAMPLE RECOVERY

Client: Aecos, Incorporated
Service Request: K1403135
Project No.: 29885
Units: UG/L
Project Name: Lualualei
Basis: NA
Matrix: WATER

Sample Name: Batch QC1S
Lab Code: K1403029-001S

Analyte	Control Limit %R	Spike Result	C	Sample Result	C	Spike Added	%R	Q	Method
Arsenic	70 - 130	52.6		0.2	J	50.0	104.8		200.8
Lead	70 - 130	52.3		0.0		50.0	104.6		200.8
Zinc	70 - 130	35.9		6.6		25.0	117.2		200.8

An empty field in the Control Limit column indicates the control limit is not applicable

Metals
- 6 -
DUPLICATES

Client: Aecos, Incorporated
Service Request: K1403135
Project No.: 29885
Units: UG/L
Project Name: Lualualei
Basis: NA
Matrix: WATER

Sample Name: Batch QC1D
Lab Code: K1403029-001D

Analyte	Control Limit	Sample (S)	C	Duplicate (D)	C	RPD	Q	Method
Arsenic		0.20	J	0.17	J	16.2		200.8
Lead		0.033		0.034		3.0		200.8
Zinc	20	6.65		7.10		6.5		200.8

An empty field in the Control Limit column indicates the control limit is not applicable.

Metals
-7-
LABORATORY CONTROL SAMPLE

Client: Aecos, Incorporated

Service Request: K1403135

Project No.: 29885

Project Name: Lualualei

Aqueous LCS Source: CAS MIXED

Solid LCS Source:

Analyte	Aqueous (ug/L)			Solid (mg/kg)				
	True	Found	%R	True	Found	C	Limits	%R
Arsenic	50.0	51.8	103.6					
Lead	50.0	53.5	107.0					
Zinc	25.0	27.2	108.8					

Analytical Results

Client:	Aecos, Incorporated	**Service Request:**	K1403135
Project:	Lualualei/29885	**Date Collected:**	03/25/2014
Sample Matrix:	Water	**Date Received:**	03/28/2014

Organochlorine Pesticides and Polychlorinated Biphenyls

Sample Name:	Confluence	**Units:**	ug/L
Lab Code:	K1403135-001	**Basis:**	NA
Extraction Method:	EPA 3520C	**Level:**	Low
Analysis Method:	608		

Analyte Name	Result	Q	MRL	MDL	Dilution Factor	Date Extracted	Date Analyzed	Extraction Lot	Note
alpha-BHC	ND	U	0.0099	0.00065	1	03/31/14	04/14/14	KWG1403033	
beta-BHC	ND	Ui	0.028	0.028	1	03/31/14	04/14/14	KWG1403033	
gamma-BHC (Lindane)	**0.0042**	JP	0.0099	0.0020	1	03/31/14	04/14/14	KWG1403033	
delta-BHC	ND	U	0.0099	0.0035	1	03/31/14	04/14/14	KWG1403033	
Heptachlor	**0.0021**	JP	0.0099	0.0010	1	03/31/14	04/14/14	KWG1403033	
Aldrin	**0.0028**	J	0.0099	0.0017	1	03/31/14	04/14/14	KWG1403033	
Heptachlor Epoxide	ND	U	0.0099	0.0010	1	03/31/14	04/14/14	KWG1403033	
Endosulfan I	ND	U	0.0099	0.0013	1	03/31/14	04/14/14	KWG1403033	
Dieldrin	ND	U	0.0099	0.00085	1	03/31/14	04/14/14	KWG1403033	
4,4'-DDE	ND	U	0.0099	0.0011	1	03/31/14	04/14/14	KWG1403033	
Endrin	ND	U	0.0099	0.0013	1	03/31/14	04/14/14	KWG1403033	
Endosulfan II	ND	U	0.0099	0.0010	1	03/31/14	04/14/14	KWG1403033	
4,4'-DDD	ND	U	0.0099	0.0015	1	03/31/14	04/14/14	KWG1403033	
Endrin Aldehyde	ND	U	0.0099	0.0017	1	03/31/14	04/14/14	KWG1403033	
Endosulfan Sulfate	**0.0063**	J	0.0099	0.0012	1	03/31/14	04/14/14	KWG1403033	
4,4'-DDT	ND	U	0.0099	0.0018	1	03/31/14	04/14/14	KWG1403033	
Toxaphene	ND	U	0.50	0.083	1	03/31/14	04/14/14	KWG1403033	
Chlordane	ND	U	0.20	0.021	1	03/31/14	04/14/14	KWG1403033	
Aroclor 1016	ND	U	0.050	0.043	1	03/31/14	04/14/14	KWG1403033	
Aroclor 1221	ND	U	0.099	0.058	1	03/31/14	04/14/14	KWG1403033	
Aroclor 1232	ND	U	0.099	0.049	1	03/31/14	04/14/14	KWG1403033	
Aroclor 1242	ND	U	0.099	0.018	1	03/31/14	04/14/14	KWG1403033	
Aroclor 1248	ND	U	0.099	0.035	1	03/31/14	04/14/14	KWG1403033	
Aroclor 1254	ND	U	0.099	0.029	1	03/31/14	04/14/14	KWG1403033	
Aroclor 1260	ND	U	0.099	0.053	1	03/31/14	04/14/14	KWG1403033	

Surrogate Name	%Rec	Control Limits	Date Analyzed	Note
Decachlorobiphenyl	52	10-134	04/14/14	Acceptable

Comments:

Analytical Results

Client:	Aecos, Incorporated	**Service Request:**	K1403135
Project:	Lualualei/29885	**Date Collected:**	03/25/2014
Sample Matrix:	Water	**Date Received:**	03/28/2014

Organochlorine Pesticides and Polychlorinated Biphenyls

Sample Name:	Basil Farm	**Units:**	ug/L
Lab Code:	K1403135-002	**Basis:**	NA
Extraction Method:	EPA 3520C	**Level:**	Low
Analysis Method:	608		

Analyte Name	Result	Q	MRL	MDL	Dilution Factor	Date Extracted	Date Analyzed	Extraction Lot	Note
alpha-BHC	ND	U	0.010	0.00065	1	03/31/14	04/14/14	KWG1403033	
beta-BHC	ND	U	0.010	0.00079	1	03/31/14	04/14/14	KWG1403033	
gamma-BHC (Lindane)	ND	U	0.010	0.0020	1	03/31/14	04/14/14	KWG1403033	
delta-BHC	ND	U	0.010	0.0035	1	03/31/14	04/14/14	KWG1403033	
Heptachlor	ND	U	0.010	0.0010	1	03/31/14	04/14/14	KWG1403033	
Aldrin	ND	U	0.010	0.0017	1	03/31/14	04/14/14	KWG1403033	
Heptachlor Epoxide	ND	U	0.010	0.0010	1	03/31/14	04/14/14	KWG1403033	
Endosulfan I	ND	U	0.010	0.0013	1	03/31/14	04/14/14	KWG1403033	
Dieldrin	**0.0069**	J	0.010	0.00085	1	03/31/14	04/14/14	KWG1403033	
4,4'-DDE	ND	U	0.010	0.0011	1	03/31/14	04/14/14	KWG1403033	
Endrin	ND	U	0.010	0.0013	1	03/31/14	04/14/14	KWG1403033	
Endosulfan II	ND	U	0.010	0.0010	1	03/31/14	04/14/14	KWG1403033	
4,4'-DDD	ND	U	0.010	0.0015	1	03/31/14	04/14/14	KWG1403033	
Endrin Aldehyde	ND	U	0.010	0.0017	1	03/31/14	04/14/14	KWG1403033	
Endosulfan Sulfate	ND	U	0.010	0.0012	1	03/31/14	04/14/14	KWG1403033	
4,4'-DDT	ND	U	0.010	0.0018	1	03/31/14	04/14/14	KWG1403033	
Toxaphene	ND	U	0.50	0.083	1	03/31/14	04/14/14	KWG1403033	
Chlordane	ND	U	0.20	0.021	1	03/31/14	04/14/14	KWG1403033	
Aroclor 1016	ND	U	0.050	0.043	1	03/31/14	04/14/14	KWG1403033	
Aroclor 1221	ND	U	0.10	0.058	1	03/31/14	04/14/14	KWG1403033	
Aroclor 1232	ND	U	0.10	0.049	1	03/31/14	04/14/14	KWG1403033	
Aroclor 1242	ND	U	0.10	0.018	1	03/31/14	04/14/14	KWG1403033	
Aroclor 1248	ND	U	0.10	0.035	1	03/31/14	04/14/14	KWG1403033	
Aroclor 1254	ND	U	0.10	0.029	1	03/31/14	04/14/14	KWG1403033	
Aroclor 1260	ND	U	0.10	0.053	1	03/31/14	04/14/14	KWG1403033	

Surrogate Name	%Rec	Control Limits	Date Analyzed	Note
Decachlorobiphenyl	37	10-134	04/14/14	Acceptable

Comments:

Analytical Results

Client:	Aecos, Incorporated	**Service Request:**	K1403135
Project:	Lualualei/29885	**Date Collected:**	NA
Sample Matrix:	Water	**Date Received:**	NA

Organochlorine Pesticides and Polychlorinated Biphenyls

Sample Name:	Method Blank	**Units:**	ug/L
Lab Code:	KWG1403033-5	**Basis:**	NA
Extraction Method:	EPA 3520C	**Level:**	Low
Analysis Method:	608		

Analyte Name	Result	Q	MRL	MDL	Dilution Factor	Date Extracted	Date Analyzed	Extraction Lot	Note
alpha-BHC	ND	U	0.0096	0.00065	1	03/31/14	04/14/14	KWG1403033	
beta-BHC	ND	U	0.0096	0.00079	1	03/31/14	04/14/14	KWG1403033	
gamma-BHC (Lindane)	ND	U	0.0096	0.0020	1	03/31/14	04/14/14	KWG1403033	
delta-BHC	ND	U	0.0096	0.0035	1	03/31/14	04/14/14	KWG1403033	
Heptachlor	**0.0014**	JP	0.0096	0.0010	1	03/31/14	04/14/14	KWG1403033	
Aldrin	ND	U	0.0096	0.0017	1	03/31/14	04/14/14	KWG1403033	
Heptachlor Epoxide	ND	U	0.0096	0.0010	1	03/31/14	04/14/14	KWG1403033	
Endosulfan I	ND	U	0.0096	0.0013	1	03/31/14	04/14/14	KWG1403033	
Dieldrin	ND	U	0.0096	0.00085	1	03/31/14	04/14/14	KWG1403033	
4,4'-DDE	ND	U	0.0096	0.0011	1	03/31/14	04/14/14	KWG1403033	
Endrin	ND	U	0.0096	0.0013	1	03/31/14	04/14/14	KWG1403033	
Endosulfan II	ND	U	0.0096	0.0010	1	03/31/14	04/14/14	KWG1403033	
4,4'-DDD	ND	U	0.0096	0.0015	1	03/31/14	04/14/14	KWG1403033	
Endrin Aldehyde	ND	U	0.0096	0.0017	1	03/31/14	04/14/14	KWG1403033	
Endosulfan Sulfate	ND	U	0.0096	0.0012	1	03/31/14	04/14/14	KWG1403033	
4,4'-DDT	ND	U	0.0096	0.0018	1	03/31/14	04/14/14	KWG1403033	
Toxaphene	ND	U	0.48	0.083	1	03/31/14	04/14/14	KWG1403033	
Chlordane	ND	U	0.20	0.021	1	03/31/14	04/14/14	KWG1403033	
Aroclor 1016	ND	U	0.048	0.043	1	03/31/14	04/14/14	KWG1403033	
Aroclor 1221	ND	U	0.096	0.058	1	03/31/14	04/14/14	KWG1403033	
Aroclor 1232	ND	U	0.096	0.049	1	03/31/14	04/14/14	KWG1403033	
Aroclor 1242	ND	U	0.096	0.018	1	03/31/14	04/14/14	KWG1403033	
Aroclor 1248	ND	U	0.096	0.035	1	03/31/14	04/14/14	KWG1403033	
Aroclor 1254	ND	U	0.096	0.029	1	03/31/14	04/14/14	KWG1403033	
Aroclor 1260	ND	U	0.096	0.053	1	03/31/14	04/14/14	KWG1403033	

Surrogate Name	%Rec	Control Limits	Date Analyzed	Note
Decachlorobiphenyl	88	10-134	04/14/14	Acceptable

Comments:

QA/QC Report

Client:	Aecos, Incorporated	**Service Request:**	K1403135
Project:	Lualualei/29885		
Sample Matrix:	Water		

Surrogate Recovery Summary
Organochlorine Pesticides and Polychlorinated Biphenyls

Extraction Method:	EPA 3520C	**Units:**	Percent
Analysis Method:	608	**Level:**	Low

Sample Name	Lab Code	Sur1
Confluence	K1403135-001	52
Basil Farm	K1403135-002	37
Method Blank	KWG1403033-5	88
Lab Control Sample	KWG1403033-1	82
Duplicate Lab Control Sample	KWG1403033-2	64

Surrogate Recovery Control Limits (%)

Sur1	=	Decachlorobiphenyl	10-134

Results flagged with an asterisk (*) indicate values outside control criteria.

Results flagged with a pound (#) indicate the control criteria is not applicable.

QA/QC Report

Client:	Aecos, Incorporated	**Service Request:**	K1403135
Project:	Lualualei/29885	**Date Extracted:**	03/31/2014
Sample Matrix:	Water	**Date Analyzed:**	04/14/2014

Lab Control Spike/Duplicate Lab Control Spike Summary
Organochlorine Pesticides and Polychlorinated Biphenyls

Extraction Method:	EPA 3520C	**Units:**	ug/L
Analysis Method:	608	**Basis:**	NA
		Level:	Low
		Extraction Lot:	KWG1403033

	Lab Control Sample KWG1403033-1 **Lab Control Spike**			Duplicate Lab Control Sample KWG1403033-2 **Duplicate Lab Control Spike**					
Analyte Name	**Result**	**Spike Amount**	**%Rec**	**Result**	**Spike Amount**	**%Rec**	**%Rec Limits**	**RPD**	**RPD Limit**
alpha-BHC	0.0812	0.100	81	0.0787	0.100	79	37-134	3	30
beta-BHC	0.0936	0.100	94	0.0895	0.100	89	17-147	4	30
gamma-BHC (Lindane)	0.0948	0.100	95	0.0912	0.100	91	32-127	4	30
delta-BHC	0.0208	0.100	21	0.0197	0.100	20	19-140	5	30
Heptachlor	0.0906	0.100	91	0.0893	0.100	89	34-111	1	30
Aldrin	0.0951	0.100	95	0.0945	0.100	95	42-122	1	30
Heptachlor Epoxide	0.105	0.100	105	0.101	0.100	101	37-142	4	30
Endosulfan I	0.103	0.100	103	0.0986	0.100	99	45-153	4	30
Dieldrin	0.108	0.100	108	0.103	0.100	103	36-146	4	30
4,4'-DDE	0.113	0.100	113	0.108	0.100	108	30-145	4	30
Endrin	0.112	0.100	112	0.108	0.100	108	30-147	4	30
Endosulfan II	0.105	0.100	105	0.101	0.100	101	10-202	4	30
4,4'-DDD	0.111	0.100	111	0.106	0.100	106	31-141	5	30
Endrin Aldehyde	0.0896	0.100	90	0.0881	0.100	88	43-125	2	30
Endosulfan Sulfate	0.0834	0.100	83	0.0802	0.100	80	26-144	4	30
4,4'-DDT	0.112	0.100	112	0.107	0.100	107	25-160	5	30

Results flagged with an asterisk (*) indicate values outside control criteria.

Percent recoveries and relative percent differences (RPD) are determined by the software using values in the calculation which have not been rounded.

Analytical Results

Client:	Aecos, Incorporated	**Service Request:**	K1403135
Project:	Lualualei/29885	**Date Collected:**	03/25/2014
Sample Matrix:	Water	**Date Received:**	03/28/2014

Organophosphorus Pesticides

Sample Name:	Confluence	**Units:**	ug/L
Lab Code:	K1403135-001	**Basis:**	NA
Extraction Method:	EPA 3535A	**Level:**	Low
Analysis Method:	614M		

Analyte Name	Result	Q	MRL	MDL	Dilution Factor	Date Extracted	Date Analyzed	Extraction Lot	Note
Demeton-O,S	ND	U	3.4	0.14	1	03/31/14	04/08/14	KWG1402986	
Chlorpyrifos	ND	U	3.4	0.14	1	03/31/14	04/08/14	KWG1402986	
Malathion	ND	U	3.4	0.14	1	03/31/14	04/08/14	KWG1402986	
Ethyl Parathion	ND	U	3.4	0.14	1	03/31/14	04/08/14	KWG1402986	
Azinphos-methyl (Guthion)	ND	U	3.4	0.14	1	03/31/14	04/08/14	KWG1402986	

Surrogate Name	%Rec	Control Limits	Date Analyzed	Note
Triphenyl Phosphate	15	57-112	04/08/14	Outside Control Limits
Tributyl Phosphate	14	54-115	04/08/14	Outside Control Limits

Comments:

Client:	Aecos, Incorporated	**Service Request:**	K1403135
Project:	Lualualei/29885	**Date Collected:**	03/25/2014
Sample Matrix:	Water	**Date Received:**	03/28/2014

Organophosphorus Pesticides

Sample Name:	Basil Farm	**Units:**	ug/L
Lab Code:	K1403135-002	**Basis:**	NA
Extraction Method:	EPA 3535A	**Level:**	Low
Analysis Method:	614M		

