APPENDIX B:

East Maui Irrigation Assessment of Streams and the Ocean

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East Maui Irrigation
Assessment of Streams and the Ocean
Water Chemistry

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1. INTRODUCTION

Sea Engineering, Inc., working with Marine Research Consultants, Inc., conducted field and data investigation of the stream and marine environments in the designated East Maui Irrigation (EMI) License Area of East Maui. The project is focused on providing a comprehensive depiction of the existing conditions offshore of stream discharges in terms of two major components: 1) physical/chemical composition of marine waters, including the forcing factors that affect the composition, and 2) characterization of physical marine habitats and biotic communities that occur within the survey area. The purpose of obtaining these data is to provide the information to depict the effects of discharge of East Maui streams on the nearshore ocean. The linkages between streams and the adjacent ocean will provide insights into possible changes to marine ecosystem structure in response to changes in rates and volumes of stream discharge. This report provides a comprehensive background on the oceanographic and geological setting for the stream diverted by the EMI Aqueduct System. The report also provides the results and conclusions of the effects of stream waters on the marine environment from field surveys conducted in East Maui.

1.1 Survey Areas

Along the entire License Area there are 37 streams that reach the shoreline. The project team investigated six representative streams systems shown in Figure 1-1. The selection process for the study areas was based on the accessibility of streams by either motor vehicle or helicopter—streams with no accessibility were not investigated. Each of these streams was investigated during different seasonal conditions, with one field survey in January 2018 and one in July 2018. Some streams presently have no diversion of water and represent background conditions, and some streams presently have diversions occurring. While accessibility was the primary factor in the choice of study areas, it was also intended to evaluate the effect of diversion on the characterization of the offshore marine habitats.

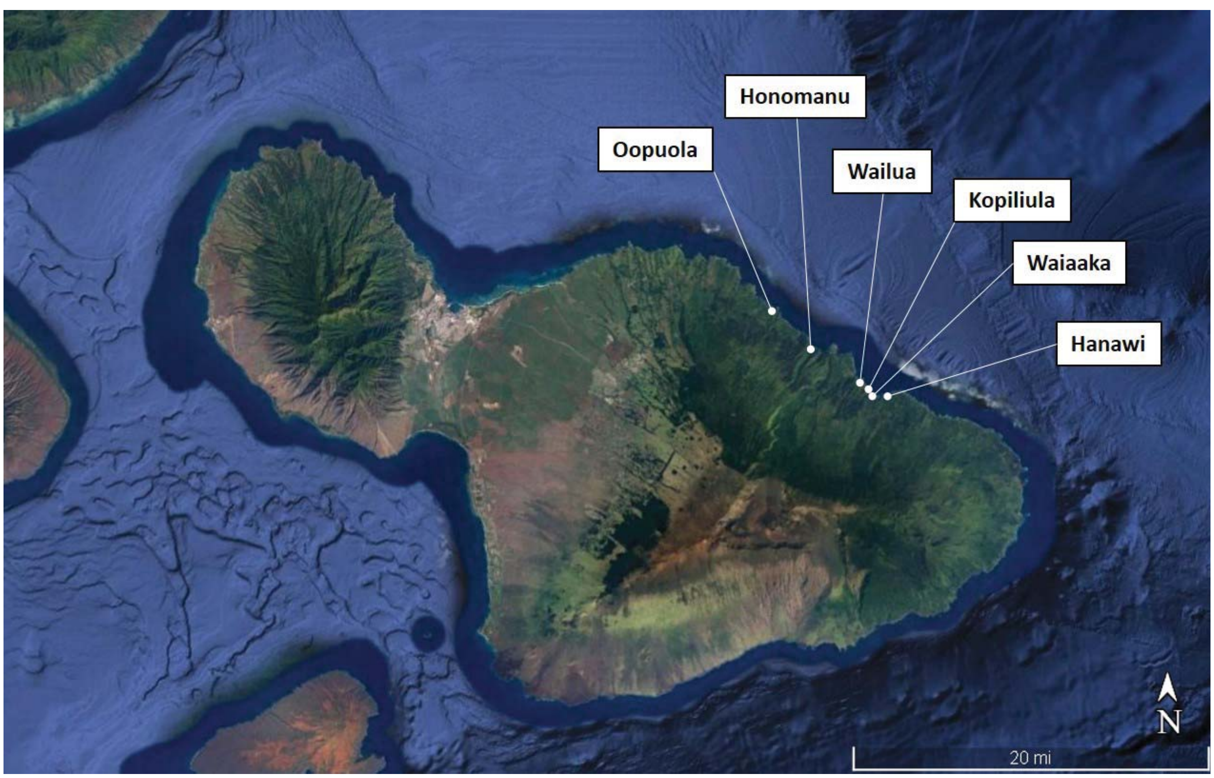


Figure 1-1. Locations of survey streams on East Maui.

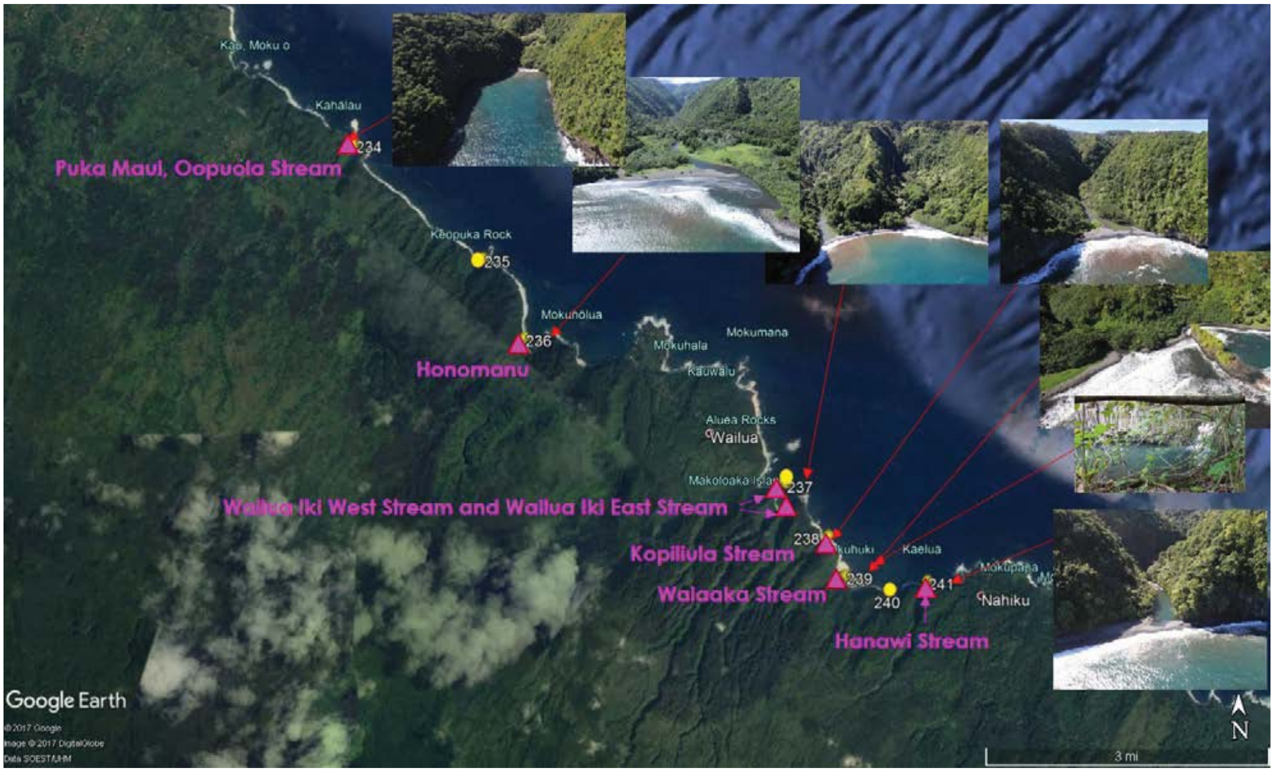


Figure 1-2. Google earth image of East Maui showing locations of streams that were surveyed in 2018 during winter (January) and summer (July). Yellow circles indicate streams that were considered by the survey team from a helicopter, but were not included in the survey owing to lack of access or absence of flowing water.

2. OCEANOGRAPHIC SETTING

The oceanographic environmental evaluation is based on existing available information. This evaluation includes a description of regional tides, currents, sea level rise, and waves for the License Area.

Understanding the existing oceanographic environment is critical for evaluating current and future impacts of these streams on the marine ecosystem.

2.1 Tides

Hawaii tides are semi-diurnal with pronounced diurnal inequalities (i.e., two high and low tides each 24-hour period with different elevations). A modulation of the tidal range results from the relative position of the moon and the sun: when the moon is new or full, the moon and the sun act together to produce larger "spring" tides; when the moon is in its first or last quarter, smaller "neap" tides occur (Rapaport, 2013). The cycle of spring to neap tides and back is half the 27-day period of the moon's revolution around the earth and is known as the fortnightly cycle. The combination of diurnal, semi-diurnal and fortnightly cycles dominates variations in sea level throughout the islands.

The geometry of the oceans - the basin shape, local coastline, bays, and even harbor geometry - has a major effect on the local behavior of the tides. On scales of oceanic basins, tides exist as very long waves propagating in patterns determined by their period and the geometry of the basin. Lines along which high tide occurs at the same time (called phase lines), converge to several points where the tidal range is zero. There are four of these points, called "amphidromes" in the Pacific: one on the North Pacific near the dateline, one near the equator in the eastern North Pacific, one in the central South Pacific near Tahiti, and one east of New Zealand. Phase lines rotate counter-clockwise around the amphidromes in the North Pacific and clockwise around the ones in the South Pacific. For example, at the Hawaiian Islands, the offshore diurnal tide reaches the Hawaii Island first, then sweeps across Maui, Oahu and finally Kauai. Tidal currents result from tidal variations of sea level, and near the shore are often stronger than the large-scale circulation (Rapaport, 2013).

Tidal predictions and historical extreme water levels are given by the Center for Operational Oceanographic Products and Services (COOPS), National Ocean Service (NOS), and NOAA. The nearest tide station to the project site is at Kahului Harbor on the north side of Maui. The water level data from this station is shown in Table 2-1 and is based on the 1983-2001 tidal epoch.

Hawaii is also subject to periodic extreme tide levels due to large scale oceanic eddies that propagate through the islands. Eddies are circulations of about 50 to 200 km across that are often variable over a period of weeks to months depending on the latitude. These eddies produce tide levels up to 0.5 to 1.0 feet higher than normal for periods of up to several weeks in the Hawaiian Islands.

Table 2-1. Water level data for Kahului Harbor, Station 1615680 (NOAA)

Datum	Elevation (feet, MLLW)	Elevation (feet, MSL)
Mean Higher High Water	+2.25	+1.13
Mean High Water	+1.90	+0.78
Mean Sea Level	+1.12	0.00
Mean Low Water	+0.33	-0.79
Mean Lower Low Water	0.00	-1.12

2.2 Currents

The License Area is primarily influenced by the North Hawaiian Ridge Current that moves from the southeast to the northwest along the north side of the Main Hawaiian Islands Figure 2-1. Shown in Figure 2-2 are the ocean currents from the Regional Ocean Modeling System (ROMS) model near the project region that are predominately from the southeast to the northwest. Local currents can vary with the tidal cycle and eddies passing through the License Area.

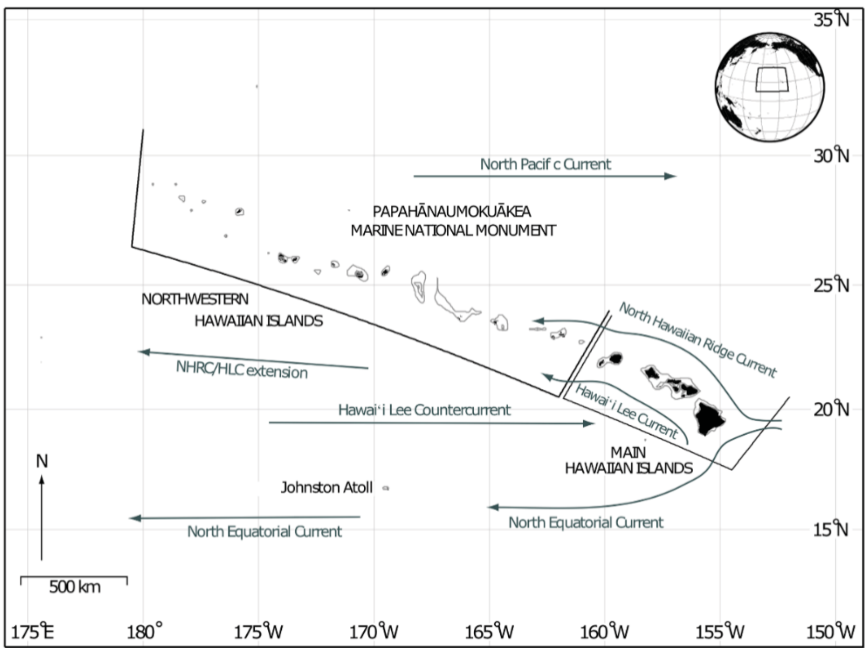


Figure 2-1. Regional ocean currents in the Hawaiian Islands (Wren, 2016).

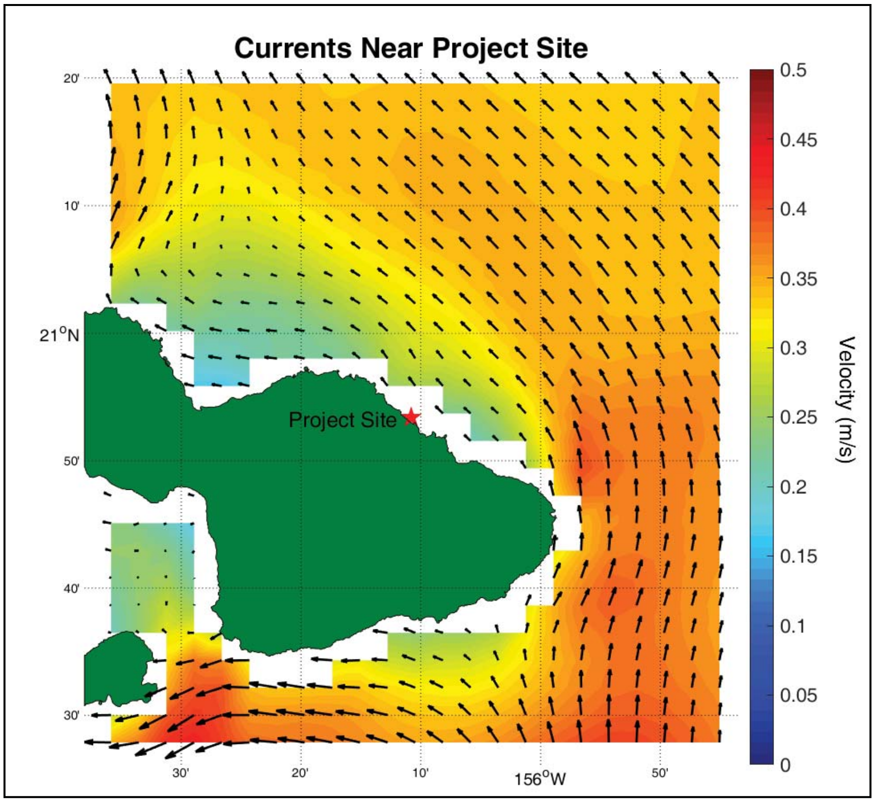


Figure 2-2. Local ocean currents for the Island of Maui (PacIOOS).

2.3 Sea Level Rise

The present rate of global mean sea-level change (SLC) is +3.4 ± 0.4 mm/year (Sweet, 2017), where a positive number represents a rising sea level. SLC appears to be accelerating compared to the mean of the 20th Century. Factors contributing to the measured rise in sea level include decreasing global ice volume and warming of the ocean. Sea level, however, is highly variable. The historical sea level trend for Kahului Harbor is shown in Figure 2-3 (NOAA, 2017). The mean historical rate of sea level change (RSLC) is +2.21 ± 0.42 mm/yr based on monthly data for the period 1947 to 2017. The tide gauge data also show interannual anomalies exceeding 0.5 feet (15 cm) in Kahului Harbor.

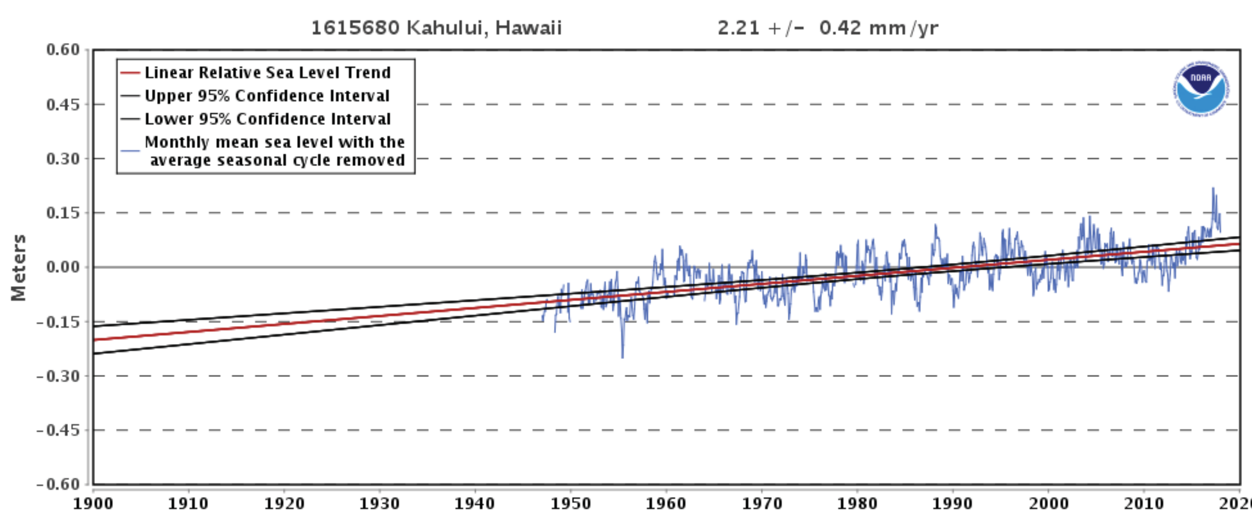


Figure 2-3. Mean sea level trend, Kahului Harbor, 1905 to present (NOAA, 2017).

The National Oceanic and Atmospheric Administration (NOAA) recently revised their sea level change projections through 2100 taking into account up-to-date scientific research and measurements NOAA is projecting that global sea level rise as shown by their "Extreme" scenario could be as high as about 8 feet by 2100. NOAA's recent report also identifies specific regions that are susceptible to a higher than average rise in sea level. Hawaii has thus far experienced a rate of sea level rise that is less than the global average; however, this is expected to change. Hawaii is in the "far field" of the effects of melting land ice. This means that those effects have been significantly less in Hawaii compared to areas closer to the ice melt. Over the next few decades, this effect is predicted to spread to Hawaii, which will then experience sea level rise greater than the global average.

Figure 2-4 presents mean sea level rise scenarios for Hawaii based on the revised NOAA projections, taking into account the far-field effects. While the projections are based on the most current scientific models and measurements, discretion is necessary in selecting the appropriate scenario. Selecting the appropriate sea level change projection is a function of many parameters, including topography, coastal setting, criticality of infrastructure, potential for resilience, budget, and function.

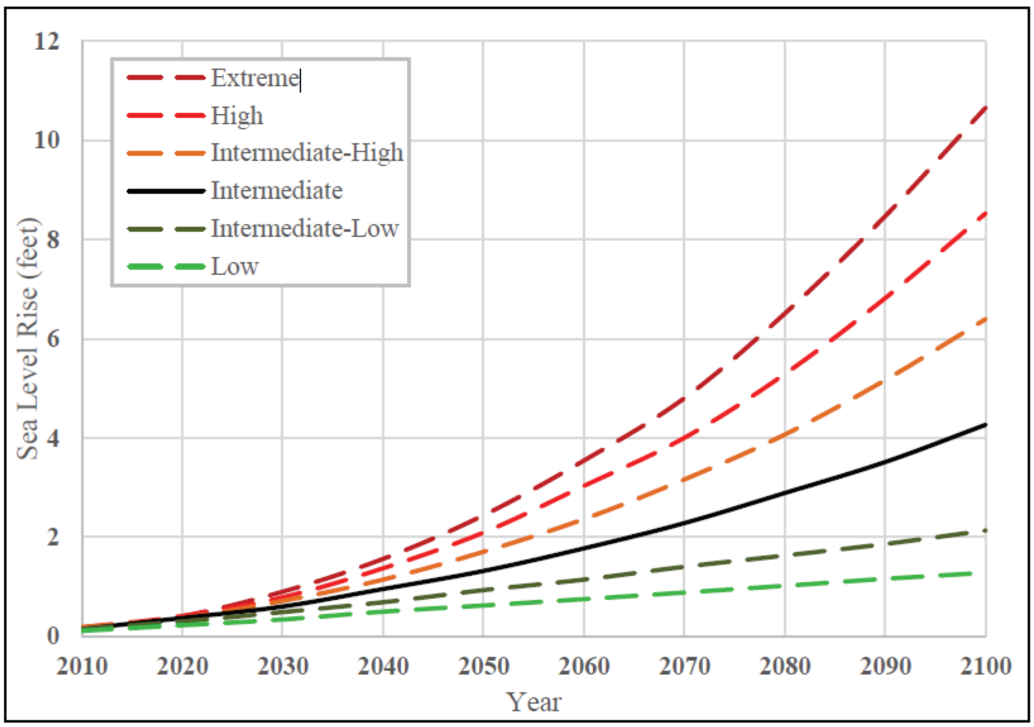


Figure 2-4. Hawaii sea level rise projections (adapted from NOAA, 2017).

Table 2-2 Hawaii Local Mean Sea Level rise scenarios (feet)

Scenario	2010	2020	2030	2040	2050	2060	2070	2080	2090	2100
Low	0.1	0.2	0.3	0.5	0.6	0.7	0.9	1.0	1.2	1.3
Intermediate-Low	0.1	0.3	0.5	0.7	0.9	1.1	1.4	1.6	1.9	2.1
Intermediate	**0.1**	**0.4**	**0.6**	**1.0**	**1.3**	**1.8**	**2.3**	**2.9**	**3.5**	**4.2**
Intermediate-High	0.2	0.4	0.7	1.1	1.7	2.4	3.2	4.1	5.0	6.3
High	0.2	0.4	0.8	1.4	2.1	3.0	4.0	5.3	7.0	8.4
Extreme	0.2	0.4	0.9	1.6	2.4	3.5	4.8	6.5	8.3	10.5

(Adapted from NOAA, 2017)

An important conclusion of the regional climate assessment is that NOAA's revised *Intermediate* rate is recommended for planning and design purposes in Hawaii. The *Intermediate* rate projects that sea level in Hawaii will rise 4.2 feet by 2100 (Table 2-2). Given the recent upwardly revised projections and the potential for future revisions, consideration may also be given to the *Intermediate-High* rate for planning and design purposes, which projects that sea level in Hawaii will rise 6.3 feet by 2100.

Sea level rise has the potential to impact beaches and shorelines in Hawaii. Impacts may include beach narrowing and beach loss, loss of land due to erosion, and infrastructure damage due to inundation and flooding. The impacts from anomalous sea level events (e.g., king tides, mesoscale eddies, storm surge) are also likely to increase. A 2015 study found that, due to increasing sea level rise, average shoreline recession (erosion) in Hawaii is expected to be nearly twice the historical extrapolation by 2050, and nearly 2.5 times the historical extrapolation by 2100 (Anderson et al., 2015).

The State of Hawaii recently published the *Sea Level Rise Vulnerability and Adaptation Report for Hawaii*, which discusses the anticipated impacts of projected future sea level rise on coastal hazards, and the potential physical, economic, social, environmental, and cultural impacts of sea level rise in Hawaii (Hawai'i Climate Change Mitigation and Adaptation Commission, 2017). The University of Hawaii conducted numerical modeling to estimate the potential impacts from sea level rises of 0.5 feet, 1.1 feet, 2.0 feet, and 3.2 feet on coastal hazards including passive flooding, annual high wave flooding, and coastal erosion. These sea level elevations were identified using the predictions associated with the United Nations Intergovernmental Panel on Climate Change's 2014 reports for time marks at 2030, 2050, 2075, and 2100, respectively. These same elevations are correlated to the more recent and comprehensive scientific predictions made in the 2017 NOAA report, using the *Intermediate* rate, for time marks at 2025, 2043, 2064, and 2085, respectively. In summary, the 2017 NOAA report provides state-of-the-science predictions for rates of sea-level rise, while the Hawaii vulnerability report estimates projected coastal impacts at key sea level elevations.

The Pacific Islands Ocean Observing System (PacIOOS) data viewer presents the State sea level rise report's predictions for passive flooding impacts in East Maui. Presented below (Figure 2-5 through Figure 2-10) are the areas predicted to be passively flooded by a sea level rise of +3.2 ft. This sea level equates to the 2085 *Intermediate* rate sea level prediction by the 2017 NOAA report. Passive flooding assumes there are no changes to the existing surface of the land and sea floor, and elevated water levels are projected across existing elevations. The blue areas indicate existing dry land that would become submerged under +3.2 ft of sea level rise.

Figure 2-5. PacIOOS +3.2 ft sea level rise passive flooding projection Ooopuola Stream

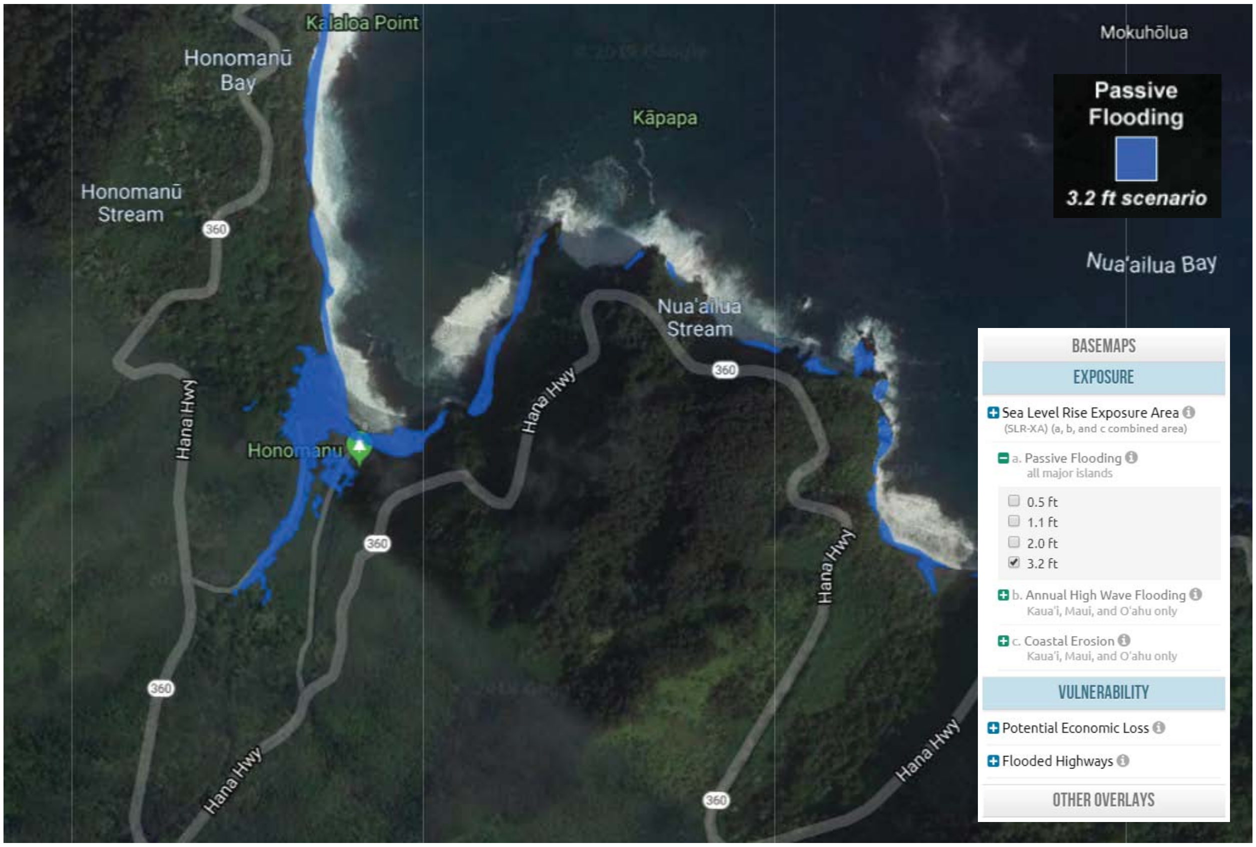


Figure 2-6. PacIOOS +3.2 ft sea level rise passive flooding projection Honomanu Stream

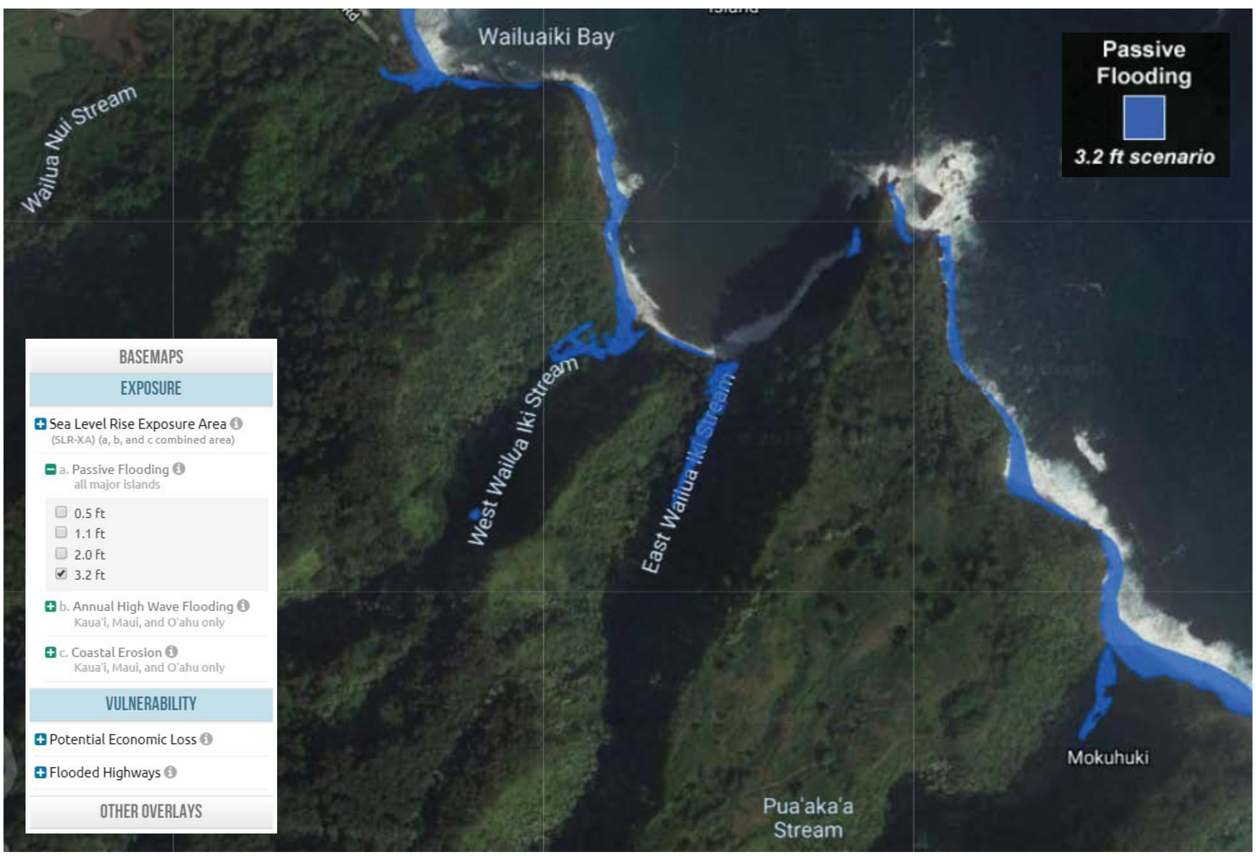


Figure 2-7. PacIOOS +3.2 ft sea level rise passive flooding projection East and West Wailua Iki streams

Figure 2-8. PacIOOS +3.2 ft sea level rise passive flooding projection Kopiliula Stream

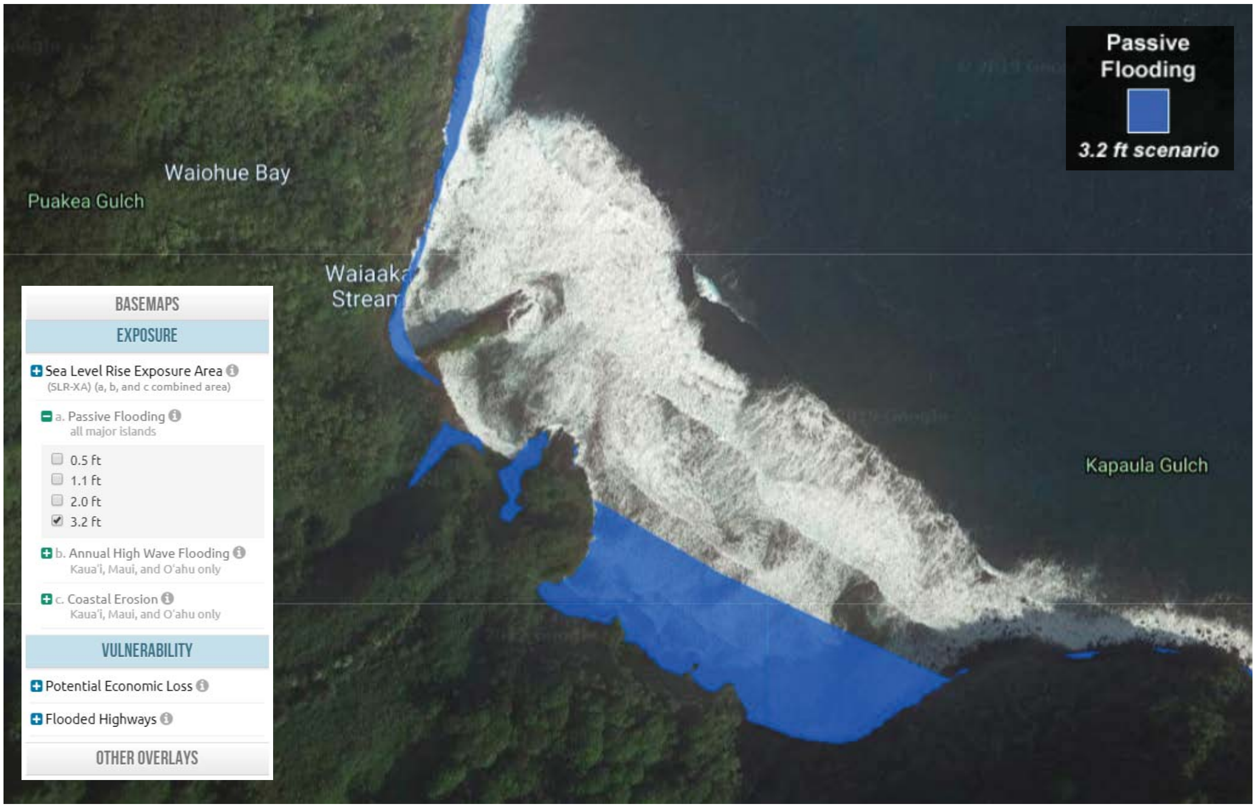


Figure 2-9. PacIOOS +3.2 ft sea level rise passive flooding projection Waiaaka Stream

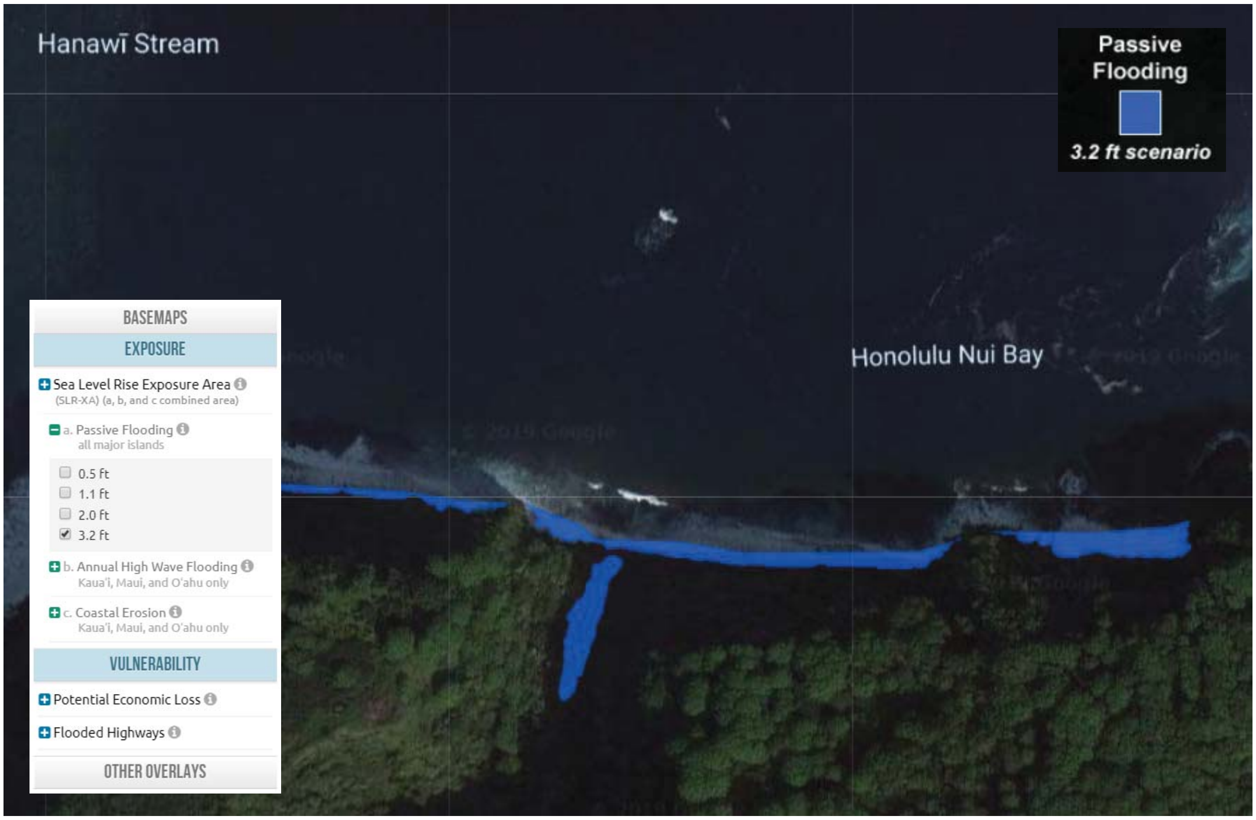


Figure 2-10. PacIOOS +3.2 ft sea level rise passive flooding projection Hanawi Stream

Additional impacts to the East Maui area from sea level rise include increased inundation from wave flooding and typically increased rates of coastal erosion, as discussed above. The State sea level rise vulnerability report did not assess impacts to the project area related to wave inundation or coastal erosion. However, several results can be predicted for the project region based on existing conditions and empirical littoral response to progressively elevated water levels.

Typically, dynamic sediment coastlines, such as the cobble beaches and deltas at the East Maui stream mouths, respond to changes in water level, sediment supply, and wave energy in short time periods. Erosion or accretion along the shoreline becomes a function of the balance between these three primary factors. Rising seas, if all other factors are static, will typically result in the coastal landform rising up and moving landward, as the makai portions of the active profile are eroded to provide the volume required to elevate the entire landform. Storm and seasonally high waves provide the energy required to reshape the landform, carrying sediment higher on the profile.

Rising seas will likely result in the deltaic beaches, bars, and storm berms at the East Maui streams to rise in elevation, while also migrating landward. Storm and seasonal waves, which are typically depth limited by their interaction with the seafloor near the stream mouths, will also likely increase in size and possibly frequency as sea level rises and climate changes. Storm and seasonal wave inundation will migrate inland with the dynamic landforms. The predicted increase in frequency of heavier rain events and flooding may counter the landward migration of these features to some degree, as additional sediment is provided to the deltaic features during flood events. That said, the net change to the project area stream mouths, beaches, bars, and storm berms, resulting from the estimated +3.2 ft of sea level rise is expected to be a landward regression of the landforms combined with an increase in elevation.

2.4 Deepwater Wave Climate

The wave climate in Hawaii is dominated by long period swell generated by distant storm systems, by relatively low amplitude, short period waves generated by more local winds, and the occasional bursts of energy associated with intense local storms. Typically, Hawaii receives five general surface gravity wave types: 1) northeast tradewind waves, 2) southeast tradewind waves 3) southern swell, 4) North Pacific swell, and 5) Kona wind waves. The dominant swell regimes for Hawaii are shown in Figure 2-11.

As waves reach the shallow waters of a reef and island, they shoal, increase in amplitude and eventually break (Rapaport, 2013). The short period, tradewind sea produces relatively small surf height because of the short wavelengths. Large surf is produced by the long period swell from distant storms because of the correspondingly longer wavelength. The north shores of the Pacific islands receive this long-period swell in the northern hemisphere winter, and the south shores in the southern hemisphere winter. Tropical storms and hurricanes also generate waves that can approach the islands from virtually any direction. Unlike winds, all these wave conditions may occur at the same time.

Wave data available from the National Oceanographic and Atmospheric Administration (NOAA) was compiled and analyzed, in order to identify the primary components of the wave climate affecting the project coastline. These data provide a 31-year wave record and were statistically analyzed to determine the frequency of occurrence of different wave heights, periods, and directions along the coast. Coastal processes in this region are dominated by wave energy, as this coastline is exposed to both Tradewind waves and North Pacific swell. Understanding the magnitude and frequency of these events at the stream mouths and along the entire region's coastline is a key aspect of evaluating stream flow impacts to the marine ecosystem.

Wave hindcasting is a tool used to calculate past wave events based on weather models and historical data (Hubertz, 1992). With the proper inputs, wave hindcast models can calculate historical wave climates anywhere in the world. Hindcast model outputs are often recorded for a single location, known as a "virtual buoy".

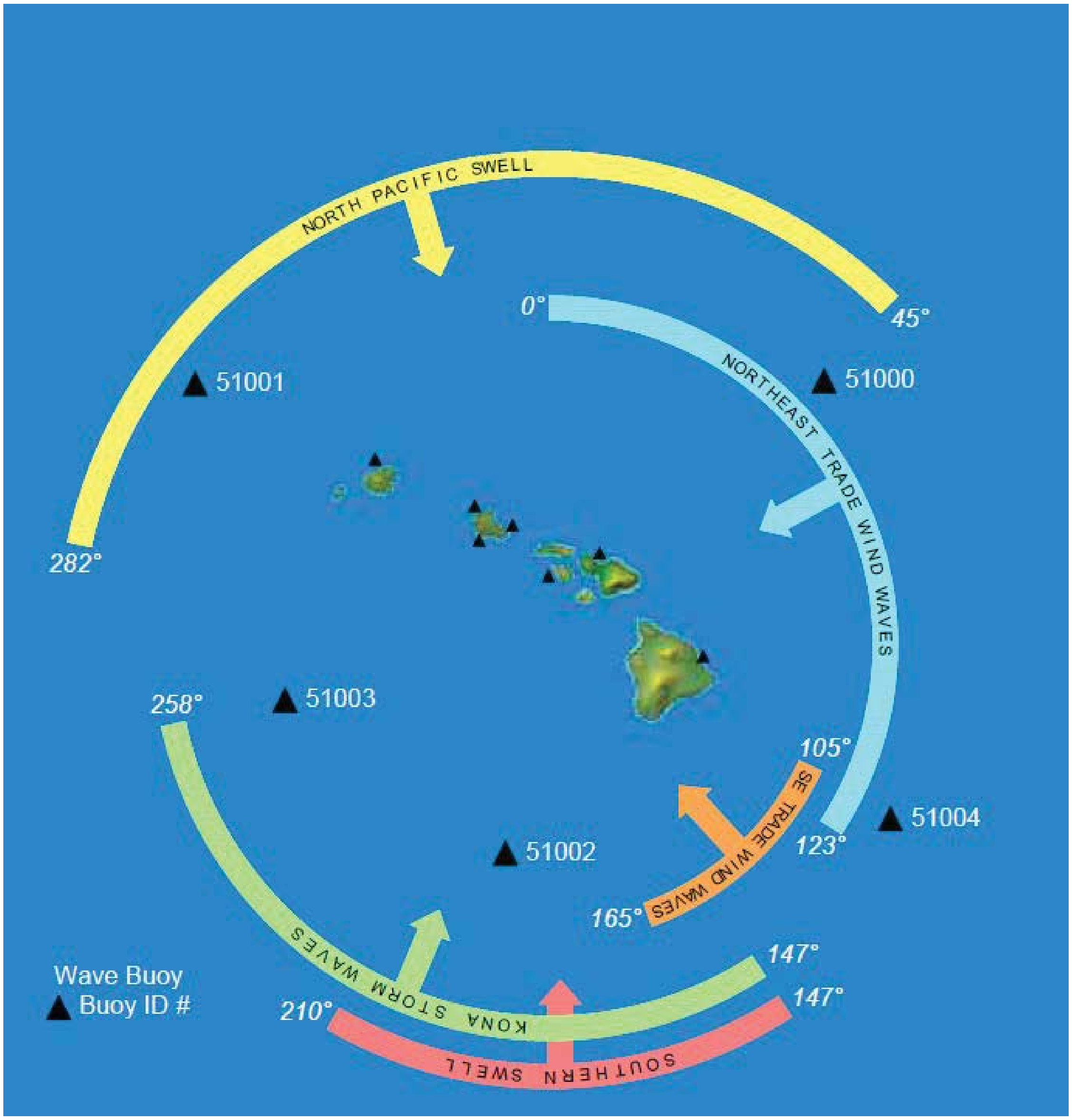


Figure 2-11. Hawaii dominant swell regimes.

