East Honolulu Watershed Management Plan

Final Draft

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Prepared by SSFM International for the City and County of Honolulu Board of Water Supply and the Department of Planning and Permitting

SSFM International

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ACRONYMS

2016 WMP: Board of Water Supply 2016 Water Master Plan*
ACS: American Community Survey
ADC: Agribusiness Development Corporation, State of Hawaiʻi
ASA: Aquifer Sector Area
ASYA: Aquifer System Area
AWUDP: Agricultural Water Use and Development Plan
BLNR: Board of Land and Natural Resources, State of Hawaiʻi
BMP: Best Management Practice
BWS: Honolulu Board of Water Supply
CCH: City and County of Honolulu
CFS: Cubic Feet per Second
CIP: Capital Improvement Program
CNPCP: Coastal Nonpoint Pollution Control Program
CWA: Clean Water Act
CWRM: Commission on Water Resource Management, State of Hawaiʻi
CZARA: Coastal Zone Act Reauthorization Amendments
CZD: Capture Zone Delineations
DBEDT: Department of Business, Economic Development, and Tourism, State of Hawaiʻi
DDC: City and County of Honolulu, Department of Design and Construction
DFM: City and County of Honolulu, Department of Facilities Maintenance
DHHL: Department of Hawaiian Home Lands, State of Hawaiʻi
DPR: City and County of Honolulu, Department of Parks and Recreation
DLNR: Department of Land and Natural Resources, State of Hawaiʻi
DLNR-DAR: Department of Land and Natural Resources – Division of Aquatic Resources
DLNR-DOCARE: Department of Land and Natural Resources – Division of Conservation and Resources Enforcement
DLNR-DOFAW: Department of Land and Natural Resources – Division of Forestry and Wildlife

DLNR-OCCL: Department of Land and Natural Resources – Office of Coastal and Conservation Lands
DOA: Department of Agriculture, State of Hawaiʻi
DOE: Department of Education, State of Hawaiʻi
DOH: Department of Health, State of Hawaiʻi
DOH-WWB: Department of Health Wastewater Branch, State of Hawaiʻi
DOT: Department of Transportation, State of Hawaiʻi
DP: Development Plan
DPP: City and County of Honolulu, Department of Planning and Permitting
DPR: City and County of Honolulu, Department of Parks and Recreation
DTS: City and County of Honolulu, Department of Transportation Services
EHSCP: East Honolulu Sustainable Communities Plan
EHWMP: East Honolulu Watershed Management Plan
EMS: City and County of Honolulu, Emergency Medical Services
EPA: Environmental Protection Agency
ENV: City and County of Honolulu, Department of Environmental Services
FEMA: Federal Emergency Management Agency
FIRM: Flood Insurance Rate Maps
GAP: Hawaiʻi Gap Analysis Program
GDE: Ground Water Dependent Ecosystem
GHG: Greenhouse Gases
GIS: Geographic Information Systems
GMSL: Global Mean Sea Level
GPCD: Gallons Per Person Per Day
HECO: Hawaiian Electric Company
HFD: Honolulu Fire Department
HI-EMA: Hawaiʻi Emergency Management Agency
HIMB: Hawaiʻi Institute of Marine Biology
HPD: Honolulu Police Department
HRS: Hawaiʻi Revised Statues
HWP: Hawaiʻi Water Plan
HMP: Hazard Mitigation Plan
IFS: Instream Flow Standards
IIFS: Interim Instream Flow Standards
IPCC: Intergovernmental Panel on Climate Change
KMWP: Koʻolau Mountain Watershed Partnership
KS: Kamehameha Schools
LDS: Latter Day Saints (Church of Jesus Christ of)
LHKH: Livable Hawaiʻi Kai Hui
LID: Low Impact Development
LUC: Land Use Commission
M: Million
MAV: Monthly Moving Average
MCL: Maximum Contaminant Level
MGD: Millions of Gallons Per Day
MLCD: Marine Life Conservation District
MS4: Municipal Separate Storm Sewer System
NHB: Neighborhood Board
NFIP: National Flood Insurance Program
NFWF: National Fish and Wildlife Foundation
NOAA: National Oceanic and Atmospheric Administration
NPDES: National Pollutant Discharge Elimination System
NRCS: Natural Resources Conservation Service
NSF: National Science Foundation
OP: Office of Planning, State of Hawaiʻi
OP-CZM: Office of Planning Coastal Zone Management Program, State of Hawaiʻi
OPSD: Office of Planning and Sustainable Development, State of Hawaiʻi (formerly OP)
OHA: Office of Hawaiian Affairs
OCCSR: Honolulu Office of Climate Change, Sustainability and Resiliency
ONMS: Office of National Marine Sanctuaries
ORMP: Ocean Resources Management Plan
OWMP: Oʻahu Watershed Management Plan

PacIOOS: Pacific Islands Ocean Observing System
PIRCA: Pacific Islands Regional Climate Assessment
PPH: Protect and Preserve Hawaiʻi
PRC: Hawaiʻi Polluted Runoff Control Program
PU: Permitted Use
PUC WMP: Primary Urban Center Watershed Management Plan
RFP: Request for Proposals
ROH: Revised Ordinances of Honolulu
SCP: Sustainable Communities Plan
SHPD: Hawaiʻi State Historic Preservation Division
SLH: Session Laws of Hawaiʻi
SLR: Sea Level Rise
SMA: Special Management Area
SLUD: State Land Use District
SLR-XA: Sea Level Rise Exposure Area
SWAP: Source Water Assessment and Protection Program
SWPP: State Water Projects Plan
SY: Sustainable Yield
TMDL: Total Maximum Daily Load
UH: University of Hawaiʻi
UHCC: University of Hawaiʻi Community Colleges
UH-SOEST: University of Hawaiʻi - School of Ocean and Earth Science and Technology
UIC: Underground Injection Control Program
USACE: United States Army Corps of Engineers
USDA: United States Department of Agriculture
USFWS: United States Fish and Wildlife Service
USGS: United States Geographical Survey
WAI: Wastewater Alternatives Innovations
WMA: Water Management Area
WMP: Watershed Management Plan*
WQR: Water Quality Rules
WRRC: Water Resources Research Center
WUDP: Water Use and Development Plan
WUP: Water Use Permit
WWTP: Wastewater Treatment Plant

*Note: The 2016 WMP acronym refers to the BWS's 2016 Water Master Plan while the WMP acronym refers to the BWS's regional watershed management plans.

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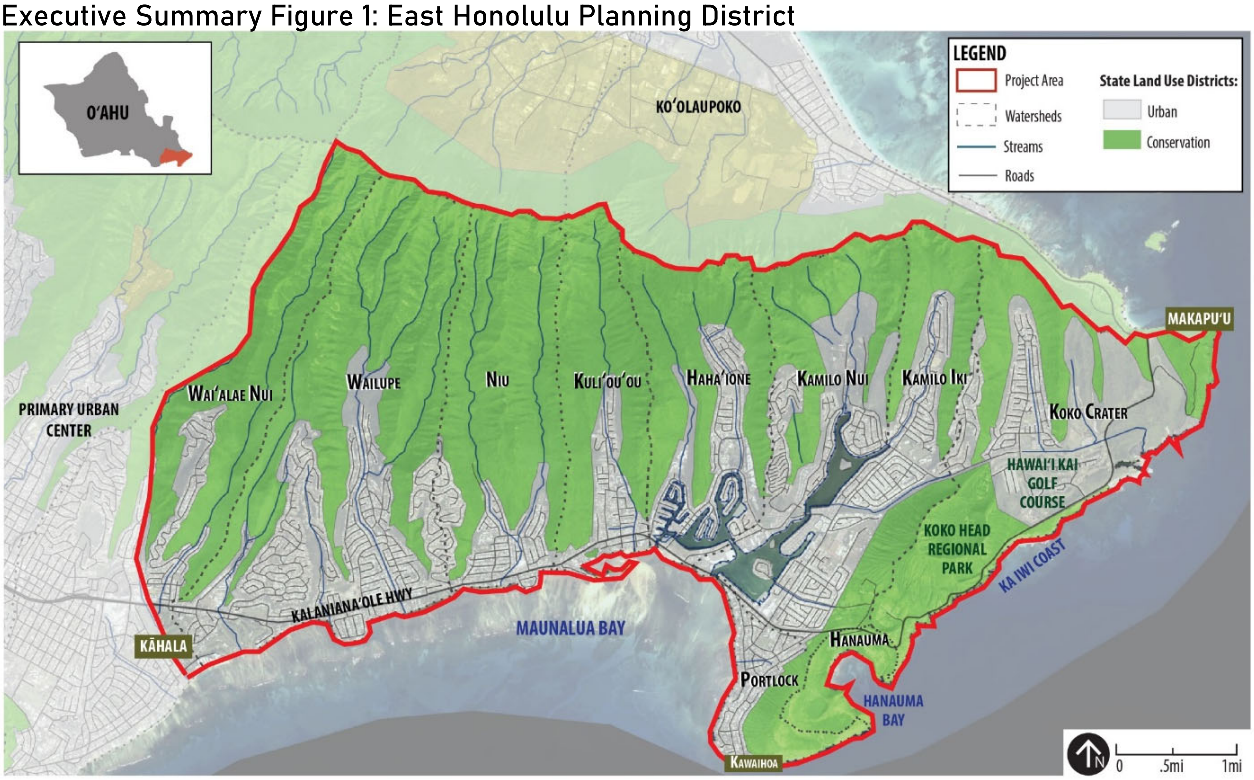
ES EXECUTIVE SUMMARY

ES.1 PURPOSE, GOALS & OBJECTIVES

The East Honolulu Watershed Management Plan (EHWMP or Plan) is a long-range, holistic water resources plan for the East Honolulu planning district, as shown in *Executive Summary Figure 1*. The EHWMP provides an integrated set of goals, policies, projects, and strategies that together seek to manage, protect, and preserve all water resources within East Honolulu, including potable groundwater (i.e., drinking water), non-potable groundwater (i.e., caprock water), surface waters, and nearshore waters through the planning horizon of 2040.

Executive Summary Figure 1: East Honolulu Planning District



The Plan is presented in five chapters:

- **Chapter 1:** Oʻahu Water Management Plan Overview
- **Chapter 2:** East Honolulu Watershed Profile
- **Chapter 3:** East Honolulu Water Demand Analysis
- **Chapter 4:** Policies, Programs and Strategies
- **Chapter 5:** Implementation

The Honolulu Board of Water Supply (BWS) and City and County of Honolulu Department of Planning and Permitting (DPP) have jointly prepared the Plan with support from consultant SSFM International. The EHWMP is one of eight plans which together comprise the Oʻahu Water Management Plan (OWMP). The OWMP is being prepared in accordance with the requirements of the State Water Code and Revised Ordinances of the City and County of Honolulu (ROH). The State Water Code, Hawaiʻi Revised Statues (HRS) Chapter 174C, protects, controls and regulates the use of the State's water resources for the benefit of its people and the environment. Under the Code, the County is responsible for preparing the Water Use and Development Plan (WUDP) for the City and County of Honolulu. In response, ROH Chapter 30 Water Management, established the OWMP, which has evolved into a framework of regional Watershed Management Plans (WMPs) by City planning district to plan for the management of all water resources within each district. As such, the OWMP serves as the WUDP for the City and County of Honolulu.

The State Water Code requires that the WUDPs be consistent with County land use plans and policies. The City established regional Development Plans (DP) and Sustainable Communities Plans (SCP) for each of the eight planning areas on Oʻahu. Each DP/SCP is intended to help guide public policy, investment, and decision making over the next 20 years. For East Honolulu, the East Honolulu Sustainable Communities Plan (EHSCP) provides land use policies and public programs to support the existing populations. According to the latest update of the EHSCP, adopted in 2022, population and development within East Honolulu is projected to remain stable through 2040.

BWS and DPP established several guiding principles for all of the WMPs. They directed that the Plans be:

- Community-based.
- Environmentally holistic.
- Reflective of ahupuaʻa management principles.
- Action-oriented.
- In alignment with State and City water and land use policies.

BWS and DPP established an overall GOAL and five supporting OBJECTIVES for the WMPs:

> **GOAL:** To formulate an environmentally holistic, community-based, and economically viable watershed management plan that will provide a balance between: (1) the preservation and restoration of Oahu's watersheds, and (2) sustainable ground water and surface water use and development to serve present and future generations.

The five major objectives which are common to all of the WMPs for Oʻahu are:

- **OBJECTIVE #1:** Promote Sustainable Watersheds
- **OBJECTIVE #2:** Protect And Enhance Water Quality and Quantity
- **OBJECTIVE #3:** Protect Native Hawaiian Rights and Traditional and Customary Practices
- **OBJECTIVE #4:** Facilitate Public Participation and Education, and Project Implementation
- **OBJECTIVE #5:** Meet Future Water Demands at Reasonable Cost

Each of the WMPs developed district-specific sub-objectives (also referred to as policies) under each of the major objectives. These sub-objectives were articulated based on the issues and values that emerged for the district from both the technical research work and the stakeholder consultation process. Water supply and watershed management projects and strategies that would respond to and implement these sub-objectives were then researched and documented.

Further discussion on the authority, purpose, and goals of the OWMP is provided in *Chapter 1*. WMP goals, objectives, and East Honolulu-specific sub-objectives are provided in *Chapter 4.*

ES.2 PLANNING PROCESS

The planning process for the development of the EHWMP was both technical and community-based in nature. It involved:

1) **Technical research** including data collection and analysis, review of relevant plans, studies, and programs, development of maps, charts and graphs, and projections of existing and future water demands;
2) **Stakeholder outreach and consultation** including individual interviews and small group meetings with community leaders, groups, and organizations, public agencies, and elected officials; and community meetings to provide a forum for the discussion of watershed issues and needed actions.
3) **Development of working papers** synthesizing technical research and stakeholder input, which later became the Chapters of this EHWMP.

The EHWMP also includes a "Ka Paʻakai Analysis" that follows the framework outlined by the Hawaiʻi Supreme Court in Ka Paʻakai O Ka ʻĀina vs. Land Use Commission (2000). Under this framework, State and County agencies must independently assess three criteria when reviewing land use applications to protect Traditional and Customary Hawaiian practices to the extent feasible.

Further discussion on the EHWMP planning process is provided in *Chapter 2*.

ES.3 PHYSICAL SETTING & POLITICAL BOUNDARIES

The East Honolulu district is located in the southeastern region of the island of Oʻahu and is defined by the City and County of Honolulu East Honolulu planning district boundaries. The district covers approximately 24 square miles, encompassing 4% of Oʻahu's land mass. Its physical landscape is defined by steep mauka topography of ridges and gulches transitioning to flatter coastal lowlands and inland brackish and saltwater bays around Hawaiʻi Kai. The coastline is characterized by coastal cliffs in some areas, hardened shoreline in others, and sandy beaches. The ridge Koʻolau Mountain Range forms the mauka (inland) boundary of the district. Its makai boundary spans Oʻahu's south shore from Waiʻalae Beach Park to Kawaihoa (tip of Portlock), and along the Ka Iwi Coast from Kawaihoa to Makapuʻu Point.

Ahupuaʻa, traditional Hawaiian land divisions within larger areas called moku, generally extend from the mountain tops to the sea, allowing their inhabitants access to a full range of resources. Although ahupuaʻa boundaries often followed ridgelines, ahupuaʻa vary in size and shape based on political divisions and the resources that exist in the watershed. Two ahupuaʻa are located in the East Honolulu district: Waikīkī and Waimānalo.

In East Honolulu, each ahupuaʻa contains several watersheds. In total, the district has ten named watersheds: Waiʻalae Nui, Wailupe, Niu, Kuliʻouʻou, Hahaʻione, Kamilo Nui, Kamilo Iki, Portlock, Hanauma, and Koko Crater. The majority of these watersheds (with the exception of Hanauma and Portlock) are relatively medium in size, steep in the upper watershed, and have little embayment. The Hanauma and Portlock watersheds are both small in size, and the Hanauma watershed has a large defined embayment. Eight of the ten watersheds in East Honolulu drain into Maunalua Bay. These watersheds form a series of natural drainageways extending across the region. These stream channels are the primary means for carrying water from the inland areas to the sea and are capable of handling runoff from normal rainfall events. During periods of intense rainfall, however, a number of these drainageways have experienced severe flooding problems.

The coastal areas in East Honolulu typically experience moderate to low rainfall. However, rainfall is highly variable and is largely dependent upon elevation. According to the 2011 Rainfall Atlas of Hawaiʻi, the coastal plains of East Honolulu experiences less than 30 inches of annual rainfall, while the upper reaches of the Koʻolau Mountains in East Honolulu experience more than 80 inches of annual rainfall.

Approximately 60% of the district's total land area is classified as Conservation. These lands are generally found in the district's mauka areas, some of which are within the State's Forest Reserves. Conservation lands are also found within coastal areas in the Hanauma Bay Nature Park, Koko Head Regional Park, and the Ka Iwi State Scenic Shoreline. Outside of these areas, lands are designated as Urban, primarily consisting of residential development. In regards to political boundaries, the district is comprised of three neighborhood board (NHB) districts: the entirety of the Hawaiʻi Kai (#1) and Kuliʻouʻou-Kalani Iki (#2) NHB districts are within the East Honolulu district, as well as a small portion of the Waiʻalae-Kāhala (#3) NHB area.

Further discussion on East Honolulu's physical setting is provided in *Section 2.2*.

ES.4 SOCIO-ECONOMIC CONDITIONS

According to the U.S. Census, the population in the East Honolulu District was 50,922 people in 2020. The district's total population increased by 15.5% between 1980 and 2010, yet between 2010 and 2020 its population was relatively stable. East Honolulu's population is expected to remain stable at 50,000 over the next 20 years. The residents of East Honolulu are generally older than the residents of Oʻahu as a whole. A large percentage of East Honolulu residents identify as Asian (47.6%) and white (25.3%). Only 3.4% of East Honolulu residents identify as Native Hawaiian or Pacific Islander, a smaller percentage than Oʻahu-wide.

East Honolulu's annual median household income (in 2021 dollars) is $139,041 significantly higher than the island's median household income of $92,600. East Honolulu is also in many ways characteristic of suburban development, representing a bedroom community with residents that depend upon economic opportunities located within Honolulu's urban center.

Further discussion on East Honolulu's socio-economic conditions is provided in *Section 2.10*.

ES.5 CRITICAL WATER ISSUES

Extensive research and stakeholder consultation (see *Section 2.14*) was undertaken to identify eight critical water resource issues facing East Honolulu. The project team used these critical water issues to inform the development of the policies, projects, and strategies developed for the EHWMP. These eight critical water resource issues are provided below:

1) Climate Change
2) Sea Level Rise
3) Nearshore Water Quality
4) Water Conservation Efforts
5) Protecting Traditional and Customary Practices
6) Flooding and Drainage
7) Access to Mauka and Makai Areas
8) Wildfires

Further discussion on East Honolulu's critical water issues is provided in *Section 2.14*.

ES.6 EXISTING & FUTURE WATER DEMAND

Existing Water Demand and Supply:

To determine existing water demand, the project team analyzed multiple data sets, including:

- Transfer data from BWS indicating how much water is transferred into the district from other areas, and how much is supplied from sources within the district, based on a five-year average of data collected for the years 2013-2017.

- Pumpage data from the State Commission on Water Resource Management (CWRM) indicating how much water was pumped in during the baseline year (2015) from permitted wells (both potable and caprock) and reported to CWRM.
- BWS water demand data with information on how much water was produced from BWS sources, and how much use was recorded through BWS water meters.

Based on the findings presented in *Chapter 3*, East Honolulu's total existing (based on the 2013-2017 five-year average) potable water demand is approximately 8.676 million gallons of water per day (MGD). This includes both potable municipal (BWS) water demand (8.38 MGD) and potable irrigation water demand (0.296 MGD). BWS meets approximately 96% of the district's total water demand. Irrigation demand is met by water provided by the private Waiʻalae Golf Course Well. This water is used to irrigate the Waiʻalae Golf Course and accounts for about 4% of the district's water usage. There are two caprock wells in East Honolulu which are privately owned, however, both wells have not reported any pumpage over the last decade.

Based on 2010 data, East Honolulu's per capita water demand is 194 gallons per person per day (GPCD). This is 25% higher than the island-wide average of 155 GPCD, due to the district's land use and socio-economic characteristics (see *Section 3.3* for further detail). While BWS's 2016 Water Master Plan (WMP) demand forecasted that the East Honolulu district would lower its per capita water use to 180 GPCD by 2040, preliminary census data shows that the district's per capita water demand had already dropped to 170 GPCD in 2020. This is largely due to ongoing conservation efforts and limited anticipated population growth in the district.

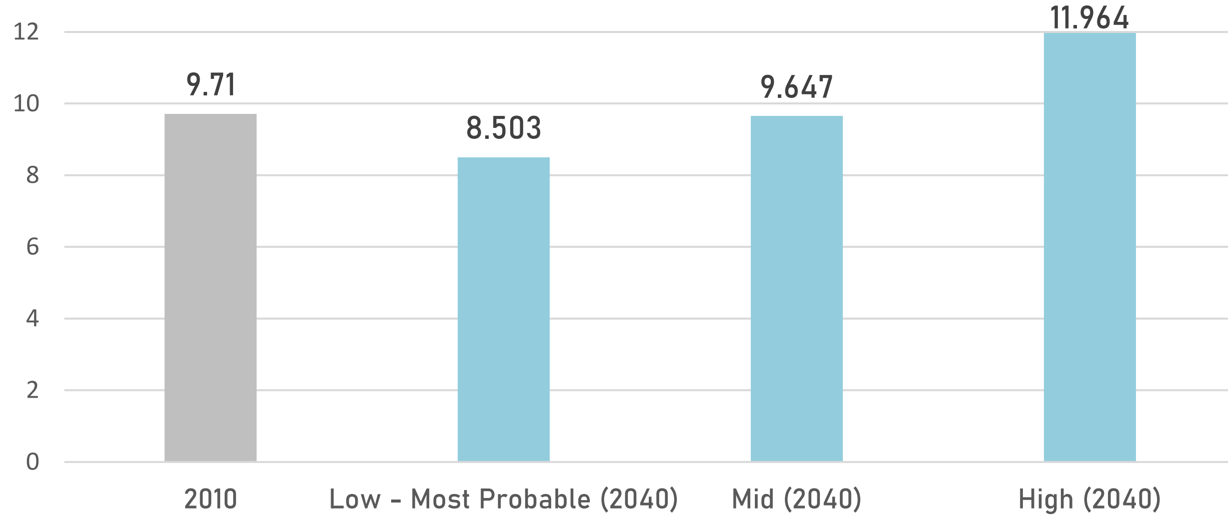
With regard to water availability, compared to other areas of Oʻahu, the East Honolulu planning district has limited ground water resources. This is largely due to the fact that the Waiʻalae-West and Waiʻalae-East have a relatively thin fresh water lens, and also in part due to the district's relatively low rainfall and dry climate. There are also no developed surface water sources in East Honolulu. Because of this, nearly 85% of the district's potable groundwater is supplied by water transferred from BWS's Honolulu and Windward water systems. In 2015, approximately 16%, or 1.32 MGD, of East Honolulu's potable water demand was provided by BWS and privately-owned wells within the district.

2040 Water Demand and Supply:

To project East Honolulu's water demand in 2040, the project team developed water demand scenarios to account for potential variations in population growth, water use, and implementation of conservation strategies. Three scenarios were developed to envision East Honolulu in 2040: the Low Demand, Mid Demand, and High Demand scenarios. The Low Demand Scenario is also assumed to be the most probable as it incorporates the same population projections provided in the 2016 WMP and water use projections based on preliminary census data.

In the Low, Mid, and High Demand scenarios, the total projected water demand ranges from 8.503 MGD in the Low scenario to 11.964 MGD in the High Demand Scenario (see *Executive Summary Figure 2*). The Low Demand Scenario, which is the "most probable" scenario, projects 12.43% less total water demand for the East Honolulu in the year 2040 than the 2010 baseline because of the continued implementation of conservation measures to lower per capita demand. The Mid Demand Scenario results in a projected demand of 0.64% less than the 2010 baseline, due to a slight decrease in BWS-served population (decreasing from 48,100 in 2010 to 47,800 in 2040). The High Demand Scenario incorporates a larger BWS-served population and increased irrigation demand due to climate change, results in a projected demand of nearly 12 MGD, a 23.21% increase over 2010.

Executive Summary Figure 2: EHWMP Water Demand Scenarios for 2040 (MGD)*



It is expected that East Honolulu will continue to depend on BWS transfers of water from other areas for its future water supply. Based on the Low/Most Probable Demand Scenario, the EHWMP anticipates that through 2040, East Honolulu will have a BWS water demand of 8.6 MGD. This demand will be accommodated by 1.83 MGD of in-district pumpage, 5.27 MGD of water transfers from the Honolulu water system, and 1.5 MGD of water transfers from the Windward water system.

The EHMWP projects that anticipated water usage in the Mid and High Demand Scenarios will exceed the estimated supply. This means that East Honolulu will need to pursue both new source development and conservation efficiencies to mitigate the uncertainties of climate change and regulatory actions to restore Windward stream flows. Within the 2040 projected water supply constraints, the overall water demand in the Mid Demand Scenario would need to be reduced by 0.67 MGD (7.23%), and the overall water demand in the High Demand Scenario would need to be reduced by 2.92 MGD (25.35%).

Further discussion on East Honolulu's existing and future water demand and supply is provided in *Chapter 3*. Further discussion on strategies to ensure water source availability is provided in *Section 5.2*.

ES.7 2100 ULTIMATE DEMAND SCENARIO

The EHWMP imagined future for East Honolulu in 2100 was developed as the "Ultimate Demand Scenario". This scenario incorporates current climate change projections which assume that by 2100, mean sea level will rise by 3.2 ft. This is expected to cause more pronounced nuisance flooding as well as increased high wave run-up and coastal erosion, primarily in low-lying areas makai of the highway, as well as in some areas surrounding Kuapā Pond and within Kuliʻouʻou valley. Critical infrastructure, such as the State highway and water supply facilities, will also be impacted by increased flooding and saltwater intrusion into groundwater and drainage systems. Higher frequency and severity of storms will likely result in increased flooding and storm surge, which could damage properties, raise insurance rates, and decrease property values in vulnerable areas. Depending on impacts to beaches and coastal destinations, tourism may also experience a decline.

Adaptation measures such as seawalls, raising roads, and pumping seawater out of inundated coastal areas may mitigate some of these anticipated impacts in East Honolulu. However, the City and County's approach to sea level rise adaptation is yet to be determined and will be subject to many complex factors and tradeoffs, including where to direct limited funding for the greatest public good. The reality is likely that in some areas subject to repeated losses and flooding, retreat of development away from coastal hazard areas will be necessary. Over time, this could reduce the population of parts of the island, including the East Honolulu district. If displaced residents leave the district, this could commensurately reduce water demand. Taking all these factors into account, the scenario assumes that some impacted residents would either retreat to inland areas or move out of the district, leading to a 10% decrease in population and a BWS-served population of 42,600.

The per capita water demand for BWS users from 2040 through 2100 is assumed to remain steady at an average of 170 GPCD. In developing the storyline for East Honolulu through 2100, the EHWMP took two potential future rainfall scenarios into consideration – the "Dry" and "Wet" Scenarios. The Dry Scenario, based on the statistical downscaling rainfall model, projects that in 2100, rainfall in East Honolulu (during the dry season) could decrease by 22 to 39%. As an outcome, the EHWMP assumes there will be a 22% increase in demand for irrigation water in this scenario. Conversely, the Wet Scenario is based on the dynamical downscaling rainfall model, and projects that rainfall in East Honolulu will substantially increase by 30 to 50% over current levels. It is uncertain how this would impact irrigation demand, as the increased rainfall will likely occur as heavy rainfall and flooding events (sometimes called "rain bombs" or cloudburst events), which does not necessarily increase groundwater aquifer recharge. Because of these uncertainties, the EHWMP assumes there will be no changes to the district's irrigation demand in 2100.

With all these factors in mind, the EHWMP estimates that the realization of the Dry Scenario will lead to a water demand of 8.413 MGD and the Wet Scenario will lead to a water demand of 7.617 MGD. In regards to water availability in 2100, there are many uncertainties. In the Dry Scenario, there could be a substantial decrease to the sustainable yield (SY) of Oʻahu's groundwater aquifer systems. Given these potential reductions to the island's groundwater aquifer systems, under the Dry Scenario we assume that East Honolulu's water availability will be reduced due to anticipated changes in water transfers, including a 50% reduction in water transfers from BWS's Honolulu water system to East Honolulu, as well as a return to 2010 levels of water transfer from BWS's Windward water system to East Honolulu.

Availability of water in East Honolulu (from the Waiʻalae-West and Waiʻalae-East aquifer system areas) is expected to remain consistent through 2100 (even under the Dry Scenario), providing 2.5 MGD of water to the district. With these factors in mind, the estimated water supply for East Honolulu is 5.54 MGD under the Dry Scenario. To ensure water source adequacy, the EHWMP projects that East Honolulu would need to reduce its per capita water demand by approximately 25%, from 170 GPCD to 130 GPCD by 2100.

Conversely, if the Wet Scenario is realized, it is assumed that there will be no changes to water availability in 2100, given that expected increases in rainfall are likely to come in form of flooding, which does not necessarily increase aquifer recharge or groundwater availability. As such, the EHWMP estimates that the realization of the Wet Scenario would lead to a total water supply 8.6 MGD for East Honolulu, suggesting there would be sufficient water supply to meet district's water demand.

While the EHWMP is intended to serve as a guide to manage the district's water resources through 2040, and will be updated as climate modeling and rainfall forecasting improves, given the uncertainties in projecting late-century water demand and supply, research and investment is needed to better understand how climate change, sea level rise, and other natural and man-made hazards may impact the district's future groundwater availability and access to water resources which lay the foundation to cultural, recreational, and subsistence activities. By taking steps now to understand East Honolulu's 2100 water supply and demand, we are more equipped to take the necessary steps to protect and preserve the island's fragile water ecosystem.

Further discussion on the Ultimate Demand Scenario for East Honolulu is provided in *Chapter 3* and *Chapter 5*.

ES.8 POLICIES, PROJECT & STRATEGIES

EHWMP Objectives and Sub-Objectives

Chapter 4 of the Plan identifies 23 sub-objectives that address the critical water issues and areas of concern identified in *Chapter 2* of the EHWMP. These sub-objectives or policies are categorized by the overarching Objectives that are shared across all eight of Oʻahu's Watershed Management Plans. The EHWMP objectives and sub-objectives are provided on the following page.

OBJECTIVE #1: PROMOTE SUSTAINABLE WATERSHEDS

- **Sub-Objective 1.1:** Increase native reforestation and implement measures to slow the spread of invasive species and ungulates to improve the overall health of East Honolulu's forest reserves and increase recharge into the East and West Waiʻalae aquifers.
- **Sub-Objective 1.2:** Implement preventative measures that reduce wildfire risks.
- **Sub-Objective 1.3:** Enhance ecosystem diversity within East Honolulu's streams and nearshore waters.
- **Sub-Objective 1.4:** Prepare for the anticipated impacts of sea level rise on existing ecosystems, properties and infrastructure through remediation, adaptation, and other measures.
- **Sub-Objective 1.5:** Conserve natural shorelines to protect beaches, coastal ecosystems, recreational and cultural resources, and public shoreline access.

OBJECTIVE #2: PROTECT AND ENHANCE WATER QUALITY AND QUANTITY

- **Sub-Objective 2.1:** Encourage the use of xeriscaping and other low impact development strategies to reduce irrigation water demand from current aquifer sources and mitigate flooding impacts, with a focus on arge landscaped areas such as parks, schools, golf courses, roadway landscaping, farms and large residential lots.
- **Sub-Objective 2.2:** Improve the water quality of Maunalua Bay by capturing and infiltrating stormwater runoff and reducing the transfer of sediment and other pollutants from mauka areas to the Bay.
- **Sub-Objective 2.3:** Improve the water quality of Maunalua Bay by increasing the amount of freshwater that enters the Bay.
- **Sub-Objective 2.4:** Reduce the impacts from extreme rain events and flooding.
- **Sub-Objective 2.5:** Reduce groundwater contamination through cesspool conversion and wastewater system improvements in East Honolulu.
- **Sub-Objective 2.6:** Maintain and improve the water supply of aquifers serving East Honolulu by maximizing groundwater infiltration and encouraging urban recharge.
- **Sub-Objective 2.7:** Re-evaluate aquifer sustainable yields to support groundwater dependent ecosystems.

OBJECTIVE #3: PROTECT NATIVE HAWAIIAN RIGHTS AND TRADITIONAL AND CUSTOMARY PRACTICES

- **Sub-Objective 3.1:** Restore fishponds and springs for cultural and educational use.
- **Sub-Objective 3.2:** Provide support to community organizations that are stewarding cultural and natural resources.
- **Sub-Objective 3.3:** Improve public shoreline access to allow for the practice of cultural traditions and subsistence activities.
- **Sub-Objective 3.4:** Increase community awareness of Maunalua's unique history of water through educational programs.

OBJECTIVE #4: FACILITATE PUBLIC PARTICIPATION AND EDUCATION, AND PROJECT IMPLEMENTATION

- **Sub-Objective 4.1:** Promote public participation in planning of watershed management projects and programs.
- **Sub-Objective 4.2:** Provide educational opportunities for the community to learn about protecting and preserving water resources in East Honolulu with a particular emphasis on youth education.
- **Sub-Objective 4.3:** Collaborate among government agencies, landowners, and other stakeholders to implement mutually beneficial projects and strategies, obtain community support, and secure the necessary funding and legislation.

OBJECTIVE #5: MEET FUTURE WATER DEMANDS AT REASONABLE COST

- **Sub-Objective 5.1:** Maintain and improve the reliability, adequacy, and efficiency of the potable water system.
- **Sub-Objective 5.2:** Adapt to and plan for drought and its impacts on water supply in East Honolulu.
- **Sub-Objective 5.3:** Implement conservation measures that improve water efficiency and decrease per capita water demand among residential, commercial, and agricultural water users.
- **Sub-Objective 5.4:** Through a One Water framework, promote an integrated demand-side management water conservation program with stormwater management and recycled water for all land uses to extend limited water supply and system capacity.

Projects with Champions

Chapter 4 of the EHWMP identifies 30 projects, strategies, and programs to address water resource issues and meet the plan's policies. Projects are those that have an identified champion, which constitutes a designated lead agency or organization that is proposing, planning, or already implementing the project. The EHWMP's projects with champions are listed on below.

1. Kalauhaʻihaʻi Fishpond Restoration
2. Wailupe Stream Restoration
3. Kuliʻouʻou Watershed Retention and Infiltration Retrofit
4. Kamilo Nui Watershed Kipuka Reforestation
5. Kamilo Nui Watershed Sustainable Agriculture Pilot Project
6. Kamilo Nui Watershed Kuapā Pond Restoration
7. Keawāwa Wetland & Hawea Heiau Restoration
8. Ka Iwi Coast Mauka Lands Preservation
9. Restoration of Upper Niu & Wailupe Watersheds
10. Maunalua Watershed Hui Coordination
11. Maunalua Watershed Talk Stories
12. Mālama Maunalua Programs
13. Coral Assisted Evolution Project
14. Community Cleanups & Water Quality Phone Application
15. Work-4-Water Initiative
16. DFM Community Programs
17. Low Impact Design and Green Infrastructure Standards & Guidelines
18. Stormwater Utility Oʻahu
19. Watershed Boulder Basins & Detention Basins
20. Drainage System Upgrades
21. Implement Mayor's Directive on Climate Change & Sea Level Rise
22. Climate Change Sustainable Yield Scenarios
23. Infrastructure Planning in the Sea Level Rise Exposure Area
24. Oʻahu Climate Adaptation Strategy
25. Wastewater Long Range Master Plan for Treatment, System Capacity Expansion, and Infrastructure Renewal and Replacement
26. Drainage and Stormwater Master Plans for Drainage System Capacity Expansion, Infrastructure Renewal and Replacement, and Stormwater Quality Management
27. BWS Long Range Water Master Plan and Infrastructure Renewal and Replacement Program
28. BWS Water Conservation Incentives Program
29. One Water Collaboration for Climate Resilience
30. Develop R-1 Recycled Water for Irrigation Users in Hawaiʻi Kai

Strategies

Chapter 4 of the EHWMP identifies 23 watershed management strategies and programs that would help to implement the plan's objectives, but do not currently have a championing agency or organization. These strategies and programs include:

A. Southern Koʻolau Mountains Native Species Reforestation Program
B. Stream Restoration, Dechannelization & Maintenance
C. Stream Debris Educational Program
D. Coordinated Pig Hunting Program
E. Trail Educational Program
F. Trail Erosion Mitigation
G. Kuliʻouʻou Ridge Trail Entrance Improvements
H. Firebreak Plan
I. Golf Course Xeriscaping & Water Efficiency Plan
J. Lateral Shoreline Access Plan
K. Awāwāmalu Access Improvements
L. Agricultural Water Use Plans
M. Grey Water Reuse Plan
N. Climate Adaptation Neighborhood Plans
O. Climate Change & Resilience Education
P. Restoration of Freshwater Spring Flows to Nearshore Coastal Waters
Q. Strengthening of Codes & Standards for Building Resilience
R. Build Back Better & Smarter
S. Restrictions on Shoreline Armoring
T. Redevelopment District

Further discussion on the EHWMP's policies, projects, strategies, and programs is provided in *Chapter 4* of the EHWMP.

ES.9 PLAN IMPLEMENTATION

Implementation of the EHWMP will be a long-term, ongoing process involving many project champions, including public agencies, non-profit entities, community groups, and private landowners and businesses. The Implementation chapter (*Chapter 5*) focuses on three approaches to meeting future water demand in East Honolulu: 1) reducing water transfers from Honolulu and Windward water systems through limited source development within East Honolulu; 2) water conservation to manage per-capita demand; and 3) preservation of existing sources and water system infrastructure to maintain reliable service.

These approaches will be implemented through two "catalyst projects" within priority watersheds identified for East Honolulu. Within the EHWMP, a priority watershed is defined as a watershed that: 1) provides various opportunities to promote sustainable watersheds; and/or 2) needs protection or enhancement of water quality and quantity; and/or 3) provides many opportunities to protect Native Hawaiian rights and traditional customary practices; and/or 4) presents special opportunities for organizing and implementing important watershed management actions; and/or 5) provides significant ground water or surface water supplies to meet current and future demand.

A “catalyst project” is defined as a high priority project that, when implemented, will provide energy, connectivity, information, and inspiration for other projects and programs within the watershed. Two catalyst projects have been identified within the East Honolulu planning district: 1) improving the water quality in Maunalua Bay; and 2) improving water efficiency throughout East Honolulu.

The implementation of the first catalyst project to improve water quality in Maunalua Bay will be focused on the district’s priority watersheds. The EHWMP has identified six priority watersheds within the East Honolulu planning district: 1) Wailupe; 2) Niu; 3) Kuliʻouʻou; 4) Hahaʻione; 5) Kamilo Nui; and 6) Kamilo Iki. These priority watersheds represent the highest pollution reduction benefits as determined through consulting local experts as well as relevant studies and literature. The implementation of the second catalyst project to improve water efficiency will be implemented district-wide.

The projects and strategies identified within this plan are the result of a comprehensive watershed analysis and stakeholder consultation process and may involve various governmental agencies and non-governmental organizations. The implementation and funding of these projects will need to be advanced by many stakeholders in addition to the Board of Water Supply, City and County of Honolulu, and State of Hawaiʻi. The EHWMP is intended to guide agencies and organizations in implementing the most important initiatives for East Honolulu and its water resources; however, implementation will depend on budgetary priorities, the availability of grants, and partnering efforts over the long term. Where available, estimated costs are provided for the projects identified in this Plan. Potential funding sources are also identified in *Chapter 5*.

Further discussion on plan implementation is provided in *Chapter 5*.

Chapter 1: O‘ahu Water Management Plan Overview

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1 O‘AHU WATER MANAGEMENT PLAN OVERVIEW

PREFACE: HAWAIIAN AHUPUA‘A: A MODEL FOR HOLISTIC RESOURCE MANAGEMENT

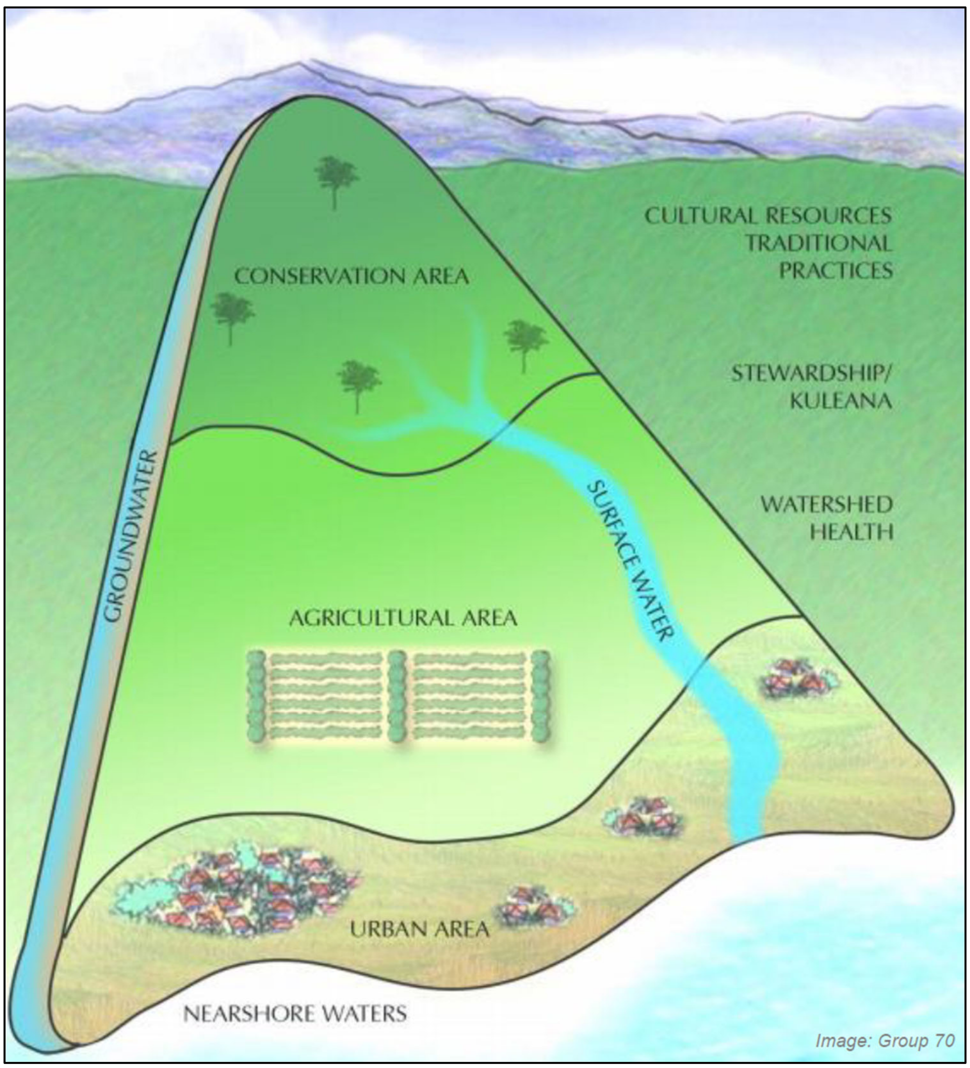
Traditional Hawaiian land management is recognized for being a model of sustainability and community-based decision-making. It is estimated that prior to European contact, there were approximately 800,000 to 1.5 million people living in the islands. Under traditional Hawaiian management, the ahupua‘a system allowed the Hawaiian people to thrive in their natural environment, with fewer of the resource issues that Hawai‘i has today. Presently, Hawai‘i's resident population of 1.4 million is confronted with many serious environmental and natural resource issues, with water supply being one of the most important, especially in the face of climate change.

The ahupua‘a system is a holistic approach that recognizes the interconnectedness between land and sea and all the plants and animals within the ahupua‘a. It is part of a complex system of traditional land divisions that extend into the ocean, with the largest units on each island known as moku (O‘ahu has six moku). Moku are further divided into ahupua‘a, which extend from mauka to makai, and typically encompass an entire watershed. Ahupua‘a were geographically defined so that historically, families living in the area would have all the necessary foods and resources needed to live comfortably. Thus, the shape and size of the ahupua‘a vary depending on the resources of the area. Resources were managed for the collective good of all residents within the ahupua‘a.

In today's context of modern resource management, the ahupua‘a concept provides a useful approach that recognizes the ecological and hydrological connections between mauka and makai resources and the complex interactions and dependencies that exist among environmental, economic, and sociocultural uses. The ahupuaʻa approach to resource management functions as a model with respect to how economic, social, and environmental goals can all be achieved.

This Watershed Management Plan strives to incorporate principles from the ahupuaʻa approach (see *Figure 1-1*), including a holistic mauka to makai perspective that recognizes the ecological connections between land-based and aquatic-based natural resources and the dependent relationships between the built environment, with a triple bottom line balancing environment, economic, and social/cultural values. This style of resource management requires greater collaboration among jurisdictional authorities as well as community involvement and stewardship. Projects that are featured in this plan are related to varied topics that are representative of the ahupuaʻa approach, including projects related to watershed management, cultural resources management, nearshore resources management, educational opportunities, sustainable use of water resources, and others.

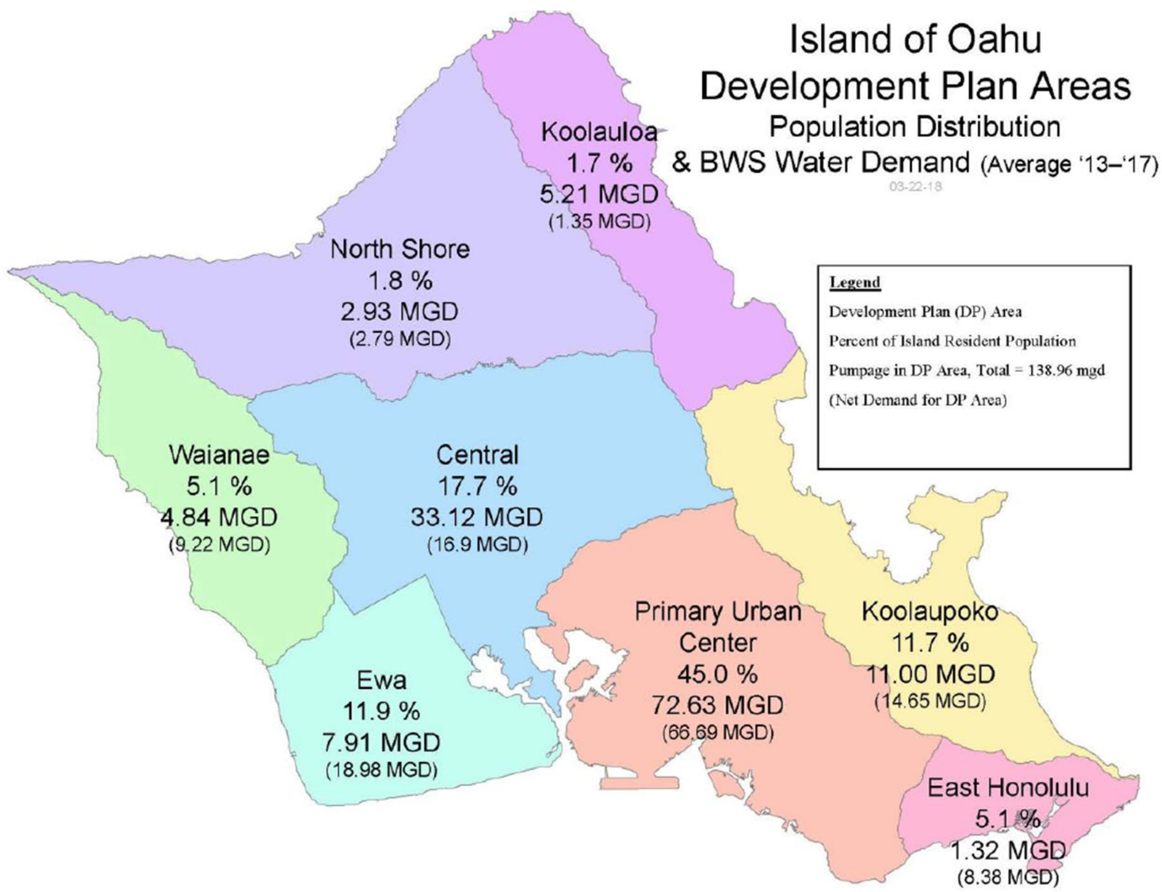
Figure 1-1: Conceptual Illustration of an Ahupuaʻa: The Holistic Watershed



1.1 AUTHORITY AND PURPOSE

The Watershed Management Plans (WMPs) for Oʻahu have been prepared in accordance with the requirements of the State Water Code and Revised Ordinances of the City and County of Honolulu. The State Water Code, Hawaiʻi Revised Statues (HRS) Chapter 174C protects, controls and regulates the use of the State's water resources for the benefit of its people and the environment. Under the Code, the County is responsible for preparing the water use and development plan for the City and County of Honolulu. In response, ROH Chapter 30 Water Management, established the Oʻahu Water Management Plan (OWMP), which has evolved into a framework of regional WMPs by City planning area to plan for the management of all water resources within each watershed (Appendices A and B). Each of the eight City planning areas, known as Development Plan (DP) areas or Sustainable Community Plan (SCP) areas, are shown in *Figure 1-2*.

Figure 1-2: Island of Oʻahu Development Plan Areas



The State Water Code's Declaration of Policy recognizes the need for comprehensive water resources planning and establishes the Hawaiʻi Water Plan (HWP) as the guide for developing and implementing this policy (HRS §174C-2). The HWP is intended to serve as a continuing long-range guide for the Commission on Water Resource Management (CWRM) in executing its general powers, duties, and responsibilities assuring economic development, good municipal services, agricultural stability, and environmental protection.

The HWP currently consists of five major components (plans) identified as the: 1) Water Resource Protection Plan; 2) Water Quality Plan; 3) State Water Projects Plan; 4) Agricultural Water Use and Development Plan; and 5) County Water Use and Development Plans.

The Water Code recognizes that the HWP must be "continually updated to remain useful and relevant and further specifies that each County shall update and modify its water use and development plans as necessary to maintain consistency with its zoning and land use policies" (HRS §174C-31(q)).

WATER USE AND DEVELOPMENT PLAN (WUDP)

A separate WUDP is to be prepared by each of the four counties and adopted by ordinance. The objective of the WUDPs is to set forth the allocation of water to land use in that County. Hawaiʻi Administrative Rules (HAR) §13-170-31 states that each WUDP shall include, but not be limited to:

(1) Status of county water and related land development including an inventory of existing water uses for domestic, municipal, and industrial users, agriculture, aquaculture, hydropower development, drainage, reuse, reclamation, recharge, and resulting problems and constraints;

(2) Future land uses and related water needs; and

(3) Regional plans for water developments including recommended and alternative plans, costs, adequacy of plans, and relationship to the water resource protection plan and water quality plan.

Additional guidelines for preparing the WUDPs are provided in Administrative Rule §13-170-32:

(4) Each water use and development plan shall be consistent with the water resource protection plan and the water quality plan.

(5) Each water use and development plan and the state water projects plan shall be consistent with the respective county land use plans and policies, including general plan and zoning as determined by each respective county.