Analyte Name	Result	Q	MRL	MDL	Dilution Factor	Date Extracted	Date Analyzed	Extraction Lot	Note
Demeton-O,S	ND	U	1.0	0.040	1	03/31/14	04/08/14	KWG1402986	
Chlorpyrifos	ND	U	1.0	0.040	1	03/31/14	04/08/14	KWG1402986	
Malathion	ND	U	1.0	0.040	1	03/31/14	04/08/14	KWG1402986	
Ethyl Parathion	ND	U	1.0	0.040	1	03/31/14	04/08/14	KWG1402986	
Azinphos-methyl (Guthion)	ND	U	1.0	0.040	1	03/31/14	04/08/14	KWG1402986	

Surrogate Name	%Rec	Control Limits	Date Analyzed	Note
Triphenyl Phosphate	118	57-112	04/08/14	Outside Control Limits
Tributyl Phosphate	108	54-115	04/08/14	Acceptable

Comments:

Analytical Results

Client:	Aecos, Incorporated	**Service Request:**	K1403135
Project:	Lualualei/29885	**Date Collected:**	NA
Sample Matrix:	Water	**Date Received:**	NA

Organophosphorus Pesticides

Sample Name:	Method Blank	**Units:**	ug/L
Lab Code:	KWG1402986-5	**Basis:**	NA
Extraction Method:	EPA 3535A	**Level:**	Low
Analysis Method:	614M		

Analyte Name	Result	Q	MRL	MDL	Dilution Factor	Date Extracted	Date Analyzed	Extraction Lot	Note
Demeton-O,S	ND	U	1.0	0.040	1	03/31/14	04/08/14	KWG1402986	
Chlorpyrifos	ND	U	1.0	0.040	1	03/31/14	04/08/14	KWG1402986	
Malathion	ND	U	1.0	0.040	1	03/31/14	04/08/14	KWG1402986	
Ethyl Parathion	ND	U	1.0	0.040	1	03/31/14	04/08/14	KWG1402986	
Azinphos-methyl (Guthion)	ND	U	1.0	0.040	1	03/31/14	04/08/14	KWG1402986	

Surrogate Name	%Rec	Control Limits	Date Analyzed	Note
Triphenyl Phosphate	111	57-112	04/08/14	Acceptable
Tributyl Phosphate	103	54-115	04/08/14	Acceptable

Comments:

ALS Group USA, Corp. dba ALS Environmental

QA/QC Report

Client: Aecos, Incorporated
Project: Lualualei/29885
Sample Matrix: Water

Service Request: K1403135

Surrogate Recovery Summary
Organophosphorus Pesticides

Extraction Method: EPA 3535A
Analysis Method: 614M

Units: Percent
Level: Low

Sample Name	Lab Code	Sur1		Sur2	
Confluence	K1403135-001	15	*	14	*
Basil Farm	K1403135-002	118	*	108	
Method Blank	KWG1402986-5	111		103	
Lab Control Sample	KWG1402986-1	114	*	107	
Duplicate Lab Control Sample	KWG1402986-2	110		104	

Surrogate Recovery Control Limits (%)

Sur1	=	Triphenyl Phosphate	57-112
Sur2	=	Tributyl Phosphate	54-115

Results flagged with an asterisk (*) indicate values outside control criteria.

Results flagged with a pound (#) indicate the control criteria is not applicable.

Client:	Aecos, Incorporated	**Service Request:**	K1403135
Project:	Lualualei/29885	**Date Extracted:**	03/31/2014
Sample Matrix:	Water	**Date Analyzed:**	04/08/2014

Lab Control Spike/Duplicate Lab Control Spike Summary
Organophosphorus Pesticides

Extraction Method:	EPA 3535A	**Units:**	ug/L
Analysis Method:	614M	**Basis:**	NA
		Level:	Low
		Extraction Lot:	KWG1402986

	Lab Control Sample KWG1402986-1 **Lab Control Spike**			Duplicate Lab Control Sample KWG1402986-2 **Duplicate Lab Control Spike**					
Analyte Name	**Result**	**Spike Amount**	**%Rec**	**Result**	**Spike Amount**	**%Rec**	**%Rec Limits**	**RPD**	**RPD Limit**
Demeton-O,S	1.33	2.00	66	1.52	2.00	76	16-100	13	30
Chlorpyrifos	2.34	2.00	117	2.23	2.00	111	44-119	5	30
Malathion	1.70	2.00	85	1.78	2.00	89	43-116	4	30
Ethyl Parathion	1.89	2.00	94	1.90	2.00	95	46-127	1	30
Azinphos-methyl (Guthion)	2.67	2.00	134	2.72	2.00	136	30-151	2	30

Results flagged with an asterisk (*) indicate values outside control criteria.

Percent recoveries and relative percent differences (RPD) are determined by the software using values in the calculation which have not been rounded.

Client:	Aecos, Incorporated	**Service Request:**	K1403135
Project:	Lualualei/29885	**Date Collected:**	03/25/2014
Sample Matrix:	Water	**Date Received:**	03/28/2014

Chlorinated Herbicides

Sample Name:	Confluence	**Units:**	ug/L
Lab Code:	K1403135-001	**Basis:**	NA
Extraction Method:	Method	**Level:**	Low
Analysis Method:	8151A		

Analyte Name	Result	Q	MRL	MDL	Dilution Factor	Date Extracted	Date Analyzed	Extraction Lot	Note
Dalapon	ND	U	0.39	0.20	1	04/01/14	04/03/14	KWG1402902	
Dicamba	ND	U	0.20	0.025	1	04/01/14	04/03/14	KWG1402902	
MCPP	ND	U	97	14	1	04/01/14	04/03/14	KWG1402902	
MCPA	ND	U	97	8.7	1	04/01/14	04/03/14	KWG1402902	
Dichlorprop	ND	Ui	0.44	0.44	1	04/01/14	04/03/14	KWG1402902	
2,4-D	ND	Ui	0.39	0.039	1	04/01/14	04/03/14	KWG1402902	
2,4,5-TP (Silvex)	ND	U	0.20	0.045	1	04/01/14	04/03/14	KWG1402902	
2,4,5-T	ND	Ui	0.20	0.12	1	04/01/14	04/03/14	KWG1402902	
2,4-DB	ND	Ui	2.0	0.85	5	04/01/14	04/04/14	KWG1402902	
Dinoseb	ND	Ui	0.20	0.034	1	04/01/14	04/03/14	KWG1402902	

Surrogate Name	%Rec	Control Limits	Date Analyzed	Note
2,4-Dichlorophenylacetic Acid	64	17-113	04/03/14	Acceptable

Comments:

ALS Group USA, Corp. dba ALS Environmental

Analytical Results

Client:	Aecos, Incorporated	**Service Request:**	K1403135
Project:	Lualualei/29885	**Date Collected:**	03/25/2014
Sample Matrix:	Water	**Date Received:**	03/28/2014

Chlorinated Herbicides

Sample Name:	Basil Farm	**Units:**	ug/L
Lab Code:	K1403135-002	**Basis:**	NA
Extraction Method:	Method	**Level:**	Low
Analysis Method:	8151A		

Analyte Name	Result	Q	MRL	MDL	Dilution Factor	Date Extracted	Date Analyzed	Extraction Lot	Note
Dalapon	ND	U	0.39	0.20	1	04/01/14	04/03/14	KWG1402902	
Dicamba	ND	U	0.20	0.025	1	04/01/14	04/03/14	KWG1402902	
MCPP	ND	U	97	14	1	04/01/14	04/03/14	KWG1402902	
MCPA	ND	U	97	8.7	1	04/01/14	04/03/14	KWG1402902	
Dichlorprop	ND	U	0.39	0.030	1	04/01/14	04/03/14	KWG1402902	
2,4-D	ND	U	0.39	0.036	1	04/01/14	04/03/14	KWG1402902	
2,4,5-TP (Silvex)	ND	U	0.20	0.045	1	04/01/14	04/03/14	KWG1402902	
2,4,5-T	ND	Ui	0.20	0.082	1	04/01/14	04/03/14	KWG1402902	
2,4-DB	ND	U	2.0	0.50	5	04/01/14	04/04/14	KWG1402902	
Dinoseb	ND	U	0.20	0.015	1	04/01/14	04/03/14	KWG1402902	

Surrogate Name	%Rec	Control Limits	Date Analyzed	Note
2,4-Dichlorophenylacetic Acid	62	17-113	04/03/14	Acceptable

Comments:

Analytical Results

Client:	Aecos, Incorporated	**Service Request:**	K1403135
Project:	Lualualei/29885	**Date Collected:**	NA
Sample Matrix:	Water	**Date Received:**	NA

Chlorinated Herbicides

Sample Name:	Method Blank	**Units:**	ug/L
Lab Code:	KWG1402902-3	**Basis:**	NA
Extraction Method:	Method	**Level:**	Low
Analysis Method:	8151A		