WaveWatch III (WWIII) is a numerical wave model used to forecast and hindcast waves. Hindcast data for a 31-year period (1979-2010) are available around the Hawaiian Islands from NOAA/NCEP. For this study, hindcast data were obtained from virtual buoy Station 82517, located approximately 35 miles north-northwest of the project site (Figure 2-12)

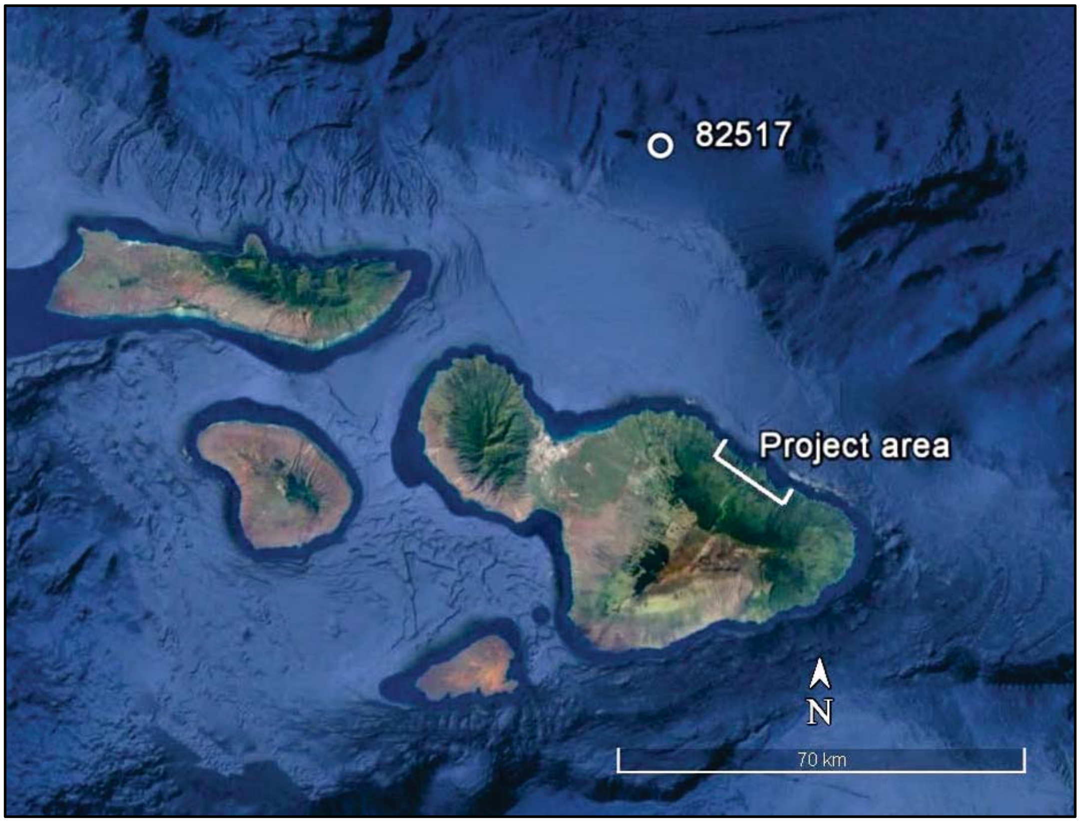


Figure 2-12 Project site and virtual buoy locations.

It is rare for the sea state to consist of a singular wave condition. Wave events are described by wave height, peak period, and peak direction. The wave parameters from the hindcast model are calculated from a modeled wave spectrum. The spectrum shows the distribution of wave energy relative to wave frequency (wave frequency is the inverse of wave period) and wave direction. This methodology allows multiple wave conditions to be accounted for at the same time for a more accurate description of the sea state. Figure 2-13 is a wave height rose diagram that shows the percent occurrence of wave height and direction for waves as measured at Station 82517. Table 2-3 is the corresponding histogram. Figure 2-14 is a wave period rose diagram that shows the percent occurrence of wave period and direction for waves as measured at Station 82517. Table 2-4 is the corresponding histogram.

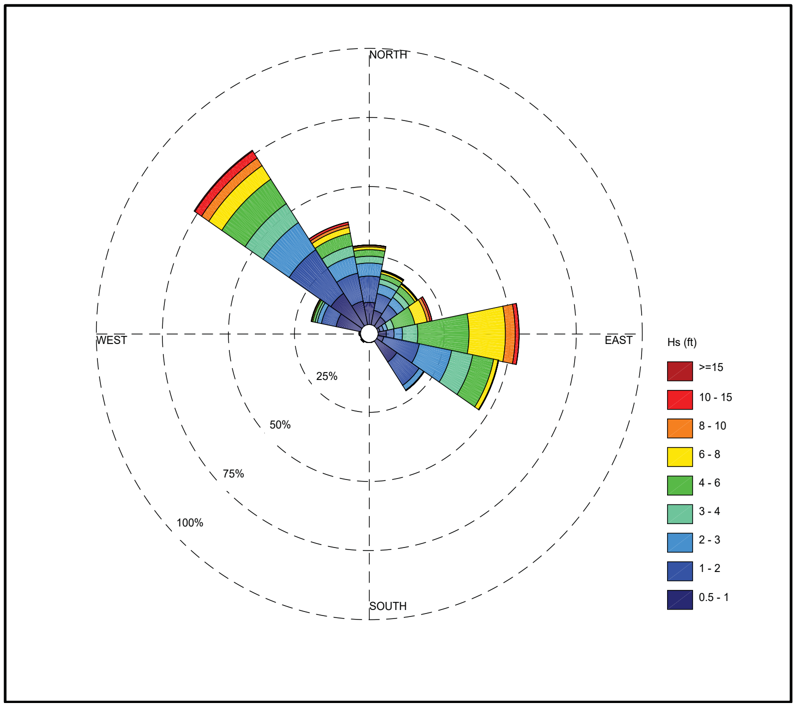


Figure 2-13. Station 82517 virtual buoy wave height rose from Jan 1979 – Jan 2010.

Table 2-3. Station 82517 wave height and direction histogram from Jan 1979 – Jan 2010.

Hs (ft)\Dir	0	22.5	45	67.5	90	112.5	135	157.5	180	202.5	225	247.5	270	292.5	315	337.5	Total
0.5-1.0	8.0	5.3	4.0	0.8	3.1	2.3	9.2	0.0	0.0		0.0	0.0	0.4	9.5	14.2	8.7	65.50
1-2	9.5	6.2	5.3	1.5	3.0	13.7	10.2	0.0	0.0	0.0	0.0	0.0	0.1	5.7	19.0	10.3	84.32
2-3	4.7	3.5	3.2	1.5	3.2	12.5	2.0	0.0	0.0	0.0	0.2	0.0	0.0	1.6	11.8	6.3	50.72
3-4	2.5	1.9	2.3	2.5	5.8	8.1	0.3	0.0	0.0	0.0	0.2	0.0	0.0	0.8	8.2	3.8	36.45
4-6	2.4	1.9	2.5	8.0	19.4	8.1	0.0			0.0	0.1	0.0	0.0	0.9	10.6	4.6	58.65
6-8	1.0	0.8	0.8	4.7	13.8	1.7	0.0			0.0	0.0	0.0	0.0	0.4	5.9	2.1	31.35
8-10	0.5	0.3	0.3	1.1	3.7	0.2		0.0		0.0	0.0	0.0	0.0	0.1	3.3	1.1	10.65
10-12	0.1	0.1	0.1	0.4	1.1	0.1						0.0	0.0	0.1	1.9	0.6	4.46
12-14	0.1	0.1	0.0	0.2	0.2	0.0							0.0	0.0	0.9	0.3	1.82
14-16	0.0	0.0	0.0	0.1	0.1									0.0	0.4	0.1	0.71
16-20	0.0	0.0	0.0	0.0	0.0									0.0	0.2	0.0	0.32
20+															0.0		0.02
Total	28.80	20.15	18.68	20.89	53.40	46.62	21.64	0.02	0.00	0.07	0.54	0.19	0.57	19.11	76.44	37.84	
	0	22.5	45	67.5	90	112.5	135	157.5	180	202.5	225	247.5	270	292.5	315	337.5	Overall
Mean	28.80	20.15	18.68	20.89	53.40	46.62	21.64	0.02	0.00	0.07	0.54	0.19	0.57	19.11	76.44	37.84	344.97
StDev	2.25	2.38	2.61	5.13	5.17	2.87	1.24	1.97	1.93	3.38	3.62	3.49	1.40	1.61	3.39	2.85	3.21
Min	1.94	2.04	2.00	2.45	2.37	1.53	0.58	1.32	1.16	0.97	1.28	2.47	1.51	1.62	2.97	2.52	2.56
Max	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.82	1.28	0.52	0.52	0.52	0.52	0.52	0.52	0.52

Note: The color scheme on the histogram is a visual aid to help view the differences in percent occurrence. Empty cells indicate where the value is precisely zero. Cells ranging from green to yellow to red indicate lower to intermediate to higher values, respectively.

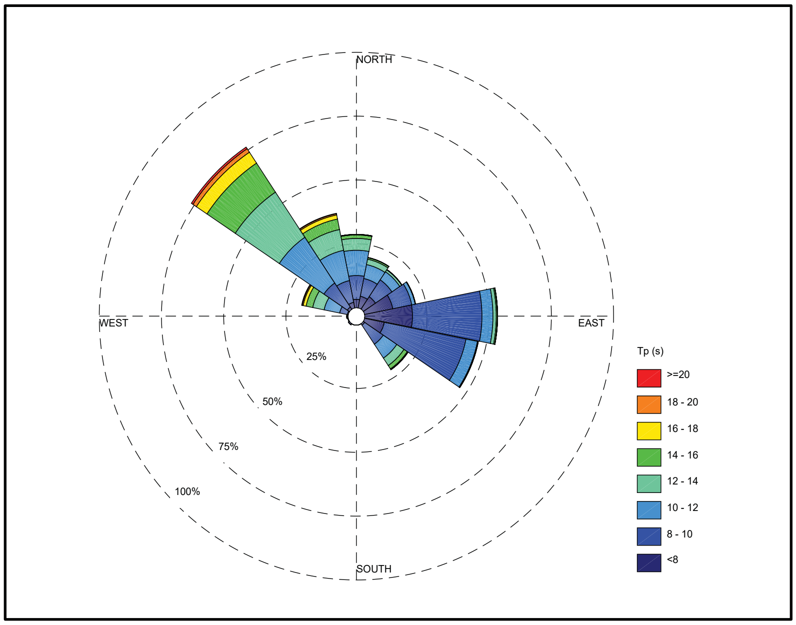


Figure 2-14. Station 82517 virtual buoy wave period rose from Jan 1979 – Jan 2010.

Table 2-4. Station 82517 wave period and direction histogram from Jan 1979 – Jan 2010.

Tp (s)\Dir	0	23	45	68	90	113	135	158	180	203	225	248	270	293	315	338	Total
4-6	0.3	0.4	0.6	1.0	2.2	1.1	0.1	0.0	0.0	0.1	0.5	0.1	0.1	0.1	0.1	0.1	6.81
6-8	3.0	4.2	5.3	10.6	17.0	7.0	0.6	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.9	2.2	51.26
8-10	9.3	7.1	8.0	7.8	27.9	33.5	9.0	0.0	0.0	0.0	0.0	0.0	0.2	3.1	11.3	8.7	125.87
10-12	9.9	5.6	3.8	1.4	4.4	4.7	6.5	0.0			0.0	0.0	0.1	6.4	21.6	12.1	76.45
12-14	4.7	2.2	0.9	0.2	1.3	0.3	3.5				0.0	0.0	0.1	4.7	21.3	8.3	47.28
14-16	1.3	0.6	0.1	0.0	0.4	0.1	1.6					0.0	0.0	2.7	13.7	4.2	24.74
16-18	0.2	0.1	0.0	0.0	0.1	0.0	0.3						0.0	1.2	5.1	1.6	8.75
18-20	0.0	0.0	0.0		0.0	0.0	0.0						0.0	0.4	1.6	0.5	2.62
20+	0.0	0.0			0.0		0.0							0.2	0.8	0.2	1.19
Total	28.80	20.15	18.68	20.89	53.40	46.62	21.64	0.02	0.00	0.07	0.54	0.19	0.57	19.11	76.44	37.84	

	0	23	45	68	90	113	135	158	180	203	225	248	270	293	315	338	Overall
Mean	10.44	9.69	8.97	7.98	8.51	8.80	10.78	7.78	6.41	4.60	4.79	5.76	9.08	12.31	12.60	11.60	10.36
StDev	2.10	2.15	1.80	1.28	1.59	1.15	2.09	2.19	1.54	0.59	0.97	1.74	3.04	2.70	2.62	2.61	2.71
Min	4.01	4.01	4.02	4.01	4.01	4.01	4.03	4.01	4.43	4.01	4.01	4.01	4.01	4.01	4.02	4.05	4.01
Max	21.22	20.76	19.77	17.77	20.96	18.38	20.21	11.75	8.52	9.79	13.74	14.42	18.63	24.42	25.38	24.48	25.38

Note: The color scheme on the histogram is a visual aid to help view the differences in percent occurrence. Empty cells indicate where the value is precisely zero. Cells ranging from green to yellow to red indicate lower to intermediate to higher values, respectively.

2.4.1 *Deep Water Wave Generation Regions*

Sea-swell waves in the ocean are generated by surface winds. As the wind blows, energy is put into the ruffled sea surface and waves begin to grow in both height and length (Agustin, 2017). Waves will travel along great circle routes until their energy is dissipated. We use the ESTELA (Evaluating the Source and Travel-time of the wave Energy reaching a Local Area) model by Perez et. Al. (2014) to determine the source of waves arriving at the project site. The ESTELA model begins by evaluating geographic criteria to remove areas where wave propagation to the project site is clearly obstructed by land (Agustin, 2017). These criteria rely on the assumption that deep water waves travel along great circle paths. A limitation of this assumption is that it does not capture refraction and diffraction around islands. The model then calculates the wave energy in wave generation regions that have met the geographic criteria

Shown in Figure 2-15 is the mean energy flux per unit degree for the wave generation regions that impact the project site over 1993 to 2012. Energy flux is the product of wave energy, proportional to wave height squared, and group velocity, the rate at which wave energy moves. The colored regions show the effective energy flux for generation regions that met the geographic criteria. Black dashes show the great circle routes waves travel along, and black contours represent the wave travel time in days. Yellow areas represent the regions with the highest wave energy flux traveling toward the project site whereas the effective energy flux of dark blue areas is negligible. The primary source of energy impacting the study site is the northwest swell according to the ESTELA model. The northwest wave source region in the model output is known to be an area of high storm activity (Bromirski et al., 2005). Lower in energy, but also a source of waves shown in the ESTELA output are trade wind waves. Trade wind waves are generated by the trade winds from the northeast to east throughout the year forced by the subtropical high-pressure region (Stopa, 2011).

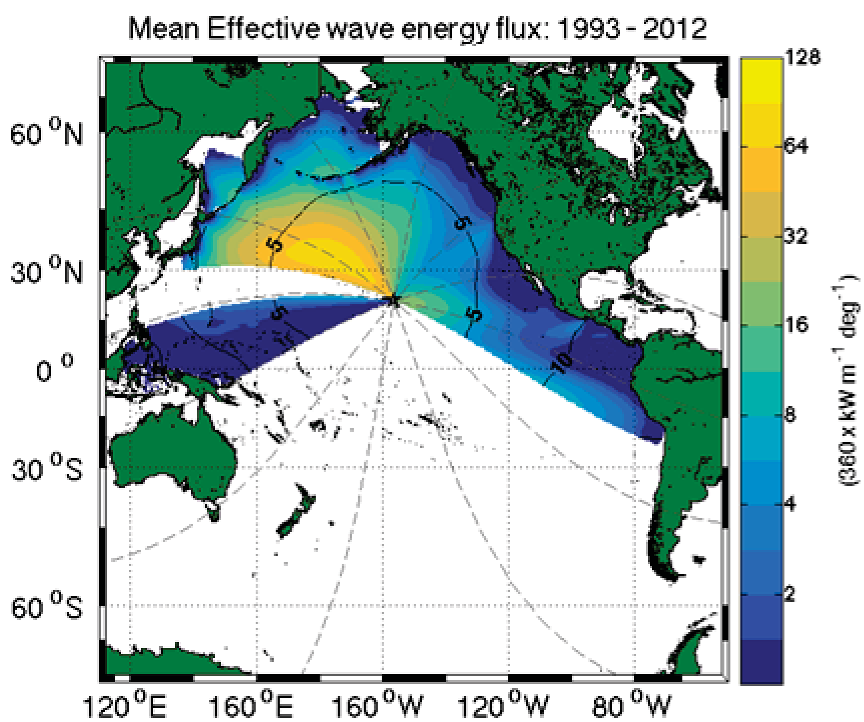


Figure 2-15. North Maui mean effective wave energy flux ESTELA model output.

3. COASTAL GEOLOGY

The east flank of Haleakala is dominated by basalt flows from the Kula Volcanics and Hana Volcanics. These overlapping flows are incised by deep valleys with steep walls, dropping rapidly from the upper terrace landscape down to the stream beds that continually erode the basalt substrate (Figure 3-1). Smaller watersheds may produce valleys have not fully incised the basalt flows and exit the coastline at waterfalls nestled within the seacliffs (Figure 3-2). The ongoing erosion of the basalt terrace, from the crater walls of Haleakala down to the coastline, produces ample volume of basalt boulders, cobbles, pebbles, and sand for both the stream beds and the cobble and shingle beaches (Figure 3-4). Honomanu Basalt flows outcrop as many of the headlands along this stretch coastline, providing stable seacliffs and sides to the small embayments notched into the shore (Figure 3-5, Figure 3-6).

Figure 3-1. Aerial view of Wailua Iki East and Wailua Iki West streams showing valleys cut into the basalt slope of East Maui.

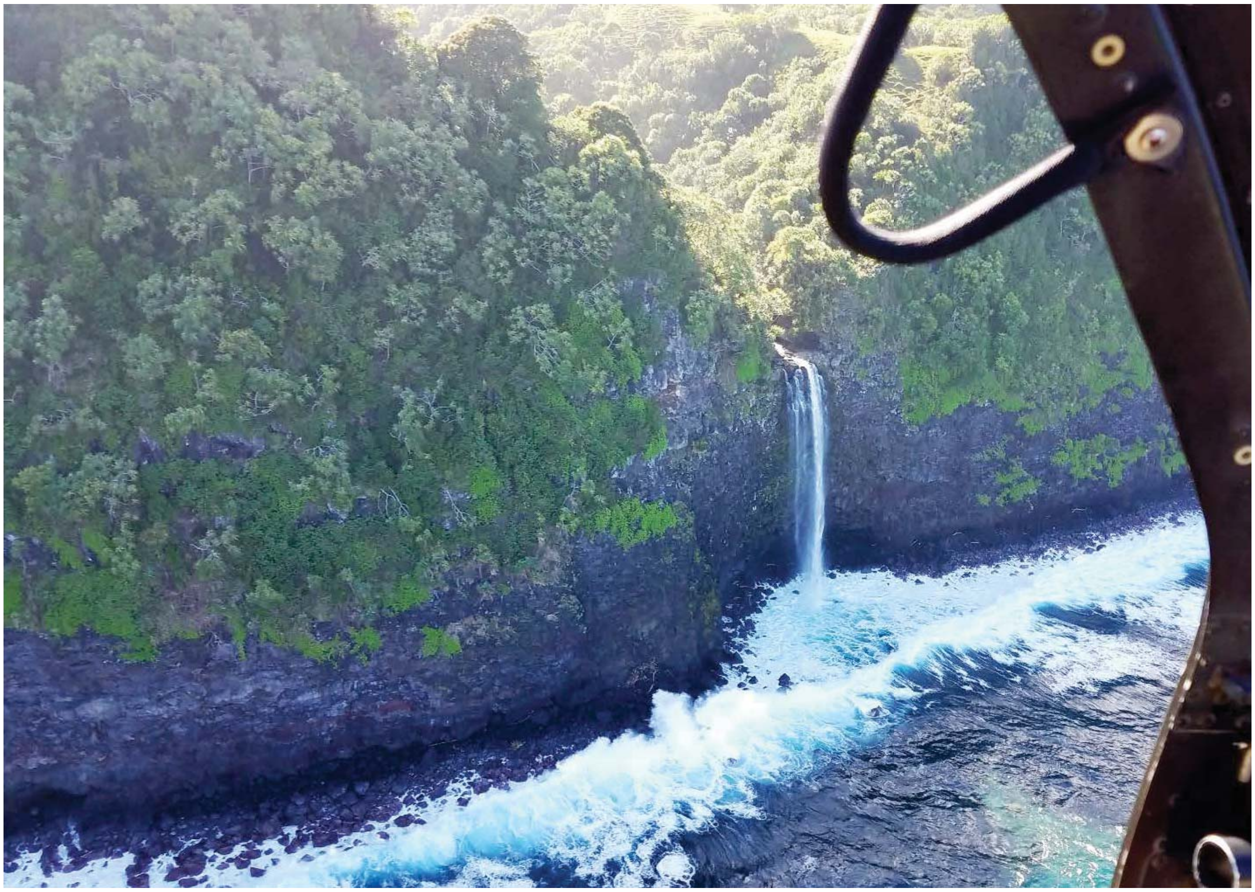


Figure 3-2. Stream valley exiting the coastline at a seacliff.

Figure 3-3. Basalt sediment from the stream bed mixing with the basalt beach at Wailua Iki East stream.

Figure 3-4. Stream bed basalt sediment mixing with the basalt sediment beach at Honomanu stream.

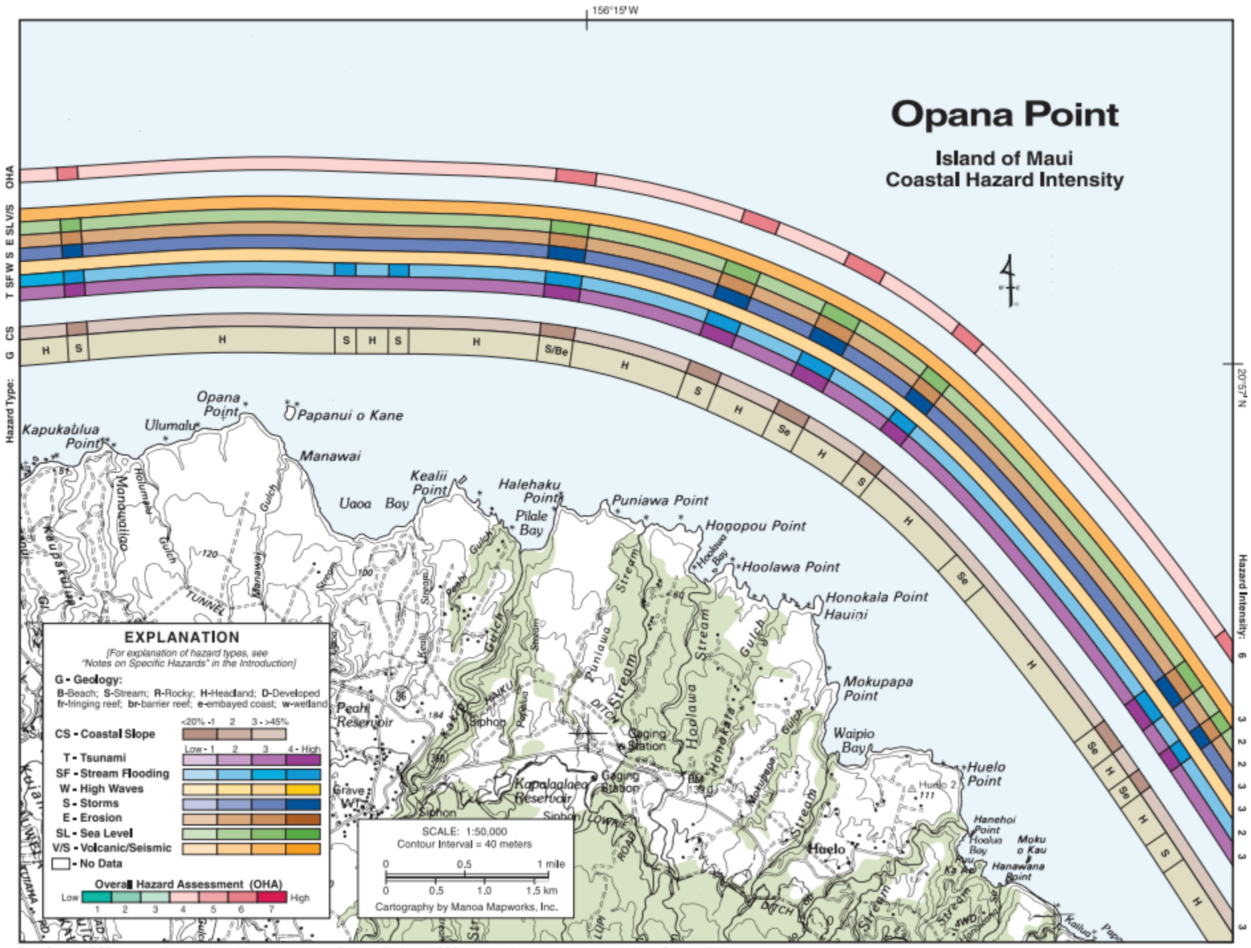
Figure 3-5. Rocky seacliff headlands alongside basalt cobble and shingle beaches at Kopiliula Stream.


Figure 3-6. Steep, columnar basalt headland next to basalt boulder beach on the west side of Waiaaka Stream.

Beaches along this coast comprise almost entirely basalt sediment. The limited reef environment and high energy coastline are neither amenable to producing carbonate sand grains nor allowing for settling of carbonate sand grains along the shoreline. Instead, these beaches are made of basalt sediment ranging in size from coarse sand to boulders (Figure 3-7).

Figure 3-7. Basalt beaches with sediment sizes ranging from coarse sand to boulder at Wailua Iki West Stream.

The rugged, exposed coastline is battered year-round by large waves. In the summer months, unobstructed Tradewind waves attack the shore and in the winter months large North Pacific swell and local storm events send large waves toward the coast. The seafloor drops off quickly from the shoreline and does not provide significant protection from offshore waves. Though the shoreline is generally rocky, there is still an erosion hazard present, especially within the low-lying stream valleys. The small islets along the coast are erosional relicts left after the seacliffs migrated inland. The coastal natural hazards for East Maui are categorized and evaluated in the Atlas of Natural Hazards in the Hawaiian Coastal Zone (2002) (Figure 3-8, Figure 3-9, and Figure 3-10). These hazards in coastal erosion, as well as tsunami, stream flood, sea-level rise, and storm hazards. The Atlas ranks the stream mouths and valley shorelines as high coastal hazard areas due to their low-lying topography and unprotected coast (Figure 3-11). By contrast, the taller seacliffs and headlands that surround the valleys have a moderate exposure level due to their elevation and substrate characteristics.



Base Credit: USGS 1:50,000 Kipahulu Valley, Hawaii 5719 II W733 Edition 1-DMA and USGS 1:50,000 Makawao, Hawaii 5719 IV W733 Edition 1-DMA

Figure 3-8. Atlas of Natural Hazards in the Hawaiian Coastal Zone – Opana Point Region.

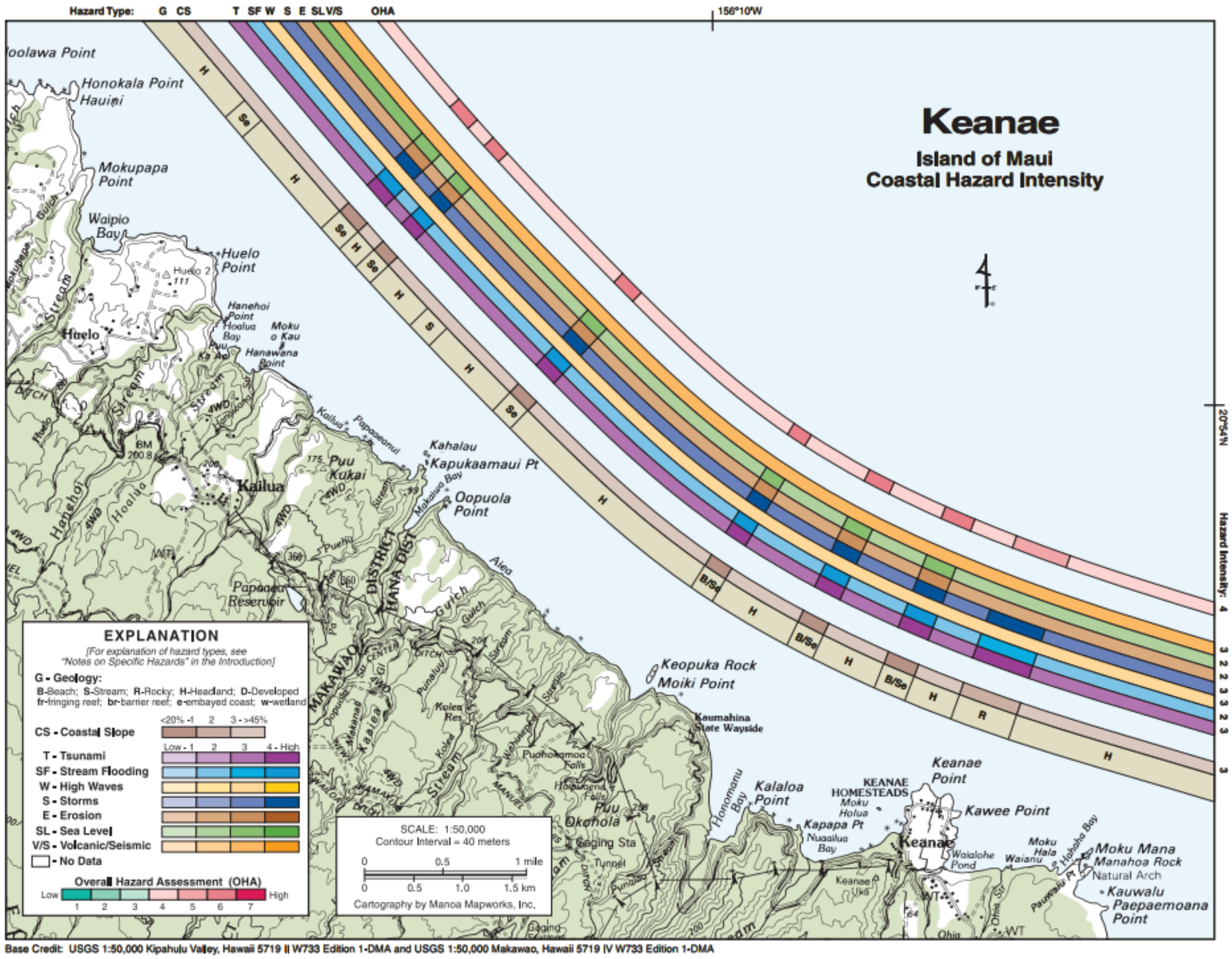


Figure 3-9. Atlas of Natural Hazards in the Hawaiian Coastal Zone – Keanae Region.

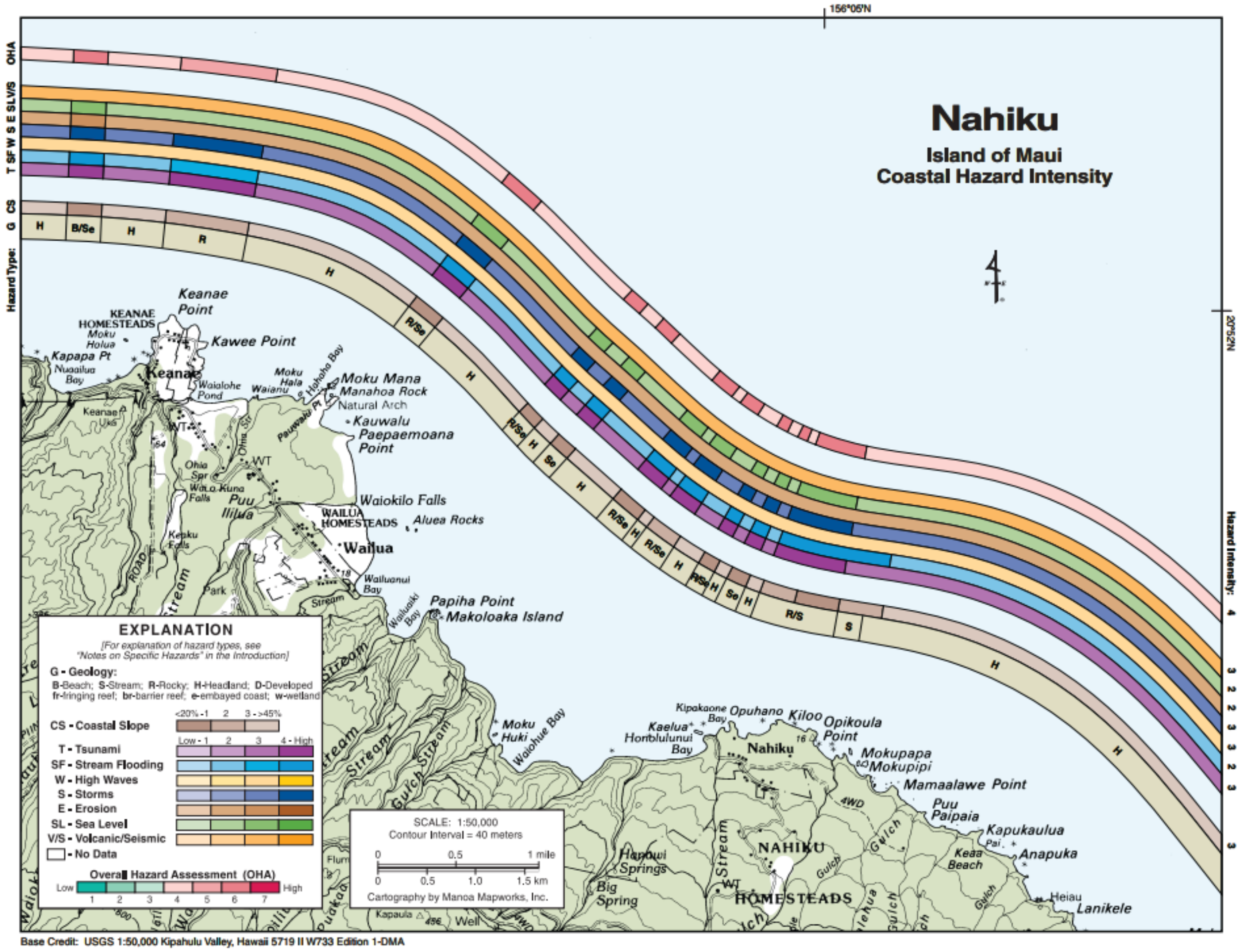


Figure 3-10. Atlas of Natural Hazards in the Hawaiian Coastal Zone –Nahiku Region.

Figure 3-11. Aerial view of waves washing across the low-lying basalt cobble and boulder beaches, at the base of basalt seacliffs at Hanawi Stream.

The Hawaii Sea Level Rise Vulnerability and Adaptation Report, completed in 2017, specifically addresses sea-level rise exposure due to waves, passive flooding, and shoreline erosion. This report identified limited sea-level rise exposure along much of the coastline. The rocky, cliffed shorelines have minimal exposure due to their steep slopes and durable substrate. The areas showing sea-level rise exposure are near the shoreline within the stream valleys and low-lying basalt terraces near the waterline (Figure 3-12).

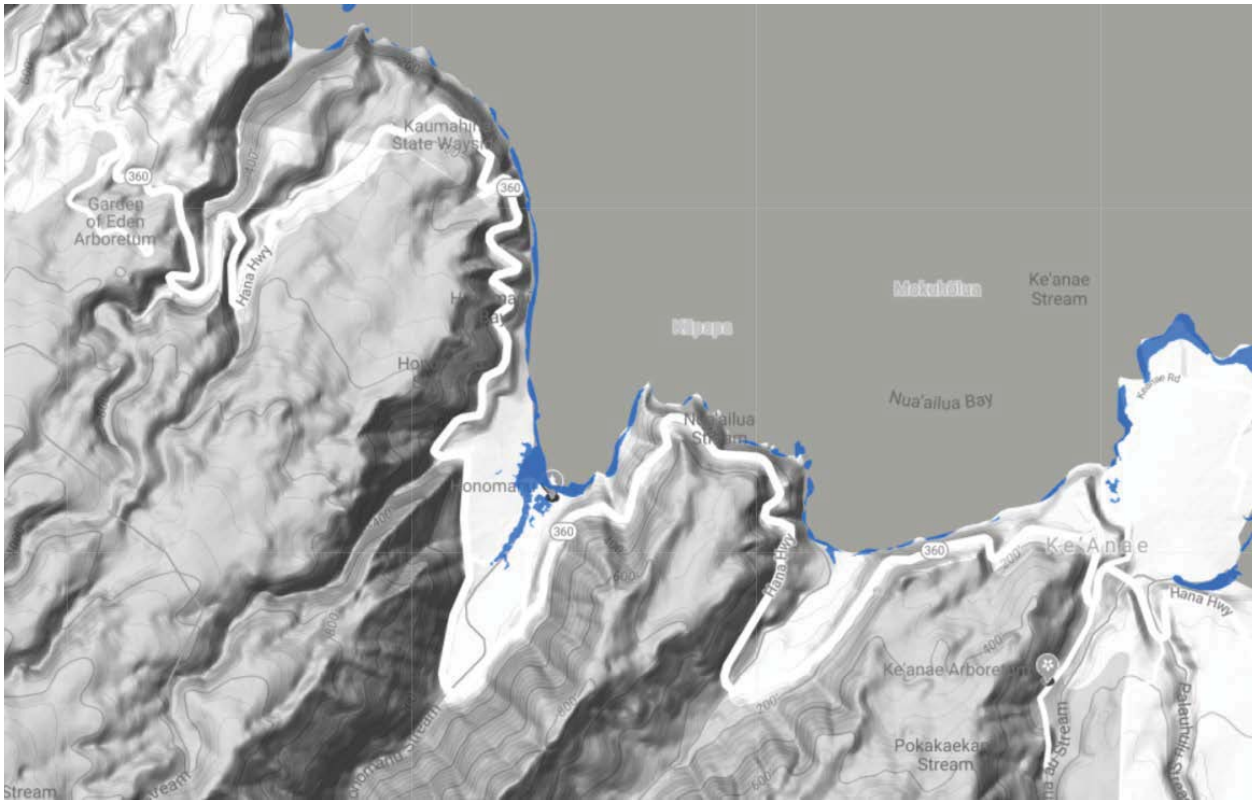


Figure 3-12. Example - Sea Level Rise Exposure Area at shoreline for Honomanu Stream, 3.2 ft rise, PacIOOS viewer for Hawaii Sea Level Rise Vulnerability and Adaptation Report.

4. EAST MAUI STREAM FIELD SAMPLING

Field surveys were conducted twice (winter, summer) at six stream systems on East Maui that were accessible by either roads or helicopter (Figures 1-1, 1-2). During an initial reconnaissance flight several other streams were observed, but were not included in the survey owing to either inaccessibility or absence of water flowing to the ocean (Figure 1-2). The winter survey commenced on January 2, 2018 with collection of sediment and water samples from Honomanu Stream and estuary. On January 3, four streams/estuaries along the northern coast of East Maui (Hanawi, Kopiliula, Waiaaka East and Waiaaka West) were accessed by helicopter and sampled. On January 5 Wailua Iki and Wailua Nui streams and Oopuola were sampled in a similar manner. For the summer sampling, the Honomanu Stream and estuary were sampled on July 19, 2018, Hanawi, Kopiliula, Waiaaka East and Waiaaka West were sampled on July 20, and Oopuola, Wailua Nui East and West were sampled on July 23.

At each of the survey streams water samples were collected by investigators walking along transects that extended from the most inland accessible upstream areas through the transition zone where stream water mixes with ocean water, and as far seaward in the nearshore ocean as was possible. At each sampling point, location was recorded using a hand-held GPS. All sampling done in both January and July 2018 was conducted during periods of normal seasonal swell which limited safe access to offshore sites. Samples were stored on ice and delivered to the analytical laboratory in Honolulu as soon as possible following collection.

4.1 Water Chemistry Analytical Methods

Water quality parameters evaluated included all of the specific criteria designated for open coastal waters in Chapter 11-54, Section 06 (Open Coastal waters) of the State of Hawaii Department of Health (DOH) Water Quality Standards. These criteria include: total nitrogen (TN), nitrate + nitrite nitrogen (NO_3^- + NO_2^-, hereafter referred to as NO_3^-), ammonium nitrogen (NH_4^+), total phosphorus (TP), chlorophyll a (Chl *a*), turbidity, pH, salinity and temperature. In addition, orthophosphate phosphorus (PO_4^{3-}) and silica (Si) were also reported because these parameters are sensitive indicators of biological activity and the degree of stream water and groundwater mixing.

Following collection, subsamples for nutrient analyses were immediately placed in 125-milliliter (ml) acid washed, triple rinsed, polyethylene bottles and stored on ice. Analyses for NH_4^+, PO_4^{3-}, and NO_3^- were performed with a Technicon autoanalyzer using standard methods for seawater analysis. TN and TP were analyzed in a similar fashion following oxidative digestion. Total organic nitrogen (TON) and total organic phosphorus (TOP) were calculated as the difference between TN and dissolved inorganic N and TP and dissolved inorganic P, respectively.

Water for other analyses was subsampled from 1-liter polyethylene bottles and kept chilled until analysis. Chl *a* was measured by filtering enough water through glass fiber filters for color to be visible; pigments on filters were extracted in 90% acetone in the dark at 20° C for 12-24 hours. Fluorescence before and after acidification of the extract was measured with a Turner Designs fluorometer. Salinity was determined using an AGE Model 2100 laboratory salinometer with a readability of 0.0001‰ (ppt). Turbidity was determined on 60 ml subsamples using a Monitek Model 21 nephelometer, and reported in nephelometric turbidity units (NTU).

In situ field measurements of water temperature, pH, dissolved oxygen and salinity were acquired using an RBR Concerto CTD calibrated to factory specifications. The CTD has a readability of 0.001°C, 0.001pH units, 0.001% saturation, and 0.001 parts per thousand (salinity). All laboratory analyses were conducted by Marine Analytical Specialists in Honolulu, Hawaii. Marine Analytical Specialists possesses the acceptable rating for EPA-compliant proficiency and quality control testing.

4.2 Water Chemistry Results

Appendix A contains results of all water chemistry analyses for each stream during each sampling period. Figures 4-1 through 4-12 show pictographic representations of the distribution of temperature in each stream and the nearshore ocean for the winter and summer sampling events. Figures 4-13 through 4-24 show similar pictographs for temperature, Figures 4-25 through 4-36 show data for phosphate phosphorus, and Figures 37 through 48 show distributions of nitrate nitrogen. These data are plotted within accurate topographic representations of the stream beds with the intent of providing a clear depiction of the relationship between the streams and the ocean. Symbols on the pictographs are color-coded to vary in intensity according to the magnitude of the values, which are shown in the table embedded in each figure.

The best delineator between stream water and ocean water is salinity. Examination of the pictographs reveals that there are generally similar patterns of salinity for all six of the streams. In all of the streams sampled, salinity at the inland ends of the sampling transects was near zero, indicating that water in these areas was of terrestrial origin, and above the reach of tidal exchange with the ocean. Near the shorelines of all streams, there was a narrow transition zone where stream water mixed with ocean water, resulting in salinity of intermediate values. Beyond the shoreline, salinity rose sharply to near oceanic values. It is of interest, however, that at none of the samples collected at the most offshore stations had oceanic values of salinity of about 34 ppt. The highest values measured in ocean samples occurred at Kopiliula stream in the summer (~33 ppt) (Figure 4-6), Oopuola in the winter (~32 ppt) (Figure 4-7), and Honomanu stream in the winter (~31 ppt) (Figure 4-1). Such a result indicates that there is at least a slight effect of freshwater input in the nearshore marine areas that were investigated.