(6) Each water use and development plan shall consider a twenty-year projection period for analysis purposes.

(7) *The water use and development plan for each county shall also be consistent with the state land use classification and policies.*

(8) *The cost of maintaining the water use and development plan shall be borne by the counties; state water capital improvement funds appropriated to the counties shall be deemed to satisfy Article VIII, section 5 of the State Constitution.*

STATEWIDE FRAMEWORK FOR UPDATING THE HAWAIʻI WATER PLAN

In February 2000, CWRM adopted the Statewide Framework for Updating the Hawaiʻi Water Plan. The objectives of developing and outlining a statewide framework for the HWP are:

- To achieve integration of land use and water planning efforts that are undertaken by Federal, State, County, and private entities so that a consistent and coordinated plan for the protection, conservation and management of our water resources is achieved;
- To recommend guidelines for the HWP update so that the plan and its component parts are useful to CWRM, other State agencies, the counties, and the general public;
- To develop a dynamic planning process that results in a "living document" for each component of the HWP which will provide County and state decision-makers with well formulated options and strategies for addressing future water resource management and development issues;
- To better define roles and responsibilities of all State and County agencies with respect to the development and updating of the HWP components;
- To describe and outline the techniques and methodologies of integrated resource planning as the basic approach that should be utilized in developing and updating the County WUDPs;
- To facilitate permitting and to identify potential critical resource areas where increased monitoring or baseline data gathering should proceed;
- To establish an overall schedule for phased updating of the HWP; and
- To outline an Implementation Plan for near-term and long-term actions.

The Statewide Framework includes the following recommended plan elements for the County WUDP update process:

- County-Specific WUDP Project Description
- Coordination with CWRM on Water Resource Management
- Stakeholder and Public Involvement
- Development of Policy Objectives and Evaluation Criteria
- Description of Water System Profiles
- Identification of Resource and Facility Options
- Development and Evaluation of Strategy Options
- Implementation Plan

The Statewide Framework further recommends integration of HWP components at the County level.

O'AHU WATER MANAGEMENT PLAN: 1990 ADOPTION TO PRESENT

The initial HWP, including all component plans, was adopted by CWRM in 1990. In compliance with the State Water Code, the City and County of Honolulu enacted the O'ahu Water Management Plan (OWMP) by Ordinance No. 90-62 and codified as ROH Chapter 30, Articles 1, 2 and 3, 1990, as amended. The OWMP serves as the WUDP for the City and County of Honolulu. The OWMP consists of policies and strategies, which guide the activities of the City and County of Honolulu and advise CWRM in the areas of planning, management, water development, and use and allocation of O'ahu's natural water resources.

The 1990 OWMP described existing uses of water and contemplated future needs for the island of O'ahu. The plan highlighted regional water problems and identified major water development projects. It also described the quality of water required for the contemplated uses. Informational needs and data gaps identified in the plan included surface water availability and use and agricultural water demand projections.

CWRM deferred adoption of the 1992 OWMP update pending additional refinement of plan components. Subsequent updates were complicated because of rapid changes to the water resources situation on O'ahu with the closing of the sugar plantations and the resulting Waiāhole Ditch Contested Case in 1995.

In 1999, the Honolulu Board of Water Supply (BWS) began the integrated island-wide water planning effort to update the OWMP as recommended by CWRM. However, this approach was met with significant opposition by the public. One of the major concerns expressed by the public was that it is important to have equal focus on resource protection, conservation, and restoration as on water use and development. Communities also desired to be active participants in a community-based planning process. In addition, the communities consulted wanted assurance that there were sufficient water resources within their watersheds before island-wide regional water needs were discussed.

In August 2000, the Hawai'i Supreme Court announced its landmark decision that changed the way Hawai'i's water laws were interpreted. The court drew upon principles of the Public Trust Doctrine and the Precautionary Principle and have over time, identified four Public Trust uses of water that have priority over other water uses: 1) maintenance of waters in their natural state; 2) domestic water use; 3) the exercise of Native Hawaiian and traditional and customary rights, including appurtenant rights; and 4) reservations of water for Hawaiian Home Lands. In response to these Supreme Court decisions, BWS decided to expand the water planning approach to include these principles through a holistic watershed-based approach modeled after the Hawaiian concept of ahupua'a and encompassing environmental, economic, and social/cultural values and behaviors. A planning framework for watershed protection and water use and development was established for updating the OWMP that is inclusive of various legal and planning documents with extensive community participation to guide the plan. On March 17, 2004, CWRM approved the OWMP framework, scope of work and planning elements for regional watershed management plans as meeting the statutory and statewide framework provisions for updating the County WUDP.

The Ordinance further states that in conjunction with BWS, the City and County of Honolulu Department of Planning and Permitting (DPP) shall be responsible for the preparation of the regional watershed management plans for the OWMP. The regional WMPs shall be adopted by ordinance and then submitted to CWRM for adoption. Each regional WMP shall be updated, at a minimum, in tandem with the respective Development Plans/Sustainable Communities Plans. The Honolulu City Council adopted the Waiʻanae and Koʻolau Loa WMPs on August 18, 2010, the Koʻolau Poko WMP on August 15, 2012, and the North Shore WMP on October 5, 2016. These regional watershed management plans will, together with island-wide water management policies and strategies in ROH Article 2 of Chapter 30, form the updated Oʻahu Water Management Plan. In areas where a regional watershed plan has not been adopted, ROH Chapter 30, and the Technical Reference Document for the OWMP, dated March 1990, shall serve as the County WUDP.

CWRM has approved the regional, watershed-based approach to water resource management as a viable methodology for the integration of HWP components within the County WUDP. On March 16, 2011, CWRM adopted the Waiʻanae and Koʻolau Loa WMPs into the Hawaiʻi Water Plan. The Koʻolau Poko WMP was adopted on September 19, 2012 and the North Shore WMP on December 20, 2016.

Each of these Watershed Management Plans is 400 to 500 pages long, including Technical Appendices. The Watershed Management Plans are listed below in chronological order, beginning with the Waiʻanae WMP and the Koʻolau Loa WMP, which were completed in 2010. Some of the key themes of each of the WMPs are summarized as follows:

WAIʻANAE WMP: This Plan is the first BWS watershed management plan to articulate the importance of incorporating traditional Hawaiian concepts and values into the Plan process and content, including an understanding of the importance of the Hawaiian ahupuaʻa system of natural and cultural resources management. The Plan also emphasizes water resources management and water conservation programs for this relatively dry and water-scarce region of the island of Oʻahu.

KOʻOLAU LOA WMP: This Plan emphasizes the importance of incorporating the Hawaiian ahupuaʻa system into natural and cultural resources management and sets forth policies for ensuring sufficient water supply for Koʻolau Loa on the Windward side of Oʻahu.

KOʻOLAU POKO WMP: This district of Oʻahu has four distinct communities with four separate Neighborhood Boards: Waimānalo, Kailua, Kāneʻohe and Kahaluʻu. This Watershed Management Plan was thus developed as four Plans with common themes, including the importance of water supply for small-scale local farms and the preservation and restoration of important streams in the District.

NORTH SHORE WMP: The North Shore is the only one of Oʻahu's eight districts that is not connected to the island-wide BWS water distribution system. The Plan emphasizes the importance of the North Shore's agricultural lands and food production potential and sets forth policies, projects and strategies that will provide sustainable water resources for present and future agricultural and community use.

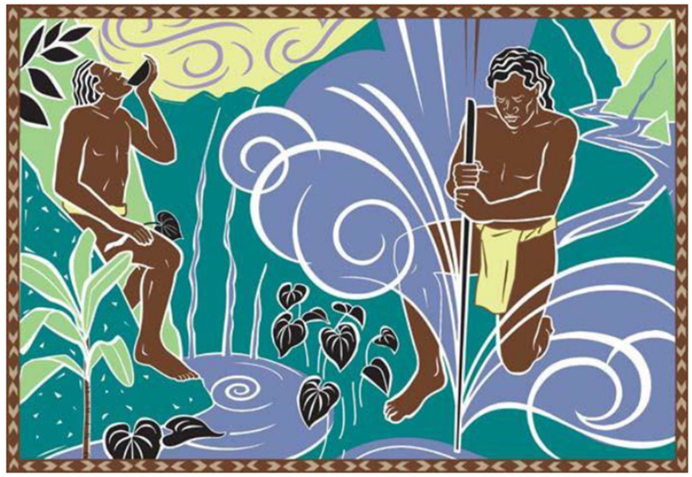
ʻEWA WMP: This Plan emphasizes the critical importance of existing and future recycled water production, conservation, and desalination for this dry, water-scarce, master planned region which City policies have established as the secondary urban growth center for Oʻahu.

CENTRAL OʻAHU WMP: This Plan addresses the District's water resources needs for both urban development and agricultural activities, and identifies the need to "export" significant amounts of available water to the neighboring districts of the Primary Urban Center, ʻEwa, and Waiʻanae.

PRIMARY URBAN CENTER WMP: This Plan is the first WMP to address the potential impacts of climate change and sea level rise on water resources, critical urban infrastructure, and urban land uses. The Plan also includes plans and strategies based on the concepts of "One Water" – an integrated planning and implementation approach to managing finite water resources for long-term resilience and reliability, meeting both community and ecosystem needs. One Water considers the water cycle as an integrated system, recognizing the interconnectedness of surface water, ground water, storm water, wastewater, sea water, and energy.

EAST HONOLULU WMP: This East Honolulu Watershed Management Plan focuses on the need for increased water conservation and efficiency and mauka to makai management issues including flooding, stormwater runoff, and other factors impacting the quality of Kuapā Pond and the nearshore waters of Maunalua Bay. The Plan also discusses the future impacts of climate change on the communities of East Oʻahu.

1.2 OʻAHU WATER MANAGEMENT PLAN FRAMEWORK



"Water for Life – Ka Wai Ola"

The Oʻahu Water Management Plan (OWMP) consists of overall policies and strategies and regional watershed management plans that will guide the activities of the City and County of Honolulu and will also provide advice to CWRM regarding the planning, management, conservation, use, development, and allocation of Oʻahu's limited surface water and ground water resources for the next 20 years to 2040.[1] The OWMP shall be consistent with relevant Federal, State, and City laws and policy documents, including:

- Federal Clean Water Act and Safe Drinking Water Act
- Hawaiʻi State Water Plan
- State Water Code
- Statewide Framework for Updating the Hawaiʻi Water Plan
- Hawaiʻi Supreme Court Decisions on the Waiāhole Ditch and the Waiʻola O Molokaʻi contested cases
- State land use classifications and policies
- Hawaiʻi Sea Level Rise Vulnerability and Adaptation Report (2017)
- City and County of Honolulu Mayor's Directive on Climate Change and Sea Level Rise (2018)
- City and County of Honolulu Chapter 30, ROH establishing the OWMP island-wide polices and strategies and regional WMPs.
- City and County of Honolulu General Plan (GP), Development Plans (DP), and Sustainable Communities Plans (SCP) for Oʻahu's eight planning areas
- City Zoning Designations
- BWS Mission of "Water for Life, Ka Wai Ola"

The resulting WMPs are built on the following key planning principles:

- Community-based
- Environmentally holistic and economically viable
- Based on ahupuaʻa management principles
- Action-oriented

[1] Revised Ordinances of Honolulu (ROH). (2022). Chapter 30, Section 30-1.1(c). *Relating to Water Management*.

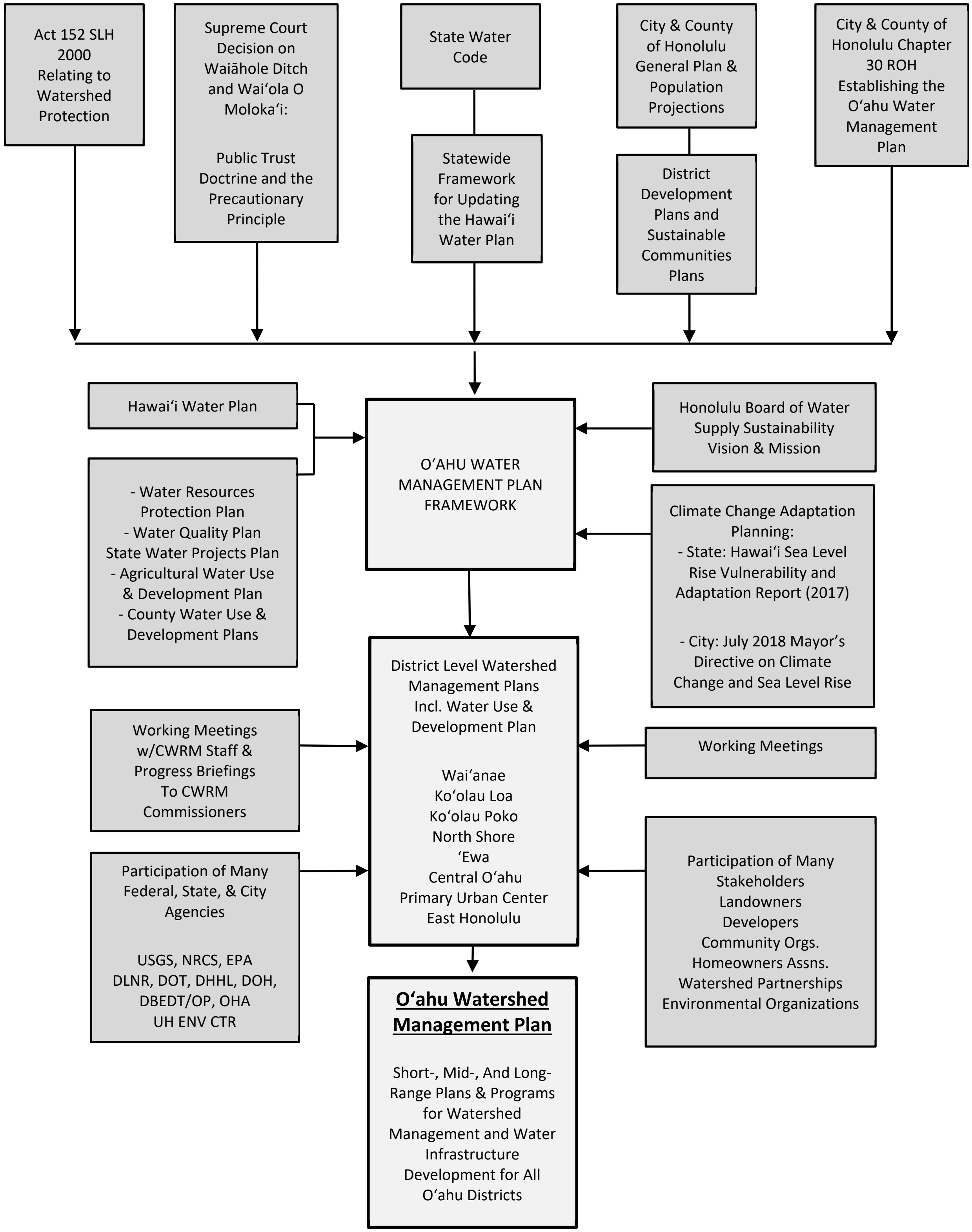
- In alignment with State and County water and land use policies.

Figure 1-3 illustrates the planning framework for the OWMP. The framework identifies the various legal and planning documents that guide the plan. Each of the eight WMPs by Oʻahu General Plan DP/SCP area will be organized within this framework and the island overview chapter will provide a consolidating mechanism to place each of the regions into the proper island-wide perspective.

The framework is meant to establish and guide the watershed management objectives and strategies specific to each region. The eight WMPs tie directly into the eight land use plans through common boundaries, vision, and policies. A key denominator integrating land use and water planning is the maintenance of a healthy watershed. Land use plans and water use and development plans that support growth and existing communities on Oʻahu must ensure that watersheds remain healthy through sustainable planning practices, watershed protection projects, and best management practices that minimize impacts.

Given these expressed inter-relationships between land and water, Chapter 30 ROH now requires that each regional WMP shall be updated, at a minimum, in tandem with the respective Development Plans/Sustainable Communities Plans. With each iteration, land use and water planning will become increasingly integrated in vision, policies, goals, and objectives, so that resource protection and management and infrastructure development support a sustainable future.

Figure 1-3: Watershed Management Plans for Oʻahu, County and State Level Planning Framework Diagram



Based on the planning principles and through a consultation process with community leaders, community groups, public agencies, landowners, and other stakeholders in the watershed management planning process, BWS developed an overall statement of Goals and Objectives for the OWMP, as follows:

GOAL

To formulate an environmentally holistic, community-based, and economically viable WMP that will provide a balance between: 1) the preservation, restoration, and management of Oʻahu's watersheds; and 2) sustainable ground water and surface water use and development to serve present users and future generations.

OBJECTIVES

(1) Promote sustainable watersheds.
(2) Protect and enhance water quality and quantity.
(3) Protect Native Hawaiian rights and traditional and customary practices.
(4) Facilitate public participation, education, and project implementation.
(5) Meet future water demands at reasonable costs.

The WMP objectives were derived from an extensive stakeholder consultation process and reflect their values and thinking about water resources. These values and thinking were then consolidated into broad goals and objectives that apply island-wide thus providing the overall guidance, balance, and consistency for each of the eight DP/SCP area WMPs. Each WMPs will define more specific sub-objectives, policies, strategies, and actions that reflect specific planning area conditions, issues, and needs and provide a balance among all five plan objectives under the OWMP Framework.

Objective 1. Promote Sustainable Watersheds

Sustainable watersheds are biologically diverse, renewable, and resource productive land and water ecosystems extending from the mountains to the coral reefs, that meet present needs without compromising those of future generations. In a sustainable watershed, there is a holistic interrelationship among watershed resources including geologic structures, soil characteristics, forest communities, endemic and indigenous animals, native and introduced species, ground water aquifers, streams and wetlands, reefs and near-shore waters, traditional and cultural practices, land use and land development. Healthy, sustainable watersheds should be the foundation for both land use and water resources management planning.

Sustainable watersheds can be achieved by implementing a comprehensive WMP that promotes a healthy watershed by emphasizing habitat and native species preservation, active forestry management practices, invasive species and pollution controls, resource conservation and demand-side management programs, low impact development concepts, recycling, renewable energy development, and climate change and sea level rise adaptation.

Objective 2. Protect and Enhance Water Quality and Quantity

Water is essential to human life and to the health of the environment. As a valuable natural resource, it comprises marine, estuarine, wetlands, fresh water streams and ground water environments, across coastal and inland areas. Water has two dimensions that are closely linked - quality and quantity. Water quality relates to the composition of water as affected by natural processes and human activities. It depends not only on water's chemical condition, but also its biological, physical and radiological condition. Water quantity relates to the amount of renewable ground water supply or base stream flow existing on a sustainable basis. In a healthy environment, water quality and quantity support a rich and varied community of organisms and protect public health. Water quality and quantity influence the way in which communities use the water for activities such as drinking, swimming, fishing, farming, gathering, or commercial purposes.

Drinking water systems are regularly tested for compliance with U.S. Environmental Protection Agency (EPA) Safe Drinking Water Standards and BWS criteria for system operations and resource monitoring. Watershed protection projects and programs will ensure that aquifers and streams are healthy and sustainable. Source water protection programs and the monitoring of hydrologic indicators of rainfall, stream and spring flows, and aquifer water levels will ensure consistently high source water quality.

BWS ensures the health of the ground water aquifers by monitoring the island-wide index and deep monitor wells for water levels and chlorides at the top and mid-point of the fresh water/sea water transition zone. Source water quality can be affected by sea water intrusion or up-coning brackish water especially during extended drought. Reducing pumping during high rainfall periods from specific sources impacted during drought and continuous resource monitoring ensures sufficient aquifer recovery during post-drought periods.

BWS, CWRM, University of Hawaiʻi (UH), and the U.S. Geological Survey (USGS) are advancing research and analytical modeling tools to increase understanding of recharge and ground water aquifers and streams. The agencies work collaboratively to fund, construct and utilize 3-dimensional solute transport ground water modeling calibrated with new deep monitor wells in basal aquifers to:

- Evaluate individual source yields to prevent up-coning and salt water intrusion during normal rainfall and drought events.
- Optimize existing source pumpage to meet water system demands and avoid detrimental impacts to the aquifer's utility (quality and quantity); ensure adequate aquifer recovery after long drought periods.

- Evaluate aquifer sustainable yields as allocations and pumpage approach sustainable yield limits to ensure new sources are sustainable.
- Site and size new wells to develop remaining ground water and minimize impacts to adjacent and down-gradient sources and surface waters.

Objective 3. Protect Native Hawaiian Rights and Traditional and Customary Practices

Native Hawaiian water rights are set forth in the State Constitution, Section 221 of the Hawaiian Homes Commission Act and Section 174C-101 of the State Water Code, providing for: a) Department of Hawaiian Home Lands water; b) traditional and customary gathering rights; and c) appurtenant water rights of kuleana and kalo lands. Native Hawaiian water uses also include cultural uses for spiritual/religious practices, kalo and other traditional agriculture, as well as adequate flows of fresh water into the nearshore water ecosystem.

The Hawaiʻi Supreme Court held that title to water resources is held in trust by the State for the benefit of its people and established the exercise of Native Hawaiian and traditional and customary practices as a Public Trust purpose, along with the maintenance of waters in their natural state, domestic water use, and reservation of water for Hawaiian Home Lands. In Ka Paʻakai O Ka ʻĀina vs. Land Use Commission (2000), the Hawaiʻi Supreme Court provided an analytical framework *"to effectuate the State's obligation to protect native Hawaiian customary and traditional practices while reasonably accommodating competing private [property] interests."* The Court enumerated three criteria for agencies to protect traditional and customary Hawaiian practices to the extent feasible. Under this framework, Hawaiʻi State and County agencies must independently assess the following three criteria when reviewing land use applications:

KA PAʻAKAI CRITERIA
1) The identity and scope of valued cultural, historical, or natural resources in the petition area, including the extent to which traditional and customary native Hawaiian rights are exercised in the petition area;
2) The extent to which those resources – including traditional and customary native Hawaiian rights – will be affected or impaired by the proposed action; and
3) The feasible action, if any, to be taken to reasonably protect native Hawaiian rights if they are found to exist.

Some of the objectives proposed for implementing the Public Trust purposes and protecting traditional and customary practices include the provision of adequate stream flows, riparian restoration, and control of alien species. The objectives in the WMPs strive to ensure the availability of healthy and plentiful water resources and comply with the State's Public Trust obligations.

Protecting Native Hawaiian rights and traditional and customary practices must be done in conjunction with setting measurable instream flow standards (IFS) for all perennial streams and stream segments, and balancing in-stream uses, domestic uses, and Native Hawaiian and traditional and customary uses with off-stream reasonable and beneficial uses. In developing those standards, a precautionary order consisting of instream studies such as stream hydrology and bio-assessments for habitat and gathering, is proposed. Studies of water for Public Trust purposes are also needed. Only after completing this evaluation of stream water can a determination of surface water availability for additional agricultural uses and urban non-potable uses be accomplished.

Where practical, the WMP will identify the conversion of existing off-stream surface water uses to recycled water and implement conservation measures to create an opportunity for stream restoration. BWS will continue to develop new ground water sources that do not impact surface waters. However, if instream flow standards are established and surface water becomes available, surface water diversions and ground water development that may reduce surface water within the allowances granted by the measurable IFS may be pursued.

<u>Objective 4. Facilitate Public Participation, Education, and Project Implementation</u>

Planning and managing our island's water and related resources involves a variety of stakeholders including end users, landowners, public and private water purveyors, and government agencies. A collaborative process can result in innovative planning and implementation that incorporates local knowledge and directly involves area residents. Public education of water resource issues can support collaboration with informed stakeholders. Directed water resource curriculum for schools will ensure that knowledge and respect for water resources will extend to future generations. Ultimately public participation will result in benefits to the water resources, water users, and the related ecosystems.

Several watershed partnerships have been established in both conservation and urban areas with community groups, agencies and organizations with similar objectives. These partnerships pool funding, resources and initiatives toward common objectives of watershed health, education, project funding, and implementation.

The "One Water" framework is an integrated planning and implementation approach to managing finite water resources for long-term resilience and reliability, meeting both community and ecosystem needs. It considers the water cycle as an integrated system, recognizing the interconnectedness of surface water, ground water, storm water, wastewater, and energy. The integrated nature of One

Water offers the opportunity for public and private party collaboration on planning for projects that have mutual cross-sector benefits.

<u>Objective 5. Meet Water Demands at Reasonable Costs</u>

Water is essential to all life. Oʻahu's population relies on an abundant and reliable water supply for drinking, irrigation, agriculture, commercial and industrial use, and fire protection. Oʻahu's residents are educated in watershed management practices; water conservation is not just a message, but a way of life. Efficient water systems promote public health and safety and deliver water to meet current and future demands at reasonable costs. Reasonable costs encompass a balancing of the other plan objectives and are not necessarily the lowest economic costs. Capital improvements and operations and maintenance costs should not place an unreasonable burden on water rate payers. Water systems are flexible yet secure to account for uncertainties and are expanded concurrent with land use plans and growth forecasts. Withdrawal rates are precautionary with respect to the resource and are well within established sustainable yields and instream flow standards, which protect the long-term viability of the water resource and do not detrimentally impact cultural uses and natural environments.

The allocation of water to land use considers a full range of alternative water sources. Water quality should be matched with appropriate use. Thus, high quality water is used for drinking and lower quality water, such as recycled water, is used for irrigation and industrial processes. New technology allows cost effective, diversified, drought-proof water systems that develop ground water, surface water, recycled and sea water resources that meet water demands while balancing other plan objectives.

The following categories describe the primary water planning elements of this objective:

<u>Water Conservation</u>

- Improving distribution system efficiencies will reduce Operations and Maintenance (O&M) costs and reduce water loss. Infrastructure water loss and efficiency measures include leak detection and repair of existing pipelines and ditch systems and the renewal and replacement of water system facilities (pipelines, ditches, pump stations, reservoirs and treatment systems). Advanced corrosion protection systems and pipe materials and coatings will maximize the life of existing and new pipelines.
- Promoting demand-side management programs provides hardware and behavioral modifications on customer water use. Water conservation tips, public service announcements and specific programs tailored to distinct user categories will effectively reduce water use and defer development of new water sources.

- Educational programs promote conservation as a way of life that affects a generational change in thinking that starts with the education of our children. BWS has been promoting water conservation best practices in schools for over 40 years.

Efficient Water Use and New Sources of Supply

- New source development can be deferred with increases in system efficiency, which is more cost effective. New source options must balance economic costs with environmental, cultural and social values.

Growth Projections

- Improving water demand forecasting methodologies will ensure that new sources become available at the appropriate time. The level of accuracy will improve as the calibration of leading indicators and trends improve.

Drought Mitigation

- A diversified and sustainable water system can mitigate drought impacts. A diversified and sustainable water system can mitigate drought impacts. The State and Oʻahu County Drought Plans have identified mitigation strategies and projects for water supply, agriculture and wildland fire prevention, to reduce the detrimental impacts of drought on water uses, the economy and the environment.
- Water shortage plans are important to ensure available water supply for essential needs through progressively restrictive water conservation strategies and resilient infrastructure during shortages caused by low ground water levels from drought and disruptions of source capacities from contamination and infrastructure failure.

Operational Flexibility

- An integrated island-wide water system provides operational flexibility, water service reliability, and hydraulic efficiency. A flexible water system maintains level of service standards while allowing planned repair and maintenance. An important element of optimization integrates efficient operations of the existing water systems with sustainable aquifer pumpage levels.

Water System Reliability, Adequacy and Efficiency

- Water system reliability reflects the ability of the distribution system to consistently deliver water with minimal interruptions during normal and emergency conditions. Water systems are constantly improved to meet BWS Water System Standards providing standby pump capacity, infrastructure redundancy, treatment systems, enhanced security measures, drought mitigation, and disaster response.

- Adequate capacity reflects the ability to deliver an acceptable quantity and quality of water at a suitable pressure and overall responsiveness to customer needs and planned growth. As aging pipelines are replaced, capacity is added to improve fire protection, increase low pressure areas and reduce high pressure transients that could reduce pipeline design life. A diversified water supply system consisting of a combination of ground water, surface water, storm water, recycled water, desalinated water and sea water resources improves water system adequacy.
- Water system efficiency reflects how well water is produced, delivered and used, and how energy is utilized. Efficiency is the ability to deliver water with a minimum of effort, expense or waste. Reliable water systems are energy efficient, have emergency power generation and are supplied with an increasing proportion of renewable energy supplies reducing reliance on imported oil. Elements of this objective include:
    - Reducing water system energy use per MGD produced.
    - Energy efficiency measures in pumping facilities include motors, variable frequency drives, lighting, heating, ventilation and use of photovoltaics.
    - Peak power load reduction demand response using reservoirs and diesel generators to meet peak hour water demand results in lower electric bills.
    - Researching and supporting renewable energy systems such as H-POWER, wind, solar, biofuels, ocean thermal energy conversion, and wave energy will help reduce water pumping power consumption from imported oil, mitigating some of the global energy uncertainties.

Planning for Uncertainty

- Maximize the ability to effectively plan and respond to uncertainties in water supply, forecasting water demand and climate change.

Climate Change Adaptation

- Establish policies to address, minimize risks from, and adapt to the impacts of climate change and sea level rise in accordance with the findings and recommendations of the City and County of Honolulu Mayor’s Directive on Climate Change and Sea Level Rise (July 2018), the Hawaiʻi Sea Level Rise Vulnerability and Adaptation Report (2017), and the City Climate Change Commission's Sea Level Rise Guidance.
- Support climate change research, conduct vulnerability assessments for water supply and water related infrastructure, and conduct risk assessments to prioritize planning areas to efficiently focus investments.
- Conduct long-range functional plans that drive City capital improvement projects that increase infrastructure resiliency to adapt to climate change and sea level rise.

1.3 OʻAHU WATER USE AND DEVELOPMENT PLAN UPDATE

The OWMP consists of island-wide water management policies and strategies and regional watershed management plans, which guide the activities of the City and County of Honolulu and advises the State CWRM in the areas of planning, management, water development and use and allocation of Oʻahu's limited water resources. The island-wide policies and strategies listed in ROH, Article 2, Chapter 30, and restated below, apply to all City agencies *"in the performance of their powers, duties and functions as related to both public and private development."* The implementation of the strategies will carry out the policies.

Policy 1. Facilities for the provision of water shall be based on the General Plan population projections and the land use policies contained in the Development Plans and depicted on the Development Plan land use maps.

Policy 2. System flexibility shall be maintained to facilitate the provision of an adequate supply of water consistent with planned land uses. The municipal water system shall be developed and operated substantially as an integrated island-wide water system.

Policy 3. Close coordination shall be maintained between Federal, State and County agencies which are involved in the provision or management of water to ensure optimal distribution of the available water supply.

Policy 4. The quality and integrity of the water supply shall be maintained by providing for the monitoring and protection of the water supply in accordance with the requirements of the state water code.

Policy 5. The development and use of non-potable water sources shall be maximized in a manner consistent with the protection of the ground water quality.

Policy 6. Water conservation shall be strongly encouraged.

Policy 7. Alternative water sources shall be developed wherever feasible to ensure an adequate supply of water for planned uses on Oʻahu.

Strategy 1. Develop water resources in consonance with the General Plan population projections and the land use policies contained in the Development Plans and depicted on the Development Plan land use maps. Priority shall be given to affordable housing projects shown on the Development Plan land use maps or processed under HRS Chapter 201H.

Strategy 2. Continue to safely develop the remaining available ground water in accordance with the requirements of the State water code.

Strategy 3. Use surface water more effectively and efficiently.

Strategy 4. Continue to refine the near and long-term projections of agriculture on the island to more accurately project the future net release of water currently committed to agricultural use.

Strategy 5. Maintain an ongoing water conservation program through the board, using such approaches as pricing, public information, educational programs, water-saving devices, and use restrictions and allocations.

Strategy 6. Develop and use non-potable water sources, wherever feasible, for the irrigation of agricultural crops, parks and golf courses, landscaping and for certain industrial uses.

Strategy 7. Continue efforts to develop economical methods of demineralizing brackish water and desalting sea water.

Article 2 further states that *"based on the findings and projections in the OWMP, provisions for an adequate supply of water to meet island-wide needs for at least twenty years shall be addressed. This shall be determined after evaluating the anticipated demand for water use from municipal, agricultural, military and private users; the available remaining ground water which can be safely developed; the planned and proposed water source development projects; and alternative water development projects under way."* The following update provides this basis.

Water use and development on O'ahu is guided by the City's General Plan and the Development Plans and Sustainable Communities Plans for the eight DP/SCP areas. These community-based land use plans describe each community's vision of their future and provide land use and infrastructure policies and guidelines. An important aspect of the City's land use plans is the establishment of urban growth and sustainable community boundaries that separate urban and rural development from agricultural and conservation lands. These boundaries provide adequate area for urban and rural development, protect important agricultural and conservation lands and facilitate infrastructure master planning.

An essential component of the WMP is the development of region-specific watershed management projects and strategies that enhance ground water and surface water supplies, improve land management with respect to water, protect traditional and cultural practices and facilitate plan implementation. Each regional WMP will consist of about 30 to 40 watershed management projects and strategies derived from stakeholder consultation and the strategic plans and capital improvement programs of various Federal, State and City agencies, organizations, communities, and watershed partnerships. These projects meet the five WMP objectives of balancing the protection of natural resources and the sustainable use of Oʻahu's water supplies.

The following summary of Oʻahu's water use and development provides the island-wide context to review and understand the eight regional WMPs. Together, the proposed regional watershed management plans update the OWMP as designed in the OWMP Framework.

As part of the process of initiating the update of the OWMP, and consistent with the guidelines set forth in the Statewide Framework for Updating the Hawaiʻi Water Plan, BWS has compiled information on existing and projected water demands and sources of supply for the municipal system; State, Federal, and private water systems; and prime and unique agricultural lands. In summary, BWS has evaluated the adequacy of the supply to meet future potable and non-potable water needs, and through a combination of conservation, diversified water supply development and watershed protection strategies, the City can meet water demands through the 2040 planning period.

1.3.1 City and County of Honolulu Land Use Plans

The General Plan for the City and County of Honolulu is a comprehensive statement of objectives and policies, which sets forth the long-range aspirations of Oʻahu's residents and the strategies and actions to achieve them. It is the overarching policy document of a comprehensive planning system that addresses physical, social, economic and environmental concerns affecting Oʻahu. This planning system serves as the coordinating structure by which the City provides for the future growth on the island of Oʻahu. The General Plan provides objectives and policy statements which will help the City achieve a desirable and attainable residential population distribution among the eight DP/SCP areas, directing the bulk of new growth and supporting infrastructure to the primary and secondary urban centers and the ʻEwa and Central Oʻahu urban fringe areas to relieve developmental pressures in the remaining urban fringe and rural areas and to meet housing needs.

The City established regional Development Plans and Sustainable Communities Plans for each of the eight planning areas on Oʻahu. Each community-oriented land use plan is intended to help guide public policy, investment, and decision making over the next 20 years. Each plan responds to specific conditions and community values of each region. ʻEwa and the Primary Urban Center are "development plan" areas where growth and supporting facilities will be directed and be the policy guide for development decisions and actions needed to support that growth. The remaining six planning areas are "sustainable communities" plans, which are envisioned as relatively stable regions in which public programs will focus on supporting existing populations. Each DP/SCP area establishes a boundary to contain urban and rural development to protect agriculture and preservation zoned areas. These plans can be found on the City and County of Honolulu Department of Planning and Permitting's website at www.honolulu.gov/dpp/planning.

1.3.2 Population Forecasts and Municipal Water Demand

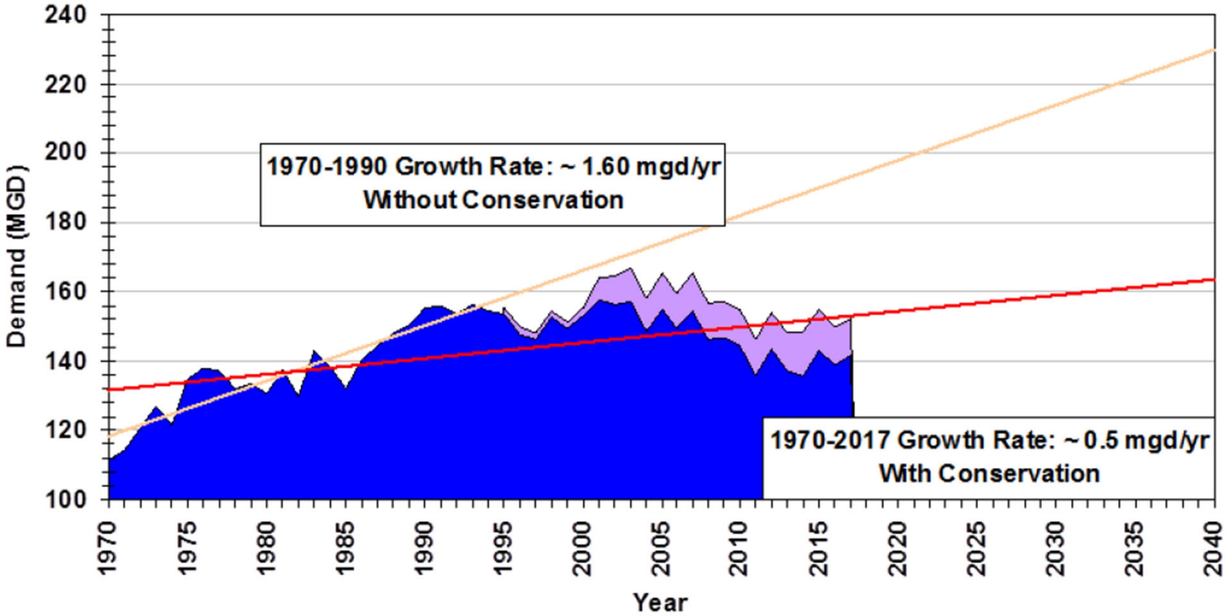
Population forecasts are provided by DPP's land use model utilizing U.S. Census Bureau and State Department of Business, Economic Development, and Tourism (DBEDT) data, development master plans and subdivision information. DPP provides the forecasts by transportation analysis zones and census tracts, which provide more discrete land use coverage information within each DP/SCP area.

BWS applies its water use data to DPP's population forecast data to derive BWS-served populations, gallon per capita demands, and water demand forecasts by DP/SCP area for long range planning of source development and water system infrastructure sizing. Note that with all long-range forecasts, a range of variation will occur due to uncertainties in changing economic climate, jobs, tourism, zoning, development starts, population distribution, and water conservation.

BWS water conservation programs starting in 1990 (in particular low-flow toilets), Honoʻuliʻuli recycled water in 2003, and the economic incentives associated with the increase in water and sewer rates over the last decade have significantly reduced potable water demand on Oʻahu. In *Figure 1-4*, potable demand (blue) plateaued at about 155 MGD from 1990 to 2000 after steady growth from 1970 to 1990. Since 2004, potable water demand has decreased to 141.6 MGD in 2017 despite a resident population increase of over 115,000 people. Recycled and brackish non-potable demands are shown in purple.

In *Figure 1-4*, potable demand growth rates are linearly projected to 2040 along two slopes: 1.60 MGD per year from 1970 to 1990 without conservation; and 0.6 MGD per year from 1970 to 2017 with conservation amounting to 164 MGD in 2040. The trend with conservation can be considered the BWS' most probable demand scenario, while the 228 MGD trend without conservation in 2040 is no longer considered a possible scenario. A trend line from 1990 to 2017 would show a decreasing trend to some future point but is not provided because there is a saturation point at which additional conservation savings will only be realized at significant costs.

Figure 1-4: BWS Potable and Non-Potable Water Systems Demands: Actual 1970-2017 and Linear Projection to 2040



BWS applies the per capita demand model to forecast future water demands because population forecasts using the DPP land use model as described above are readily available. In *Table 1-1*, the Per Capita Demand is derived by dividing BWS potable water demand, which includes water loss, by the BWS served population. The served population accounts for visitors present, residents absent and deducts military and private water systems. The per capita demand is then multiplied by the projected served population to derive the potable water demand forecast.

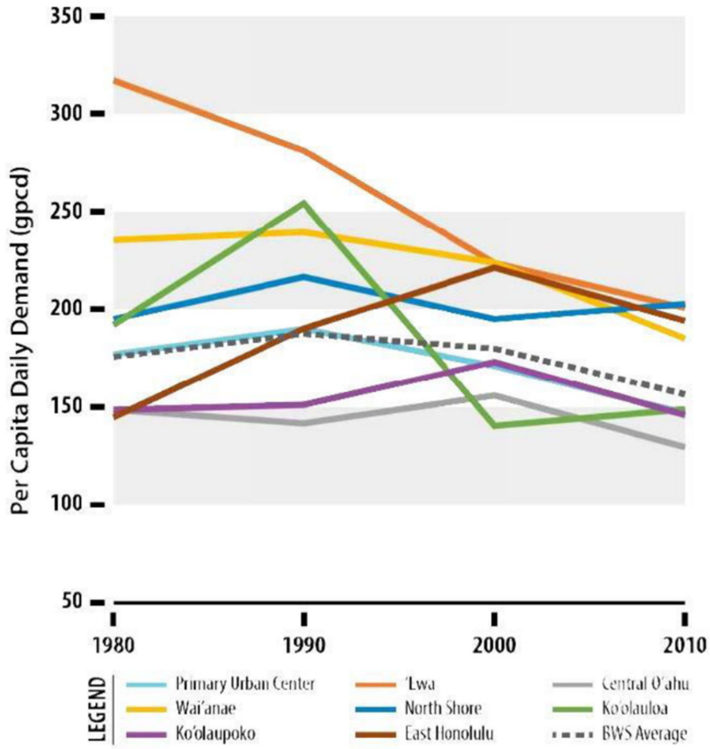
Table 1-1: O'ahu Population and Water Demand 2010, By Development/Sustainable Communities Plan Area

DP/SCP Area	Resident Population	% Resident Population	Residents Absent	Visitors Present	De facto Population	Private/ Military	BWS Population Served	DP/SCP area Demand (MGD)	Per Capita Demand (GPCD)
Waiʻanae	48,519	5%	2,667	1,349	47,201	6	47,195	9.244	196
ʻEwa	101,397	11%	5,575	2,993	98,815	6,757	92,058	17.072	185
Central Oʻahu	168,643	18%	9,271	493	159,865	18,822	141,043	17.761	126
PUC	435,118	46%	23,921	79,967	491,164	30,214	460,950	69.448	151
East Honolulu	49,914	5%	2,744	896	48,066	0	48,066	9.348	194
Koʻolau Poko	115,164	12%	6,331	293	109,126	632	108,494	15.859	146
Koʻolau Loa	16,732	2%	920	80	15,892	6,398	9,494	1.417	149
North Shore	17,720	2%	975	1,377	18,122	3,623	14,499	2.929	202
TOTAL	**953,207**	**100%**	**52,404**	**87,448**	**988,251**	**66,452**	**921,799**	**143.08**	

Table 1-1 Note: Population numbers are from DPP using 2010 census numbers.

Water conservation has a significant and beneficial effect on the per capita demand factors from 1990 to 2010 (*Figure 1-5*). From 1990-2010, the per capita demand decreased 16.5%, from 188 gallons per capita per day (GPCD) to 155 GPCD. The BWS average per capita demand tracks closely with that of the Primary Urban Center because it has the highest demands and the largest population. The per capita daily demand for ʻEwa was over 300 GPCD in 1980 but dropped to less than 200 GPCD by 2010. The per capita demand in ʻEwa was high in 1980 because there was only a small population compared to the industrial demand. From 1980 to 2010, residential population almost tripled, while corresponding industrial demand continued to decline due to water conservation and increased recycled water use that replaced potable water, thus reducing the per capita demand significantly. The per capita daily demand for Koʻolau Loa fluctuates the most out of the eight DP/SCP areas because it has the smallest population and the smallest overall demand. BWS projects per capita demand to continue to decrease as long as water conservation program goals are achieved.

Figure 1-5: BWS Gallons per Capita Daily Demand Trend 1980-2010



The following tables and descriptions highlight the BWS water demand forecasts by DP/SCP area on Oʻahu. BWS served population for Oʻahu in *Table 1-2* is forecasted to increase 14.5% (approximately 1% per year) from 921,799 in 2010 to 1,055,400 in 2040 which is less than 1 percent per year. The 2040 population growth rates range from 81% in ʻEwa to -3% in Koʻolau Poko. The Primary Urban Center, ʻEwa, and Central Oʻahu will account for 96% of the total increase in population, while Koʻolau Poko and East Honolulu are anticipated to experience negative growth as the population ages.

Table 1-2: BWS Served Population by Year and DP/SCP Area

Calendar Year:	1980	1990	2000	2010	2020	2025	2030	2035	2040
DP/SCP AREA	Given Data (Served Pop.)				Projected Data (Served Pop.)				
Waiʻanae	32,724	37,801	41,731	47,195	48,892	49,741	50,590	51,439	52,300
ʻEwa	24,614	31,321	61,660	92,058	117,085	129,598	142,111	154,625	167,100
Central Oʻahu	77,354	105,917	124,455	141,043	148,920	152,858	156,797	160,735	164,700
PUC	435,671	466,297	447,114	460,950	470,800	475,725	480,649	485,574	490,500
East Honolulu	42,829	45,646	45,702	48,066	47,962	47,910	47,858	47,806	47,800
Koʻolau Poko	107,667	116,803	113,256	108,494	107,565	107,100	106,635	106,171	105,700
Koʻolau Loa	7,816	11,212	10,409	9,494	9,984	10,229	10,474	10,719	11,000
North Shore	11,798	14,725	14,438	14,499	15,090	15,385	15,680	15,976	16,300
TOTAL Oʻahu Population	**740,473**	**829,722**	**858,765**	**921,799**	**966,297**	**998,546**	**1,010,795**	**1,033,043**	**1,055,400**

BWS gallon per capita demand for potable water is forecasted to slow its downward trend from 2010 to 2040 as water conservation capacity approaches saturation *(Table 1-3).* ʻEwa has the largest potential for water efficiency savings of 14% despite its dry climate because of the availability of recycled water for irrigation of large landscaped areas.

Table 1-3: BWS GPCD by Year and DP/SCP Area

Calendar Year:	1980	1990	2000	2010	2020	2025	2030	2035	2040
DP/SCP AREA	Given Data (GPCD Rate)				Projected Data (GPCD Rate)				
Waiʻanae	235.30	239.40	223.79	195.87	191.19	185.40	179.79	174.34	170.00
ʻEwa	316.90	281.10	223.58	185.45	167.87	160.00	160.00	160.00	160.00
Central Oʻahu	148.70	141.80	155.96	125.93	125.00	123.00	123.00	121.00	121.00
PUC	177.00	190.00	170.98	150.66	145.38	140.77	140.00	140.00	140.00
East Honolulu	144.80	190.20	221.30	194.48	180.00	180.00	180.00	180.00	180.00
Koʻolau Poko	148.60	151.20	173.17	146.17	145.00	145.00	145.00	145.00	145.00
Koʻolau Loa	191.90	254.20	140.55	149.25	140.00	140.00	140.00	140.00	140.00
North Shore	194.90	216.60	194.97	202.01	202.83	202.93	203.03	203.14	200.00
TOTAL Oʻahu GPCD	**175.70**	**187.57**	**179.91**	**155.22**	**149.80**	**146.11**	**145.57**	**145.09**	**144.78**

Assuming a continuation of conservation savings trends, the most probable average day water demand for BWS water is forecasted to increase by less than 10 MGD from 143.1 MGD in 2010 to 152.8 MGD in 2040 *(Table 1-4)*. The largest water demand increase relative to 2010 is expected in ʻEwa due to a population increase of about 75,000 people by 2040. Central Oʻahu has the second largest increase in demand. Interestingly, PUC's water demand is expected to be relatively stable despite an increase of about 29,600 people from 2010 because per capita demand is decreasing. High rise transit-oriented development uses much less water than a townhouse or single-family residence which will reduce the per capita water demand. Waiʻanae, Koʻolau Poko, and East Honolulu are projected to have negative growth in demand.

Table 1-4: BWS Demand by Year and DP/SCP Area

Calendar Year:	1980	1990	2000	2010	2020	2025	2030	2035	2040
DP/SCP AREA	Given Data (Demand)				Projected Data (Most Probable Demand)				
Waiʻanae	7.7	9.05	9.34	9.24	9.35	9.22	9.10	8.97	8.9
ʻEwa	7.8	10.60	15.30	17.07	19.65	20.74	22.74	24.74	26.7
Central Oʻahu	11.5	15.02	19.41	17.76	18.61	18.80	19.29	19.45	19.8
PUC	77.1	88.58	76.45	69.45	68.44	66.97	67.29	67.98	68.7
East Honolulu	6.2	8.68	10.11	9.35	8.63	8.62	8.61	8.61	8.6
Koʻolau Poko	16.0	17.66	19.61	15.86	15.60	15.53	15.46	15.39	15.3
Koʻolau Loa	1.5	2.85	1.46	1.42	1.40	1.43	1.47	1.50	1.5
North Shore	2.3	3.19	2.82	2.93	3.06	3.12	3.18	3.25	3.3
TOTAL Oʻahu Demand	**130.10**	**155.63**	**154.50**	**143.08**	**144.75**	**144.44**	**147.14**	**149.88**	**152.8**

Table 1-5 shows Oʻahu's ground water use as of 2015 as a monthly moving average (MAV) totaling 197 MGD. This includes the brackish ʻEwa caprock aquifer and the Waiāhole Ditch. Municipal ground water use constitutes 73% of the total, with military, agriculture, irrigation, and other uses taking up the remainder. Agriculture ground water use includes private wells, but overall agriculture ground water use has decreased post-plantation owing to the availability and use of surface water and the slow rate of diversified agriculture growth.

Table 1-5: Oʻahu's Ground Water Use (2015)

Use Category	Water Used 12-Mo. MAV (MGD)	Percentage of Total Water Use
Municipal (BWS)	144.0	73.0%
Military	20.2	10.2%
Agriculture*	15.4	7.8%
Irrigation**	9.6	4.8%
Domestic	0.5	0.2%
Industrial**	7.7	3.9%
Total	**197.4**	**100%**

* Includes Waiāhole Ditch.
** Includes ʻEwa Caprock Brackish aquifer.

Table 1-6 summarizes Oʻahu's largest permitted uses of fresh ground water by user, including Waiāhole Ditch water uses, but excluding salt water and brackish caprock water uses in 2010.