Analyte Name	Result	Q	MRL	MDL	Dilution Factor	Date Extracted	Date Analyzed	Extraction Lot	Note
Dalapon	ND	U	0.39	0.20	1	04/01/14	04/03/14	KWG1402902	
Dicamba	ND	U	0.20	0.025	1	04/01/14	04/03/14	KWG1402902	
MCPP	ND	U	96	14	1	04/01/14	04/03/14	KWG1402902	
MCPA	ND	U	96	8.7	1	04/01/14	04/03/14	KWG1402902	
Dichlorprop	ND	U	0.39	0.030	1	04/01/14	04/03/14	KWG1402902	
2,4-D	ND	U	0.39	0.036	1	04/01/14	04/03/14	KWG1402902	
2,4,5-TP (Silvex)	ND	U	0.20	0.045	1	04/01/14	04/03/14	KWG1402902	
2,4,5-T	ND	U	0.20	0.033	1	04/01/14	04/03/14	KWG1402902	
2,4-DB	ND	U	0.39	0.10	1	04/01/14	04/04/14	KWG1402902	
Dinoseb	ND	U	0.20	0.015	1	04/01/14	04/03/14	KWG1402902	

Surrogate Name	%Rec	Control Limits	Date Analyzed	Note
2,4-Dichlorophenylacetic Acid	66	17-113	04/03/14	Acceptable

Comments:

Client: Aecos, Incorporated
Service Request: K1403135
Project: Lualualei/29885
Sample Matrix: Water

Surrogate Recovery Summary
Chlorinated Herbicides

Extraction Method: Method
Units: Percent
Analysis Method: 8151A
Level: Low

Sample Name	Lab Code	Sur1
Batch QC	K1403018-001	64
Confluence	K1403135-001	64
Basil Farm	K1403135-002	62
Method Blank	KWG1402902-3	66
Lab Control Sample	KWG1402902-1	73
Duplicate Lab Control Sample	KWG1402902-2	74

Surrogate Recovery Control Limits (%)

Sur1 =	2,4-Dichlorophenylacetic Acid	17-113

Results flagged with an asterisk (*) indicate values outside control criteria.

Results flagged with a pound (#) indicate the control criteria is not applicable.

Client:	Aecos, Incorporated	**Service Request:**	K1403135
Project:	Lualualei/29885	**Date Extracted:**	04/01/2014
Sample Matrix:	Water	**Date Analyzed:**	04/03/2014 - 04/04/2014

Lab Control Spike/Duplicate Lab Control Spike Summary
Chlorinated Herbicides

Extraction Method:	Method	**Units:**	ug/L
Analysis Method:	8151A	**Basis:**	NA
		Level:	Low
		Extraction Lot:	KWG1402902

	Lab Control Sample KWG1402902-1 **Lab Control Spike**			Duplicate Lab Control Sample KWG1402902-2 **Duplicate Lab Control Spike**					
Analyte Name	**Result**	**Spike Amount**	**%Rec**	**Result**	**Spike Amount**	**%Rec**	**%Rec Limits**	**RPD**	**RPD Limit**
Dalapon	1.44	2.50	58	1.33	2.50	53	14-110	9	30
Dicamba	1.77	2.50	71	1.66	2.50	66	30-108	6	30
MCPP	185	250	74	183	250	73	16-141	1	30
MCPA	189	250	75	168	250	67	21-117	12	30
Dichlorprop	1.71	2.50	68	1.61	2.50	65	29-104	6	30
2,4-D	1.97	2.50	79	1.82	2.50	73	35-110	8	30
2,4,5-TP (Silvex)	2.01	2.50	80	1.82	2.50	73	37-114	10	30
2,4,5-T	2.12	2.50	85	1.86	2.50	74	30-120	13	30
2,4-DB	1.71	2.50	68	1.78	2.50	71	10-134	4	30
Dinoseb	1.80	2.50	72	1.27	2.50	51	11-105	35 *	30

Results flagged with an asterisk (*) indicate values outside control criteria.

Percent recoveries and relative percent differences (RPD) are determined by the software using values in the calculation which have not been rounded.

APPENDIX G. ADDENDUM TO THE MĀ’ILI’ILI WATERSHED MANAGEMENT PLAN

August 2025

Estimating Pollutant Load Reductions Resulting from Control and Removal of Invasive Plant and Animal Species and Establishment of Native Species

Introduction

This addendum has been developed by the Hawaii Department of Health (HDOH) to address additional considerations and updates relevant to watershed management efforts. This addendum supplements the Mā'ili'ili Watershed Management Plan to include activities and additional guidance related to the removal of invasive plants and animals, as well as the reintroduction of native species. In addition to including these activities in the menu of best management practices (BMPs) that are eligible for 319 funding, this addendum provides an approach for calculating the pollutant reductions associated with these restoration activities. These pollutant reductions can be used by project managers and sub-grantees to develop individual project plans and by HDOH to calculate annual pollutant reductions for the broader NPS program.

Pollutant Loading from Invasive Species

Invasive plants and animals are an increasingly challenging source of pollution in many of Hawaii's watersheds. Invasive plants, such as miconia, have shallow root systems, which are unable to stabilize the soil and are susceptible to erosion and landslides during rainfall events. Invasive animals, such as feral hogs, are destructive grazers, uprooting plant material and exposing additional areas to erosion.

As a result, sediment is the primary pollutant of concern from invasive species, although other pollutants may also be transported during rainfall events (e.g., nutrients and bacteria). Sediment has been identified by HDOH as a pollutant of concern across the state and is a focus of water quality improvement efforts. This watershed-based plan already includes a discussion of pollutants of concern and the load reductions needed to return the impaired waters to attainment. This addendum supplements that discussion; invasive species are one of multiple pollutant sources to be addressed.

Pollution Control Practices

Across Hawaii, many organizations (including federal, state and local government, as well as watershed groups) are working to mitigate these problems. In many cases, this involves removing the invasive species and replacing them with native species. Native plant species[1] are better adapted to the soils and climate and provide improved soil retention, among other benefits. Excluding invasive animals, such as using fencing to block access to an area, allows vegetation to recover and thrive.

Table 1 below includes BMPs that can address pollutant loading caused by invasive species.[2] As shown by the large number of potential BMPs, vegetative plantings are a common element of many BMPs; ensuring that native species are used (and in the necessary quantities for establishment) will help to restore native plant communities. Managing invasive animal species is typically limited to exclusion or removal.

[1] See, for example, https://dlnr.hawaii.gov/forestry/plants/ for a discussion of native plant species.
[2] The table shows only a selection of BMPs. Other BMPs may also accomplish the goals of invasive removal and re-establishment of native species. Watershed planners should consult with HDOH when developing project plans to ensure BMP eligibility.

Table 1: Selection of BMPs to Address Invasive Species

Management Practice	Description
Bioretention Cell (Rain Garden)	Depression consisting of native plant species and soil mixtures that receives stormwater flow and infiltrates to treat pollutants.
Channel Maintenance and Restoration	Practices used to control sediment and plant pollution into waterways during earthwork such as stream bank stabilization or habitat enhancement. Examples include floating booms and silt curtains extended across river or stream banks downstream of work.
Constructed Wetlands	Creation of an artificial wetland ecosystem to improve the quality of stormwater runoff or other water flows. A constructed wetland provides biological treatment in areas where wetland function can be created or enhanced. Constructed wetlands also can be used to treat runoff from agricultural land uses and stormwater runoff and other contaminated flows from urban areas and other land uses. The practice involves establishment of inlet and outlet control structures for an impoundment designed to accumulate settleable solids, decayed plant matter, and microbial biomass and support propagation of hydrophytic vegetation.
Critical Area Planting	Establishment of permanent vegetation in areas with heavy erosion problems. Particularly useful for areas that need stabilization before/after flood events.
Grassed Waterway	A shaped or graded channel that is established with suitable vegetation to convey surface water at a non-erosive velocity using a broad and shallow cross section to a stable outlet. Used to convey runoff from terraces, diversions, or similar; to prevent gully formation; and to protect or improve water quality.
Herbaceous Weed Treatment/Invasive Species Removal	The removal or control of herbaceous weeds, including invasive, noxious, and prohibited plants.
Sediment Basin	Captures and retains stormwater runoff until sediments settle out; water is released through engineered outlet.
Feral Ungulate Fencing	A structural conservation practice that prevents movement of ungulates across a given boundary. Within areas impacted by feral ungulate presence, fences prevent their movement into the forested lands. Ungulate fencing prevents direct contact of fecal matter with waterways, allows for restoration of vegetation, and reduces bacteria and nitrogen loadings and sediment input into waterways.
Feral Ungulate Removal	Hunting or trapping wild goats, pigs, and other non-native hoofed mammals to reduce erosion caused by trampling and vegetation removal, as well as nutrient and bacterial impacts from defecation in and around water bodies.

Through this addendum, these BMPs are now eligible for funding under Section 319 to address water quality concerns caused by invasive species (if the BMPs were not already identified in the original plan). Implementation of these BMPs will lead to a reduction in pollutant loading in the watershed. The original watershed-based plan may include information on specific locations or land use types that may be most appropriate for invasive species BMPs. Additional information can be found in other resources, such as the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service's *Field Office Technical Guide* for Hawaii.[3]

Calculating Pollutant Reductions

Accounting for the total pollutant reductions is an important step in tracking water quality improvements. HDOH and watershed stakeholders develop watershed-based plans under the state's nonpoint source pollution (NPS) program; these plans include a projected level of pollutant reduction for the proposed project.