The only stream that did not show salinity near ocean values was Hanawi in the winter where all samples were essentially freshwater. At Hanawi surface salinity ranged from 0.0-0.1 ppt at eight of the sampling stations and only rose to 1.56 ppt at the stream mouth (Figure 4-3). The cause of the lack of any discernable gradient was the inability to sample in the nearshore ocean owing to dangerous breaking surf.

Gradients of temperature along the transects of each steam mirror salinity, as freshwater in the streams was consistently cooler than ocean waters (Figures 4-13 to 4-24). As would be expected, stream water was substantially warmer in the summer sampling than the winter. The smallest gradient in temperature in the streams occurred at Hanawi in the winter (Figure 4-15).

The two most important macronutrients for plant growth that could affect biotic resources are phosphorus and nitrogen. The most common inorganic forms of these elements that are metabolically active in stream and marine waters are phosphate phosphorus (PO_4^{3-}) and nitrate nitrogen (NO_3^+). Examination of the pictographs of the concentrations of these elements along the stream-ocean transects reveals substantial differences in the patterns of distribution between streams.

At Honomanu peak values in stream waters for both PO_4^{3-} (Figure 4-25) and NO_3^+ (Figure 4-37) decrease by an order of magnitude in the nearshore ocean. Stream values of both PO_4^{3-} and NO_3^+ are approximately double in the winter relative to the summer, while the marine values are similar during both seasons. There are also sharp gradients between the concentrations at the shoreline indicating a narrow mixing zone. The elevated values in winter likely reflect higher winter season rainfall in upland areas. However, the sharp change at the shoreline, and the similar seasonal values in the ocean suggest that the input of stream water likely has little overall effect on concentrations in the nearshore ocean.

Other streams showed varying patterns of nutrient distribution along the stream gradients. At Hanawi the concentrations of both nutrient compounds are essentially consistent during the winter, owing to the inability to sample in the open ocean (Figure 4-39). During the summer sampling event, the elevated concentrations of NO_3^+ in the streams dropped by an order of magnitude at the shoreline (Figure 4-40). The pattern for PO_4^{3-} at Hanawi was similar to that of NO_3^+ although the magnitude of the changes were smaller (Figures 4-27, 4-28).

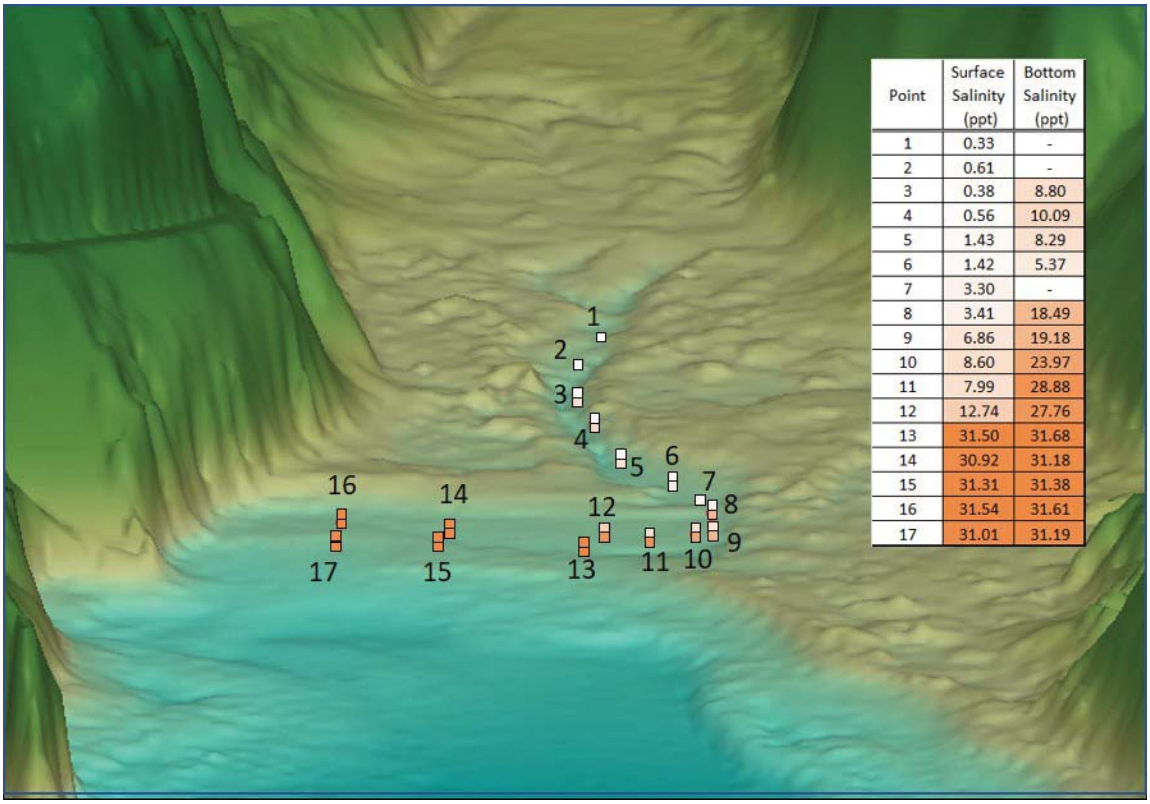
Kopiliula and Oopuola streams presents a different pattern than any of the other streams. During both the summer and winter sampling events the concentrations of PO_4^{3-} and NO_3^+ show little variation between the stream and ocean waters (Figures 4-29 to 4-32 and 4-41 to 4-44). As there are substantial changes in salinity at the shoreline transition zone during both sampling events at these sites, the lack of the same type of nutrient gradient between the stream and the ocean suggests that the source waters are substantially different than in other areas. As there is no elevated nutrient levels in stream water similar to what occurs at other locations, it is evident that the stream water that reaches the ocean emanates from different sources.

The gradients of nutrients at Waiaaka Stream display another pattern. The concentrations of PO_4^{3-} from both the East and West branches show little variation with distance from the shoreline in both winter and summer, although the winter values are overall higher than during the summer (Figure 4-34). However, values of NO_3^+ at Waiaaka West are lower in the summer by an order of magnitude than during the winter (Figures 4-45 and 4-46). Such variability in time suggests that the nutrient concentrations are sensitive to local upland conditions of rainfall and drainage.

Sampling at the two branches of Wailua Iki showed an opposite trend as at Honomanu in that nutrient concentrations in the upper reaches of the sampling transect were lower than the values in areas closer to the ocean (Figures 4-35 and 4-36, Figures 4-47 and 4-48). This pattern suggests that nutrient regeneration is occurring in still water ponds that occur at the base of the streams which are separated from the ocean by beach rock berms (Figure 3-3).

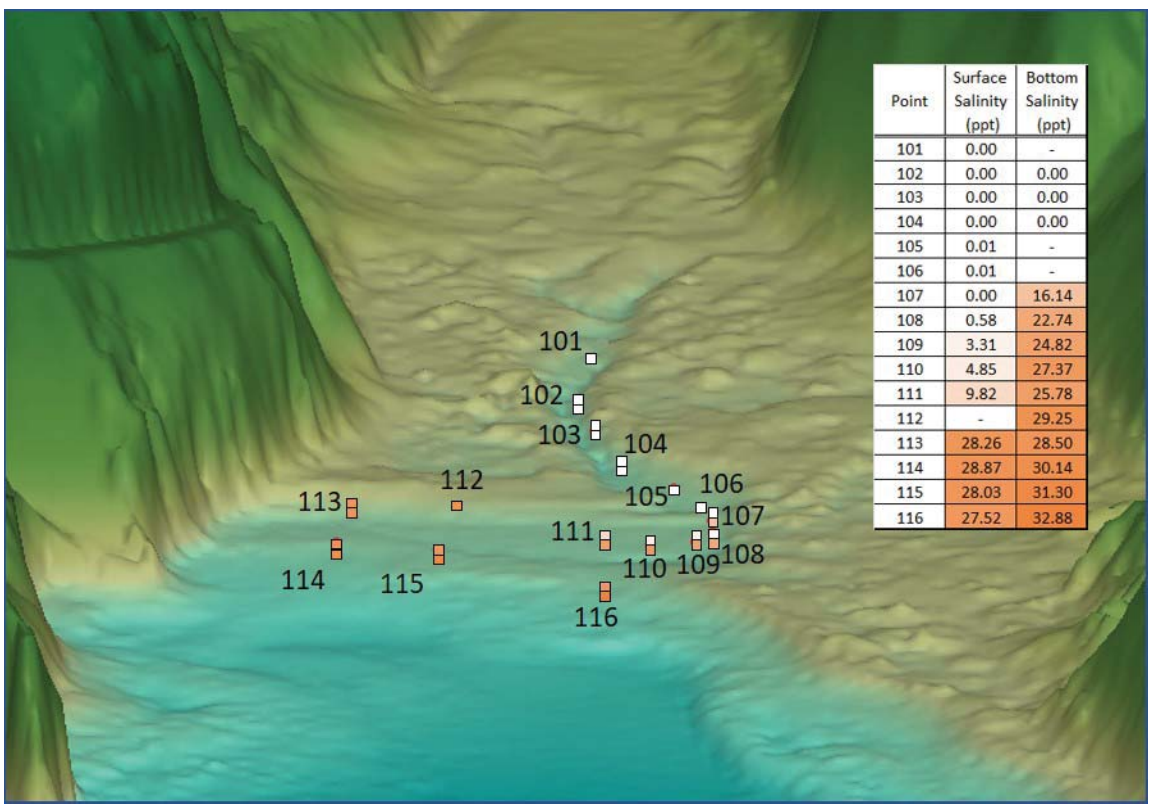
In summary, these data indicate substantial variability in nutrient dynamics between streams in terms of both sources and seasons. The consistent factor is that regardless of stream water composition, values in ocean waters seaward of the transition zone are relatively constant.

While not shown in pictographs, examination of the data tables in Appendix A indicates little evidence of consistent patterns with other water quality constituent. In particular, turbidity and Chl *a* did not display any consistent differences between streams or within streams.



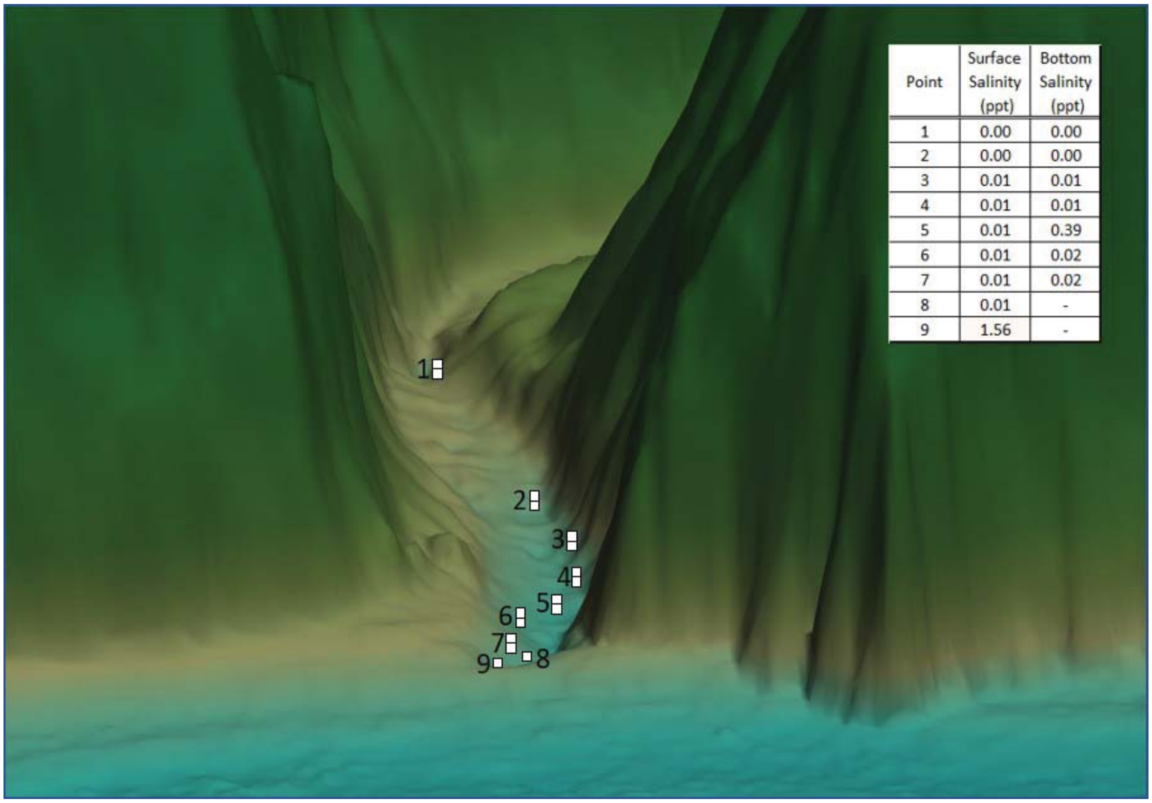
Point	Surface Salinity (ppt)	Bottom Salinity (ppt)
1	0.33	-
2	0.61	-
3	0.38	8.80
4	0.56	10.09
5	1.43	8.29
6	1.42	5.37
7	3.30	-
8	3.41	18.49
9	6.86	19.18
10	8.60	23.97
11	7.99	28.88
12	12.74	27.76
13	31.50	31.68
14	30.92	31.18
15	31.31	31.38
16	31.54	31.61
17	31.01	31.19

Figure 4-1. Honomanu Salinity Winter Sample.



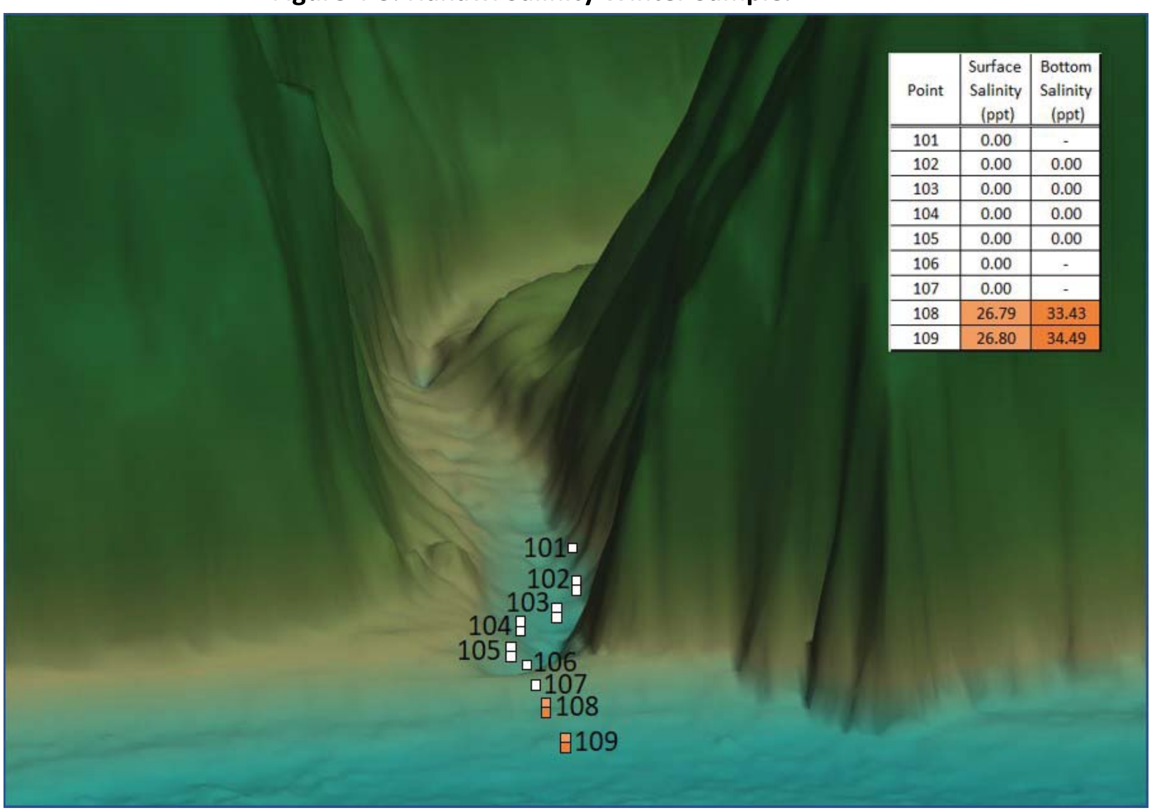
Point	Surface Salinity (ppt)	Bottom Salinity (ppt)
101	0.00	-
102	0.00	0.00
103	0.00	0.00
104	0.00	0.00
105	0.01	-
106	0.01	-
107	0.00	16.14
108	0.58	22.74
109	3.31	24.82
110	4.85	27.37
111	9.82	25.78
112	-	29.25
113	28.26	28.50
114	28.87	30.14
115	28.03	31.30
116	27.52	32.88

Figure 4-2. Honomanu Salinity Summer Sample.



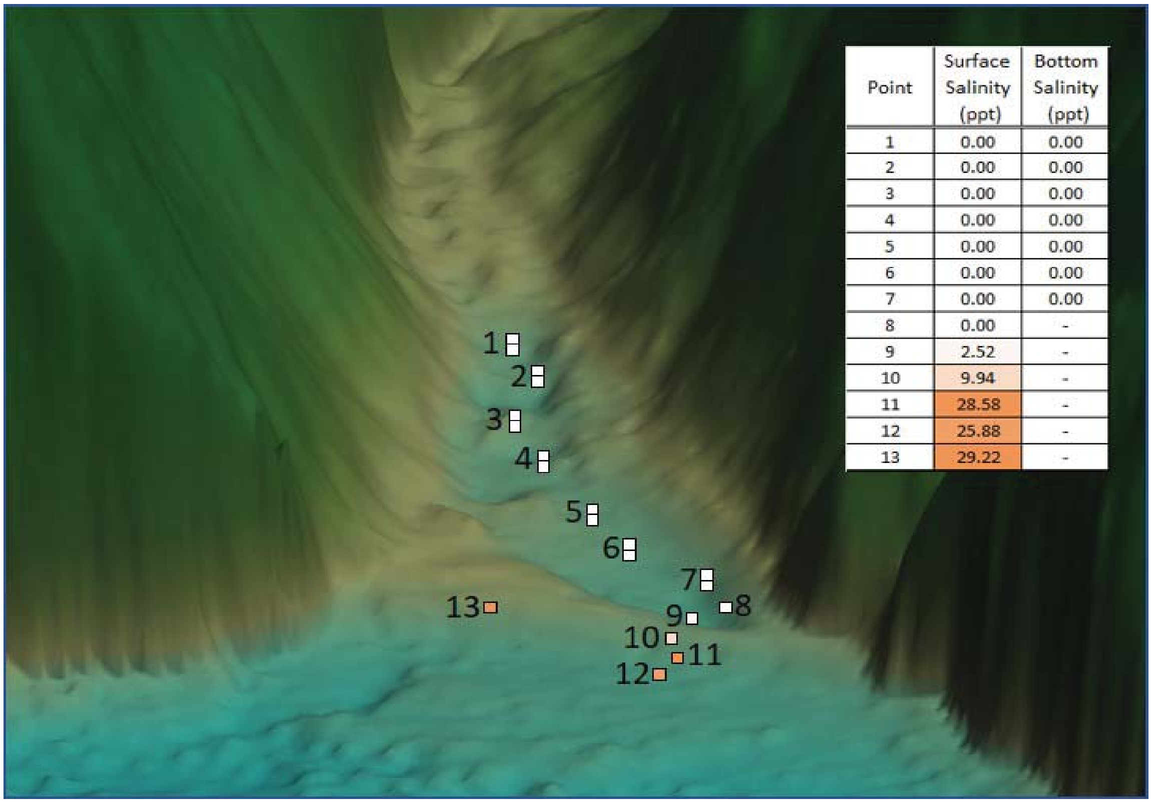
Point	Surface Salinity (ppt)	Bottom Salinity (ppt)
1	0.00	0.00
2	0.00	0.00
3	0.01	0.01
4	0.01	0.01
5	0.01	0.39
6	0.01	0.02
7	0.01	0.02
8	0.01	-
9	1.56	-

Figure 4-3. Hanawi Salinity Winter Sample.



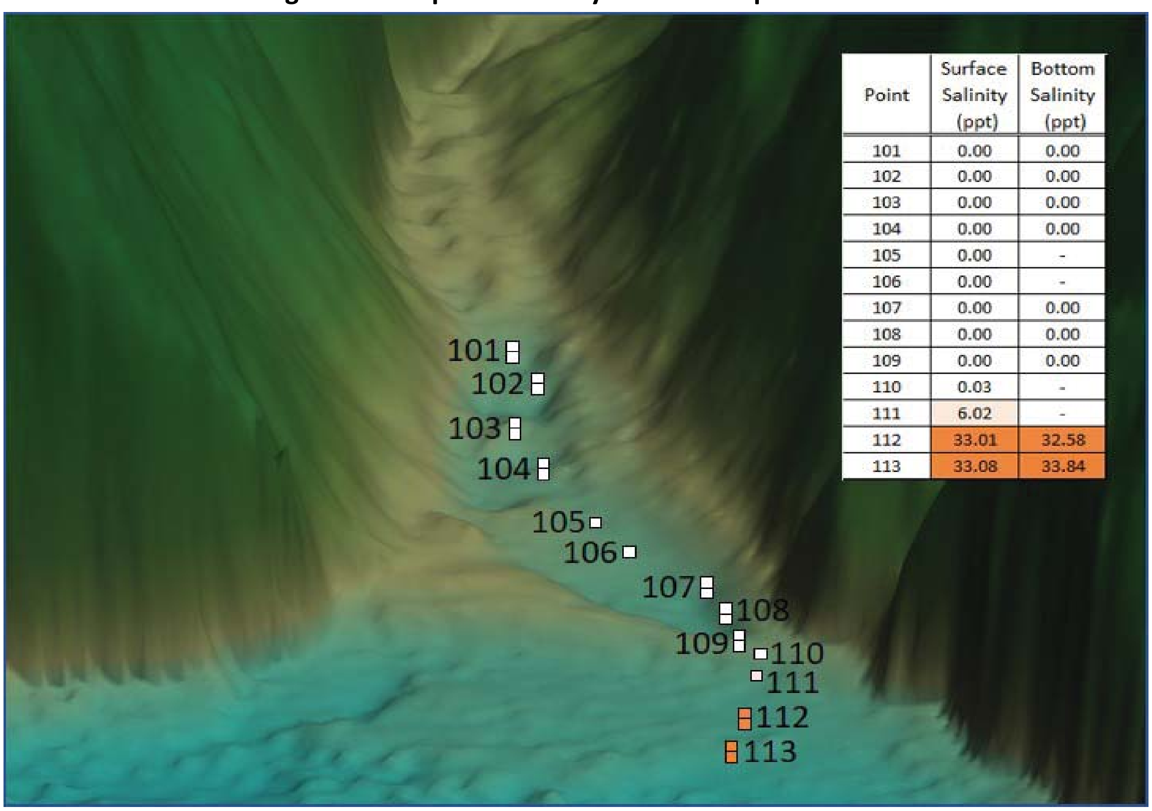
Point	Surface Salinity (ppt)	Bottom Salinity (ppt)
101	0.00	-
102	0.00	0.00
103	0.00	0.00
104	0.00	0.00
105	0.00	0.00
106	0.00	-
107	0.00	-
108	26.79	33.43
109	26.80	34.49

Figure 4-4. Hanawi Salinity Summer Sample.



Point	Surface Salinity (ppt)	Bottom Salinity (ppt)
1	0.00	0.00
2	0.00	0.00
3	0.00	0.00
4	0.00	0.00
5	0.00	0.00
6	0.00	0.00
7	0.00	0.00
8	0.00	-
9	2.52	-
10	9.94	-
11	28.58	-
12	25.88	-
13	29.22	-

Figure 4-5. Kopiliula Salinity Winter Sample.



Point	Surface Salinity (ppt)	Bottom Salinity (ppt)
101	0.00	0.00
102	0.00	0.00
103	0.00	0.00
104	0.00	0.00
105	0.00	-
106	0.00	-
107	0.00	0.00
108	0.00	0.00
109	0.00	0.00
110	0.03	-
111	6.02	-
112	33.01	32.58
113	33.08	33.84

Figure 4-6. Kopiliula Salinity Summer Sample.

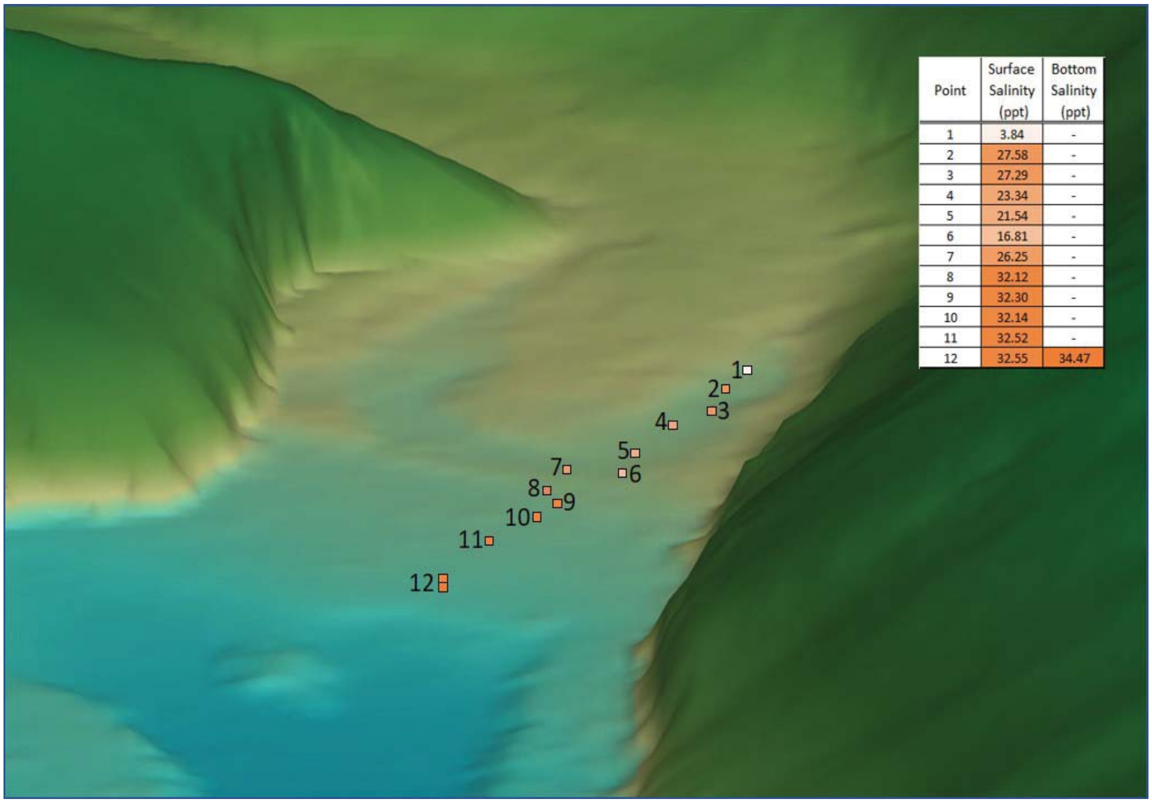


Figure 4-7. Oopuola Salinity Winter Sample.

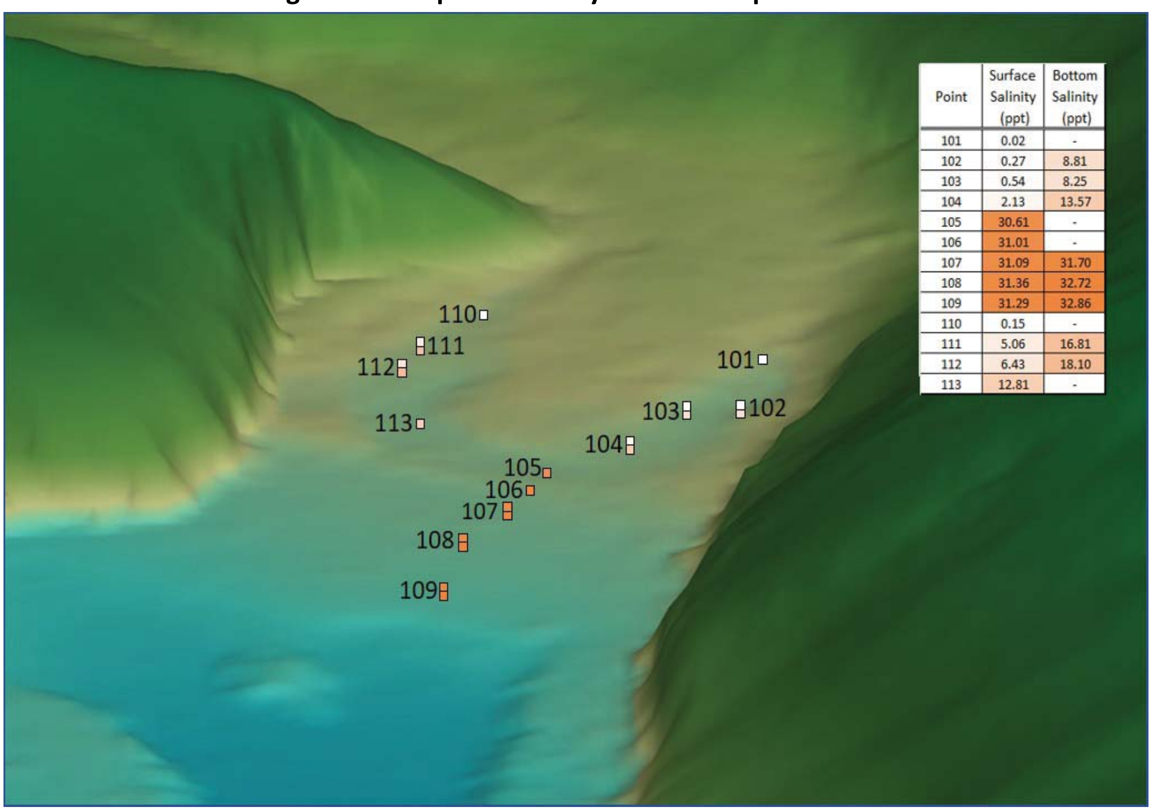
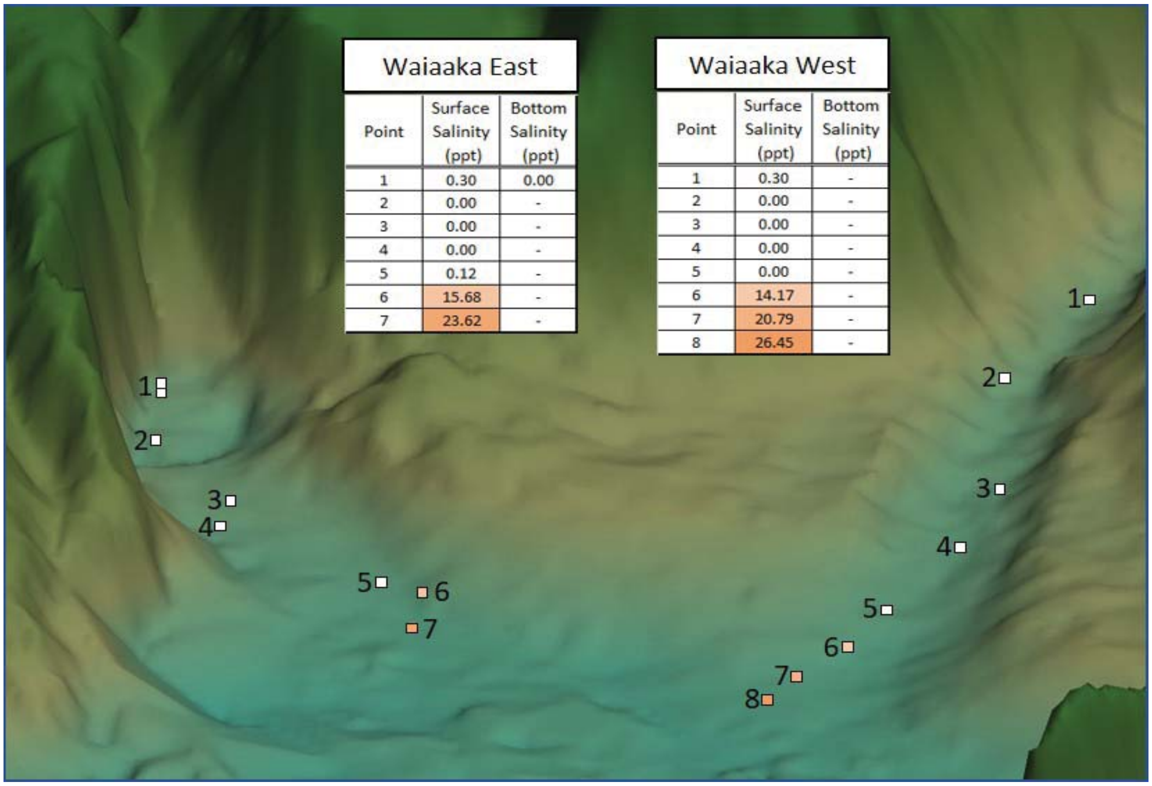


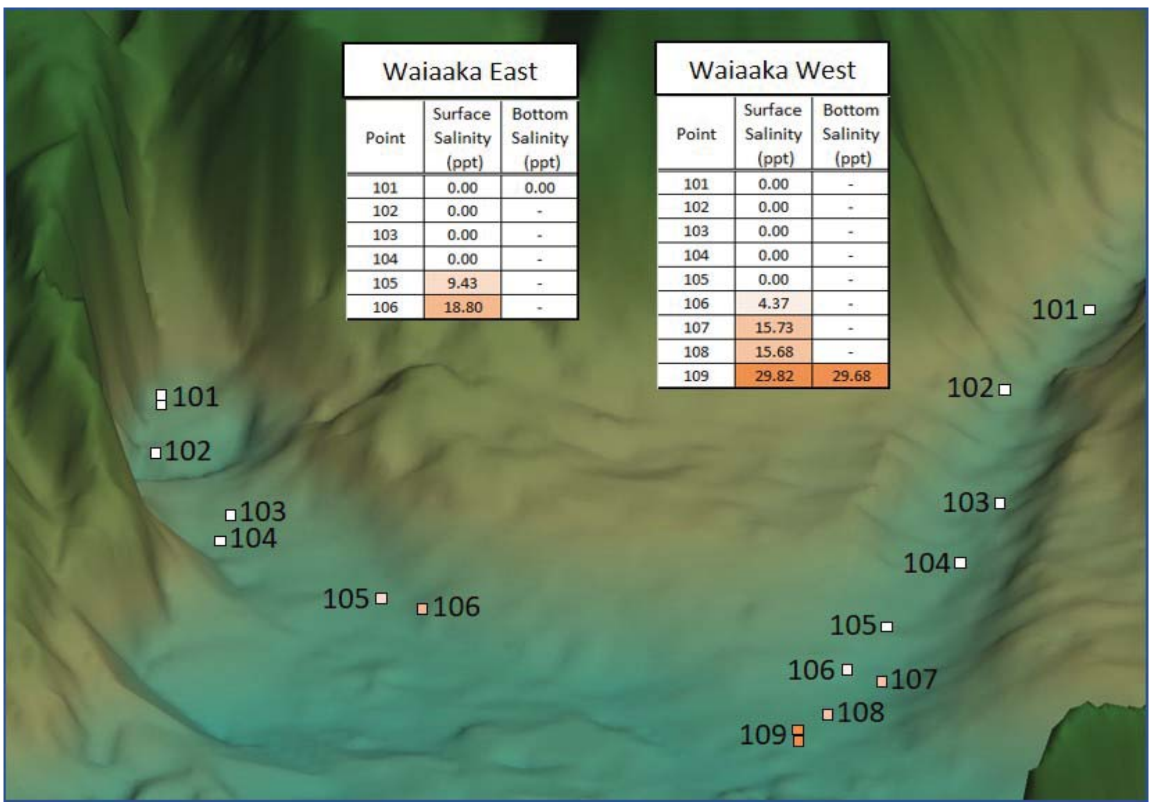
Figure 4-8. Oopuola Salinity Summer Sample.



Waiaaka East		
Point	Surface Salinity (ppt)	Bottom Salinity (ppt)
1	0.30	0.00
2	0.00	-
3	0.00	-
4	0.00	-
5	0.12	-
6	15.68	-
7	23.62	-

Waiaaka West		
Point	Surface Salinity (ppt)	Bottom Salinity (ppt)
1	0.30	-
2	0.00	-
3	0.00	-
4	0.00	-
5	0.00	-
6	14.17	-
7	20.79	-
8	26.45	-

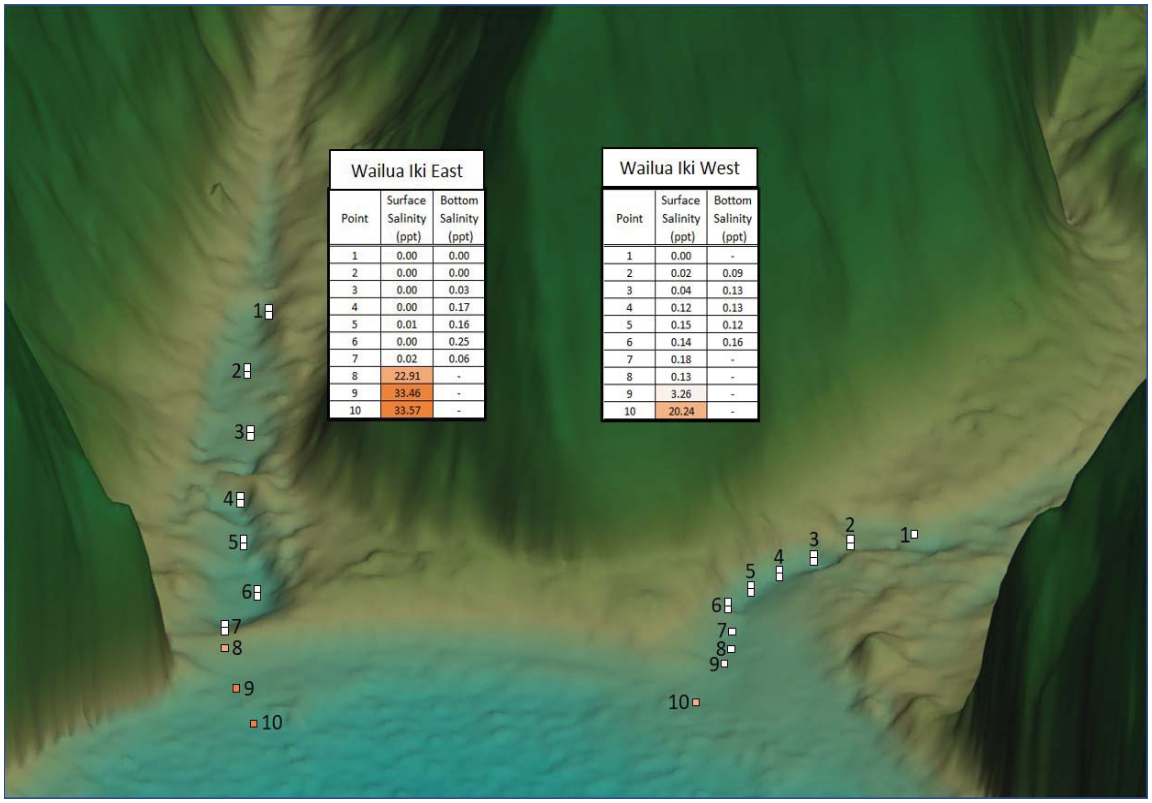
Figure 4-9. Waiaaka Salinity Winter Sample.



Waiaaka East		
Point	Surface Salinity (ppt)	Bottom Salinity (ppt)
101	0.00	0.00
102	0.00	-
103	0.00	-
104	0.00	-
105	9.43	-
106	18.80	-

Waiaaka West		
Point	Surface Salinity (ppt)	Bottom Salinity (ppt)
101	0.00	-
102	0.00	-
103	0.00	-
104	0.00	-
105	0.00	-
106	4.37	-
107	15.73	-
108	15.68	-
109	29.82	29.68

Figure 4-10. Waiaaka Salinity Summer Sample.



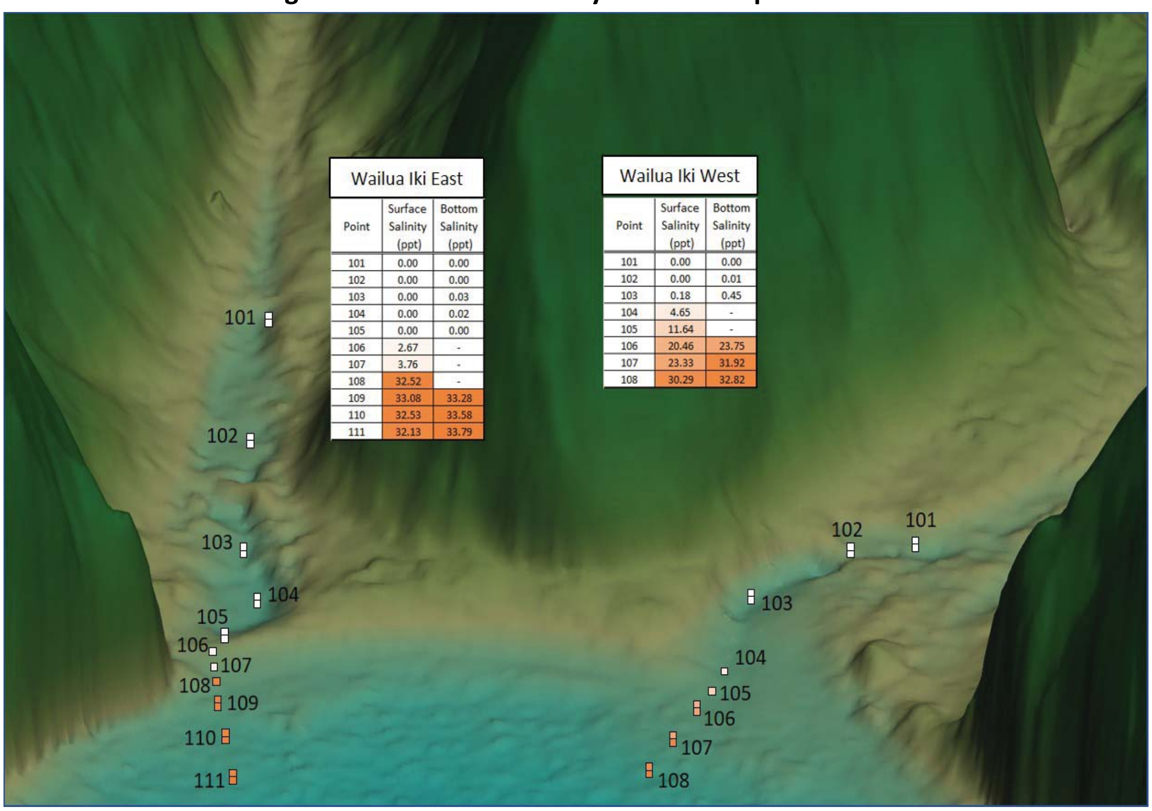
Wailua Iki East

Point	Surface Salinity (ppt)	Bottom Salinity (ppt)
1	0.00	0.00
2	0.00	0.00
3	0.00	0.03
4	0.00	0.17
5	0.01	0.16
6	0.00	0.25
7	0.02	0.06
8	22.91	-
9	33.46	-
10	33.57	-

Wailua Iki West

Point	Surface Salinity (ppt)	Bottom Salinity (ppt)
1	0.00	-
2	0.02	0.09
3	0.04	0.13
4	0.12	0.13
5	0.15	0.12
6	0.14	0.16
7	0.18	-
8	0.13	-
9	3.26	-
10	20.24	-

Figure 4-11. Wailua Salinity Winter Sample.