Table 1-6: Oʻahu's Top Fresh Ground Water Users by Permitted Use 2017

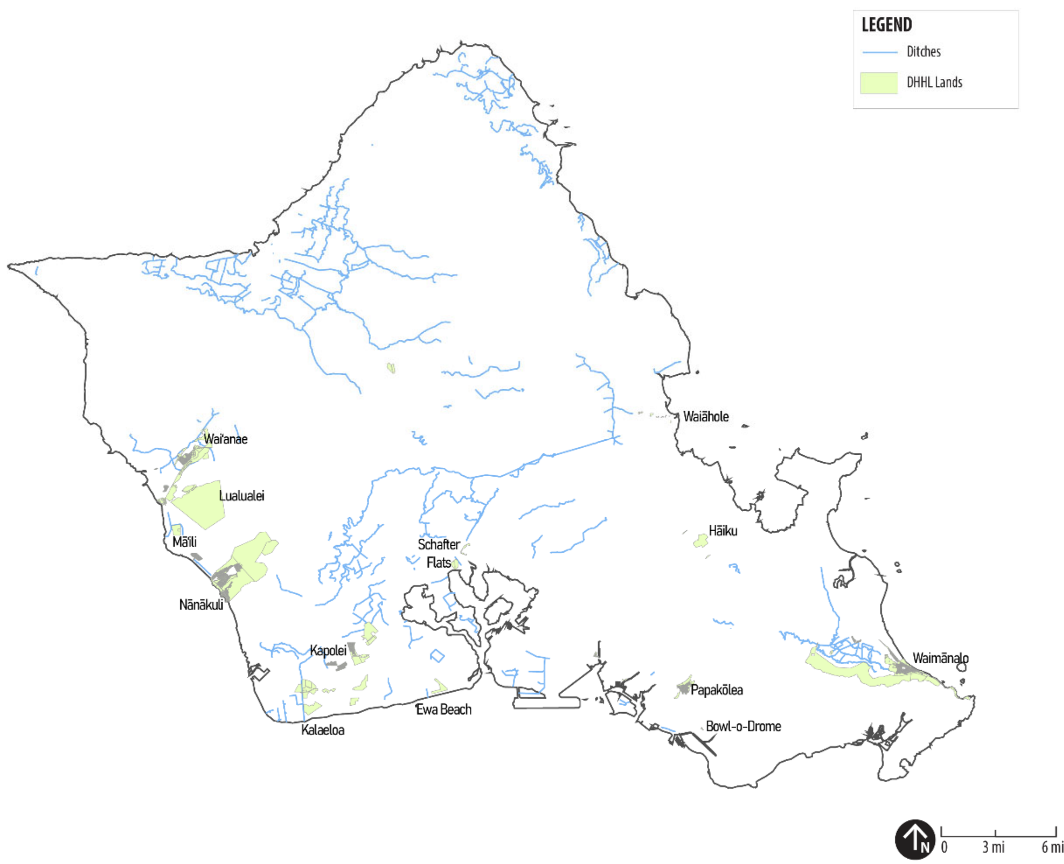
	Owner	Permitted Use (MGD)
1.	Honolulu Board of Water Supply (BWS)	184.09
2.	U.S. Navy	23.11
3.	D.R. Horton - Schuler Homes, LLC	7.97
4.	Waialua Sugar Company, Inc.	7.38
5.	U.S. Army Garrison	7.36
6.	Kamehameha Schools	4.37
7.	Agribusiness Development Corporation (ADC)	4.00
8.	Kunia Water Association, Inc	3.96
9.	Dole Food Company, Inc.	3.94
10.	Monsanto Company	2.64
11.	Robinson Kunia Land, LLC	2.49
12.	Dillingham Ranch ʻĀina, LLC	2.35
13.	Hawaii Reserves, Inc.	2.32
14.	Serenity Park, LLC	1.54
15.	Department of Hawaiian Home Lands (DHHL)	1.48
16.	Kelena Farms, LLC	1.44

1.3.3 Department of Hawaiian Home Lands Demands

The Department of Hawaiian Home Lands (DHHL) owns approximately 8,154 acres in Mākaha, Waiʻanae, Lualualei, Nānākuli, Kalaeloa, Kapolei, ʻEwa Beach, Papakōlea, Mōʻiliʻili, Waimānalo, and Haʻikū. This amounts to approximately 4% of DHHL's total landholdings (*Figure 1-6*). The 2014 DHHL Oʻahu Island Plan was developed to provide recommendations for the future uses of DHHL lands and to analyze the need for possible land acquisitions on Oʻahu to meet beneficiary and department needs over the next 20 years. The plan does not include specific details about water use and development, however, it states that DHHL has distinct water rights that may be pursued to meet the needs of DHHL and beneficiaries, based on the Hawaiian Homes Commission Act, the State Constitution, State statutes, and case law.

The May 2017 update to the State Water Projects Plan (2003) for DHHL projects a total potable water demand of 5.43 MGD by 2031 for DHHL lands on Oʻahu. Of the total demand projection, 3.07 MGD is for municipal uses and 2.36 is for industrial uses, including 2.20 MGD of industrial use at Kalaeloa which will not be served by the BWS system. Most of the other potable water projects identified in the update will be served by the BWS system; these projections are incorporated into the BWS municipal water demand forecasts using the population based per capita demand method. DHHL holds water reservations according to Hawaiʻi Administrative Rules §13-171-61 in the Waimānalo aquifer of 0.124 MGD and in the Waipahu-Waiawa aquifer of 1.358 MGD for their projects. DHHL will request that CWRM assign their reservations toward new or existing sources as their lands are developed.

Figure 1-6: Department of Hawaiian Home Lands Landholdings on Oʻahu



1.3.4 State Water Projects Plan Water Demands

The 2003 State Water Projects Plan (SWPP) identified a total of 24.5 MGD of water demand for housing, commercial, industrial, institutional, and agricultural uses for State agencies on Oʻahu to the year 2020. Approximately 51% of Oʻahu's SWPP demand, or 12.5 MGD, is non-potable use. The Department of Agriculture (DOA)'s demand of 7.6 MGD, DBEDT's demand of 7.2 MGD, and the University of Hawaiʻi's demand of 3.1 MGD comprise the largest water needs among State agencies.

The SWPP identified several water development strategies to meet their projected water demands including the use of existing State water system capacity; developing new water systems based on development master plans such as East Kapolei and Kalaeloa; utilizing existing BWS water credits from previous source development; and pursuing recycled and brackish water for non-potable irrigation. These strategies constitute approximately 17.9 MGD or 73% of Oʻahu's SWPP total. The remaining 6.7 MGD or 27% of State water demand can be obtained from BWS through the payment of Water System Facilities Charges. The BWS municipal water demand forecasts using the population based per capita demand method of assessing State and County land use plans can be assumed to incorporate most of the SWPP's demands except for State-owned water systems. An accounting tying specific source names to projected State agency demands would be helpful in the next SWPP update.

The SWPP update should add stronger water conservation and water loss reduction strategies, which were largely absent in the 2003 SWPP. Leak detection and repair projects in aging State water systems, such as agriculture, could reduce new source development, reduce operating and maintenance costs, and provide more capacity for drought mitigation. The SWPP is currently being updated and the findings will be incorporated in future WMPs.

1.3.5 Agricultural Water Demand

The State and City have adopted objectives and policies for the preservation of agricultural lands and for the long-term support of a viable agriculture industry on Oʻahu. City land use plans have been adopted with growth boundaries in part to protect prime agricultural lands.

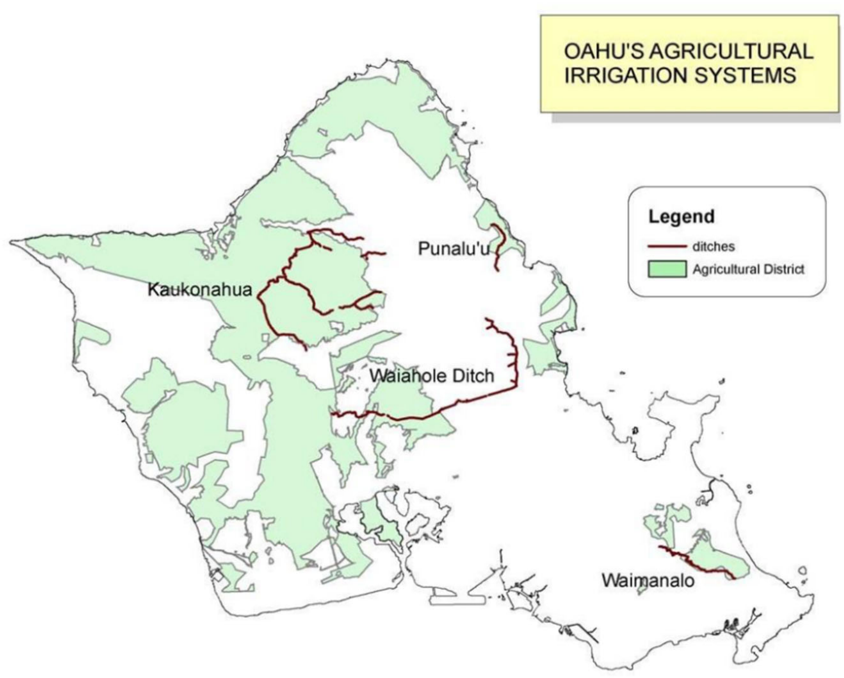
Oʻahu's projected agricultural water demands have a wide variation and are uncertain yet important for water use planning because of the substantial quantities consumed for irrigation. Future water demand for agricultural crops depends on the type of crops cultivated, climate, and number of acres in cultivation. The State Agricultural Water Use and Development Plan (AWUDP, 2004) estimated a worst- and best-case range of 7.6 MGD and 30.4 MGD, respectively, of additional water demand for Oʻahu based on population projections, partial replacement of imported produce with locally grown produce, and maintaining farm value growth in diversified agriculture.

Approximately 13 MGD of the projected best-case agricultural demand was assumed to be assigned to private irrigation systems, with the remaining 17 MGD accommodated by the State's Waiāhole Ditch and Waimānalo irrigation systems. The AWUDP focused on maintaining existing State diversified agriculture systems and on transforming plantation water systems to serve diversified agriculture. *"With available farm lands and adequate irrigation water, a significant expansion of diversified agriculture is an attainable and economically worthwhile goal which can be achieved largely by: 1) replacing much of Hawaiʻi's imported produce with locally grown produce, 2) pursuing niche and off-season markets of fruits and vegetables for export, 3) growing new or Asian-based specialty crops for export, and 4) meeting increased demand from the tourism and cruise ship industries for fresh fruits and vegetables."*

The two irrigations systems studied on Oʻahu are the Waiāhole Ditch and Waimānalo irrigation systems. The Wahiawā Irrigation System in Central Oʻahu and North Shore was not included in the State AWUDP. Based on water metered data from the Lālāmilo system (South Kohala, Hawaiʻi Island), dry and wet season water use per acre varied between 2,500 gallons per day per acre (gpd/acre) to 4,600 gpd/acre. According to the AWUDP, an average of 3,400 gpd/acre is considered the best available estimate and a reliable value for use in planning and forecasting irrigation water demand for Hawaiʻi's diversified agriculture industry. It should be noted that 3,400 gpd/acre is considered a practical consumptive water use rate which does not include irrigation system water loss.

Figure 1-7 shows the agricultural zoned lands on Oʻahu with the four major irrigation systems: Waiāhole Ditch, Wahiawā, Waimānalo, and Punaluʻu. Existing stream diversions and distribution systems should be inventoried, leaks and evaporation losses reduced to a reasonable goal and water use verified. Diversion works should include control gates to maintain diverted flows at reasonable and beneficial use plus losses. The practice of diverting maximum stream flow and then releasing unused diverted water into downstream drainage systems or into different streams should be minimized. Improvements to existing ditch systems, such as lining or piping ditches, have the potential to reduce water loss and thereby provide water for the expansion of agriculture without adding new diversions. Cost and benefit considerations should be factored into the feasibility of these improvements and will affect implementation. Significant new surface water diversions require amendments to the IFS, but the studies and processes are cost prohibitive.

Figure 1-7: Agricultural Zoned Lands on Oʻahu



Kamehameha Schools has renovated its Punaluʻu and Kawailoa irrigation systems with cultural and eco-friendly stream diversion modifications and piped ditch systems to conserve and enhance the availability of stream water, *Figure 1-8*. The diversions include fish ladders on both stream banks and grated intakes to prevent debris and fish from entering the system. The ditch system was piped to reduce water loss and ditch maintenance and provide a pressurized irrigation system for farmers. The improvements keep unused water in the stream because as irrigation declines during the day or season, the pipe fills up to the intake and diverted flow reduces to zero.

Figure 1-8: Punaluʻu Stream Diversion and Piped Ditch

There are large tracts of agricultural lands in the ʻEwa, Central Oʻahu, North Shore, Koʻolau Loa and Koʻolau Poko planning areas. The 2004 AWUDP estimated that of the 49,500 acres of prime agriculture lands on Oʻahu, 11,000 acres are in monocrop cultivation. The remaining 38,500 acres are idle and available for cultivation. *Table 1-7* lists the projected most probable water demands for each DP/SCP area, compiled from the regional WMPs and based on the projected use of agricultural lands within a 2030 and 2035 planning horizon.

Table 1-7: **Oʻahu Agricultural Irrigation Water Demand**

DP/SCP Area	Existing Agricultural Irrigation Water Demand (MGD)	Projected Agricultural Irrigation Water Demand (MGD)*
Primary Urban Center	0.3	0.3
North Shore	24.2	29.3
Central Oʻahu	15.8	15.7
ʻEwa	7.0	4.7
Koʻolau Loa	14.5	17.4
Koʻolau Poko	4.2	6.0
Waiʻanae	2.3	2.4
Total	**68.3**	**86.8**

* Agricultural water demands are the most probable demand scenarios for agriculture from Watershed Management Plans for Koʻolau Loa (2030), Koʻolau Poko (2030), Waiʻanae (2030) and North Shore (2035). Central Oʻahu (2040), ʻEwa (2035), and PUC (2040) are from calculations for watershed management plans under development. Loʻi kalo water demand is not included.

The total agricultural lands water demand of 86.5 MGD utilizes 3,400 gallons per day per acre (gpd/acre) from the State AWUDP for low rainfall areas and 2,500 gpd/acre for high rainfall areas. Studies indicate that water demands for diversified agriculture in high rainfall areas such as Punaluʻu, Waiāhole, Kahaluʻu and Kāneʻohe, where rainfall exceeds 60 to 70 inches per year, requires less water and averaged 2,500 gpd/acre. Agricultural irrigation water demand is met with both ground and surface water supplies.

In the Waiāhole Ditch contested case, CWRM allocated an average of 2,500 gpd/acre for large-tract Kunia farms allowing for some continuous proportions of fallow and cultivated lands. Small farms do not have the area to fallow their fields and will therefore have higher water demands per acre. Existing systems like the Waiāhole Ditch, Wahiawā, Kawailoa, Punaluʻu, Waimānalo and the ʻEwa Plantation irrigation systems already provide a portion of this total. Additional potable ground water supplies in these aquifer system areas could provide supplemental agricultural water supply especially during drought. Diversified agricultural water demands in Waiʻanae, PUC, East Honolulu, and a portion of North Shore are largely incorporated into the municipal demand forecasts. Agricultural water use constitutes only 3% of BWS potable metered water use. Ground water development is more costly for agriculture than gravity and surface water sources and may compete with urban uses.

Traditional wetland kalo occurs in almost all DP/SCP areas, but according to various studies, the variability of water demands is large, and inflows can range from approximately 100,000 gpd/acre to 300,000 gpd/acre with temperature as one of the key factors to prevent rot. While net consumptive use (evapotranspiration and infiltration) averages approximately 50,000 gpd/acre the additional water flow, which is returned to the stream, is needed to manage temperature and account for ditch losses. This plan therefore assumes 100,000 gpd/acre as the wetland kalo water demand estimate as presented in the Koʻolau Poko WMP in discussions with Waiāhole kalo farmers. Kalo's high water use per acre and limited surface water supplies will limit the expansion and restoration of loʻi kalo but because it is important to preserve the remaining traditional kalo lands, the lower range of water demand will allow a greater amount of restoration. Water loss reduction strategies in ʻauwai and ditch systems (lining and piping) could provide additional water reducing the necessity of constructing additional stream diversions and potentially divert less stream water.

1.3.6 Ground Water Availability

Table 1-8, "Sustainable Yield and Ground Water Use by Aquifer System Area," was provided by CWRM and BWS for 2015. The table shows the seven aquifer sector areas and 26 aquifer system areas on Oʻahu with their associated revised sustainable yields adopted in 2019 by CWRM, water use permits, water use in 2015, and the unallocated sustainable yields. CWRM reduced Oʻahu's sustainable yields by 39 MGD in 2008 from 446 MGD to 407 MGD. The Water Resources Protection Plan was again updated by CWRM in 2019 with additional adjustments regionally and island-wide. A complete listing of Oʻahu Water Use Permit Index is provided in Appendix C of the WRPP, and additional information on sustainable yields is included in Appendix D of the WRPP.

Overall, there is available water on Oʻahu, in comparing permitted use that has been allocated and/or actual withdrawal to sustainable yield. A significant portion of the remaining untapped supplies exist in remote areas of the island where growth is limited, infrastructure does not exist, or pumping may affect stream flows and will be subject to future measurable IFS. 2015 was a variable rainfall year with the first half of the year at 60% below normal rainfall and the second half at 160% above normal rainfall. Total ground water use decreased by 3.5 MGD in 2015 relative to 2010, which was a below normal rainfall year.

Table 1-8: Sustainable Yield and 2015 Ground Water Use by Aquifer System Area (MGD)

Aquifer Sector	Aquifer System	Notes	Sustainable Yield (SY)	Water Use Permits Issued	Unallocated Sustainable Yield	Water Use (2015)	SY Minus Water Use
Honolulu	Waiʻalae - East		2	0.79	1.21	*NRU*	2
	Waiʻalae - West		2.5	2.797	-0.297	1.709	0.791
	Palolo		5	5.646	-0.646	6.11	-1.11
	Nuʻuanu	1	14	15.165	-1.165	17.208	-3.208
	Kalihi		9	8.767	0.234	4.861	4.139
	Moanalua	1	16	19.96	-3.96	15.339	0.661
Total Honolulu			**48.5**	**53.125**	**-4.624**	**45.227**	**3.273**
Pearl Harbor	Waimalu		45	46.951	-1.951	36.499	8.501
	Waipahu-Waiawa		105	84.465*	20.535	50.315	54.685
	ʻEwa-Kunia		16	15.045	0.955	15.07	0.93
	Makaiwa		0	*na*	*na*	*NRU*	0
Total Pearl Harbor			**166**	**146.461**	**19.539**	**101.884**	**64.116**
Central	Wahiawā		23	22.978	0.022	9.392	13.608
Total Central			**23**	**22.978**	**0.022**	**9.392**	**13.608**
Waiʻanae	Nānākuli	1,2,4	1	*na*	*na*	*NRU*	1
	Lualualei	1,2,4	3	*na*	*na*	0.331	2.669
	Waiʻanae	2	3	*na*	*na*	3.113	-0.113
	Mākaha	1,2	3	*na*	*na*	2.774	0.226
	Keaʻau	2,4	3	*na*	*na*	0	3
Total Waiʻanae			**13**	*na*	*na*	**6.218**	**6.782**
North	Mokulēʻia	1	17	7.62	9.38	0.509	16.491
	Waialua	1	17	13.25	3.75	3.518	13.482
	Kawailoa	1	22	1.641	20.359	0.37	21.63
Total North			**56**	**22.511**	**33.489**	**4.397**	**51.603**
Windward	Koʻolau Loa	1	35	19.97	15.03	7.556	27.444
	Kahana	1,4	15	1.101	13.899	0.866	14.134
	Koʻolau Poko	1,3,4	28	10.312	17.688	10.064	17.936
	Waimānalo	1,4	9	1.843**	7.157	0.956	8.044
Total Windward			**87**	**33.226**	**57.774**	**19.442**	**67.558**
Total Aquifer Sector			**393.5**	**278.301**	**102.2**	**186.56**	**206.94**
ʻEwa Caprock	Malakole	5	1,000 mg/L		-	4.211	-
	Kapolei	5	1,000 mg/L		-	0.488	-
	Puʻuloa	5	1,000 mg/L		-	1.396	-
Total ʻEwa Caprock			**0**	**0**	**0**	**6.095**	**0**
Waiāhole Ditch			15	12.241	2.759	6.359	8.641
Grand Total Fresh and Brackish			**408.5**	**290.542**	**104.959**	**192.919**	**215.581**

NRU = No Reported Use.

[1] 2019 Water Resource Protection Plan updates on sustainable yield.

[2] Waiʻanae is not a designated water management area; therefore, there is no permitted use.

[3] Waiheʻe Tunnel and Waiheʻe Inclined Wells: *not included* under Permitted Use; but *included* under 2015 Water Use.

[4] BWS Recoverable Yield expected to be lower due to economics, land constraints, small yields, etc. and regulatory actions involving instream flow standards.

[5] Brackish Water. Managed by chloride limit of 1,000 mg/l for irrigation wells.

* The Waipahu-Waiawa aquifer system includes DHHL reservation for 1.358 MGD, which should not be considered available for allocation.

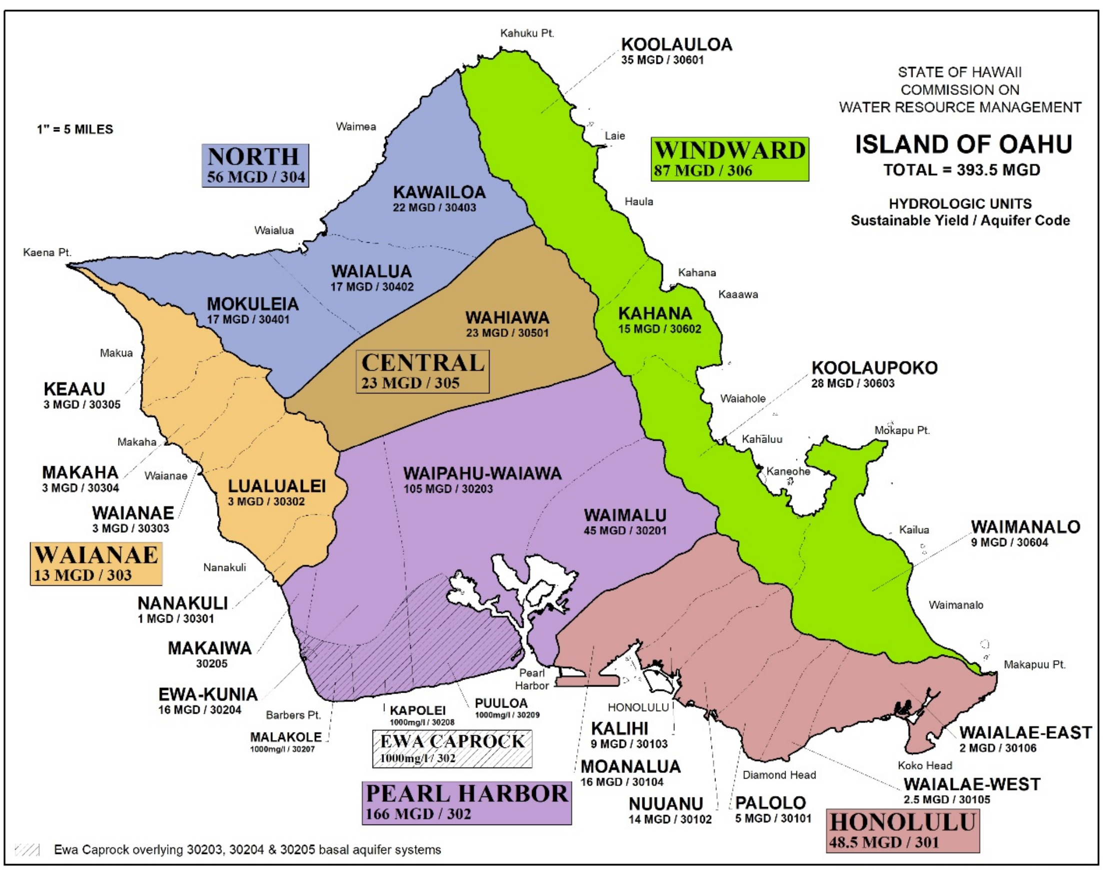
** The Waimanalo aquifer system includes DHHL reservation for 0.124 MGD, which should not be considered available for allocation.

Excluded salt water wells

In general, the Honolulu sector is fully allocated to the adopted sustainable yields. The Pearl Harbor, Wahiawā and North Shore sectors have a significant amount of unallocated sustainable yield, unused or released by the sugar plantations. The Windward sector’s unused sustainable yields (Waimānalo, Koʻolau Poko and Kahana) may interact with streams due to dike influences and therefore, availability may be subject to amendments of the interim IFS. Waiʻanae’s remaining water is small, in remote areas and also subject to interim IFS in dike areas.

Due to these land, economic, operational and environmental reasons, BWS has identified the concept of recoverable yield for its own municipal planning purposes. Recoverable yield is an estimate of the amount of ground water that could feasibly be developed for an aquifer system area and is slightly less than CWRM adopted sustainable yields. BWS has identified Waimānalo, Koʻolau Poko, Kahana, Keaʻau, Lualualei and Nānākuli aquifer system areas where recoverable yields are less than or equal to sustainable yields. The concept of recoverable yield allows BWS to plan and respond to uncertainties.

Figure 1-9: **Oʻahu Aquifer System Areas**



CWRM has adopted sustainable yields to protect ground water resources and regulate water use by water use permits. *Table 1-9* summarizes the available ground water by aquifer sector area accounting for the uncertainties of ground water/surface water interaction in dike formations in Windward and BWS operational experience in Waiʻanae.

Table 1-9: Summary of Available Ground Water by Aquifer Sector Area

Aquifer Sector	Sustainable Yield	Water Use Permits Issued	Unallocated Sustainable Yield (MGD)	Water Use 2015	SY minus Water Use
Honolulu	48.5	53	-5	45	3
Pearl Harbor	166	147	19	102	64
Central	23	23	1	9	14
Waiʻanae	13	---	--	6	0*
North	56	23	33	4	52
Windward	87	33	54	19	27**
Waiāhole Ditch	15	12	3	6	9
Total	**408.5**	**291**	**105**	**191**	**169**

* Adjusted: Based on pumping operations and BWS assessed recoverable yields. Waiʻanae and Mākaha systems: (6 MGD SY – 6 MGD use)

** Adjusted: Koʻolau Loa system: (35 MGD SY – 8 MGD use). Excludes for planning purposes the balance of Kahana, Koʻolau Poko and Waimānalo systems per CWRM ruling due to possible surface water interactions in dike formations.

On Oʻahu in 2015, about 35% or 100 MGD (291 minus 191 total use) of permitted use was unused. 2015 was a variable rainfall year on Oʻahu, with the first half of the year at 60% below normal rainfall and the second half at 160% above normal rainfall. An estimate of available and recoverable ground water on Oʻahu is approximately 169 MGD, based on CWRM revised sustainable yields for Oʻahu minus water use in 2015, excluding the balance of the Keaʻau, Lualualei, Nānākuli, Kahana, Koʻolau Poko, and Waimānalo aquifer systems. Ground water use on Oʻahu decreased by 3.5 MGD in 2015 relative to 2010.

1.3.7 Surface Water Availability

Instream Flow Standards (IFS) are similar to sustainable yields for ground water, in that their establishment provides a management system that protects instream and cultural uses while allowing for possible non-instream water use. CWRM is tasked with setting IFS for Hawaiʻi's streams in accordance with the State Water Code. The code defines instream flow standards as "the quantity or flow of water or depth of water which is required to be present at a specific location in a stream system at certain specified times of the year to protect fishery, wildlife, recreational, aesthetic, scenic, and other beneficial instream uses."[2] These instream flow standards need to consider the best available information in assessing the range of present or potential instream and non-instream uses.

The current instream flow standards for Oʻahu streams are called interim instream flow standards (IIFS) and are based on the *"amount of water flowing in each stream on the effective date of the standard without further amounts of water being diverted off-stream through new or expanded diversions".* The effective dates are December 10, 1988 for Leeward Oʻahu and May 4, 1992 for Windward Oʻahu.[3] In the Waiāhole Contested Case Hearing, CWRM recognized that *"retaining the status quo (through the adoption of the previous interim standards) helped to prevent any future harm to streams while the scientific basis for determining appropriate instream flow standards is developed and an overall stream protection program put into place."* The stream flows and diversions were not quantified in the standard; however, users of surface water and ground water were required to register their uses with CWRM.

CWRM amended the interim instream flow standards for four Windward streams - Waiāhole, Waianu, Waikāne, and Kahana. The amended IIFS have been established via the Waiāhole Ditch Combined Contested Case on July 13, 2006 *(Table 1-10)*.

Table 1-10: Amended Oʻahu Interim Instream Flow Standards

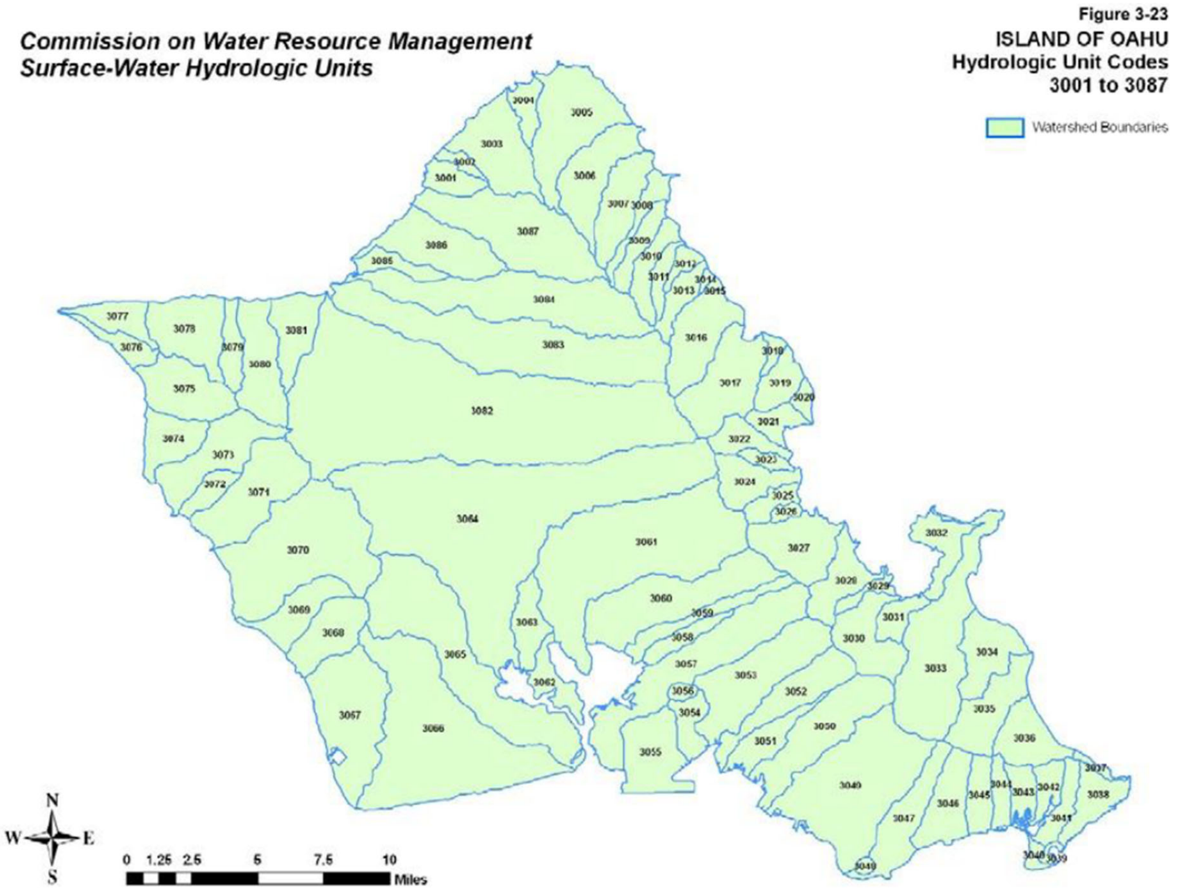
Stream	1960s Streamflow	Amended Interim Instream Flow Standard	Percent Increase
Waiāhole	3.9 MGD	8.7 MGD	124%
Waianu	0.5 MGD	3.5 MGD	600%
Waikāne	1.4 MGD	3.5 MGD	150%
Kahana	11.2 MGD	13.3 MGD	19%

The SWPP established surface water hydrologic units and provided an inventory of basic data for Oʻahu's streams (*Figure 1-10)*. Table 3-22 of the WRPP lists 87 streams on Oʻahu, including the watershed area, number of diversions and stream gages. Diverted stream flows and their uses are not measured or reported and could not be included. The stream diversion inventory process continues, and new information will be added to future WMPs.

[2] State Water Code Section 174-C3.

[3] HAR Section 13-169-49 and 49.1

Figure 1-10: O‘ahu Surface Water Hydrologic Units



The hydrogeology appendix of the SWPP describes the complexity of setting measurable IFS balancing hydrology with instream and non-instream uses. It is difficult to plan for additional non-instream uses of surface water without measurable IFS, because non-instream uses of surface water are an essential IFS component. Punalu‘u Stream and irrigation system studies have cost over $500,000, and therefore, new diversions, while permit-able, are not cost effective unless a simpler methodology for setting measurable IFS is proposed. The planning approach to surface water availability is to plan within the diverted amounts existing when the status quo interim IFS were adopted, or as subsequently amended by CWRM. Additional surface water can be provided for non-instream uses through improvements in distribution system efficiency, leakage reduction, crop selection and through efficient irrigation techniques. Significant new stream diversions will require amendments to IFS. In general, a starting point for surface water availability assumes 50% of Q70, stream flowing 70% of the time. *Table 1-11* lists some of O‘ahu’s largest perennial streams.

Table 1-11: Oʻahu's Largest Streams and Mean Flows (Water Years 2004, 2010, and 2015)

Stream Name	USGS Stream Gage no.	Mean Flow Water (2004) (CFS / MGD)	Mean Flow Water (2010) (CFS / MGD)	Mean Flow Water (2015) (CFS / MGD)
Kaluanui	16304200	7.5 / 4.8	3.9 / 2.5	5.7 / 3.7
Punaluʻu (above ditch)	16301050	31.2 / 20.2	19.0 / 12.3	23.6 / 15.3
Kahana	16296500	53.5 / 34.6	28.1 / 18.1	36.7 / 23.7
Waikāne	16294900	19.1 / 12.3	7.9 / 5.1	8.5 / 5.5
Waiāhole (Kamehameha Hwy)	16294100	55.0 / 35.5	26.3 / 17.0	35.9 / 23.2
Waiheʻe	16284200	9.2 / 6.0	5.3 / 3.4	6.9 / 4.4
Kahaluʻu	16283200	5.1 / 3.3	1.6 / 1.1	2.6 / 1.7
Heʻeia (Haʻikū)	16275000	3.6 / 2.3	1.8 / 1.2	2.2 / 1.4
Kamoʻoaliʻi - Kāneʻohe	16272200	17.5 / 11.3	-- / --	-- / --
Makawao – Kailua	16254000	7.2 / 4.7	3.2 / 2.1	4.6 / 3.0
Mānoa (Waiakeakua at Kānewai)	16240500	5.9 / 3.8	3.0 / 1.9	4.9 / 3.2
Kalihi*	16229000	9.2 / 5.9	4.0 / 2.6	4.4 / 2.8
North Hālawa	16226200	9.9 / 6.4	2.8 / 1.8	5.6 / 3.6
Waiawa	16216000	50.0 / 32.3	-- / --	-- / --
Waikele	16213000	53.7 / 34.7	24.5 / 15.8	34.6 / 22.4
Mākaha	16211600	2.2 / 1.4	0.5 / 0.3	1.1 / 0.7
N. Kaukonahua	16200000	19.1 / 12.3	10.4 / 6.7	14.3 / 9.2
S. Kaukonahua	16208000	29.6 / 19.1	15.1 / 9.8	18.2 / 11.8
ʻŌpaeʻula	16345000	18.8 / 12.2	11.9 / 7.7	13.8 / 8.9
Kamananui - Waimea	16330000	24.7 / 16.0	12.9 / 8.3	13.0 / 8.4
Total		**432.0 / 279.2**	**182.1 / 117.7**	**236.6 / 152.9**

Source: USGS Surface-Water Annual Statistics for Hawaiʻi.
* The Kalihi Stream gage does not have annual streamflow statistics available; calculated mean streamflow using the daily streamflow data for the applicable water year.

Notes: The USGS defines a "water year" as the 12-month period October 1st through September 30th (the year is designated by the calendar year in which the water year ends and which includes 9 of the 12 months).
2004 had above normal rainfall; 2010 had below normal rainfall; 2015 was a variable rainfall year with the first half of the year at 60% below normal rainfall and the second half at 160% above normal rainfall.
Q70 is less than mean stream flow. Several USGS gages have been discontinued due to cost considerations.

1.3.8 Planned Source Development

New sources recently completed or in construction and potential potable sources to provide for future water demands are listed in *Table 1-12*. Alternative sources are listed in *Table 1-13*.

Table 1-12: Existing and Potential Ground Water Resources of Potable Water

New Ground Water Sources	Estimated Yield (MGD)	Additional Permitted Use Required (MGD)	CWRM Water Management Area	Potential Development Plan Area(s) Served
1. Kahuku Wells Pump 3	1.0	0.4	Koʻolau Loa	Koʻolau Loa
2. ʻŌpana Wells*	1.0	0.654	Koʻolau Loa	Koʻolau Loa
3. Kaipapaʻu or Wailele Well[1]	1.0		Koʻolau Loa	Koʻolau Poko
4. Kaluanui Wells* [1]	1.5		Koʻolau Loa	Koʻolau Poko
5. Maʻakua Wells* [1]	1.0		Koʻolau Loa	Koʻolau Poko
6. Kahana Well	1.0	0.4	Kahana	Koʻolau Poko
7. Keaahala Well (State Hospital)	0.7		Koolaupoko	Koʻolau Poko
8. Waimānalo Well III* [##]	0.5	0.3	Waimānalo	Koʻolau Poko
9. ʻĀina Koa Well II	1.0		Waiʻalae-West	East Honolulu
10. Waiʻalae West Well	0.5	0.34	Waiʻalae-West	East Honolulu
11. Waiʻalae Nui Well*	0.7		Waiʻalae-West	East Honolulu
12. Pia Well	0.2		Waiʻalae-East	East Honolulu
13. Wahiawā Well III	3.0	3.0	Wahiawā	Central
14. Mililani Tech Park Well	0.3		Wahiawā	Central
15. Waikele Gulch Well	3.0		Waipahu-Waiawa	Ewa, Waiʻanae
16. Mililani Wells IV *	3.0	1.0	Waipahu-Waiawa	Central
17. Waiawa Wells I-I[2]	6.0	6.0	Waipahu-Waiawa	Central
18. Manana Well *	1.0	0.3	Waipahu-Waiawa	PUC
19. Kunia Wells III *	3.0		Waipahu-Waiawa	ʻEwa
20. Kunia Wells IV***	3.0		Waipahu-Waiawa	ʻEwa
21. Waipahu Wells II *	3.0	1.0	Waipahu-Waiawa	Central
22. Waipahu Wells III * [#]	3.0		Waipahu-Waiawa	PUC
23. Waipahu Wells IV*	3.0		Waipahu-Waiawa	ʻEwa, Waiʻanae
24. ʻEwa Shaft*	10.0	2.4	Waipahu-Waiawa	ʻEwa
25. Waipiʻo Heights II*	2.0	1.0	Waipahu-Waiawa	Central
26. Waipiʻo Heights Wells III*	3.0	1.75	Waipahu-Waiawa	Central
27. Waimalu Aquifer Wells^	{13.0}		Waimalu	PUC
Total Potable Resources	**51.65**	**18.05****		

Notes:
1 Potential transfer of existing permitted use from Punaluʻu Wells to optimize pumpage
2 Waiawa Water Master Plan, Revised Dec 14, 2004.
* Source already has an existing permitted use equal to or a portion of the estimated yield.
** Total does not include transfers of existing permitted use.
*** State funded portion for subsidized Agricultural Rate for farmers
# Includes 0.5 MGD water reservation for Department of Hawaiian Home Lands (DHHL)
0.124 MGD water reservation exists for DHHL in the Waimānalo WMA
^ Various sites to replace Halawa Shaft, Aiea and Halawa Wells shut down due to Red Hill fuel release. Not counted in totals.

Table 1-13: Existing and Potential Alternative Potable and Non-Potable Water Sources

Resource[1]		Minimum Estimate	Maximum Estimate	Development Plan Areas Served
Desalination (potable)				
1	Kapolei Brackish Desalination Plant	0.5	0.7	ʻEwa
2	Kalaeloa Sea water Desalination Plant	1.7	5.0	ʻEwa
Recycled Water				
4	Wahiawā WWTP[1]	1.6	2.0	Central (Galbraith)
5	Schofield WWTP	2.6	4.0	Central (Kunia)
5	Honouliuli Recycled Water	16.0	20.0	ʻEwa
6	Waiʻanae Recycled Water[2]	1.0	1.0	Waiʻanae
7	Kahuku, Turtle Bay, Lāʻie Recycled Water	0.8	2.6	Koʻolau Loa
8	Waimānalo Recycled Water	0.7	1.0	Koʻolau Poko
9	Ala Wai Golf Course MBR[3]	0.25	0.5	PUC
10	Mililani WWTP MBR	1.0	2.0	Central
Non-Potable Water				
9	Waiāhole Ditch[4]	15.0	15.0	ʻEwa, Central
10	Wahiawā Reservoir[5]	8.5	16.0	North Shore, Central
11	Kalauao Spring	0.8	3.0	PUC
12	ʻEwa Brackish Basal Wells[6]	4.0	5.0	ʻEwa
13	Koʻolau Loa Agricultural Wells[7]	6.3	12.6	Koʻolau Loa
14	Punaluʻu Stream Irrigation System[8]	2.0	7.0	Koʻolau Loa
15	Maunawili Ditch/Waimānalo I	0.4	1.4	Koʻolau Poko
16	Kawailoa Irrigation System[9]	8.0	8.0	North Shore
17	Glover Tunnel – Mākaha	0.55	0.55	Waiʻanae
18	Barbers Point NPW Well I & II[10]	1.5	0.5	Ewa
19	Waipio-Makalena NPW System	1.0	1.0	Central Oʻahu
Total Alternative Resources		**73.7**	**108.8**	

Notes:
1 Wahiawā Wastewater Treatment Plant (WWTP) avg flow = 2 MGD, Schofield (Army) avg flow = 2 MGD.
2 Waiʻanae WWTP effluent chlorides at 800-900 mg/l may constrain full expansion.
3 The proposed Ala Wai Golf Course membrane bioreactor (MBR) may be detrimentally impacted by sea level rise.
4 Waiāhole Ditch Min = 2009 CWRM permitted use. 2.43 MGD remains unpermitted.
5 Kaukonahua Streams minimum average month = 8.5 MGD, 2004 mean flow = 31 MGD, 2010 mean flow = 16 MGD.
6 Revised ʻEwa Development Plan. EP2 (1 MGD), EP5&6 (2 MGD), EP10 (1-2 MGD).
7 Sustainable yield exists, but well sites have not been identified.
8 Effects of Surface Water Diversion and Ground Water Withdrawal on Streamflow and Habitat, USGS Report 2006-5153.
9 Approximately 80% is surface water and 20% is ground water sources.
10 Potential transfer of existing permitted use from Ewa Kunia sources for Barber's Point NPW Well II

Table 1-14 summarizes planned potable ground water sources and alternative potable and non-potable sources from *Tables 1-12* and *1-13*.

Table 1-14: Planned Water Sources Summary

Resource		Quantity (MGD)
Ground Water – Potable		**52**
Desalination – Potable (minimum estimate)		**2.2**
Recycled Water (minimum estimate)		**24**
Ground Water – Non-Potable		**27**
Surface Water – Non-Potable		**21**
	Total	**126.2**

Increases in potable and non-potable demand are offset by water conservation, released agricultural ground water from the close of the sugar plantations, sea water desalination and the development of brackish and recycled irrigation water systems. Surface water is continuing to supply agriculture and although new stream diversions are not planned, additional water demands could be supplied by water loss control measures in ditch irrigation systems. Surface water will not be evaluated for municipal use until measurable IFS are set and water availability is determined.

Ground water will be developed utilizing available sustainable yield including released agricultural water for agricultural lands rezoned to urban use. Ground water supply evaluations will be conducted to refine available ground water estimates especially as permitted use approaches sustainable yields. New sources of supply will be developed in locations that do not impact streams or other sources.

- Recycled water facilities in ʻEwa and Central Oʻahu are planned for expansion to continue to offset additional ground water development.
- BWS has been operating the 12 MGD Honouliuli Water Recycling Facility since 2003, supplying 10 MGD of R-1 water and 2 MGD of R-O water for irrigation and industrial uses in ʻEwa. In 2019, BWS added 2 MGD of R-1 capacity for a total of 14 MGD R-1 to accommodate ʻEwa's growth. The recycled water distribution system can be supplemented with brackish water.
- The Army's Schofield Wastewater Treatment Plant (WWTP) produces about 2.6 MGD of R-1 quality recycled water. With a planned distribution system within Schofield and to Kunia farms and back up storage, the water could be used for R-1 uses.
- The City's Wahiawā WWTP has completed upgrades to produce 1.6 MGD of R-1 quality recycled water. With a water distribution system to State Agribusiness Development Corporation's Galbraith Lands in Wahiawā and back up storage, the water can be used as R-1 water.

In the mid-term, sea water and brackish water desalination plants will be constructed to provide for future demand and offset additional ground water development and provide a cost competitive alternative to increasing transfers among and between DP/SCP areas.

- The Kalaeloa Sea Water Desalination Plant is currently planned for construction in the early 2020 timeframe and will bring an additional 1.7 MGD minimum of potable water supply to the ʻEwa DP area. The plant will be capable of further expansion as needed.
- The Kapolei brackish water desalination plant in Kapolei Business Park is currently being master planned adjacent to a new operations base yard. The brackish desalination plant is expected to produce approximately 0.7 MGD of potable water supply for Kapolei.

1.3.9 Adequacy of Supply and Future Demand and Population Distribution

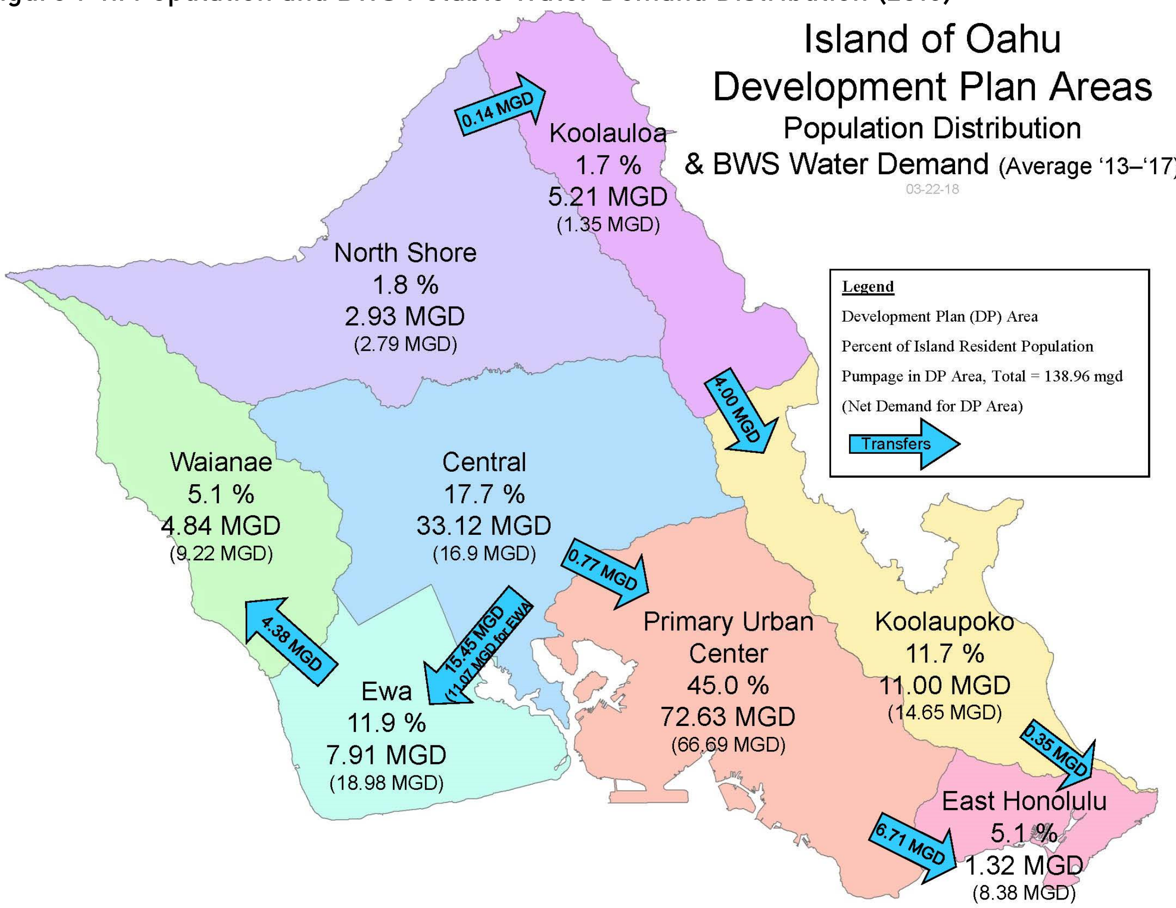
The 169 MGD of unused ground water available on Oʻahu in 2015 (*Table 1-9*), adjusted for recoverability, and the existing large agricultural irrigation systems (Wahiawā Reservoir (16 MGD), Maunawili Ditch (1.4 MGD), Punaluʻu Stream (7.0 MGD), Kawailoa (8 MGD) and the Waiāhole Ditch (15 MGD)) totaling 47 MGD are available to meet future urban and agricultural water demands beyond the 2040 planning horizon.

Existing stream diversions will continue to provide for agricultural uses, including kalo, and reduce the need for potable ground water, although supplemental wells are recommended as a drought mitigation strategy. No new stream diversions are planned for non-instream uses until interim IFS are amended to protect and support appurtenant rights, traditional and customary rights in the stream, estuary and nearshore water environments. However, water efficiency improvements in the stream diversion and ditch systems should provide additional surface water for additional agricultural irrigation. Recycled water is planned to supply a minimum of 20 MGD for urban irrigation. Future sea water desalination could supply approximately 1.7 MGD of potable water for ʻEwa.

The City's General Plan directs the majority of future growth to ʻEwa and the Primary Urban Center, the two Development Plan areas where plans and infrastructure investment will support a total of 59% of Oʻahu's population. Adding Central Oʻahu, the total General Plan population increases to 76% in these three planning areas. Therefore, natural and alternative water supplies, such as ground water, storm water, recycled water and desalination as well as advanced water conservation and watershed management to sustain the natural water resources must be fully integrated. In the remaining five sustainable communities of Waiʻanae, North Shore, Koʻolau Loa, Koʻolau Poko and East Honolulu, little change in BWS water demand is expected throughout the planning horizon. The existing sources and infrastructure in these sustainable areas are adequate, and therefore, additional transfers of water between these planning areas will be stable.