There are various models that can be used to calculate the pollutant reductions associated with BMP implementation. HDOH researched the advantages and disadvantages of each model, including the ease of use for watershed project managers and evaluating the model's appropriateness for use in Hawaii. After reviewing several models, HDOH selected the Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) model.

Description of the InVEST Model

InVEST is a suite of models focused on ecosystems and how they connect to downstream economics. This addendum is focused on the sediment delivery ratio model in the InVEST suite. The InVEST sediment delivery ratio model was chosen by HDOH because it is easy to use and its ability to estimate sediment loading both with current condition and with BMPs implemented. Additionally, the InVEST model can be modified to accommodate the unique geologic conditions in Hawaii.

The InVEST sediment delivery ratio model is focused on sediment loading and erosion. The model outputs a set of maps showing the sediment erosion, including the amount of sediment soil loss per pixel, and the amount of erosion that is prevented by the presence of vegetation per pixel. The effect of BMPs on sediment erosion can be measured by comparing model outputs ran under the current conditions against model outputs ran with BMPs implemented. To calculate the annual soil loss per pixel, the InVEST model uses the Revised Universal Soil Loss Equation (RUSLE; Renard et al., 1997). Along with the factors that are in the RUSLE equation (rainfall erosivity, soil erodibility, slope length gradient, cover management, and support practice), this addendum recommends including an additional terrain factor to accommodate for the geology of Hawaii. The inclusion of the terrain factor prevents the model from overestimating the soil loss in places with geologically new basaltic bedrock which has minimal soil cover (Falinski, 2016). The required data inputs for this model are integrated into the RUSLE equation. To determine the effects of BMPs on sediment load reduction and erosion, the model should be run with altered data inputs.

The required data inputs include GIS data, a table, and five additional values. These five inputs are described in detail in the Step-by-Step Procedure below. To measure the reduction in sediment load and erosion with BMP implementation, these inputs can be changed to integrate the increase in vegetation that would come along with BMP implementation. The Step-by-Step Procedure section of this addendum describes each of these required inputs in further detail along with recommended values and sources for GIS data inputs.

[3] https://efotg.sc.egov.usda.gov/#/state/HI/documents

Step-by-Step Procedure

The step-by-step procedure begins with collecting and creating the proper data inputs for the current conditions in the watershed and running the InVEST model with those data inputs. After the first model run, the next step is to use multiple lines of evidence, including model outputs and other information, to determine the most appropriate areas in the watershed to implement BMPs. Next, the model should be run again with inputs that incorporate the impacts that BMPs would have on the land cover or support practices. The reduction in pollutant loading is the difference between the two model output runs. The steps to compile each data input and descriptions of each required data input are shown in Table 2. All GIS inputs must be the same coordinate reference system. The coordinate reference system must be projected and in linear units of meters.

Table 2: Required Data Inputs for the Invest Model

GIS Data Inputs		
Input Name and Description	**Data Type**	**Suggested Sources**
Digital Elevation Model: A digital elevation map (DEM) showing elevation in meters. The map should be clipped beyond the watershed boundary.	Raster	The 3D Elevation Program (3DEP) from USGS.[4] The best available resolution for the state is 1/3 arc-second.
		The Hawaii Statewide GIS Program's Digital Terrain Model.[5] Data is only available for portions of the state and as a JPEG or PNG, so it must be converted to a raster format. The resolution is 1 meter, and the elevation values are in meters.
Erosivity: A map of rainfall erosivity in units of MJ • mm/(h • ha • year). The map should illustrate both intensity and duration of rainfall.	Raster	For the island of Hawaii, NOAA's digitized version of the rainfall erosivity map from the Agriculture Handbook No. 703.[6] The units are US customary units, so the units must be converted by multiplying each value by 17.02 (Renard, et al., 1997).
		For the island of Oahu, NOAA's digitized version of the rainfall erosivity map from the Agriculture Handbook No. 703.[7] The units are US customary units, so the units must be converted by multiplying each value by 17.02 (Renard, et al., 1997).
		The rainfall erosivity map on page 57 of the Agriculture Handbook No. 703. This map must be digitized into raster data by a GIS specialist and units must be converted to SI by multiplying each value by 17.02 (Renard, et al., 1997).
		A rainfall erosivity raster can be made using precipitation from the Hawaii Climate Data Portal.[8] Rainfall erosivity can be calculated using the Roose equation (Renard and Freimund, 1994): $R = 0.5 \times P \times 17.02$, where R is the rainfall erosivity value in the proper SI units and P is the annual rainfall in mm/year.
Soil Erodibility: A map showing the soil erodibility in the watershed. Soil erodibility, also called K factor, is the likelihood of soil particles to erode and be	Raster	Soil data, including K factors, is available from the Soil Survey Geographic Database (SSURGO).[9] This database provides raster data of soil type in an area of interest, and a table showing the K factor of each soil type. Raster

[4] https://apps.nationalmap.gov/downloader/
[5] https://geoportal.hawaii.gov/datasets/HiStateGIS::hawaii-dtm-elevation/about
[6] https://www.fisheries.noaa.gov/inport/item/48225
[7] https://www.fisheries.noaa.gov/inport/item/48230
[8] https://www.hawaii.edu/climate-data-portal/data-portal/
[9] https://www.nrcs.usda.gov/resources/data-and-reports/soil-survey-geographic-database-ssurgo

transported downstream by precipitation or runoff. The soil erodibility raster must be in units of t · h · ha / (ha · MJ · mm).		data of K factors in a projected coordinate system will have to be generated by combining the soil raster data and the K factor table.
Land Use/Land Cover: A map showing the land use and land cover within the watershed. The C-CAP raster described below must also be combined with geology data. Each pixel should be categorized by its land use/land cover and geologic origin from the geology dataset. Every combination of land use/land cover and geologic origin should be assigned a unique LULC code.	Raster	NOAA has C-CAP high resolution land cover raster data available for the entire state of Hawaii from 2021.[10] NOAA's land cover data has a resolution of 1-meter and includes up to 25 classifications including forests and urban development.
		Geology data for the state of Hawaii is available for download from USGS.[11] This data is available as shapefiles, so it must be converted to raster data.
Watersheds: A map of the boundary of the watershed.	Vector (polygon/ multipolygon)	The USGS Watershed Boundary Dataset has vector watershed delineation data available at different hydrologic unit levels for the entire state of Hawaii.[12]
		The Hawaii Statewide GIS Program has vector watershed delineation data available that was created by the Division of Aquatic Resources (DAR).[13]
		The InVEST suite includes the DelineateIt tool, used for generating watersheds based on user inputs. This tool outputs a GeoPackage containing a vector with the model's estimated watershed delineations. More information on this tool can be found in the DelineateIt section of the InVEST suite.[14]
		Watershed delineations can be generated using a USGS StreamStats's tool.[15] Delineations can be downloaded as vectors.
Other Required Data Inputs		
Input Name and Description	**Data type**	**Suggested Input Value**

[10] https://coast.noaa.gov/digitalcoast/data/
[11] https://pubs.usgs.gov/of/2007/1089/
[12] https://www.usgs.gov/national-hydrography/watershed-boundary-dataset
[13] https://geoportal.hawaii.gov/datasets/HiStateGIS::watersheds-dar-version/about
[14] https://storage.googleapis.com/releases.naturalcapitalproject.org/invest-userguide/latest/en/delineateit.html
[15] https://www.usgs.gov/streamstats

Threshold Flow Accumulation: The minimum number of pixels that flow into another pixel for it to be classified as a stream.	Number of pixels	This value should be determined by the user via trial and error. Users should test different values until the streams on the output maps resemble the streams in the watershed.
Borselli k Parameter: A calibration parameter in the sediment delivery ratio equation.	Number	This value is based on watershed location. Table 3 shows the Borselli k Parameter by location.
Maximum SDR Value: The maximum sediment delivery ratio a pixel is allowed to have.	Number between 0 and 1	For all watersheds in the state of Hawaii, the value should be 0.5 (Falinski, 2016).
Borselli IC_0 Parameter: A calibration parameter in the sediment delivery ratio equation.	Number	For all watersheds in the state of Hawaii, the value should be 0.1 (Falinski, 2016).
Maximum L Value: The maximum allowed slope value in the slope length-gradient factor.	Number	For all watershed in the state of Hawaii, the value should be 122 (Falinski, 2016).
Biophysical Table: A table mapping each LULC code to its cover-management factor (C) and support practice factor (P). One column should be named "lucode" and contain the LULC code from the land cover and land use raster. The other two columns should be named "usle_c" and "usle_p" and contain the associated C factor and P factor, respectively. The C factor indicates how much erosion is likely to occur at this land use/land cover type. The smaller the C factor value, the less erosion is expected to come from that type. To account for the terrain factor in the model run, the C factor in the biophysical table should be modified. The C factor for each LULC code should be the original C factor from Table 4 multiped by the terrain factor from Table 5 that is associated with the geologic origin under that LULC code. The P factor indicates whether erosion reduction practices are implemented in that area. A value of 1 means there are no erosion reduction practices implemented in that land cover/land use type and a smaller value indicates best management practices are implemented in that land cover/land use type.	.CSV file	Table 4 shows the C factors for land use/land covers in Hawaii, and Table 5 shows the terrain factor by geologic origin.
Workspace: The folder where outputs will be written.	Folder name	--