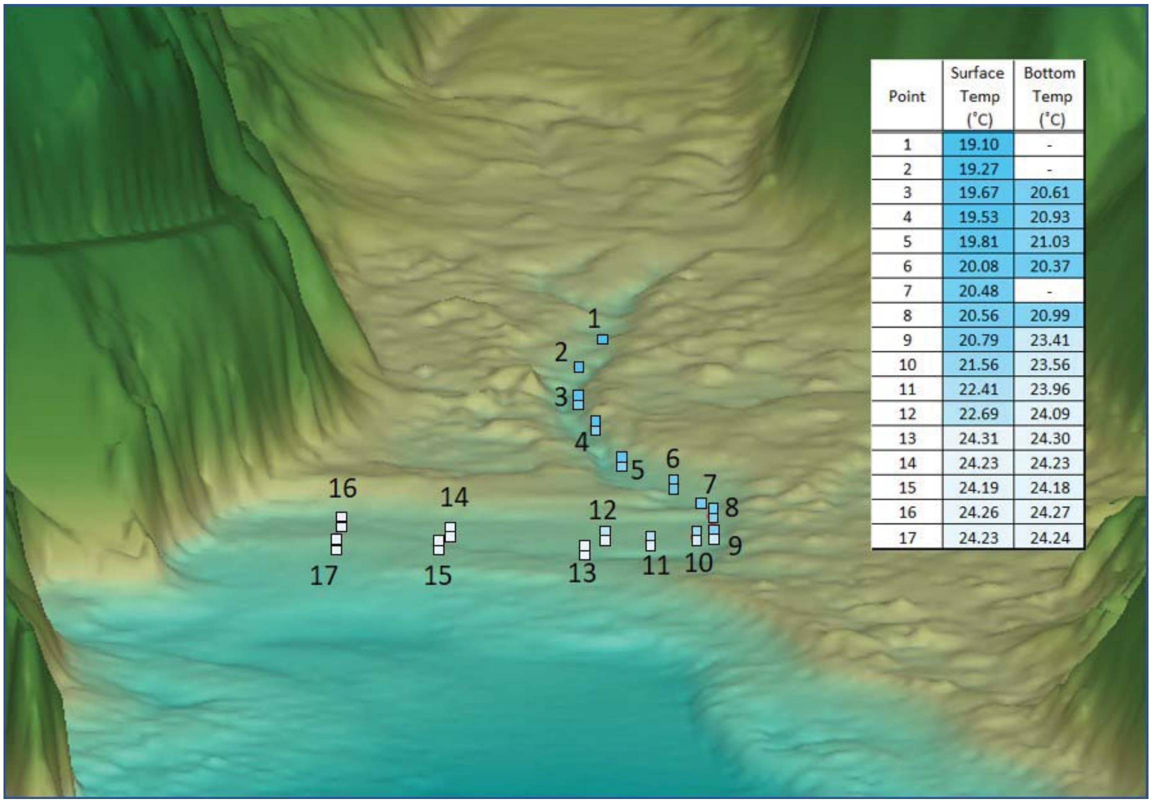
Wailua Iki East

Point	Surface Salinity (ppt)	Bottom Salinity (ppt)
101	0.00	0.00
102	0.00	0.00
103	0.00	0.03
104	0.00	0.02
105	0.00	0.00
106	2.67	-
107	3.76	-
108	32.52	-
109	33.08	33.28
110	32.53	33.58
111	32.13	33.79

Wailua Iki West

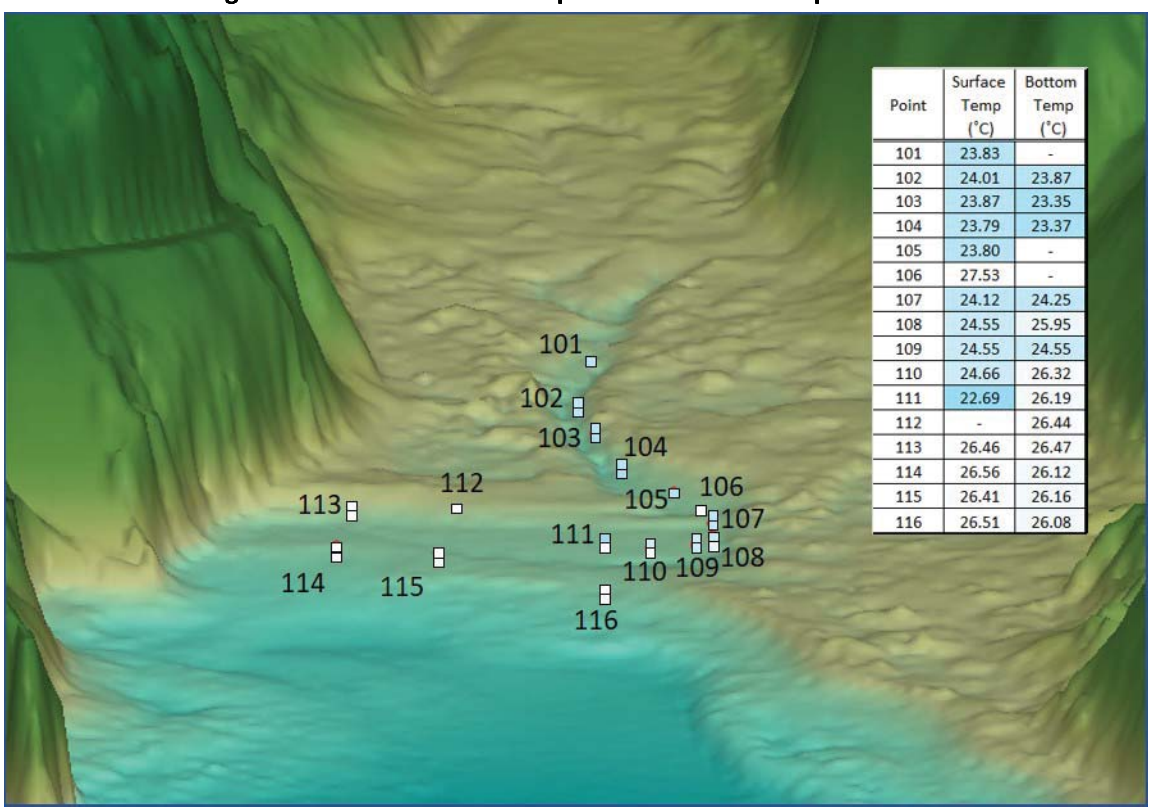
Point	Surface Salinity (ppt)	Bottom Salinity (ppt)
101	0.00	0.00
102	0.00	0.01
103	0.18	0.45
104	4.65	-
105	11.64	-
106	20.46	23.75
107	23.33	31.92
108	30.29	32.82

Figure 4-12. Wailua Salinity Summer Sample.



Point	Surface Temp (°C)	Bottom Temp (°C)
1	19.10	-
2	19.27	-
3	19.67	20.61
4	19.53	20.93
5	19.81	21.03
6	20.08	20.37
7	20.48	-
8	20.56	20.99
9	20.79	23.41
10	21.56	23.56
11	22.41	23.96
12	22.69	24.09
13	24.31	24.30
14	24.23	24.23
15	24.19	24.18
16	24.26	24.27
17	24.23	24.24

Figure 4-13. Honomanu Temperature Winter Sample.



Point	Surface Temp (°C)	Bottom Temp (°C)
101	23.83	-
102	24.01	23.87
103	23.87	23.35
104	23.79	23.37
105	23.80	-
106	27.53	-
107	24.12	24.25
108	24.55	25.95
109	24.55	24.55
110	24.66	26.32
111	22.69	26.19
112	-	26.44
113	26.46	26.47
114	26.56	26.12
115	26.41	26.16
116	26.51	26.08

Figure 4-14. Honomanu Temperature Summer Sample.

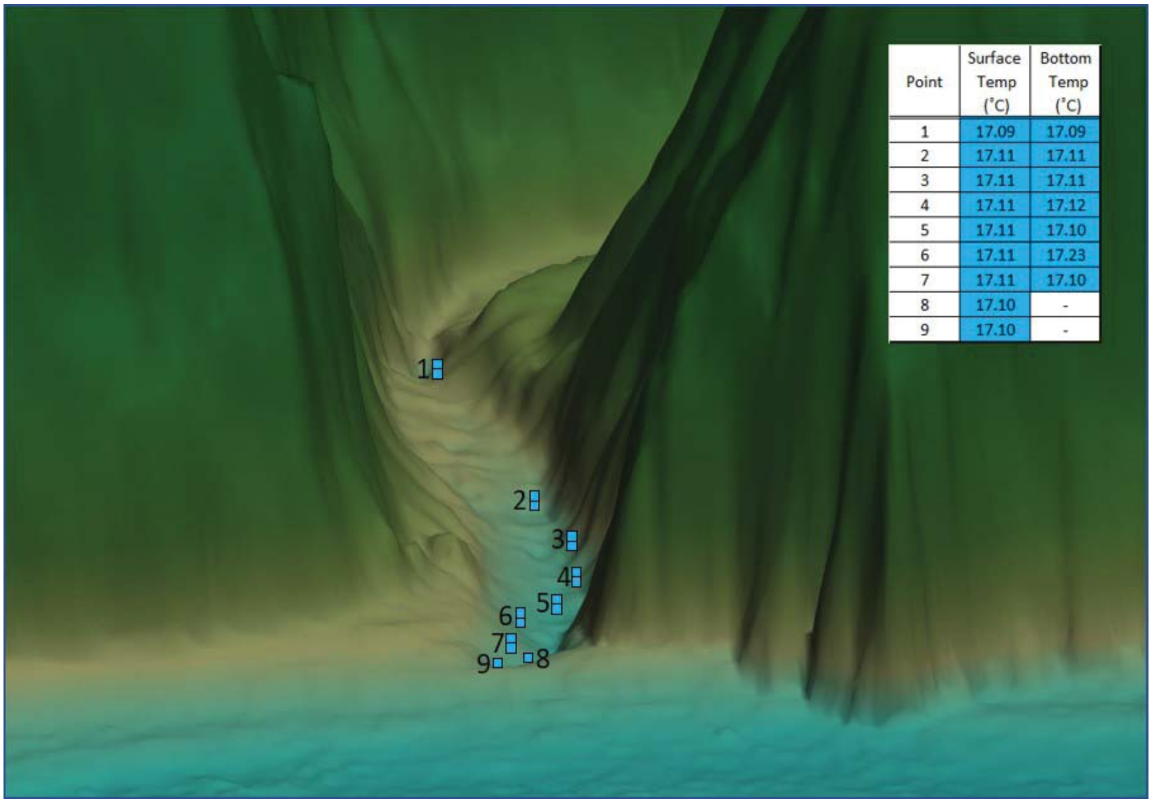


Figure 4-15. Hanawi Temperature Winter Sample.

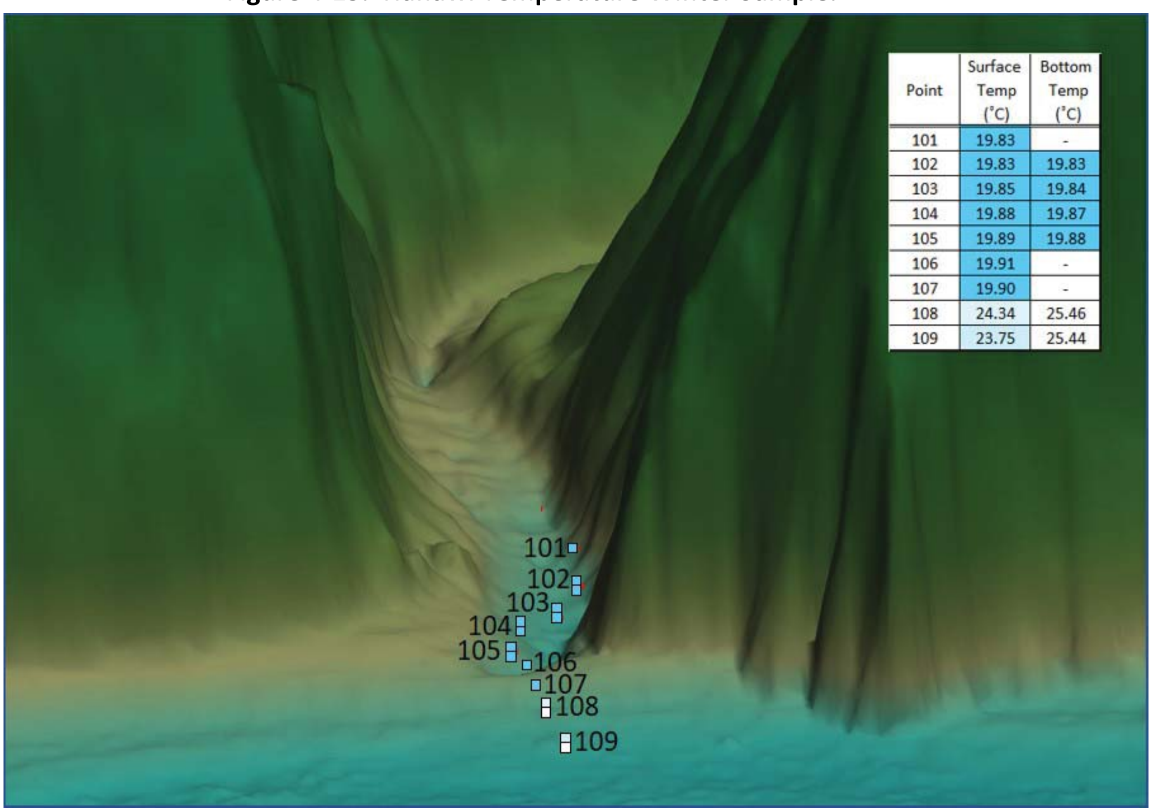
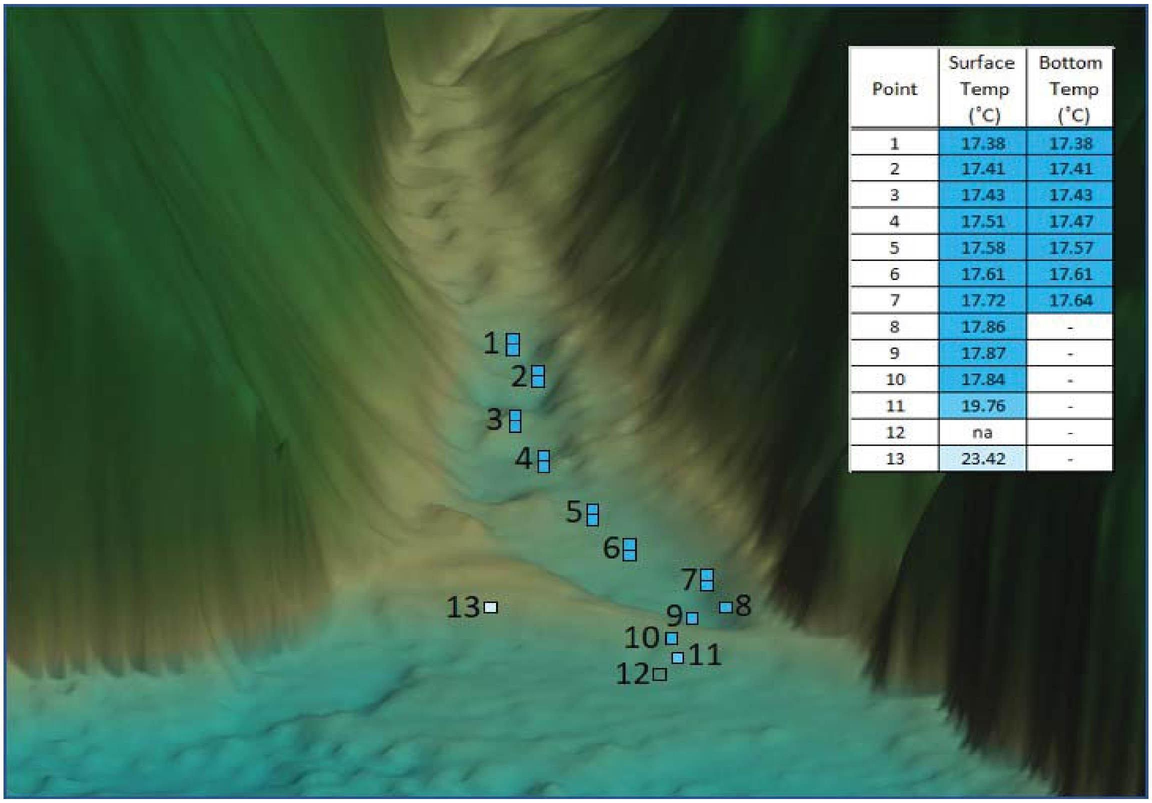
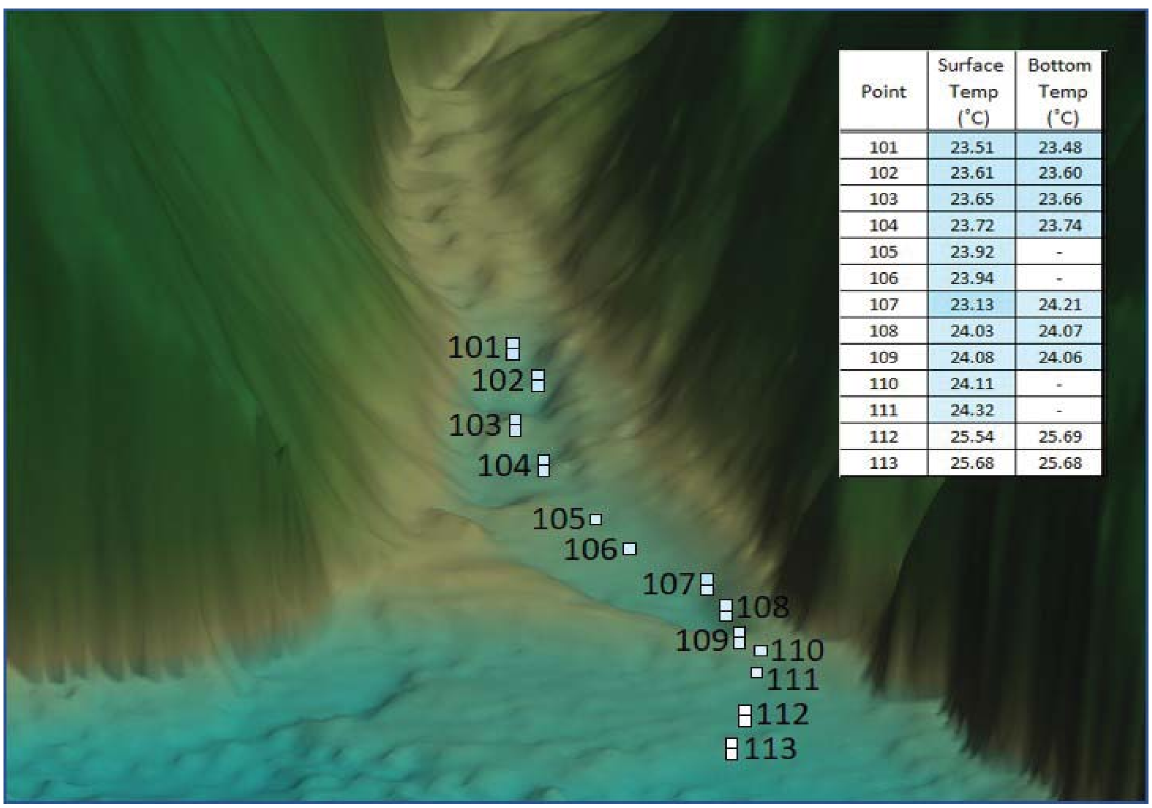


Figure 4-16. Hanawi Temperature Summer Sample.



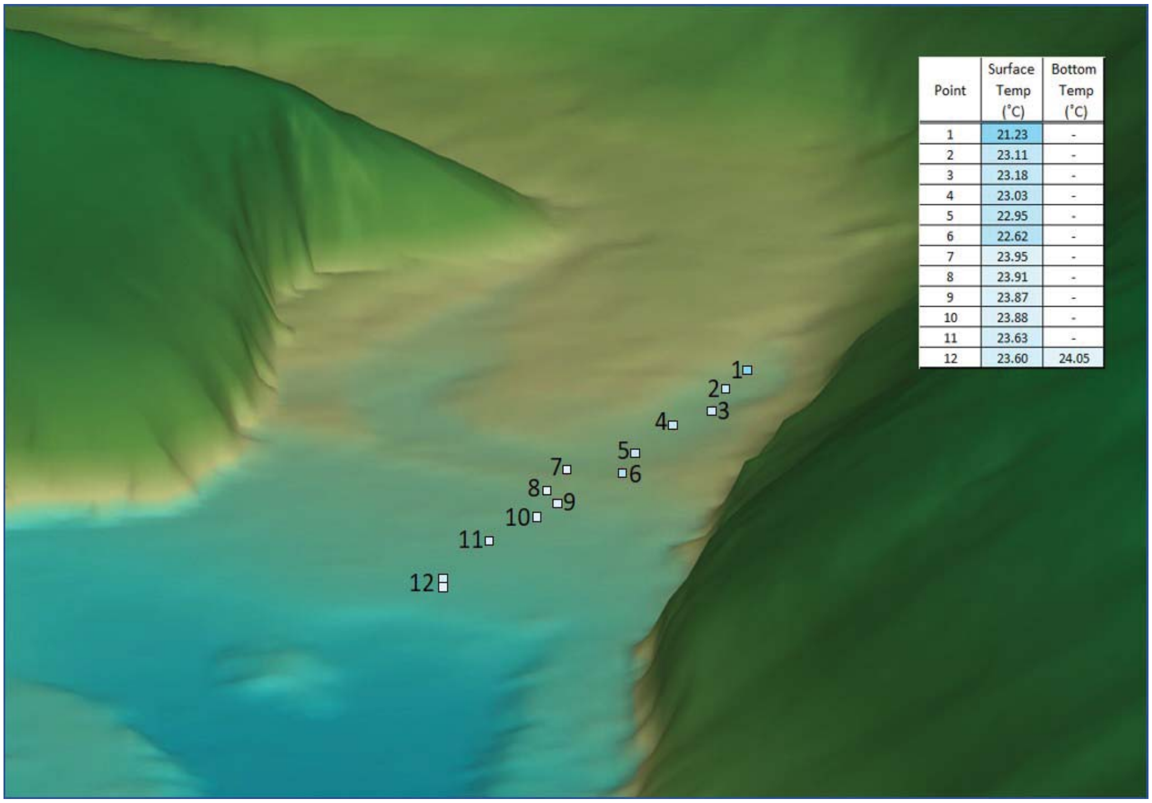
Point	Surface Temp (˚C)	Bottom Temp (˚C)
1	17.38	17.38
2	17.41	17.41
3	17.43	17.43
4	17.51	17.47
5	17.58	17.57
6	17.61	17.61
7	17.72	17.64
8	17.86	-
9	17.87	-
10	17.84	-
11	19.76	-
12	na	-
13	23.42	-

Figure 4-17. Kopiliula Temperature Winter Sample.



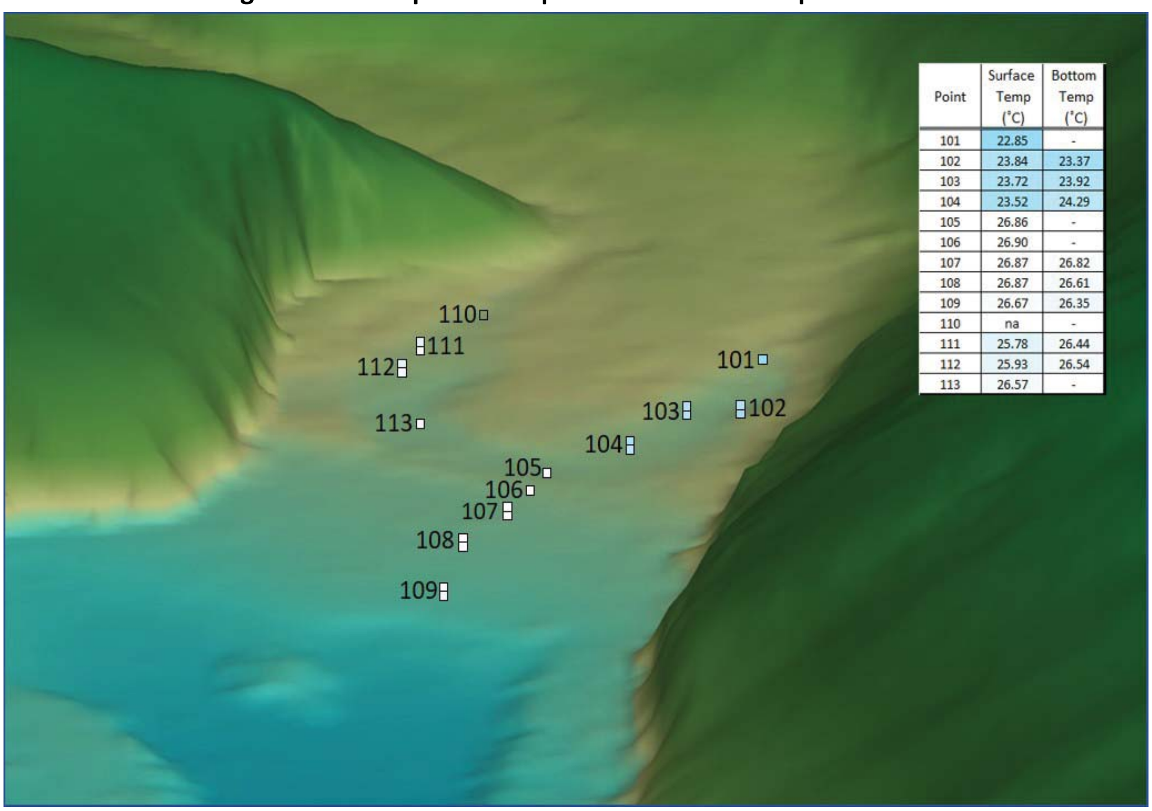
Point	Surface Temp (˚C)	Bottom Temp (˚C)
101	23.51	23.48
102	23.61	23.60
103	23.65	23.66
104	23.72	23.74
105	23.92	-
106	23.94	-
107	23.13	24.21
108	24.03	24.07
109	24.08	24.06
110	24.11	-
111	24.32	-
112	25.54	25.69
113	25.68	25.68

Figure 4-18. Kopiliula Temperature Summer Sample.



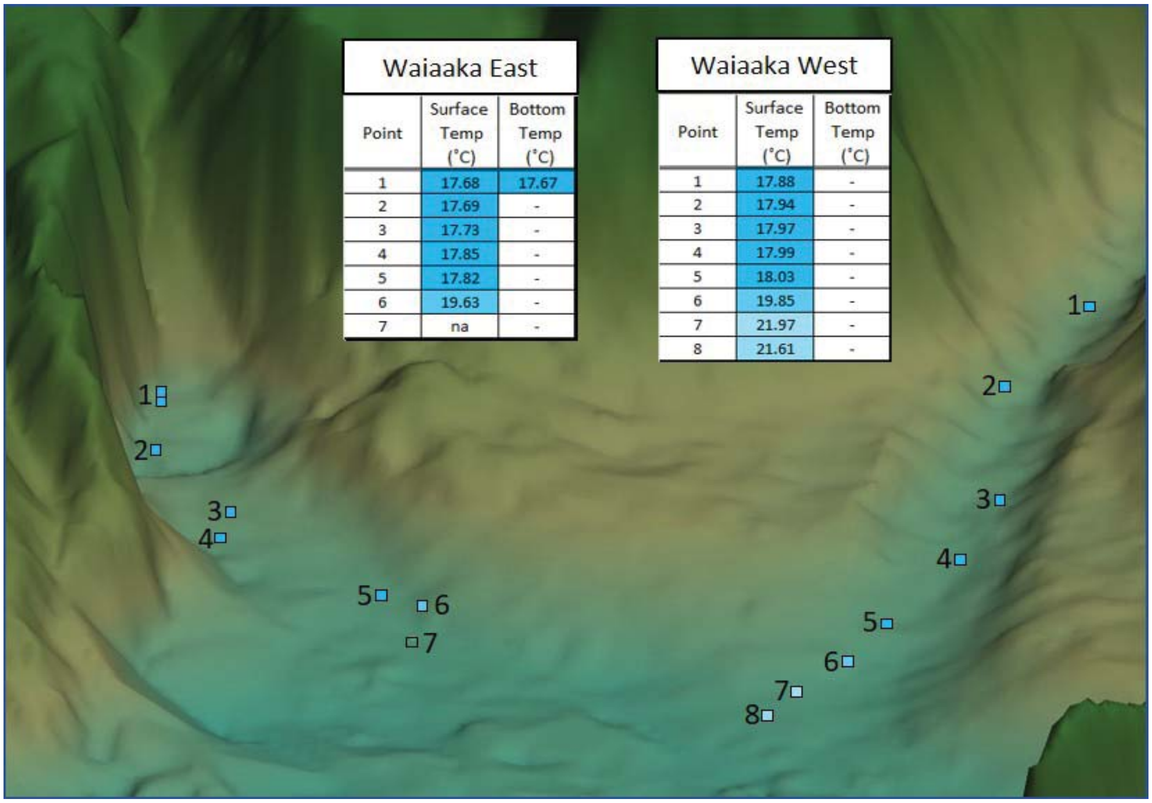
Point	Surface Temp (˚C)	Bottom Temp (˚C)
1	21.23	-
2	23.11	-
3	23.18	-
4	23.03	-
5	22.95	-
6	22.62	-
7	23.95	-
8	23.91	-
9	23.87	-
10	23.88	-
11	23.63	-
12	23.60	24.05

Figure 4-19. Oopuola Temperature Winter Sample.



Point	Surface Temp (˚C)	Bottom Temp (˚C)
101	22.85	-
102	23.84	23.37
103	23.72	23.92
104	23.52	24.29
105	26.86	-
106	26.90	-
107	26.87	26.82
108	26.87	26.61
109	26.67	26.35
110	na	-
111	25.78	26.44
112	25.93	26.54
113	26.57	-

Figure 4-20. Oopuola Temperature Summer Sample.



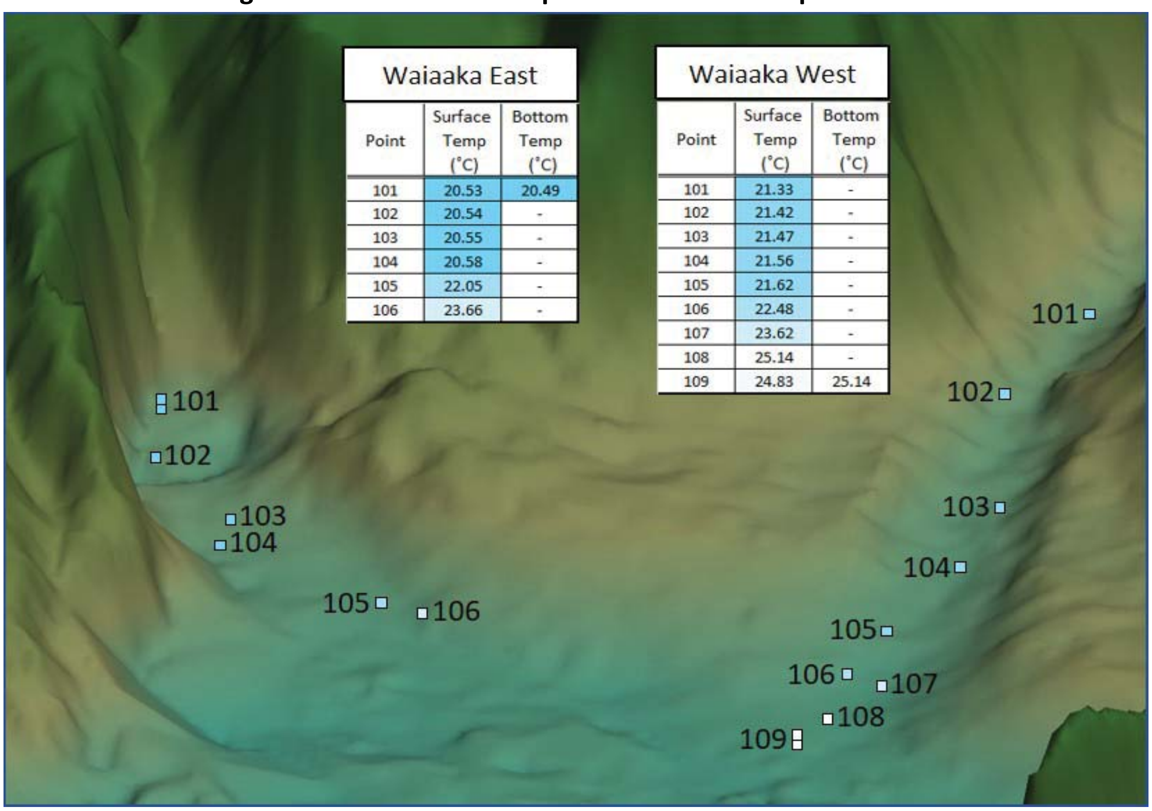
Waiaaka East

Point	Surface Temp (°C)	Bottom Temp (°C)
1	17.68	17.67
2	17.69	-
3	17.73	-
4	17.85	-
5	17.82	-
6	19.63	-
7	na	-

Waiaaka West

Point	Surface Temp (°C)	Bottom Temp (°C)
1	17.88	-
2	17.94	-
3	17.97	-
4	17.99	-
5	18.03	-
6	19.85	-
7	21.97	-
8	21.61	-

Figure 4-21. Waiaaka Temperature Winter Sample.



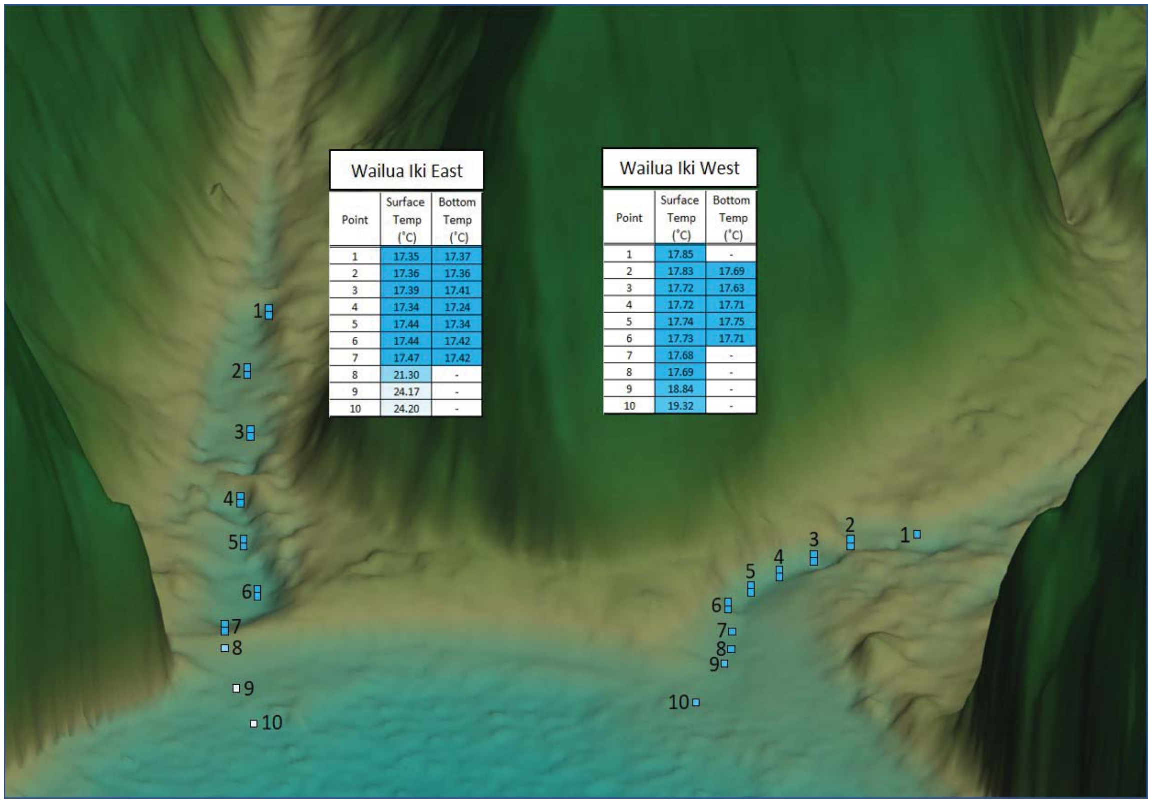
Waiaaka East

Point	Surface Temp (°C)	Bottom Temp (°C)
101	20.53	20.49
102	20.54	-
103	20.55	-
104	20.58	-
105	22.05	-
106	23.66	-

Waiaaka West

Point	Surface Temp (°C)	Bottom Temp (°C)
101	21.33	-
102	21.42	-
103	21.47	-
104	21.56	-
105	21.62	-
106	22.48	-
107	23.62	-
108	25.14	-
109	24.83	25.14

Figure 4-22. Waiaaka Temperature Summer Sample.



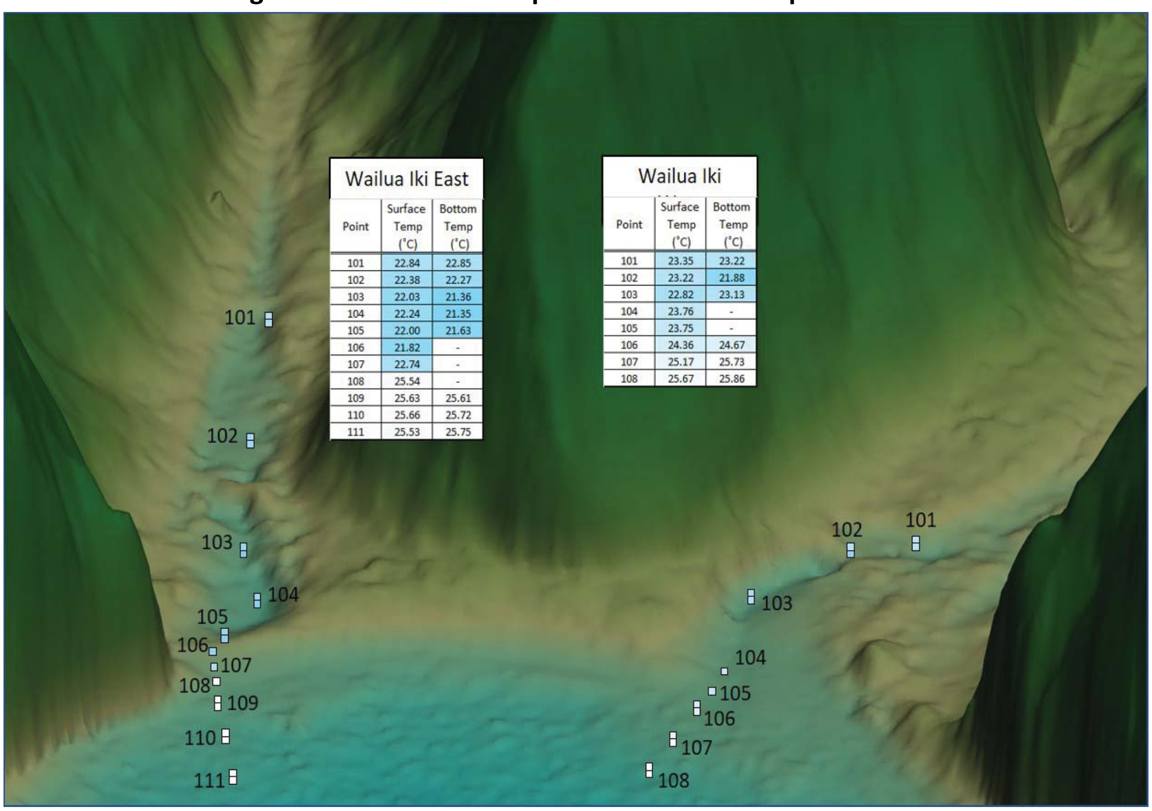
Wailua Iki East

Point	Surface Temp (˚C)	Bottom Temp (˚C)
1	17.35	17.37
2	17.36	17.36
3	17.39	17.41
4	17.34	17.24
5	17.44	17.34
6	17.44	17.42
7	17.47	17.42
8	21.30	-
9	24.17	-
10	24.20	-

Wailua Iki West

Point	Surface Temp (˚C)	Bottom Temp (˚C)
1	17.85	-
2	17.83	17.69
3	17.72	17.63
4	17.72	17.71
5	17.74	17.75
6	17.73	17.71
7	17.68	-
8	17.69	-
9	18.84	-
10	19.32	-

Figure 4-23. Wailua Temperature Winter Sample.



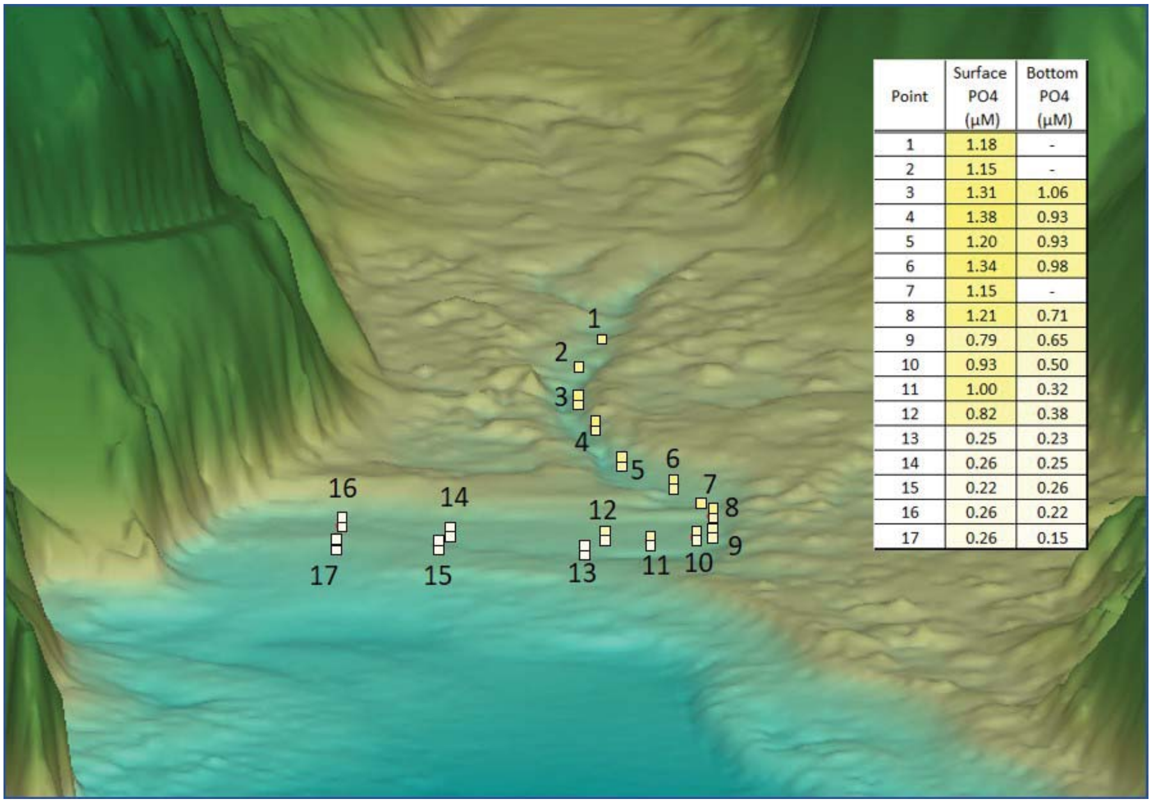
Wailua Iki East

Point	Surface Temp (˚C)	Bottom Temp (˚C)
101	22.84	22.85
102	22.38	22.27
103	22.03	21.36
104	22.24	21.35
105	22.00	21.63
106	21.82	-
107	22.74	-
108	25.54	-
109	25.63	25.61
110	25.66	25.72
111	25.53	25.75

Wailua Iki

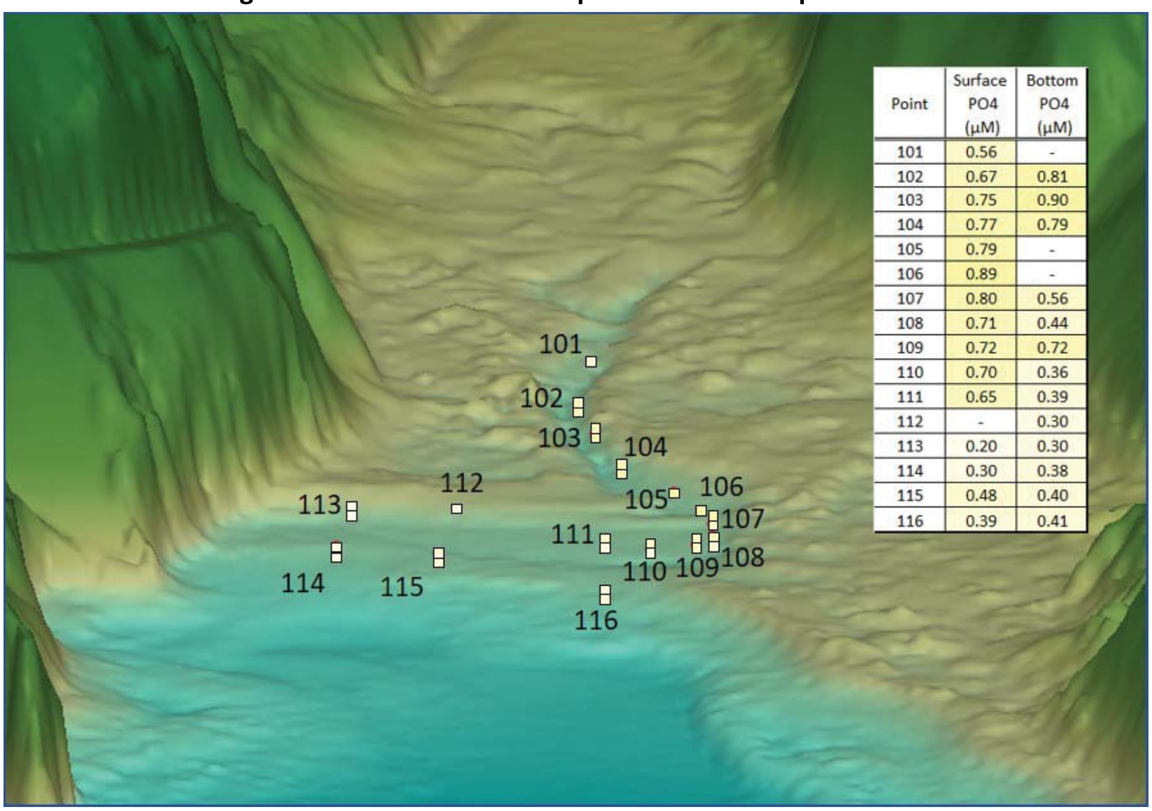
Point	Surface Temp (˚C)	Bottom Temp (˚C)
101	23.35	23.22
102	23.22	21.88
103	22.82	23.13
104	23.76	-
105	23.75	-
106	24.36	24.67
107	25.17	25.73
108	25.67	25.86

Figure 4-24. Wailua Temperature Summer Sample.