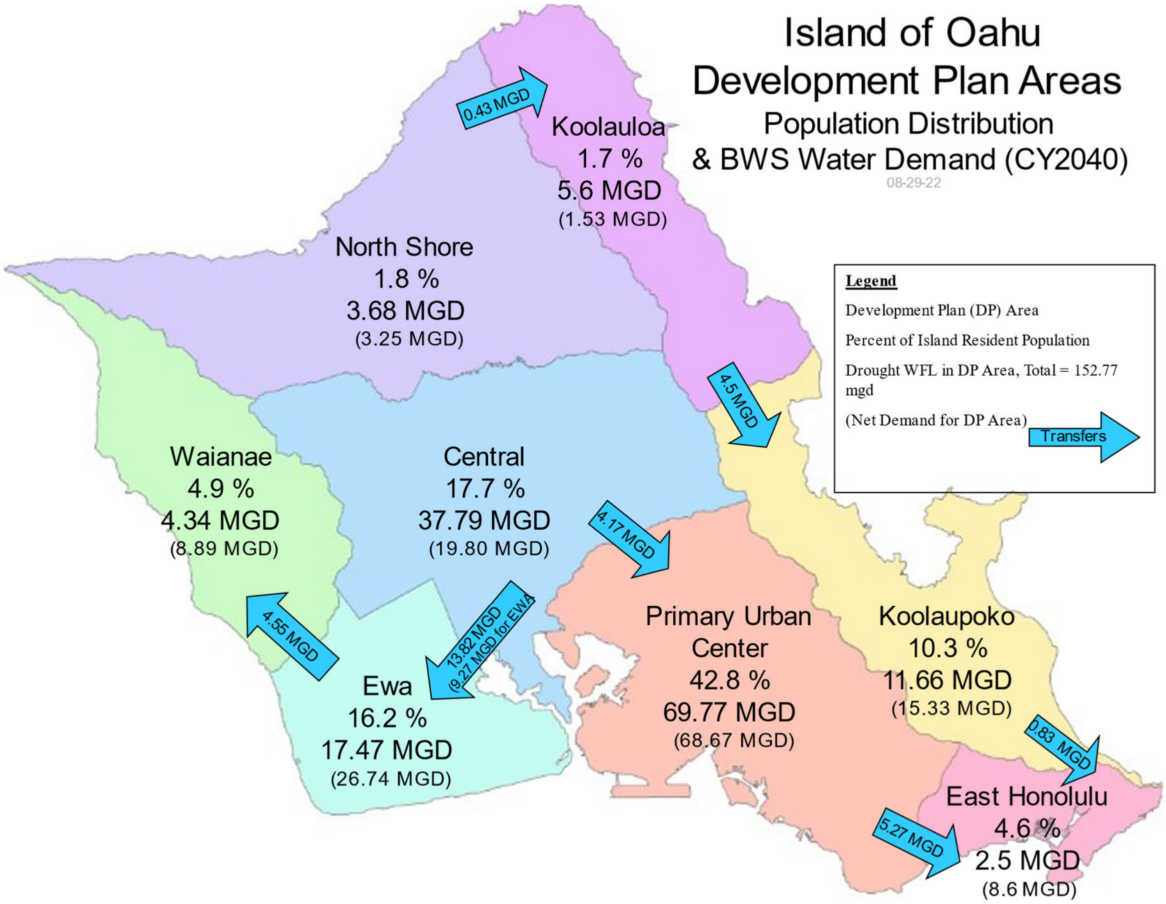
A summary graphic of O'ahu's population distribution based on the 2010 census, BWS potable water demand, and water transfers is provided for the eight City planning areas in *Figure 1-11.* The demand and transfers are based on an average of five years, from 2013 to 2017.

Figure 1-11: Population and BWS Potable Water Demand Distribution (2015)



A second summary graphic (*Figure 1-12*) of O'ahu's estimated population distribution and water demand based on DPP's 2040 forecast is the BWS most probable demand scenario. Potable water demand is increasing by about 13.8 MGD from 139 MGD in 2015 to 152.8 MGD in 2040, anticipating continued decreasing trends in per capita water use. Desalination is included in the 'Ewa DP area along with recycled water for irrigation that will be reducing the amount of additional potable water demand.

Figure 1-12: Estimated Population and BWS Potable Water Demand Distribution (2040)



The following findings summarize *Figures 1-10* and *1-11* Population Distribution and Potable Water Demand 2015 and 2040.

- The Oʻahu General Plan directs growth to South Oʻahu, (ʻEwa, Central Oʻahu, and PUC). The directed growth policy allows the remaining areas of Waiʻanae, North Shore, Koʻolau Loa, Koʻolau Poko, and East Honolulu to be sustainable communities with limited growth.
- The projected increase of 13.8 MGD in 2040 water demand relative to 2015 for Oʻahu's eight DP/SCP areas can be met with the current BWS water system. However, to realize this low forecasted demand, it is important that the following strategies be pursued:
    - Continue to advance water conservation programs of water loss control in distribution systems and on-site plumbing/irrigation systems, high efficiency toilets and water fixtures, economic incentives and education, etc.
    - Diversify water supplies through a combination of ground water, recycled water, storm water and desalination, which will preserve the natural ground water resource by providing drought proof water supplies and capture storm water to supplement irrigation. New potable ground water sources will be developed to distribute source

withdrawals to reduce concentrated pumping in select large pump stations in anticipation of decreasing rainfall predicted by some climate change models. Brackish ‘Ewa Plantation wells will continue to be converted for urban irrigation in ‘Ewa to reduce potable ground water use. New distributed recycled water systems including membrane bioreactor (MBR) scalping plants are planned.

- Promote green infrastructure and low impact development standards that reduce water use. Consider new policies that utilize recycled water to irrigate single-family lots and dual water systems for toilet flushing in new construction.
- Ensure watershed protection projects are adequately funded and implemented to preserve native species and water supplies in a climate change future so that existing source capacities can be maintained.
- Prepare for the impacts of climate change and sea level rise. In a “worst case” scenario based on rainfall projections derived from a statistical downscaling model, aquifer recharge rates will be severely impacted, and sustainable yields may decrease island-wide by 26% by the year 2100.[4]

The BWS most probable demand scenario of population and potable water distribution in 2040 is based on the best available estimates of supply and demand, analysis of decreasing water demand trends experienced since 1990 plus a significant commitment to advanced water conservation and alternative water development (see *Chapter 3* for additional explanation of future demand scenarios). New aquifer studies and climate change research will continue to refine estimates of sustainable yield and pumpage optimization plans will be adapted to avoid salinity and other water quality impacts.

The most conservative estimates of available remaining ground water sustainable yields, a reasonable accounting of uncertainties and climate change, planned ground water source projects, advanced water conservation and green infrastructure programs and alternative water source projects, such as recycled water, storm water and desalination, are used to accommodate future demands while also providing a comprehensive, watershed based suite of strategies, programs and projects to accommodate future growth and water demands within and beyond the 2040 planning horizon.

1.3.10 Uncertainties and Contingencies

Planning efforts have uncertainties due to assumptions made about existing conditions and future scenarios. Identifying these uncertainties provides an opportunity to plan for a practical range of

[4] Statistical downscaling rainfall projections are from Elison Timm et al. 2015; sustainable yield projections are from an unpublished and ongoing study conducted by the Water Resources Foundation, Brown & Caldwell, and the Honolulu Board of Water Supply.

contingencies. This section highlights the major uncertainties and contingencies of this watershed management plan. Many of the watershed protection projects and water supply options discussed in *Chapter 4* and *Chapter 5* incorporate contingencies designed to plan for uncertainties in supply and demand.

1.3.10.1 Ground Water Supply Uncertainties and Contingencies

Ground water supply uncertainties and contingencies are presented in this section and include the following topics:

- Estimating Sustainable Yield
- Recoverability of Sustainable Yield
- Climate Change and impacts to aquifer sustainable yields
- Ground Water Contamination
- Ground Water Dependent Ecosystems

The uncertainties are discussed followed by contingencies, or planning strategies to mitigate effects of the ground water supply uncertainties.

Estimating Sustainable Yield

Sustainable yields for all aquifer system areas have been adopted as part of the State Water Code's Water Resources Protection Plan and are used for resource management, protection and development. The current sustainable yields are based on the best available information of hydrologic factors but have acknowledged limitations in estimating rainfall distribution, vegetative transpiration, overland runoff, aquifer leakage to the ocean and to the brackish transition zone and recharge to the various dike, basal, perched and caprock aquifers.

Contingency for Estimating Sustainable Yield

- Periodically update information on rainfall, evapotranspiration, runoff, leakage and recharge to reflect current hydrologic trends due to climate change.
- Evaluate and account for aquifer boundary conditions recognizing separate geological formations such as dike, basal, alluvial and caprock aquifers within each aquifer system area.
- Construct deep monitor wells in important basal aquifers to provide the ability to monitor water levels, fresh water lens and transition zone thickness and trends in response to pumping.
- Develop advanced numerical ground water models to improve sustainable yield estimates. CWRM with BWS, USGS, and UH participates in various efforts, dedicated to monitoring key hydrologic indicators such as rainfall, evapotranspiration, recharge, head, salinity, and transition zone trends, and to reaffirm the adopted sustainable yields in key aquifer

systems. The USGS is constructing a 3-dimensional solute transport ground water model of the Pearl Harbor aquifer system calibrated to deep monitor wells.

Recoverability of Sustainable Yield

Recoverability is the ability to feasibly extract ground water through wells or tunnels, up to the adopted sustainable yield. Recoverability is a major uncertainty due to surface and ground water interactions, presence of separate hydrogeological formations within an aquifer system area, extended drought, and well location and spacing constraints. There are also regulatory, political, financial and public acceptance uncertainties surrounding additional ground water development and regional transport of water with respect to environmental impacts, local water needs and available supply.

Contingency for Recoverability of Sustainable Yield

- Until IIFS are amended, seek new ground water wells that do not impact surface waters. Develop long-term monitoring plans of stream and watershed indicators.
- Optimize well spacing and pump sizing on an aquifer system area basis to increase recoverability and avoid lens shrinkage, up-coning and sea water intrusion. Align water system infrastructure capital plans to more readily accommodate smaller wells spaced throughout the water system when practical.
- During severe, long-term droughts usually greater than three years, the full sustainable yield may not be recoverable. Dike source yields will likely drop below permitted use. BWS operational experience accounts for source yields in normal rainfall and drought years. The difference, approximately 14 MGD, is supplemented by the following drought mitigation strategies that will improve the water system's resilience to climate variability:
- In non-drought years, ensure pumping does not exceed normal rainfall level estimates to preserve sufficient aquifer storage to meet maximum day demands during drought.
- During drought years, reduce pumping to drought level estimates to protect the fresh water lens. Reducing pumping is difficult, as water demands will increase during drought, therefore:
    - Implement the BWS low ground water and water shortage plans and other progressively restrictive conservation measures to reduce water demands.
    - Develop additional ground water wells to supplement reductions in source yields due to severe drought.
    - Develop alternative, drought-proof water supplies such as recycled water, brackish and sea water desalination facilities to increase resilience to climate change impacts.
    - Mandate dual water systems for new large developments to maximize non-potable water use to conserve the potable water supply.

- Ensure sufficient aquifer recovery during post-drought periods by reducing pumpage and implementing the applicable watershed protection projects for the most important and/or impacted watersheds.

- Regulatory, political, financial and public acceptance uncertainties can be addressed by environmental disclosure, cost benefit analysis, public outreach, education, alternative source analyses, and holistic watershed management and integrated resource planning.

Climate Change

Climate change is expected to cause more severe droughts and floods, and as global temperatures increase, sea water levels are expected to rise affecting coastal environments, brackish aquifers and stream estuaries. The 2017 Hawaiʻi Sea Level Rise Vulnerability and Adaptation Report adopted modeling by the Intergovernmental Panel on Climate Change (IPCC) Assessment Report 5 (2013), which projected sea level rise of one foot by mid-21st century and 3.2 ft by year 2100. Based on these projections, a 3.2 ft of sea level rise would result in 9,400 acres of land unusable on Oʻahu. Of the 9,400 acres, more than half of the land is in the State Urban District. Approximately 3,880 structures and 17.7 miles of major coastal roads on Oʻahu would be chronically flooded. Total structure and land loss would equate to more than $12.9 billion. Approximately 13,300 residents living near the shoreline would be displaced and in need of new homes.

The Climate Change Commission of the City and County of Honolulu provides leadership in developing analysis and policies relating to critical climate change issues and impacts that City departments and agencies must incorporate into their plans and capital improvement programs. The Commission has published a number of papers that provide important information and insight on climate change, including the "Climate Change Brief" adopted on June 5, 2018. This paper provides a grim summary of expected climate change impacts, both globally and locally, including the following:

- *The likely global temperature increase this century is a median 5.76 degrees F (3.2 degrees C). The last time it was this warm was 125,000 years ago when global sea level was 20 ft (6.6 m) higher.*
- *Warming air temperatures lead to heat waves, expanded pathogen ranges and invasive species, thermal stress for native flora and fauna, increased electricity demand, increased wildfire, potential threats to human health, and increased evaporation which both reduces water supply and increases demand. Rapid warming at highest elevations impedes precipitation, the source of Hawaiʻi's fresh water.*
- *Hawaiʻi has seen an overall decline in rainfall over the past 30 years, with widely varying precipitation patterns on each island. The period since 2008 has been particularly dry.*

- *Even under moderate warming, 10 of 21 existing native forest birds are projected to lose over 50% of their range by 2100. Of those, three may lose their entire ranges and three others are projected to lose more than 90% of their ranges making them of high concern for extinction.*
- *Ocean warming and acidification are projected to cause annual coral bleaching in some areas, like the central equatorial Pacific Ocean, as early as 2030 and almost all reefs by 2050.*
- *Indigenous populations will be disproportionally impacted by climate change due to their strong ties to place and greater reliance on natural resources for sustenance.*
- *In Hawaiʻi, climate change impacts, such as reduced streamflow, sea level rise, salt water intrusion, episodes of intense rainfall, and long periods of drought, threaten the ongoing cultivation of taro and other traditional crops.*
- *CO2 concentration has now passed 400 ppm, a level not seen since 3 million years ago, when global temperature and sea level were significantly higher than today. Testing revealed most climate models underestimate the effects of anthropogenic greenhouse gases....If countries stay on a high-emissions trajectory, there is a 93% chance the planet will warm more than 4 degrees C by the end of the century.... What will this >5.4 degrees (3 degrees C) look like?*
  - *Heat waves drive a global scale refugee crisis, as low-latitude lands lose habitability;*
  - *Drought, wildfires, water scarcity, crop failure and other threats to critical resources leading to increased human conflict and migration;*
  - *Multi-meter sea level rise continuing over many centuries;*
  - *Extreme weather disasters, massive floods, great tropical cyclones, mega-drought, and torrential rainfall will be widespread.*
- *To hold global temperature below an increase of 3.6 degrees F (2 degrees C) per the 2015 Paris Agreement, it is necessary to decrease carbon emissions by 50% per decade. Clearly the projections by the U.S. Energy Information Administration (EIA) – 'World energy-related carbon dioxide emissions rise by 15% by 2040' - move in the opposite direction and present a massive challenge to humanity.*

Rainfall data from 1990 to 2010 show rainfall decreasing by 12% on Oʻahu. However, local climate models are mixed on the severity of future rainfall trends. The uncertainties introduced by climate change emphasize the importance of incorporating water system flexibility, conservation and alternative supplies in the range of planning options. From Miller and Yates (2006): *"Although most scientists worldwide agree that our planet's climate is warming, they recognize the uncertainty inherent in assessing climate change impacts. Uncertainties in projected greenhouse gas emissions, limitations of climate models, information loss when climate projections are downscaled to watershed resolution, and imperfections in hydrological models all contribute to the uncertainty."*

There are currently two leading models that are used to project future annual average rainfall in Hawaiʻi through 2100: statistical downscaling and dynamical downscaling. The statistical downscaling model projects a generally drier climate while the dynamical downscaling model projects a generally wetter climate. Climate change scientists are not certain which model yields the more probable projections; the projections will be refined as new data become available (see *Section 2.6.1)*.

According to preliminary findings from an on-going project being conducted by the BWS Water Resources Foundation and Brown & Caldwell, titled "Impacts of Climate Change and Honolulu Water Supply Planning Strategies for Mitigation," the reduced rainfall projection (statistical downscaling) may lead to a "worst case" scenario where the island-wide aquifer sustainable yields decrease by 26% by the year 2100. In the increased rainfall projection (dynamical downscaling), the island-wide sustainable yields may increase by 9% by 2100.

Contingency for Climate Change, Sea Level Rise, and Impacts to Aquifer Sustainable Yields

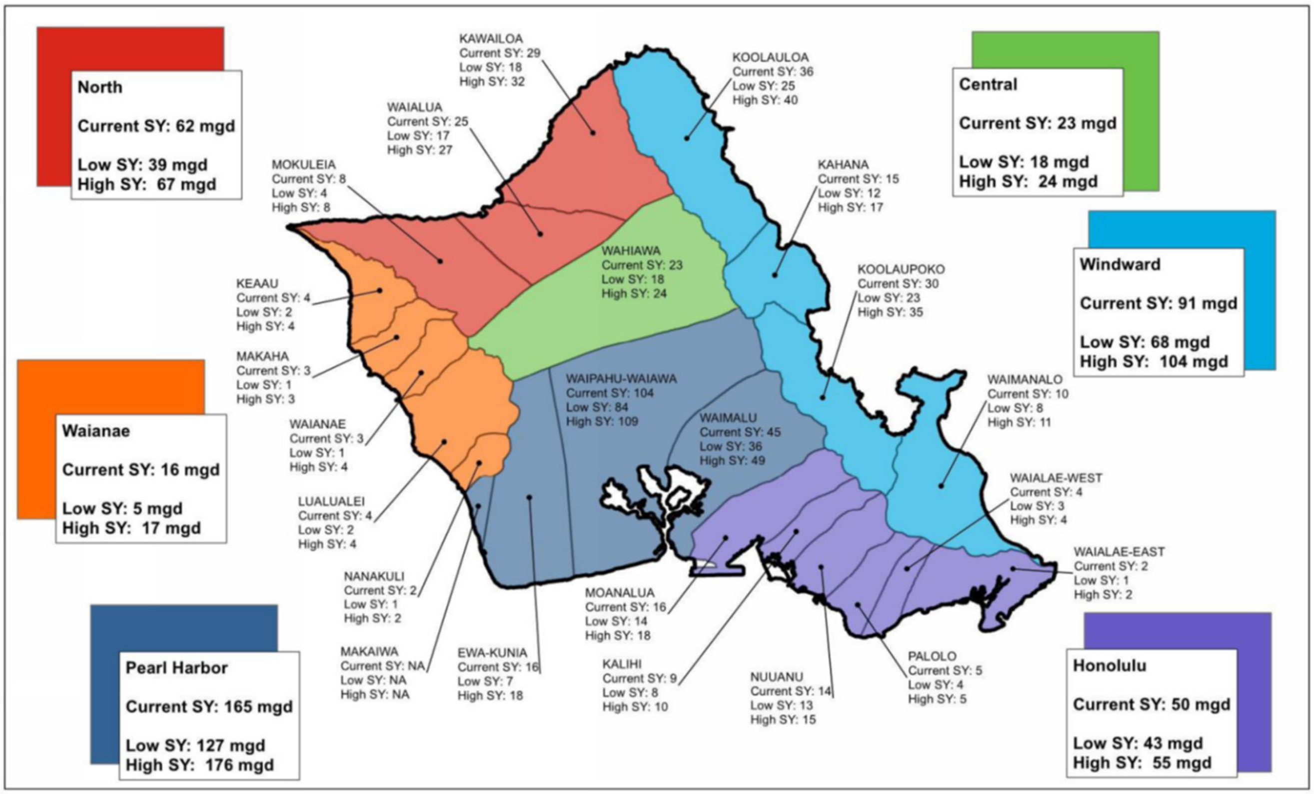
Rising sea levels and rainfall variability are global issues that may have long-term impacts for Hawaiʻi. A precautionary approach to adaptation and mitigating impacts of rising sea levels and rainfall variability is to: 1) identify the water system's most critical vulnerabilities; 2) suggest how climate variability and extremes might aggravate those vulnerabilities; and 3) design a range of solutions covering the climate uncertainty. The following contingencies could be evaluated:

- In July 2018, the Mayor issued a directive for all City departments and agencies *"…to take a proactive approach in both reducing greenhouse gas emissions and adapting to impacts caused by sea level rise, and to align programs wherever possible to help protect and prepare the infrastructure, assets, and citizens of the City for the physical and economic impacts of climate change."* The Directive requires City departments and agencies to:
    - Use the most current versions of the City Climate Change Commission's Guidance and accompanying Brief as well as the Hawai'i Sea Level Rise Vulnerability and Adaptation Report (2017) and Sea Level Rise Viewer as resources for managing assets, reviewing permitting requests, and assessing project proposals.
    - Use the Climate Commission's Guidance, Brief, and 2017 State Sea Level Rise Report in their plans, programs, and capital improvement decisions, to mitigate impacts to infrastructure and facilities subject to sea level rise exposure, which may include the elevation or relocation of infrastructure and critical facilities, the elevating of surfaces, structures, and utilities, and/or other adaptation measures.
    - Work cooperatively to develop and implement land use policies, hazard mitigation actions, and design and construction standards that mitigate and adapt to the impacts of climate change and sea level rise.
    - Work cooperatively to propose revisions to amend shoreline rules and regulations to incorporate sea level rise into the determination of shoreline setbacks and Special Management Area (SMA) considerations.

- Bill 65 (2020) amended Article 2 Climate Change Sustainability and Resiliency to mandate discrete programs on energy, coastal and water, climate resilience and equity, food security and sustainability, zero waste, pre-disaster multi-hazard mitigation, long term disaster recovery, climate action and climate change adaptation. The climate change adaptation section is based on the One Water concept (integrated water resources of fresh water, stormwater, wastewater, recycled water, sea water, etc.) institutionalizing collaboration among City agencies and others, for example, to prioritize coastal infrastructure and elevate streets and private developments to adapt to forecasted sea level rise. Many cities are embracing the One Water integrated resources framework, but this ordinance is the first in the nation to institutionalize collaboration for climate resilience.
- BWS wells will not be impacted by sea level rise because of the overlying caprock formation preventing sea water from entering into the basal aquifer. If sea level rises by 3.2 ft, the fresh water lens due to density differences will also rise 3.2 ft, which will not detrimentally affect source yields. In areas of thin caprock above mean sea level, such as in Pearl Harbor, constructed hydraulic barriers could prevent rising sea levels from intruding over the caprock into the fresh water aquifers. This solution is similar to Orange County California's Ground Water Replenishment System, recycled water hydraulic barrier injection system. However, the recycled water is treated by reverse osmosis to better than drinking water standards. In many systems in California, potable reuse has become the preferred strategy.
- Private brackish caprock wells near the coast may become more brackish or unusable increasing potable demand if converted and may need to be replaced with alternative supplies, such as recycled water.
- Recycled water and sea water desalination provide drought proof water supplies and watershed management projects will ensure healthier forests that capture a larger percentage of decreasing rainfall, stabilizing recharge fluctuations and maintaining current aquifer sustainable yields.
- BWS has engaged UH and the Water Research Foundation in climate change research projects to increase its understanding of climate change impacts to fresh water supplies. Vulnerable water systems to severe drought and coastal inundation will be identified and resolved through the BWS capital improvement program.
- BWS collaborated with the Water Research Foundation on a project titled "Impacts of Climate Change on Honolulu Water Supplies and Planning Strategies for Mitigation" to evaluate climate change impacts on BWS and its assets and develop a suite of management and treatment strategies. This project provided an Adaptive Management Plan for Honolulu based on climatic and hydrologic modeling, scenario modeling, and evaluation of adaptive management strategies. Initial findings are shown in *Figure 1-13*.

- BWS is engaging UH in an aquifer storage and recovery study of storm water impoundment in Nuʻuanu Reservoir No. 4. Impounded storm water could be treated and injected into the Kalihi and Nuʻuanu aquifers to supplement natural recharge and sustain existing pumping stations down gradient.

Figure 1-13: Range of Sustainable Yields based on UH Statistical and Dynamical Rainfall Models to 2100



Ground Water Contamination

Contaminants infiltrating into ground water and spreading through the aquifers place uncertainty in the amount of available water supply. Contamination from agricultural, underground fuel storage and distribution, and urban activities has previously occurred in Central O'ahu, Waialua, Red Hill, and Honolulu. Contamination could also result from on-site sewage disposal systems (OSDS), such as cesspools, and from purposeful human activities, such as illegal dumping. The contamination can be mitigated, but treatment is very expensive and time consuming. If treatment is too costly, the well will be shut down and pump capacity will be permanently reduced. Replacement wells are also expensive. Therefore, prevention is the most cost-effective measure against ground water contamination.

Contingency for Impacts from Ground Water Contamination

- Prevent ground water contamination from happening in the first place.
- EPA and DOH provide extensive regulatory guidelines to address contamination of drinking water. EPA has developed a list of Best Available Technologies (BAT) to remove various contaminants in drinking water and restore the drinking water source for public consumption.
- Conduct regular water quality samples and track trends of contaminants. If trends are rising toward the maximum contaminant level (MCL), initiate planning and engineering of the recommended BAT so that the treatment system is in place before the MCL is reached.
- Apply DOH Source Water Assessment Protection program guidelines to water systems, such as conducting sanitary surveys, protecting source water delineation/capture zones above wells, and best management practices (BMPs) for potential contaminating activities. Conditions for source water protection should be placed on land use plan approvals.
- Implement the water system vulnerability assessment recommendations and other security measures for well stations and other facilities.
- Seal old, unused wells with cement grout to prevent direct contamination to the aquifer and leakage from the aquifer.
- Replace cesspools with septic systems or connect to municipal sewer.
- Defuel and decommission the U.S. Navy's Red Hill Bulk Fuel Storage Facility. The DOH Emergency Order is in response to the fuel release and Navy water system contamination of November 2021. Requiring the Navy to defuel and decommission the Red Hill Bulk Fuel Storage Facility to eliminate future releases and remediate the aquifer to protect human health and the environment.

Ground Water Dependent Ecosystems

Driven by gravity, all aquifer ground water flows to the ocean, whether emerging as visible stream flow, springs or estuaries or as stream under-flow and nearshore underwater springs. On Oʻahu, the coastal caprock formation of marine and terrestrial sediments formed when sea levels were higher, have the effect of slowing the movement of fresh water to the coast, creating fresh water aquifers hundreds of feet thick. Fresh water mixing with salt water creates brackish water environments that support unique ecosystems and fisheries.

Drought or diversion of fresh water flows could have an impact on these ground water dependent ecosystems (GDE), and is under CWRM consideration. While direct measurement is difficult or not possible, ground water flow to the coast can be generally estimated as the difference between recharge and sustainable yield accounting for actual pumpage. Recharge is calculated in a hydrologic budget consisting of rainfall, evapotranspiration, runoff and recharge. Sustainable yield is calculated as a percentage of recharge based on aquifer thickness. The health and impacts to coastal ecosystem environments vary by region, land use, well location and pumping rates and therefore have to be evaluated on a watershed-by-watershed basis. *Table 1-15* estimates ground water flow to nearshore waters as the difference between recharge and sustainable yield that support coastal ecosystems.

<u>Contingency for Ground Water Dependent Ecosystems (GDE)</u>

- Site specific studies of coastal ecosystems are needed to evaluate the benefits and impacts of fresh water flows affected by diversions and climate change.
- Develop capture zone delineations (CZD), for GDE, (similar to DOH SWAP), that supply ground water flow to high value coastal ecosystems, such as fishponds and 1) avoid new source development within the GDE CZD (2 or 10 year travel time); and 2) identify water conservation actions to reduce pumpage from the existing sources within the GDE CZD.
- Physical restoration of coastal habitats and fishponds and removing invasive species can enhance ecosystems, supplementing actions that increase natural ground water flows to nearshore waters.
- CWRM enhances ground water flows to dependent ecosystems by applying a conservative approach in selecting the lower range of ground water sustainable yields in the WRPP. Of the 660 MGD of recharge to Oahu aquifers in 2017, 266 MGD or 40% of recharge would naturally flow to the coast if all aquifers were pumped to their respective sustainable yields. In practice, full development of sustainable yields will not likely happen and currently about half of Oahu's sustainable yield or an additional 200 MGD is not used and therefore, 466 MGD of recharge continues to naturally flow to the coast in support of GDE.

Should CWRM consider increasing ground water flows to the coast to enhance GDE, sustainable yields could be decreased based upon the results of future studies.

Table 1-15: Estimate of Ground Water Flow to the Coast (MGD) Supporting Ground Water Dependent Ecosystems

Aquifer system	Recharge Entire Watershed (USGS 2017)	Adjusted Recharge with Wahiawa Spillover	Adopted Sustainable Yield WRPP 2019	Difference of Recharge and Sustainable Yield as Ground water Flow to Nearshore Waters
Pālolo	8.28	8	5	3
Nuʻuanu	18.62	19	14	5
Kalihi	10.57	11	9	2
Moanalua	20.79	21	16	5
Waiʻalae-West	5.56	6	2.5	3
Waiʻalae-East	9.80	10	2	8
Waimalu	62.81	63	45	18
Waipahu-Waiawa	96.60	138	105	33
ʻEwa-Kunia	14.69	22	16	6
Makaīwa	1.44	1	0	1
Nānākuli	3.02	3	1	2
Lualualei	10.80	11	3	8
Waiʻanae	7.09	7	3	4
Mākaha	8.57	9	3	6
Keaʻau	7.79	8	3	5
Mokulēʻia	21.60	38	17	21
Waialua	13.45	35	17	18
Kawailoa	34.10	45	22	23
Wahiawā	129.07	31	23	8
Koʻolauloa	76.24	76	35	41
Kahana	43.24	43	15	28
Koʻolau Poko	39.08	39	28	11
Waimānalo	17.00	17	9	8
Oʻahu Total	**660.21**	**660**	**393.5**	**266**

1.3.10.2 Surface Water Supply Uncertainties

Surface water supply uncertainties and contingencies are presented in this section and include the following topics:

- Amending Interim Instream Flow Standards
- Quantifying Stream Flows, Diversions and Use
- Drought Impacts on Surface Water

The uncertainties are discussed followed by contingencies, or planning strategies to account for surface water supply uncertainties:

Amending Interim Instream Flow Standards

The most significant uncertainty related to the availability of surface water and dike ground water sources affecting stream flow is the lack of measurable IIFS for the majority of streams on Oʻahu. Other uncertainties relate to the complexity of stream studies (scientific, cultural, economic and environmental) and their potential cost. These uncertainties realistically mean that additional surface water is not available now or for the foreseeable future. The following is a range of possible outcomes:

- If there is additional water available after instream uses are met, water will be available for agricultural use.
- If no additional water is available, status quo instream and non-instream uses will be maintained.
- If there is insufficient water in the stream to meet the measurable IIFS, water from existing non-instream uses will need to be returned to the stream, and alternative water sources for agriculture and urban uses may be needed.

<u>Contingency for amending IIFS</u>

- CWRM identifies high natural quality streams to amend interim IFS using best available information.
- CWRM will be acting on the pending petitions for amending interim IFS and should develop a standardized measurable IIFS methodology to fulfill Public Trust uses of water emphasizing practicality and consistency.
- Until measurable IIFS are established, new stream diversions are <u>not</u> recommended in this plan, other than for the restoration of traditional and customary practices, such as kalo cultivation. Other surface water users should work within the existing diverted flows, applying conservation and water loss prevention strategies such as lining distribution ditch systems to increase system efficiencies.

Quantifying Stream Flows, Diversions and Use

There is a level of uncertainty in the amount of surface water flowing in Oʻahu's streams and stream segments (low, mean, median and peak variations of flows), the number of diversions and diverted flows, and their associated use and loss. On Oʻahu there are 87 surface water hydrologic units containing approximately 232 stream diversions. In order to adequately protect streams and manage surface water use, streams need to be gaged, diversion structures must be inventoried, and surface water use reported on a regular basis. As with ground water use, non-instream water use must be reasonable and beneficial, conserved or returned to the stream.

Contingency for Inventories of Stream Flow, Diversion, and Use

- Cooperative partnerships, such as with USGS, will be expanded to jointly fund the gaging of important perennial streams.
- Legislative appropriations should continue to conduct statewide field investigations to verify and inventory surface water uses and stream diversions and update existing surface water information. BWS hydrogeologists have conducted field surveys using CWRM survey protocols of stream diversions to supplement CWRM efforts.
- The stream permitting process is being revised to improve the acquisition of pertinent information, and a surface water use reporting system will be established.

Drought Impacts on Surface Water

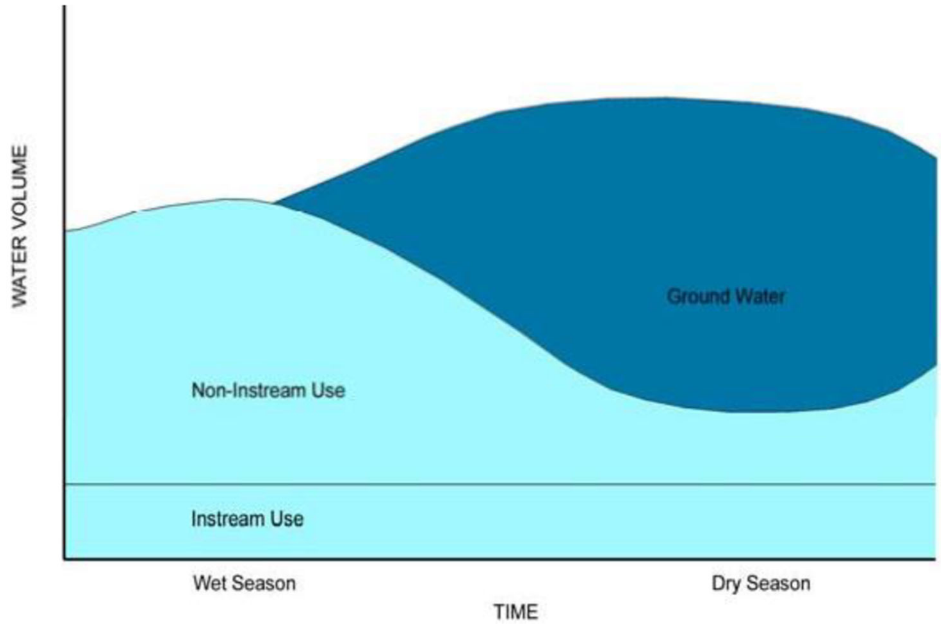
Drought impacts instream uses and surface water availability and is another uncertainty. Surface water is supplied by rainfall and ground water leakage as base flow and is impacted more readily during drought than ground water. Extended drought can have dire implications, especially for agriculture, much of which relies solely on surface water for irrigation.

Contingency for Drought Impacts on Surface Water

- Alternative sources such as ground water and recycled water should be developed to mitigate drought impacts on agriculture. Barriers to recycled water especially for edible vegetable crops will need to be addressed.
- Water loss strategies will extend existing diverted flows. Agricultural crops could also be modified to use less water, markets permitting.
- Watershed forestation and protection projects will focus on critical watersheds to increase base flows and natural storage supplying streams.

A significant limitation to using surface water is its variability and lack of reliability, especially during dry periods and drought. By increasing water storage, or by supplementing surface water with ground water, which is called conjunctive use, additional agricultural lands may be irrigated year-round cost effectively with minimal impact. *Figure 1-14* shows the seasonal relationship between surface water in conjunction with ground water for agricultural irrigation. During dry seasons and drought, when demand increases and limited stream water is available, ground water can supplement surface water, protecting instream uses. Surface water, which is more abundant during the wet season, can be economically used, allowing time for the ground water source to be replenished.

Figure 1-14: Seasonal Agricultural Water Use Supplementing Surface Water with Ground Water



1.3.10.3 Agricultural Water Demand Projection Uncertainties and Contingencies

Predicting agricultural water demands is challenging because of market uncertainties, variable regional crop type and associated water demand numbers, climate variability, etc. In addition, the general lack of metering agricultural water use severely hampers not only demand estimates but the protection and management of the water resource. Hawai'i's diversified agricultural production has increased in recent years.

Regional crop water demand uncertainties are related to crop types, operational variables for each crop type such as fallow periods and frequency of harvest, and local climatic conditions. Crop water demands are challenging because of the diversity of crops and of the relatively few crop numbers that are geographically specific or agreed upon.

Contingency for Agricultural Water Demands

CWRM funded a UH study to develop a crop water demand model that is now used to provide discreet water demands by specific crop type, climate and soil condition. The model allows CWRM to tailor water allocations to specific lands thereby assuring reasonable and beneficial water use.

1.3.10.4 Urban Water Demands Uncertainties and Contingencies

Predicting population growth depends on public policies in the Development and Sustainable Communities Plans and the fluctuating economic trends affecting the pace of urban growth. The urban growth and rural community boundaries provide essential guidance on discreet limits to urban growth to protect agricultural and conservation lands. A significant uncertainty is estimating water demands associated with urban growth concurrently with decreasing unit water demands that masks the true effect of water conservation programs.

Contingency Plans for Demand Projection Uncertainties

The following strategies can mitigate the uncertainties in demand forecasting:

- Compiling trend data to analyze the extent, causes and effects of decreasing per capita water demand to develop reliable and accurate water demand forecasts. Improved conservation measures and economic forces have slowed both urban and agricultural water demand growth extending existing supplies.
- Demand forecasts provide a range of possible future demands (low, mid and high) with associated water supplies. Adjusting the timing of water supply projects will accommodate changes in the rate of demand growth. If growth is slower or faster than predicted, projects can be deferred until needed or developed in a shorter timeframe. Regular updates of this plan will allow course corrections.
- With the integrated One Water resources strategies of watershed protection, advanced conservation, and sustainable diversified ground water and surface water supplies, and new technologies in recycled water and desalination using renewable energy sources, there should be sufficient water supply to accommodate variability in climate and domestic and agricultural water demand growth.

1.4 PLAN IMPLEMENTATION

The implementation of the watershed management plans will be accomplished by:

1. Guiding public investment in infrastructure through agency functional and facilities plans, which are consistent with the Sustainable Communities and Development Plans and the WMPs of the City.
2. Including watershed and water supply projects in agency capital improvement programs for short-, mid- and long-term horizons that balance the five WMP objectives.
3. Incorporating major watershed management strategies and projects through the City's land use planning processes such as the Development Plans, Sustainable Communities Plans, special area plans, land use permitting process for private and public development, and through the Public Infrastructure Map.

4. Creating watershed partnerships of Federal, State, and City agencies, landowners, organizations, and communities that can pool resources toward common objectives and creating groups that choose to assume the responsibility or obtain authorization to implement specific watershed projects.
5. Using the "One Water" approach for agency and landowner collaboration to implement cross-sector projects that benefit multiple goals for conservation, reuse, and storm water capture and recharge.
6. Securing sufficient funding sources to support watershed and water supply projects through a combination of appropriations, grants, fees, and dedicated funds. Each project is subject to annual budget approval and available funding.
7. Recommending approval, approval with conditions or denial of developments seeking water based on the adequacy and timing of planned water system infrastructure.

Water Allocation and System Development

The OWMP sets forth the allocation of water to land use by identifying new water supplies for the planned urban developments and agricultural lands as designated in Oʻahu's Sustainable Communities Plans and Development Plans. The land use plans and watershed management plans will be used as a guide for the review and approval of CWRM water use permit applications and water commitments and land use approvals by BWS and DPP. CWRM review of Stream Diversion Works Permits and Stream Channel Alteration Permits for new diversions of surface water can also use the plans for guidance. Water use permits are not required for domestic consumption of water by individual users (Chap. 174C-48(a) HRS). Regular updates of the regional land use plans and watershed plans will integrate land use and water planning and with iteration, will improve consistency and ultimately achieve healthy watersheds.

Adequate Facilities Requirement

All land use actions for developments requiring water, including domestic service, irrigation and fire protection from the BWS water systems are reviewed for adequacy of supply and level of service in compliance with BWS Rules and Regulations, Chapter 1, Water and Water System Requirements for Developments and BWS Water System Standards.

BWS issues water commitments based on an assessment of the adequacy of water supply and water system capacity. There are three categories of available water of which Category 2 currently applies island-wide:

1. Areas with Adequate Water Supply: BWS may issue advance water commitments to proposed developments in areas where the water system has adequate supplies to assume new or additional services.

2. Areas with Limited Additional Water Supply: BWS may restrict the issuance of advance water commitments to proposed developments in areas where the water system has limited additional supplies to assume new or additional services.
3. Areas with No Additional Water Supply: BWS shall not issue water commitments to proposed developments in areas where the water system has no additional supplies to assume new or additional services. The only exceptions shall be the issuance of a single 5/8-inch meter to proposed developments on existing single vacant lots.

BWS assists CWRM with permit reviews for new development. New ground water sources, both public and private, must comply with the State Water Code, Chapter 174C-51, Application for a Permit. Water Use Permits are required for sources of supply in designated water management areas. All areas except Wai‘anae are designated ground water management areas. HRS Chapter 174C-49 Conditions for a Permit, establishes that the proposed use of water:

1. Can be accommodated with the available water source;
2. Is a reasonable-beneficial use as defined in Section 174C-3;
3. Will not interfere with any existing legal use of water;
4. Is consistent with the public interest;
5. Is consistent with State and County general plans and land use designations;
6. Is consistent with County land use plans and policies; and
7. Will not interfere with the rights of the Department of Hawaiian Home Lands.

The evaluation of Chapter 174C-49 permit conditions including reasonable and beneficial use occurs during the CWRM Water Use Permit approval of BWS wells. Once permitted, BWS then commits water on a first-come, first-serve basis, based on an assessment of the projects proposal, efficient water utilization, and the adequacy of water supply and water system capacity. BWS commits water applying the same procedure in designated and non-designated areas, the latter does not require a CWRM water use permit. A non-designated aquifer is not pumped above 90% of sustainable yield and does not have water quality issues or serious disputes.

Review of Zoning and Other Development Applications

Before zoning is approved for new residential, commercial and industrial development, the BWS will indicate to DPP that adequate potable and non-potable water is available or recommend conditions that should be included as part of the zone change approval in order to assure adequacy.

Large Developments Requiring Major New Water System Infrastructure

BWS requires new large developments to submit potable and non-potable water master plans for review and approval, showing the necessary infrastructure to accommodate the development. The master plan should provide land use, site layout, phasing, water demands, and infrastructure including proposed source, storage, transmission and treatment facilities with hydraulic analysis. The master plan then guides the review and approval of construction plans, and the installation of infrastructure to be dedicated to BWS in compliance with BWS Water System Standards. Applications for Water Service are contingent upon the fulfillment of these conditions.

Existing Lot Developments and Small Subdivisions

BWS capital program expands the water system to accommodate planned growth. Each application for water service is evaluated for system adequacy to provide domestic and fire protection services. Water System Facilities Charges, the BWS impact fees, are applied to all new developments requiring new or additional water service. If water system infrastructure is not adequate, the development can be denied or conditions to ensure adequacy can be placed before water service is approved.

BWS Capital Improvement Program (CIP)

The OWMP is the long-range strategic water resource plan for the City and the BWS Water Master Plan informs and guides the BWS long-range capital program plan of source, storage, transmission, treatment infrastructure by providing a watershed-based evaluation of available sources of supply and water demand forecasts. The capital projects plan is an integral part of the BWS responsibility, authorized by City Charter as the public water system purveyor and water resource manager. The capital projects program is integrated with the BWS long-term financial plan and water rate structure. BWS is authorized by City Charter to set water rates to provide water supply for Oʻahu. The capital program accommodates water system expansion and infrastructure renewal and replacement as guided specifically by the strategies in Objective #5 to meet demands at reasonable costs while balancing the other plan objectives.

In October 2016, BWS adopted the BWS Water Master Plan (WMP), a 30-year infrastructure plan that evaluates the entire water system, identifies improvements, and balances needs and costs. The water master planning process included efforts to:

- Assess existing conditions of pipes, pumps, reservoirs, wells, treatment plants, and other facilities;
- Develop and compare projections of future (2040) needs with existing water supplies and infrastructure;
- Identify needs for future supplies and improvements to existing facilities;
- Develop CIP projects and a prioritized 30-year CIP (with a more detailed focus of the first 10 years) based on risks to the system and providing reliable service to customers; and
- Develop a comprehensive plan to implement improvements, including priorities, schedules, costs, financing, and rates, in conjunction with the CIP.

The 2016 WMP sets forth water demand and BWS-served population projections which are utilized in the WMPs to assess the district's most-probable water demand. However, the two plans differ in that the 2016 WMP solely assesses BWS water supply, infrastructure, system efficiency, etc. The WMPs utilize a holistic approach to protecting and improving watershed health. The WMPs consider both private and municipal water sources, and review various water types (drinking water, wastewater, stormwater, etc.).

The 2016 WMP includes 24 different performance metrics within seven criteria to help the BWS to assess risk and make clear how each CIP project will help the BWS meet its mission to provide safe, dependable, and affordable water now and into the future. The seven criteria are as follows: 1) System Reliability; 2) System Adequacy; 3) Regulatory Compliance; 4) Cost and Efficiency; 5) Public Confidence; 6) Water Resource Sustainability; and 7) Agency Coordination and Other Considerations. Refer to the 2016 WMP (Section 13) for details.

CHAPTER 1 REFERENCES

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CHAPTER 2: EAST HONOLULU WATERSHED PROFILE

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2 EAST HONOLULU WATERSHED PROFILE

2.1 INTRODUCTION

Over the years, the City and County of Honolulu Board of Water Supply (BWS) has recognized the importance of focusing on resource protection and management, conservation, and restoration, in addition to water use and development. An ahupuaʻa-based approach was developed for the Oʻahu Watershed Management Plan (OWMP) to understand the interrelationships among physical, biological, and human environments. The OWMP is comprised of eight watershed management plans (WMPs), representing Oʻahu's eight different planning districts. The authority and purpose of the OMWP and the district WMPs, including the EHWMP, is described in detail in *Chapter 1*.

Figure 2-1 depicts the status of the OWMP. As of October August 2022, the Waiʻanae, Koʻolau Loa, Koʻolau Poko, and North Shore WMPs have been completed; the ʻEwa, Primary Urban Center, Central Oʻahu, and East Honolulu WMPs are still in progress.

Figure 2-1: Oʻahu Watershed Management Plan Adoption Dates (as of December 2022)

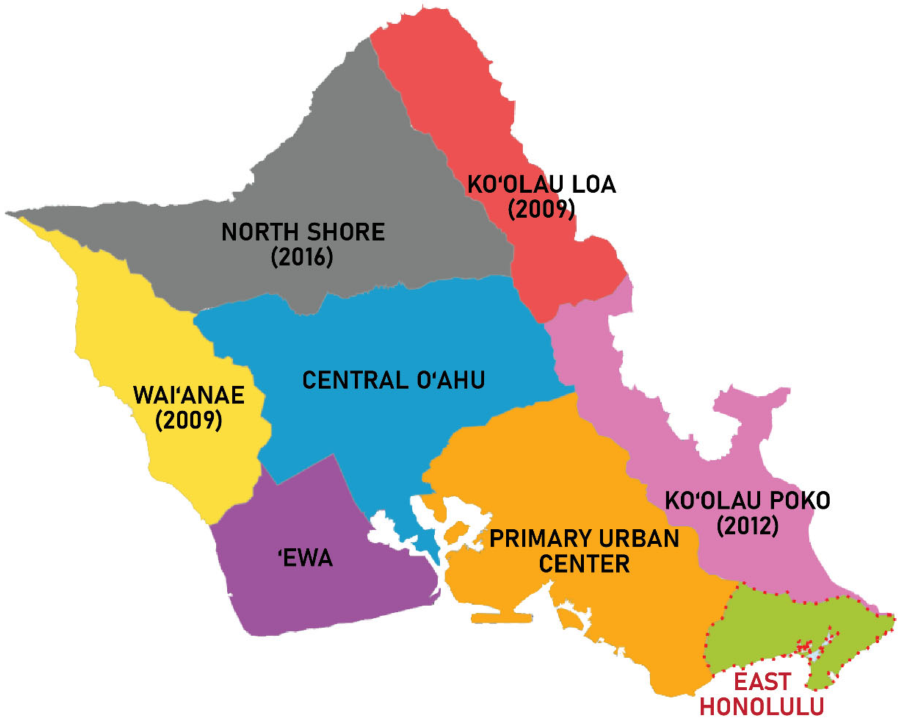


Figure 2-1 Note: The ʻEwa, Primary Urban Center, Central Oʻahu, and East Honolulu WMPs are in progress and anticipated to be finalized in 2023.

Chapter 2 of the EHWMP, also referred to as the "East Honolulu Watershed Profile", is intended to be a comprehensive reference on water resource issues in East Honolulu. It includes an overview of the district's terrestrial, land use, socio economic, and water resources and a summary of critical water resource issues for East Honolulu based on research and stakeholder input. It also includes a summary of the stakeholder engagement process that was undertaken for the EHWMP. The critical water resource issues identified in this Chapter inform the policies, projects, and strategies provided in *Chapter 4*.

2.1.1 Methodology

The process to develop the East Honolulu Watershed Profile involved research and stakeholder consultation to identify issues and needs, data gaps, and resource management opportunities related to watershed health in the East Honolulu district. The project team reviewed studies, plans, and reports done by various agencies, organizations, and academic institutions (*Table 2-1*). These documents provided information on specific topics within East Honolulu and on watershed issues in general. Geographic Information System (GIS) analysis was used to complement the research. Various individuals, agencies and organizations were then contacted to provide follow-up details or updated information, and to confirm water resource values, issues, and needs as reported by East Honolulu stakeholders. These were verified through a community meeting held in March 2019. Findings of research and stakeholder input were synthesized to develop an overall assessment of East Honolulu natural resources and to identify critical water resource issues for East Honolulu. The following section provides an overview of the stakeholder engagement process for the EHWMP.