Table 3: Borselli k Parameter by Watershed Location (Falinski, 2016)

Watershed Location	Borselli k Parameter
Windward part of the island of Hawaii	4
Leeward part of the island of Hawaii	2.5
Oahu	2.5
Maui	2
Lanai	2
Molokai	1.25
Kahoolawe	2.4
Kauai	1.6
Niihau	1.5

Table 4: C Factor Values for Land Use/Land Cover (Falinski, 2016)

Land Use/Land Cover	C Factor	Land Use/Land Cover	C Factor
Evergreen	0.014[16]	Developed, Medium Intensity	0.01
Scrub Shrub	0.014[17]	Impervious Surface	0.001
Bare Land	0.7	Palustrine Scrub Shrub Wetland	0.003
Pasture/Hay	0.05	Palustrine Emergent Wetland	0.003
Grassland	0.05	Unconsolidated Shore	0.003
Open Water	0	Estuarine Forested Wetland	0.003
Cultivated Land	0.24[18]	Estuarine Scrub Shrub Wetland	0.003
Developed, Low Intensity	0.03	Estuarine Emergent Wetland	0.003
Palustrine Forested Wetland	0.003	Background	0
Open Space Developed	0.05	Palustrine Aquatic Bed	0

Table 5: Terrain Factor by Geologic Origin (Falinski, 2016)

Hawaii		**Oahu, Kauai and Niihau**	
Geologic origin	**Terrain factor**	**Geologic origin**	**Terrain factor**
Hamakua Volcanics	1	Honolulu Volcanics	1
Hawi Volcanics	1	Kolekole Volcanics	1
Hilina Basalt	0.001	Koolau Basalt	1
Hualalai Volcanics	0.001	Waianae Volcanics	1
Kahuku Basalt	0.001	Kiekie Volcanics	1
Kau Basalt	0.001	Koloa Volcanics	1
Laupahoehoe Volcanics	0.1	Paniau Basalt	0.1
Ninole Basalt	1	Waimea Canyon	0.1
Pololu Volcanics	1	--	--
Puna Basalt	0.001	--	--
Maui, Molokai, Lanai and Kahoolawe		**All Islands**	

[16] Evergreen forest: 0.035 for Hamakua and Kohala volcanoes
[17] Scrub/shrub: 0.05 for leeward volcanic units
[18] Cultivated land: 0.4 for pineapple (Lanai) or 0.51 for sugarcane crop (central Maui)

Geologic Origin	Terrain factor	Geologic origin	Terrain factor
East Molokai Volcanics	1	Open water	1
Hana Volcanics	0.001	Fill	1
Honolua Volcanics	1	Alluvium	1
Honomanu Basalt	1	Landslide Deposits	1
Kalaupapa Volcanics	1	Slope Deposits	0.001
Kanapou Volcanics	1	Tephra Deposits	0.1
Kaupo Mud Flow	1	Beach Deposits	0.1
Kula Volcanics	0.01	Lagoon Deposits	1
Lahaina Volcanics	1	Older Dune Deposits	1
Lanai Basalt	1	Younger Dune Deposits	0.1
Wailuku Volcanics	1	Talus and Colluvium	0.1
West Molokai Volcanics	1	Marine Conglomerate and Breccia	0.1
--	--	Caldera Wall Rocks	0.001

The most relevant output is the "sed_export.tif', showing the sediment exported from every pixel. Because of the geology of Hawaii, data on the pixel level from this raster may be inaccurate. The model tends to predict higher sediment export from areas with steeper slopes. In Hawaii, high slopes occur in high elevation areas where the sediment supply may be naturally limited by the unique geology of Hawaii. Therefore, the model overestimates the amount of sediment export in the mountains because it assumes unlimited sediment supply in steep areas with thin or little soil. For this reason, the sediment export raster data should not be used as the sole or main method for determining where BMPs should be implemented within the watershed.

The sediment export raster can be combined with land use/land cover data to determine which land use classes are disproportionately contributing to sediment loading. The amount of sediment mass exported per acre for each land use can be calculated by adding up the value of every pixel in the sediment export raster in each land use and dividing that sum by the number of acres that the land use covers.

It is crucial that multiple lines of evidence are considered when determining where BMPs should be implemented. The normalized difference vegetation index (NDVI)[19] is a satellite-based measurement that could be useful in identifying areas with minimal vegetation which may be susceptible to increased erosion. The NDVI quantifies vegetative health and density. NDVI values closer to positive 1 indicate the presence of abundant and healthy vegetation, and a value closer to 0 indicates there is less vegetation (NASA, 2025). Looking at NDVI data in a raster format would allow a user to visualize areas within the watershed that have little vegetation or unhealthy vegetation, indicating that the area could benefit from BMP implementation. If the resolution of the NDVI data is a lower resolution, it may be difficult to pinpoint areas where BMP implementation would be the most valuable. Therefore, further evidence should be used when selecting areas for BMP implementation. A high resolution and recent satellite image can supplement older land use/land cover data and lower resolution NDVI raster data. A satellite image can be used to more accurately identify areas with minimal vegetative cover which could benefit most from BMP implementation. Further useful evidence can be collected on-site in the watershed. If possible, a person can walk along streams in the watershed and identify locations in the watershed

[19] One potential source of NDVI data is NOAA's Suomi National Polar-orbiting Partnership (Suomi NPP) Visible Infrared Imaging Radiometer Suite (VIIRS) Vegetation Indices (VNP13A2) Version 2 data product which can be queried using the 'modisfast' R package.

where BMP implementation would be the most advantageous, such as locations with invasive plant species, minimal vegetation and/or the presence of feral ungulates. Each of the options listed above is important evidence that should be considered when the user is deciding on locations for BMP implementation.

After determining where BMPs will be implemented, the next step is to re-run the model with inputs that account for the BMPs that would be implemented to determine how they would affect sediment loading. The model inputs for the revised run should remain almost entirely the same. A different directory should be entered into the Workspace field or the results from the last model run will be overwritten. Additionally, either the support practice factors in the biophysical table or the land use/cover raster should be edited:

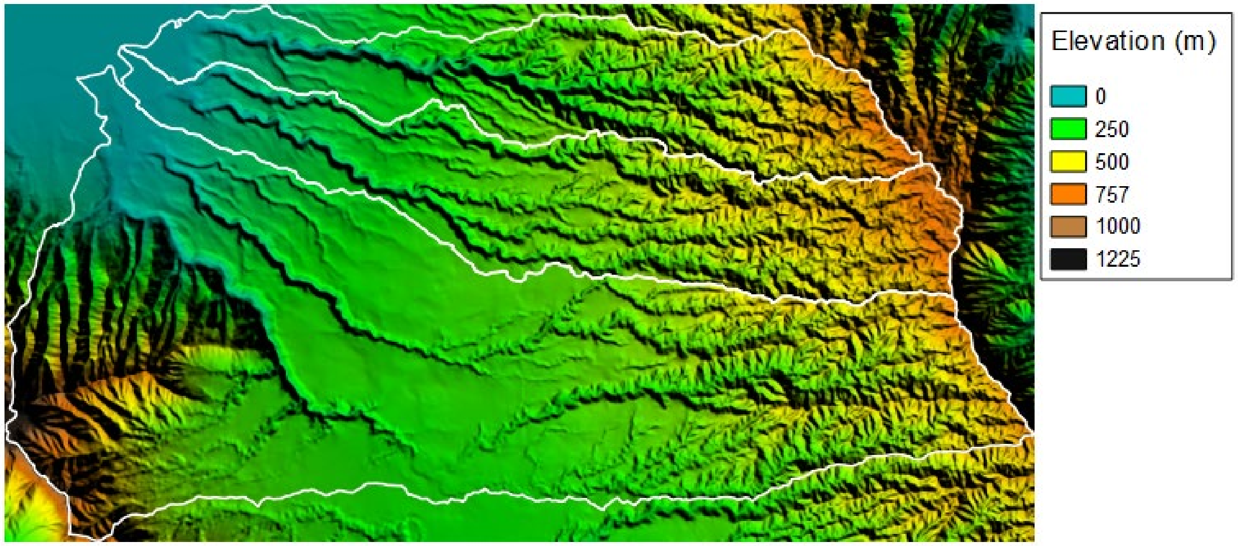
- The P factors in the biophysical table should be decreased for each land use/land cover type where an erosion reduction practice will be implemented.
- Alternatively, the land cover/land use raster should be edited to show how the land use/land cover would change with erosion reduction practices implemented. For example, bare land could be changed to a type of forest cover if a best management practice would be to plant native species on non-vegetated land.