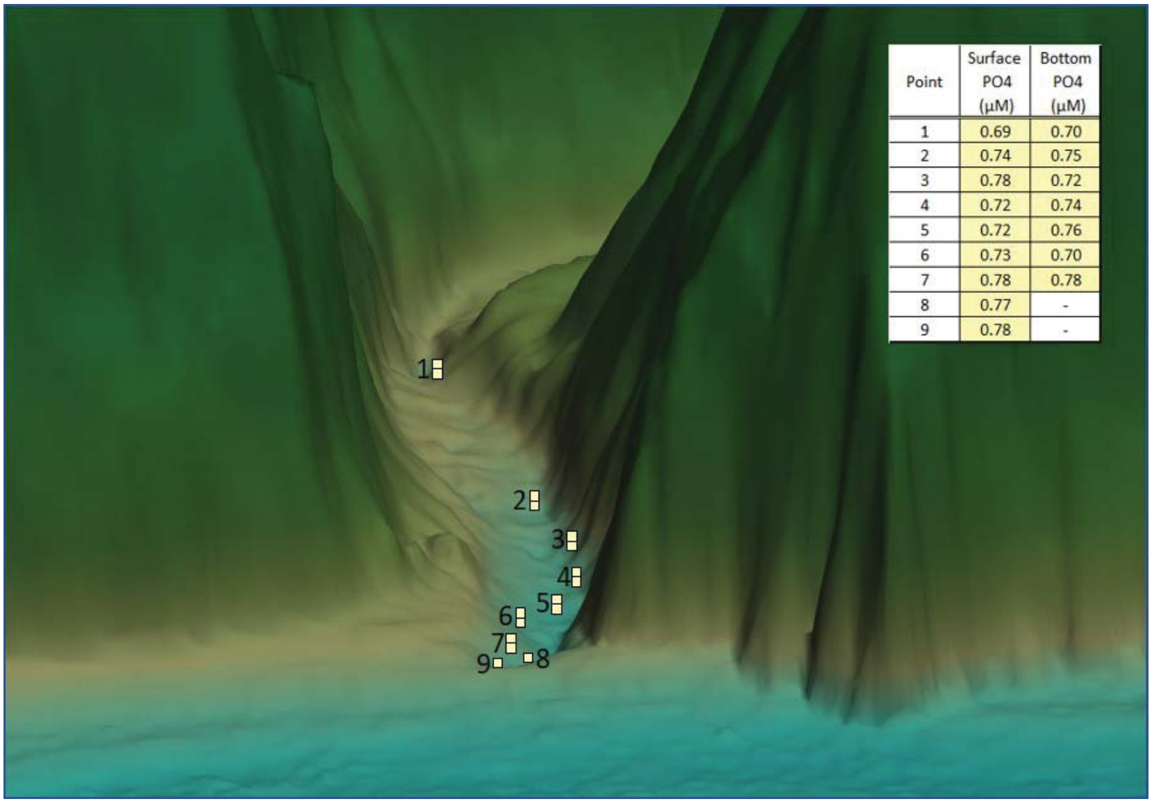
Point	Surface PO4 (µM)	Bottom PO4 (µM)
1	1.18	-
2	1.15	-
3	1.31	1.06
4	1.38	0.93
5	1.20	0.93
6	1.34	0.98
7	1.15	-
8	1.21	0.71
9	0.79	0.65
10	0.93	0.50
11	1.00	0.32
12	0.82	0.38
13	0.25	0.23
14	0.26	0.25
15	0.22	0.26
16	0.26	0.22
17	0.26	0.15

Figure 4-25. Honomanu Phosphate Winter Sample.



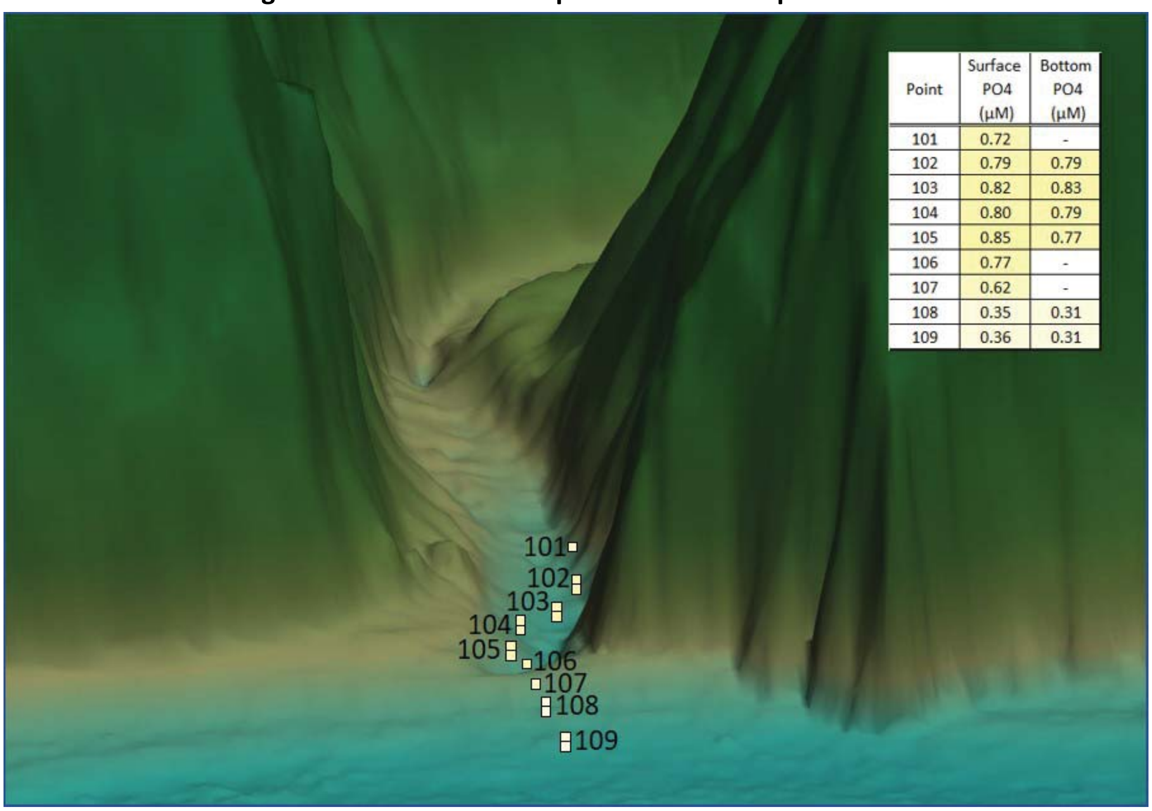
Point	Surface PO4 (µM)	Bottom PO4 (µM)
101	0.56	-
102	0.67	0.81
103	0.75	0.90
104	0.77	0.79
105	0.79	-
106	0.89	-
107	0.80	0.56
108	0.71	0.44
109	0.72	0.72
110	0.70	0.36
111	0.65	0.39
112	-	0.30
113	0.20	0.30
114	0.30	0.38
115	0.48	0.40
116	0.39	0.41

Figure 4-26. Honomanu Phosphate Summer Sample.



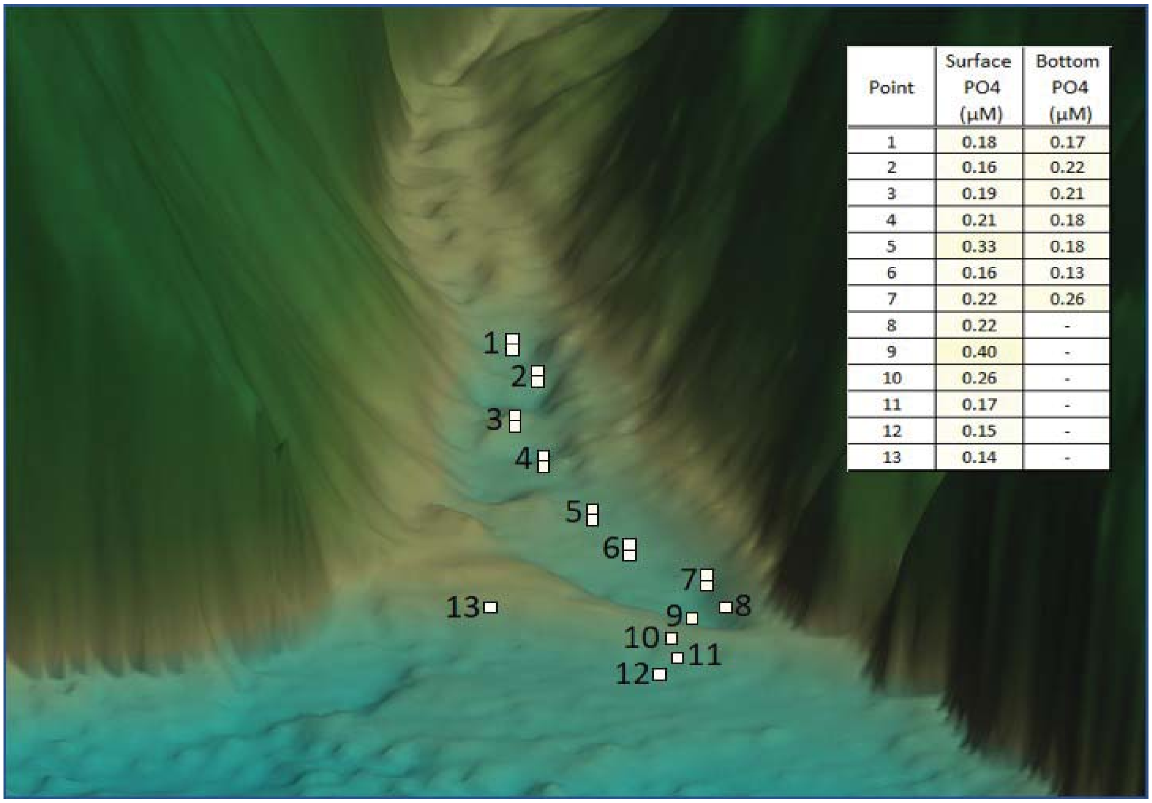
Point	Surface PO4 (µM)	Bottom PO4 (µM)
1	0.69	0.70
2	0.74	0.75
3	0.78	0.72
4	0.72	0.74
5	0.72	0.76
6	0.73	0.70
7	0.78	0.78
8	0.77	-
9	0.78	-

Figure 4-27. Hanawi Phosphate Winter Sample.



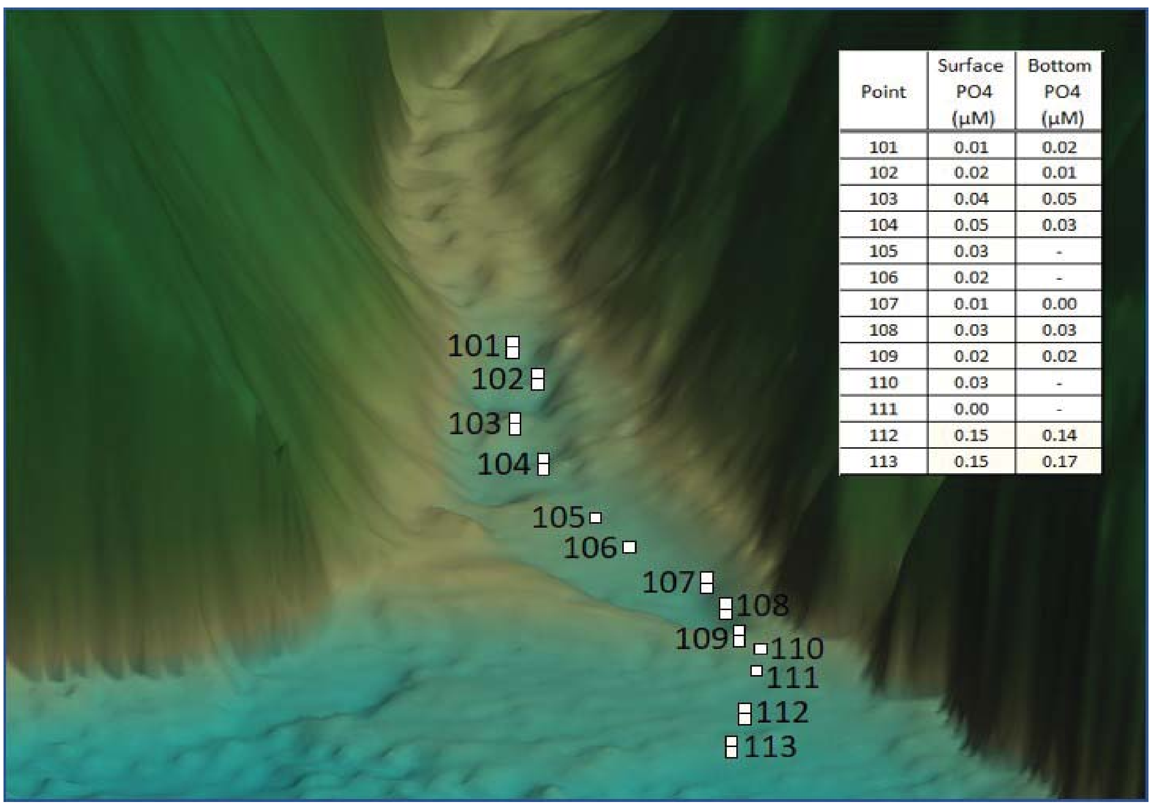
Point	Surface PO4 (µM)	Bottom PO4 (µM)
101	0.72	-
102	0.79	0.79
103	0.82	0.83
104	0.80	0.79
105	0.85	0.77
106	0.77	-
107	0.62	-
108	0.35	0.31
109	0.36	0.31

Figure 4-28. Hanawi Phosphate Summer Sample.



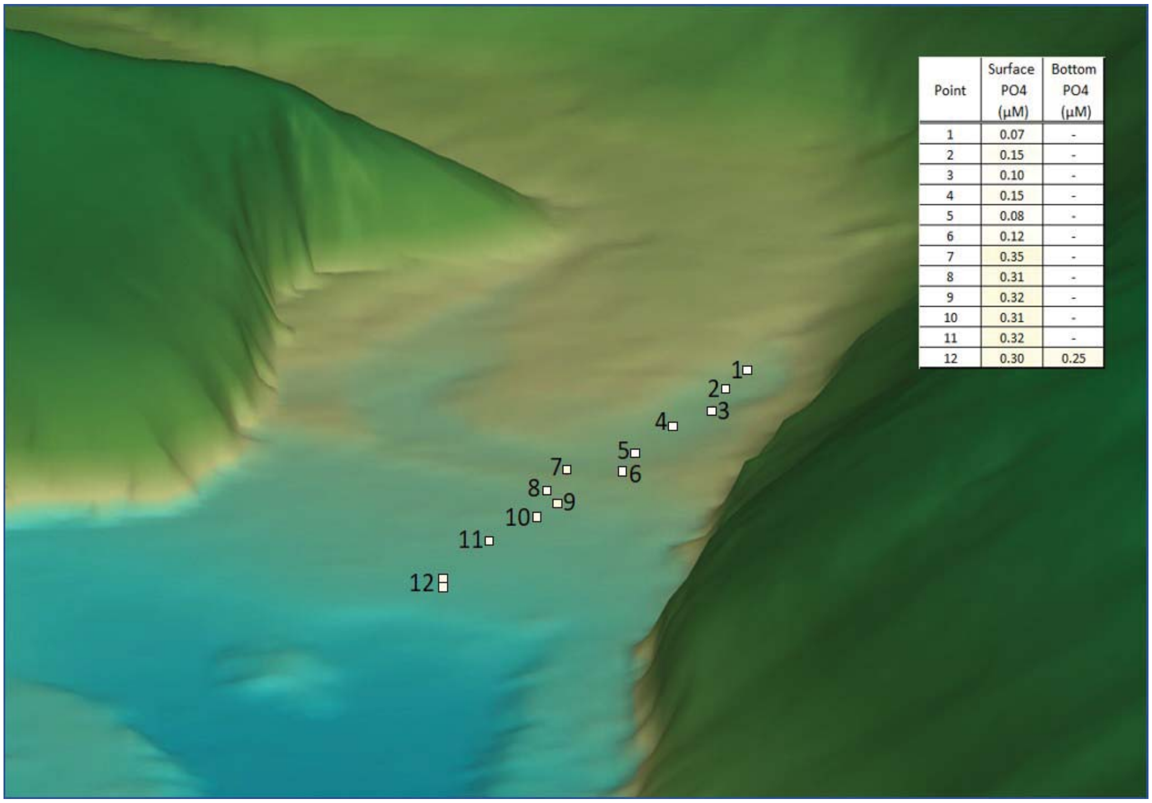
Point	Surface PO4 (µM)	Bottom PO4 (µM)
1	0.18	0.17
2	0.16	0.22
3	0.19	0.21
4	0.21	0.18
5	0.33	0.18
6	0.16	0.13
7	0.22	0.26
8	0.22	-
9	0.40	-
10	0.26	-
11	0.17	-
12	0.15	-
13	0.14	-

Figure 4-29. Kopiliula Phosphate Winter Sample.



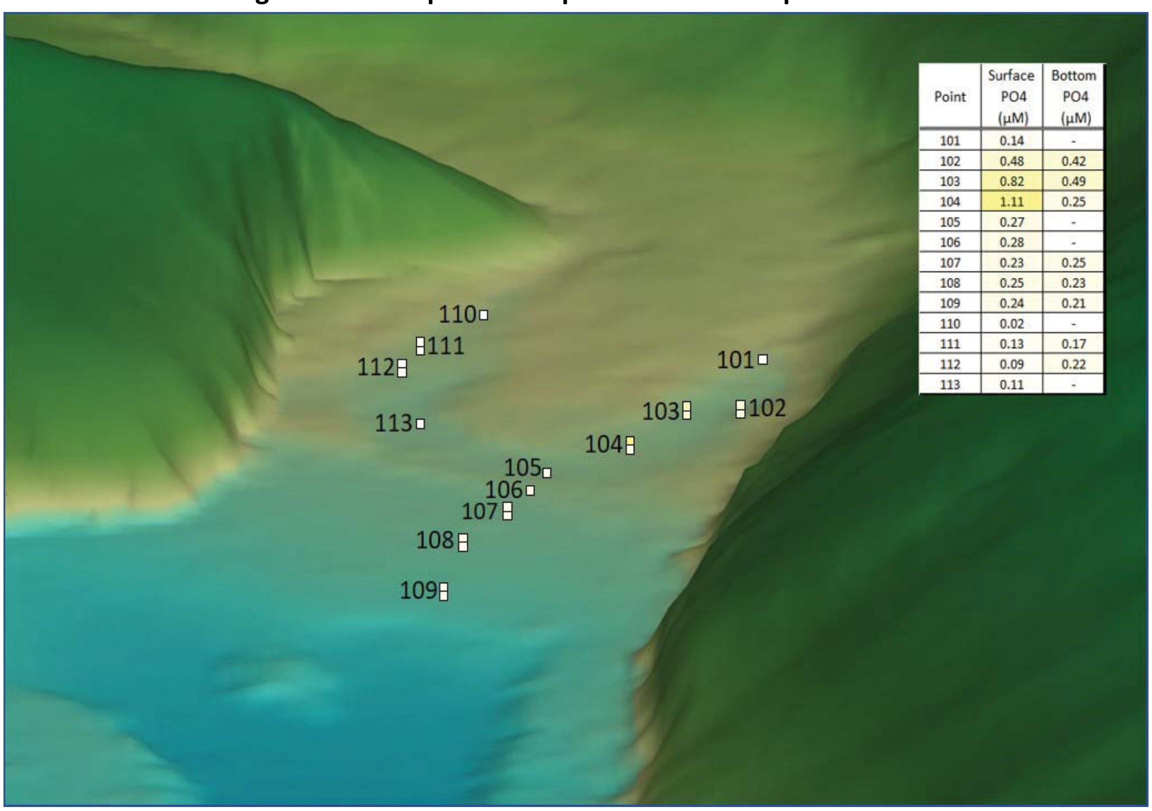
Point	Surface PO4 (µM)	Bottom PO4 (µM)
101	0.01	0.02
102	0.02	0.01
103	0.04	0.05
104	0.05	0.03
105	0.03	-
106	0.02	-
107	0.01	0.00
108	0.03	0.03
109	0.02	0.02
110	0.03	-
111	0.00	-
112	0.15	0.14
113	0.15	0.17

Figure 4-30. Kopiliula Phosphate Summer Sample.



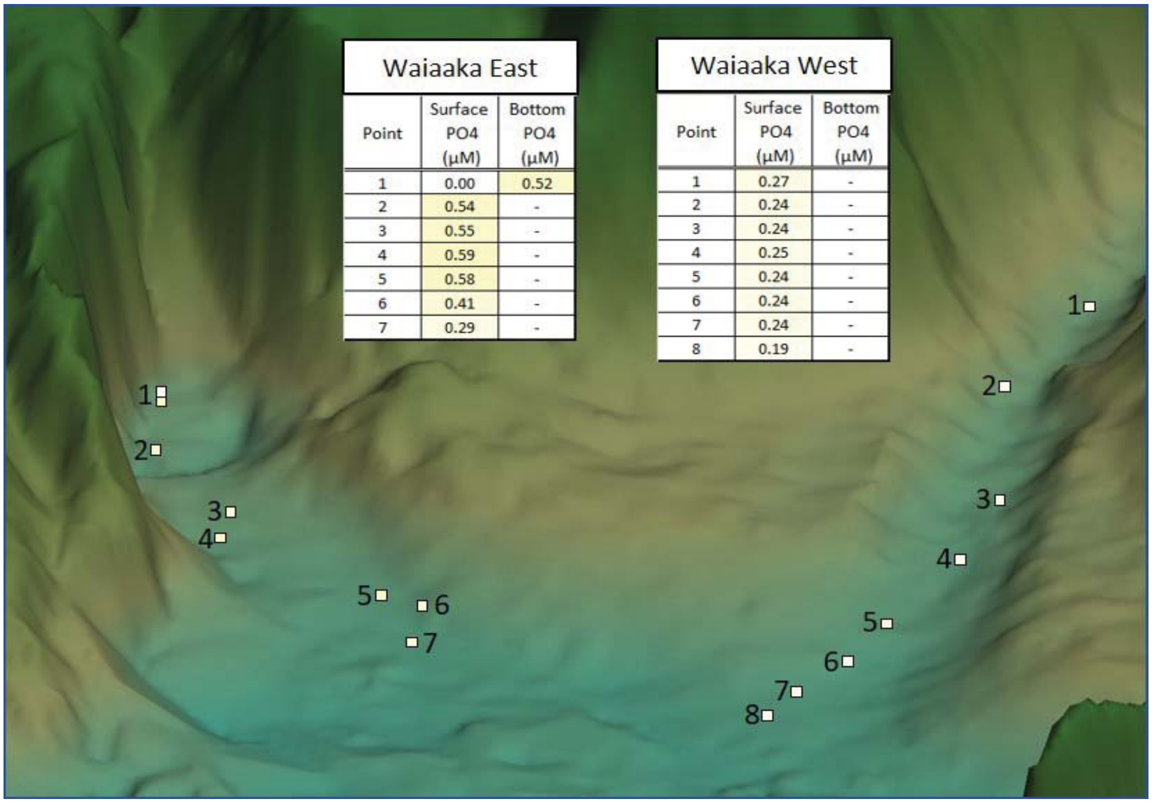
Point	Surface PO4 (µM)	Bottom PO4 (µM)
1	0.07	-
2	0.15	-
3	0.10	-
4	0.15	-
5	0.08	-
6	0.12	-
7	0.35	-
8	0.31	-
9	0.32	-
10	0.31	-
11	0.32	-
12	0.30	0.25

Figure 4-31. Oopuola Phosphate Winter Sample.



Point	Surface PO4 (µM)	Bottom PO4 (µM)
101	0.14	-
102	0.48	0.42
103	0.82	0.49
104	1.11	0.25
105	0.27	-
106	0.28	-
107	0.23	0.25
108	0.25	0.23
109	0.24	0.21
110	0.02	-
111	0.13	0.17
112	0.09	0.22
113	0.11	-

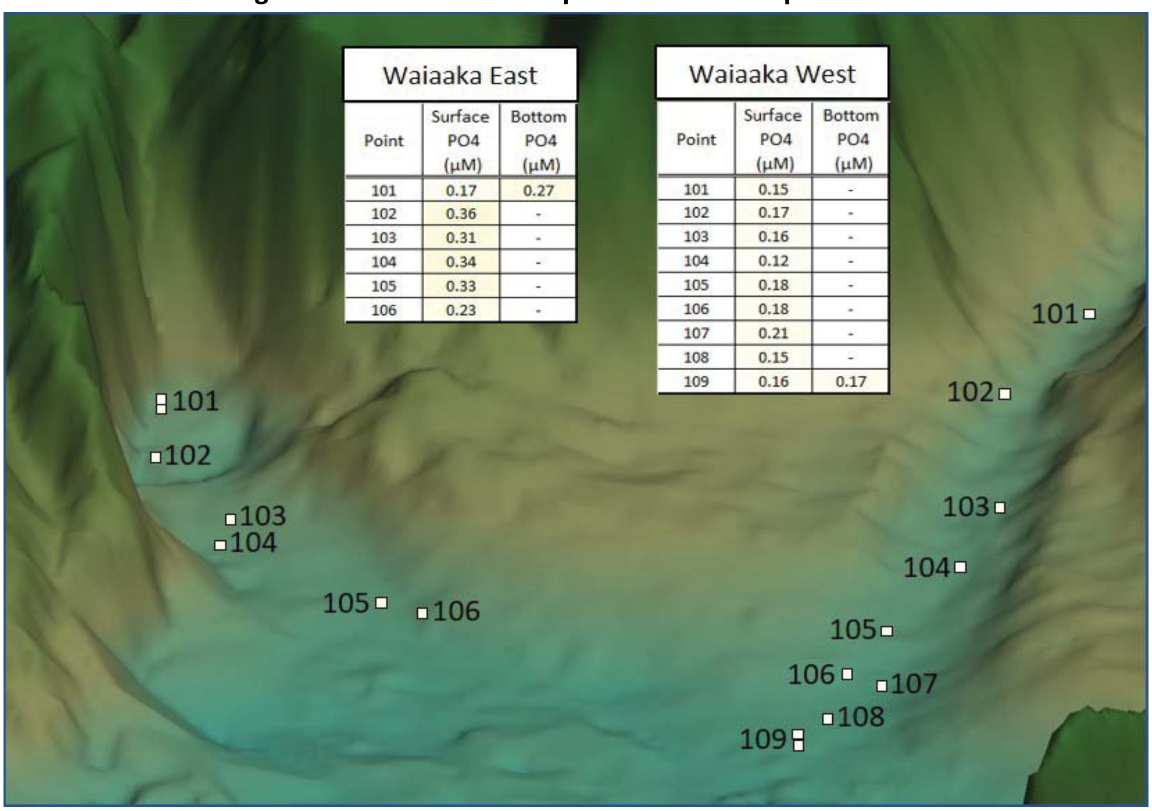
Figure 4-32. Oopuola Phosphate Summer Sample.



Waiaaka East		
Point	Surface PO4 (µM)	Bottom PO4 (µM)
1	0.00	0.52
2	0.54	-
3	0.55	-
4	0.59	-
5	0.58	-
6	0.41	-
7	0.29	-

Waiaaka West		
Point	Surface PO4 (µM)	Bottom PO4 (µM)
1	0.27	-
2	0.24	-
3	0.24	-
4	0.25	-
5	0.24	-
6	0.24	-
7	0.24	-
8	0.19	-

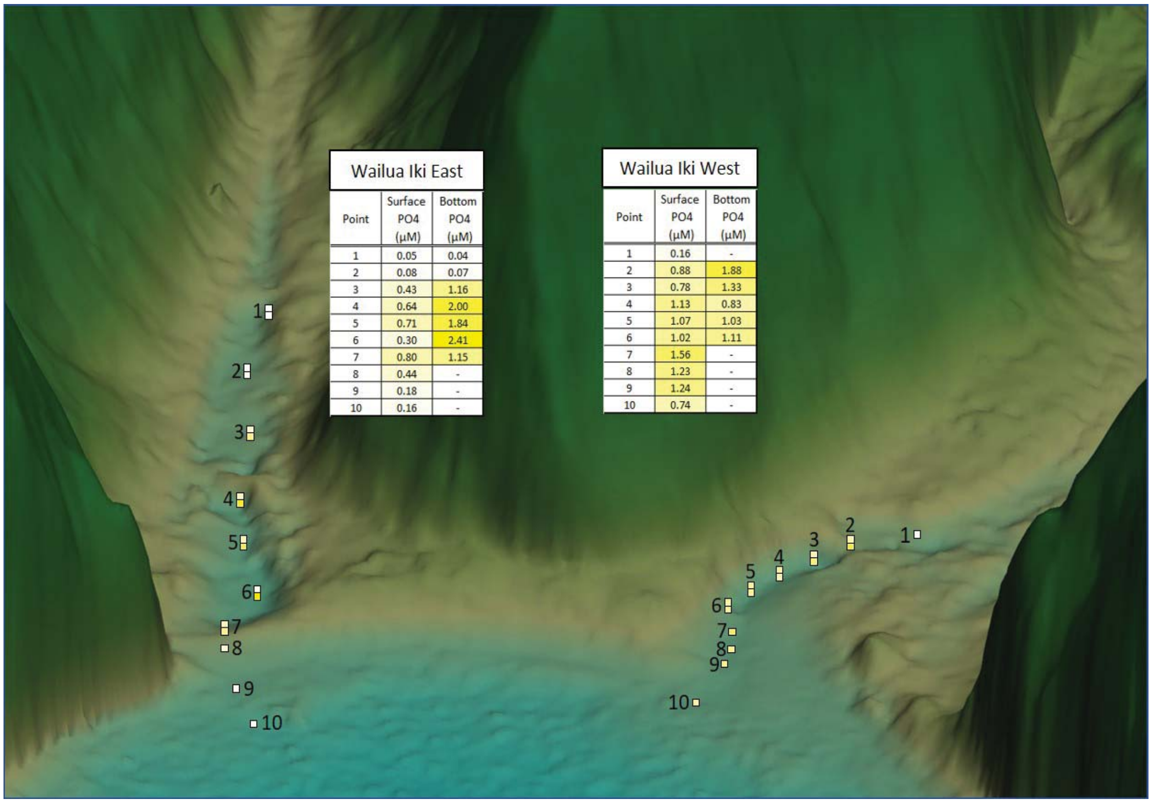
Figure 4-33. Waiaaka Phosphate Winter Sample.



Waiaaka East		
Point	Surface PO4 (µM)	Bottom PO4 (µM)
101	0.17	0.27
102	0.36	-
103	0.31	-
104	0.34	-
105	0.33	-
106	0.23	-

Waiaaka West		
Point	Surface PO4 (µM)	Bottom PO4 (µM)
101	0.15	-
102	0.17	-
103	0.16	-
104	0.12	-
105	0.18	-
106	0.18	-
107	0.21	-
108	0.15	-
109	0.16	0.17

Figure 4-34. Waiaaka Phosphate Summer Sample.



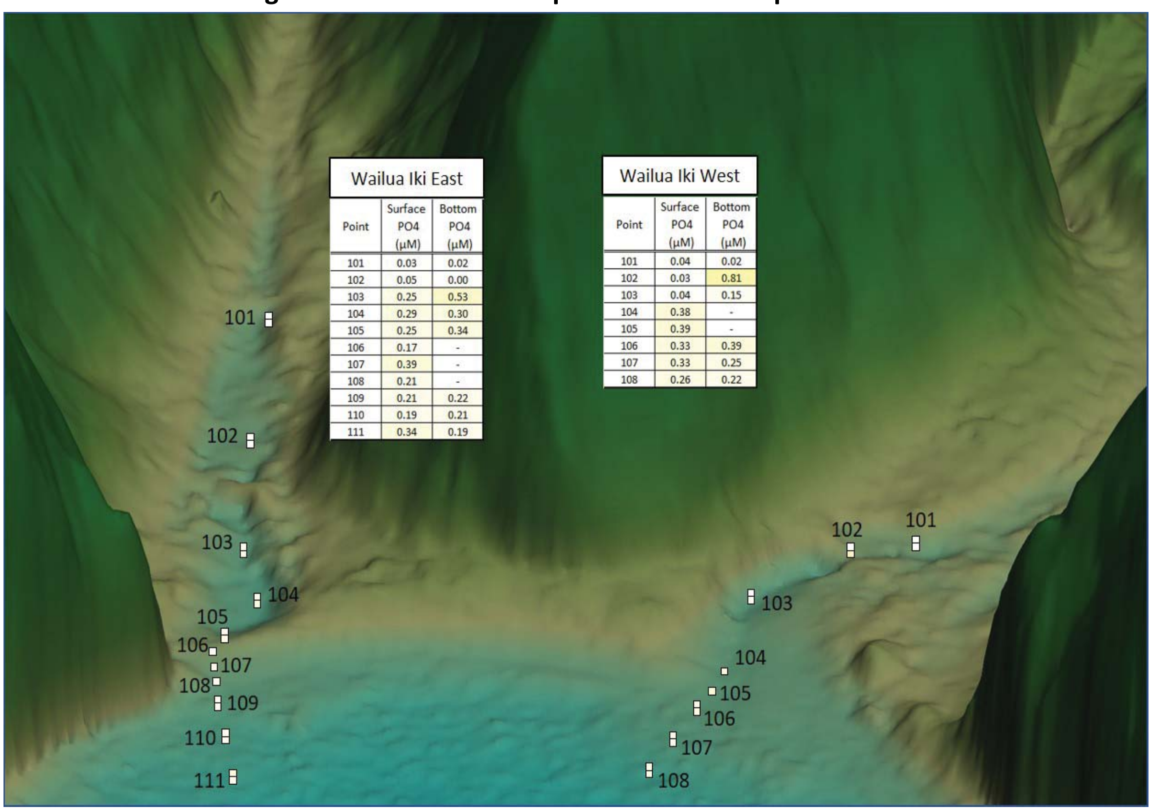
Wailua Iki East

Point	Surface PO4 (µM)	Bottom PO4 (µM)
1	0.05	0.04
2	0.08	0.07
3	0.43	1.16
4	0.64	2.00
5	0.71	1.84
6	0.30	2.41
7	0.80	1.15
8	0.44	-
9	0.18	-
10	0.16	-

Wailua Iki West

Point	Surface PO4 (µM)	Bottom PO4 (µM)
1	0.16	-
2	0.88	1.88
3	0.78	1.33
4	1.13	0.83
5	1.07	1.03
6	1.02	1.11
7	1.56	-
8	1.23	-
9	1.24	-
10	0.74	-

Figure 4-35. Wailua Phosphate Winter Sample.



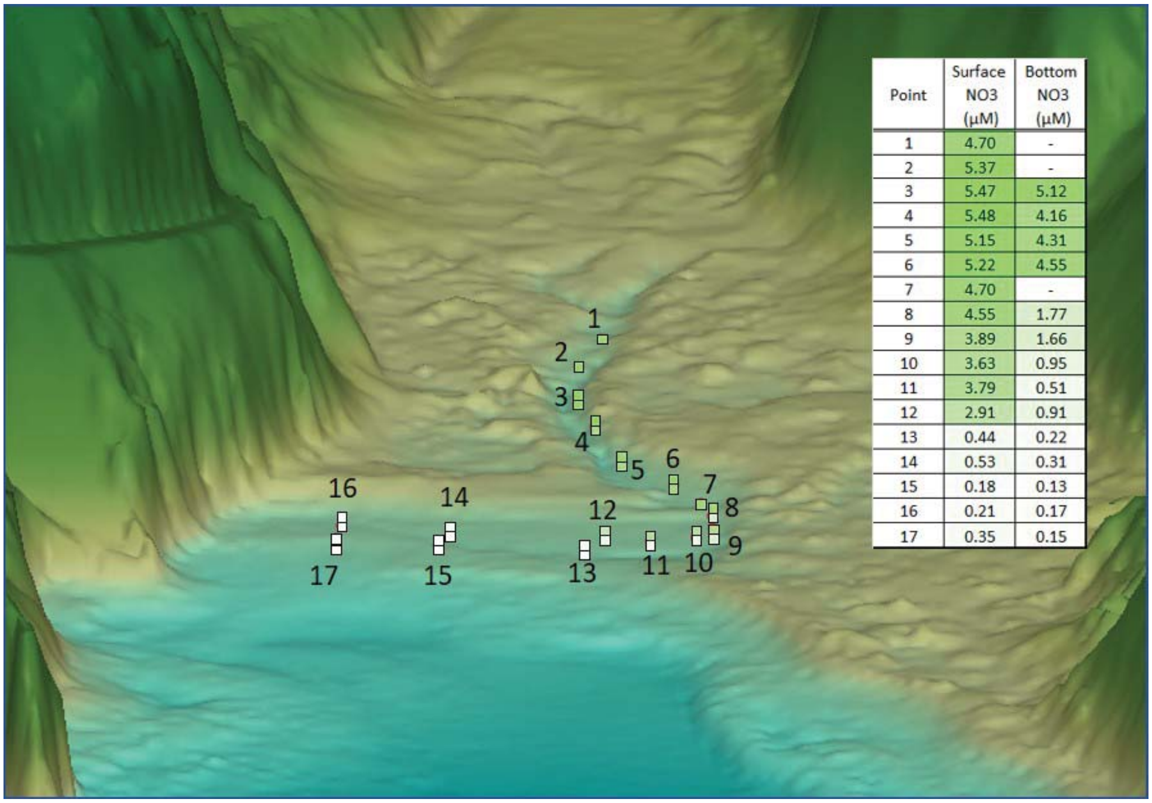
Wailua Iki East

Point	Surface PO4 (µM)	Bottom PO4 (µM)
101	0.03	0.02
102	0.05	0.00
103	0.25	0.53
104	0.29	0.30
105	0.25	0.34
106	0.17	-
107	0.39	-
108	0.21	-
109	0.21	0.22
110	0.19	0.21
111	0.34	0.19

Wailua Iki West

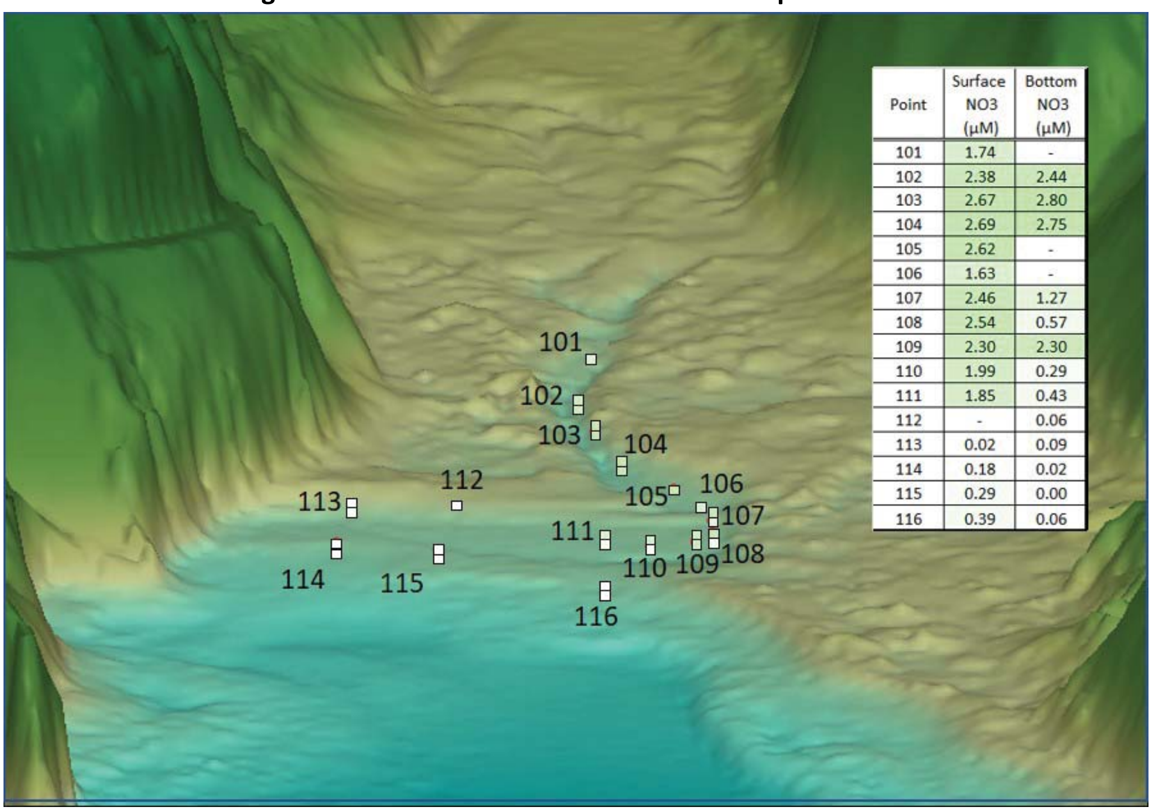
Point	Surface PO4 (µM)	Bottom PO4 (µM)
101	0.04	0.02
102	0.03	0.81
103	0.04	0.15
104	0.38	-
105	0.39	-
106	0.33	0.39
107	0.33	0.25
108	0.26	0.22

Figure 4-36. Wailua Phosphate Summer Sample.



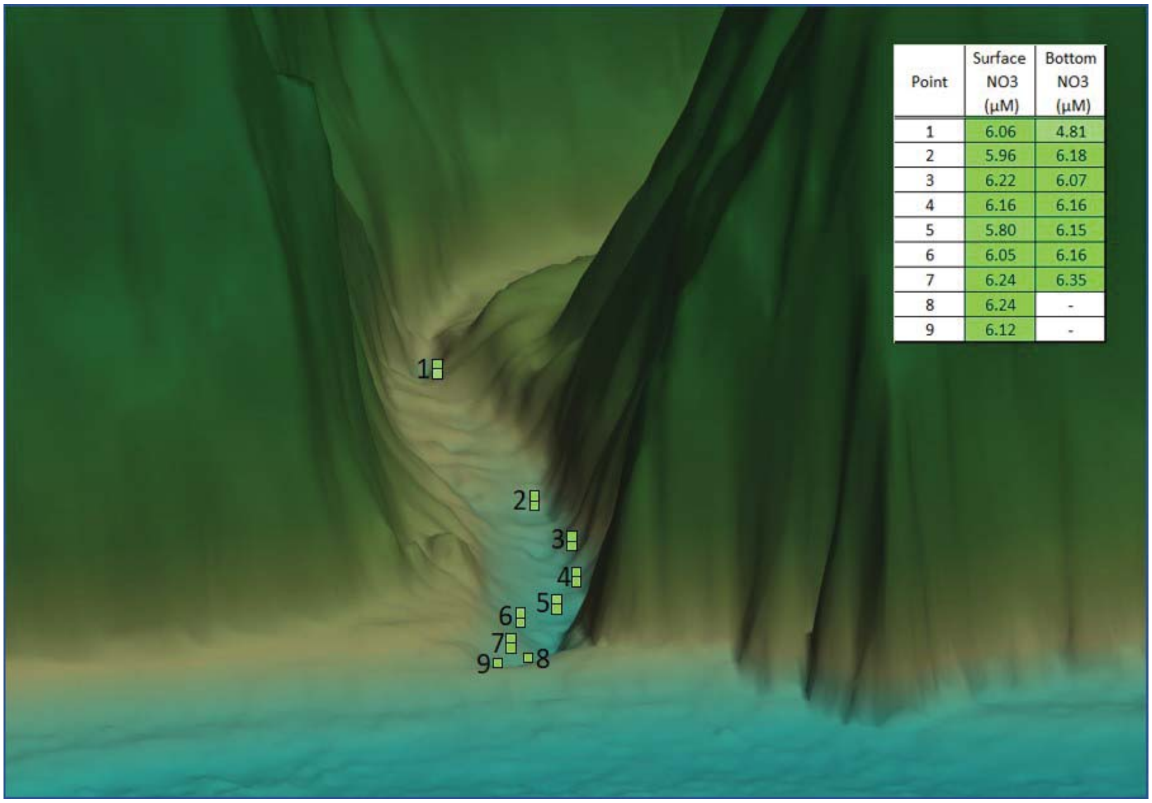
Point	Surface NO3 (µM)	Bottom NO3 (µM)
1	4.70	-
2	5.37	-
3	5.47	5.12
4	5.48	4.16
5	5.15	4.31
6	5.22	4.55
7	4.70	-
8	4.55	1.77
9	3.89	1.66
10	3.63	0.95
11	3.79	0.51
12	2.91	0.91
13	0.44	0.22
14	0.53	0.31
15	0.18	0.13
16	0.21	0.17
17	0.35	0.15

Figure 4-37. Honomanu Nitrate Winter Sample.