Table 2-1: Reviewed Sources

Category	Source
State Water Plans	- Hawaiʻi Water Quality Plan (DOH, 2019) - Water Resource Protection Plan Update (CWRM, 2019) - State Water Projects Plan (DLNR, 2003) - Agricultural Water User and Development Plan (DOA, 2019)
City and County WMPs	- Waiʻanae Watershed Management Plan (BWS, 2009) - Koʻolau Loa Watershed Management Plan (BWS, 2009) - Koʻolau Poko Watershed Management Plan (BWS, 2012) - North Shore Watershed Management Plan (BWS, 2016) - Central Oʻahu Watershed Management Plan (BWS, 2014) - ʻEwa Watershed Management Plan – Public Review Draft (BWS, 2016) - Primary Urban Center Watershed Management Plan – Public Review Draft (BWS, 2019)
City and County Land Use Plans	- Oʻahu General Plan (DPP, 2021) - East Honolulu Sustainable Communities Plan (DPP, Adopted July 2022)
Other Plans	- BWS Water Master Plan (BWS, 2016) - Ocean Resources Management Plan (OP, 2020) - State of Hawaiʻi Multi-Hazard Mitigation Plan (Hawaiʻi Emergency Management Agency, 2018) - The Rain Follows the Forest: A Plan to Replenish Hawaiʻi's Source of Water (DLNR, 2011) - Watershed Based Plan for Reduction of Nonpoint Source Pollution in Wailupe Stream Watershed, Oʻahu (Mālama Maunalua, 2010) - Ka Iwi Coast Master Plan (DLNR, 1996) - Hawaiʻi Watershed Guidance (OP and DOH, 2010) - Maunalua-Makapuʻu State Scenic Byway Corridor Management Plan (Livable Hawaiʻi Kai Hui and Ka Iwi Coalition, 2018)
Studies / Reports	- Effects of Invasive Alien Plants on Fire Regimes (Brooks et al., 2014) - The phenology, tissue water relations, and taxonomy of Marsilea vilosa (Bruegmann, 1986)

Category	Source
	- Hawaiʻi Sea Level Rise Vulnerability and Adaptation Report (Hawaiʻi Climate Change Mitigation and Adaptation Commission, 2017) - One Water for Climate Resiliency (Honolulu Climate Change Commission, 2020) - Climate Change and Financial Risk Guidance (Honolulu Climate Change Commission, 2020) - Shoreline Setback Guidance: ROH Ch. 23 (Honolulu Climate Change Commission, 2019) - Sea Level Rise Guidance (Honolulu Climate Change Commission, 2018) - Wetland Loss in Hawaiʻi Since Human Settlement (Van Rees and Reed, 2013) - Atlas of Hawaiian Resources and Their Aquatic Resources (DLNR Division of Aquatic Resources and Bishop Museum, 2008) - Spatial Trend Analysis of Hawaiian Rainfall from 1920 to 2012 (Frazier and Giambelluca, 2017) - Hawaiʻi has a Devastating Wildfire Problem (Hawaiʻi Wildfire Management Organization, 2016) - Development of a Model to Simulate Ground Water Inundation Induced by Sea Level Rise and High Tides in Honolulu, Hawaiʻi (Habel et al., 2017) - Distribution of Soil Orders in Hawaiʻi (Hue et al., 2007) - Community Structure Of Fish And Macrobenthos At Selected Sites Waiʻanae,Oʻahu, -Hawaiʻi, In Relation To The Waiʻanae Deep Ocean Sewage Outfall, 1990-1998 (Moncur et al., 2002). - This is My Land: The Role of Place in Native Hawaiian Identity (Kanaʻiaupuni and Malone, 2006). - Archaeology of Oʻahu (McAllister, 1933) - Ecosystems and human wellbeing: wetlands and water, synthesis (Millennium Ecosystem Assessment, 2005) - Pacific Islands Regional Climate Assessment (NOAA, 2012) - Regional Climate Trends and Scenarios for the U.S. National Climate Assessment, Part 8 (NOAA, 2013) - Environmental Setting and the Effects of Natural and Human-related Factors on Water Quality and Aquatic Biota, Oʻahu, Hawaiʻi: U.S. (Oki and Brasher, 2003) - Rapid Growth of the U.S. Wildland-urban Interface Raises Wildfire Risk (Radeloff, 2018) - Before the Horror: The Population in Hawaiʻi before the Eve of Western Demographic Statistics of Hawaiʻi 1778–1965 (Stannard, 1989) - Global and Regional Sea Level Rise Scenarios for the United States (Sweet et al., 2017) - Oʻahu Shoreline Study: Data on Beach Changes (DPP, 2011) - Final Feasibility Report: Wailupe Stream Flood Control Study, Oʻahu, Hawaiʻi (USACE, 1998 - Reconnaissance Survey: Ka Iwi Shoreline Study (United States Department of the Interior, 1992) - Ground Water Source Assessment Program for the State of Hawaiʻi, USA: Methodology and Example Application (Whittier et al., 2008) - New Produce Safety Regulations (Yang and Swinburne, 2016) - Dynamical Downscaling of the Climate for the Hawaiian Islands (Zhang et al., 2016)
Other	Relevant municipal data, GIS maps, news articles, and others.

2.1.2 Stakeholder Engagement

The project team engaged in extensive consultations with residents, community leaders, community organizations, land owners, business owners, public agencies and elected officials throughout the development of the EHWMP. Public and private sector stakeholders provided valuable input regarding values, water uses, and watershed related issues in East Honolulu, as well as potential policies, actions, and strategies to consider during the EHWMP planning process.

Stakeholders engaged during the EHWMP planning process are listed in *Table 2-2.* Three resources were used to identify the stakeholders: 1) Stakeholder lists from previous planning work by BWS; 2) Referrals from community members; and 3) Referrals from government agencies and elected officials.

The engagement process included twenty small group and individual meetings ("stakeholder consultations); outreach with elected officials; three rounds of neighborhood board presentations; and four rounds of community meetings.

Small Group and Individual Meetings

Small group and individual meetings were held with more than twenty elected officials, various community organizations, land owners, government agencies, and individuals who were active in and/or knowledgeable about water resources in East Honolulu. The purpose of these meetings was to inform people about the plan and the planning process and to gather input on community values and issues. Input from these consultations is summarized in *Section 2.14* of the EHWMP.

Image: EHWMP Presentation at the February 2019 Maunalua Watershed Hui Meeting.

Elected Officials

BWS notified East Honolulu elected officials, including two City Council candidates (election results were still pending for the district at the time), one State Senator, and two State Representatives about the EHWMP and its planning process. Elected officials were also asked to share their thoughts and concerns regarding water resource issues within East Honolulu.

Table 2-2: Stakeholder Consultations

Category	Stakeholders Consulted
Elected Officials	1. City Councilmember Candidates for Council District #4 (Trevor Ozawa and Tommy Waters) 2. State Senator Stanley Chang (9th Senate District) 3. State Representative Gene Ward (17th Rep. District) 4. State Representative Mark Hashem (18th Rep. District)
Government Agencies	5. City and County of Honolulu, Department of Planning and Permitting, Planning Division 6. Koʻolau Mountains Watershed Partnership 7. Department of Land and Natural Resources, Division of Forestry and Wildlife 8. Department of Land and Natural Resources, Nā Ala Hele Program 9. City and County of Honolulu, Office of Climate Change, Sustainability, and Resiliency 10. Ocean Resources Management Coordinated Working Group
Community Groups, Nonprofits, and Academic / Research Institutions	11. Sierra Club, Marine Action Team 12. ʻĀina Haina Prepared 13. Hawaiʻi Kai Strong 14. Hui O Koʻolaupoko 15. Kamilo Nui Farmers 16. Ka Iwi Coalition 17. Livable Hawaiʻi Kai Hui 18. Maunalua Heritage Fishpond Center 19. Mālama Maunalua 20. Maunalua-Ka Iwi Watershed Hui 21. ʻĀina Haina Community Association 22. University of Hawaiʻi at Mānoa, Department of Urban and Regional Planning 23. University of Hawaiʻi at Mānoa Sea Grant Program 24. Water.App

Neighborhood Board Presentations

The project team provided three rounds of presentations to the three Neighborhood Board (NHBs) that are within East Honolulu. These NHBs included: Hawaiʻi Kai, NHB #1; Kuliʻouʻou – Kalani Iki, NHB #2; and Waiʻalae – Kāhala, NHB #3. After each NHB briefing, NHB members and community members were invited to ask questions and provide input on the discussed water resources issues, policies and programs. More details about each round of NHB presentations are provided below.

- **Round #1** was held in late 2018. The presentations focused on the purpose, scope, and objectives of the EHWMP. Input was gathered on the NHB's key water resource values and concerns.

- **Round #2** was held in early 2021. The presentations focused on gathering input on the EHWMP's policies, projects, and strategies. Due to the COVID-19 pandemic, the NHB presentations were given virtually.
- **Round #3** was held in 2023. The presentations focused on gathering input on the EHWMP's catalyst projects and implementation plan, as well as announcing the schedule for the EHWMP Public Review Draft.

A fourth round of outreach to the three East Honolulu NHB's is planned around the release of the Final Draft.

<u>Community Meetings</u>

Four community meetings were held as part of the EHWMP planning process. Notes and recordings (if available) from the community meetings were posted on the BWS website. These community meetings are described in further detail below.

Image: EHWMP / EHSCP March 2019 Community Meeting.

- **Meeting #1** was held in March 2019 at Koko Head Elementary School to inform the development of *Chapter 2*. The community meeting was held jointly by DPP and BWS. The meeting objectives were: 1) presenting and receiving feedback on the East Honolulu Sustainable Communities Plan (EHSCP); 2) presenting the EHWMP objectives and planning process; and 3) presenting and receiving feedback on East Honolulu's critical water resource issues.
- **Meeting #2** was held in November 2019 at the Koko Head Elementary School to inform the development of *Chapter 3*. The purpose of the meeting was to present information regarding East Honolulu's existing and future water demand and supply. The meeting was also used to gather input on the preliminary EHWMP water demand scenarios.
- **Meeting #3** was held virtually (due to the COVID-19 pandemic) via Zoom in December 2020 to inform the development of *Chapter 4*. The purpose of the meeting was to present and gather input on the preliminary EHWMP policies, projects, and strategies. The meeting was supplemented by an online open house (i.e., an interactive webpage) which also allowed users to learn and provide input on proposed policies, projects, and strategies. The webpage was made publicly available from November 2020 to February 2021.
- **Meeting #4** was held in August 2023 on Zoom. The purpose of the meeting was to present and gather community input on the EHWMP Public Review Draft. The meeting was supplemented by an online open house where participants could review and comment on the Public Review Draft. The comment period for the Public Review Draft extended through September 2023.

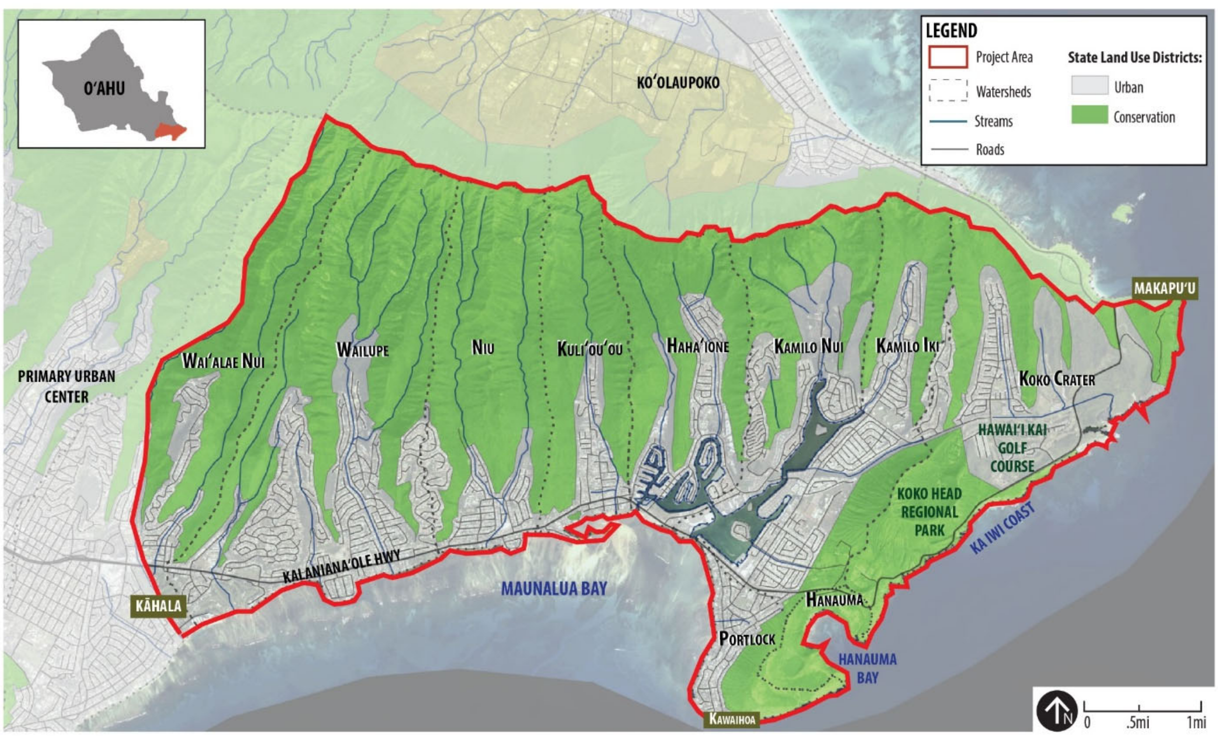
2.2 PHYSICAL SETTING

Encompassing 15,042 acres, the East Honolulu district makes up approximately 4% of Oʻahu's land mass. The physical landscape of East Honolulu district is defined by steep mountain ridges and gulches transitioning to to flatter coastal lowlands. The shoreline features coastal cliffs in some areas, sandy or hardened shoreline in others, and inland brackish and salt water bays, especially around Hawaiʻi Kai. The district has ten watersheds (see *Section 2.2.3* for further discussion on the district's watersheds).

2.2.1 Political Boundaries

The East Honolulu district is located in the southeastern sector of the island of Oʻahu and is defined by the City and County of Honolulu East Honolulu Planning District boundaries. The district spans Oahu's south shore from Waiʻalae Beach Park to Kawaihoa Point (tip of Portlock), and along the Ka Iwi Coast from Kawaihoa to Makapuʻu Point (*Figure 2-2*). The Koʻolau Mountain Range forms the inland (mauka) boundary of the district. The East Honolulu district is comprised of three neighborhood board (NHB) districts: the entirety of the Hawaiʻi Kai (#1) and Kuliʻouʻou-Kalani Iki (#2) NHB districts are within the East Honolulu district, as well as a small portion of the Waiʻalae-Kāhala (#3) NHB area.

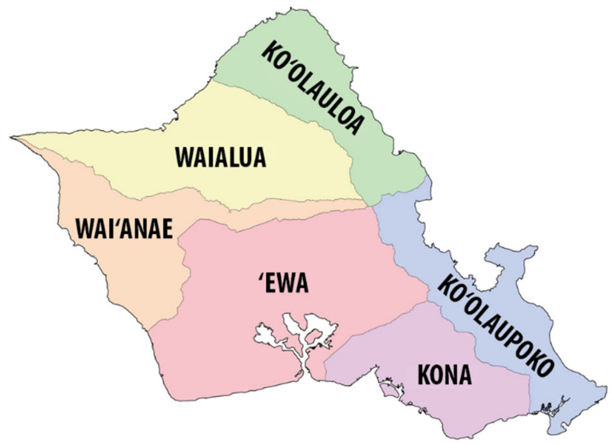
Figure 2-2: East Honolulu Watershed Management Project Area



2.2.2 Ahupuaʻa

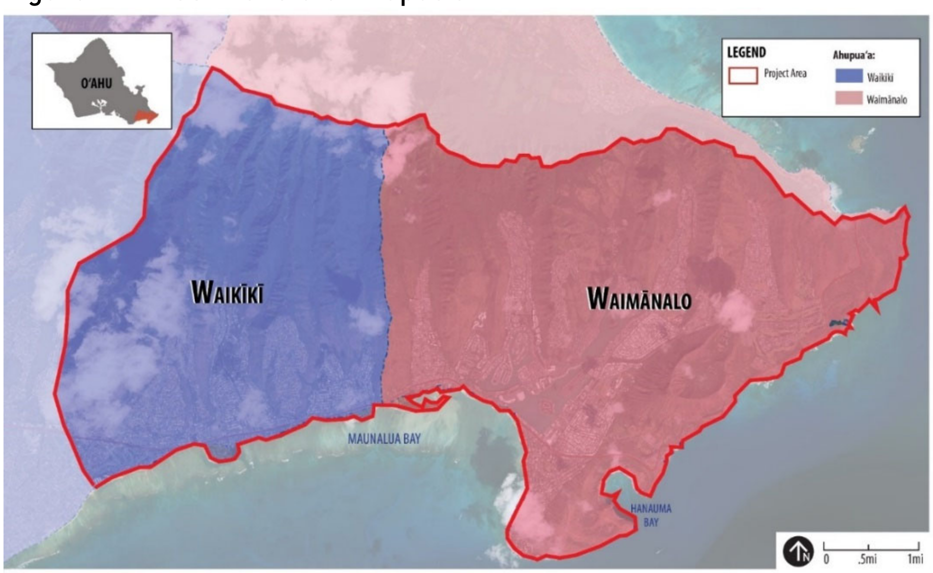
Prior to Western contact, each island, or mokupuni, was divided into districts called moku. The moku boundaries ran from the top of the mountains to the sea, and each moku was again divided insto smaller sections called ahupuaʻa (further described in *Section 2.9*).[5] The traditional moku boundaries on the mokupuni of Oʻahu are somewhat comparable to those of the City and County of Honolulu's eight planning districts (*Figure 2-3*). Traditionally, the Kona moku encompassed the area along Oʻahu's south shore from Hālawa (west) to Kuliʻouʻou (east) and the Koʻolau Poko moku spanned the Ka Iwi and Windward Coast from Hawaiʻi Kai (south) to Kualoa (north).

Figure 2-3: Oʻahu Moku



Ahupuaʻa were typically long narrow strips of land running from the mountain tops to the sea, often following natural features such as streams and ridges, and were delineated to allow their chiefs access to a broad range of resources.[6] Two ahupuaʻa are located in the East Honolulu district: Waikīkī and Waimānalo (*Figure 2-4*). In East Honolulu, each ahupuaʻa contains several watersheds.

Figure 2-4: East Honolulu Ahupuaʻa



[5] Handy et. al. (1968). *Ancient Hawaiian Civilization*.
[6] Sterling and Summers. (2008). *Sites of Oʻahu*.

2.2.3 Watersheds

A watershed is defined as a drainage basin that catches, collects, and stores water that travels toward the ocean via rivers, streams, or through subterranean springs or seepages. The East Honolulu district consists of 10 named watersheds: Wai'alae Nui, Wailupe, Niu, Kuli'ou'ou, Haha'ione, Kamilo Nui, Kamilo Iki, Portlock, Hanauma, and Koko Crater (see *Table 2-3* and *Figure 2-5).*

The size and shape of a watershed are important characteristics that determine the way water moves within the watershed. The movement of water, in turn, affects several aspects of water resource management. These factors are used in the 2008 Atlas of Hawaiian Resources and Their Aquatic Resources to categorize watersheds into eight different "clusters". Generally speaking, watersheds with higher cluster codes are geographically larger and steeper than watersheds with smaller cluster codes.

Some of the watersheds in the East Honolulu district – including Wailupe and Niu – are categorized by the DLNR Division of Aquatic Resources (DAR) as belonging to the DAR cluster 5 category, meaning the watershed is medium in size, steep in the upper watershed, with little embayment.7 The DAR Clusters of many East Honolulu watersheds have not been determined – including Wai'alae Nui, Kuli'ou'ou, Haha'ione, Kamilo Nui, Kamilo Iki, Portlock, Hanauma, and Koko Crater. Given the size and topography of these watersheds, they would likely be categorized as DAR Cluster 4 or 5, with the exception of Hanauma and Portlock watersheds. The Hanauma and Portlock watersheds are both small in size, and the Hanauma watershed has a large defined embayment. The rest of the watersheds drain into Maunalua Bay or the Pacific Ocean (*Figure 2-5*).

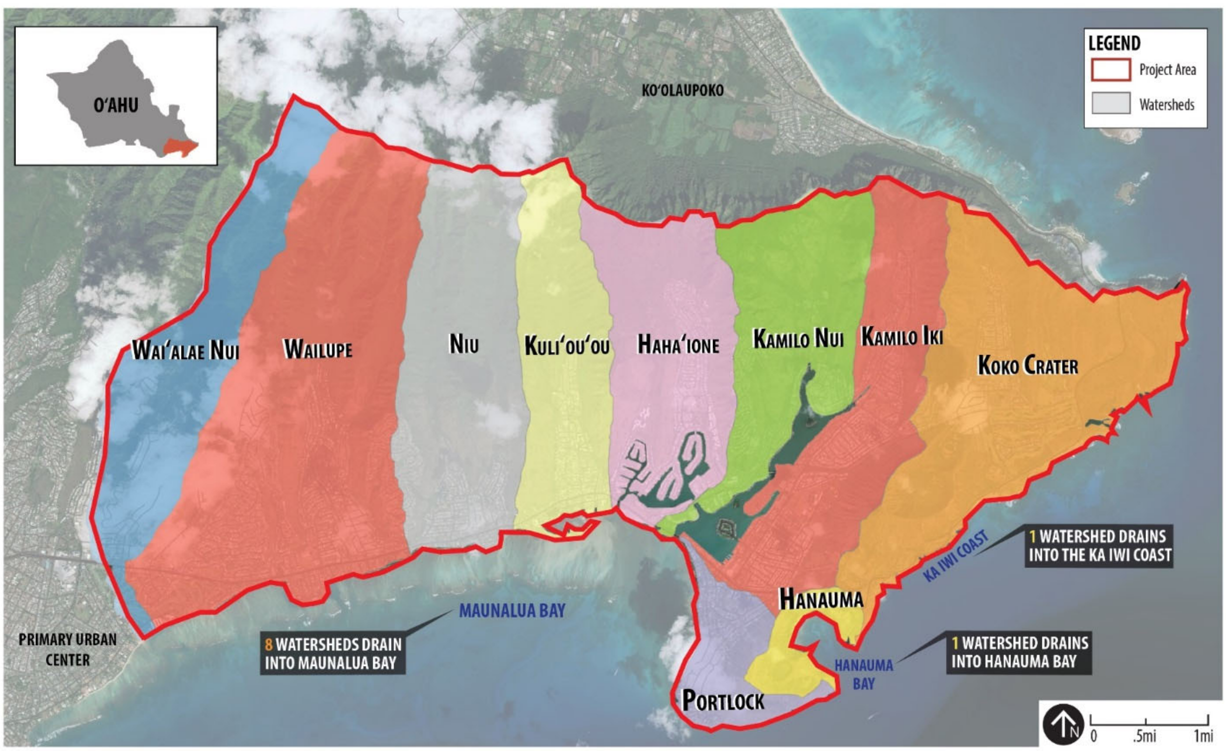
The watersheds in East Honolulu form a series of natural drainageways extending across the region. These stream channels are the primary means for carrying water from the inland areas to the sea and are capable of handling runoff from normal rainfall events. During periods of intense rainfall, however, a number of these drainageways have experienced flooding problems.

[7] Hawai'i Division of Aquatic Resources and Bishop Museum. (2008). *Atlas of Hawaiian Resources & Their Aquatic Resources*. Available from: http://hawaiiwatershedatlas.com/.

Table 2-3: East Honolulu Watersheds

#	Watershed	Watershed Size (Acres)
1	Wai'alae Nui	3,821
2	Wailupe	3,245
3	Niu (also referred to as *Pia*)	1,709
4	Kuli'ou'ou	1,152
5	Haha'ione	1,382
6	Kamilo Nui	1,280
7	Kamilo Iki	1,517
8	Portlock	467
9	Hanauma	250
10	Koko Crater (also referred to *Napaia*)	2,323

Figure 2-5: East Honolulu Watersheds



2.2.4 Climate

The Koʻolau mountain range spans the length of the Oʻahu's Windward coast for approximately 34 miles from Kahuku in the north to Makapuʻu in the south. The Koʻolau range separates the Windward side from the Leeward side of Oʻahu. Generally speaking, the Leeward side of Oʻahu is considerably drier and warmer than the Windward side. East Honolulu is on the Leeward side of the Koʻolau range and can likewise be characterized as warm and dry, however there are many microclimates within the district.

Coastal areas in East Honolulu typically experience moderate to low rainfall. However, average rainfall on Oʻahu is highly variable and is largely dependent upon elevation. According to the 2011 Rainfall Atlas of Hawaiʻi, the coastal plains of East Honolulu experience less than 750 mm (~30 inches) of annual rainfall. The upper reaches of the Koʻolau Mountains in East Honolulu experience more than 2,000 mm (~80 inches) of annual rainfall (*Figure* 2-6)**.**

Average temperatures in the East Honolulu district range from 75 degrees Fahrenheit near the coast to 68 degrees Fahrenheit in the mountains.[8] The warmest month is typically August (mean temperature of 78 degrees Fahrenheit along the coast) and the coolest month is typically January (71 degrees Fahrenheit along the coast).[9] The small temperature difference between the warmest and coolest months is largely attributable to the influence of the surrounding ocean, the persistence of the cooling trade winds, and the small seasonal variation in solar radiation.

Trade wind patterns have a significant effect on Oʻahu's climate. The prevailing trade winds in East Honolulu blow from the northeast most of the year and bring warm moist air from the ocean onto the land. When northeast trade winds hit the Koʻolau Mountains at a perpendicular angle, moist air is lifted and condensed as rainfall. This phenomenon is called orographic rain. When trade winds shift to the East, there is less orographic rainfall. The trade winds usually vary between 10 to 20 miles per hour and are steadier during the summer months (90% of the time during June to August) than during the winter (50% of the time between January and March).

Evapotranspiration, which is water loss due to evaporation from plants, land, and water surfaces, is also a major factor impacting East Honolulu's hydrologic cycle. The evapotranspiration potential on Oʻahu averages about 50 inches annually. When evapotranspiration exceeds rainfall, areas are dry. Thus, annual rainfall above 50 inches creates wet forests and promotes aquifer recharge.

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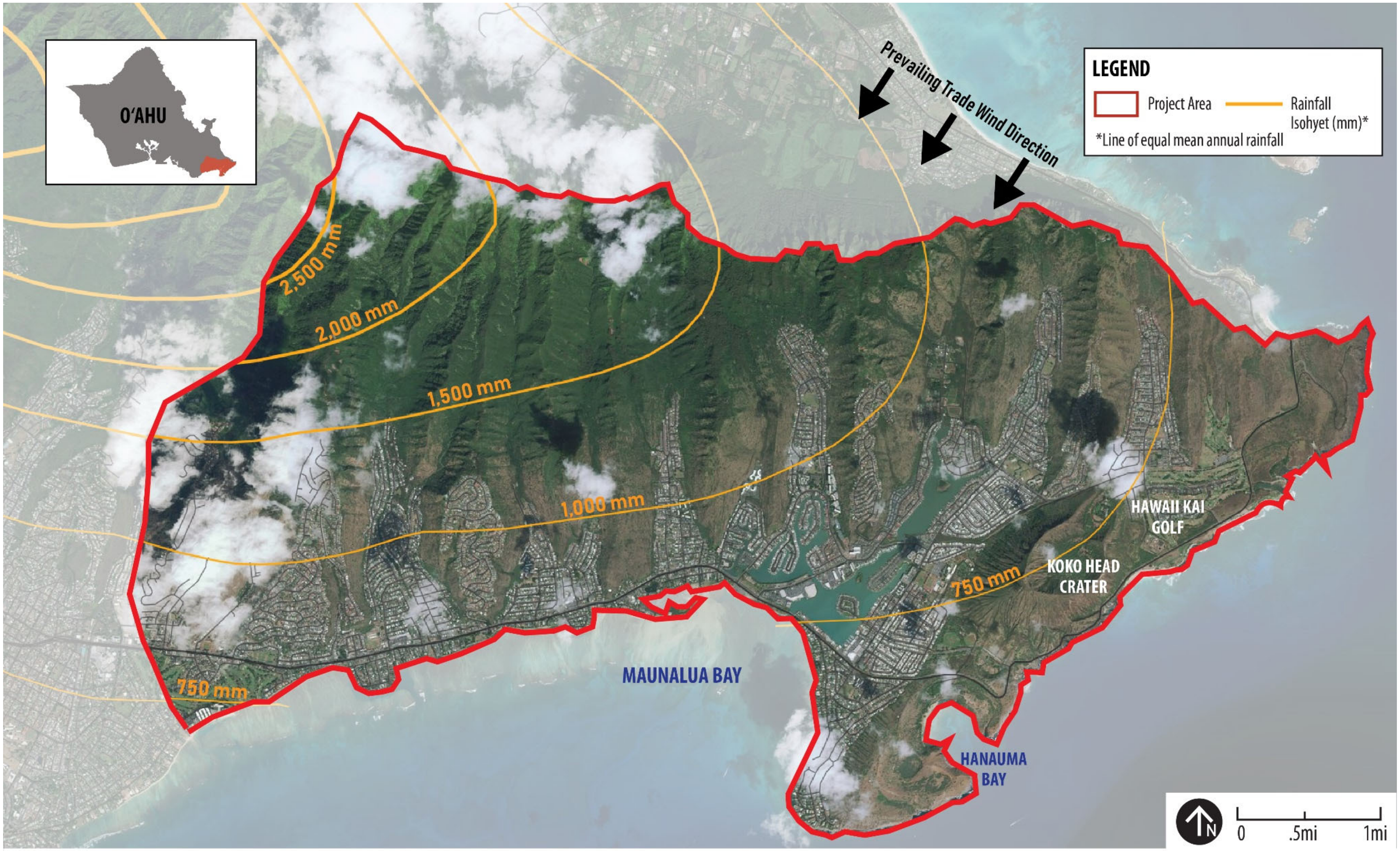
[8] Giambelluca et al. (2014). *Evapotranspiration of Hawaiʻi*. Final report submitted to the U.S. Army Corps of Engineers—Honolulu District, and the Commission on Water Resource Management, State of Hawaiʻi.
[9] Ibid.

Figure 2-6: East Honolulu Average Rain and Wind Patterns (based on the 2011 Rainfall Atlas of Hawaiʻi)



2.1.3 Geology and Soils

Geology

The island of Oʻahu was created by the Waiʻanae and Koʻolau volcanoes. East Oʻahu was formed by two major volcanic events: the Koʻolau volcanic series that formed the Koʻolau mountain range about 2.5 million years ago, and the Honolulu volcanic series that formed over parts of the eroding Koʻolau series approximately 30,000 years ago.[10] The volcanic formations along the corridor, such as Koko Crater, Hanauma Bay, and Makapuʻu, are a linear chain of cones known as the Honolulu volcanic series' Koko Rift. The eastern flank of Koko Crater contains the only base surge deposits known on the islands, and the Koko Head-Hanauma Bay-Koko Crater complex contains one of the best examples of tuff cones in the Hawaiian Islands. Because of these reasons, the Koko Rift is considered geologically significant, and is being considered as a possible addition to the National Park System.[11]

Soils

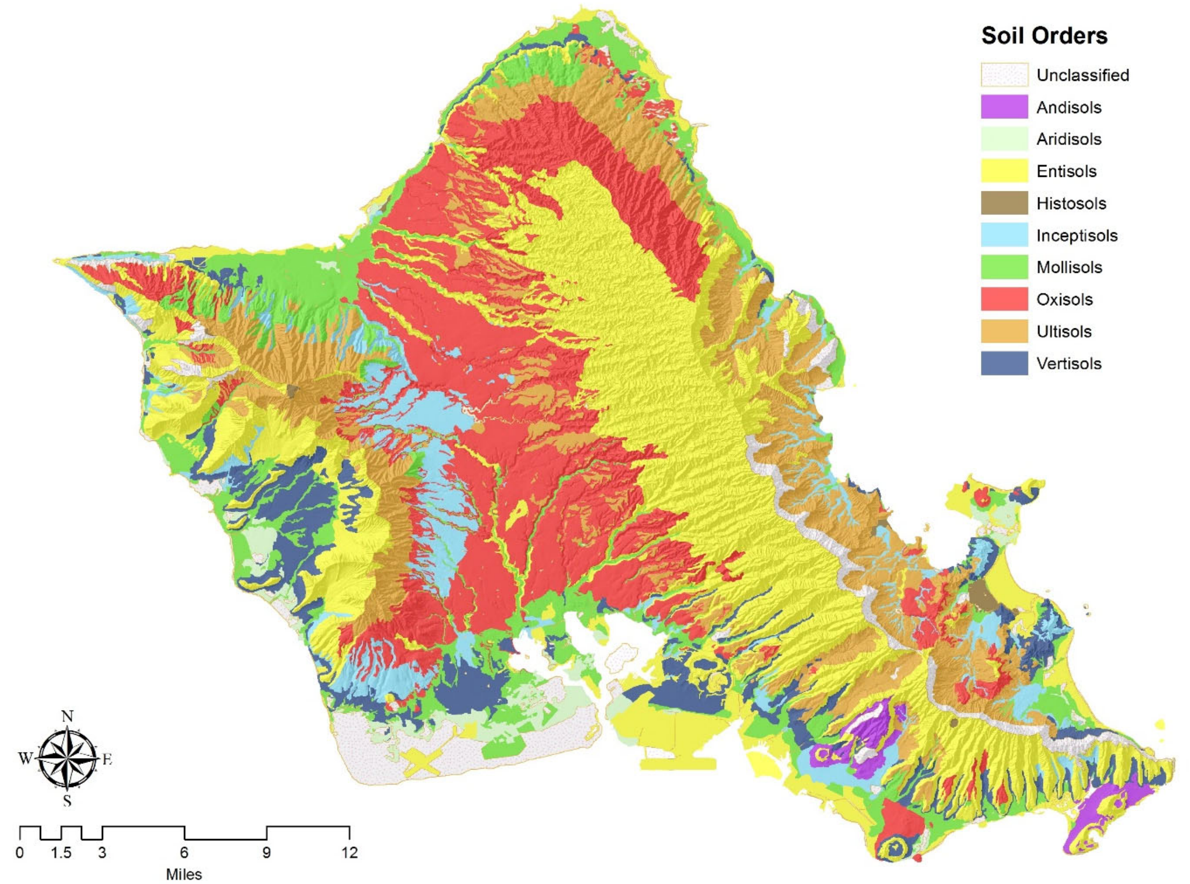
Soil scientists have devised standard procedures to describe, characterize and name all possible kinds of soil. This classification system is hierarchical, consisting of six categories. Soils in Hawaiʻi have been mapped by the Soil Conservation Service (now called the Natural Resources Conservation Service, NRCS).[12] The highest classification of soils is the "order," which groups soils by general characteristics and the soil-forming process. Of the 12 soil orders in the world, nine (perhaps ten) are found throughout Hawaiʻi, and five soil orders (*Table 2-4*) are found in the East Honolulu district (*Figure 2-7*).

Table 2-4: Soil Orders in East Honolulu[13]

Soil Order	Description
Andisols	Derived from volcanic ash. Fertility can range from highly productive to requiring lots of fertilizers for crop production.
Iceptisols	Minimal development of soil horizons.
Mollisols	Fertile soils with high organic content and high base saturation.
Oxisols	The most weathered soils of the tropics, with low nutrient holding capacity and high iron and aluminum oxides.
Vertisols	Shrink when dry and swell when wet. They usually occur in valleys with poor drainage. They are fertile but pose severe limitations for roads, housing, and related uses.

[10] Department of the Interior, National Parks Service. (1992). *Reconnaissance Survey: Ka Iwi Shoreline Study*.
[11] Livable Hawaiʻi Kai Hui & Ka Iwi Coalition. (2018). *Maunalua-Makapuʻu State Scenic Byway Corridor Management Plan*.
[12] Soil Conservation Service. (1972). *Soil Survey of Islands of Kauaʻi, Oʻahu, Maui, Molokaʻi, and Lanaʻi, State of Hawaiʻi*.
[13] Hue, N.V., G. Uehara, R.S. Yost, and M. Ortiz-Escobar. (2007). *Distribution of Soil Orders in Hawaiʻi*.

Figure 2-7: O‘ahu Soil Orders[14]



“Soil series” is the lowest and most restrictive category in soil taxonomy, consisting of soils that are similar in all major profile characteristics. In total, there are 190 soil series found in Hawai‘i. Of these, 23 exist in the East Honolulu district. The major soil series' that make up the East Honolulu, as well as soil attributes, are listed in *Table 2-5* and shown in *Figure 2-8*. Nearly half of the soil in the district is categorized as Rock Land or Rock Outcrop, which primarily consists of exposed bedrock. Nearly 15% of the district’s soil is categorized as Rough Mountainous Land. Generally speaking, these soil series (Rock Land, Rough Mountainous Land, Rock Outcrop) are not conducive to agricultural use. Over 10% of the district’s soil is categorized as Koko Silt Loam, which is a dry volcanic-ash soil found surrounding Koko Crater. This soil series, as well as Lualualei, Lahaina, and Kawaihapai are good agricultural soils with moderate to high water holding capacity, but have primarily been converted to urban uses.

Fill Land, a soil series that is commonly found in the urban areas of the Primary Urban Center district, makes up only 3% of the East Honolulu district’s soils. Fill Land is generally located around Kuapā

[14] Hue, N.V., G. Uehara, R.S. Yost, and M. Ortiz-Escobar. (2007). *Distribution of Soil Orders in Hawai‘i*.

Pond, which was dredged and filled for urban development. The dredged material is corrosive to metallic pipes and can cause main breaks.

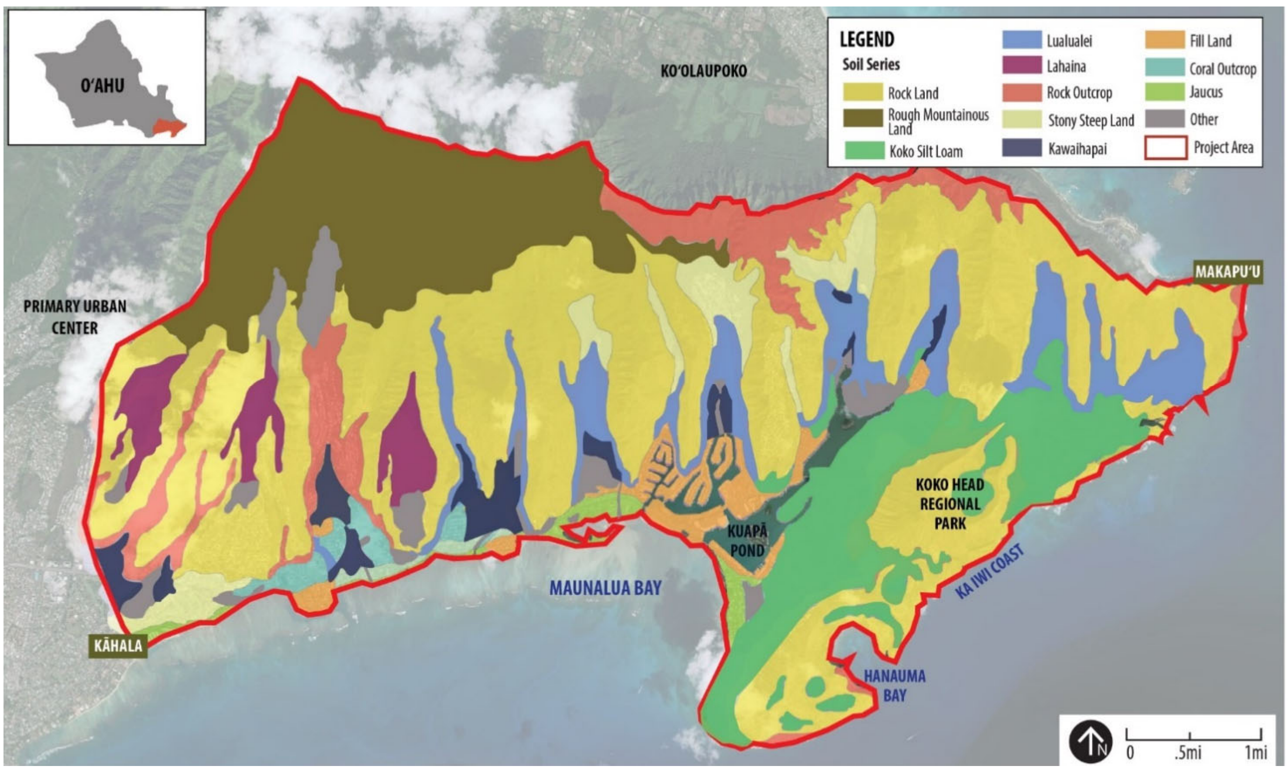
Table 2-5: Soil Series in East Honolulu[15]

Soil Series	Acres	Percent of Total	Soil Description
Rock Land	6,189.44	42%	Shallow soil; often composed of exposed bedrock and found on the district's mountain ridges; susceptible to runoff and erosion on steep slopes.
Rough Mountainous Land	2,173.65	14.8%	Very steep land broken by deep V-shaped drainages, creating narrow ridges and steep slopes; susceptible to runoff and erosion on steep slopes.
Koko Silt Loam	1,557.12	10.6%	Dry volcanic-ash soil found on Koko Head and the lands surrounding it; good agricultural soil, but it has primarily been converted into residential areas; high water holding capacity and experiences dry conditions throughout most of the year; susceptible to runoff and erosion on steeper slopes.
Lualualei	1,034.24	7%	Clayey soil found on valley floors and coastal plains in dry areas of Oʻahu; excellent agricultural soil, but much of this soil series has been converted to residential areas; irrigation is required.
Lahaina	412.16	3.8%	Red soil once used for farming and pasture purposes that has been converted for residential uses on some areas on Oʻahu; moderate water holding capacity.
Rock Outcrop	508.48	3.5%	Mostly comprised of exposed bedrock; no water holding capacity.
Stony Steep Land	411	2.7%	Primarily covered with stones and boulders, as well as forest or brush; moderate water holding capacity; moderate permeability.
Kawaihapai	393.6	2.7%	Soil found along coastal plains and streams; high water holding capacity; moderate permeability; dry conditions require irrigation in some areas.

[15] Soil series acres (%) calculated from Hawaiʻi Statewide GIS layer: "Soils (MU) – Soils of Hawaiʻi". Soil descriptions provided by the *Hawaiʻi Soil Atlas* (retrieved from: http://gis.ctahr.hawaii.edu/SoilAtlas).

Soil Series	Acres	Percent of Total	Soil Description
Fill Land	387.2	2.6%	Generally found in coastal, low-lying areas; once used for disposal of dredging, garbage, and old sugar mill waste, and now used for urban uses.
All Others	1,662.07	11.3%	Beaches, Coral Outcrop, ʻEwa, Hanalei, Helemano, Honouliuli, Jaucus, Keaʻau, Pamoa, Pearl Harbor, Makalapa, Mālama, Mokulēʻia, and Waialua.

Figure 2-8: East Honolulu Soil Series

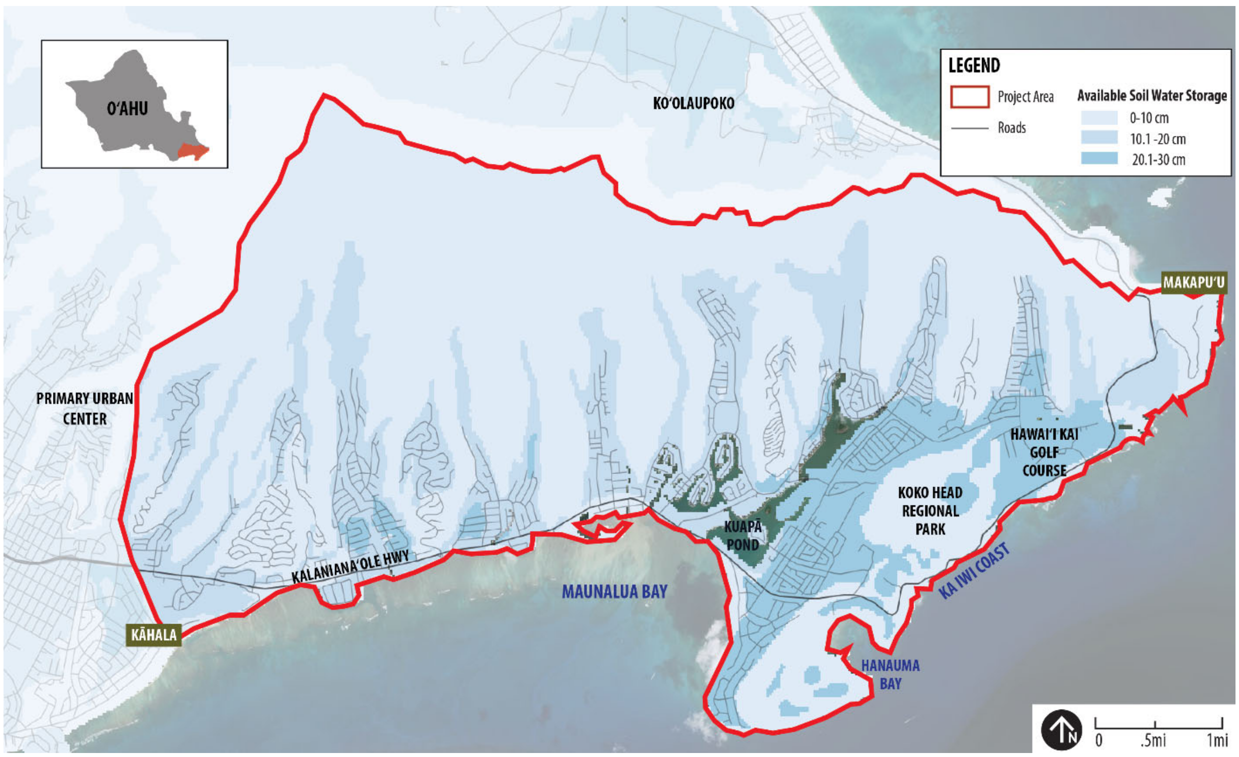


Available Water Storage

Soils vary in their water holding capacity, also referred to as ‘available water storage.’ Information regarding water storage can be used to develop water budgets, manage droughts, design and operate irrigation systems, design drainage systems, protect water resources, and estimate yields. The amount of water in soil is based on rainfall amount, what proportion of rain infiltrates into the soil, the slope of the watershed, and the soil's storage capacity. Available water storage is the maximum amount of plant available water a soil can provide. It is an indicator of a soil’s ability to retain water and make it sufficiently available for plant use.

A 2017 GIS layer created by the U.S. Department of Agriculture (USDA) and NRCS provides current available water storage estimates for the United States – it depicts the capacity estimate for the top 150 centimeters of soil. It is calculated from the difference between soil water content at field capacity and the permanent wilting point adjusted for salinity and fragments. Available water storage in the East Honolulu district ranges from 0-30 cm, which is typical for most areas of Oʻahu (*Figure 2-9*).[16] Only select areas on the Windward side of Oʻahu have a water storage greater than 40 cm. The steep land along the Koʻolau mountain range has the lowest water storage in the East Honolulu district (below 10 cm). The areas with the highest amounts of available water storage in the district (20-30 cm) are primarily within Hawaiʻi Kai and along the Ka Iwi Coast; these areas with relatively high water storage are likely the most suitable lands for agriculture in the district. However, most of this land has been developed for residential purposes.

Figure 2-9: East Honolulu Available Soil Water Storage



[16] USDA NRCS. (2018). "USA Soils Available Water Storage" (GIS Layer). Available from ArcGIS Online.

2.3 GROUND WATER

Ground water resources supply Hawaiʻi with nearly 90% of its water drinking supply. Monitoring existing ground water sources and ensuring the quality of ground water into the future is vital to the State's public health. The following section describes ground water resources and factors influencing ground water quantity and quality in East Honolulu. A detailed discussion of ground water as it relates to the district's available supply and demand is included in *Chapter 3.*

2.3.1 Ground Water Resources

Aquifer Sectors and System Areas

CWRM defines six hydrologic units, or aquifer sector areas (ASA), across Oʻahu, which are largely determined by regional geology (see *Figure 2-10*). These ASAs also serve as management boundaries for the regulation and allocation of ground water resources. Aquifer sector areas are subdivided into aquifer system areas (ASYA), which are largely determined based on hydrogeology, although there may be movement of water between systems. ASYAs and ASAs serve as management boundaries for the regulation and allocation of ground water resources. The East Honolulu district falls entirely within the Honolulu ASA, which spans along Oʻahu's south shore from Moanalua to Makapuʻu. The East Honolulu district lies primarily within the Waiʻalae East ASYA, however the western most portion of the district lies within the Waiʻalae West ASYA (the East Honolulu district is outlined in red in *Figure 2-10*).

Sustainable Yield

Sustainable yield is the maximum rate at which water may be withdrawn from a water source without impairing the utility or quality of the water source. Sustainable yields are defined and established for each aquifer system according to the 2019 Water Resource Protection Plan update. The Honolulu ASA has a total sustainable yield of 48 MGD. However, the existing permitted uses for ground water withdrawals (53.134 MGD) exceeds the sustainable yield. This is because CWRM reduced the sustainable yield of aquifers within the Honolulu ASA, but has not yet reduced the permitted uses of these aquifers. The Waiʻalae-East ASYA has a SY of 2 million gallons per day (MGD); the Waiʻalae-West ASYA has a SY of 2.5 MGD. Notably, the Waiʻalae West ASYA's SY was decreased in the 2019 Water Resource Protection Plan (WRPP), from 4 MGD to 2.5 MGD, due to a USGS revision to aquifer recharge estimates. See *Chapter 3* for a detailed discussion of water supply and sustainable yields (*Figure 2-11*).

East Honolulu's limited ground water availability is largely due to the fact that the Waiʻalae-West and Waiʻalae-East have a relatively thin fresh water lens. The majority of fresh water in East Honolulu exists between ʻAina Koa and Kuliʻouʻou. Ground water east of Hahaʻione is mostly brackish water.