To determine the effect that the implementation of best management practices would have on sediment exports, the outputs from both model runs can be compared. The sum across every pixel in "sed_export.tif" outputs illustrate how much sediment load reduction would occur with BMP implementation on the watershed level.

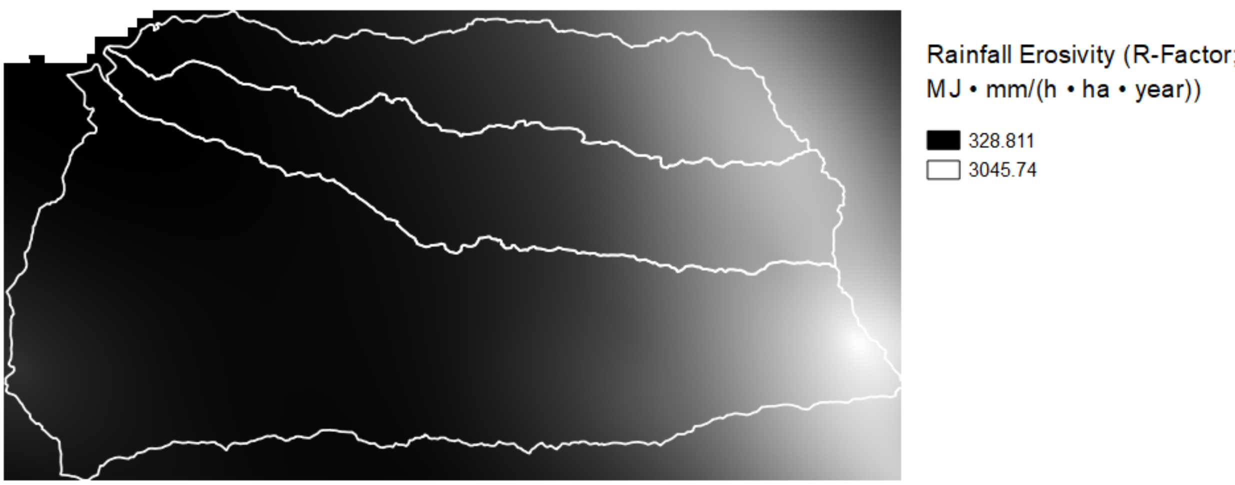
<u>Example Use of the Procedure</u>

To illustrate the Step-by-Step Procedure, this section looks at an example watershed: Kaiaka Bay. The Kaiaka Bay watershed is on the coast of the island of Oahu. The Kaiaka Bay and several streams that drain into the bay are listed as impaired. Both invasive plant species and feral ungulates are thought to cause high levels of erosion in this watershed, making the Kaiaka Bay watershed a good example watershed for the procedure (AECOM et al., 2018). The GIS data inputs for the InVEST model must all be in the same projected coordinate reference system, so every GIS data input is in the NAD83 coordinate reference system. The data inputs used for running the model with current conditions are below:

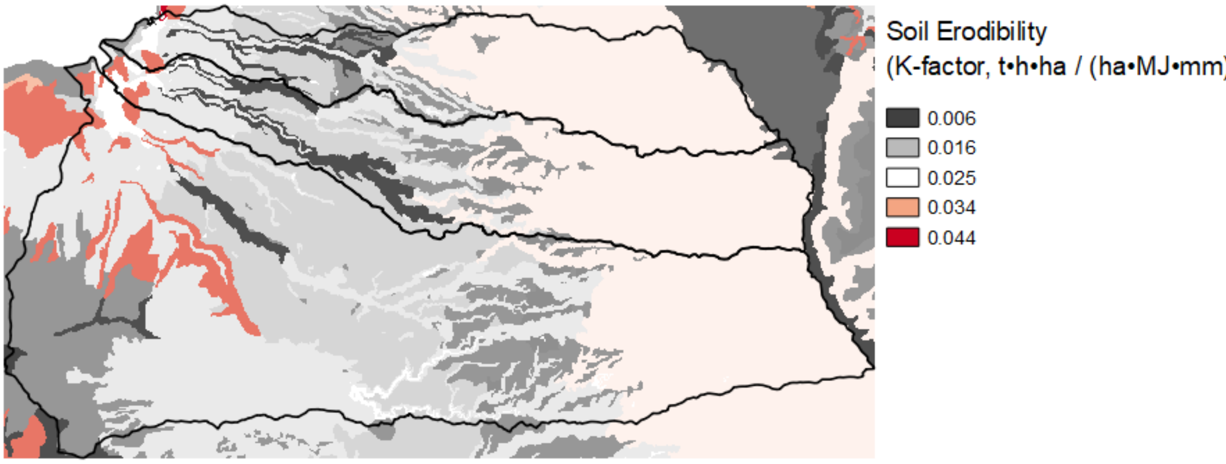
- Elevation Map: A DEM raster showing elevation in meters in the Kaiaka Bay and the surrounding area. This raster is a valid input for the InVEST model because the elevation is in meters and it extends beyond the Kaiaka Bay watershed boundary.



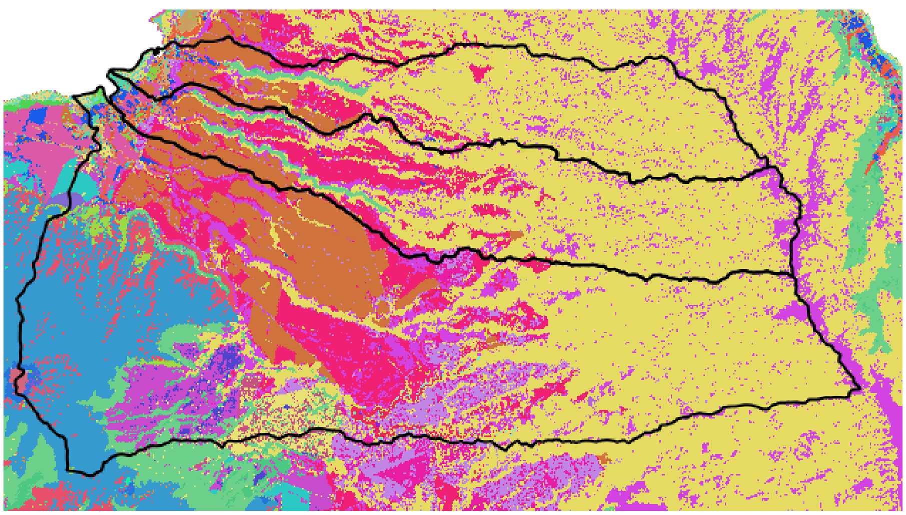
- Rainfall Erosivity: A rainfall erosivity map in raster format showing the rainfall erosivity throughout the Kaiaka Bay watershed in MJ • mm/(h • ha • year), the units required by the model.



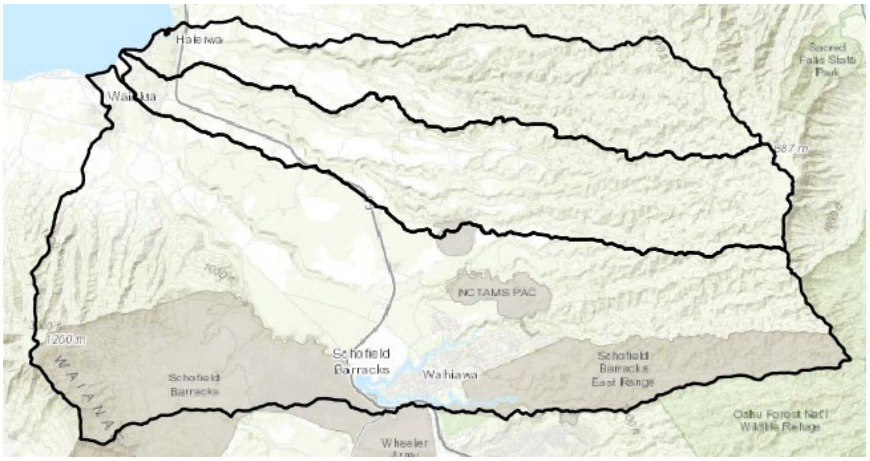
- Soil Erodibility: A map showing soil erodibility, or K factors, within the Kaiaka Bay watershed in raster format. The values in the raster format are in the proper units for the model, t • h • ha / (ha • MJ • mm).



- Land Use & Land Cover and Geologic Formation: A raster categorizing the land in Kaiaka Bay watershed by their land use/land cover and their geologic formation. This raster has over 1000 land cover/geologic formation categories, but not all categories have pixels that belong to them. Each land cover/geologic formation category has a unique LULC code so that this raster can be connected to the biophysical table.



- Watershed boundary: A vector outlining the Kaiaka Bay watershed.



- Threshold Flow Accumulation: 200. Value was derived through trial and error, and was identified when the delineated stream network approximately matched the "real" stream network for the watershed.