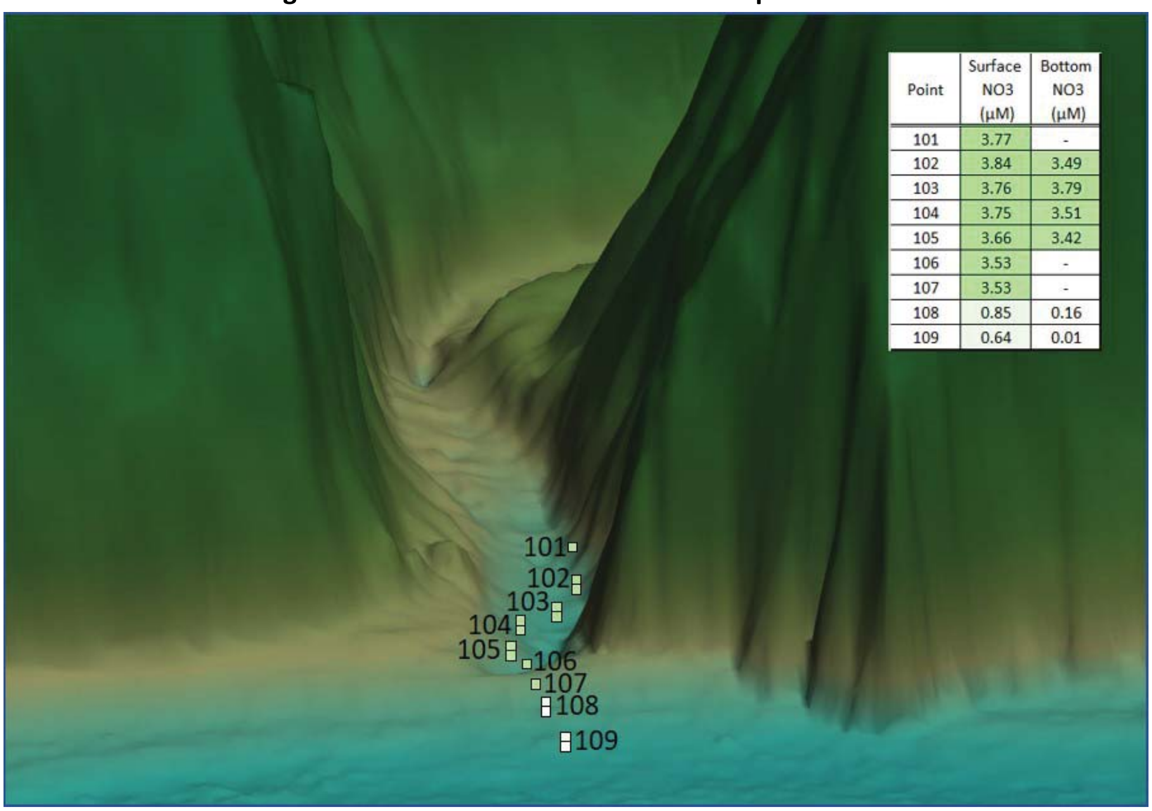
Point	Surface NO3 (µM)	Bottom NO3 (µM)
101	1.74	-
102	2.38	2.44
103	2.67	2.80
104	2.69	2.75
105	2.62	-
106	1.63	-
107	2.46	1.27
108	2.54	0.57
109	2.30	2.30
110	1.99	0.29
111	1.85	0.43
112	-	0.06
113	0.02	0.09
114	0.18	0.02
115	0.29	0.00
116	0.39	0.06

Figure 4-38. Honomanu Nitrate Summer Sample.



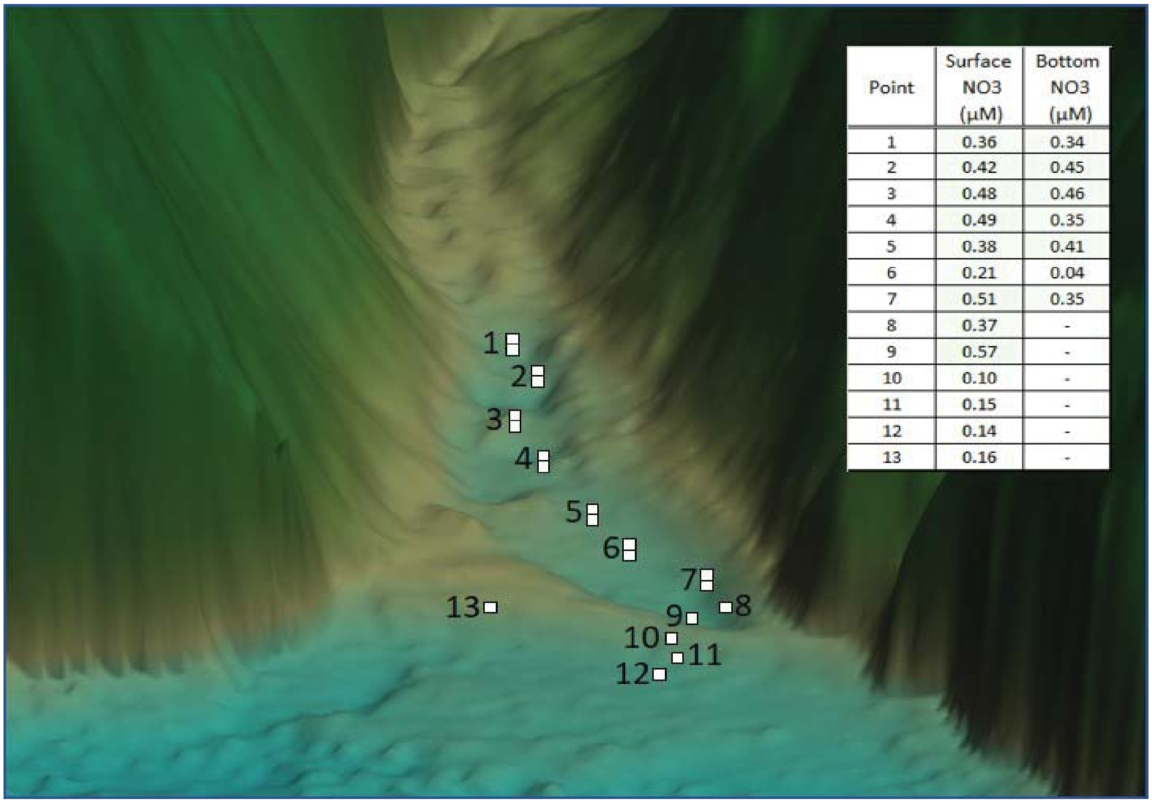
Point	Surface NO3 (µM)	Bottom NO3 (µM)
1	6.06	4.81
2	5.96	6.18
3	6.22	6.07
4	6.16	6.16
5	5.80	6.15
6	6.05	6.16
7	6.24	6.35
8	6.24	-
9	6.12	-

Figure 4-39. Hanawi Nitrate Winter Sample.



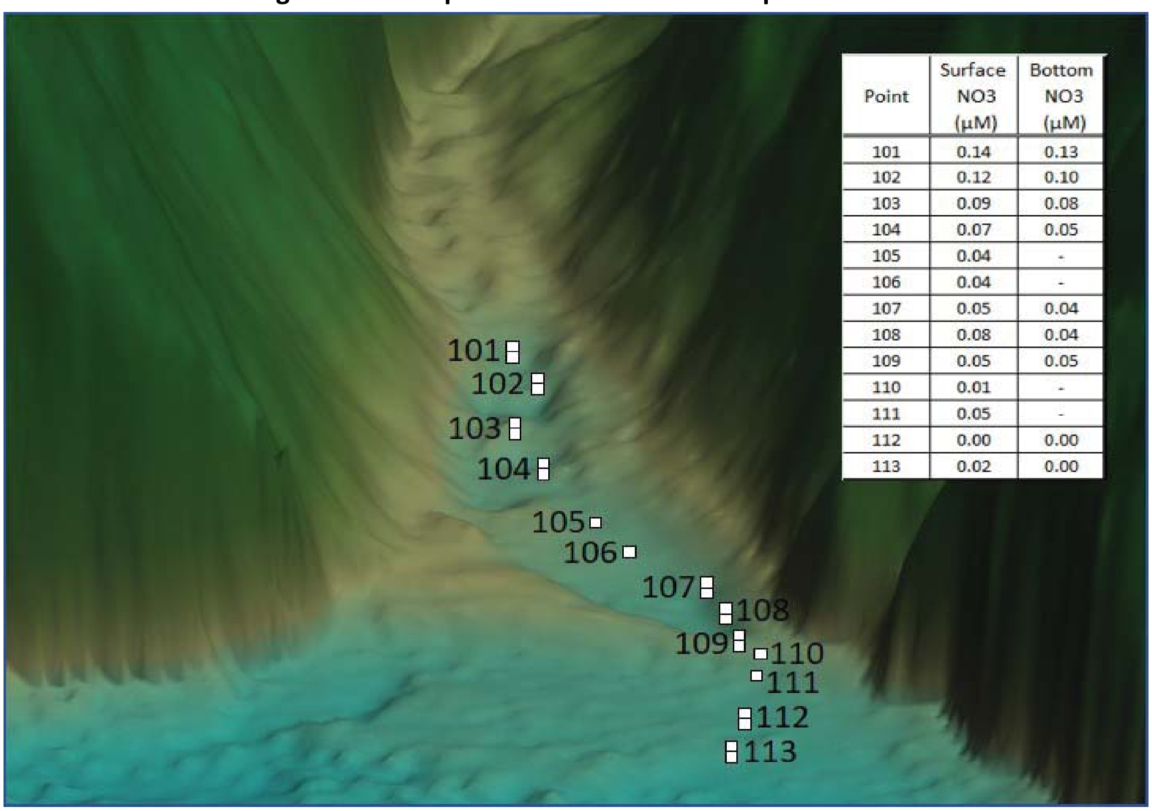
Point	Surface NO3 (µM)	Bottom NO3 (µM)
101	3.77	-
102	3.84	3.49
103	3.76	3.79
104	3.75	3.51
105	3.66	3.42
106	3.53	-
107	3.53	-
108	0.85	0.16
109	0.64	0.01

Figure 4-40. Hanawi Nitrate Summer Sample.



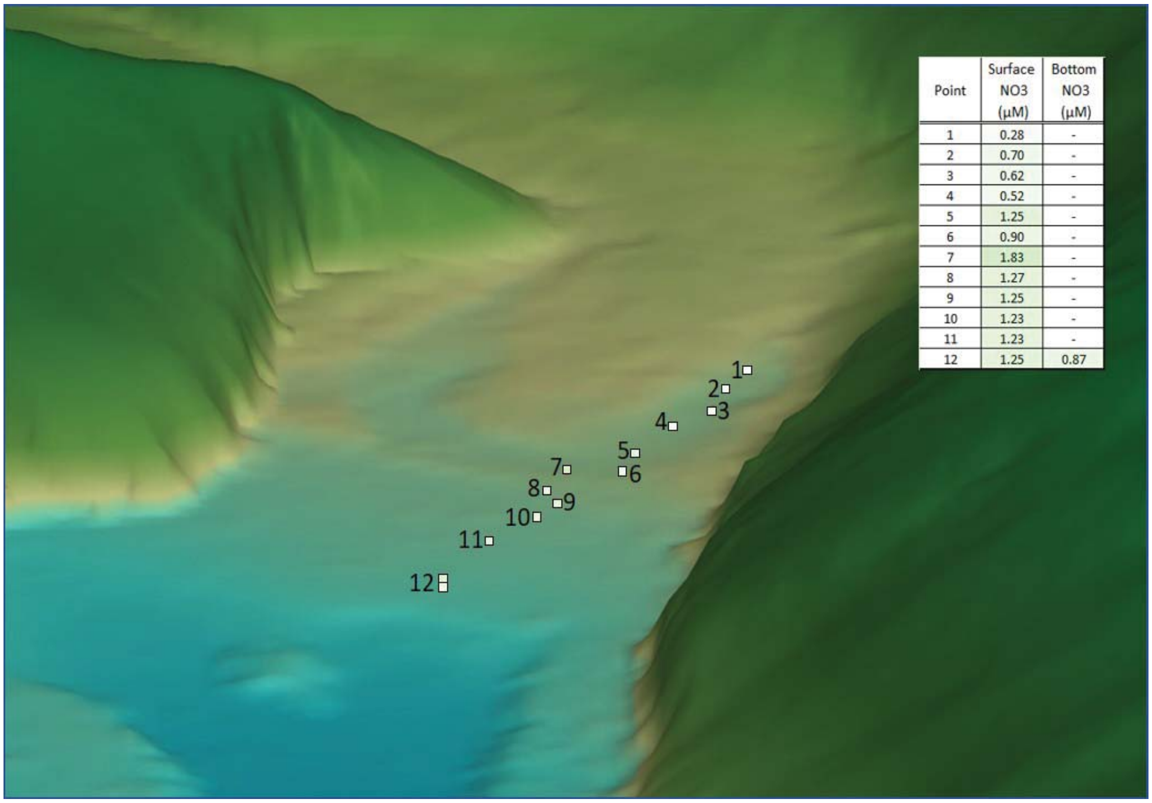
Point	Surface NO3 (µM)	Bottom NO3 (µM)
1	0.36	0.34
2	0.42	0.45
3	0.48	0.46
4	0.49	0.35
5	0.38	0.41
6	0.21	0.04
7	0.51	0.35
8	0.37	-
9	0.57	-
10	0.10	-
11	0.15	-
12	0.14	-
13	0.16	-

Figure 4-41. Kopiliula Nitrate Winter Sample.



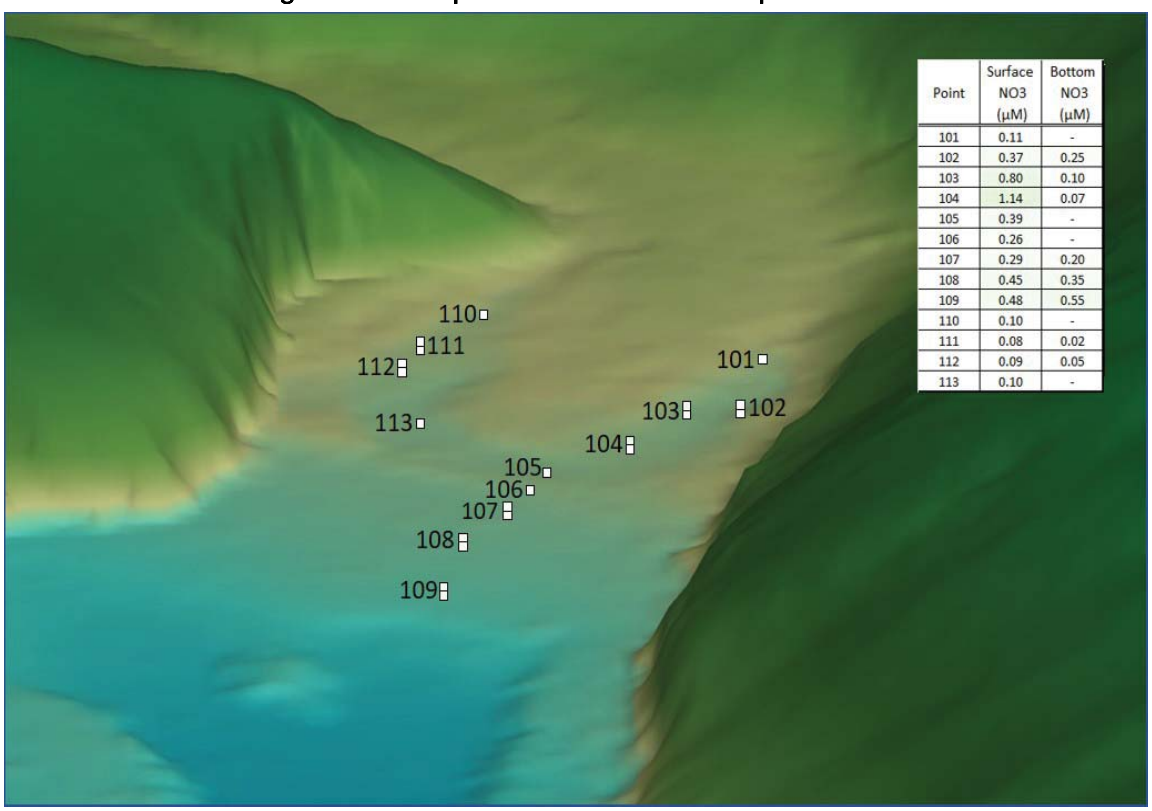
Point	Surface NO3 (µM)	Bottom NO3 (µM)
101	0.14	0.13
102	0.12	0.10
103	0.09	0.08
104	0.07	0.05
105	0.04	-
106	0.04	-
107	0.05	0.04
108	0.08	0.04
109	0.05	0.05
110	0.01	-
111	0.05	-
112	0.00	0.00
113	0.02	0.00

Figure 4-42. Kopiliula Nitrate Summer Sample.



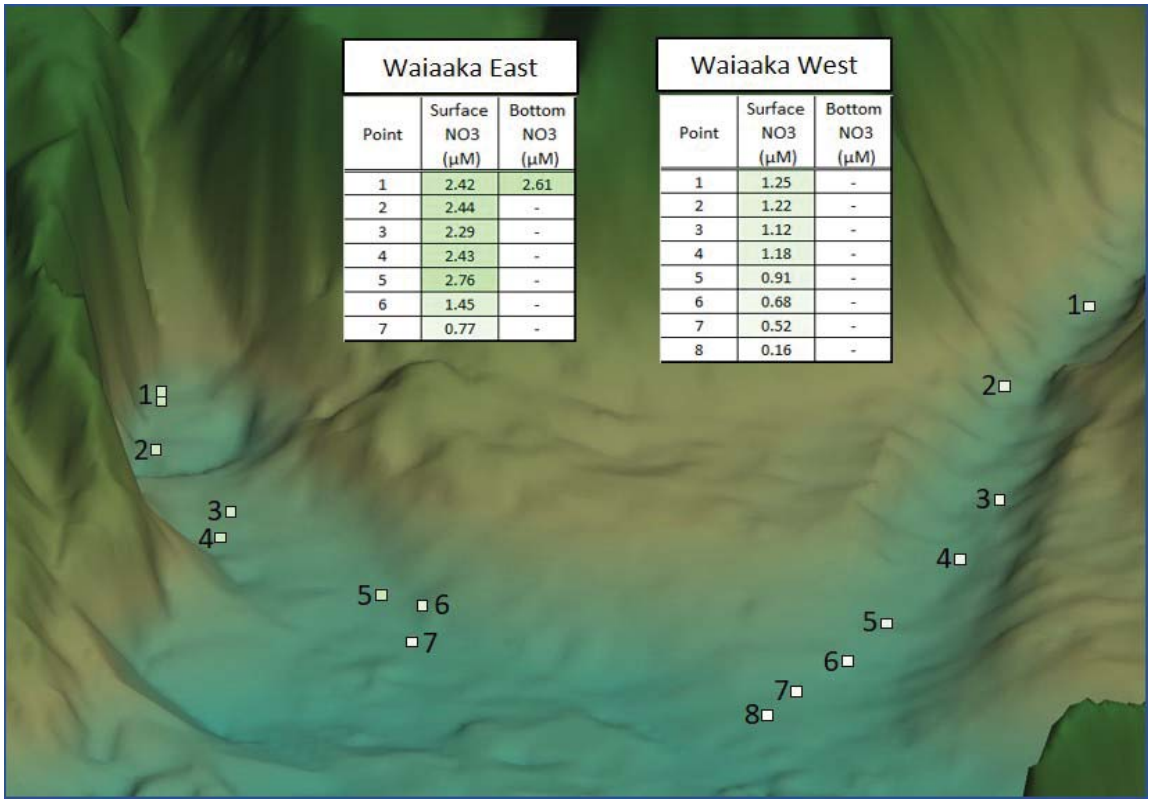
Point	Surface NO3 (µM)	Bottom NO3 (µM)
1	0.28	-
2	0.70	-
3	0.62	-
4	0.52	-
5	1.25	-
6	0.90	-
7	1.83	-
8	1.27	-
9	1.25	-
10	1.23	-
11	1.23	-
12	1.25	0.87

Figure 4-43. OopuolaNitrate Winter Sample.



Point	Surface NO3 (µM)	Bottom NO3 (µM)
101	0.11	-
102	0.37	0.25
103	0.80	0.10
104	1.14	0.07
105	0.39	-
106	0.26	-
107	0.29	0.20
108	0.45	0.35
109	0.48	0.55
110	0.10	-
111	0.08	0.02
112	0.09	0.05
113	0.10	-

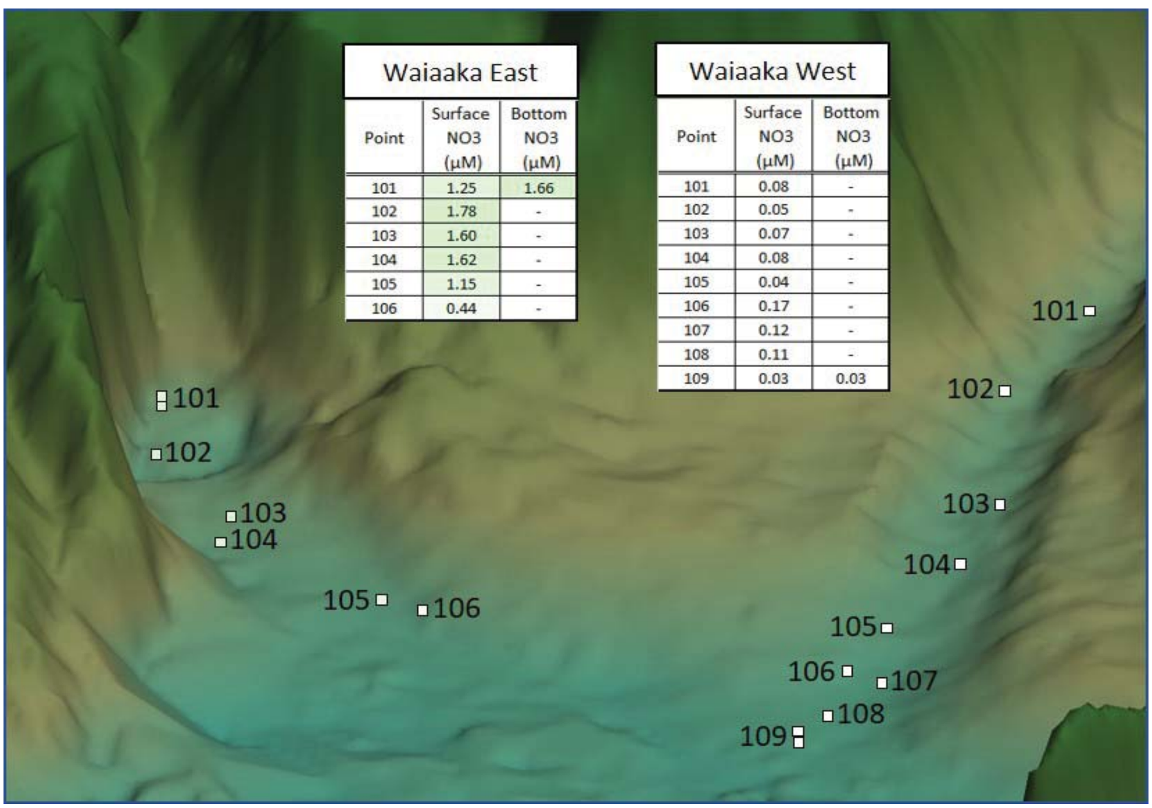
Figure 4-44. Oopuola Nitrate Summer Sample.



Waiaaka East		
Point	Surface NO3 (µM)	Bottom NO3 (µM)
1	2.42	2.61
2	2.44	-
3	2.29	-
4	2.43	-
5	2.76	-
6	1.45	-
7	0.77	-

Waiaaka West		
Point	Surface NO3 (µM)	Bottom NO3 (µM)
1	1.25	-
2	1.22	-
3	1.12	-
4	1.18	-
5	0.91	-
6	0.68	-
7	0.52	-
8	0.16	-

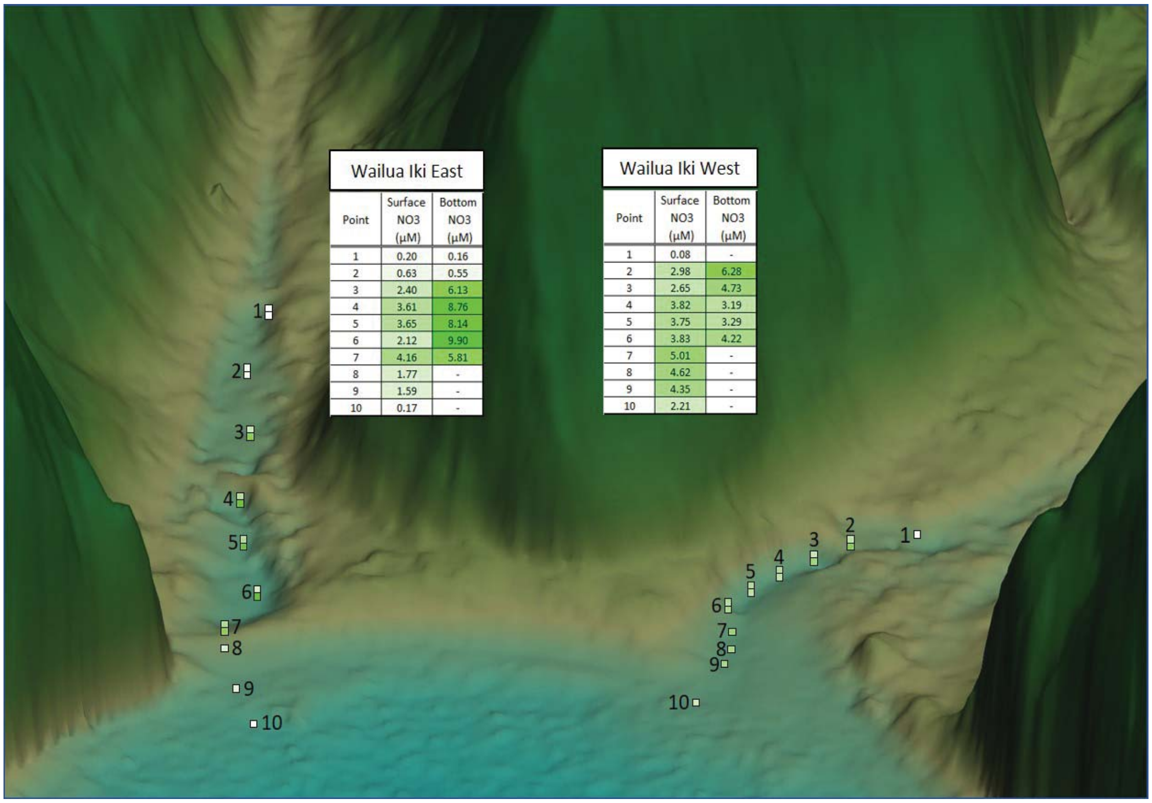
Figure 4-45. Waiaaka Nitrate Winter Sample.



Waiaaka East		
Point	Surface NO3 (µM)	Bottom NO3 (µM)
101	1.25	1.66
102	1.78	-
103	1.60	-
104	1.62	-
105	1.15	-
106	0.44	-

Waiaaka West		
Point	Surface NO3 (µM)	Bottom NO3 (µM)
101	0.08	-
102	0.05	-
103	0.07	-
104	0.08	-
105	0.04	-
106	0.17	-
107	0.12	-
108	0.11	-
109	0.03	0.03

Figure 4-46. Waiaaka Nitrate Summer Sample.



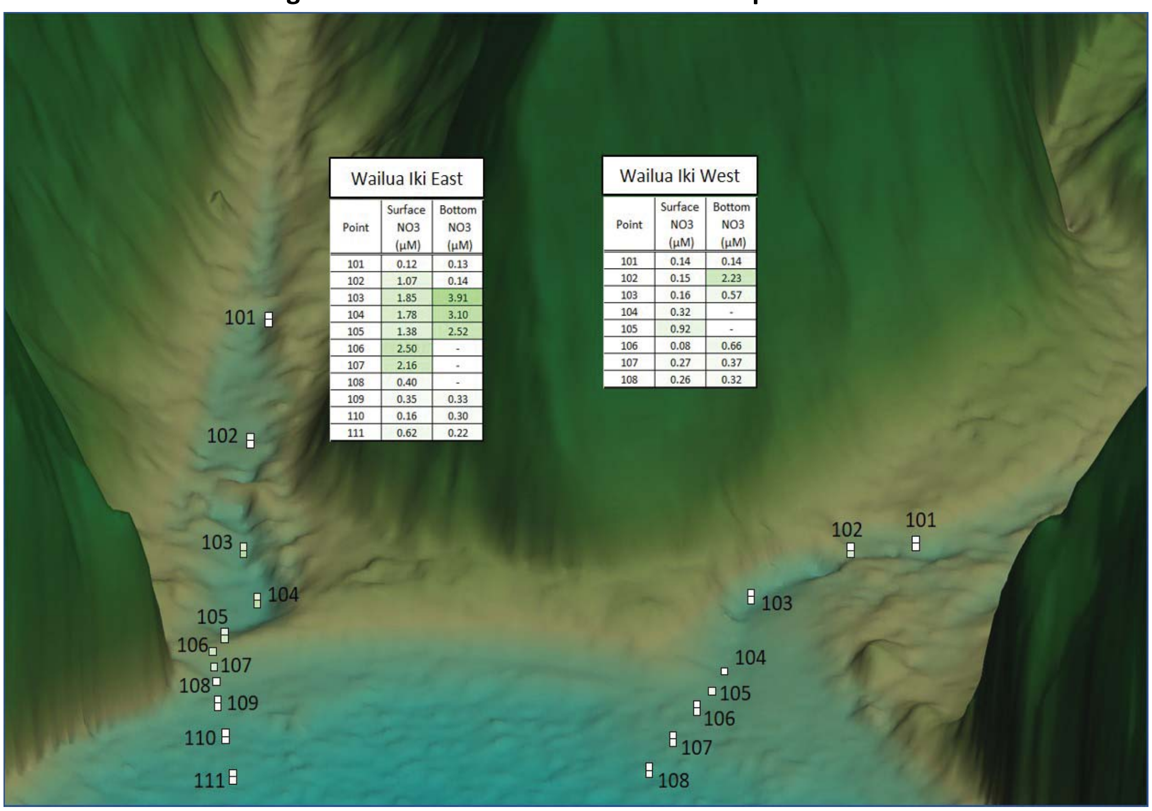
Wailua Iki East

Point	Surface NO3 (µM)	Bottom NO3 (µM)
1	0.20	0.16
2	0.63	0.55
3	2.40	6.13
4	3.61	8.76
5	3.65	8.14
6	2.12	9.90
7	4.16	5.81
8	1.77	-
9	1.59	-
10	0.17	-

Wailua Iki West

Point	Surface NO3 (µM)	Bottom NO3 (µM)
1	0.08	-
2	2.98	6.28
3	2.65	4.73
4	3.82	3.19
5	3.75	3.29
6	3.83	4.22
7	5.01	-
8	4.62	-
9	4.35	-
10	2.21	-

Figure 4-47. Wailua Nitrate Winter Sample.



Wailua Iki East

Point	Surface NO3 (µM)	Bottom NO3 (µM)
101	0.12	0.13
102	1.07	0.14
103	1.85	3.91
104	1.78	3.10
105	1.38	2.52
106	2.50	-
107	2.16	-
108	0.40	-
109	0.35	0.33
110	0.16	0.30
111	0.62	0.22

Wailua Iki West

Point	Surface NO3 (µM)	Bottom NO3 (µM)
101	0.14	0.14
102	0.15	2.23
103	0.16	0.57
104	0.32	-
105	0.92	-
106	0.08	0.66
107	0.27	0.37
108	0.26	0.32

Figure 4-48. Wailua Nitrate Summer Sample.

5. SUMMARY AND CONCLUSIONS

Six stream complexes within the License Area that were accessible by land or air were surveyed in 2018 in order to determine to the best degree possible the contribution of stream waters to the function of marine systems. Each of the streams and adjacent ocean were surveyed twice, once in the winter (January) and once in the summer (July). Investigators collected water and sediment samples along transects that extended from upstream areas beyond the influence of the ocean, across the stream/ocean boundary, and into the nearshore marine environment. During both seasonal surveys, typical tradewind conditions prevailed, which created significant breaking surf in the nearshore area. These hazardous conditions resulted in restricted sample collection owing to severe surge and limited underwater visibility. As a result only limited observations of the biotic community structure were possible.

Results of the investigation showed that streams along the coast of East Maui show a wide range of geographical/morphological characteristics. Flow in the streams is highly variable and dynamic, with much of the variability resulting from factors in the upland watershed, as well as diversion of stream water. The two sampling events that were completed can only serve to describe the conditions at those points in time. However, results of the surveys provided some important information regarding the interactions of streams and the ocean. Of particular significance is that the effects of stream water on marine waters must be considered minor in these habitats. This result is supported by the physical processes associated with relatively small input of stream water to the vastly larger ocean environment. The prevailing conditions of extreme mixing by physical forces is the most important factor in diminishing the zone of influence of stream water in the marine setting. In all cases where it was possible to sample across the boundary where streams flowed to the ocean, there were sharp gradients reflecting the intense mixing of stream water to background ocean levels. Observations of the habitats in these transition zones indicated that they were composed primarily of sand and barren rock. Owing to continual, intense wave energy, these nearshore areas do not constitute important habitats for coral reef communities and associated marine species. Beyond the narrow transition zone, the influence of stream water is minimal owing to rapid and intense mixing. These processes should not be affected by changes in stream flow related to seasonal variation or diversions.

In summary, while the end result of the present study was intended to be development of a function to associate variation in stream flow rates to marine ecosystem function, the actual environmental conditions at the survey sites prohibited such a theoretical relationship. The field surveys, conducted under difficult logistical and extremely hazardous circumstances, demonstrate why such an objective is not applicable in this particular region. In other habitats that are not subjected to the same range of harsh physical conditions as East Maui, the results of studies aimed at establishing the relationships between stream input are likely to have a far different outcome with respect to linking stream discharge to estuarine function.

Results of the study provided a unique data set that characterizes the physical and chemical composition of streams in East Maui that supply the EMI Aqueduct System . Such a data set can provide an important baseline for any future evaluations of these streams.

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APPENDIX A.

Water Chemistry Data
East Maui Streams
January and July 2018

TABLE A-1. Results of water chemistry sampling conducted on January 2, 2018, at Honomanu Stream in East Maui. "S" indicates surface sample; "B" indicates bottom sample. Nutrient concentrations are shown in micromolar units (µM). Location of sampling station is shown in Chapter 4 of text.

STREAM	STATION	DEPTH	LAT	LON	PO4 (µM)	NO3 (µM)	NH4 (µM)	Si (µM)	TOP (µM)	TON (µM)	TP (µM)	TN (µM)	TURB (NTU)	SALT (ppt)	pH (rel)	Chl-a (µg/l)	TEMP deg C	DO %sat
HONOMANU	1	S	20.859136	-156.16755	1.18	4.70	0.46	436.70	0.17	5.60	1.35	10.76	1.52	0.33	7.352	0.132	19.10	86.09
	2	S	20.85945996	-156.167374	1.15	5.37	0.49	446.65	0.23	5.36	1.38	11.22	2.76	0.61	7.243	0.374	19.27	88.34
	3	S	20.85975903	-156.167197	1.31	5.47	0.60	461.58	0.20	3.88	1.51	9.95	1.23	0.38	7.252	0.109	19.67	88.31
	3	B	20.85975903	-156.167197	1.06	5.12	0.98	432.32	0.03	6.48	1.09	12.58	6.25	8.80	7.138	0.358	20.61	83.00
	4	S	20.86011602	-156.167096	1.38	5.48	0.56	471.21	0.12	4.60	1.50	10.64	1.16	0.56	7.331	0.086	19.53	86.84
	4	B	20.86011602	-156.167096	0.93	4.16	0.92	403.83	0.04	6.65	0.97	11.73	30.32	10.09	7.108	0.623	20.93	76.56
	5	S	20.86055598	-156.166999	1.20	5.15	0.62	458.14	0.14	4.07	1.33	9.84	1.48	1.43	7.261	0.132	19.81	87.08
	5	B	20.86055598	-156.166999	0.93	4.31	1.09	418.92	0.03	6.31	0.96	11.71	12.97	8.29	7.180	1.036	21.03	84.00
	6	S	20.86089302	-156.167073	1.34	5.22	0.58	459.23	0.05	3.42	1.38	9.22	4.08	1.42	7.264	0.203	20.08	88.24
	6	B	20.86089302	-156.167073	0.98	4.55	1.00	437.43	0.02	5.66	1.00	11.21	3.48	5.37	7.135	1.020	20.37	87.50
	7	S	20.86114699	-156.167206	1.15	4.70	0.82	446.71	0.01	4.19	1.16	9.71	NA	3.30	7.217	0.662	20.48	89.66
	8	S	20.86132703	-156.167159	1.21	4.55	0.74	451.07	0.04	5.17	1.25	10.46	3.64	3.41	7.221	0.343	20.56	87.29
	8	B	20.86132703	-156.167159	0.71	1.77	0.78	251.54	0.07	6.14	0.78	8.69	4.94	18.49	7.910	2.820	20.99	88.01
	9	S	20.86148302	-156.167056	0.79	3.89	0.74	412.20	0.03	4.79	0.81	9.42	3.27	6.86	7.397	0.771	20.79	91.56
	9	B	20.86148302	-156.167056	0.65	1.66	0.72	242.33	0.15	6.36	0.80	8.74	35.64	19.18	7.945	1.605	23.41	96.87
	10	S	20.86156701	-156.166911	0.93	3.63	0.52	391.50	0.03	6.59	0.96	10.74	2.98	8.60	7.508	0.405	21.56	90.40
	10	B	20.86156701	-156.166911	0.50	0.95	0.79	171.95	0.22	6.50	0.72	8.24	16.61	23.97	8.049	2.726	23.56	98.14
	11	S	20.86149903	-156.166707	1.00	3.79	0.77	401.08	0.03	6.70	1.03	11.26	2.97	7.99	7.513	0.234	22.41	94.07
	11	B	20.86149903	-156.166707	0.32	0.51	0.73	95.50	0.28	6.89	0.60	8.13	24.04	28.88	8.084	0.740	23.96	100.94
	12	S	20.86139099	-156.166555	0.82	2.91	0.58	339.00	0.05	5.00	0.87	8.49	3.72	12.74	7.796	0.288	22.69	97.16
	12	B	20.86139099	-156.166555	0.38	0.91	0.77	113.63	0.30	5.78	0.67	7.46	7.28	27.76	8.101	0.631	24.09	100.05
	13	S	20.861467	-156.166435	0.25	0.44	0.78	60.75	0.33	6.09	0.58	7.31	4.26	31.50	8.081	0.358	24.31	103.57
	13	B	20.861467	-156.166435	0.23	0.22	0.89	57.11	0.30	5.41	0.53	6.52	6.04	31.68	8.097	0.499	24.30	104.19
	14	S	20.861129	-156.166013	0.26	0.53	0.77	68.93	0.33	5.94	0.58	7.24	8.96	30.92	8.128	0.257	24.23	102.60
	14	B	20.861129	-156.166013	0.25	0.31	0.82	64.89	0.30	6.23	0.55	7.36	10.09	31.18	8.131	0.530	24.23	102.69
	15	S	20.861252	-156.165905	0.22	0.18	0.88	61.69	0.30	5.52	0.52	6.58	27.12	31.31	8.107	2.820	24.19	102.06
	15	B	20.861252	-156.165905	0.26	0.13	1.35	60.39	0.30	6.99	0.56	8.47	38.84	31.38	8.095	5.118	24.18	101.92
	16	S	20.860888	-156.165653	0.26	0.21	0.85	58.40	0.31	7.48	0.57	8.54	4.71	31.54	8.117	1.589	24.26	103.57
	16	B	20.860888	-156.165653	0.22	0.17	0.65	57.21	0.32	5.85	0.54	6.67	40.41	31.61	8.123	2.539	24.27	103.03
	17	S	20.861031	-156.165578	0.26	0.35	0.59	66.81	0.29	5.27	0.54	6.21	9.73	31.01	8.141	0.265	24.23	103.60
	17	B	20.861031	-156.165578	0.15	0.15	0.64	63.57	0.34	5.94	0.49	6.73	17.17	31.19	8.137	0.467	24.24	102.98

TABLE A-2. Results of water chemistry sampling conducted on January 2, 2018, at Honomanu Stream in East Maui. "S" indicates surface sample; "B" indicates bottom sample. Nutrient concentrations are shown as micrograms per liter (µg/L). Location of sampling station is shown in Chapter 4 of text.

STREAM	STATION	DEPTH	LAT	LON	PO4 (µg/L)	NO3 (µg/L)	NH4 (µg/L)	Si (µg/L)	TOP (µg/L)	TON (µg/L)	TP (µg/L)	TN (µg/L)	TURB (NTU)	SALT (ppt)	pH (rel)	Chl-a (µg/l)	TEMP deg C	DO %sat
HONOMANU	1	S	20.859136	-156.16755	36.63	65.83	6.45	12228	5.31	78.39	41.94	150.67	1.52	0.33	7.352	0.132	19.10	86.09
	2	S	20.85945996	-156.167374	35.67	75.21	6.87	12506	7.20	75.03	42.87	157.11	2.76	0.61	7.243	0.374	19.27	88.34
	3	S	20.85975903	-156.167197	40.66	76.61	8.41	12924	6.24	54.31	46.90	139.33	1.23	0.38	7.252	0.109	19.67	88.31
	3	B	20.85975903	-156.167197	32.85	71.71	13.73	12105	1.04	90.71	33.88	176.15	6.25	8.80	7.138	0.358	20.61	83.00
	4	S	20.86011602	-156.167096	42.81	76.75	7.85	13194	3.79	64.39	46.59	148.99	1.16	0.56	7.331	0.086	19.53	86.84
	4	B	20.86011602	-156.167096	28.97	58.27	12.89	11307	1.19	93.09	30.16	164.25	30.32	10.09	7.108	0.623	20.93	76.56
	5	S	20.86055598	-156.166999	37.12	72.13	8.69	12828	4.20	56.97	41.32	137.79	1.48	1.43	7.261	0.132	19.81	87.08
	5	B	20.86055598	-156.166999	28.88	60.37	15.27	11730	0.98	88.33	29.85	163.97	12.97	8.29	7.180	1.036	21.03	84.00
	6	S	20.86089302	-156.167073	41.47	73.11	8.13	12859	1.41	47.87	42.87	129.11	4.08	1.42	7.264	0.203	20.08	88.24
	6	B	20.86089302	-156.167073	30.46	63.73	14.01	12248	0.63	79.23	31.09	156.97	3.48	5.37	7.135	1.020	20.37	87.50
	7	S	20.86114699	-156.167206	35.66	65.83	11.49	12508	0.39	58.65	36.05	135.97	NA	3.30	7.217	0.662	20.48	89.66
	8	S	20.86132703	-156.167159	37.51	63.73	10.37	12630	1.33	72.37	38.84	146.47	3.64	3.41	7.221	0.343	20.56	87.29
	8	B	20.86132703	-156.167159	22.09	24.81	10.93	7043	2.18	85.95	24.27	121.69	4.94	18.49	7.910	2.820	20.99	88.01
	9	S	20.86148302	-156.167056	24.39	54.49	10.37	11542	0.81	67.05	25.20	131.91	3.27	6.86	7.397	0.771	20.79	91.56
	9	B	20.86148302	-156.167056	20.15	23.27	10.09	6785	4.74	89.03	24.89	122.39	35.64	19.18	7.945	1.605	23.41	96.87
	10	S	20.86156701	-156.166911	28.84	50.85	7.29	10962	1.01	92.25	29.85	150.39	2.98	8.60	7.508	0.405	21.56	90.40
	10	B	20.86156701	-156.166911	15.56	13.33	11.07	4815	6.85	90.99	22.41	115.39	16.61	23.97	8.049	2.726	23.56	98.14
	11	S	20.86149903	-156.166707	31.08	53.09	10.79	11230	0.94	93.79	32.02	157.67	2.97	7.99	7.513	0.234	22.41	94.07
	11	B	20.86149903	-156.166707	10.02	7.17	10.23	2674	8.67	96.45	18.69	113.85	24.04	28.88	8.084	0.740	23.96	100.94
	12	S	20.86139099	-156.166555	25.56	40.77	8.13	9492	1.50	69.99	27.06	118.89	3.72	12.74	7.796	0.288	22.69	97.16
	12	B	20.86139099	-156.166555	11.70	12.77	10.79	3182	9.16	80.91	20.86	104.47	7.28	27.76	8.101	0.631	24.09	100.05
	13	S	20.861467	-156.166435	7.85	6.19	10.93	1701	10.22	85.25	18.07	102.37	4.26	31.50	8.081	0.358	24.31	103.57
	13	B	20.861467	-156.166435	7.21	3.11	12.47	1599	9.31	75.73	16.52	91.31	6.04	31.68	8.097	0.499	24.30	104.19
	14	S	20.861129	-156.166013	7.92	7.45	10.79	1930	10.15	83.15	18.07	101.39	8.96	30.92	8.128	0.257	24.23	102.60
	14	B	20.861129	-156.166013	7.89	4.37	11.49	1817	9.25	87.21	17.14	103.07	10.09	31.18	8.131	0.530	24.23	102.69
	15	S	20.861252	-156.165905	6.94	2.55	12.33	1727	9.27	77.27	16.21	92.15	27.12	31.31	8.107	2.820	24.19	102.06
	15	B	20.861252	-156.165905	8.18	1.85	18.91	1691	9.28	97.85	17.45	118.61	38.84	31.38	8.095	5.118	24.18	101.92
	16	S	20.860888	-156.165653	8.16	2.97	11.91	1635	9.61	104.71	17.76	119.59	4.71	31.54	8.117	1.589	24.26	103.57
	16	B	20.860888	-156.165653	6.91	2.41	9.11	1602	9.92	81.89	16.83	93.41	40.41	31.61	8.123	2.539	24.27	103.03
	17	S	20.861031	-156.165578	7.91	4.93	8.27	1871	8.92	73.77	16.83	86.97	9.73	31.01	8.141	0.265	24.23	103.60
	17	B	20.861031	-156.165578	4.79	2.13	8.97	1780	10.49	83.15	15.28	94.25	17.17	31.19	8.137	0.467	24.24	102.98

TABLE A-3. Results of water chemistry sampling conducted on January 3, 2018, at Hanawi, Kopiliula, and Waiaaka Streams in East Maui. "S" indicates surface sample; "B" indicates bottom sample. "na" indicates lost sample. Nutrient concentrations are shown in micromolar units (µM) . Locations of sampling stations are shown in Chapter 4 of text.