Figure 2-10: O‘ahu Aquifer System and Sector Areas[17]

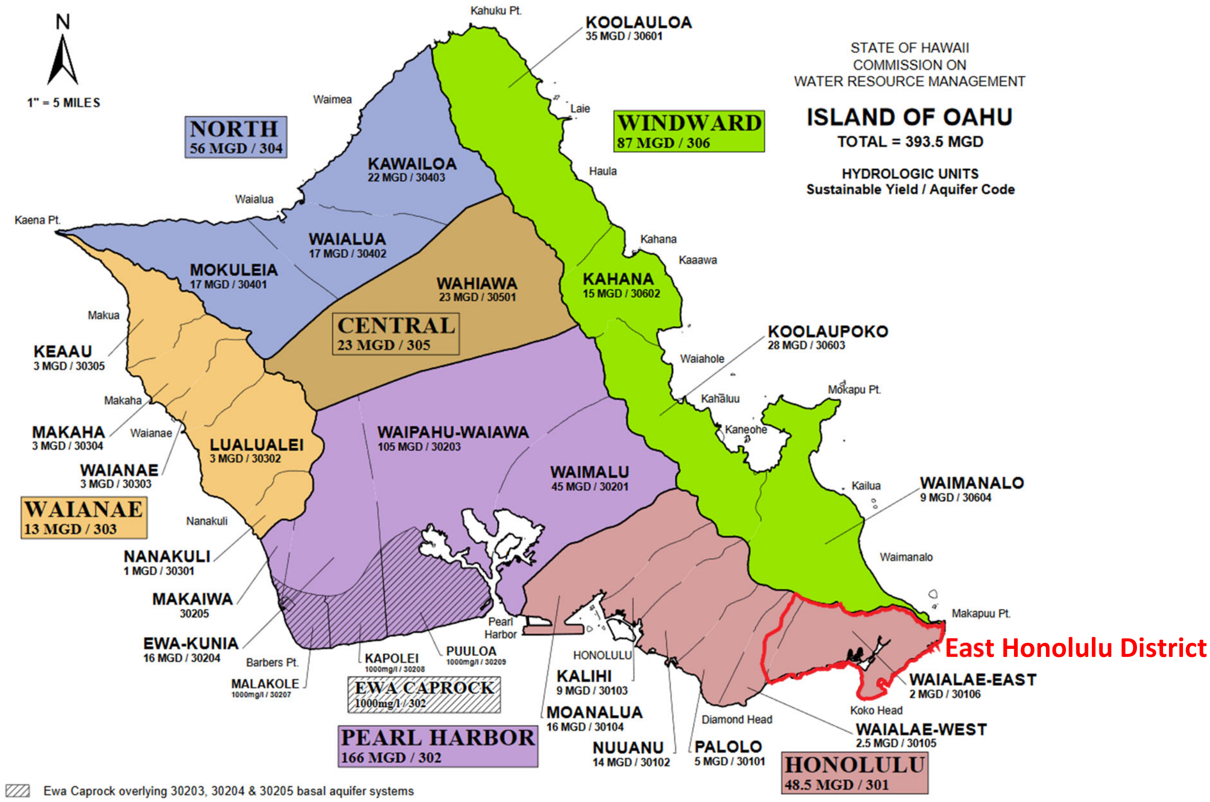
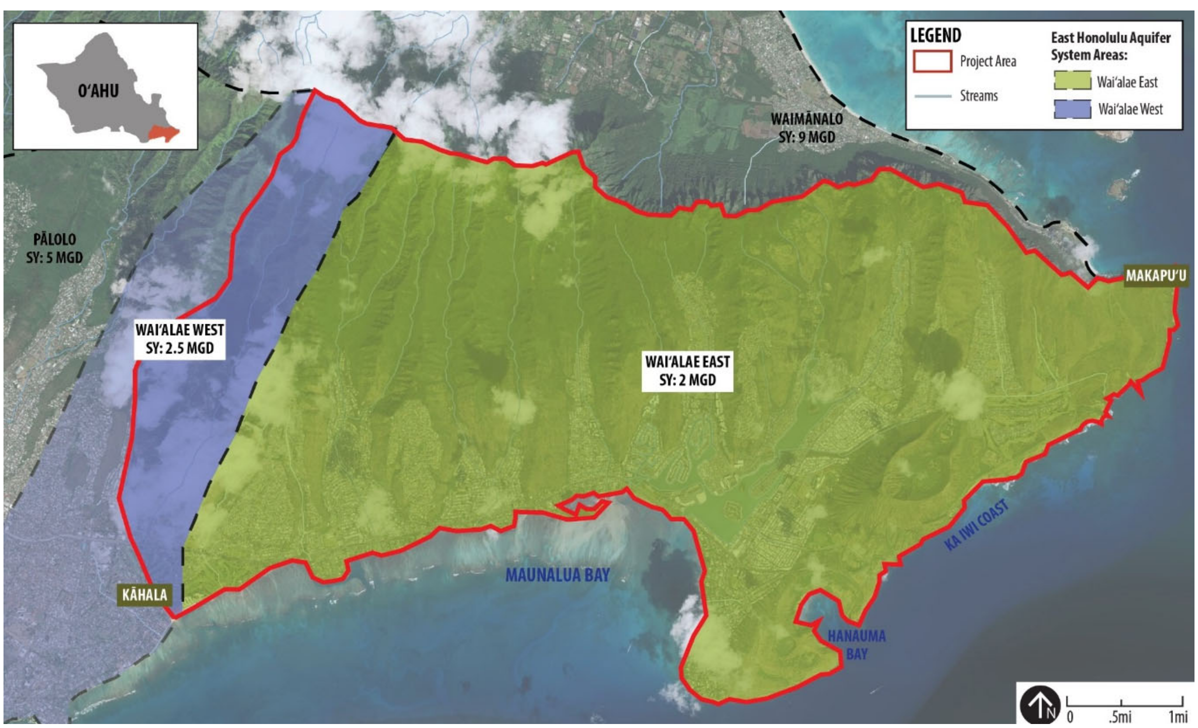


Figure 2-11: East Honolulu Ground Water Aquifer System Areas and Sentainable Yields



2.3.2 Ground Water Quality

Ground water quality in Hawaiʻi is generally very good. However, certain human activities and land uses, particularly industrial uses, can contaminate underlying aquifers as pollutants leach into the ground. Land uses can also contaminate adjacent water bodies as water flows down gradient through gravity flow. Pesticides, herbicides, and other chemicals associated with agriculture and residential termite-treatment are common ground water pollutants. Another indicator of poor aquifer health is increased levels of chlorides, an indication of salt water intrusion into the fresh water aquifer due to a thinning of the fresh water lens. Some man-made chemicals, such as pesticides and industrial chemicals, have been detected in ground water throughout the State. However, generally speaking this contamination has been limited to localized areas along the direction of ground water flow. For example, dieldrin and chlordane have been found in urban areas of Honolulu.[18]

Ground water quality in Hawaiʻi is monitored and enforced by three separate branches of the State of Hawaiʻi Department of Health (DOH) including the Safe Drinking Water, Wastewater, and Hazardous Waste Branches. The primary function of the Safe Drinking Water Branch is to ensure public water systems meet State and Federal health-related standards for drinking water. The Safe Water Drinking Branch also:

- Regulates the 130+ public water systems in the State;
- Operates the Underground Injection Control (UIC) Program;
- Conducts the Source Water Assessment and Protection (SWAP) Program;
- Updates the Ground Water Contamination Viewer; and
- Provides guidance for rainwater catchment systems.

The DOH Safe Drinking Water Branch ensures the State's public water systems meet State and Federal health-related standards. These standards include ten treatment technique requirements, three Maximum Residual Disinfectant Level requirements, and 75 Maximum Contaminant Level (MCL) standards that water must fall below to considered safe drinking water. In the calendar year 2013, 96.2% of Hawaiʻi's residents and visitors were served water that fell below all of the MCLs on a monthly basis.[19] This indicates the majority of Hawaiʻi residents are served safe drinking water that is in compliance with MCL standards.

The State's DOH Water Quality Plan (2019) outlines a strategy to ensure the protection of human health and sensitive ecological systems by outlining a path forward to protect, restore, and enhance

[17] Commission on Water Resources Management. (2019). *Water Resource Protection Plan Update*.
[18] DOH. (2014). Water Quality Plan (Draft). Available from: http://health.hawaii.gov/water/files/2014/09/2014-DOH-DRAFT-Water-Quality-Plan.pdf.
[19] DOH. (2014). Water Quality Plan (Draft). Available from: http://health.hawaii.gov/water/files/2014/09/2014-DOH-DRAFT-Water-Quality-Plan.pdf.

the quality of waters in Hawaiʻi. The Water Quality Plan lists specific program goals for the Safe Drinking Water Branch efforts described above.

<u>Underground Injection Control Program</u>

Underground injection wells are wells used for injecting water or other fluids into a ground water aquifer. The majority of injection wells in Hawaiʻi fall under one of three types: drainage, domestic wastewater, or industrial injection wells. When wastewater is injected into the ground it becomes part of the ground water system and eventually discharges into the ocean. When a well's effluent migrate far from its sites without a sufficient amount of dilution, potable water and coastal waters can become contaminated. Consequently, injection sites can pose threats to ground water quality.

DOH's Underground Injection Control (UIC) program serves to protect the quality of Hawaiʻi's underground sources of drinking water from chemical, physical, radioactive, and biological contamination that could originate from injection well activity. DOH Administrative Rules, Title 11, Chapter 23 provides conditions governing the location, construction, and operation of injection wells so that injected fluids do not migrate and pollute underground sources of drinking water.

The UIC Program regularly monitors and controls UIC sites and issues UIC permits. The boundary between exempted aquifers and underground sources of drinking water is generally referred to as the "UIC Line". Restrictions on injection wells differ depending on whether the area is *mauka* or *makai* of the UIC line. Generally speaking, in East Honolulu, the UIC line runs along Kalanianaʻole Highway from Kāhala to Hawaiʻi Kai, and along Hawaiʻi Kai Drive from the Hawaiʻi Kai Marina to Makapuʻu (see *Figure 2-12*).[20] Makai of the UIC line, the underlying aquifer is not considered a drinking water source and a wider variety of injection wells are allowed. Mauka of the UIC line, the underlying aquifer is considered a drinking water source and limited types of injection wells are allowed. In both cases, UIC permits or permit exemptions are required and permit limitations are imposed, while they are more stringent mauka of the UIC line.

In 2014, there were 927 UIC permitted facilities with 6,106 injection wells across Hawaiʻi.[21] The location of injection wells is not publicly available. The overall percentage of UIC well facilities in compliance with State and Federal regulations (i.e., those with a permit) for the State fiscal year 2013 has increased slightly, to 58% up from 57% in 2012.[22] Most of the non-compliant injection well

[20] The UIC boundary description is based on UIC maps available online (http://health.hawaii.gov/sdwb/underground-injection-control-program/). DOH holds the official UIC maps, which contain detailed information about the UIC line.

[21] DOH. (2014). Water Quality Plan (Draft). Available from: http://health.hawaii.gov/water/files/2014/09/2014-DOH-DRAFT-Water-Quality-Plan.pdf.

[22] DOH. (2014).

facilities use drainage injection wells for rainfall runoff disposal; domestic-related and industrial-related wastewater disposal injection wells had a higher compliance percentage at 72%.

Source Water Assessment and Protection Program

The 1996 reauthorization of the Safe Drinking Water Act required each state in the U.S. to address the protection of public drinking water sources, including the development and implementation of a source water assessment program. The State was required to submit the Source Water and Protection Plan in 1999. Upon EPA approval of this Plan, the State was required to conduct source water assessments of all of its drinking water, which includes delineating source water assessment areas, inventorying potential contaminant sources within this area, and determining the water system's susceptibility to contamination.

As of 2014, assessments have been conducted on over 500 existing drinking water sources throughout the State. In 2006, DOH completed the Hawaiʻi Source Water Assessment Program Report, Volume I, Approach Used for the Hawaiʻi Source Assessments. Likewise, ground water in 2009 was assessed by a group of UH researchers and published in the article "Ground Water Source Assessment Program for the State of Hawaiʻi: Methodology and Example Application." The study mapped capture zone delineations (CZDs) for Oʻahu's ground water sources and potential contaminating scores. A capture zone is the area that surrounds a drinking water supply well that contributes water to the well. In short, CZDs are areas that store, transmit, use, or produce contaminants, and have the potential of releasing these contaminants within capture zones. This study found the areas with the highest susceptibility to contaminants are areas with high density populations, and areas with high levels of agricultural and industrial uses.[23] Within the East Honolulu district, there were two CZDs identified, with two corresponding potential contaminating activities with scores less than 100 (scores range from 0 to 2200).[24]

Ground Water Contamination Viewer

Since 1989, the DOH Ground Water Protection Program has issued Ground Water Contamination Maps for the State of Hawaiʻi. These maps identify locations where ground water contaminants have been detected and confirmed. The detected levels reported in the maps are below Federal and State drinking water standards. Data from some contaminated wells may not be reported because of lack of confirmed data or because the well has not been tested.

[23] Whittier et al. (2008). *Ground water Source Assessment Program for the State of Hawaiʻi, USA: Methodology and Example Application*.

[24] Ibid.

The DOH Safe Drinking Water Branch now publishes its Ground Water Contamination Maps online via the Ground Water Contamination Viewer. Currently, this Viewer provides information on contamination samples collected from 1981 to 2018 throughout the Hawaiian Islands. At the time of EHWMP preparation, there was only one contamination sample from 2014 in the East Honolulu district identified on the Ground Water Contamination Viewer. The sample was located in the Waiʻalae Nui watershed, mauka of Kalanianaʻole Highway. The potential source was identified as herbicide runoff.

Comprehensive State Ground Water Protection Program Strategy/Plan

The Comprehensive State Ground Water Protection Program Strategy/Plan for Hawaiʻi was last updated in 2017. Its mission is to protect human health and sensitive ecosystems through the protection and enhancement of ground water quality throughout the State. Its goals are to monitor and assess ground water quality and mitigate and prioritize contamination threats. The Plan identified the following priority threats to ground water quality: onsite sewage disposal systems / cesspools / injection wells; large scale use of recycled water; large fuel storage facilities; increasing nitrate concentrations; and agricultural chemicals.

As part of the Comprehensive State Ground Water Protection Program Strategy/Plan, a leaching risk assessment was conducted. This assessment evaluated the potential for various contaminants to leach to ground water. In East Honolulu district, there are areas on the western side of the district that have been identified as "likely" to have the pesticide Carbofuran (an agricultural chemical) leach into ground water. The majority of the district is classified as "unlikely" or "uncertain" in regards to this contaminant leaching into ground water.

2.3.3 Wastewater

The City and County of Honolulu treats about 113 MGD of wastewater.[25] When treated effluent is emitted from a pipe or some other identifiable point of discharge, it is termed a point source. Hawaiʻi has seven major wastewater treatment plants that discharge into coastal waters. In certain cases, wastewater can infiltrate ground water sources and cause public health concerns. Combined primary and secondary treatment of wastewater removes 97% of suspended solids, 95-97% of oxygen-using organic waste, 70% of most toxic metal compounds and non-persistent organic chemicals, 70% of phosphorous, 50% of nitrogen, and 5% of dissolved salts. However, only a small percentage of persistent chemical compounds such as pesticides are removed.[26]

[25] Water Resources Research Center, University of Hawaiʻi at Mānoa.

[26] Fletcher, Chip. (2010). *Sewage Treatment and Polluted Runoff.* Chapter 7 of "Living on the Shores Of Hawaiʻi: Natural Hazards, The Environment, And Our Communities".

The Federal government plays a significant role in regulating the discharge of point source pollution through the Clean Water Act (CWA) of 1972. According to a recent study to reduce the environmental and public health risks associated with primary wastewater effluent, managers have three basic options at their disposal: improve the treatment level, change the discharge location, and upgrade the facilities operation to minimize leakage and emergency bypassing of untreated water due to flooding during rainstorms. For example, extensions of sewage outfalls at Sand Island and Kāneʻohe Bay from shallow water to deeper water in the 1970's and 1980's have resulted in significant improvements with regard to both seafloor ecology and human health concerns.[27]

Point source pollution is of particular concern for the areas surrounding the East Honolulu Wastewater Treatment plant (WWTP), which has an outfall near Sandy Beach along the Ka Iwi Coast. The outfall for the WWTP is located in waters that are shallower than 130 ft. In 2002, a study of the East Honolulu sewage outfalls by UH researchers found that discharge from East Honolulu WWTP at Sandy Beach has a negligible effect on reef communities, but the communities are continually oscillating in coral abundance as a result of periodic large storm surf from the east.[28]

Since that study, there have been periodic incidents of sewage discharge from the East Honolulu WWTP. In August 2015, a million gallons of treated but not yet disinfected sewage was discharged into the ocean near Sandy Beach, thereby closing the beaches from the Halona Blowhole to Erma's Beach until testing deemed bacteria levels were safe. Hawaiʻi American Water, the private company that operates the East Honolulu WWTP, attributed the sewage spill to heavy rains that shorted the electrical cable that feeds the chlorination system. As storms become more frequent and severe due to climate change, wastewater discharge into oceans and potable water sources will be a growing concern.

The salinity or 'saltyness' of the wastewater treated at the East Honolulu WWTP also poses barriers for future grey water reuse. The East Honolulu WWTP currently treats 3.6 MGD of wastewater. On average, this wastewater has 2,000 milligrams/liter of chloride present. Chloride levels differ depending on tide, with higher chloride levels experienced during high tide, and lower chloride levels experienced during low tide. When chloride-levels are 1,000 milligrams/liter or above, desalination is required to recycle water for irrigation purposes (R-1). While this technically feasible, desalination presents economic constraints, as it is a costly and time-intensive process.

<u>No Pass Areas</u>

The City and State both protect ground water quality by identifying areas that require special protection. In accordance with §3-301 of the BWS Rules and Regulations, BWS has delineated a

[27] Ibid.
[28] Fletcher. (2010).

"Pass/No Pass" line, which identifies where wastewater disposal sites are restricted or prohibited, and in which no cesspools or septic tanks are allowed. The Pass/No-Pass zone delineation is based upon hydrogeologic literature research and data analysis by the BWS Hydrology-Geology Branch. These restricted "No Pass" areas include portions of the East Honolulu District that are mauka of Kalanianaʻole Highway from Kāhala to Hawaiʻi Kai, and mauka of Lunalilo Home Road/Hawaiʻi Kai Drive in Hawaiʻi Kai. The Pass/No Pass line in the East Honolulu district is shown in *Figure 2-12*.

The Pass/No-Pass Zone delineation maps are used as guidelines for ground water protection in implementing Section 3-301 of the BWS Rules and Regulations regarding Waste Disposal Facilities. The Pass Zone represents areas overlain by thick "caprock" (including unconsolidated and consolidated sediments, corals, and weathered volcanic rock) above the permeable volcanic rock aquifers. The No Pass Zone represents areas of the fresh water aquifer with a smaller or nonexistent area of caprock.

Cesspools

According to DOH, Hawaiʻi has nearly 90,000 cesspools (i.e., on-site underground sewage disposal systems), more than any other state in the U.S. Act 125 (SLH 2017) requires all cesspools in Hawaiʻi to be upgraded or converted, or the property must connect to a sewer system before January 1, 2050. Act 125 identifies priority areas for cesspool upgrades.

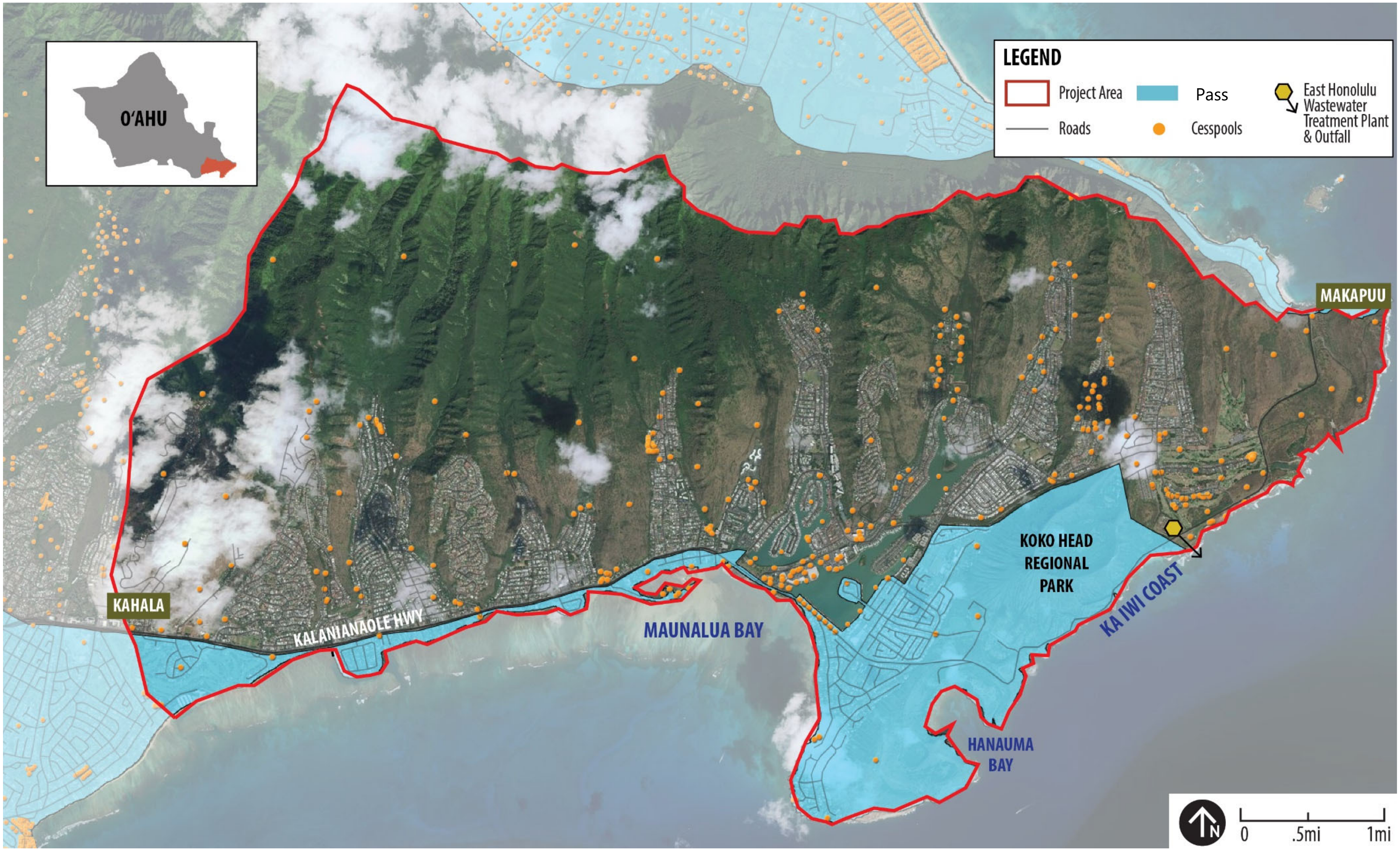
Spatial cesspool data for Hawaiʻi was originally published in 2008. The 2021 *Hawaiʻi Cesspool Hazard Assessment and Prioritization Tool* detailed a methodology on how to better assess cesspool data and refine the priority areas for cesspool conversion originally identified in 2017.[29] This tool integrates multiple types of risk factors to visualize, assign, and rank cesspools by 15 different risk factors, such as distance to drinking wells, depth to groundwater, sea level rise zones, and others. No areas in the East Honolulu district are currently considered as priority areas for cesspool upgrades.

Based on the Hawaiʻi Cesspool Prioritization Tool, there are 300 active cesspools in the East Honolulu district (shown in *Figure 2-12*). A 2016 GIS layer published by DOH Safe Drinking Water Branch also shows that there are 346 cesspools within 200 ft of Maunalua Bay or bodies of water that connect to Maunalua Bay. Moreover, many cesspools on or near the coast are expected to become inundated as sea level rises. A 2017 study conducted by UH scientists found that of the 259 active cesspools in urban Honolulu, 86% of them are already partially inundated with ground water.[30]

[29] DOH Wastewater Branch. (2021). *Hawaiʻi Cesspool Hazard Assessment and Prioritization Tool*. Available at https://health.hawaii.gov/wastewater/files/2022/01/priortizationtoolreport.pdf.

[30] Habel et al. (2017). *Development of a model to simulate ground water inundation induced by sea-level rise and high tides in Honolulu, Hawaiʻi*. Water Research, Volume 114.

Figure 2-12: East Honolulu Ground Water Quality



2.4 SURFACE WATER

Surface water within the East Honolulu District exists in streams, wetlands, human made ponds, and nearshore and offshore bodies of water. Named surface waters in the East Honolulu district are listed in *Table 2-6* below.

Table 2-6: East Honolulu Named Surface Waters[31]

<table>
<tr><th>Shoreline/ Bay</th><th>Watershed</th><th>Spring or Pond</th><th>Intermittent Streams</th><th>Ephemeral Streams</th></tr>
<tr><td rowspan="8">Maunalua Bay</td><td>Waiʻalae Nui</td><td rowspan="3">None</td><td>Waiʻalae Nui</td><td>None</td></tr>
<tr><td>Wailupe</td><td>Wailupe
Kului Gulch</td><td>Waiʻalae Iki</td></tr>
<tr><td>Niu</td><td>Pia</td><td rowspan="2">None</td></tr>
<tr><td>Kuli iʻouʻou</td><td>Kalauhaʻihaʻi Fishpond</td><td>Kuliʻouʻou</td></tr>
<tr><td>Portlock</td><td>None</td><td>None</td><td>Kohelepelepe</td></tr>
<tr><td>Hahaʻione</td><td>Kuapā Pond</td><td>Kamilo Nui</td><td rowspan="3">None</td></tr>
<tr><td>Kamilo Nui</td><td>Kuapā Pond</td><td>Kamilo Iki</td></tr>
<tr><td>Kamilo Iki</td><td>Kuapā Pond</td><td>Kamilo Iki</td></tr>
<tr><td>Hanauma Bay</td><td>Hanauma Bay</td><td>None</td><td>None</td><td>None</td></tr>
<tr><td>Ka Iwi</td><td>Koko Crater</td><td>None</td><td>None</td><td>Napaia</td></tr>
</table>

2.4.1 Streams

Intermittent streams only have flowing water during certain times of the year. Most of East Honolulu's intermittent streams flow year-round in their *mauka* reaches, but will only flow in the lower reaches during the wet season. Intermittent streams in the East Honolulu district include the Waiʻalae Nui Stream, Wailupe Stream, Pia Stream, Kuliʻouʻou Stream, Kamilo Nui Stream, and Kamilo Iki Stream. When flowing along the entirety of their reach, the district's streams begin in the Koʻolau range and discharge into Maunalua Bay. The drainage basins are long and narrow and range from 0.3 to 3.2 square miles in area. The upper reaches of the basins are very steep, while the lower reaches are almost flat.

[31] Hawaiʻi Statewide GIS Program. (2018). "Streams" (GIS Layer). Extracted from DLNR DAR data.

The district's ephemeral streams (meaning they typically only flow during or shortly after periods of rainfall) include the Waiʻalae Iki stream, Kohelepelepe, and Napaia. When flowing, the Waiʻalae Iki and Kohelepelepe Streams discharge into Maunalua Bay, and the Napaia Stream discharges into the Ka Iwi Coast. In the area between Kamehame Ridge and the Hawaiʻi Kai Golf Course, a 40-foot wide concrete channel alters the natural drainage pattern.[32] Water collected from this area is carried along the drainageway which passes under Kalanianaʻole Highway and into Kailiili Inlet. No streams in the East Honolulu district are diverted for potable or non-potable purposes.

DOH is obligated by the Clean Water Act Sections (§) 303(d) and §305(b) to report on the State's water quality on a two-year cycle. The 2022 State of Hawaiʻi Water Quality Monitoring and Assessment Report, known as the Integrated Report (IR), is the latest IR to inform the public on the status of marine and inland water bodies. The 2022 IR assessed the quality of 151 marine and 12 inland waters across the state and identified if these listings met applicable water quality standards. The Kuliʻouʻou Stream was the only inland water located in East Honolulu included in the 2022 IR. According to the DOH's 2022 IR, the Kuliʻouʻou Stream is now considered an impaired inland water body, due to the high level of enterococci (indicating potential contamination by fecal waste).

The USGS monitors stream flows and publishes the updated and historical flow data annually and as a database on the internet. There are 43 stream gages on the Island of Oʻahu, and one within the East Honolulu district, which monitors Kuliʻouʻou Valley. The recorded peak stream flows for water years 2013 to 2017 for Kuliʻouʻou Valley are provided in *Table 2-7*.

Table 2-7: East Honolulu Stream Flow[33]

Name / USGS Gauge Number	Drainage Area	Water Year	Monitor Elevation (Ft)	Peak Stream Flow (CFS)
Kuliʻouʻou Valley/ 16247900	1.27 sq miles	2013	26.22	83
		2014	27.62	624 (estimate)
		2015	27.07	381
		2016	24.46	155
		2017	27.04	368

[32] DPP. (2022). *East Honolulu Sustainable Communities Plan.*

[33] USGS. (2019). *Peak Streamflow for the Nation: USGS 16247900 Kuliʻouʻou Valley at Kuliʻouʻou Oʻahu, HI.* URL: https://nwis.waterdata.usgs.gov/nwis/peak?site_no=16247900&agency_cd=USGS&format=html.

Wetlands

In Hawaiʻi, wetlands help support human water demands for agriculture, a rapidly expanding urban population, and 222 federally listed threatened or endangered plants and animals. Despite the importance of wetlands, it is estimated that that during the 20th century, more than 50 % of wetlands in parts of North America, Europe, and Australia were lost due to environmental impacts and changes in land use.[34] A 2013 study published by the Society of Wetland Scientists estimated that the State of Hawaiʻi has lost 192 sq km, or 15% of its total pre-Western settlement area of wetlands. Oʻahu had the highest gross wetland loss, about 106 sq km, or 65% of the island's estimated pre-settlement wetlands.[35] Wetlands in lower elevations account for 88% of wetlands across the State. Pre-Western settlement, there were large areas of coastal wetlands surrounding Maunalua Bay and Kuapā Pond. Nearly all have been lost as the areas developed in the late 20th century.

Today, according to National Wetlands Inventory Maps, there are several small wetlands in the East Honolulu district (excluding deep water habitats). These wetlands are primarily located along the district's coastal plains and are classified as estuarine and marine wetlands. The National Wetlands Inventory defines estuaries as areas with deep water tidal habitats and adjacent tidal wetlands that are usually semi-enclosed by land but have open, partly obstructed, or sporadic access to the open ocean, and in which ocean water is at least occasionally diluted by fresh water runoff from the land. Areas of estuarine and marine wetlands in the East Honolulu district are densest at Paikō Lagoon and along the Ka Iwi Coast, makai of the highway.

There are also several small fresh water ponds and fresh water forested/shrub wetland areas located in the district. The fresh water ponds are primarily located along the Ka Iwi Coast, *mauka* of the highway. The largest of the fresh water forested/shrub wetlands (2.08 acres) is located within Hanauma Bay State Park. The Keawāwa Wetland is notable it lies adjacent to the Hāwea heiau complex and once was used for fishing and farming purposes. Today, it provides a home for native wildlife such as the endangered ʻalae ʻula (Hawaiian moorhen) and other bird and insect species. Following a proposal to build condominiums on the Keawāwa Wetland, the Trust for Public Land purchased the property and transferred rights to local community non-profit Livable Hawaiʻi Kai Hui.

[34] Millennium Ecosystem Assessment. (2005). *Ecosystems and human wellbeing: wetlands and water, synthesis*. World Resources Institute, Washington, D.C.

[35] C. Van Rees & J. Michael Reed. (2013). *Wetland Loss in Hawaiʻi Since Human Settlement*. DOI 10.1007/s13157-013-0501-2.

2.4.2 Nearshore Areas

Shoreline and Marine Ecosystem Characteristics

East Honolulu's shoreline extends for approximately 13 miles between Waiʻalae and Makapuʻu.[36] Nearshore waters are defined by the EPA as an indefinite zone extending seaward of the shoreline well beyond the breaker zone. Nearshore waters in the East Honolulu district are divided into three segments, into which the district's watersheds drain: 1) Maunalua Bay, extending from Waiʻalae to Kawaihoa (tip of Portlock); 2) Hanauma Bay; and 3) Ka Iwi Coast, extending from Kawaihoa to Makapuʻu. The shorelines associated with these three distinct nearshore areas are discussed further below:

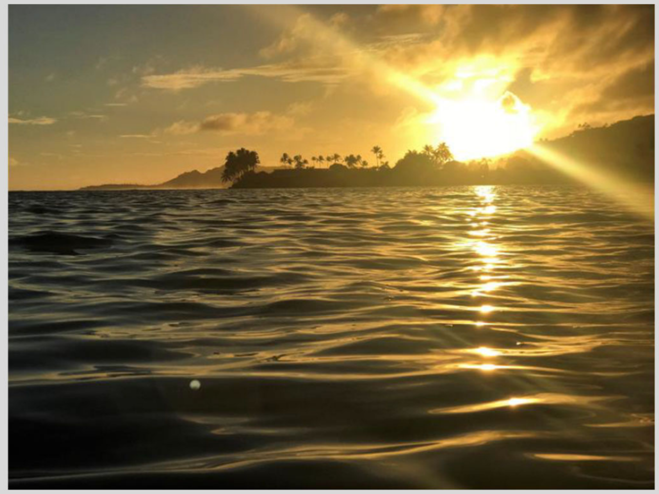


Image: Maunalua Bay

- **Maunalua Bay (Waiʻalae to Kawaihoa)** is a traditionally and culturally important area, but today its accessibility to the public is limited due to residential development along Kalanianaʻole Highway and the proliferation of seawalls. Access points to the shoreline along this stretch include the Wailupe, Kawaikui, Kuliʻouʻou, and Maunalua Bay Beach Parks and a few mauka-makai pedestrian easements. Most of the shoreline in this section is stable. Many of the properties have seawalls and other shoreline armoring. Chronic erosion or accretion appears to be occurring only in two locations, at Paikō Peninsula and in the Portlock area between the Hawaiʻi Kai Marina entrance channel and the former Henry Kaiser Estate.[37] Hard armoring in this area is believed to have contributed to accelerated shoreline erosion and beach loss in these identified areas. When wave action comes into contact with seawalls, beach sand is eroded due to the dynamic forces of waves and currents.
  - Maunalua Bay is known for its calm, shallow waters and abundance of coral reefs. Traditionally, Maunalua Bay was an area that was abundant in fishing resources, which sustained settlements surrounding the bay. Today, Maunalua Bay is considered an impaired water body (see following section on Nearshore Water Quality). According to NOAA Nautical Charts, coral reefs extend 0.25 to 0.5 miles from the shoreline in most of Maunalua Bay. Maunalua Bay lies within certain Marine Managed

[36] DPP (2022)

[37] UH Manoa, SOEST. *Oʻahu Shoreline Study Erosion Maps*. Available from: http://www.soest.hawaii.edu/coasts/erosion/oahu.

Areas (MMA), which are geographic areas designated by statute or administrative rule for the purpose of managing a variety of marine, estuarine, or anchialine resources and their use. Under MMA regulations, the use of lay net fishing is prohibited in Maunalua Bay, as well as Kuapā Pond. Moreover, in the Paikō Lagoon Wildlife Sanctuary (located within Maunalua Bay), it is prohibited to remove, disturb, injure, kill, possess, or introduce any form of plant or wildlife.

- **Hanauma Bay** is abundant in coral and fish resources and is world-renowned for its snorkeling. Hanauma Bay was an area once frequented by Hawaiian aliʻi (see *Section 2.9.3* Cultural Resources and Wahi Pana for further discussion on the historic and cultural importance of Hanauma Bay). Due to its marine resources, it is one of the top visitor attractions in Hawaiʻi, seeing an average of 3,000 visitors a day, approximately 1 million per year.[38] High visitor volumes have caused negative environmental impacts since the mid-20th century. In response to this, Hanauma Bay was declared a protected marine sanctuary in 1967. Hanauma Bay is one of three Marine Life Conservation Districts (MLCD) on Oʻahu. The MLCD extends from the highwater mark seaward to a line across the bay's mouth from Palea Point on the left to Paiʻoluʻolu Point on the right. A channel near the bay's center, dredged for telephone cables, provides access to the outer reef flat. Coral beds are found just outside the fringing reef, especially on the right side. Numerous fishes, particularly schooling species, are found here. Turtles are also fairly common. Water depths range to about 30 ft, and visibility is generally good. Fishing in the Hanauma Bay MLCD is prohibited.

Image: Hanauma Bay

  In 1990 measures were taken to preserve the area and reduce the impacts of tourists. For example, before visitors can enter Hanauma bay, they must visit the education center to learn about Hanauma Bay and what activities are prohibited. This approach could be applied at

[38] Hanuama Bay State Park Website. (2019). *Hanuma Bay History.* Available from: https://hanaumabaystatepark.com/hanauma-bay-history/.

other environmentally and culturally sensitive areas in the East Honolulu district to teach residents and tourists about the appropriate way to enjoy these special places.

- **Ka Iwi Coast (Kawaihoa to Makapuʻu)** is a unique stretch of shoreline which remains undeveloped due to community-led preservation efforts. Ka Iwi is frequented by residents and visitors for its access to recreational activities and stunning views. Compared to the shoreline along Maunalua Bay, mauka-makai and lateral shoreline accessways are more prevalent along the Ka Iwi Coast. The rocky shoreline east of Sandy Beach to the base of Makapuʻu is stark and only accessible by footpaths. A prominent feature of this stretch is the Ka Iwi State Scenic Shoreline. The Ka Iwi Coast is also known for its heavy shore breaks and its deep, rough waters that extend into the Ka Iwi Channel (also known as the Molokaʻi Channel).

The nearshore waters that border the East Honolulu district are also frequented by seasonal marine life, most notably humpback whales. The Humpback Whale Sanctuary was created by Congress in 1992 to protect humpback whales and their habitat in Hawaiʻi. It is administered by NOAA and the Office of National Marine Sanctuaries (ONMS). The boundary of the sanctuary encompasses approximately 1,218 square nautical miles of coastal and ocean waters around the main Hawaiian Islands. On Oʻahu, the Sanctuary is comprised of the nearshore waters that border area from Diamond Head to Makapuʻu. ONMS regulations prohibit specific kinds of activities that impact humpback whales.

Nearshore Water Quality

The topography of watersheds in Hawaiʻi is such that rainfall and surface runoff flows from mauka mountainous terrain down through developed makai areas before reaching nearshore waters. This interrelationship between mauka and makai resources and ecosystems forms the basis of the ahupuaʻa system of land division and management that was used by native Hawaiians prior to western contact and remains relevant today.

Pollutants that enter nearshore waters can threaten human health and cause damage to fragile marine ecosystems. Nearshore waters throughout the East Honolulu district including Maunalua Bay, Hanauma Bay, and the Ka Iwi Coast have been subject to periodic water quality advisories and beach closures by the State Department of Health due to elevated levels of bacteria, sediments, and other pollutants generated through point and nonpoint sources.[39]

The water quality and ecosystem health of Maunalua Bay is of particular concern to East Honolulu stakeholders. Traditionally an area used for fishing and other subsistence activities, today there has been an alarming decline of the water quality of Maunalua Bay. It is an "impaired open coastal

[39] Department of Health, Clean Water Branch: https://eha-cloud.doh.hawaii.gov/cwb/#!/landing

waterbody" on the CWA Section 303(d) list of impaired waterbodies. Terrigenous sediments (originating from erosion of rocks on land) have been identified as one of the primary sources of pollution in the bay. Nutrients transported through polluted runoff and sediment have allowed invasive alien algae to thrive in Maunalua Bay. As invasive algae spreads, it covers coral reefs and native algal communities, killing native marine habitat. The three species of invasive algae that are considered most damaging are Gorilla Ogo (*Gracilaria salicornia*), Leather Mudweed (*Avrainvillea amadelpha*), and Prickly Seaweed (*Acanthophora spicifera*). Local non-profit Mālama Maunalua has engaged the community in efforts to remove invasive algae; to date, nearly 3,000 volunteers have removed 3.5 million pounds of invasive algae from the bay and recycled it to be used as soil amendment at local farms.[40]

Erosion from natural and agricultural areas also brings sediment and pollutants into nearshore waters. Hoofed animals in particular have an adverse impact on ground cover and soil conditions in upland areas. Ground disturbance from feral pigs in Oʻahu's upper watersheds is considered to be a major detriment to water quality in streams and other water bodies. The Koʻolau Mountain Watershed Partnership (KMWP) leads initiatives to control ungulate populations and install fencing to keep them out of sensitive areas. These efforts may prove to have significant downstream benefits on water quality. Contamination from sewage spills and cesspools can also result in elevated levels of bacteria and contaminants in nearshore waters. Sewage in the East Honolulu district is handled through a mix of public and private systems, as discussed elsewhere in Chapter 2.

Nearshore water quality is also heavily impacted by runoff, which is described in the following section.

2.4.3. Drainage and Runoff

In East Honolulu, several streams transport water from the Koʻolau Mountains to Maunalua Bay. Manmade drainage systems collect runoff from developed areas. Runoff transported via natural and manmade drainageways as well as flowing over land transfers pollutants and sediments generated from upland eroded areas, impervious surfaces, and human activities to nearshore waters. Runoff generated from impervious surfaces in urban and residential areas impacts the health of the watershed, as it transports a wide range of contaminants into the ocean. Stormwater pollutants include nutrients, solids, pathogens, metals, and hydrocarbons, among others.[41] Common activities that add pollutants to runoff include driving, maintenance to automobiles, gardening and lawn maintenance, construction and landscaping, use of metal roofs and gutters, and discharge of chlorinated water from pools and fountains. These activities are largely associated with single-family

[40] Mālama Maunalua Website. (2016). *Habitat Restoration Program*. Available from: http://www.malamamaunalua.org/habitat-restoration/.
[41] Field et al. (2004).

home residential development. The residential development present in the valleys and ridges of East Honolulu, and the high amount of impervious surfaces makes Maunalua Bay, Hanauma Bay, and the Ka Iwi Coast highly susceptible to runoff pollutants.

Urban areas have large expanses of impervious surfaces including roads, buildings, and pavement, increasing the amount of runoff that flows over land. Approximately 40% of the East Honolulu district is designated by the State as Urban land, with 60% of the district being Conservation land. Urban development exists in all of the district's watersheds except the Hanauma watershed. Generally, urban development spans from the watershed's coastal plains into its gulches. The majority of urban development in the district is zoned as residential and is already fully built out. The Portlock, Hanauma, and Koko Crater watersheds are unique as they have some undeveloped coastal land.

Nearshore water quality impacts from runoff can be addressed through improvements that retain stormwater on land or filter out pollutants before stormwater enters coastal waters. This includes improvements to municipal storm drain systems as well as to privately owned properties. Both land use policy changes and education are needed to reduce runoff. However, since East Honolulu is largely already developed, educating and incentivizing existing residents and property owners to take measures to reduce pollutants and debris on their properties and collect more water on site is critically important.

The EHSCP provides policies to mitigate urban runoff by requiring the use of low impact development (LID) practices for any significant new construction or redevelopment, and by providing incentives to existing homeowners to install rain gardens, permeable driveways, and other technologies to retain stormwater on site instead of discharging it into storm drains or stream channels. The EHSCP also includes policies that promote LID and other green infrastructure along natural gulches and drainage ways to restore ecological function to these areas, with a particular focus along stream channels.

The City and County of Honolulu Department of Facilities Maintenance (DFM) is piloting several technologies in East Honolulu to filter debris and pollutants from stormwater before it enters the City's drainage system, including retrofitting storm drains with retractable screens and catch basins. DFM is also developing design standards for rain gardens and other features that can be incorporated into public rights of way to mitigate water quality impacts from stormwater runoff. Finally, a Stormwater Utility and Enterprise Fund is being considered that would be funded in part through fees to landowners based on impervious surfaces and other sources of runoff.

Because of its shallow water and fragile reef system, stormwater runoff has been particularly damaging to Maunalua Bay. Results from the Watershed Based Plan for Reduction of Nonpoint Source Pollution in the Wailupe Stream Watershed, prepared for Mālama Maunalua, indicate that much of the fine sediment from the Wailupe watershed is discharged into the Maunalua Bay during the ‘first flush’ stage of floods. Potential surface water contaminants due to runoff and other activities are made publicly available on the DOH Water Pollution Control Viewer.[42] This viewer demonstrates where potential contamination activities are occurring.

Polluted Runoff Control Program and Coastal Nonpoint Pollution Control Program

Hawaiʻi's Polluted Runoff Control Program and the Hawaii's Coastal Nonpoint Pollution Control Program (CNPCP) are the two primary State government programs responsible for addressing nonpoint source pollution. These programs, established through 1987 Water Quality Act amendments to the CWA and Coastal Zone Act Reauthorization Amendments (CZARA) of 1990, are designed to provide technical guidance and financial support to reduce nonpoint source pollution that results in impaired water quality in Hawaiʻi's streams and coastal waters.

The CNPCP was established by Congress in 1990 under Section 6217 of the CZARA and is jointly administered by the National Oceanic and Atmospheric Administration (NOAA) and EPA. Hawaiʻi's CNPCP, developed jointly by the Hawaiʻi CZM Program and DOH, is responsible for ensuring that the management measures are implemented. It is also provides accountability through a variety of tools, including rules, ordinances, voluntary approaches, educational campaigns, and financial incentives, all backed by enforceable policies and mechanisms. These measures are monitored and tracked to assess implementation across the State.

Hawaiʻi's CNPCP builds on existing State coastal zone management and water quality programs. The primary focus is on pollution prevention, minimizing creation of polluted runoff rather than cleaning up already contaminated water— which can be a difficult and expensive process. To this end, the CNPCP establishes management measures to address nonpoint source pollution from a variety of sources. Management measures are the best available, economically achievable practices or combinations of practices that can be used to address nonpoint source pollution.

Hawaiʻi's Polluted Runoff Control (PRC) Program, administered by DOH, receives funding from the EPA through Section 319(h) of the CWA to address nonpoint source pollution. Since 2004, the focus of Hawaiʻi's PRC Program has been on development and implementation of watershed plans to reduce nonpoint source pollution in priority watersheds. The PRC Program provides funding through an annual competitive process to address watershed priorities.

Hawaiʻi's CNPCP Management Measures are designed to control runoff from six main sources:

- Forestry
- Agriculture

[42] DOH Water Pollution Control Viewer. Available from the DOH Website.

- Urban areas
- Marinas and Recreational Boating
- Hydromodification
- Wetlands, Riparian Areas, and Vegetated Treatment Systems

Data is compiled in DOH’s Section 319 Annual Report to EPA to convey monitoring and tracking information where watershed implementation efforts have been initiated. Data includes tracking of management measures implemented and associated pollutant load reductions. Management measures within each of these six categories listed in Hawaiʻi Watershed Guidance (OP, 2010) are provided in a table in *Appendix B.*

2.4.4 Flooding

Urbanization and climate change have contributed to an increase in flooding. This is particularly true in the East Honolulu district where development has occurred in coastal plains susceptible to flooding. Several drainageways in the district have been prone to flooding during more intense rainstorms, including Niu Valley, Kuliʻouʻou Valley, Hahaʻione Valley, and Wailupe Valley. Heavy rainfall at the head of these valleys, combined with falling rocks and debris, can overwhelm the capacities of the stream channels.[43] Along the Niu and Hahaʻione drainageways, debris clogging bridges and culverts contribute significantly to the flooding problems.

The U.S. Army Corps of Engineers (USACE) previously conducted a Flood Feasibility Assessment for Wailupe Stream to determine if there was Federal interest in investing in channel improvements for Wailupe Stream.[44] Improvements would have enhanced conveying water flow from the upper urban district out to the ocean, which often carries sediments, woody debris, and other pollutants to the ocean. The project was terminated in 2015 because the USACE concluded based on its cost-benefit analysis that there was not enough economic benefit to proceed with the project. However, the City and County of Honolulu Department of Design and Construction (DDC) has indicated that they are interested in continuing the feasibility study and would participate in a cost-sharing of the study.

[43] (DPP) (2022)
[44] USACE. (1998). *Final Feasibility Report: Wailupe Stream Flood Control Study, Oʻahu, Hawaiʻi*.

In 2010, Mālama Maunalua published the Draft Watershed Based Plan for Reduction of Nonpoint Source Pollution in Wailupe Stream. The Plan identifies locations within the Wailupe watershed for management practices to reduce flooding and nonpoint source pollution. Many of the practices in the Plan are applicable to other watersheds in East Honolulu as well. Mālama Maunalua is working with the City to further implementation and maintenance of proposed projects, as described further in *Chapter 3*.

Image: April 2018 flooding in ʻĀina Haina (image credit: Honolulu Star Advertiser)

In April 2018, historic rainfall brought flooding in East Honolulu to the public spotlight when the area experienced by some accounts the worst flooding it had seen in 30 years. During the height of the storm, some of the waterways in the district discharged 1 million gallons of water per minute, an equivalent to a 25-50 year storm.[45] Nearly 400 homes were damaged in the storm. The flooding resulted in lawsuits from landowners claiming damages from the City to repair their homes. In 2023, the City agreed to pay more than $2 million to settle the lawsuits.[46]

Natural and channelized stream drainageways in East Honolulu are steep, narrow and prone to clogging with debris. In general, natural drainageways provide better flood protection and ecosystem benefits than channelized drainageways. However, East Honolulu's options for restoring stream channels to their natural state properties are limited by the district's steep topography and the fact that many properties are built too close to the stream channels. Enlarging existing City-owned boulder basins and creating additional boulder basins could help to slow water flows and prevent transport of debris during flooding. There are opportunities for improving existing storm drain infrastructure through repairs or retrofits as well.

45 Drewes, Paul. (April 16, 2018). *Worst flooding for East Oʻahu in 30 years*. KITV4. Available from: https://www.kitv.com/story/37971283/worst-flooding-for-east-oahu-in-30-years.

46 Daysog, Rick. (2023). *City agrees to pay $2M to settle lawsuits over flood damage in East Honolulu*. Hawaiʻl News Now. Available from: https://www.hawaiinewsnow.com/2023/02/14/city-agrees-pay-2m-settle-lawsuits-over-flood-damage-east-oahu/.

National Flood Insurance Program

The Federal Emergency Management Agency (FEMA)'s Flood Insurance Rate Maps (FIRM) provide the basis for defining flood hazard areas and associated insurance risk premiums.[47] East Honolulu's FIRM Flood Hazard Zones are shown in *Figure 2-13*. A limitation of the FIRM maps is that they are based on historical flooding patterns and do not take into account anticipated impacts from climate change and sea level rise. Global warming will increase the intensity of storm and flood events such that the 100-year floods of the future will be significantly higher and more destructive than historical events.

FIRM maps remain important tools for identifying areas that may be subject to repetitive losses from flooding, and can be used in conjunction with the SLR-XA maps in the Hawaiʻi Sea Level Rise Vulnerability Assessment. The State of Hawaiʻi and individual counties are advancing efforts to develop guidance for sea level rise adaptation and post-disaster recovery that may include regulatory changes such as limiting or prohibiting rebuilding, elevating development, or constructing flood wall improvements, within certain flood or disaster-prone areas.

In 2015, Maui became the first County in Hawaiʻi to develop post-disaster rebuilding guidelines and protocols. The guidelines offer clear guidance on a range of topics, such as how reconstruction will be permitted, when adaptation and mitigation will be required, the effect of substantial damage determinations, and how non-conforming structures will be addressed by Maui County.[48] UH Sea Grant is currently building upon these efforts and developing guidelines to support the implementation of resilience focused rebuilding practices, policies, and regulations at the State and County level. Over time, these may lead to regulatory changes that change the existing coastal development patterns in East Honolulu as properties become flooded or inundated by sea level rise.

The use of shoreline setbacks is also a critical tool in regulating coastal development and adapting to flooding and natural hazards. Shoreline setbacks are set by the State and counties and establish the minimum distance that development must be from the shoreline. The State requires that shoreline setbacks must not be "less than twenty feet and not more than forty feet inland from the shoreline".[49] Kauaʻi and Maui Counties, and most recently the City and County of Honolulu, have adopted variable setbacks that are based upon the annual average shoreline erosion rate, times a certain amount of planning years, plus an additional buffer zone. For example, in 2008 Kauaʻi County adopted a 70 year planning period plus 40 ft additional buffer, making it among the most stringent shoreline setbacks in the U.S. The City and County of Honolulu's shoreline setbacks are regulated by ROH Chapter 23, which

[47] FEMA Flood Map Service Center (2017)

[48] County of Maui, Planning Department. (2015). *Post-Disaster Reconstruction Guidelines and Protocols for the Conservation of Coastal Resources and Protection of Coastal Communities, Maui County, Hawaiʻi.*

[49] HRS § 205A-43

was amended through Bill 22 (2022) and now requires a shoreline setback area of 60 feet plus 70 times the annual erosion rate.[50]

Based on the hazard zones identified in the district's FIRM maps, locations that may be prone to flooding in the East Honolulu district include:

- **Coastal areas makai of the highway** within the VE Hazard Zone, which defines high risk areas that have a 1% or greater chance of flooding and additional hazards associated with storm waves. These areas also face increased exposure to sea level rise and coastal hazards.
- **Wailupe Valley, Niu Valley, Kuliʻouʻou Valley, Hahaʻione Valley, and Kamilo Iki** are areas that experienced severe flooding during the New Year's Eve flood of 1987, as well as the flooding in April 2018. These valleys have areas that lie within the Hazard Zone AE, which defines high risk areas at the base flood elevation (i.e., within a 100-year flood plain).
- **Kalanianaʻole Highway** lies partially with Hazard Zone AE in the East Honolulu district.