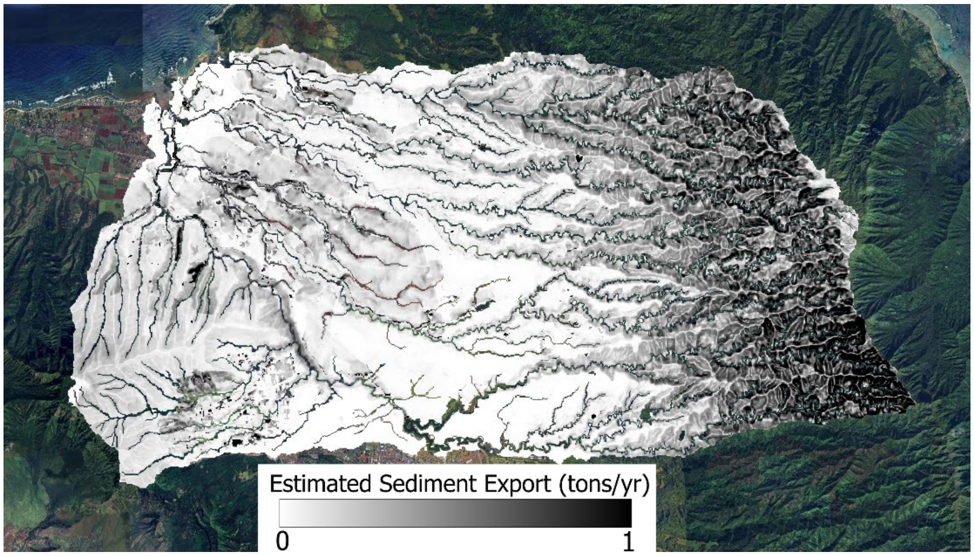
- Borselli k Parameter: The Borselli k parameter for this model run is 2.5, the value for all watersheds on Oahu.

- Maximum SDR Value: The maximum SDR value for this model run is 0.5, the value for all watersheds on the state of Hawaii.

- Maximum L Value: The maximum L value for this model run is 122, the value for all watersheds on the state of Hawaii.

- Biophysical Table: The biophysical table for this model run contains a column with each LULC code from the land use and land cover raster. Each LULC code is mapped to a modified C factor that is the original C factor from Table 4 multiplied by the terrain factor from Table 5 or the geologic origin associated with the LULC code. For example, a small piece of land in the Kaiaka Bay watershed is scrub shrub land (C factor = 0.014) with beach deposits as its geologic formation (terrain factor = 0.1), so the modified C factor in the biophysical table is 0.0014. The P factor for every LULC code is 1 because no support practices have been implemented in this watershed.

Once the inputs have been gathered, the baseline scenario is run. The model outputs suggest that a disproportionate amount of sediment export is occurring in the mountainous area of the Kaiaka Bay watershed. The sediment export raster is shown below:



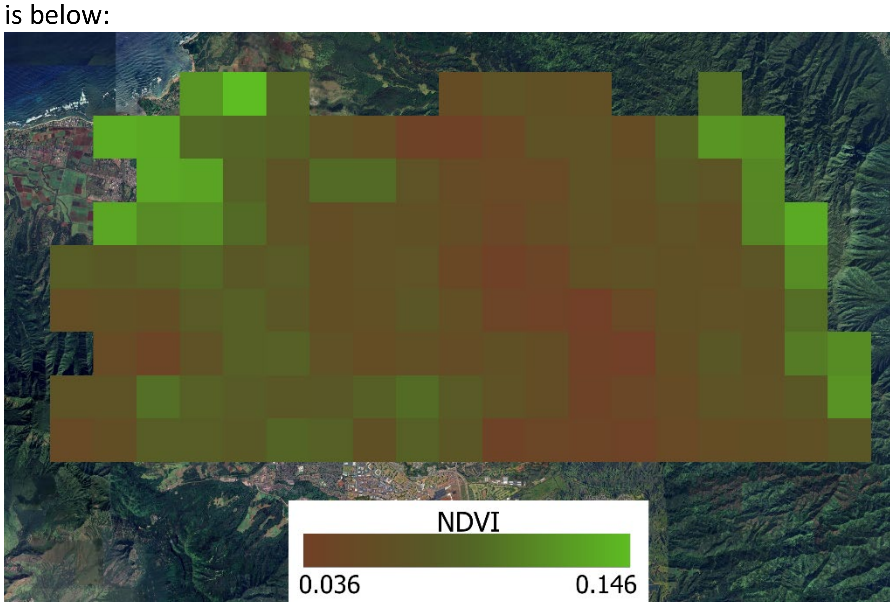
This raster indicates that the model expects the highest amount of sediment export to occur at the higher elevations of the watershed, but as discussed in the Step-by-Step Procedure section, the InVEST model tends to overestimate sediment export in high elevation areas. For this reason, multiple lines of evidence are considered when deciding on the locations for BMP implementation in this example. To determine the land class/land uses that contribute the most to sediment export relative to their area in the watershed, the pounds of sediment exported per acre is important evidence to evaluate as well. This value is calculated by adding the sediment export for every pixel in each land use/land cover and then dividing this sum by the acres each land use covers in the watershed. For example, bare land covers 405 acres of land in the Kaiaka Bay watershed and the model estimates that 1790.5 pounds of sediment are exported from bare land each year, so the pounds of sediment load per acre per year for bare land is 1790.5 divided by 405 which is 4.42. The sediment load per acre for each land use is shown in Table 6.

Table 6: Pounds of Sediment Load Per Acre Per Year by Land Use

Class	Edge of Stream Sediment Load (lbs/acre/year)
Developed, High Intensity	0.00
Developed, Med Intensity	0.00
Developed, Low Intensity	0.00
Developed, Open Space	0.11
Cultivated Crops	1.08
Pasture/Hay	0.26
Grassland/Herbaceous	0.44
Evergreen Forest	1.37
Scrub/Shrub	0.90
Palustrine Emergent Wetland	0.01
Palustrine Forested Wetland	0.01
Palustrine Scrub/Shrub Wetland	0.01
Estuarine Forested Wetland	0.03
Estuarine Scrub/Shrub Wetland	0.23

Class	Edge of Stream Sediment Load (lbs/acre/year)
Unconsolidated Shore	0.00
Bare Land	4.42
Open Water	0

This table indicates that bare land areas contribute the most sediment per acre in the Kaiaka Bay watershed, so bare land within the watershed may be a beneficial target for BMP implementation. Planting native plant species could minimize the sediment load coming from areas that are currently bare land by transforming it into vegetative cover (or evergreen forest in terms of land cover classes). Currently, bare land covers 405 acres of the watershed and the sediment export from this land is 1790.5 pounds. To calculate the amount of sediment load from this land after BMP implementation, assuming all the bare land becomes evergreen forest, the acres of bare land should be multiplied by the sediment load per acre for evergreen forest. This returns a value of 554.85 pounds of sediment load per year from this land, a 1235.65 pound decrease. These calculations should be considered when selecting locations for BMP implementation, but additional evidence should be evaluated as well. As discussed in the Step-by-Step Procedure section, NDVI data can be useful evidence as well. The NDVI data in raster format for the Kaiaka Bay is below:



The pixels with a lower NDVI index, which are shown in darker brown, are less vegetated areas. This image indicates that the middle section of the Kaiaka Bay watershed is less vegetated, so BMP implementation could be especially valuable in this area. However, the resolution of this raster data is low, so it is difficult to use it to precisely choose locations for BMP implementation. Therefore, other evidence such as high-resolution satellite images and drone footage can be used to pinpoint areas with minimal or invasive vegetation. As an additional line of evidence, people familiar with the Kaiaka Bay watershed can be interviewed to collect information on areas with minimal vegetation, invasive plants and/or feral ungulates. Furthermore, a person can walk along streams in the Kaiaka Bay watershed and document the most eroded areas. The information gathered from the InVEST model run, the NDVI index raster, satellite images, drone footage, interviews and documentation from someone on site should all be carefully considered when determining where BMPs should be implemented.

Useful Resources and Materials

To supplement the information included in this addendum, more information on the InVEST model and using this model in the state of Hawaii is linked below:

- More information on the InVEST sediment ratio delivery model including background information, required data inputs, and guidance on interpreting outputs is here: SDR: Sediment Delivery Ratio — InVEST® documentation
- More information on the InVEST DelineateIt tool discussed in the Step-by-Step Procedure to create watershed boundaries: DelineateIt — InVEST® documentation
- Further details on the Kaiaka Bay watershed: Kaiaka Bay Watersheds Characterization
- For more information on running the InVEST model for watersheds in Hawaii, including the rationale for many of the non-GIS inputs see Predicting Sediment Export into Tropical Coastal Ecosystems to Support Ridge to Reef Management [dissertation], available for download here: (PDF) PREDICTING SEDIMENT EXPORT INTO TROPICAL COASTAL ECOSYSTEMS TO SUPPORT RIDGE TO REEF MANAGEMENT

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United States Geological Survey (USGS). 2025. 1/3rd arc-second Digital Elevation Models (DEMs) - USGS National Map 3DEP Downloadable Data Collection. https://data.usgs.gov/datacatalog/data/USGS:3a81321b-c153-416f-98b7-cc8e5f0e17c3