STREAM	STATION	DEPTH	LAT	LON	PO4 (µM)	NO3 (µM)	NH4 (µM)	Si (µM)	TOP (µM)	TON (µM)	TP (µM)	TN (µM)	TURB (NTU)	SALT (ppt)	pH (rel)	Chl-a (µg/l)	TEMP deg C	DO %sat
HANAWI	1	S	20.823663	-156.1013	0.69	6.06	0.23	325.15	0.17	3.16	0.86	9.45	1.07	0.00	7.911	0.101	17.09	97.78
	1	B	20.823663	-156.1013	0.70	4.81	0.05	327.75	0.22	5.69	0.92	10.55	1.19	0.00	7.865	0.678	17.09	96.62
	2	S	20.824242	-156.1013	0.74	5.96	0.13	327.69	0.19	2.63	0.93	8.72	1.39	0.00	7.867	0.195	17.11	98.05
	2	B	20.824242	-156.1013	0.75	6.18	0.06	327.50	0.20	3.26	0.95	9.50	1.38	0.00	7.845	0.148	17.11	98.19
	3	S	20.824466	-156.1013	0.78	6.22	0.10	327.61	0.16	3.23	0.94	9.55	1.39	0.01	7.832	0.140	17.11	97.81
	3	B	20.824466	-156.1013	0.72	6.07	0.33	328.18	0.18	1.94	0.90	8.34	1.43	0.01	7.824	0.312	17.11	96.07
	4	S	20.824702	-156.1013	0.72	6.16	0.35	328.27	0.17	2.64	0.89	9.15	1.11	0.01	7.835	0.234	17.11	98.32
	4	B	20.824702	-156.1013	0.74	6.16	0.30	329.36	0.16	2.84	0.90	9.30	1.14	0.01	7.832	1.192	17.12	98.16
	5	S	20.82486	-156.1011	0.72	5.80	0.45	328.28	0.17	3.82	0.89	10.07	1.23	0.01	7.825	0.171	17.11	99.19
	5	B	20.82486	-156.1011	0.76	6.15	0.30	325.42	0.13	4.66	0.89	11.11	1.10	0.39	7.776	0.335	17.10	98.02
	6	S	20.824886	-156.1009	0.73	6.05	0.23	329.11	0.12	2.65	0.85	8.93	1.35	0.01	7.835	0.125	17.11	98.91
	6	B	20.824886	-156.1009	0.70	6.16	0.35	329.64	0.19	3.52	0.89	10.03	1.22	0.02	7.823	0.460	17.23	98.03
	7	S	20.824988	-156.1009	0.78	6.24	0.20	329.73	0.19	2.14	0.97	8.58	1.23	0.01	7.825	0.164	17.11	98.82
	7	B	20.824988	-156.1009	0.78	6.35	0.55	329.19	0.16	3.94	0.94	10.84	1.19	0.02	7.816	0.148	17.10	98.40
	8	S	20.825059	-156.1009	0.77	6.24	0.57	328.12	0.16	3.29	0.93	10.10	1.17	0.01	7.821	0.132	17.10	99.05
	9	S	20.825059	-156.1009	0.78	6.12	0.52	316.15	0.04	1.42	0.82	8.06	1.95	1.56	7.854	0.125	17.10	98.73
KOPILIULA	1	S	20.831179	-156.1187	0.18	0.36	0.54	230.09	0.25	3.96	0.43	4.86	2.10	0.00	7.721	0.280	17.38	98.10
	1	B	20.831179	-156.1187	0.17	0.34	0.46	228.63	0.23	5.64	0.40	6.44	1.69	0.00	7.687	0.343	17.38	98.20
	2	S	20.831266	-156.1187	0.16	0.42	0.40	227.61	0.26	4.70	0.42	5.52	5.45	0.00	7.669	0.561	17.41	98.45
	2	B	20.831266	-156.1187	0.22	0.45	0.49	228.18	0.18	4.70	0.40	5.64	4.19	0.00	7.675	1.013	17.41	98.09
	3	S	20.831399	-156.1185	0.19	0.48	0.68	229.12	0.20	4.30	0.39	5.46	1.90	0.00	7.655	0.335	17.43	97.95
	3	B	20.831399	-156.1185	0.21	0.46	0.41	228.82	0.16	4.07	0.37	4.94	2.42	0.00	7.668	0.748	17.43	97.90
	4	S	20.83157	-156.1185	0.21	0.49	0.39	229.28	0.12	3.84	0.33	4.72	1.72	0.00	7.653	0.397	17.51	95.87
	4	B	20.83157	-156.1185	0.18	0.35	0.65	228.45	0.15	3.65	0.33	4.65	2.70	0.00	7.660	2.142	17.47	97.21
	5	S	20.831828	-156.1184	0.33	0.38	0.62	227.93	0.11	3.71	0.44	4.71	2.64	0.00	7.676	0.499	17.58	98.25
	5	B	20.831828	-156.1184	0.18	0.41	0.63	232.50	0.17	3.64	0.35	4.68	2.54	0.00	7.676	0.865	17.57	98.43
	6	S	20.831973	-156.1184	0.16	0.21	0.56	227.57	0.16	4.05	0.32	4.82	2.70	0.00	7.689	3.015	17.61	97.70
	6	B	20.831973	-156.1184	0.13	0.04	0.59	226.02	0.18	3.79	0.31	4.42	2.91	0.00	7.758	4.767	17.61	98.60
	7	S	20.832204	-156.1184	0.22	0.51	0.71	229.08	0.10	3.64	0.32	4.86	2.12	0.00	7.696	0.701	17.72	98.62
	7	B	20.832204	-156.1184	0.26	0.35	0.56	228.26	0.13	3.25	0.39	4.16	2.71	0.00	7.726	0.312	17.64	98.82
	8	S	20.83228	-156.1184	0.22	0.37	0.60	228.24	0.17	3.45	0.39	4.42	1.52	0.00	7.715	0.187	17.86	98.86
	9	S	20.832306	-156.1183	0.40	0.57	1.19	212.56	0.06	6.38	0.46	8.14	na	2.52	8.125	1.083	17.87	99.44
	10	S	20.832352	-156.1182	0.26	0.10	0.99	166.79	0.24	6.29	0.51	7.38	na	9.94	8.210	3.949	17.84	99.08
	11	S	20.832418	-156.1182	0.17	0.15	1.13	43.41	0.37	6.84	0.54	8.12	na	28.58	8.089	9.644	19.76	98.02
	12	S	20.832451	-156.1181	0.15	0.14	1.26	63.00	0.33	5.64	0.48	7.04	na	25.88	8.141	6.146	na	na
	13	S	20.832086	-156.118	0.14	0.16	1.25	43.35	0.34	6.00	0.48	7.41	na	29.22	8.111	5.375	23.42	96.30
WAIAAKA WEST	1	S	20.826257	-156.1159	0.27	1.25	0.47	227.19	0.28	4.73	0.55	6.45	2.19	0.30	7.647	0.125	17.88	96.89
	2	S	20.82634	-156.1157	0.24	1.22	0.51	227.74	0.17	5.85	0.41	7.58	3.27	0.00	7.584	0.226	17.94	98.65
	3	S	20.826543	-156.1156	0.24	1.12	0.50	227.68	0.24	4.59	0.48	6.21	5.28	0.00	7.651	0.382	17.97	98.49
	4	S	20.826633	-156.1156	0.25	1.18	0.55	229.73	0.16	3.53	0.41	5.26	2.90	0.00	7.594	0.514	17.99	99.14
	5	S	20.826725	-156.1154	0.24	0.91	0.61	229.06	0.31	2.99	0.55	4.51	3.23	0.00	7.608	0.195	18.03	99.10
	6	S	20.826781	-156.1154	0.24	0.68	1.01	143.81	0.15	4.29	0.40	5.98	na	14.17	8.099	0.436	19.85	100.12
	7	S	20.826817	-156.1153	0.24	0.52	1.14	108.64	0.20	4.06	0.45	5.72	na	20.79	8.114	1.114	21.97	101.47
	8	S	20.826836	-156.1153	0.19	0.16	1.32	65.08	0.28	4.67	0.47	6.15	na	26.45	8.099	1.005	21.61	100.39
WAIAAKA EAST	1	S	20.826048	-156.1149	0.52	2.42	0.51	296.11	0.26	2.94	0.78	5.87	1.43	0.30	7.725	0.148	17.68	96.49
	1	B	20.826048	-156.1149	0.52	2.61	0.31	297.49	0.19	2.99	0.71	5.91	1.30	0.00	7.704	0.234	17.67	97.10
	2	S	20.826098	-156.1148	0.54	2.44	0.28	301.12	0.20	3.30	0.74	6.02	1.03	0.00	7.713	0.179	17.69	97.69
	3	S	20.826287	-156.115	0.55	2.29	0.32	310.44	0.20	3.30	0.75	5.91	1.11	0.00	7.773	0.421	17.73	98.19
	4	S	20.826317	-156.1149	0.59	2.43	0.50	311.88	0.17	2.79	0.76	5.72	1.06	0.00	7.806	0.257	17.85	98.46
	5	S	20.826492	-156.115	0.58	2.76	0.43	311.34	0.13	2.34	0.71	5.53	1.07	0.12	7.755	0.436	17.82	98.33
	6	S	20.826518	-156.1151	0.41	1.45	1.03	171.65	0.15	5.39	0.56	7.87	1.11	15.68	8.053	1.496	19.63	99.53
	7	S	20.826575	-156.115	0.29	0.77	2.74	102.61	0.24	4.81	0.53	8.32	na	23.62	8.079	0.569	na	na

TABLE A-4. Results of water chemistry sampling conducted on January 3, 2018, at Hanawi, Kopiliula, and Waiaaka Streams in East Maui. "S" indicates surface sample; "B" indicates bottom sample. "na" indicates lost sample. Nutrients concentrations are shown in units of micrograms per liter (μg/L) . Locations of sampling stations are shown in Chapter 4 of text.

STREAM	STATION	DEPTH	LAT	LON	PO4 (μg/L)	NO3 (μg/L)	NH4 (μg/L)	Si (μg/L)	TOP (μg/L)	TON (μg/L)	TP (μg/L)	TN (μg/L)	TURB (NTU)	SALT (ppt)	pH (rel)	Chl-a (μg/l)	TEMP deg C	DO %sat
HANAWI	1	S	20.82366304	-156.101345	21.30	84.78	3.23	9104	5.27	44.23	26.57	132.24	1.07	0.00	7.911	0.101	17.09	97.78
	1	B	20.82366304	-156.101345	21.61	67.28	0.71	9177	6.82	79.65	28.43	147.64	1.19	0.00	7.865	0.678	17.09	96.62
	2	S	20.82424197	-156.101287	22.85	83.38	1.83	9175	5.89	36.81	28.74	122.02	1.39	0.00	7.867	0.195	17.11	98.05
	2	B	20.82424197	-156.101287	23.16	86.46	0.85	9170	6.20	45.63	29.36	132.94	1.38	0.00	7.845	0.148	17.11	98.19
	3	S	20.82446602	-156.101327	24.09	87.02	1.41	9173	4.96	45.21	29.05	133.64	1.39	0.01	7.832	0.140	17.11	97.81
	3	B	20.82446602	-156.101327	22.23	84.92	4.63	9189	5.58	27.15	27.81	116.70	1.43	0.01	7.824	0.312	17.11	96.07
	4	S	20.82470197	-156.101255	22.23	86.18	4.91	9192	5.27	36.95	27.50	128.04	1.11	0.01	7.835	0.234	17.11	98.32
	4	B	20.82470197	-156.101255	22.85	86.18	4.21	9222	4.96	39.75	27.81	130.14	1.14	0.01	7.832	1.192	17.12	98.16
	5	S	20.82485997	-156.101089	22.23	81.14	6.31	9192	5.27	53.47	27.50	140.92	1.23	0.01	7.825	0.171	17.11	99.19
	5	B	20.82485997	-156.101089	23.41	86.04	4.21	9112	4.08	65.23	27.50	155.48	1.10	0.39	7.776	0.335	17.10	98.02
	6	S	20.82488604	-156.10093	22.54	84.64	3.23	9215	3.72	37.09	26.26	124.96	1.35	0.01	7.835	0.125	17.11	98.91
	6	B	20.82488604	-156.10093	21.60	86.18	4.91	9230	5.89	49.27	27.50	140.36	1.22	0.02	7.823	0.460	17.23	98.03
	7	S	20.82498796	-156.100885	24.09	87.30	2.81	9232	5.89	29.95	29.98	120.06	1.23	0.01	7.825	0.164	17.11	98.82
	7	B	20.82498796	-156.100885	24.08	88.84	7.71	9217	4.96	55.15	29.05	151.70	1.19	0.02	7.816	0.148	17.10	98.40
	8	S	20.82505904	-156.100885	23.78	87.30	7.99	9187	4.96	46.05	28.74	141.34	1.17	0.01	7.821	0.132	17.10	99.05
	9	S	20.82505904	-156.100885	24.18	85.62	7.29	8852	1.15	19.87	25.33	112.78	1.95	1.56	7.854	0.125	17.10	98.73
KOPILIULA	1	S	20.831179	-156.118693	5.49	4.98	7.57	6442	7.75	55.43	13.24	67.98	2.10	0.00	7.721	0.280	17.38	98.10
	1	B	20.831179	-156.118693	5.18	4.70	6.45	6402	7.13	78.95	12.31	90.10	1.69	0.00	7.687	0.343	17.38	98.20
	2	S	20.83126601	-156.118672	4.87	5.82	5.61	6373	8.06	65.79	12.93	77.22	5.45	0.00	7.669	0.561	17.41	98.45
	2	B	20.83126601	-156.118672	6.73	6.24	6.87	6389	5.58	65.79	12.31	78.90	4.19	0.00	7.675	1.013	17.41	98.09
	3	S	20.83139903	-156.11854	5.80	6.66	9.53	6415	6.20	60.19	12.00	76.38	1.90	0.00	7.655	0.335	17.43	97.95
	3	B	20.83139903	-156.11854	6.42	6.38	5.75	6407	4.96	56.97	11.38	69.10	2.42	0.00	7.668	0.748	17.43	97.90
	4	S	20.83157002	-156.118481	6.42	6.80	5.47	6420	3.72	53.75	10.14	66.02	1.72	0.00	7.653	0.397	17.51	95.87
	4	B	20.83157002	-156.118481	5.49	4.84	9.11	6397	4.65	51.09	10.14	65.04	2.70	0.00	7.660	2.142	17.47	97.21
	5	S	20.83182801	-156.118409	10.14	5.26	8.69	6382	3.41	51.93	13.55	65.88	2.64	0.00	7.676	0.499	17.58	98.25
	5	B	20.83182801	-156.118409	5.49	5.68	8.83	6510	5.27	50.95	10.76	65.46	2.54	0.00	7.676	0.865	17.57	98.43
	6	S	20.83197302	-156.118373	4.87	2.88	7.85	6372	4.96	56.69	9.83	67.42	2.70	0.00	7.689	3.015	17.61	97.70
	6	B	20.83197302	-156.118373	3.94	0.50	8.27	6329	5.58	53.05	9.52	61.82	2.91	0.00	7.758	4.767	17.61	98.60
	7	S	20.83220403	-156.118383	6.73	7.08	9.95	6414	3.10	50.95	9.83	67.98	2.12	0.00	7.696	0.701	17.72	98.62
	7	B	20.83220403	-156.118383	7.97	4.84	7.85	6391	4.03	45.49	12.00	58.18	2.71	0.00	7.726	0.312	17.64	98.82
	8	S	20.83227997	-156.118362	6.73	5.12	8.41	6391	5.27	48.29	12.00	61.82	1.52	0.00	7.715	0.187	17.86	98.86
	9	S	20.83230603	-156.118274	12.27	7.92	16.67	5952	1.90	89.31	14.17	113.90	na	2.52	8.125	1.083	17.87	99.44
	10	S	20.83235197	-156.11821	8.13	1.34	13.87	4670	7.58	88.05	15.72	103.26	na	9.94	8.210	3.949	17.84	99.08
	11	S	20.83241802	-156.118164	5.23	2.04	15.83	1215	11.41	95.75	16.65	113.62	na	28.58	8.089	9.644	19.76	98.02
	12	S	20.832451	-156.11811	4.68	1.90	17.65	1764	10.11	78.95	14.79	98.50	na	25.88	8.141	6.146	na	na
	13	S	20.83208601	-156.118012	4.21	2.18	17.51	1214	10.57	83.99	14.79	103.68	na	29.22	8.111	5.375	23.42	96.30
WAIAAKA WEST	1	S	20.82625698	-156.1159	8.24	17.44	6.59	6361	8.72	66.21	16.96	90.24	2.19	0.30	7.647	0.125	17.88	96.89
	2	S	20.82633996	-156.115739	7.35	17.02	7.15	6377	5.27	81.89	12.62	106.06	3.27	0.00	7.584	0.226	17.94	98.65
	3	S	20.82654297	-156.115641	7.35	15.62	7.01	6375	7.44	64.25	14.79	86.88	5.28	0.00	7.651	0.382	17.97	98.49
	4	S	20.826633	-156.115556	7.66	16.46	7.71	6432	4.96	49.41	12.62	73.58	2.90	0.00	7.594	0.514	17.99	99.14
	5	S	20.82672503	-156.115439	7.35	12.68	8.55	6414	9.61	41.85	16.96	63.08	3.23	0.00	7.608	0.195	18.03	99.10
	6	S	20.82678102	-156.115371	7.55	9.46	14.15	4027	4.76	60.05	12.31	83.66	na	14.17	8.099	0.436	19.85	100.12
	7	S	20.826817	-156.115303	7.56	7.22	15.97	3042	6.30	56.83	13.86	80.02	na	20.79	8.114	1.114	21.97	101.47
	8	S	20.826836	-156.115265	5.84	2.18	18.49	1822	8.64	65.37	14.48	86.04	na	26.45	8.099	1.005	21.61	100.39
WAIAAKA EAST	1	S	20.82604802	-156.114927	15.99	33.82	7.15	8291	8.10	41.15	24.09	82.12	1.43	0.30	7.725	0.148	17.68	96.49
	1	B	20.82604802	-156.114927	16.03	36.48	4.35	8330	5.89	41.85	21.92	82.68	1.30	0.00	7.704	0.234	17.67	97.10
	2	S	20.82609798	-156.114823	16.65	34.10	3.93	8431	6.20	46.19	22.85	84.22	1.03	0.00	7.713	0.179	17.69	97.69
	3	S	20.82628699	-156.114969	16.96	32.00	4.49	8692	6.20	46.19	23.16	82.68	1.11	0.00	7.773	0.421	17.73	98.19
	4	S	20.826317	-156.114938	18.20	33.96	7.01	8733	5.27	39.05	23.47	80.02	1.06	0.00	7.806	0.257	17.85	98.46
	5	S	20.82649201	-156.115027	17.87	38.58	6.03	8717	4.05	32.75	21.92	77.36	1.07	0.12	7.755	0.436	17.82	98.33
	6	S	20.826518	-156.115057	12.61	20.24	14.43	4806	4.66	75.45	17.27	110.12	1.11	15.68	8.053	1.496	19.63	99.53
	7	S	20.826575	-156.11502	9.02	10.72	38.37	2873	7.31	67.33	16.34	116.42	na	23.62	8.079	0.569	na	na

TABLE A-5. Results of water chemistry sampling conducted on January 5, 2018, at Wailua Nui, Wailua Iki, and Oopuola Streams in East Maui. "S" indicates surface sample; "B" indicates bottom sample. Nutrients concentrations are shown in micromolar units (µM. Locations of sampling stations are shown in Chapter 4 of text.

STREAM	Station	DEPTH	LAT	LON	PO4 (µM)	NO3 (µM)	NH4 (µM)	Si (µM)	TOP (µM)	TON (µM)	TP (µM)	TN (µM)	TURB (ntu)	SALT (ppt)	pH (rel)	Chl-a (µg/l)	TEMP deg C	DO %sat
WAILUA NUI EAST	1	B	20.83491	-156.12458	0.05	0.20	0.12	251.54	0.16	4.26	0.21	4.58	1.49	0.00	7.557	0.140	17.35	97.58
	1	S	20.83491	-156.12458	0.04	0.16	0.27	253.90	0.17	5.92	0.21	6.35	1.24	0.00	7.573	0.241	17.37	97.34
	2	S	20.835239	-156.12461	0.08	0.63	0.38	263.07	0.16	4.49	0.24	5.50	2.87	0.00	7.554	0.312	17.36	97.89
	2	B	20.835239	-156.12461	0.07	0.55	0.29	265.81	0.17	4.05	0.24	4.89	2.90	0.00	7.565	0.771	17.36	97.31
	3	S	20.835485	-156.12449	0.43	2.40	0.16	326.96	0.21	5.36	0.64	7.92	1.53	0.00	7.514	0.491	17.39	97.14
	3	B	20.835485	-156.12449	1.16	6.13	0.15	419.75	0.16	3.02	1.32	9.30	1.93	0.03	7.476	0.179	17.41	96.42
	4	S	20.835744	-156.12435	0.64	3.61	0.19	352.93	0.19	4.10	0.83	7.91	1.01	0.00	7.478	0.117	17.34	93.30
	4	B	20.835744	-156.12435	2.00	8.76	0.18	513.44	0.23	3.39	2.23	12.33	1.05	0.17	7.419	0.857	17.24	90.54
	5	S	20.835969	-156.12437	0.71	3.65	0.18	354.89	0.16	6.79	0.87	10.63	2.24	0.01	7.410	0.187	17.44	91.51
	5	B	20.835969	-156.12437	1.84	8.14	0.16	498.75	0.21	4.41	2.05	12.71	NA	0.16	7.373	0.312	17.34	91.97
	6	S	20.836194	-156.12409	0.30	2.12	0.17	309.29	0.22	5.98	0.52	8.28	1.32	0.00	7.405	0.148	17.44	86.41
	6	B	20.836194	-156.12409	2.41	9.90	0.20	540.47	0.20	4.55	2.62	14.65	1.53	0.25	7.325	0.662	17.42	85.23
	7	S	20.836328	-156.12394	0.80	4.16	0.19	371.96	0.12	4.36	0.92	8.72	1.18	0.02	7.348	0.203	17.47	91.25
	7	B	20.836328	-156.12394	1.15	5.81	0.14	420.61	0.23	4.91	1.38	10.87	1.14	0.06	7.323	0.249	17.42	91.28
	8	S	20.83642	-156.1239	0.44	1.77	0.25	150.82	0.25	7.00	0.70	9.02	NA	22.91	8.086	0.428	21.30	99.62
	9	S	20.836602	-156.12388	0.18	1.59	0.33	32.63	0.41	5.93	0.59	7.86	11.98	33.46	8.088	1.464	24.17	98.60
	10	S	20.836783	-156.12386	0.16	0.17	0.33	30.53	0.40	8.34	0.56	8.84	10.47	33.57	8.120	1.986	24.20	96.96
WAILUA IKI WEST	1	S	20.83651	-156.12599	0.16	0.08	0.26	215.91	0.18	6.20	0.34	6.54	3.54	0.00	7.506	0.257	17.85	96.45
	2	S	20.836493	-156.1258	0.88	2.98	0.28	340.03	0.15	6.88	1.03	10.14	3.15	0.02	7.351	0.319	17.83	92.26
	2	B	20.836493	-156.1258	1.88	6.28	0.25	445.48	0.19	4.26	2.07	10.80	4.15	0.09	7.280	0.319	17.69	93.78
	3	S	20.836518	-156.12568	0.78	2.65	0.32	325.84	0.11	4.71	0.89	7.69	4.65	0.04	7.296	0.249	17.72	94.82
	3	B	20.836518	-156.12568	1.33	4.73	0.34	387.01	0.21	4.45	1.54	9.52	5.70	0.13	7.279	0.413	17.63	93.29
	4	S	20.836564	-156.12555	1.13	3.82	0.33	357.70	0.22	4.49	1.35	8.64	2.17	0.12	7.281	0.460	17.72	93.68
	4	B	20.836564	-156.12555	0.83	3.19	0.33	351.39	0.08	4.77	0.91	8.30	2.30	0.13	7.288	0.241	17.71	93.34
	5	S	20.836603	-156.12545	1.07	3.75	0.30	351.62	0.25	4.83	1.32	8.89	4.81	0.15	7.316	0.210	17.74	93.31
	5	B	20.836603	-156.12545	1.03	3.29	0.30	345.77	0.01	4.63	1.04	8.23	4.63	0.12	7.318	0.280	17.75	94.28
	6	S	20.836674	-156.12536	1.02	3.83	0.34	357.91	0.20	5.73	1.22	9.91	3.79	0.14	7.320	0.280	17.73	93.41
	6	B	20.836674	-156.12536	1.11	4.22	0.33	363.43	0.26	4.93	1.37	9.48	3.74	0.16	7.311	0.343	17.71	93.07
	7	S	20.836785	-156.12533	1.56	5.01	1.23	389.94	0.17	8.77	1.73	15.01	4.72	0.18	7.412	0.608	17.68	93.99
	8	S	20.836866	-156.12529	1.23	4.62	0.25	381.41	0.17	6.52	1.40	11.39	3.89	0.13	7.355	0.312	17.69	94.99
	9	S	20.836927	-156.12526	1.24	4.35	0.19	368.55	0.07	3.59	1.32	8.13	7.27	3.26	7.578	0.319	18.84	97.08
	10	S	20.83707	-156.12511	0.74	2.21	0.27	197.02	0.15	5.71	0.89	8.19	NA	20.24	8.115	0.343	19.32	98.77
OOPUOLA	1	S	20.888981°	-156.196642	0.07	0.28	0.35	233.43	0.17	4.68	0.24	5.31	2.44	3.84	6.193	0.078	21.23	22.99
	2	S	20.889016°	-156.196580	0.15	0.70	4.82	100.61	0.31	8.32	0.47	13.85	8.24	27.58	6.675	0.070	23.11	27.41
	3	S	20.889068°	-156.196523	0.10	0.62	3.94	108.18	0.35	6.71	0.46	11.28	NA	27.29	6.595	0.070	23.18	16.14
	4	S	20.889098°	-156.196435	0.15	0.52	6.49	134.40	0.24	6.55	0.40	13.57	NA	23.34	6.555	0.156	23.03	19.12
	5	S	20.889143°	-156.196341	0.08	1.25	4.12	154.85	0.29	7.19	0.37	12.57	6.86	21.54	6.627	0.047	22.95	29.42
	6	S	20.889191°	-156.196283	0.12	0.90	7.45	184.36	0.27	5.75	0.40	14.11	6.24	16.81	6.538	0.055	22.62	27.79
	7	S	20.889156	-156.19621	0.35	1.83	0.26	90.60	0.22	5.97	0.57	8.06	NA	26.25	7.802	0.335	23.95	100.86
	8	S	20.889205	-156.19615	0.31	1.27	0.73	42.02	0.30	7.69	0.62	9.69	5.06	32.12	8.087	0.374	23.91	101.09
	9	S	20.889236	-156.19614	0.32	1.25	0.88	41.05	0.25	7.06	0.58	9.19	7.59	32.30	8.090	0.514	23.87	100.72
	10	S	20.889266	-156.19609	0.31	1.23	0.48	43.05	0.30	5.82	0.62	7.53	3.63	32.14	8.095	0.397	23.88	100.82
	11	S	20.889304	-156.19598	0.32	1.23	0.91	38.22	0.29	5.42	0.62	7.56	3.53	32.52	8.088	0.335	23.63	98.60
	12	S	20.889408	-156.19583	0.30	1.25	0.79	39.30	0.32	5.62	0.62	7.66	3.84	32.55	8.081	0.226	23.60	100.08
	12	B	20.889408	-156.19583	0.25	0.87	0.79	12.41	0.32	7.27	0.58	8.93	2.59	34.47	8.069	0.288	24.05	93.86

TABLE A-6. Results of water chemistry sampling conducted on January 5, 2018, at Wailua Nui, Wailua Iki, and Oopuola streams in East Maui. "S" indicates surface sample; "B" indicates bottom sample. Nutrient concentrations are shown as micrograms per liter (µg/L). Locations of sampling stations are shown in Chapter 4 of text.

STREAM	Station	DEPTH	LAT	LON	PO4 (µM)	NO3 (µM)	NH4 (µM)	Si (µM)	TOP (µM)	TON (µM)	TP (µM)	TN (µM)	TURB (ntu)	SALT (ppt)	pH (rel)	Chl-a (µg/l)	TEMP deg C	DO %sat
WAILUA NUI EAST	1	B	20.83491	-156.12458	1.43	2.79	1.68	7043	4.96	59.57	6.39	64.05	1.49	0.00	7.557	0.140	17.35	97.58
	1	S	20.83491	-156.12458	1.12	2.23	3.78	7109	5.27	82.82	6.39	88.83	1.24	0.00	7.573	0.241	17.37	97.34
	2	S	20.835239	-156.12461	2.36	8.81	5.31	7366	4.96	62.81	7.32	76.93	2.87	0.00	7.554	0.312	17.36	97.89
	2	B	20.835239	-156.12461	2.05	7.69	4.02	7443	5.27	56.68	7.32	68.39	2.90	0.00	7.565	0.771	17.36	97.31
	3	S	20.835485	-156.12449	13.21	33.59	2.22	9155	6.51	75.00	19.72	110.81	1.53	0.00	7.514	0.491	17.39	97.14
	3	B	20.835485	-156.12449	35.83	85.82	2.10	11753	4.96	42.21	40.80	130.13	1.93	0.03	7.476	0.179	17.41	96.42
	4	S	20.835744	-156.12435	19.72	50.54	2.67	9882	5.89	57.47	25.61	110.67	1.01	0.00	7.478	0.117	17.34	93.30
	4	B	20.835744	-156.12435	61.85	122.64	2.47	14376	7.15	47.44	69.01	172.55	1.05	0.17	7.419	0.857	17.24	90.54
	5	S	20.835969	-156.12437	21.88	51.10	2.52	9937	4.96	95.13	26.85	148.75	2.24	0.01	7.410	0.187	17.44	91.51
	5	B	20.835969	-156.12437	56.89	113.96	2.23	13965	6.53	61.68	63.43	177.87	NA	0.16	7.373	0.312	17.34	91.97
	6	S	20.836194	-156.12409	9.18	29.68	2.38	8660	6.82	83.79	16.00	115.85	1.32	0.00	7.405	0.148	17.44	86.41
	6	B	20.836194	-156.12409	74.86	138.61	2.77	15133	6.23	63.66	81.10	205.03	1.53	0.25	7.325	0.662	17.42	85.23
	7	S	20.836328	-156.12394	24.67	58.25	2.66	10415	3.72	61.11	28.40	122.01	1.18	0.02	7.348	0.203	17.47	91.25
	7	B	20.836328	-156.12394	35.52	81.35	1.96	11777	7.14	68.81	42.66	152.11	1.14	0.06	7.323	0.249	17.42	91.28
	8	S	20.83642	-156.1239	13.76	24.74	3.48	4223	7.82	97.99	21.58	126.21	NA	22.91	8.086	0.428	21.30	99.62
	9	S	20.836602	-156.12388	5.48	22.22	4.67	914	12.68	83.09	18.17	109.97	11.98	33.46	8.088	1.464	24.17	98.60
	10	S	20.836783	-156.12386	4.85	2.33	4.63	855	12.39	116.73	17.24	123.69	10.47	33.57	8.120	1.986	24.20	96.96
WAILUA IKI WEST	1	S	20.83651	-156.12599	4.84	1.11	3.64	6045	5.58	86.74	10.42	91.49	3.54	0.00	7.506	0.257	17.85	96.45
	2	S	20.836493	-156.1258	27.15	41.72	3.91	9521	4.65	96.25	31.81	141.89	3.15	0.02	7.351	0.319	17.83	92.26
	2	B	20.836493	-156.1258	58.14	87.93	3.49	12473	5.90	59.71	64.05	151.13	4.15	0.09	7.280	0.319	17.69	93.78
	3	S	20.836518	-156.12568	24.05	37.11	4.48	9123	3.42	66.01	27.47	107.59	4.65	0.04	7.296	0.249	17.72	94.82
	3	B	20.836518	-156.12568	41.09	66.23	4.74	10836	6.53	62.24	47.62	133.21	5.70	0.13	7.279	0.413	17.63	93.29
	4	S	20.836564	-156.12555	34.89	53.49	4.60	10016	6.84	62.80	41.73	120.89	2.17	0.12	7.281	0.460	17.72	93.68
	4	B	20.836564	-156.12555	25.59	44.67	4.62	9839	2.50	66.84	28.09	116.13	2.30	0.13	7.288	0.241	17.71	93.34
	5	S	20.836603	-156.12545	33.03	52.51	4.20	9845	7.77	67.68	40.80	124.39	4.81	0.15	7.316	0.210	17.74	93.31
	5	B	20.836603	-156.12545	31.79	46.07	4.19	9682	0.33	64.89	32.12	115.15	4.63	0.12	7.318	0.280	17.75	94.28
	6	S	20.836674	-156.12536	31.48	53.63	4.75	10021	6.22	80.29	37.70	138.67	3.79	0.14	7.320	0.280	17.73	93.41
	6	B	20.836674	-156.12536	34.26	59.09	4.61	10176	8.08	68.95	42.35	132.65	3.74	0.16	7.311	0.343	17.71	93.07
	7	S	20.836785	-156.12533	48.21	70.14	17.19	10918	5.29	122.74	53.51	210.07	4.72	0.18	7.412	0.608	17.68	93.99
	8	S	20.836866	-156.12529	37.99	64.68	3.49	10679	5.29	91.21	43.28	159.39	3.89	0.13	7.355	0.312	17.69	94.99
	9	S	20.836927	-156.12526	38.49	60.89	2.65	10319	2.31	50.21	40.80	113.75	7.27	3.26	7.578	0.319	18.84	97.08
	10	S	20.83707	-156.12511	22.81	30.89	3.77	5517	4.66	79.93	27.47	114.59	NA	20.24	8.115	0.343	19.32	98.77
OOPUOLA	1	S	20.888981°	-156.196642	2.14	3.86	4.91	6536	5.18	65.50	7.32	74.27	2.44	3.84	6.193	0.078	21.23	22.99
	2	S	20.889016°	-156.196580	4.75	9.85	67.49	2817	9.70	116.49	14.45	193.83	8.24	27.58	6.675	0.070	23.11	27.41
	3	S	20.889068°	-156.196523	3.24	8.73	55.17	3029	10.90	93.95	14.14	157.85	NA	27.29	6.595	0.070	23.18	16.14
	4	S	20.889098°	-156.196435	4.71	7.34	90.86	3763	7.56	91.71	12.28	189.91	NA	23.34	6.555	0.156	23.03	19.12
	5	S	20.889143°	-156.196341	2.48	17.55	57.69	4336	8.87	100.67	11.35	175.91	6.86	21.54	6.627	0.047	22.95	29.42
	6	S	20.889191°	-156.196283	3.75	12.66	104.31	5162	8.52	80.50	12.28	197.47	6.24	16.81	6.538	0.055	22.62	27.79
	7	S	20.889156	-156.19621	10.82	25.60	3.63	2537	6.73	83.55	17.55	112.77	NA	26.25	7.802	0.335	23.95	100.86
	8	S	20.889205	-156.19615	9.70	17.74	10.21	1177	9.40	107.65	19.10	135.59	5.06	32.12	8.087	0.374	23.91	101.09
	9	S	20.889236	-156.19614	9.98	17.46	12.30	1149	7.87	98.84	17.86	128.59	7.59	32.30	8.090	0.514	23.87	100.72
	10	S	20.889266	-156.19609	9.70	17.18	6.71	1205	9.40	81.47	19.10	105.35	3.63	32.14	8.095	0.397	23.88	100.82
	11	S	20.889304	-156.19598	9.95	17.18	12.73	1070	9.14	75.86	19.10	105.77	3.53	32.52	8.088	0.335	23.63	98.60
	12	S	20.889408	-156.19583	9.33	17.46	11.06	1100	9.77	78.66	19.10	107.17	3.84	32.55	8.081	0.226	23.60	100.08
	12	B	20.889408	-156.19583	7.82	12.14	11.05	347	10.03	101.76	17.86	124.95	2.59	34.47	8.069	0.288	24.05	93.86

TABLE A-7. Results of water chemistry sampling conducted on July 19, 2018, at Honomanu Stream in East Maui. "S" indicates surface sample; "B" indicates bottom sample. Nutrient concentrations are shown in micromolar units (µM). Location of sampling station is shown in Chapter 4 of text.

STREAM	STATION	DEPTH	LAT	LON	PO4 (µM)	NO3 (µM)	NH4 (µM)	Si (µM)	TOP (µM)	TON (µM)	TP (µM)	TN (µM)	TURB NTU	SALT ‰	pH	Chl-a (µg/L)	TEMP deg C	DO %sat
HONOMANU	101	S	20.85930	-156.16746	0.56	1.74	0.50	272	0.61	5.32	1.17	7.56	3.01	0.00	7.259	0.358	23.83	103.9
	102	S	20.85976	-156.16720	0.67	2.38	0.50	297	0.54	5.66	1.21	8.54	3.05	0.00	7.248	0.709	24.01	103.17
	102	B	20.85976	-156.16720	0.81	2.44	0.50	337	0.48	4.67	1.29	7.61	3.41	0.00	7.272	1.020	23.87	103.07
	103	S	20.86012	-156.16710	0.75	2.67	0.53	314	0.55	6.47	1.30	9.67	3.54	0.00	7.237	0.857	23.87	107.04
	103	B	20.86012	-156.16710	0.90	2.80	0.57	343	0.46	4.91	1.36	8.28	5.16	0.00	7.247	4.074	23.35	102.46
	104	S	20.86056	-156.16700	0.77	2.69	0.43	331	0.49	6.02	1.26	9.14	3.96	0.00	7.228	0.654	23.79	103.25
	104	B	20.86056	-156.16700	0.79	2.75	0.48	335	0.45	4.84	1.24	8.07	4.48	0.00	7.224	1.137	23.37	101.50
	105	S	20.86089	-156.16707	0.79	2.62	0.51	331	0.51	7.16	1.30	10.29	7.96	0.01	7.221	0.966	23.80	102.29
	106	S	20.86115	-156.16721	0.89	1.63	0.83	376	0.32	6.12	1.21	8.58	4.62	0.01	7.209	0.506	27.53	111.33
	107	S	20.86133	-156.16716	0.80	2.46	0.67	339	0.41	6.18	1.21	9.31	4.85	0.00	7.233	0.592	24.12	103.79
	107	B	20.86133	-156.16716	0.56	1.27	0.73	188	0.16	5.46	0.72	7.46	4.82	16.14	8.044	0.405	24.25	104.23
	108	S	20.86148	-156.16706	0.71	2.54	0.50	328	0.45	5.41	1.16	8.45	4.49	0.58	7.342	0.280	24.55	103.25
	108	B	20.86148	-156.16706	0.44	0.57	0.44	122	0.11	5.41	0.55	6.42	12.55	22.74	8.154	0.452	25.95	104.71
	109	S	20.86157	-156.16691	0.72	2.30	0.47	309	0.41	5.70	1.13	8.47	4.49	3.31	7.402	0.413	24.55	102.46
	109	B	20.86157	-156.16691	0.37	0.40	0.45	101	0.11	6.15	0.48	7.00	6.89	24.82	8.173	0.374	26.22	107.90
	110	S	20.86150	-156.16671	0.70	1.99	0.49	293	0.43	8.07	1.13	10.55	4.41	4.85	7.526	0.475	24.66	104.84
	110	B	20.86150	-156.16671	0.36	0.29	0.50	78	0.13	6.24	0.49	7.03	4.54	27.37	8.181	0.343	26.32	109.73
	111	S	20.86139	-156.16656	0.65	1.85	0.57	248	0.39	5.34	1.04	7.76	5.50	9.82	7.924	0.358	22.69	105.07
	111	B	20.86139	-156.16656	0.39	0.43	0.48	91	0.10	7.51	0.49	8.42	6.07	25.78	8.193	0.374	26.19	109.45
	112	B	20.86084	-156.16629	0.30	0.06	0.36	56	0.27	6.74	0.57	7.16	16.11	29.25	8.182	1.472	26.44	113.21
	113	S	20.86068	-156.16589	0.20	0.02	0.30	69	0.24	7.70	0.44	8.02	6.05	28.26	8.200	1.098	26.46	106.1
	113	B	20.86068	-156.16589	0.30	0.09	0.37	66	0.15	6.69	0.45	7.15	8.38	28.50	8.202	1.091	26.47	111.45
	114	S	20.86105	-156.16563	0.30	0.18	0.38	64	0.15	6.74	0.45	7.30	7.94	28.87	8.195	1.262	26.56	110.19
	114	B	20.86105	-156.16563	0.38	0.02	0.49	35	0.19	11.45	0.57	11.96	110.86	30.14	8.171	14.614	26.12	112.36
	115	S	20.86121	-156.16600	0.48	0.29	0.44	70	0.02	9.17	0.50	9.90	14.57	28.03	8.211	0.849	26.41	107.77
	115	B	20.86121	-156.16600	0.40	0.00	0.26	30	0.02	5.57	0.42	5.83	98.44	31.30	8.184	8.919	26.16	114.19
	116	S	20.86164	-156.16613	0.39	0.39	0.36	82	0.09	6.44	0.48	7.19	2.25	27.52	8.213	0.436	26.51	105.02
	116	B	20.86164	-156.16613	0.41	0.06	0.31	24	0.02	7.20	0.43	7.57	20.65	32.88	8.196	0.826	26.08	115.90

TABLE A-8. Results of water chemistry sampling conducted on July 19, 2018, at Honomanu Stream in East Maui. "S" indicates surface sample; "B" indicates bottom sample. Nutrient concentrations are shown as micrograms per liter (µg/L). Location of sampling station is shown in Chapter 4 of text.