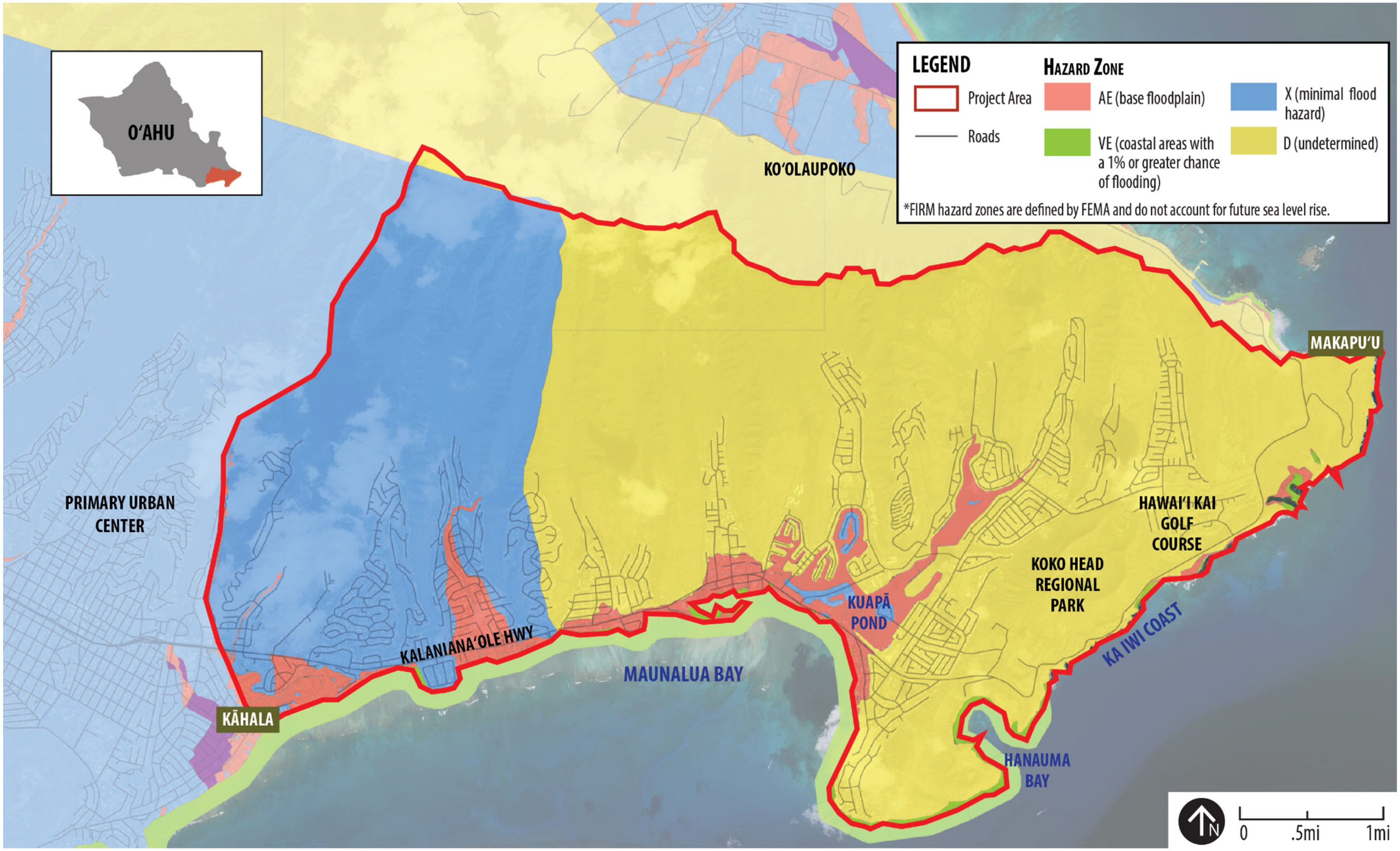
In the East Honolulu district, the majority of the district is classified by the National Flood Insurance Program (NFIP) as "undetermined" flood hazards (See *Figure 2-13*). As demonstrated by the previous description of the 2018 flooding, there are flood prone areas outside of the hazard zones designated on FIRMs. Because of this, it is also important to identify areas that may be subject to increasing flooding and repetitive loss over time, particularly with the advent of climate change. A strategy will be needed to determine what measures are feasible to protect, adapt, or retreat these areas from flood waters over the long term. Understanding the "trigger points" of when measures should be taken to protect, adapt, or retreat development will be influenced by a multitude of economic, social, and environmental factors, such as how will property and landowners be compensated, how repetitive loss events will influence flood insurance rates, how cultural and recreational resources will be impacted, and many others.

Image: Debris from the 2018 flooding event in Kamilo Nui (image credit: Hawaiʻi News Now)

Sea level rise will increase flooding risks in certain areas of East Honolulu. Sea level rise impacts are described in *Section 2.6.3*.

[50] ROH Chapter 26, Ordinance 23-3. (2022). Relating to Shoreline Setbacks.

Figure 2-13: East Honolulu Flood Hazard Zones



2.5 TERRESTRIAL ECOSYSTEMS

2.5.1 Wildlife Preserves

East Honolulu is home to three formal wildlife preserves that are described below:

- **Paikō Lagoon Wildlife Sanctuary,** formerly a coastal fishpond, is fed by a fresh water spring and Kuliʻouʻou Stream and is managed by the State DLNR. The lagoon's water level varies with the tides and occasionally exposes the saline mudflats. This wildlife sanctuary provides habitat to the endangered Hawaiian stilt (aeʻo) as well as other migratory waterbirds. The proximity of residential uses may threaten the sanctuary due to intrusions by humans and domesticated animals.

Image: Paikō Lagoon Wildlife Sanctuary

- **ʻIhiʻihilauakea Preserve** is located on the southern rim of the Hanauma Bay ridgeline on land owned by the City and County of Honolulu, and is managed by the Nature Conservancy of Hawaiʻi (NCH) through a cooperative agreement with the City. This preserve maintains a pool for the endangered ʻIhiʻihi (*Marsilea villosa*), an ephemeral plant appearing only during periods of rainfall.

- **Hanauma Bay Marine Life Conservation District (MLCD)** was established in 1967 by the Department of Land and Natural Resources. The Hanauma Bay MLCD was once a popular site for fishing and throw netting. Wildlife within Hanauma Bay is now protected by State law. The adjoining beach park is part of Koko Head Regional Park, administered by the City. In order to protect the marine resources of this popular visitor destination, the City restricts the daily number of visitors that have access to the bay, and closes the beach on Monday and Tuesday mornings. The City also collects entry and parking fees used to fund maintenance and capital projects at Hanauma Bay.

2.5.2 Wildfire Threats

Image: 2018 Wildfire in Kamilo Nui (Credit: Hawai'i News Now)

According to U.S. Forest Service data, across the U.S. wildfires are burning more than twice the area than they did in 1970.[51] Wildfires occurring during dry conditions represent a significant problem on all the major Hawaiian Islands. From 2006 to 2016, wildfires burned an average of 20,000 acres per year statewide, with some years reaching close to 45,000 acres.[52] More than 99% of known wildfires are attributed to human activities. As drought and temperatures increase, wildfires threaten the urban interface with loss of life and property. Wildfires impact watershed health in numerous ways:[53]

- Wildfires destroy native forests and change soil chemistry, potentially threatening native species and habitats.
- Heavy rains after fires can erode topsoil, leaving some areas denuded and unable to support vegetation.
- Post-fire erosion can transport sediment into streams, ultimately depositing it in the ocean. This sedimentation can smother coral reefs, impacting water quality, fisheries, and long term ecosystem health.
- Burned soil from wildfires decreases ground water recharge, potentially affecting drinking water supplies.

In 2007, the DLNR Division of Forestry and Wildlife's Fire Management Program assigned fire risk ratings for populated areas of the Hawaiian Islands. All Urban designated areas in the East Honolulu district fall within Hazard Zone 3, which represents "medium" fire risk. Generally, there is no score assigned to the district's Conservation land. The district's mixed land cover also impacts its vulnerability to wildfires. The "wildland-urban interface" describes the area between unoccupied wildland and human development. The U.S. Forest Service defines the wildland-urban interface as properties within a half mile of the zone where wildland and human development intersects. Nationwide, between 1990 and 2010, the amount of homes within the wildland-urban interface grew

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[51] Russell, Pam Radtke. (April 10, 2019). *California Towns Rebuild After Wildfires With Resilience in Mind*. ENR California.
[52] Hawaiʻi Wildfire Management Organization. (2016). *Hawaiʻi has a Devastating Wildfire Problem*.
[53] Hawaiʻi Wildfire Management Organization (2016).

by 41%, from 30.8 to 43.4 million homes.[54] About 80% of the land within the East Honolulu district falls within the wildland-urban interface, with the exception of the northwest portion of the district in the upper Koʻolau Mountains (*Figure 2-14*).

Studies have shown that urban development in proximity to forests and natural vegetation poses major problems related to wildfires. First, there is a greater likelihood of wildfires due to human ignitions. Second, when wildfires occur, they become harder to manage and pose greater safety risks. Landowners may play a role in improving the urban-forest interface, including creating managed buffer zones to cut back brush, reducing landscaping in fire prone areas, and installing more fire-resistant building materials. In 2008, the State of California enacted the Wildland-Urban Interface Code, which requires homes in fire hazard areas to be built with interior sprinklers, a fine mesh on attic vents to keep embers out, tempered glass that can withstand temperature changes and is stronger than standard glass, and fire-resistant walls, roofs, and other exterior materials. This code also requires the removal of flammable materials and landscaping near homes and businesses.

A majority of the East Honolulu district's land cover is shrubs and grass (*Figure 2-15*).[55] Studies indicate that when alien plant species invade native shrub species, they can alter the vegetation's fuel properties, and ultimately cause increased wildfire intensity, extent, type, and seasonality of fire.[56]

The Wildfire Management Organization of Hawaiʻi mapped wildfire incidents for the main Hawaiian Islands from 2000 to 2012 (measured per square mile per year). Certain areas of the East Honolulu district had a high density of wildfires:

- **Upland Areas** have a higher density of wildfire incidents compared to shoreline areas. Upland fires are particularly prevalent in the mauka areas near Hawaiʻi Kai and the Ka Iwi Coast.
- **Ka Iwi Coast** also had a higher density of wildfires.
- **Kamilo Nui (Mariner's Ridge)** experienced a large brush fire in August of 2018.

If climate change impacts trend toward magnifying existing conditions, East Honolulu can be expected to become drier and hotter, potentially worsening wildfire risks.

[54] Russell, Pam Radtke (April 10, 2019)
[55] Based on 2012 GIS layer "Tree Canopy – Land Cover" created for southern Oʻahu. Primary sources include 2009 LiDAR and 2010 WorldView2 satellite imagery.
[56] Brooks et al. (2004). *Effects of Invasive Alien Plants on Fire Regimes*.

Figure 2-14: East Honolulu Wildland-Urban Interface

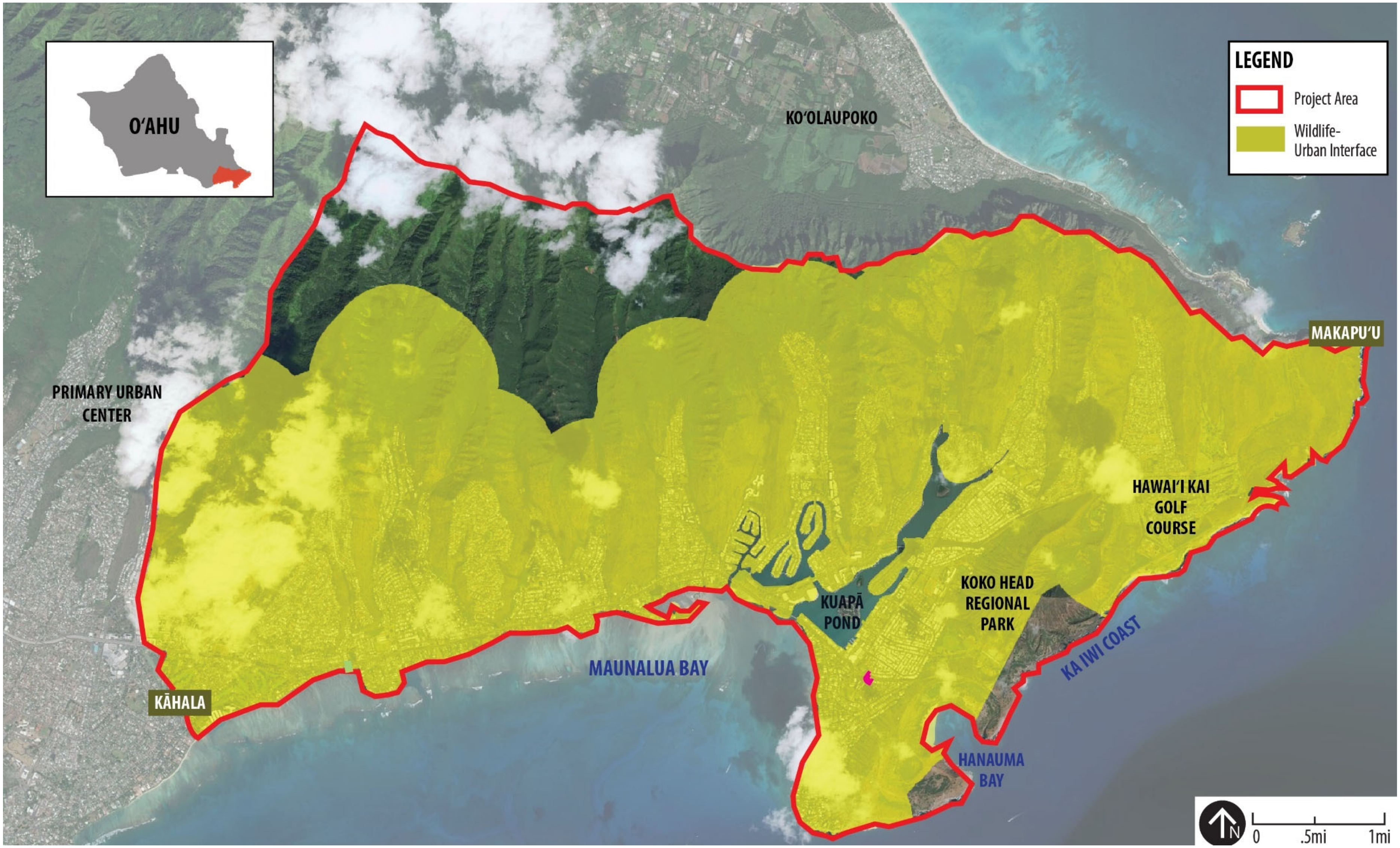
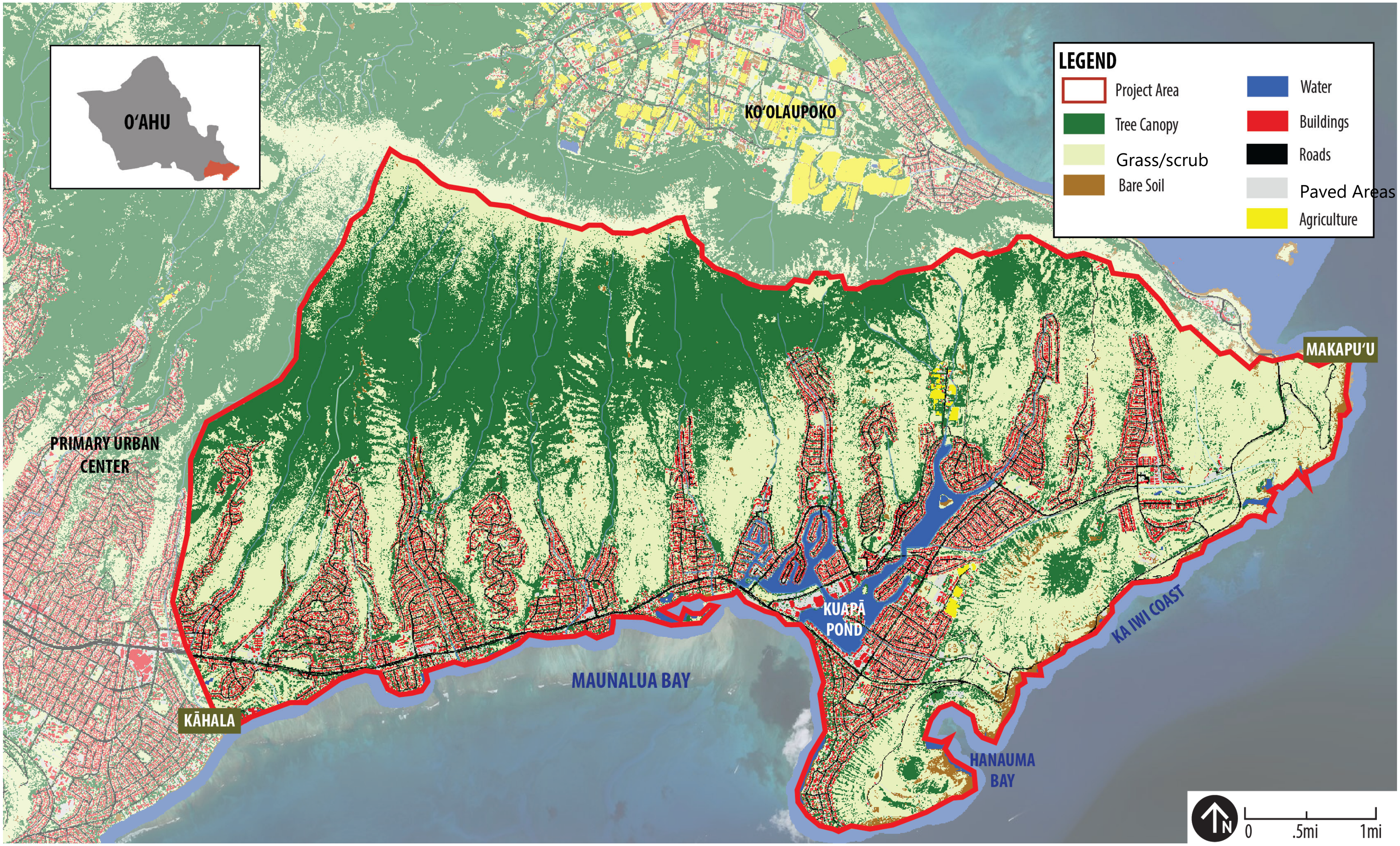


Figure 2-15: East Honolulu Land Cover



2.6 CLIMATE CHANGE AND SEA LEVEL RISE

Climate change is expected to impact Hawaiʻi's land, climate, and people in many ways over the coming decades. Impacts such as sea level rise, coastal erosion, and salt water intrusion into aquifers and drainage systems are expected to impact coastal areas. Other impacts such as increased storms and wildfire hazards, changes in rainfall, temperature increases, and increased drought will have statewide effects on Hawaiʻi's lands and watersheds.

State policy has recognized and anticipated potential climate change impacts for over a decade. In 2007, Act 234 recognized that "climate change poses a serious threat to the economic wellbeing, public health, natural resources, and the environment of Hawaiʻi." More recent policy calls for action to anticipate and adapt to these impacts. Act 83 (SLH 2014) and Act 32 (SLH 2017) establish policy and action committees to plan for and address the effects of climate change in order to protect the State's economy, health, environment, and way of life. In 2018, the Mayor of the City and County of Honolulu issued a formal directive to all City departments and agencies to take action to address, minimize the risks from, and adapt to the impacts of climate change and sea level rise (Directive 18-2). The Mayor's directive mandates that City agencies plan for future sea level rise through incorporating the most current versions of the Honolulu Climate Commission's Guidance and accompanying Brief into their planning, asset management, projects, capital expenditures, and permit reviews. Agencies planning for critical infrastructure should consider higher end projections of sea level rise in designing and siting facilities. Consequently, addressing climate change and sea level rise impacts are required components of all City planning efforts going forward, including the EHWMP.

Many of the impacts of climate change are interrelated. In 2012, the Pacific Islands Regional Climate Assessment (PIRCA) released a report which outlined many of the potential threats to watersheds in Hawaiʻi.[57] Some of these threats are depicted in *Figure 2-16*. For the purposes of identifying critical issues and special areas of concern specific to water resources in East Honolulu, climate change, sea level rise, and wildfires are addressed as separate issues, each having unique implications for water resources and watershed health. Special areas of concern related to climate change are described below.

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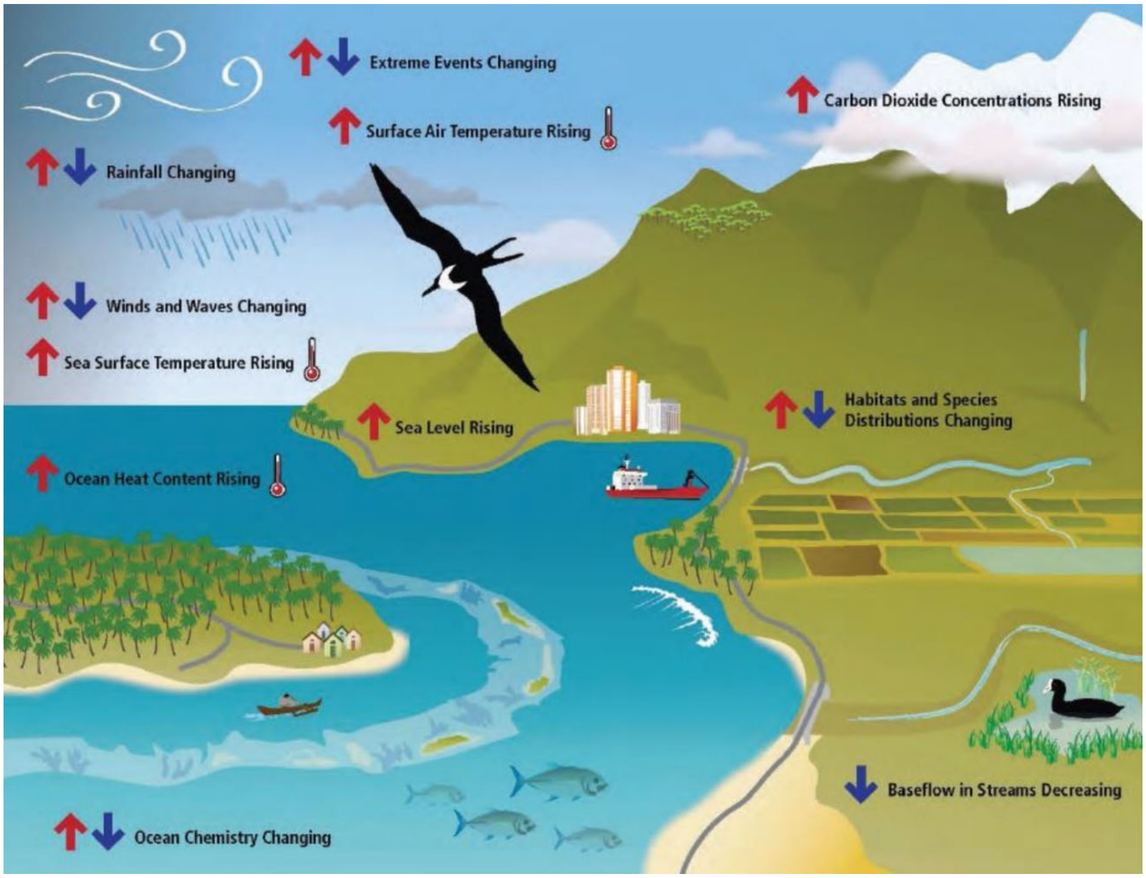
[57] Keener, V.W., Marra, J.J., Finucane M.L., Spooner, D., & Smith, M.H. (Eds.). (2012). *Climate Change and Pacific Islands: Indicators and Impacts.* Report for the 2012 Pacific Islands Regional Climate Assessment (PIRCA). Washington, D.C.: Island Press.

Figure 2-16: Climate Change Impacts to Watersheds[58]



In Hawaiʻi, climate change impacts have been recorded by NOAA, including:[59]

- *"Average annual temperature has generally increased over the past 50-90 years. In Hawaiʻi, high elevation stations have been warming faster than low elevation stations over the past 30 years;*
- *There has been a decline in northeast tradewind frequency in Hawaiʻi since 1973;*
- *Precipitation has trended downward over the past 100 years in Hawaiʻi;*
- *Hawaiʻi has experienced a trend toward increasing drought during the winter rainy season."*

Some of these impacts are described in further detail in the following sections.

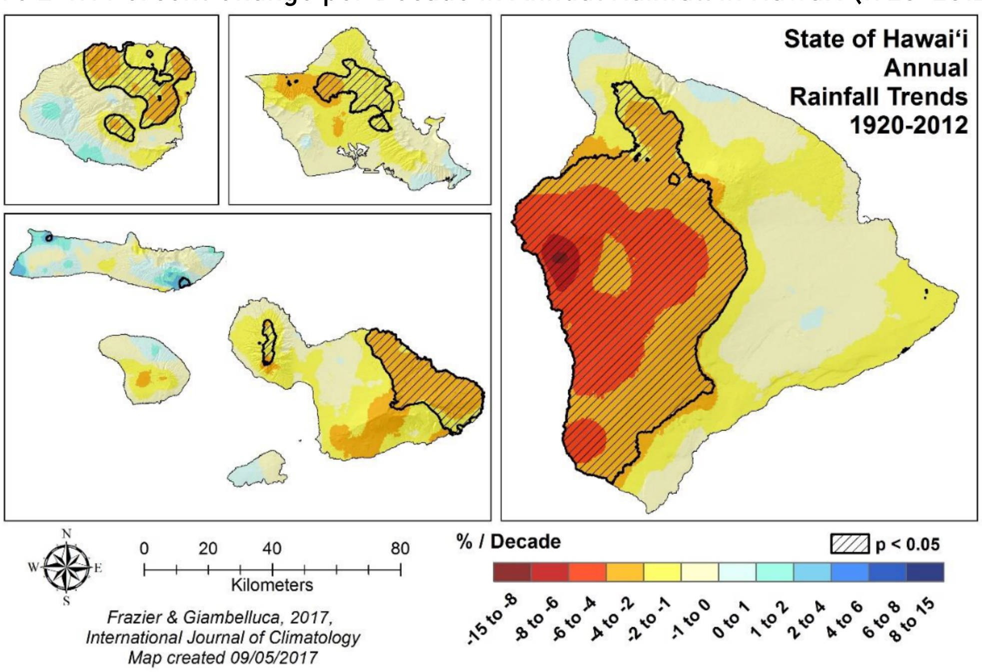
[58] Ibid.
[59] NOAA. (January, 2013). *Regional Climate Trends and Scenarios for the U.S. National Climate Assessment, Part 8.* Climate of the Pacific Islands.

2.6.1 Impacts to Rainfall

Based on the findings from a rainfall trend analysis in Hawaiʻi, there has been a statewide decline of 1.78% of annual rainfall per decade since 1920.[60] On Oʻahu, there has been a decline of 1.14% of annual rainfall per decade since 1920, the equivalent of a decline of 20.4 millimeters in annual rainfall per decade.[61] This analysis also found that the highest rates of rainfall decline during dry season months (October to May) were found in high elevation areas, while wet season (November to April) trends were fairly consistent across elevation (see *Figure 2-17*).

Figure 2-17 suggests that areas of the East Honolulu district experienced a slight increase (0-1% increase per decade) in annual rainfall between 1920 to 2012. The largest rainfall declines occurred in the northern Koʻolau Mountains, which are critical watershed areas for recharging the island's aquifers.[62] These trends are consistent with the statistically significant downward trends in streamflow and base flow in Hawaiʻi during 1913–2008,[63] which suggests that observed hydrological changes are being driven, at least in part, by changes in rainfall.[64]

Figure 2-17: Percent Change per Decade in Annual Rainfall in Hawaiʻi (1920-2012)



[60] Frazier, A.G. and Giambelluca, T. (2017). *Spatial trends analysis of Hawaiian rainfall from 1920 to 2012.* International Journal of Climatology. DOI: 10.1002/joc.4862.

[61] Ibid.

[62] Ibid.

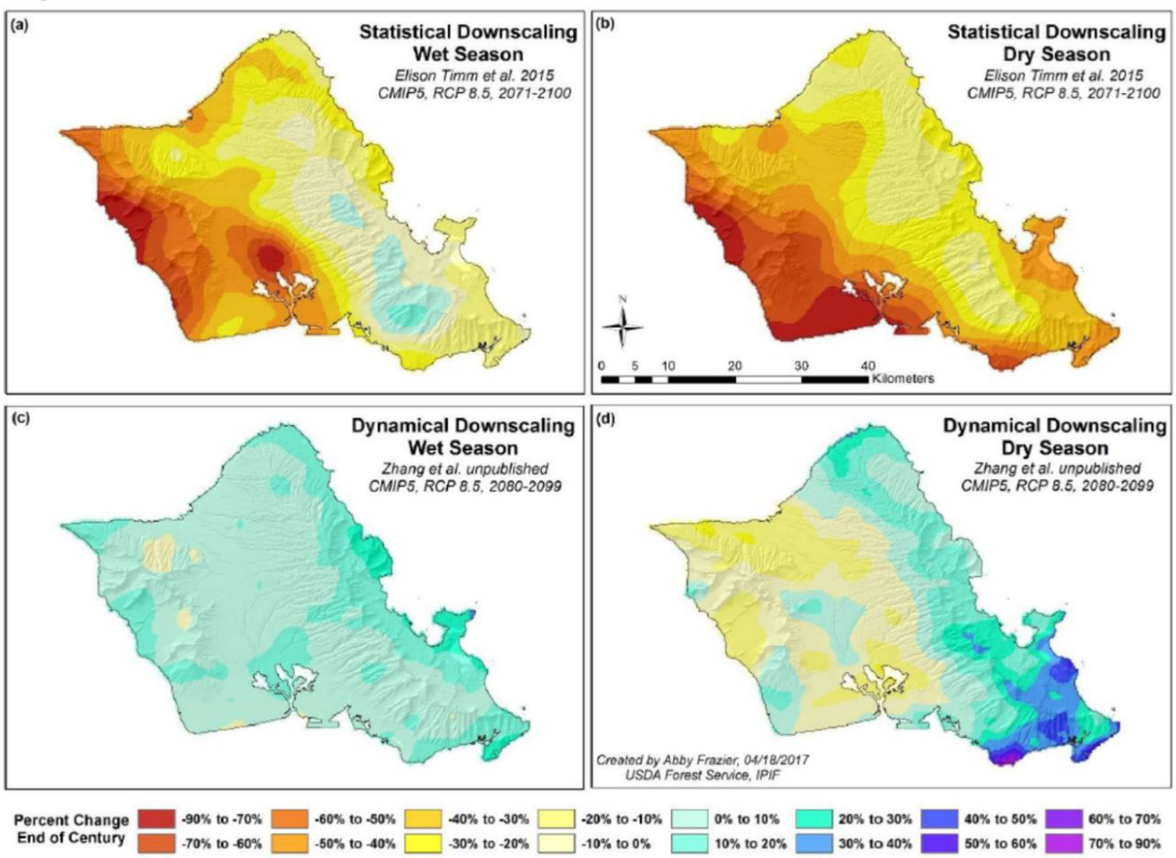
[63] Bassiouni M, Oki DS. (2013). *Trends and shifts in streamflow in Hawaiʻi, 1913–2008*. Hydrol. Processes 27: 1484–1500. doi:10.1002/hyp.9298.

[64] Frazier and Giambelluca (2017).

Climate change adds layers of uncertainty to the understanding of future drinking water availability. While BWS currently has sufficient potable water supply to meet existing demand, increasing temperatures and decreasing rainfall may impact BWS' ability to meet O'ahu's water demands into the future. Statistical and dynamical downscaling models have both been employed in recent studies to measure rainfall change by the end of the century. These studies resulted in notably different findings. 2100 rainfall model projections for both statistical downscaling and dynamical downscaling analyses are shown in *Figure 2-18*.

These two divergent rainfall forecasts represent the uncertainty of future conditions and serve as a guide for evaluating risk. *Chapter 4* evaluates both of these projections and considers risk tolerance to water supply and demand. In the decades to follow, these models will invariably be updated with new data, technologies, and applications and will hopefully converge into a consistent hydrologic future that will be used in future plan updates.

Figure 2-18: 2100 Rainfall Scenarios



Statistical downscaling modeling predicts a substantial decrease in rainfall by the end of this century, during both wet and dry seasons. On the Leeward side of the island, a region already prone to drought, future projections suggest rainfall reductions of more than 50% [65] While less dramatic, this model also predicts a decrease in rainfall by the end of the century in East Honolulu, estimating a 10% rainfall decrease during the wet season, and a 30 to 50% rainfall decrease during the dry season. Under this scenario, the aquifers which supply drinking water to the East Honolulu district (generally within the Koʻolau Poko and Primary Urban Center districts) would be adversely impacted by decreasing rainfall.

Dynamical downscaling modeling predicts a substantial increase in rainfall by the end of the century during both the wet and dry seasons. This model estimates that areas of the Windward side, East Honolulu, and the Primary Urban Center would experience the greatest increase in rainfall during the dry season.[66] East Honolulu would see a 0 to 30% rainfall increase during the wet season, and a 20 to 60% rainfall increase during the dry season. While the increase in rainfall may be beneficial regarding drinking water supply, this scenario could also mean an increase in flooding.

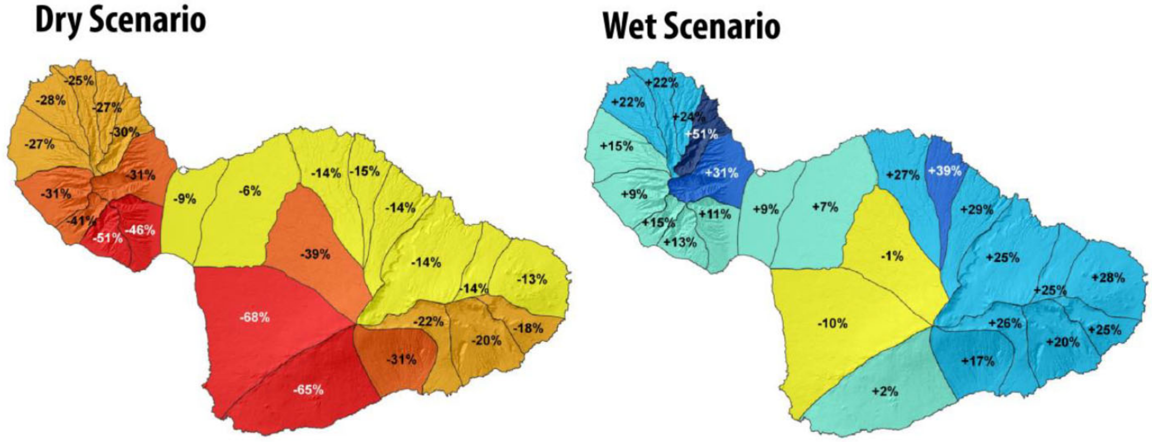
A study conducted by the Pacific Island Water Science Center[67] estimated ground water recharge and sustainable yields on Maui based on these differing climate conditions (referred to as the “dry” and “wet” scenario). In the dry scenario, the study found that ground water recharge on Maui would decrease by an average of 21%. In the wet scenario, the study found that ground water recharge on Maui would increase by an average of 21% (*Figure 2-19*). These findings indicate that estimates of future ground water recharge are heavily dependent upon projected rainfall. While a similar study has not yet been completed for Oʻahu, it is likely similar trends would emerge concerning the differences in ground water recharge in the dry and wet scenario.

[65] Elison Timm et al. (2015). *Statistical Downscaling of Rainfall Changes in Hawaiʻi based on CMIP5 Global Model Predictions*. Journal of Geophysical Research: Atmospheres. Doi: 10.1002/2014JD022059.

[66] Zhang et al. (2016). *Dynamical Downscaling of the Climate for the Hawaiian Islands*. Part II: Projection for the Late Twenty-First Century. Journal of Climate. Available from: https://doi.org/10.1175/JCLI-D-16-0038.1

[67] Pacific Islands Water Science Center. (2016). *Estimating Climate-Change Impacts on Ground water Recharge for the Island of Maui, Hawaiʻi*. Summary available from: http://files.hawaii.gov/dlnr/cwrm/submittal/2016/sb20160720C2.pdf.

Figure 2-19: Percent Change in Ground Water Recharge on Maui by Aquifer System (2100)[68]



Given the uncertainties concerning how climate change will impact rainfall and the conflicting results of rainfall models, it is difficult to anticipate impacts to future water supply. Decision makers should consider the full range of rainfall scenarios to capture the range of uncertainty in existing climate models.[69] Given the criticality of providing adequate water resources for Oʻahu's population, a conservative approach that emphasizes water conservation is called for. This is particularly so for East Honolulu, which relies upon water sources from the Primary Urban Center and Koʻolau Poko to meet the vast majority of the district's demand.

2.6.2 Increased Severity and Frequency of Storms

Climate change is expected to increase the frequency and severity of storms, increasing Hawaiʻi's risk and vulnerability to damaging winds, flooding, wave action, and other storm-related impacts.[70] Storm events can have wide-ranging impacts to water resources, damaging inland as well as coastal infrastructure, development, and ecosystems. Coastal development in East Honolulu, particularly areas makai of Kalanianaʻole Highway, is particularly threatened given the area's low elevation and susceptibility to coastal flooding and storm surges. Vulnerable critical infrastructure in the district includes the East Honolulu WWTP, where there have been several incidences of partially treated sewage discharge from due to electrical line failures following heavy rains. These incidents may increase as storms become more frequent and intense (see *Section 2.3.3 f*or more information on water resource issues related to the East Honolulu WWTP).

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[68] Ibid.
[69] Ibid.
[70] Knutson et al. (2015). *Global Projections of Intense Tropical Cyclone Activity of the Late Twenty-First Century from Dynamical Downscaling*; Cai et al. (2014). *Increasing Frequency of Extreme El Nino Events due to Greenhouse Warming*.

2.6.3 Sea Level Rise

Hawai'i is expected to be heavily impacted by sea level rise (SLR) and coastal flooding due to climate change. Current science and policy are generally aligned in anticipating approximately 3.2 ft of mean sea level rise in Hawai'i by the end of this century. By some forecasts, an increase of up to 6 ft is "physically plausible".[71] With 3.2 ft of sea level rise, waves and tides will reach farther inland at higher velocity. This will cause increased flooding, coastal erosion, and salt water intrusion into ground water and underground facilities, resulting in damage to coastal communities. Sea level rise will also increase the frequency and extent of extreme flooding associated with coastal storms, such as hurricanes.[72] The 2017 Hawai'i Sea Level Rise Vulnerability Assessment estimates that on O'ahu, 9,400 acres of land and 17.7 miles of major roads are expected to be chronically flooded with 3.2 ft of sea level rise.[73]

The 2017 Hawai'i Sea Level Rise Vulnerability Assessment maps the Sea Level Rise Exposure Area (SLR-XA) for the entire state. The SLR-XA represents the combined footprint of passive flooding, annual high wave flooding, and coastal erosion expected to result from 3.2 ft of sea level rise. Interactive SLR-XA maps are available online via the PACIOOS and NOAA Online Viewer.[74] The extent of the SLR-XA in the East Honolulu district is depicted in *Figure 2-20***.**

Coastal flooding and erosion will directly impact development along the East Honolulu coastline, including infrastructure for water supply, drainage, and wastewater collection and treatment. Sea level rise is not expected to impact the two aquifers located within the East Honolulu district (the Wai'alae East and Wai'alae West aquifers) because of the overlying caprock of coral and sediment.

With 3.2 ft of sea level rise, miles of East Honolulu's coastline would become chronically flooded. Predicted flooding is particularly prominent in the coastal areas of 'Āina Haina and Hawai'i Kai. Nearly all coastal areas along O'ahu's south shore from Kāhala to Portlock would be subject to increased coastal erosion. This area has historically been impacted by coastal erosion, as evidenced by extensive shoreline armoring to protect coastal homes and development. If this trend continues, increased armoring can be expected to result in additional shoreline and beach loss.

Coastal development makai of the highway primarily consists of residential single-family homes. However, critical infrastructure, such as the State highway or water supply facilities, may also be adversely impacted. Coastal erosion could affect water pipelines, and other underground and above ground infrastructure,

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71 Sweet et al. (2017). *Global and Regional Sea Level Rise Scenarios for the United States.* Silver Spring, MD: NOAA Technical Report NOS CO-OPS 083.

72 United States Global Change Research Program. (2017). *Climate Science Special Report.*

73 Hawai'i Climate Change Mitigation and Adaptation Commission. (2017). *Hawai'i Sea Level Rise Vulnerability and Adaptation Report*.

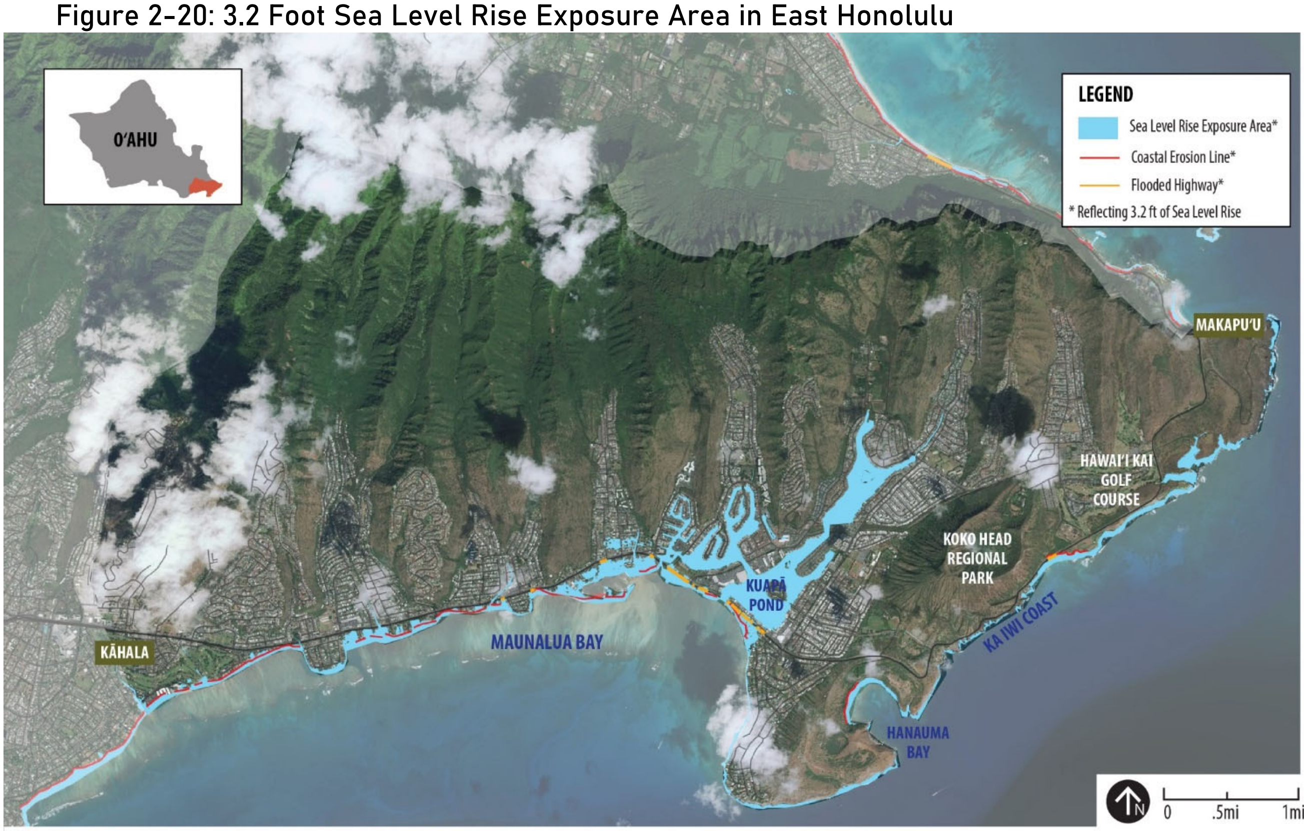
74 Available from: https://www.pacioos.hawaii.edu/shoreline/slr-hawaii/

including bridges and the utilities attached to bridges. SLR-XA maps for the district indicate that portions of Kalanianaʻole Highway in Hawaiʻi Kai may become flooded with 3.2 ft of sea level rise.

Owing to its history as a traditional fishpond, it is not surprising that areas near Kuapā Pond are predicted to be impacted by flooding as sea level rises. This includes commercial development that is located near Kuapā Pond, including Koko Marina and the Hawaiʻi Kai Towne Center. Single-family homes that currently border Kuapā Pond could also be impacted. Segments of Kalanianaʻole Highway near Kuapā Pond are also expected to be flooded.

As sea level rises, salt water has the potential to intrude underground infrastructure such as cesspools, sewers, and drainage systems. Salt water intrusion into drainage systems can damage and corrode pipes and drainage infrastructure. In East Honolulu, increasing salinity of ground water may impact the district's ability to recycle water. The State has authorized the Hawaiʻi Kai Golf Course to use recycled water from the East Honolulu WWTP for irrigation. However, recycled water is not currently being used for golf course irrigation due to its high salinity. While treated wastewater could be extracted for recycling during low tides, increasing ground water salinity would further constrain opportunities for water recycling for non-potable use, until the sewer system is replaced or the effluent is desalinated.

Figure 2-20: 3.2 Foot Sea Level Rise Exposure Area in East Honolulu



2.8 SETTLEMENT HISTORY

2.8.1 History Prior to Western Contact

It is estimated that Polynesian voyagers settled in Hawaiʻi as early as 1,500 to 2,000 years ago.[75] Native Hawaiians developed a complex system of resource management, with sophisticated skills and knowledge bases to survive on the remote islands with limited resource. Pre-Western contact, land was managed under the ahupuaʻa system, in which land was divided into units spanning mauka to makai (further described in *Section 2.2.2*).

In East Honolulu prior to Western contact, subsistence agriculture and aquacultural activities supported concentrations of people living within the coastal areas surrounding Maunalua Bay and Waimānalo Bay. Maunalua Bay was traditionally known for its offshore fishing resources and a walled fishpond—Keahupua O Maunalua[76] and sweet potato and other subsistence food crops grew in the lower valleys.[77]

Historically, the Hawaiian Islands were divided into four chiefdoms until sometime between 1791 and 1810, when King Kamehameha conquered other rulers and united the entire archipelago into one kingdom.

2.8.2 Post-Western Contact Settlement

Late 1700's to 1800's:

Decrease of Native Hawaiian Population: According to some estimates, in the late 1770's there were about 300,000 Native Hawaiians in the Kingdom, with other estimates as high as 800,000 to 1 million people.[78] The first European to set foot in Hawaiʻi was Captain James Cook, who landed on the island of Kauaʻi in 1778. Following the arrival of the first Christian missionaries to the islands in 1820, Western traders and whalers came to the Hawaiʻi. With them, diseases that devastated the native population. By 1853, the native Hawaiian population had dwindled to approximately 70,000.[79]

Foreign Control and Privatization of Land: In 1848, the ahupuaʻa system of land tenure was replaced by a new system of private land ownership. Known as the Mahele of 1848, the land privatization act awarded

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[75] Smithsonian Website. (November 6, 2007). "Hawaiʻi – History and Heritage)". Retrieved from: https://www.smithsonianmag.com/travel/hawaii-history-and-heritage-4164590/.

[76] The literal translation of Keahupua o Maunalua is "the shrine of the baby mullet at Maunalua." At 523 acres, this was once Oʻahu's largest loko kuapā (walled) fishpond. It was dredged by Henry J. Kaiser in the 1960s and replaced by the footprint of the Hawaiʻi Kai Marina.

[77] Livable Hawaiʻi Kai Hui & Ka Iwi Coalition. (2018). *Maunalua-Makapuʻu State Scenic Byway Corridor Management Plan*.

[78] Stannard, D. E. (1989). *Before the horror: The population in Hawaiʻi before the eve of Western demographic statistics of Hawaiʻi 1778–1965.* Honolulu: University of Hawaiʻi Press.

[79] Smithsonian Website (November 6, 2007)

large tracts of land to individuals. Princess Victoria Kamāmalu was awarded Land Commission Award 7713, which granted her title to the entirety of Maunalua between Kuliʻouʻou and Makapuʻu Point. These lands were subsequently inherited by Princess Bernice Pauahi Bishop in 1883, and then conveyed to the Kamehameha Schools/Bishop Estate trust upon her death in 1884.[80] The privatization of land was an important factor in the displacement of Native Hawaiians.[81]

Early 20th Century

Ranching, supplemented by an apiary (honey production) and kiawe charcoal operations, remained the primary land use in southeast Oʻahu until shortly after World War II. The Wāwāmalu Ranch is the most recent and best-known ranch in the area; it was established in 1932 by Alan Davis, a trustee of the Kamehameha Schools/Bishop Estate. The ranch occupied 600 acres near Queens Beach that were leased from Kamehameha Schools/Bishop Estate until the 1946 tsunami, which destroyed much of the ranch.[82]

The section of Kalanianaʻole Highway between Koko Head (near Hanauma Bay) and Makapuʻu Point was originally built in the early 1930s, with construction completed in 1932. Construction of the highway was instrumental in improving public access to the once remote Ka Iwi Coast.[83]

Telecommunications, military facilities, and the Makapuʻu Lighthouse were also important elements that contributed to this area's growth during the 20th century. In 1914, the Marconi Wireless Telegraph Company built a trans-pacific receiving station on Koko Head. It was eventually taken over by the Mutual Telephone Company (Hawaiian Telecom) for communications relaying.

From 1922 to 1960, the U.S. Government operated the Makapuʻu Military Reservation, consisting of a fire control and observation station and various pillboxes and shelters. An early warning radar station operated by the U.S. Army was built in 1943 at the top of Koko Crater. Remnants of these abandoned military structures demonstrates that Makapuʻu Point and Koko Head were essential links in the U.S. military's defense system during World War I.

Modern History (1950 to Present)

The present suburban character of East Honolulu was first catalyzed by the master planned community of Hawaiʻi Kai; prior to this time most of the region was considered too far removed from Honolulu to be suitable for residential development.[84] Construction of Hawaiʻi Kai began in 1959. Construction activities included dredging and fill activities that transformed Keahupua O Maunalua, the once shallow coastal

80 Livable Hawaiʻi Kai Hui & Ka Iwi Coalition. (2018).
81 Kanaʻiaupuni, S. & Malone, N. (2006). *This is My Land: The Role of Place in Native Hawaiian Identity*.
82 United States Department of the Interior. (1992). *Reconnaissance Survey: Ka Iwi Shoreline Study.*
83 Livable Hawaiʻi Kai Hui & Ka Iwi Coalition (2018).
84 DPP. (2019).

fishpond, into a private marina surrounded by residential subdivisions. New infrastructure accompanied the construction of Hawaiʻi Kai, including highway improvements to widen the two-lane highway between Kāhala and Maunalua into a four-lane highway (two lanes in each direction), water storage tanks, and a sewage treatment plant across from Sandy Beach. Following the momentum of Hawaiʻi Kai, in the 1960's and 1970's, development quickly spread to Kamilo Iki Valley, Kalama Valley, and Kamilo Nui.

During this time developers also envisioned a large-scale marina/golf course/resort community and residential subdivisions at Wāwāmalu (Queen's Beach) and nearby Kalama Valley, with a four-lane highway running inland through Hawaiʻi Kai. However, in the early 1970s residents began organizing in opposition to the proposed resort development at Wāwāmalu. Community efforts contested rezoning applications and pursued legal action; due to these actions, the proposed development at Wāwāmalu was eventually abandoned.

Today, 40% of the East Honolulu planning district is designated Urban by the State. Most of the ridges and valleys from Kāhala to Kalama Valley are filled with low-density single-family homes. Still, the spirit of community organizing in the name of preserving conservation land remains strong. Development has sharply decreased over the past few decades. Moreover, until this day, the Ka Iwi Coast portion of the East Honolulu district remains undeveloped due to initiatives by the community and environmental groups.

Image: Keahupua O Maunalua in 1931(Credit: Maunalua.Net)

2.9 TRADITIONAL PRACTICES AND CULTURAL RESOURCES

Perpetuating Native Hawaiian traditional practices and cultural resources is dependent upon access to natural and cultural resources and the ability to use and care for the water, land, and air. Given East Honolulu's relative lack of agricultural abundance, the area relied heavily upon its aquaculture and fishing resources, particularly within Maunalua Bay. Because of this, many of the area's known traditional practices and cultural resources are located along the shoreline.