STREAM	STATION	DEPTH	LAT	LON	PO4 (µg/L)	NO3 (µg/L)	NH4 (µg/L)	Si (µg/L)	TOP (µg/L)	TON (µg/L)	TP (µg/L)	TN (µg/L)	TURB NTU	SALT ‰	pH	Chl-a (µg/L)	TEMP deg C	DO %sat
HONOMANU	101	S	20.85930	-156.16746	17.36	24.36	7.00	7627	18.91	74.48	36.27	105.84	3.01	0.00	7.259	0.358	23.83	103.9
	102	S	20.85976	-156.16720	20.77	33.32	7.00	8304	16.74	79.24	37.51	119.56	3.05	0.00	7.248	0.709	24.01	103.17
	102	B	20.85976	-156.16720	25.11	34.16	7.00	9432	14.88	65.38	39.99	106.54	3.41	0.00	7.272	1.020	23.87	103.07
	103	S	20.86012	-156.16710	23.25	37.38	7.42	8793	17.05	90.58	40.30	135.38	3.54	0.00	7.237	0.857	23.87	107.04
	103	B	20.86012	-156.16710	27.90	39.20	7.98	9611	14.26	68.74	42.16	115.92	5.16	0.00	7.247	4.074	23.35	102.46
	104	S	20.86056	-156.16700	23.87	37.66	6.02	9270	15.19	84.28	39.06	127.96	3.96	0.00	7.228	0.654	23.79	103.25
	104	B	20.86056	-156.16700	24.49	38.50	6.72	9370	13.95	67.76	38.44	112.98	4.48	0.00	7.224	1.137	23.37	101.50
	105	S	20.86089	-156.16707	24.49	36.68	7.14	9279	15.81	100.24	40.30	144.06	7.96	0.01	7.221	0.966	23.80	102.29
	106	S	20.86115	-156.16721	27.59	22.82	11.62	10537	9.92	85.68	37.51	120.12	4.62	0.01	7.209	0.506	27.53	111.33
	107	S	20.86133	-156.16716	24.80	34.44	9.38	9503	12.71	86.52	37.51	130.34	4.85	0.00	7.233	0.592	24.12	103.79
	107	B	20.86133	-156.16716	17.34	17.75	10.24	5254	4.96	76.42	22.30	104.41	4.82	16.14	8.044	0.405	24.25	104.23
	108	S	20.86148	-156.16706	21.95	35.51	6.93	9193	13.95	75.81	35.90	118.25	4.49	0.58	7.342	0.280	24.55	103.25
	108	B	20.86148	-156.16706	13.59	7.98	6.09	3420	3.41	75.81	17.00	89.88	12.55	22.74	8.154	0.452	25.95	104.71
	109	S	20.86157	-156.16691	22.31	32.22	6.60	8659	12.71	79.78	35.02	118.60	4.49	3.31	7.402	0.413	24.55	102.46
	109	B	20.86157	-156.16691	11.53	5.57	6.26	2820	3.41	86.14	14.94	97.97	6.89	24.82	8.173	0.374	26.22	107.90
	110	S	20.86150	-156.16671	21.85	27.89	6.84	8202	13.33	113.00	35.18	147.73	4.41	4.85	7.526	0.475	24.66	104.84
	110	B	20.86150	-156.16671	11.28	4.11	6.94	2192	4.03	87.42	15.31	98.47	4.54	27.37	8.181	0.343	26.32	109.73
	111	S	20.86139	-156.16656	20.12	25.95	7.92	6946	12.09	74.82	32.21	108.69	5.50	9.82	7.924	0.358	22.69	105.07
	111	B	20.86139	-156.16656	12.06	6.06	6.71	2545	3.10	105.15	15.16	117.92	6.07	25.78	8.193	0.374	26.19	109.45
	112	B	20.86084	-156.16629	9.24	0.88	5.03	1573	8.37	94.37	17.61	100.28	16.11	29.25	8.182	1.472	26.44	113.21
	113	S	20.86068	-156.16589	6.24	0.26	4.17	1928	7.44	107.83	13.68	112.26	6.05	28.26	8.200	1.098	26.46	106.1
	113	B	20.86068	-156.16589	9.31	1.22	5.12	1856	4.65	93.72	13.96	100.06	8.38	28.50	8.202	1.091	26.47	111.45
	114	S	20.86105	-156.16563	9.28	2.45	5.36	1780	4.65	94.32	13.93	102.13	7.94	28.87	8.195	1.262	26.56	110.19
	114	B	20.86105	-156.16563	11.63	0.25	6.88	982	5.89	160.28	17.52	167.41	110.86	30.14	8.171	14.614	26.12	112.36
	115	S	20.86121	-156.16600	14.94	4.06	6.16	1952	0.62	128.38	15.56	138.60	14.57	28.03	8.211	0.849	26.41	107.77
	115	B	20.86121	-156.16600	12.45	0.02	3.66	852	0.62	77.96	13.07	81.64	98.44	31.30	8.184	8.919	26.16	114.19
	116	S	20.86164	-156.16613	12.20	5.50	5.10	2294	2.79	90.10	14.99	100.70	2.25	27.52	8.213	0.436	26.51	105.02
	116	B	20.86164	-156.16613	12.61	0.87	4.31	674	0.62	100.83	13.23	106.01	20.65	32.88	8.196	0.826	26.08	115.90

TABLE A-9. Results of water chemistry sampling conducted on July 20, 2018, at Hanawi, Waiaaka, and Kopiliula Streams in East Maui. "S" indicates surface sample; "B" indicates bottom sample. "na" indicates lost sample. Nutrient concentrations are shown in micromolar units (µM). Locations of sampling stations are shown in Chapter 4 of text.

STREAM	STATION	DEPTH	LAT	LON	PO4 (µM)	NO3 (µM)	NH4 (µM)	Si (µM)	TOP (µM)	TON (µM)	TP (µM)	TN (µM)	TURB NTU	SALT ‰	pH	Chl-a (µg/L)	TEMP deg C	DO %sat
HONOMANU	101	S	20.82447	-156.10133	0.72	3.77	0.47	296	0.19	4.97	0.91	9.21	1.89	0.00	8.069	1.200	19.83	110.78
	102	S	20.82470	-156.10126	0.79	3.84	0.39	297	0.13	3.44	0.92	7.67	1.24	0.00	8.043	0.530	19.83	112.34
	102	B	20.82470	-156.10126	0.79	3.49	0.35	298	0.13	3.84	0.92	7.68	1.44	0.00	8.018	0.491	19.83	113.25
	103	S	20.82486	-156.10109	0.82	3.76	0.33	298	0.15	5.30	0.97	9.39	1.33	0.00	8.005	1.799	19.85	113.60
	103	B	20.82486	-156.10109	0.83	3.79	0.35	297	0.10	3.73	0.93	7.87	1.27	0.00	8.004	0.724	19.84	114.00
	104	S	20.82489	-156.10093	0.80	3.75	0.32	297	0.08	2.42	0.88	6.49	1.90	0.00	7.989	0.779	19.88	113.58
	104	B	20.82489	-156.10093	0.79	3.51	0.31	297	0.05	3.32	0.84	7.14	1.46	0.00	7.981	0.600	19.87	113.92
	105	S	20.82499	-156.10089	0.85	3.66	0.31	297	0.15	2.98	1.00	6.95	1.40	0.00	7.983	0.467	19.89	112.07
	105	B	20.82499	-156.10089	0.77	3.42	0.30	297	0.12	3.26	0.89	6.98	1.75	0.00	7.973	0.732	19.88	113.33
	106	S	20.82506	-156.10089	0.77	3.53	0.35	298	0.02	2.88	0.79	6.76	-	0.00	7.971	0.678	19.91	108.20
	107	S	20.82518	-156.10083	0.62	3.53	0.30	299	0.07	1.87	0.69	5.70	-	0.00	7.977	0.537	19.90	110.00
	108	S	20.82525	-156.10081	0.35	0.85	0.23	72	0.02	5.30	0.37	6.38	-	26.79	8.114	0.335	24.34	114.95
	108	B	20.82525	-156.10081	0.31	0.16	0.21	17	0.03	4.98	0.34	5.35	-	33.43	8.122	0.499	25.46	117.25
	109	S	20.82546	-156.10073	0.36	0.64	0.20	74	0.03	5.14	0.39	5.98	-	26.80	8.153	0.273	23.75	111.34
	109	B	20.82546	-156.10073	0.31	0.01	0.19	7	0.02	6.31	0.33	6.51	-	34.49	8.134	0.195	25.44	116.34
WAIAAKA EAST	101	S	20.82626	-156.11590	0.15	0.08	0.28	193	0.31	4.45	0.46	4.81	2.57	0.00	7.831	1.387	21.33	112.34
	102	S	20.82634	-156.11574	0.17	0.05	0.21	190	0.19	3.81	0.36	4.07	2.72	0.00	7.863	1.052	21.42	113.43
	103	S	20.82654	-156.11564	0.16	0.07	0.21	189	0.20	3.62	0.36	3.90	3.07	0.00	7.844	1.379	21.47	114.52
	104	S	20.82663	-156.11556	0.12	0.08	0.20	189	0.30	3.38	0.42	3.66	3.32	0.00	7.822	1.106	21.56	115.62
	105	S	20.82673	-156.11544	0.18	0.04	0.13	188	0.24	3.10	0.42	3.27	3.10	0.00	7.855	0.779	21.62	116.09
	106	S	20.82678	-156.11537	0.18	0.17	0.17	167	0.18	3.05	0.36	3.39	2.04	4.37	8.146	1.075	22.48	115.52
	107	S	20.82683	-156.11542	0.21	0.12	0.19	110	0.31	4.07	0.52	4.38	6.37	15.73	8.218	0.748	23.62	115.98
	108	S	20.82688	-156.11535	0.15	0.11	0.15	110	0.23	3.80	0.38	4.06	15.09	15.68	8.228	0.779	25.14	115.71
	109	S	20.82692	-156.11529	0.16	0.03	0.13	35	0.19	5.17	0.35	5.33	25.87	29.82	8.132	0.483	24.83	111.47
	109	B	20.82692	-156.11529	0.17	0.03	0.12	37	0.16	6.73	0.33	6.88	65.97	29.68	8.141	0.444	25.14	115.19
WAIAAKA WEST	101	S	20.82605	-156.11493	0.17	1.25	0.25	254	0.32	5.41	0.49	6.91	27.22	0.00	7.874	0.405	20.53	110.09
	101	B	20.82605	-156.11493	0.27	1.66	0.20	257	0.29	5.58	0.56	7.44	26.32	0.00	7.746	0.241	20.49	111.66
	102	S	20.82610	-156.11482	0.36	1.78	0.30	255	0.24	5.96	0.60	8.04	1.45	0.00	7.831	0.280	20.54	112.61
	103	S	20.82629	-156.11497	0.31	1.60	0.31	255	0.22	5.56	0.53	7.47	2.59	0.00	7.832	0.296	20.55	110.68
	104	S	20.82632	-156.11494	0.34	1.62	0.21	256	0.25	6.25	0.59	8.08	2.12	0.00	7.839	0.382	20.58	113.27
	105	S	20.82649	-156.11503	0.33	1.15	0.55	187	0.44	8.54	0.77	10.24	9.01	9.43	8.134	0.701	22.05	112.32
	106	S	20.82652	-156.11506	0.23	0.44	0.27	120	0.30	7.46	0.53	8.17	8.26	18.80	8.172	0.421	23.66	115.73
KOPILIULA	101	S	20.83118	-156.11869	0.01	0.14	0.29	141	0.39	8.13	0.40	8.56	4.38	0.00	7.881	1.231	23.51	112.58
	101	B	20.83118	-156.11869	0.02	0.13	0.32	142	0.29	8.53	0.31	8.98	4.14	0.00	8.165	1.091	23.48	117.68
	102	S	20.83127	-156.11867	0.02	0.12	0.28	140	0.62	8.65	0.64	9.05	4.09	0.00	8.221	1.901	23.61	116.59
	102	B	20.83127	-156.11867	0.01	0.10	0.26	140	0.32	7.39	0.33	7.75	4.35	0.00	8.230	1.675	23.60	118.04
	103	S	20.83140	-156.11854	0.04	0.09	0.27	142	0.53	8.09	0.57	8.45	5.03	0.00	8.157	1.254	23.65	113.01
	103	B	20.83140	-156.11854	0.05	0.08	0.25	142	0.61	7.73	0.66	8.06	4.74	0.00	8.202	1.083	23.66	118.65
	104	S	20.83157	-156.11848	0.05	0.07	0.38	141	0.63	8.67	0.68	9.12	6.31	0.00	8.205	2.189	23.72	111.60
	104	B	20.83157	-156.11848	0.03	0.05	0.34	141	0.56	7.08	0.59	7.47	6.59	0.00	8.201	2.649	23.74	118.77
	105	S	20.83183	-156.11841	0.03	0.04	0.29	142	0.57	7.12	0.60	7.45	8.82	0.00	8.167	1.566	23.92	120.43
	106	S	20.83197	-156.11837	0.02	0.04	0.30	141	0.75	7.83	0.77	8.17	3.84	0.00	8.065	1.192	23.94	119.79
	107	S	20.83220	-156.11838	0.01	0.05	0.15	141	0.43	7.13	0.44	7.33	5.21	0.00	8.055	1.176	23.13	113.54
	107	B	20.83220	-156.11838	0.00	0.04	0.12	141	0.45	8.52	0.45	8.68	6.13	0.00	8.189	2.041	24.21	119.37
	108	S	20.83228	-156.11836	0.03	0.08	1.07	141	0.42	8.93	0.45	10.08	4.52	0.00	8.320	1.870	24.03	120.56
	108	B	20.83228	-156.11836	0.03	0.04	0.13	141	0.53	8.54	0.56	8.71	4.79	0.00	8.387	2.649	24.07	120.76
	109	S	20.83237	-156.11836	0.02	0.05	0.13	142	0.38	8.03	0.40	8.21	3.97	0.00	8.306	1.098	24.08	122.26
	109	B	20.83237	-156.11836	0.02	0.05	0.10	144	0.38	7.10	0.40	7.25	4.09	0.00	8.301	1.285	24.06	122.62
	110	S	20.83243	-156.11836	0.03	0.01	0.11	145	0.41	7.47	0.44	7.59	12.97	0.03	8.269	1.122	24.11	116.46
	111	S	20.83247	-156.11828	0.00	0.05	0.19	123	0.29	6.21	0.29	6.45	30.41	6.02	8.331	0.997	24.32	115.43
	112	S	20.83254	-156.11817	0.15	0.00	0.18	17	0.27	7.94	0.42	8.12	15.72	33.01	8.135	0.826	25.54	114.48
	112	B	20.83254	-156.11817	0.14	0.00	0.23	20	0.27	8.65	0.41	8.88	34.24	32.58	8.153	0.639	25.69	122.63
	113	S	20.83263	-156.11805	0.15	0.02	0.15	21	0.28	8.02	0.43	8.19	4.86	33.08	8.158	0.647	25.68	113.50
	113	B	20.83263	-156.11805	0.17	0.00	0.51	15	0.38	10.73	0.55	11.24	53.66	33.84	8.164	3.225	25.68	123.42

TABLE A-10. Results of water chemistry sampling conducted on July 20, 2018, at Hanawi, Waiaaka, and Kopiliula Streams in East Maui. "S" indicates surface sample; "B" indicates bottom sample. "na" indicates lost sample. Nutrient concentrations are shown as micrograms per liter (µg/L). Locations of sampling stations are shown in Chapter 4 of text.

STREAM	STATION	DEPTH	LAT	LON	PO4 (µg/L)	NO3 (µg/L)	NH4 (µg/L)	Si (µg/L)	TOP (µg/L)	TON (µg/L)	TP (µg/L)	TN (µg/L)	TURB NTU	SALT ‰	pH	Chl-a (µg/L)	TEMP deg C	DO %sat
HONOMANU	101	S	20.82447	-156.10133	22.32	52.78	6.58	8300	5.89	69.58	28.21	128.94	1.89	0.00	8.069	1.200	19.83	110.78
	102	S	20.82470	-156.10126	24.49	53.76	5.46	8307	4.03	48.16	28.52	107.38	1.24	0.00	8.043	0.530	19.83	112.34
	102	B	20.82470	-156.10126	24.49	48.86	4.90	8343	4.03	53.76	28.52	107.52	1.44	0.00	8.018	0.491	19.83	113.25
	103	S	20.82486	-156.10109	25.42	52.64	4.62	8340	4.65	74.20	30.07	131.46	1.33	0.00	8.005	1.799	19.85	113.60
	103	B	20.82486	-156.10109	25.73	53.06	4.90	8326	3.10	52.22	28.83	110.18	1.27	0.00	8.004	0.724	19.84	114.00
	104	S	20.82489	-156.10093	24.80	52.50	4.48	8320	2.48	33.88	27.28	90.86	1.90	0.00	7.989	0.779	19.88	113.58
	104	B	20.82489	-156.10093	24.49	49.14	4.34	8319	1.55	46.48	26.04	99.96	1.46	0.00	7.981	0.600	19.87	113.92
	105	S	20.82499	-156.10089	26.35	51.24	4.34	8305	4.65	41.72	31.00	97.30	1.40	0.00	7.983	0.467	19.89	112.07
	105	B	20.82499	-156.10089	23.87	47.88	4.20	8326	3.72	45.64	27.59	97.72	1.75	0.00	7.973	0.732	19.88	113.33
	106	S	20.82506	-156.10089	23.87	49.42	4.90	8343	0.62	40.32	24.49	94.64	-	0.00	7.971	0.678	19.91	108.20
	107	S	20.82518	-156.10083	19.22	49.42	4.20	8364	2.17	26.18	21.39	79.80	-	0.00	7.977	0.537	19.90	110.00
	108	S	20.82525	-156.10081	10.72	11.86	3.23	2006	0.62	74.19	11.34	89.28	-	26.79	8.114	0.335	24.34	114.95
	108	B	20.82525	-156.10081	9.76	2.23	2.99	462	0.93	69.67	10.69	74.89	-	33.43	8.122	0.499	25.46	117.25
	109	S	20.82546	-156.10073	11.03	8.92	2.80	2084	0.93	71.96	11.96	83.68	-	26.80	8.153	0.273	23.75	111.34
	109	B	20.82546	-156.10073	9.66	0.18	2.72	187	0.62	88.28	10.28	91.18	-	34.49	8.134	0.195	25.44	116.34
WAIAAKA EAST	101	S	20.82626	-156.11590	4.65	1.12	3.92	5405	9.61	62.30	14.26	67.34	2.57	0.00	7.831	1.387	21.33	112.34
	102	S	20.82634	-156.11574	5.27	0.70	2.94	5332	5.89	53.34	11.16	56.98	2.72	0.00	7.863	1.052	21.42	113.43
	103	S	20.82654	-156.11564	4.96	0.98	2.94	5292	6.20	50.68	11.16	54.60	3.07	0.00	7.844	1.379	21.47	114.52
	104	S	20.82663	-156.11556	3.72	1.12	2.80	5291	9.30	47.32	13.02	51.24	3.32	0.00	7.822	1.106	21.56	115.62
	105	S	20.82673	-156.11544	5.58	0.56	1.82	5274	7.44	43.40	13.02	45.78	3.10	0.00	7.855	0.779	21.62	116.09
	106	S	20.82678	-156.11537	5.46	2.31	2.42	4683	5.58	42.66	11.04	47.39	2.04	4.37	8.146	1.075	22.48	115.52
	107	S	20.82683	-156.11542	6.53	1.68	2.59	3067	9.61	57.05	16.14	61.32	6.37	15.73	8.218	0.748	23.62	115.98
	108	S	20.82688	-156.11535	4.67	1.55	2.04	3085	7.13	53.26	11.80	56.85	15.09	15.68	8.228	0.779	25.14	115.71
	109	S	20.82692	-156.11529	4.84	0.41	1.88	991	5.89	72.32	10.73	74.61	25.87	29.82	8.132	0.483	24.83	111.47
	109	B	20.82692	-156.11529	5.17	0.43	1.62	1033	4.96	94.28	10.13	96.33	65.97	29.68	8.141	0.444	25.14	115.19
WAIAAKA WEST	101	S	20.82605	-156.11493	5.27	17.50	3.50	7113	9.92	75.74	15.19	96.74	27.22	0.00	7.874	0.405	20.53	110.09
	101	B	20.82605	-156.11493	8.37	23.24	2.80	7192	8.99	78.12	17.36	104.16	26.32	0.00	7.746	0.241	20.49	111.66
	102	S	20.82610	-156.11482	11.16	24.92	4.20	7142	7.44	83.44	18.60	112.56	1.45	0.00	7.831	0.280	20.54	112.61
	103	S	20.82629	-156.11497	9.61	22.40	4.34	7148	6.82	77.84	16.43	104.58	2.59	0.00	7.832	0.296	20.55	110.68
	104	S	20.82632	-156.11494	10.54	22.68	2.94	7166	7.75	87.50	18.29	113.12	2.12	0.00	7.839	0.382	20.58	113.27
	105	S	20.82649	-156.11503	10.24	16.05	7.69	5239	13.64	119.57	23.88	143.31	9.01	9.43	8.134	0.701	22.05	112.32
	106	S	20.82652	-156.11506	7.16	6.20	3.76	3361	9.30	104.46	16.46	114.42	8.26	18.80	8.172	0.421	23.66	115.73
KOPILIULA	101	S	20.83118	-156.11869	0.31	1.96	4.06	3957	12.09	113.82	12.40	119.84	4.38	0.00	7.881	1.231	23.51	112.58
	101	B	20.83118	-156.11869	0.62	1.82	4.48	3983	8.99	119.42	9.61	125.72	4.14	0.00	8.165	1.091	23.48	117.68
	102	S	20.83127	-156.11867	0.62	1.68	3.92	3910	19.22	121.10	19.84	126.70	4.09	0.00	8.221	1.901	23.61	116.59
	102	B	20.83127	-156.11867	0.31	1.40	3.64	3921	9.92	103.46	10.23	108.50	4.35	0.00	8.230	1.675	23.60	118.04
	103	S	20.83140	-156.11854	1.24	1.26	3.78	3978	16.43	113.26	17.67	118.30	5.03	0.00	8.157	1.254	23.65	113.01
	103	B	20.83140	-156.11854	1.55	1.12	3.50	3965	18.91	108.22	20.46	112.84	4.74	0.00	8.202	1.083	23.66	118.65
	104	S	20.83157	-156.11848	1.55	0.98	5.32	3952	19.53	121.38	21.08	127.68	6.31	0.00	8.205	2.189	23.72	111.60
	104	B	20.83157	-156.11848	0.93	0.70	4.76	3952	17.36	99.12	18.29	104.58	6.59	0.00	8.201	2.649	23.74	118.77
	105	S	20.83183	-156.11841	0.93	0.56	4.06	3963	17.67	99.68	18.60	104.30	8.82	0.00	8.167	1.566	23.92	120.43
	106	S	20.83197	-156.11837	0.62	0.56	4.20	3950	23.25	109.62	23.87	114.38	3.84	0.00	8.065	1.192	23.94	119.79
	107	S	20.83220	-156.11838	0.31	0.70	2.10	3955	13.33	99.82	13.64	102.62	5.21	0.00	8.055	1.176	23.13	113.54
	107	B	20.83220	-156.11838	0.00	0.56	1.68	3937	13.95	119.28	13.95	121.52	6.13	0.00	8.189	2.041	24.21	119.37
	108	S	20.83228	-156.11836	0.93	1.12	14.98	3947	13.02	125.02	13.95	141.12	4.52	0.00	8.320	1.870	24.03	120.56
	108	B	20.83228	-156.11836	0.93	0.56	1.82	3952	16.43	119.56	17.36	121.94	4.79	0.00	8.387	2.649	24.07	120.76
	109	S	20.83237	-156.11836	0.62	0.70	1.82	3968	11.78	112.42	12.40	114.94	3.97	0.00	8.306	1.098	24.08	122.26
	109	B	20.83237	-156.11836	0.62	0.70	1.40	4033	11.78	99.40	12.40	101.50	4.09	0.00	8.301	1.285	24.06	122.62
	110	S	20.83243	-156.11836	0.93	0.14	1.54	4054	12.71	104.58	13.64	106.26	12.97	0.03	8.269	1.122	24.11	116.46
	111	S	20.83247	-156.11828	0.03	0.74	2.64	3454	8.99	86.96	9.02	90.34	30.41	6.02	8.331	0.997	24.32	115.43
	112	S	20.83254	-156.11817	4.53	-0.06	2.48	486	8.37	111.20	12.90	113.62	15.72	33.01	8.135	0.826	25.54	114.48
	112	B	20.83254	-156.11817	4.27	-0.01	3.23	572	8.37	121.06	12.64	124.28	34.24	32.58	8.153	0.639	25.69	122.63
	113	S	20.83263	-156.11805	4.53	0.22	2.05	600	8.68	112.33	13.21	114.60	4.86	33.08	8.158	0.647	25.68	113.50
	113	B	20.83263	-156.11805	5.38	-0.01	7.14	410	11.78	150.28	17.16	157.41	53.66	33.84	8.164	3.225	25.68	123.42

TABLE A-11. Results of water chemistry sampling conducted on July 23, 2018, at Oopuola, Oopuola East, Wailua Iki East, and Wailua Iki West Streams on East Maui. "S" indicates surface sample; "B" indicates bottom sample. Nutrient concentrations are shown in micromolar units (µM) . Locations of sampling stations are shown in Chapter 4 of text.

STREAM	STATION	DEPTH	LAT	LON	PO4 (µM)	NO3 (µM)	NH4 (µM)	Si (µM)	TOP (µM)	TON (µM)	TP (µM)	TN (µM)	TURB TURB	SALT SALT	pH pH	Chl-a Chl-a	TEMP deg C	DO %sat
OOPUOLA	101	S	20.88911	-156.19634	1.11	1.14	2.18	270.13	0.31	8.34	1.42	11.66	17.05	2.13	6.634	0.156	23.52	30.81
	101	B	20.88911	-156.19634	0.25	0.07	4.41	184.50	0.45	7.28	0.70	11.76	37.42	13.57	6.548	0.265	24.29	30.18
	102	S	20.88902	-156.19648	0.82	0.80	0.46	261.61	0.28	4.70	1.10	5.96	26.86	0.54	6.685	0.171	23.72	69.22
	102	B	20.88902	-156.19648	0.49	0.10	0.79	216.59	0.63	7.15	1.12	8.04	64.34	8.25	6.564	0.140	23.92	39.27
	103	S	20.88905	-156.19664	0.48	0.37	0.39	247.31	0.43	5.42	0.91	6.18	38.14	0.27	6.451	0.140	23.84	65.14
	103	B	20.88905	-156.19664	0.42	0.25	7.87	226.47	0.34	6.74	0.76	14.86	110.91	8.81	6.596	0.249	23.37	53.74
	104	S	20.88897	-156.19672	0.14	0.11	0.42	230.60	0.26	5.38	0.40	5.91	5.06	0.02	6.268	0.140	22.85	46.50
	105	S	20.88914	-156.19614	0.27	0.39	0.81	31.76	0.20	7.51	0.47	8.71	27.80	30.61	8.091	0.093	26.86	110.47
	106	S	20.88917	-156.19610	0.28	0.26	0.91	49.41	0.23	8.17	0.51	9.34	14.02	31.01	8.125	0.156	26.90	112.42
	107	S	20.88920	-156.19607	0.23	0.29	0.57	40.92	0.27	6.32	0.50	7.18	8.75	31.09	8.141	0.125	26.87	111.35
	107	B	20.88920	-156.19607	0.25	0.20	0.81	32.13	0.27	6.23	0.52	7.24	10.28	31.70	8.163	0.125	26.82	115.03
	108	S	20.88926	-156.19595	0.25	0.45	0.81	50.17	0.25	9.19	0.50	10.45	5.83	31.36	8.151	0.093	26.87	121.31
	108	B	20.88926	-156.19595	0.23	0.35	0.93	37.61	0.26	7.61	0.49	8.89	7.20	32.72	8.159	0.109	26.61	119.29
	109	S	20.88943	-156.19577	0.24	0.48	0.73	37.58	0.26	10.47	0.50	11.68	3.68	31.29	8.137	0.125	26.67	107.34
	109	B	20.88943	-156.19577	0.21	0.55	0.92	42.57	0.28	8.61	0.49	10.08	2.82	32.86	8.156	0.093	26.35	107.67
OOPUOLA EAST	110	S	20.88896	-156.19617	0.11	0.10	0.99	89.49	0.31	6.72	0.42	7.81	23.97	12.81	8.080	0.109	26.57	101.73
	111	S	20.88884	-156.19620	0.09	0.09	1.11	105.92	0.29	9.21	0.38	10.41	7.00	6.43	7.805	0.109	25.93	99.02
	111	B	20.88884	-156.19620	0.22	0.05	0.97	77.91	0.32	10.57	0.54	11.59	10.30	18.10	8.133	0.125	26.54	101.99
	112	S	20.88878	-156.19623	0.13	0.08	1.00	112.72	0.28	8.51	0.41	9.59	7.34	5.06	7.621	0.125	25.78	99.97
	112	B	20.88878	-156.19623	0.17	0.02	0.97	80.76	0.28	6.61	0.45	7.60	9.76	16.81	8.096	0.280	26.44	104.85
	113	S	20.88868	-156.19639	0.02	0.10	0.88	127.24	0.40	23.21	0.42	24.19	no data	0.15	7.075	0.171	26.45	100.5
WAILUA IKI EAST	101	S	20.83491	-156.12458	0.03	0.12	0.82	113.54	0.26	9.69	0.29	10.63	15.30	0.00	7.383	0.265	22.84	102.34
	101	B	20.83491	-156.12458	0.02	0.13	0.82	112.49	0.31	9.47	0.33	10.42	13.77	0.00	7.388	0.327	22.85	102.15
	102	S	20.83549	-156.12449	0.05	1.07	0.78	187.61	0.35	8.87	0.40	10.72	19.69	0.00	7.492	0.405	22.38	103.21
	102	B	20.83549	-156.12449	0.00	0.14	0.71	204.48	0.56	11.12	0.56	11.97	15.89	0.00	7.716	0.763	22.27	103.24
	103	S	20.83597	-156.12437	0.25	1.85	0.73	217.22	0.37	9.68	0.62	12.26	9.59	0.00	7.503	0.374	22.03	103.84
	103	B	20.83597	-156.12437	0.53	3.91	2.58	282.93	0.34	9.56	0.87	16.05	9.76	0.03	7.414	0.483	21.36	101.13
	104	S	20.83619	-156.12409	0.29	1.78	0.64	238.41	0.50	10.84	0.79	13.26	13.60	0.00	7.504	0.872	22.24	104.03
	104	B	20.83619	-156.12409	0.30	3.10	29.72	267.10	0.84	8.42	1.14	41.24	14.31	0.02	7.381	0.904	21.35	101.87
	105	S	20.83633	-156.12394	0.25	1.38	0.69	211.29	0.53	7.67	0.78	9.74	13.72	0.00	7.495	0.249	22.00	102.64
	105	B	20.83633	-156.12394	0.34	2.52	1.08	243.75	0.38	7.97	0.72	11.57	14.51	0.00	7.474	1.651	21.63	101.88
	106	S	20.83638	-156.12383	0.17	2.50	1.10	214.83	0.23	8.63	0.40	12.23	13.16	2.67	7.431	0.343	21.82	96.61
	107	S	20.83642	-156.12382	0.39	2.16	0.65	205.76	0.20	6.21	0.59	9.02	110.85	3.76	7.592	0.327	22.74	102.58
	108	S	20.83647	-156.12381	0.21	0.40	0.68	55.28	0.23	9.04	0.44	10.12	2.05	32.52	8.033	0.203	25.54	103.84
	109	S	20.83661	-156.12379	0.21	0.35	0.60	33.68	0.26	7.70	0.47	8.65	2.12	33.08	8.062	0.343	25.63	104.61
	109	S	20.83661	-156.12379	0.22	0.33	0.61	62.11	0.23	7.99	0.45	8.93	2.25	33.28	8.083	0.218	25.61	103.84
	110	S	20.83683	-156.12375	0.19	0.16	0.52	35.17	0.24	8.25	0.43	8.93	1.53	32.53	8.093	0.203	25.66	99.85
	110	S	20.83683	-156.12375	0.21	0.30	0.76	33.90	0.23	8.50	0.44	9.56	1.14	33.58	8.099	0.171	25.72	100.82
	111	S	20.83709	-156.12371	0.34	0.62	1.24	45.97	0.16	6.74	0.50	8.60	0.92	32.13	8.113	0.187	25.53	100.82
	111	S	20.83709	-156.12371	0.19	0.22	0.53	30.34	0.24	7.23	0.43	7.98	0.88	33.79	8.116	0.171	25.75	101.62
WAILUA IKI WEST	101	S	20.83693	-156.12526	0.38	0.32	1.39	79.30	0.17	7.45	0.55	9.16	13.75	4.65	7.711	0.530	23.76	101.50
	101	B	20.83702	-156.12521	0.39	0.92	0.16	147.92	0.33	7.40	0.72	8.48	19.02	11.64	8.074	0.171	23.75	101.69
	102	S	20.83711	-156.12512	0.33	0.08	0.10	100.01	0.38	9.99	0.71	10.17	15.20	20.46	8.158	0.086	24.36	98.79
	102	B	20.83711	-156.12512	0.39	0.66	0.22	87.56	0.21	10.60	0.60	11.48	10.90	23.75	8.166	0.171	24.67	103.39
	103	S	20.83729	-156.12496	0.33	0.27	0.30	90.45	0.24	6.90	0.57	7.47	5.33	23.33	8.178	0.109	25.17	104.70
	103	B	20.83729	-156.12496	0.25	0.37	0.74	44.07	0.20	7.58	0.45	8.69	4.24	31.92	8.133	0.171	25.73	107.37
	104	S	20.83766	-156.12466	0.26	0.26	0.52	62.06	0.21	8.56	0.47	9.34	2.75	30.29	8.146	0.109	25.67	107.19
	105	S	20.83766	-156.12466	0.22	0.32	0.44	45.24	0.22	7.85	0.44	8.61	5.30	32.82	8.141	0.156	25.86	108.28
	106	S	20.83660	-156.12545	0.04	0.16	0.54	146.66	0.45	6.94	0.49	7.64	13.14	0.18	7.385	0.312	22.82	101.16
	106	B	20.83660	-156.12545	0.15	0.57	0.56	155.47	0.43	8.00	0.58	9.13	10.14	0.45	7.317	0.187	23.13	101.72
	107	S	20.83649	-156.12580	0.03	0.15	0.89	114.18	0.35	9.08	0.38	10.12	9.88	0.00	7.421	0.187	23.22	102.62
	107	B	20.83649	-156.12580	0.81	2.23	9.96	281.88	0.38	2.64	1.19	14.83	8.54	0.01	7.352	0.576	21.88	100.55
	108	S	20.83651	-156.12599	0.04	0.14	0.92	106.06	0.32	7.03	0.36	8.09	11.60	0.00	7.355	0.249	23.35	102.67
	108	B	20.83651	-156.12599	0.02	0.14	0.56	112.08	0.52	6.93	0.54	7.63	11.30	0.00	7.283	0.187	23.22	102.60

TABLE A-12. Results of water chemistry sampling conducted on July 23, 2018, at Oopuola, Oopuola East, Wailua Iki East, and Wailua Iki West Streams on East Maui. "S" indicates surface sample; "B" indicates bottom sample. Nutrient concentrations are shown as micrograms per liter (µg/L). Locations of sampling stations are shown in Chapter 4 of text.

STREAM	STATION	DEPTH	LAT	LON	PO4	NO3	NH4	Si	TOP	TON	TP	TN	TURB	SALT	pH	Chl-a	TEMP	DO
					(µM)	(µM)	(µM)	(µM)	(µM)	(µM)	(µM)	(µM)	TURB	SALT	pH	Chl-a	deg C	%sat
OOPUOLA	101	S	20.88911	-156.19634	34.51	15.93	30.54	7564	9.61	116.74	44.12	163.21	17.05	2.13	6.634	0.156	23.52	30.81
	101	B	20.88911	-156.19634	7.67	1.01	61.79	5166	13.95	101.87	21.62	164.67	37.42	13.57	6.548	0.265	24.29	30.18
	102	S	20.88902	-156.19648	25.37	11.16	6.38	7325	8.68	65.86	34.05	83.40	26.86	0.54	6.685	0.171	23.72	69.22
	102	B	20.88902	-156.19648	15.32	1.44	11.05	6065	19.53	100.11	34.85	112.60	64.34	8.25	6.564	0.140	23.92	39.27
	103	S	20.88905	-156.19664	14.85	5.16	5.43	6925	13.33	75.91	28.18	86.50	38.14	0.27	6.451	0.140	23.84	65.14
	103	B	20.88905	-156.19664	13.09	3.50	110.24	6341	10.54	94.30	23.63	208.04	110.91	8.81	6.596	0.249	23.37	53.74
	104	S	20.88897	-156.19672	4.34	1.54	5.88	6457	8.06	75.32	12.40	82.74	5.06	0.02	6.268	0.140	22.85	46.50
	105	S	20.88914	-156.19614	8.49	5.39	11.31	889	6.20	105.17	14.69	121.87	27.80	30.61	8.091	0.093	26.86	110.47
	106	S	20.88917	-156.19610	8.76	3.68	12.80	1384	7.13	114.32	15.89	130.80	14.02	31.01	8.125	0.156	26.90	112.42
	107	S	20.88920	-156.19607	7.20	4.09	8.03	1146	8.37	88.43	15.57	100.55	8.75	31.09	8.141	0.125	26.87	111.35
	107	B	20.88920	-156.19607	7.76	2.78	11.32	900	8.37	87.24	16.13	101.34	10.28	31.70	8.163	0.125	26.82	115.03
	108	S	20.88926	-156.19595	7.79	6.31	11.36	1405	7.75	128.64	15.54	146.31	5.83	31.36	8.151	0.093	26.87	121.31
	108	B	20.88926	-156.19595	7.04	4.94	13.01	1053	8.06	106.55	15.10	124.50	7.20	32.72	8.159	0.109	26.61	119.29
	109	S	20.88943	-156.19577	7.49	6.74	10.25	1052	8.06	146.55	15.55	163.54	3.68	31.29	8.137	0.125	26.67	107.34
	109	B	20.88943	-156.19577	6.41	7.73	12.86	1192	8.68	120.56	15.09	141.15	2.82	32.86	8.156	0.093	26.35	107.67
OOPUOLA EAST	110	S	20.88896	-156.19617	3.40	1.36	13.86	2506	9.61	94.08	13.01	109.30	23.97	12.81	8.080	0.109	26.57	101.73
	111	S	20.88884	-156.19620	2.78	1.31	15.61	2966	8.99	128.87	11.77	145.79	7.00	6.43	7.805	0.109	25.93	99.02
	111	B	20.88884	-156.19620	6.92	0.65	13.65	2182	9.92	147.91	16.84	162.21	10.30	18.10	8.133	0.125	26.54	101.99
	112	S	20.88878	-156.19623	4.16	1.14	13.95	3156	8.68	119.19	12.84	134.28	7.34	5.06	7.621	0.125	25.78	99.97
	112	B	20.88878	-156.19623	5.18	0.34	13.52	2261	8.68	92.60	13.86	106.46	9.76	16.81	8.096	0.280	26.44	104.85
	113	S	20.88868	-156.19639	0.61	1.39	12.30	3563	12.40	324.96	13.01	338.65	no data	0.15	7.075	0.171	26.45	100.53
WAILUA IKI EAST	101	S	20.83491	-156.12458	0.93	1.68	11.48	3179	8.06	135.66	8.99	148.82	15.30	0.00	7.383	0.265	22.84	102.34
	101	B	20.83491	-156.12458	0.62	1.82	11.48	3150	9.61	132.58	10.23	145.88	13.77	0.00	7.388	0.327	22.85	102.15
	102	S	20.83549	-156.12449	1.55	14.98	10.92	5253	10.85	124.18	12.40	150.08	19.69	0.00	7.492	0.405	22.38	103.21
	102	B	20.83549	-156.12449	0.00	1.96	9.94	5725	17.36	155.68	17.36	167.58	15.89	0.00	7.716	0.763	22.27	103.24
	103	S	20.83597	-156.12437	7.75	25.90	10.22	6082	11.47	135.52	19.22	171.64	9.59	0.00	7.503	0.374	22.03	103.84
	103	B	20.83597	-156.12437	16.43	54.74	36.12	7922	10.54	133.84	26.97	224.70	9.76	0.03	7.414	0.483	21.36	101.13
	104	S	20.83619	-156.12409	8.99	24.92	8.96	6675	15.50	151.76	24.49	185.64	13.60	0.00	7.504	0.872	22.24	104.03
	104	B	20.83619	-156.12409	9.30	43.40	416.08	7479	26.04	117.88	35.34	577.36	14.31	0.02	7.381	0.904	21.35	101.87
	105	S	20.83633	-156.12394	7.75	19.32	9.66	5916	16.43	107.38	24.18	136.36	13.72	0.00	7.495	0.249	22.00	102.64
	105	B	20.83633	-156.12394	10.54	35.28	15.12	6825	11.78	111.58	22.32	161.98	14.51	0.00	7.474	1.651	21.63	101.88
	106	S	20.83638	-156.12383	5.32	35.07	15.36	6015	7.13	120.86	12.45	171.29	13.16	2.67	7.431	0.343	21.82	96.61
	107	S	20.83642	-156.12382	12.03	30.22	9.07	5761	6.20	86.97	18.23	126.26	110.85	3.76	7.592	0.327	22.74	102.58
	108	S	20.83647	-156.12381	6.44	5.66	9.54	1548	7.13	126.54	13.57	141.74	2.05	32.52	8.033	0.203	25.54	103.84
	109	S	20.83661	-156.12379	6.39	4.91	8.35	943	8.06	107.85	14.45	121.11	2.12	33.08	8.062	0.343	25.63	104.61
	109	S	20.83661	-156.12379	6.68	4.62	8.61	1739	7.13	111.79	13.81	125.02	2.25	33.28	8.083	0.218	25.61	103.84
	110	S	20.83683	-156.12375	5.82	2.30	7.30	985	7.44	115.48	13.26	125.08	1.53	32.53	8.093	0.203	25.66	99.85
	110	S	20.83683	-156.12375	6.65	4.17	10.67	949	7.13	118.97	13.78	133.81	1.14	33.58	8.099	0.171	25.72	100.82
	111	S	20.83709	-156.12371	10.51	8.63	17.42	1287	4.96	94.30	15.47	120.35	0.92	32.13	8.113	0.187	25.53	100.82
	111	S	20.83709	-156.12371	6.01	3.04	7.43	850	7.44	101.21	13.45	111.68	0.88	33.79	8.116	0.171	25.75	101.62
WAILUA IKI WEST	101	S	20.83693	-156.12526	11.64	4.53	19.46	2220	5.27	104.30	16.91	128.29	13.75	4.65	7.711	0.530	23.76	101.50
	101	B	20.83702	-156.12521	12.20	12.93	2.24	4142	10.23	103.60	22.43	118.77	19.02	11.64	8.074	0.171	23.75	101.69
	102	S	20.83711	-156.12512	10.10	1.16	1.46	2800	11.78	139.80	21.88	142.42	15.20	20.46	8.158	0.086	24.36	98.79
	102	B	20.83711	-156.12512	11.95	9.30	3.03	2452	6.51	148.45	18.46	160.78	10.90	23.75	8.166	0.171	24.67	103.39
	103	S	20.83729	-156.12496	10.13	3.73	4.20	2533	7.44	96.60	17.57	104.53	5.33	23.33	8.178	0.109	25.17	104.70
	103	B	20.83729	-156.12496	7.74	5.15	10.31	1234	6.20	106.17	13.94	121.63	4.24	31.92	8.133	0.171	25.73	107.37
	104	S	20.83766	-156.12466	8.21	3.60	7.29	1738	6.51	119.83	14.72	130.72	2.75	30.29	8.146	0.109	25.67	107.19
	105	S	20.83766	-156.12466	6.72	4.51	6.14	1267	6.82	109.92	13.54	120.57	5.30	32.82	8.141	0.156	25.86	108.28
	106	S	20.83660	-156.12545	1.22	2.23	7.54	4107	13.95	97.18	15.17	106.95	13.14	0.18	7.385	0.312	22.82	101.16
	106	B	20.83660	-156.12545	4.61	7.94	7.79	4353	13.33	112.05	17.94	127.78	10.14	0.45	7.317	0.187	23.13	101.72
	107	S	20.83649	-156.12580	0.93	2.10	12.46	3197	10.85	127.12	11.78	141.68	9.88	0.00	7.421	0.187	23.22	102.62
	107	B	20.83649	-156.12580	25.11	31.22	139.44	7893	11.78	36.96	36.89	207.62	8.54	0.01	7.352	0.576	21.88	100.55
	108	S	20.83651	-156.12599	1.24	1.96	12.88	2970	9.92	98.42	11.16	113.26	11.60	0.00	7.355	0.249	23.35	102.67
	108	B	20.83651	-156.12599	0.62	1.96	7.84	3138	16.12	97.02	16.74	106.82	11.30	0.00	7.283	0.187	23.22	102.60