A summary of the different components of traditional practices and cultural resources important in East Honolulu are described in the section below.

2.9.1 Ka Paʻakai Analysis

Hawaiʻi's unique traditional land tenure system and political history has led to strong legal protections for Native Hawaiians and the State's Public Trust resources. This section of the EHWMP provides a brief description of Native Hawaiian rights law and its relevance to traditional subsistence and cultural practices in East Honolulu. This section also describes the requirement for Hawaiʻi government agencies to include a Ka Paʻakai Analysis when making plans and decisions related to land use.

The Role of Kamaʻāina Knowledge and Expertise

When authenticating Hawaiian custom and usage, the courts commonly look to kamaʻāina expert testimony. In the case Application of Ashford (1968) the Supreme Court of Hawaiʻi delineated the location of seashore boundaries through testimony regarding the customs and practices of the kamaʻāina. The court held that boundary delineation is "not solely a question for a modern-day surveyor to determine the boundaries in a manner completely obvious to the knowledge and the intention of the king and old-time kamaʻāinas who knew the history and names of various lands and monuments thereof."

The law recognizes kamaʻāina expertise in authenticating customary practices that also qualify as statutorily and constitutionally protected rights (Application of Ashford, 1968). Kamaʻāina are individuals that were born of a particular place and/or who are familiar with the features, resources, and natural cycles of a place. These individuals are referred to in this section of the EHWMP as "Kamaʻāina Informants." Kamaʻāina knowledge can also help to inform watershed management planning as kamaʻāina possess intimate knowledge of their place, and their cultural practices are vital to restoring and maintaining ahupuaʻa health.

Ka Paʻakai Criteria

In Ka Paʻakai O Ka ʻĀina vs. Land Use Commission (2000), the Hawaiʻi Supreme Court held that title to water resources is held in trust by the State for the benefit of its people and established the exercise of Native Hawaiian and traditional and customary practices as a Public Trust purpose. The Court enumerated three criteria, listed below, for agencies to protect traditional and customary Hawaiian practices to the extent feasible.

Ka Paʻakai Criteria:[85]

- *The identity and scope of valued cultural, historical, or natural resources in the petition area, including the extent to which traditional and customary native Hawaiian rights are exercised in the petition area;*
- *The extent to which those resources – including traditional and customary native Hawaiian rights – will be affected or impaired by the proposed action; and*
- *The feasible action, if any, to be taken to reasonably protect native Hawaiian rights if they are found to exist.*

Ka Paʻakai Analysis Process for the EHWMP

While a Ka Paʻakai Analysis is primarily used for development projects, it should also be applied during planning processes. Its application should be used to discuss how recommended policies or strategies may affect traditional and customary rights (such as water transfers or subsistence activities) or if there are location-specific development proposals (such as new well construction). The planning process for the EHWMP included the following steps to meet the three Ka Paʻakai criteria:

- Identified what resources and subsistence activities existed East Honolulu in pre-contact days (see *Section 2.8.1* and *Section 2.9.3*).
- Identified wahi pana in East Honolulu (see *Section 2.9.3*).
- Identified and held small group and individual meetings with kamaʻāina in East Honolulu. This outreach was intended to:
    - Identify traditional and customary practices exercised within East Honolulu.
    - Identify issues and impacts to traditional and customary practices and discuss potential solutions to revive these practices within East Honolulu.
- Integrate findings throughout the EHWMP:
    - In addition to the findings presented in *Chapter 2*, projects, programs and strategies to support traditional and customary practices are also provided in *Chapter 4*. This includes, but is not limited to, the restoration of freshwater springs, fishponds, and riparian zones, as well as the removal/control of alien plant species.
    - The potential benefits and/or adverse impacts to traditional and customary practices for each project and strategy presented in *Chapter 4* are also discussed.

2.9.2 Traditional Land Management

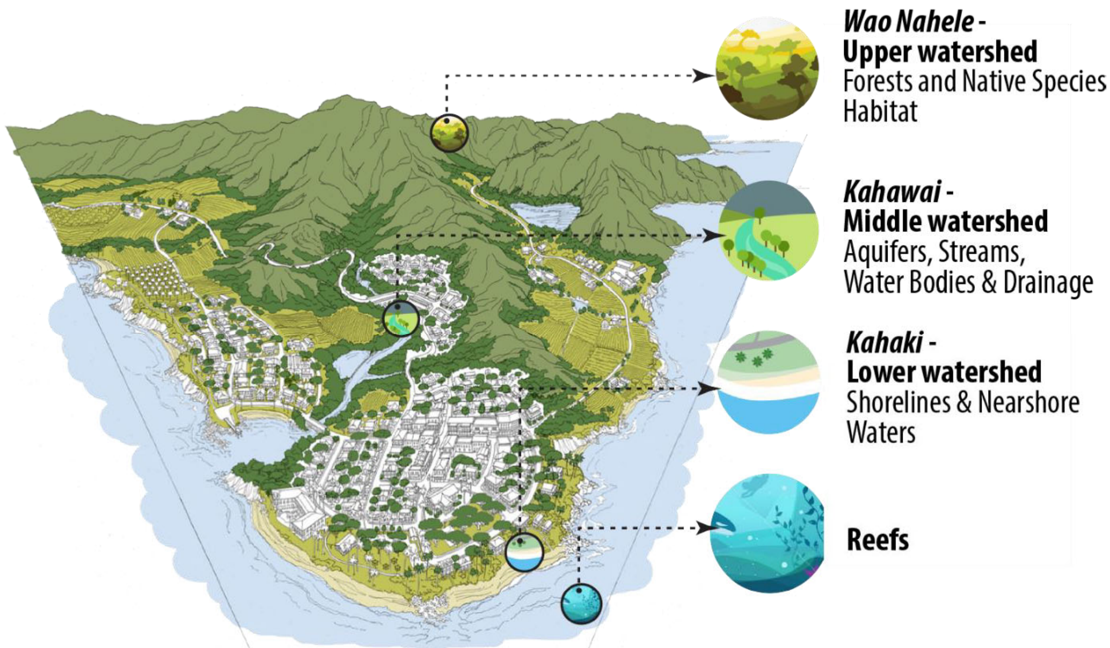
Pre-Western contact, ahupuaʻa land management was foundational to Native Hawaiian settlements, as it afforded access to subsistence activities, cultural and religious customs, and traditional practices. Under the ahupuaʻa land system, each mokupuni (island) was divided into several moku (the largest units within

[85] *Ka Paʻakai O Ka ʻĀina vs. Land Use Commission* (2000)

each island).[86] Moku were usually wedge-shaped and running from the mountain crest to shore. Oʻahu was divided into six moku. The East Honolulu district is located within two moku: Kona and Koʻolaupoko.

Each moku was divided into ahupuaʻa, narrower wedge-shaped sections of land that spanned mauka to makai, following the natural watershed boundaries. Each ahupuaʻa was ruled by aliʻi (royalty) or local chief. The size of the ahupuaʻa depended on the resources of the area; regions with limited agricultural resources were split into larger ahupuaʻa to compensate for the relative lack of natural abundance. Such was the case in the now East Honolulu district, in which only two ahupuaʻa are located: the Waikīkī ahupuaʻa and Waimānalo ahupuaʻa. This land management system allowed for holistic land and resource management, as it considered watershed health from ridges to reef, and promoted self-sufficient communities, the interrelationship of mauka and makai resources, and stewardship and kuleana of land, people, and culture (see *Figure 2-21*).

Figure 2-21: Ahupuaʻa Land Management – Ridges to Reefs



Stewardship of the land and its resources was formalized through the kapu system, which was administered and enforced by konohiki and kahuna (priests). This system placed restrictions on fishing certain species during specific seasons, on gathering and replacing certain plants, and on many aspects of social interaction as well. In this way, the community maintained a sustainable lifestyle. Through sharing

[86] Handy et. al, 1968. *Ancient Hawaiian Civilization*.

resources and working within the rhythms of their natural environment, Hawaiians enjoyed abundance and a quality lifestyle with leisure time for recreation during the harvest season of the year.

2.9.3 Cultural Resources and Wahi Pana

Wahi pana are sacred sites and significant places such as heiau, shrines, churches, observation points; prominent pōhaku (stones), burial caves, geographic and natural features, and phenomena associated with deities or significant events.[87] The southeastern shorelines of Oʻahu are home to mythical legends and sacred sites associated with Hawaiian gods. The section below describes some of East Honolulu's most prominent cultural resources and places of significance. This is not an exhaustive list as some sites are considered sensitive or may not be appropriate to identify in this Plan.

Archaeological Sites

An archaeological survey of Oʻahu in 1930 documented approximately 60 sites in the area now defined as the East Honolulu district.[88] Many of these sites have since been destroyed by the 1946 tsunami, erosion, or other land altering activities.[89]

Near Wāwāmalu, approximately 20 sites were documented in the 1930 survey. The features included fishing shrines, house platforms, and a habitation cave. Although survey work done in 1984 found none of these sites, the large quantity of sites recorded earlier make it likely that subsurface cultural deposits and scattered human burials remain in the areas within and surrounding Koko Head Regional Park.[90]

There are fewer archaeological sites West of Koko Head. Sites in this portion of East Honolulu consist of shelters, heiau, and burial caves. The following sites are the significant cultural and historic sites believed to still be present in East Honolulu, as presented in the 2000 EHSCP*:*

- Makapuʻu Point Lighthouse
- Kealakipapa Valley Road
- Kaloko Dwelling Site
- Kailiili Midden Site
- Koko Head Petroglyphs
- Makapuʻu Head Cave
- Makaniʻolu Shelter (Kuliʻouʻou)
- Burial Caves (Niu)

Although not listed in the table, there are also archaeological sites on undeveloped parcels located deep within the region's valleys. The features listed above have not been impacted by the tsunami of 1946 or

[87] HECO. (July 1997). Hawaiʻi Externalities Workbook. Pages 8-15.
[88] McAllister, J. Gilbert. (1933). *Archaeology of Oʻahu*.
[89] DPP. (2000).
[90] DPP. (2000).

by previous development activity (as of the 2000). However, some of these sites may have been subject to intensive agricultural use in the past.

The 2022 EHSCP places a greater emphasis on preserving significant historic and pre-historic features, including Hawaiian cultural and archeological sites, particularly the ʻIhiʻihilauākea Preserve, Makaniʻolu Shelter, Hāwea Heiau Complex, and Pahua Heiau.

Currently, four sites within East Honolulu are listed on the Hawaii's Historic Register of Historic Places[91], including:

- Jean Charlot Residence
- Carl and Florence Bayer Residence
- Kalauhaʻihaʻi Fishpond
- Makapuʻu Lighthouse

Makapuʻu Lighthouse is the only historic site identified in the 1930 study that is currently included in the Hawaiʻi Register of Historic Places. This may indicate that previously identified historic sites have further deteriorated in condition. Of the sites listed on the Hawaiʻi Register of Historic Places, only the Kalauhaʻihaʻi Fishpond played a culturally significant role in East Honolulu prior to Western contact.

Community groups in East Honolulu have been working to steward and protect the district's archaeological sites. Several of these efforts are identified as projects in Chapter 4. In addition, one organization, Pūʻuhonua o Wailupe, is specifically focused on protection of iwi kupuna (Native Hawaiian burials) in the area.

<u>Places of Cultural Significance</u>

Some of the areas of cultural significance in East Honolulu are described below and shown in *Figure 2-22:*

- **Makapuʻu** was the mythological home of a Hawaiian Goddess said to have bright shining eyes. On the cliffs of Makapuʻu is Kapaliokamoa (Pele's Chair) – a lava rock formation overlooking Kaloko.

- **Koko Crater (Kohelepelepe):** In myth, Hawaiian Goddess Kapo sent her feminine charm to lure Kamapuaʻa and save her sister Pele. Kamapuaʻa then followed the charm to Koko Head, where it left an imprint.

- **Hanauma Bay** was the preferred fishing spot of ancient Hawaiians and Hawaiian royalty according to moʻolelo (legend)**.** It was also a canoe launching area for royalty traveling to Molokaʻi. It is unlikely that Hawaiians had large settlements in this area due to low rainfall, nutrient poor-soil, and lack of fresh water.[92]

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[91] Historic Hawaiʻi Foundation Website. (2018). Oʻahu Historic Properties.

[92] Place Names of Hanauma Website. (No Date). "Hanauma Bay." Retrieved from: http://placenamesofhanauma.weebly.com/hanauma-bay.html.

- **Maunalua** encompasses the area from southeast Oʻahu at Koko Head to Kupikipikio on the slopes of Diamond Head. Maunalua Bay was critically important during the time of ahupuaʻa land management because of its abundant shoreline and fishing resources. The area also includes the area known today as Hawaiʻi Kai. According to moʻolelo, Maunalua was the landing spot of some of the first people to migrate to Hawaiʻi from central Polynesia. Traditionally, Maunalua was known for its loko iʻa (fishpond), and it is said many of its inhabitants were likely fishermen. The valleys within Maunalua were traditionally known for sweet potato farming. Today, the bay is a major recreational destination for fishing, surfing, diving and other coastal activities. Limited shoreline access and declining water quality are the major threats to the sustainable use and enjoyment of the bay for traditional and customary uses.

- **Ka Iwi** is home to numerous cultural and archaeological sites including heiau, house sites and rock shelters, cultivation sites, burials, rock walls, a canoe hale, and petroglyphs. These provide physical evidence of pre-contact habitation, as well as cultivation and gathering activities along the Ka Iwi Coast.[93] Shrines and rock formations near the shoreline indicate fishing and other uses of the ocean in this area. Today, the Ka Iwi Coast remains an important destination for recreational use as well as traditional and customary practices. Much of the shoreline remains publicly accessible, including popular beaches such as Sandy's. This area was also known for the Ka Iwi Channel (commonly referred to today as the Molokaʻi Channel). This is said to be one of the most dangerous channels to travel by in Hawaiʻi. Because of this, some of the iwi (burials) found in this area are attributed to the travelers who lost their lives crossing the channel.

Fishponds, Springs, and Wetlands

Relative to other areas in Hawaiʻi, East Honolulu has limited fresh water resources. However, prior to Western contact there were large fishponds in East Honolulu that provided for the Waikīkī and Waimānalo ahupuaʻa. Fishponds are rock-walled enclosures in nearshore waters, used to raise fish for communities. It is believed they were first built in Hawaiʻi in the 15th century. In ancient Hawaiʻi, fishponds were an integral component of the ahupuaʻa; however in 1848, when King Kamehameha III pronounced the Great Māhele (land distribution act), Hawaiian fishponds were considered private property by landowners and the government.[94] Some of East Honolulu's once notable fishponds and springs included:

- **Kuapā Fishpond** until the late 20th century was a fishpond named Keahupua O Maunalua, which means "the shrine of the baby mullet at Maunalua". The fishpond once covered 523 acres and was one of the largest fishponds in the Hawaiian archipelago.[95] ʻAmaʻama (mullet) was the main

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[93] Livable Hawaiʻi Kai Hui & Ka Iwi Coalition. (2018). *Maunalua-Makapuʻu State Scenic Byway Corridor Management Plan*.

[94] Young, Peter. (2017). *Wailupe Fish Pond*. Retrieved from: http://totakeresponsibility.blogspot.com/2012/06/wailupe-pond-punakou-pond.html.

[95] Place Names of Hanauma Website. (No Date). "Maunalua." Retrieved from: http://placenamesofhanauma.weebly.com/hanauma-bay.html.

fish raised in the fishpond by Hawaiians. The pond was later leased by Japanese settlers in the 20th century, and eventually dredged and partially filled by Henry Kaiser to support the construction of the Hawaiʻi Kai master planned community. It is now commonly referred to as the Hawaiʻi Kai Marina, and is managed by a privately-held marina authority. Threats to traditional and customary use of the pond include degraded water quality, loss of the traditional fishpond structures, and limited access due to its privately held status.

- **Kalauhaʻihaʻi Fishpond** (also referred to as the Kānewai Fishpond) was once home to many different types of native fresh water fish, even including prawn. Via the Kānewai Spring, a lava tube once provided fresh water to the fishpond. The fishpond is connected to Paikō Lagoon Wildlife Sanctuary by a rock ʻauwai (ditch, canal) and mākāhā (sluice gate). Water flow to the fishpond was blocked following the widening of Kalanianaʻole Highway in the 1990's. The fishpond is currently owned by DLNR. The Maunalua Fishpond Heritage Center (MFHC) is developing a lease agreement for the property and working with DLNR to return the water flow. MFHC is also interested in restoring Kalapa o Ma Ua Ridge (immediately mauka of the fishpond) by removing invasive species and replacing with native plants. The hillside is currently covered with haole koa and other weeds. The Kalapa o Ma Ua Ridge provides a good vantage point for the fishpond and could be used for cultural and educational opportunities since it allows for observation of the tide, wind, and weather.

- **Kānewai Spring** is one of Oʻahu's few remaining fresh water springs. The spring is home a variety of fresh water fish including shell fish pipiwai and hapawai, ʻamaʻama (mullet), āholehole (young Hawaiian flagtail), native shrimp ʻopae ʻoehaʻa and ʻopae huna, and endangered birds such as ʻaeʻo (Hawaiian stilt).[96] There are a number of cultural sites surrounding the fishpond, including the mākāhā (sluice gate), and kūʻula (fishing stone shrine) with an upright Kū stone balanced by a low Hina; it was at these sites that fishermen gave offerings asking for a plentiful catch. The Kānewai Spring was purchased in 2017 by the Trust for Public Land and the MFHC in the hopes of restoring one of the last remaining fresh water springs on Oʻahu. MFHC is currently

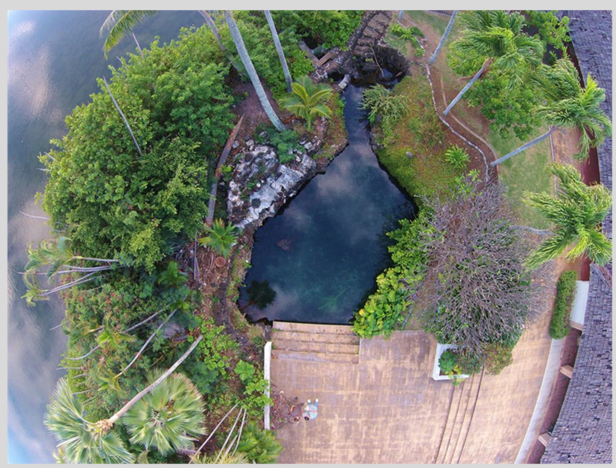


Image: Kānewai Spring Complex (Credit: Historic Hawaiʻi Foundation)

[96] Maunalua Fishpond Heritage Center Website. (2012-2015). "About Us". Retrieved from: http://maunaluafishpond.org/about/.

focusing on education and rehabilitation of the natural and cultural resources at the site. The resurgence of fish to the spring may support subsistence fishing activities in the area.

- **Keawāwa Wetland** is located on the 5-acre Hāwea Heiau complex. The property contains numerous petroglyphs, an ancient niu (coconut) grove, a once spring-fed well, and many ancient rock formations. In 2014, the Trust for Public Land purchased the property and transferred the property to the Livable Hawaiʻi Kai Hui. In the years since, Livable Hawaiʻi Kai Hui has been actively involved in restoring the area and using it for cultural education purposes. On February 3rd, 2018, Keawāwa Wetland was the site of the World Wetlands Day celebration in East Honolulu, where community members enjoyed hula, planting native plants, walking tour, alaeʻula watching, and short environmental lectures.

Image: Keawāwa Wetland (Credit: Livable Hawaiʻi Kai Hui)

- **Wailupe Fishpond** once covered an area of 41 acres and was 2,500 ft long. Like many fishponds on Oʻahu, the Wailupe Fishpond was filled and developed in the 20th century. The Wailupe Fishpond was fed by two large springs named Punakou and Puhikani.

<u>Forests and Mauka Areas</u>

While forests are important components to the ahupuaʻa, and the health of watersheds, there is limited information on pre-Western contact forest activities in East Honolulu. For many mauka parcels in the East Honolulu district, there is no archaeological data available. Pre-Western contact, circulation networks often consisted of trails and dirt roads on land which provided lateral mauka and makai access. Along the shore, these networks include landings, harbors, and piers. Trails were particularly important in large ahupuaʻa, such as Waikīkī and Waimānalo, in which people needed to traverse large distances to travel from one area of the ahupuaʻa to another. Two notable trails in East Honolulu (pre-Western contact) included:

- **Kealakīpapa Trail** (also known as the King's Highway) was a stone-paved road near Wāwāmalu, w hich connected Maunalua and Waimānalo. Only remnants of this trail remain today.

- **Niu Trail** begins in Niu, traverses through the Koʻolau Mountains, and down into Waimānalo. It was said that Native Hawaiians used it to travel from Niu to Waimānalo, and vice versa.

Many of the sites discussed in this section are shown in *Figure 2-22*. Please note, the figure only includes the district's cultural sites which are publicly known. Many sites which are not publicly accessible or are culturally sensitive are omitted from the map.

Figure 2-22: East Honolulu Cultural Sites

2.10 SOCIO-ECONOMIC CONDITIONS

2.10.1 Population

According to DPP's Annual Report on the Status of Land Use on O'ahu for Fiscal Year 2021, the population in the East Honolulu District was 50,922 people in 2020.[97] The district's total population increased by 15.5% between 1980 and 2010, yet between 2010 and 2020 its population was relatively stable (*Table 2-8*). According to the EHSCP, East Honolulu's population is expected to remain stable at around 50,000 people through 2040. DPP projections also estimate that East Honolulu will account for 6% of the total island-wide population by 2040. DPP socio-economic projections are based on the land use policies set forth in the City's General Plan, as well as the EHSCP.

Table 2-8: East Honolulu Historic and Projected Population[98]

Geographic Area	2000	2010	2020	2040
East Honolulu SCP Area	46,735	49,914	50,922	50,000
O'ahu TOTAL	876,156	953,207	1,016,508	1,068,700

2.10.2 Demographic Characteristics

The residents of East Honolulu are generally older than the residents of O'ahu as a whole. Based on American Community Survey (ACS) five-year estimates for the 2017 to 2021 time period, the median age of East Honolulu residents is 48.7 years old and 26% of the district's residents are 65 years old or older.[99] Compared to O'ahu as whole, East Honolulu also has smaller household sizes. A large percentage of East Honolulu residents identify as Asian (47.6%) and white (25.3%). Only 3.4% of East Honolulu residents identify as Native Hawaiian or Pacific Islander, compared to 9.9% island-wide. *Table 2-9* summarizes East Honolulu and island-wide demographic characteristics based on ACS five-year estimates for the 2017 to 2021 time period.

[97] 2000 to 2020 actual population figures based on DPP. (2023). *Annual Report on the Status on Land Use of O'ahu for Fiscal Year 2021.* Available at: https://www.honolulu.gov/rep/site/dpp/pd/pd_docs/Annual_Report_FY2021_Final_230222.pdf; 2040 project population figures based on DPP. (2022). *East Honolulu Sustainable Communities Plan* (EHSCP). Available at: https://www.honolulu.gov/rep/site/dpp/pd/pd_docs/EHSCP_2022.pdf.

[98] DPP. (2023). *Annual Report on the Status of Land Use on O'ahu for Fiscal Year 2021.*

[99] American Community Survey (ACS) five-year estimates for 2017-2021 time period.

Table 2-9: East Honolulu Demographic Characteristics[100]

Characteristics	East Honolulu	Island-Wide
Median Age	48.7	38.2
Race		
White (Alone)	25.3%	21.2%
Black or African American (Alone)	0.6%	2.8%
Asian (Alone)	47.6%	47.6%
Native Hawaiian / Pacific Islander (Alone)	3.4%	9.9%
American Indian and Alaska Native (Alone)	0.1%	0.3%
Two or More Races	22.5%	23.2%
Hispanic or Latino	5.8%	10.3%
Gender		
Male	49.9%	50.6%
Female	50.1%	49.4%
Average Persons per Household	2.88	2.96

2.10.3 Economics

According to ACS five-year estimates for the 2017 to 2021 time period, 60.4% of East Honolulu's working-age population (age 16 and older) is in the civilian workforce. A majority of East Honolulu's labor force drive alone to work (71%). 18% of its labor force carpool, and 4% use transit, walk, or use other means to commute to work. Nearly 7% of East Honolulu residents work from home. The median household income (in 2021 dollars) is $139,041, significantly higher than the Oʻahu-wide median income of $92,600.

In 2021, the median home value in East Honolulu was estimated to be $1.35M (million), 18.5% higher than Oʻahu's median home value of $1.1M. This is important to land use and water policy as the household

[100] ACS five-year estimates for 2017-2021 time period.

income, lot size, and landscape greenness, among other factors, have been found to be key drivers of high water demand.[101]

Employment opportunities within East Honolulu are limited, and are forecasted to remain so in the Oʻahu General Plan. According to DPP socio-economic projections, in 2020 there were an estimated 10,500 jobs located within East Honolulu.[102] East Honolulu has a total of seven commercial centers, in which the majority these jobs are located. By 2040, the number of jobs within East Honolulu is anticipated to grow slightly to 10,900 (*Table 2-10*).

Table 2-10: Jobs within East Honolulu[103]

Year	Total East Honolulu Jobs	% of Total Island-Wide Jobs
2010	10,252	2%
2020	10,500	2%
2030	10,400	1%
2040	10,900	2%

[101] C. Mini, T. S. Hogue, and S. Pincetl. (2014). "Patterns and controlling factors of residential water use in Los Angeles, California." Official Journal of the World Water Council, Water Policy. Volume 16, Issue 6. https://doi.org/10.2166/wp.2014.029.
[102] DPP. (2023). *Annual Report on the Status of Land Use on Oʻahu for Fiscal Year 2021.*
[103] DPP. (2023). *Annual Report on the Status of Land Use on Oʻahu for Fiscal Year 2021.*

2.11 LAND USE

2.11.1 Land Ownership

Compared to individual homeowners, large landowners may have the capacity to implement extensive water conservation measures, such as low-impact development practices and smart water technology. There are three major landowners in East Honolulu: Kamehameha Schools (34.6% of district), the State of Hawaiʻi (16.8% of district), and the City and County of Honolulu (13.4% of district). Collectively, these three landowners own approximately 66% of the land in East Honolulu. Other notable landowners include the district's gated communities. The Hawaiʻi Loa Ridge Association owns over 100 acres, which includes roadways, a park and parking lots, and the hillside west of the subdivision. The Waiʻalae Iki Community Association owns 15 acres of roadways and a three-acre park and parking lot.

Kamehameha Schools (KS), the district's largest landowner, uses its land for a variety of purposes within Urban designated areas, including residential and commercial development. KS also owns a significant amount of Conservation designated land, which is largely used to preserve cultural and natural resources, as well as for educational purposes. City and County of Honolulu lands are primarily used for parks and other civic purposes. State of Hawaiʻi lands are primarily used as State Parks and Conservation areas.

Both the City and County of Honolulu and the State of Hawaiʻi own substantial amounts of impervious roadway surfaces, which contribute to runoff and nearshore water quality issues. Based on GIS analysis, there are over 120 miles of local roads (owned primarily by the City and private entities) in East Honolulu. The district also has over ten miles of state-owned roadway (Kalanianaʻole Highway).

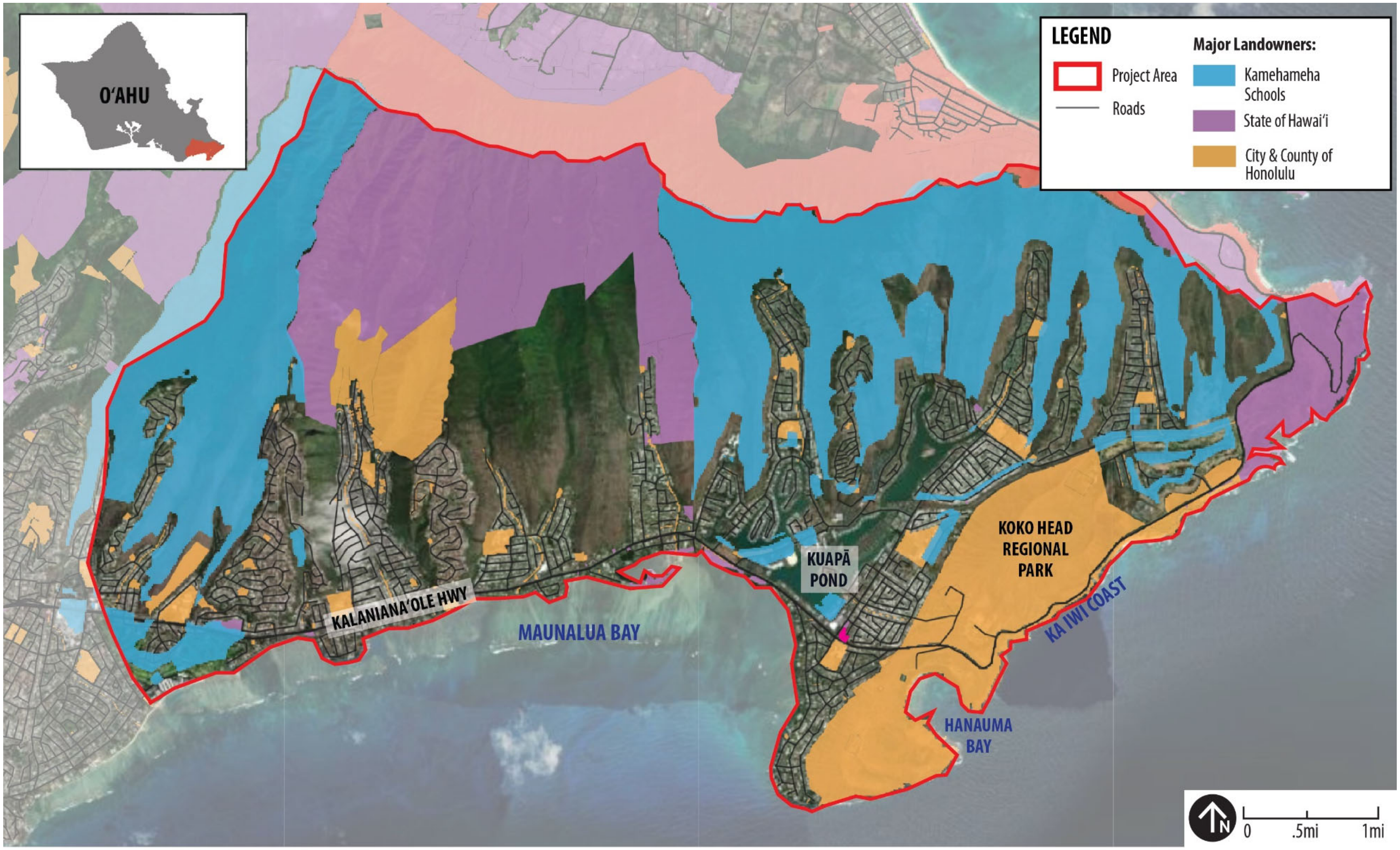
Major landowners owning more than 1% of the land in East Honolulu are shown in *Figure 2-23* and are summarized in *Table 2-11* below.

Table 2-11: East Honolulu Large Landowners[104]

Large Landowner	Acres	Percentage
Private		
Kamehameha Schools	5,108.7	34.6%
Public		
City and County of Honolulu	1,977.2	13.4%
State of Hawaiʻi	2,479.61	16.8%
TOTAL	**9,702.67**	**65.8%**

[104] Acreage based on Hawaiʻi Statewide GIS Program layer. (2022). *Government Land Ownership in the State of Hawaiʻi.*

Figure 2-23: East Honolulu Large Landowners[105]



[105] Based on Hawai'i Statewide GIS Program layer. (2022). *Government Land Ownership in the State of Hawai'i.*

2.11.2 Land Use Designations

There are 8,871.27 acres of lands within the Conservation State Land Use District (SLUD) in East Honolulu, representing approximately 60% of the district's total land area. Additionally, there are 6,170.73 acres of land within the Urban SLUD in East Honolulu, representing approximately 40% of the district's total land area. Development within the Urban SLUD primarily consists of residential development. There are no Agricultural or Rural designated lands within the East Honolulu district. State land use designations are shown in *Figure 2-2* and City and County zoning designations in East Honolulu are shown in *Figure 2-24*.

The EHSCP establishes a Community Growth Boundary (previously Urban Community Boundary) to guide development and preserve open space and agricultural areas in East Honolulu. Lands outside of the Community Growth Boundary are identified as either Agricultural Lands or Preservation Lands in the EHSCP. Given the importance of groundwater in East Honolulu, it is important to ensure that future development does not harm the district's mauka to makai groundwater flow.

Conservation Lands

Conservation lands are generally found in the district's mauka areas, some of which are within the State's Forest Reserves. Conservation lands are also found within coastal areas in the Hanauma Bay Nature Park, Koko Head Regional Park, and the Ka Iwi State Scenic Shoreline. Conservation land within the district is zoned by the City and County as Restricted Preservation (P-1). Within this zoning district, all uses and structures are governed by the appropriate State agencies. Within the General Preservation District (P-2), limited uses and structures are allowed and are maintained by the County.[106]

Agricultural Lands

The physical and economic conditions of East Honolulu limit the potential for large-scale agricultural operations.[107] Despite there being no lands classified as Agricultural SLUD within the East Honolulu district, there are approximately 140 acres of lands zoned by the City and County as Restricted Agriculture (AG-1) and General Agriculture (AG-2) (see *Figure 2-24*). These lands include two small-scale agricultural operations, one in Kamilo Nui Valley and a smaller area above Kaiser High School on the slopes of Koko Crater. In both areas, the farm lots are used for nursery and vegetable production and are on long-term leases from KS. The farm lots have largely remained commercially viable due to low lease rents.[108] However, the leasehold status and lack of land designated as Agricultural SLUD contributes to uncertainties around the future uses in these areas.

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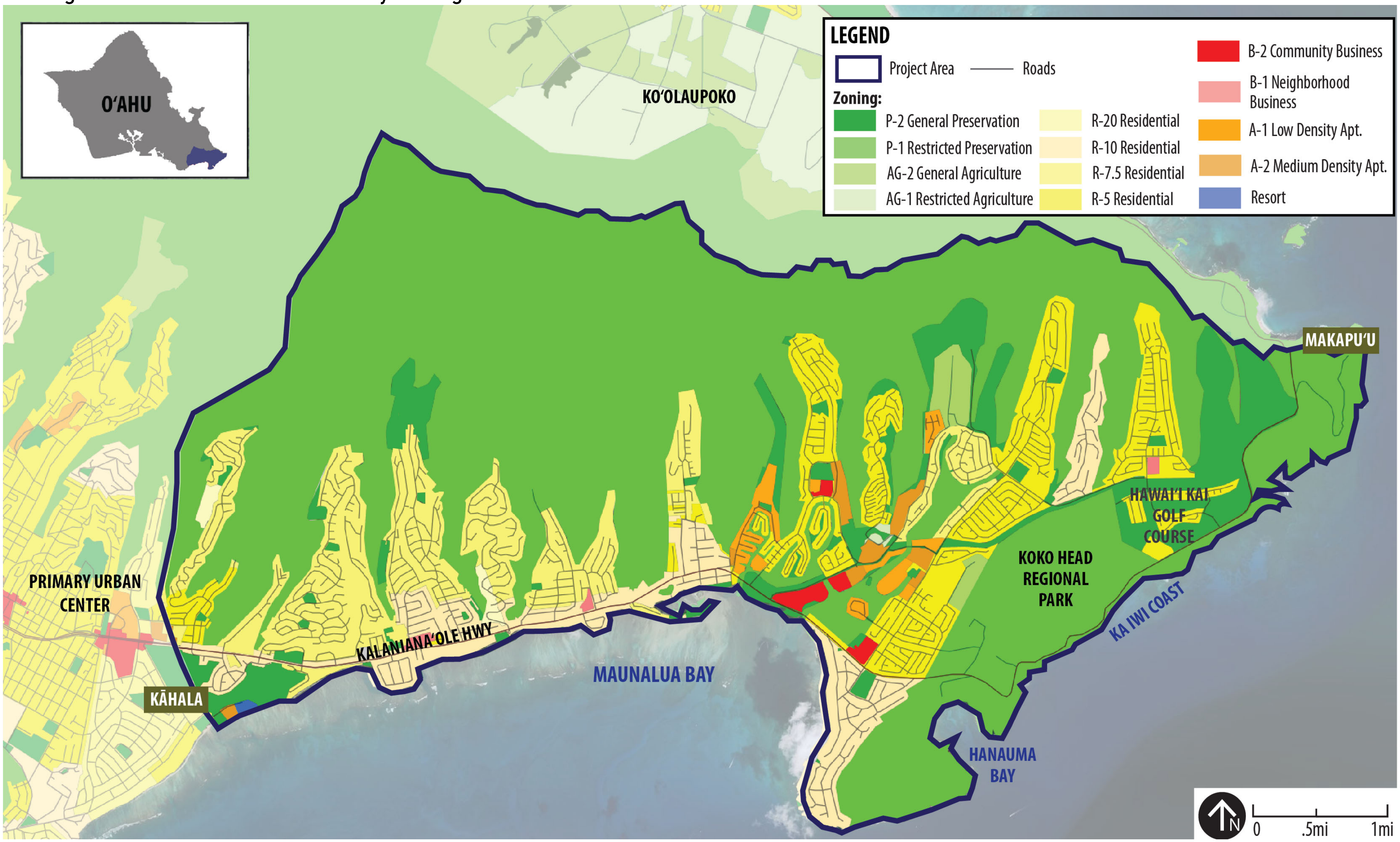
[106] HRS § 21-3. *Establishment of Zoning Districts and Zoning District Regulations*.
[107] DPP (2022)
[108] DPP (2022)

Figure 2-24: East Honolulu County Zoning Districts[109]



[109] Based on Hawai'i Statewide GIS Program layer. (2023). *City and County of Honolulu Land Use Designations as of September 2023*.

Aloha ʻĀina ʻO Kamilo Nui is a grassroots organization within East Honolulu that advocates for the community's desire to maintain the agricultural lands of Kamilo Nui Valley. The organization has identified the following goals on their website:[110]

Image: Aloha ʻĀina ʻO Kamilo Nui Nursery (Credit: Aloha ʻĀina ʻO Kamilo Nui Website)

1. *Restore Chrysanthemums of Hawaiʻi as a self-sustaining and educational non-profit nursery dedicated to restoring the Kamilo Nui Valley watershed and inspiring people to embrace aloha ʻaina as a way of life;*
2. *Develop an Ahupuaʻa Plan for this area;*
3. *Assist Kamilo Nui Valley farmers to use best management conservation practices in farming;*
4. *Increase food production in Kamilo Nui Valley and cultivate native plants;*
5. *Launch a placed-based learning program for area schools to promote responsible stewardship and caring for resources in the ahupuaʻa; and*
6. *Secure an agriculture easement for Kamilo Nui Valley.*

Residential Lands

The EHSCP recognizes three types of residential development in the East Honolulu district – all of which are found only within the Community Growth Boundary:

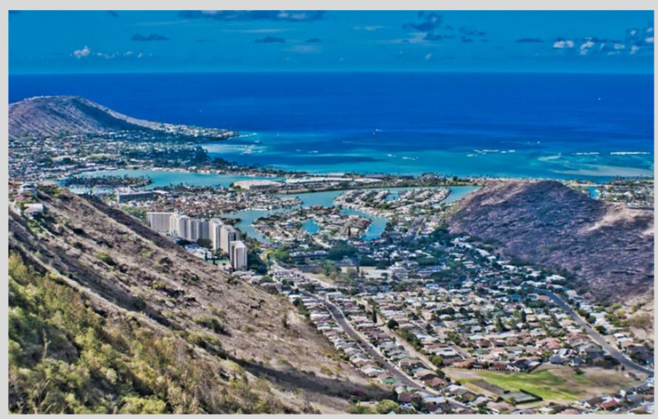


Image: Residential development in Kamilo Nui (Credit: Kyle Nishioka, via Creative Commons)

- **Residential:** Dwellings in this category consist of single-family detached and attached homes or townhouses with individual entries, with densities ranging from 5 to 12 dwelling units per acre. Residential (R-5, R-7.5, R-10, R-20) zoned land is located throughout the East Honolulu district, primarily concentrated within the region's valleys, mauka of the highway (see *Figure 2-24*). Residential areas makai of the highway are primarily zoned as R-10 Residential, which has a minimum lot area of 10,000 sq ft and typically only single-family and accessory dwelling units are permitted. However, depending on the size of the lot, in some cases detached dwelling units are also permitted.
- **Low-Density Apartment**: This category consists of predominantly of 2 to 3 story townhouse complexes, stacked flats, or low-rise apartment buildings, with densities ranging from 10-30

[110] Aloha Aina O Kamilo Nui Website. (2018). Available from: https://www.kamilonuivalley.org/.

dwelling units per acre. Low-Density Apartment (A-1) zoned land is located in Hawaiʻi Kai surrounding Kuapā Pond.

- **Medium-Density Apartment**: This category includes multi-story buildings with densities in the range of 25 to 90 dwelling units per acre. The EHSCP states that the Medium-Density Apartment designation is applied only to sites that have already been developed in a manner consistent with Medium-Density Apartment Use. Medium-Density Apartment (A-2) zoned land is located in Hawaiʻi Kai surrounding Kuapā Pond. There is also A-2 zoned land adjacent to the Kāhala Resort and Hotel.

While single-family development may produce less storm runoff than denser more urbanized areas, it can pose water resource issues. Research has found per capita water usage is typically higher within drier climates, and within single-family homes (compared to their denser, more urban counterparts).[111] The EHSCP recommends that the design of new residences consider conservation measures such as water constrictors to mitigate this.

Industrial and Commercial Lands

The Hawaiʻi Kai Towne Center is the largest retail complex in East Honolulu. According to the EHSCP, the center provides parking for approximately 1,010 vehicles. It attracts shoppers from outside the region with "big box" stores, particularly Costco. Koko Marina Shopping Center, the district's second largest complex, includes ocean recreation-related services such as boating equipment and repair and dive tour headquarters, restaurants and entertainment attractions, and other small businesses. Expansion of Costco and the addition of a storage facility has increased the commercial square footage in Hawaiʻi Kai. Commercial zones in East Honolulu appear sufficient in view of the projected population stabilization. However, an opportunity still exists for additional commercial space within existing commercial-zoned parcels, which can be accomplished through redevelopment.

Image: Costco within the Hawaiʻi Kai Towne Center (Photo Credit: Hawaiʻi.com)

With the exception of the Japan-America Institute of Management Science, most of East Honolulu's office inventory is located within and adjacent to the Koko Marina Shopping Center within two buildings, the Hawaii Kai Corporate Plaza and Hawaii Kai Executive Plaza. These plazas are located along Kalanianaʻole

[111] Barragan, Blanca. (April 7, 2015). Study: Rich LA Neighborhoods Are Using More Water Than Everyone Else. Curbed Los Angeles. Retrieved from: https://la.curbed.com/2015/4/7/9973072/rich-la-neighborhoods-use-more-water-than-everyone-else.

Highway makai of the Hawaiʻi Kai Towne Center and provide a combined total of nearly 200,000 square ft of office area in the East Honolulu district.

Resort Lands

The Kāhala Hotel and Resort (previously known as the Kāhala Hilton or the Kāhala Mandarin) is the only hotel in the East Honolulu district. No other Resort zoned land exists in the district. It opened its doors in 1964 and in 2014 the property was acquired by Resort Trust Hawaiʻi LLC (the Hawaiʻi subsidiary of a Japan-based Resort trust). In 2016, the hotel's new management announced renovation plans to improve the hotel's existing lobby and retail areas, primarily to enhance guest safety and security.[112]

Image: Kāhala Hotel & Resort (Credit: Alan Light, via Creative Commons)

Policies within the EHSCP prohibit new or expanded land areas for resorts in East Honolulu.

Educational/Institutional Lands

There are four public elementary schools in East Honolulu, one intermediate school (Niu Valley Intermediate), and two high schools (Kalani High School and Kaiser High School). Enrollment figures for these schools listed in the EHSCP show that they are operating under capacity. Due to this, the DOE does not have plans for new school construction in East Honolulu. It is expected that additional demand generated by any future residential developments can be absorbed by the existing facilities. There are also three independent schools in East Honolulu, which are either religious-affiliated or based on a particular educational philosophy. Public and private schools within East Honolulu are listed in *Table 2-12.*

Table 2-12: East Honolulu Schools

Public Schools
Elementary and Intermediate ▪ ʻĀina Haina Elementary ▪ Hahaʻione Elementary ▪ Koko Head Elementary ▪ Kamilo Iki Elementary ▪ Niu Valley Intermediate
High Schools ▪ Kalani ▪ Kaiser
Private Schools
▪ Holy Nativity School ▪ Honolulu Waldorf School ▪ Star of the Sea Early Learning Center and Elementary School

[112] Shimogawa, Duane. (December 28, 2016). Kāhala Hotel & Resort owners plan renovations. Pacific Business News. Retrieved from: https://www.bizjournals.com/pacific/news/2016/12/28/kahala-hotel-resort-owners-plan-renovations.html.

Open Space and Recreational Lands

Regional Parks

The Department of Parks and Recreation (DPR) owns and maintains 25 regional, beach/shoreline, nature, botanical garden, and community-based parks in East Honolulu (listed in *Table 2-13*). The district also has one State Park (Ka Iwi State Scenic Shoreline). In 2017, 182 acres of the Ka Iwi State Scenic Shoreline (stretching from the Hawaiʻi Kai Golf Course to Makapuʻu) was preserved in perpetuity. DLNR imposed protective deed restrictions and the City and The Trust for Public Land co-hold a conservation easement over the properties. The Trust for Public Land has conveyed the land to Livable Hawaiʻi Kai Hui, a local nonprofit that now manages the land.

Table 2-13: East Honolulu Parks

Park Name	Acres
State Park	
Ka Iwi State Scenic Shoreline	354
Regional Park	
Koko Head Regional Park	951.4
Beach/Shoreline Parks	
Maunalua Bay Beach Park	5.4
Sandy Beach Park	22.6
Kawaikui Beach Park	4.1
Kuliʻouʻou Beach Park	3.2
Waiʻalae Beach Park	4.4
Wailupe Beach Park	1.2
Nature Parks/Reserves	
Hanauma Bay Nature Park	50
Botanical Gardens	
Koko Crater Botanical Garden	200
Community-Based Parks	
Koko Head District Park	40
Kalama Valley Community Park	6
Kamilo Iki Community Park	18.5
ʻĀina Haina Community Park	6.2
ʻĀina Koa Neighborhood Park	2.4
Hahaʻione Neighborhood Park	4.1
Kamilo Iki Neighborhood Park	6.2
Koko Head Neighborhood Park	6.8
Kuliʻouʻou Neighborhood Park	4.4
Nehu Neighborhood Park	1.3
Niu Valley Neighborhood Park	2.1
Waiʻalae Iki Neighborhood Park	9.9
Wailupe Valley Neighborhood Park	2.5
Koko Kai Park	.6
Kamole Mini Park	2.2
Kōkeʻe Park	.5
TOTAL	**1,717.1**

Ka Iwi State Scenic Shoreline: This 354-acre scenic shoreline area within the Queen's Beach/Makapuʻu/Koko Head region of East Honolulu is one of five State parks on the island of Oʻahu. A master plan for the park was prepared in October 1995 by the State Department of Land and Natural Resources pursuant to House Concurrent Resolution No. 261 (1988). The State Park includes the popular Makapuʻu Point Lighthouse Trail, a 2-mile round-trip paved trail, and was a former access to the lighthouse. It also includes access to prominent natural and cultural resources, such as Pele's Chair (Kapaliokamoa).

In 2017, the 182 acres of the Ka Iwi State Scenic Shoreline (stretching from the Hawaiʻi Kai Golf Course to Makapuʻu) was preserved in perputuity. DLNR imposed protective deed restrictions and the City and The Trust for Public Land co-hold a conservation easement over the properties. The Trust for Public Land has conveyed the land to Livable Hawaiʻi Kai Hui, a local nonprofit that now manages the land.

Koko Head Regional Park: The Koko Head Regional Park is the largest City-owned park in East Honolulu. The park houses the Koko Head Shooting Complex, the only public shooting range on

Oʻahu. The EHSCP notes that expansion of Koko Head Regional Park is proposed with the addition of the Golf Course 5 and 6 properties, located mauka of Sandy Beach and Kalanianaʻole Highway. The proposed 38-acre park is envisioned to link the existing Koko Head Regional Park and the Ka Iwi State Scenic Shoreline to provide a continuous stretch of open space and recreational opportunities extending from Koko Head to Makapuʻu.

Beach Parks

East Honolulu's five existing beach parks are Maunalua Bay, Sandy Beach, Kawaikui, Kuliʻouʻou, Waiʻalae and Wailupe. Hanauma Bay is designated by the DPR as a Nature Park. According to the EHSCP, there are no current plans for additional beach parks in East Honolulu.

Image: Sandy Beach Park (Image Credit: Mike Felcyn, via Creative Commons)

Shoreline access is limited from Waiʻalae to Koko Head due to residential development makai of Kalanianaʻole Highway. This is due to the existence of shoreline armoring along much of this coastline. Armoring in this area is also believed to have contributed to accelerated shoreline erosion. According to a study conducted by the UH School of Ocean and Earth Science and Technology (SOEST), shorelines near the Kāhala Resort beach and east of the Wailupe Peninsula are eroding at a rate of up to one foot per year.[113] Lateral shoreline access is generally more intact between Koko Head and Makapuʻu.

Community-Based Parks

Park areas that serve more localized populations are categorized as community-based parks. They include district, community, and neighborhood parks as well as other smaller park areas. According to the EHSCP, there were approximately 120 acres of community-based parks in East Honolulu, of which the largest is the 40-acre Koko Head District Park. The Koko Head District Park is the most appropriate location in East Honolulu for sports and active recreation facilities designed for league play and other major sporting events. The EHSCP suggests the distribution of community-based park lands within East Honolulu is slightly uneven. The Hawaiʻi Kai Neighborhood Board area, with a 1990 population of 27,430, has a surplus

[113] UH Mānoa, SOEST, Hawaiʻi Coastal Erosion Website. *Oʻahu Shoreline Study Erosion Maps*. Available from: http://www.soest.hawaii.edu/coasts/erosion/oahu.

of approximately 34 acres of community-based parks, while the Kuliʻouʻou-Kalani Iki Neighborhood Board area has a deficit of approximately six acres.

Marinas

The Hawaiʻi Kai Marina (Kuapā Pond) consists of 260 acres of protected water located in Hawaiʻi Kai. It was originally owned by the Bishop Estate and was leased to Kaiser Development Company to develop, maintain, and manage the marina. Today, it is managed by the Hawaiʻi Kai Marina Community Association. The marina accommodates small sail and motor craft, water skiing, and fishing activities. Residences fronting Hawaiʻi Kai Marina have launching ramps and mooring facilities. There are also boating facilities adjacent to the Koko Marina Shopping center that can accommodate boats up to 40 ft in length.

East Honolulu's largest commercial centers, the Hawaiʻi Kai Towne Center, Hawaiʻi Kai Shopping Center, and Koko Marina Shopping Center front the marina on the east and west sides. The Hawaiʻi Kai Marina contributes to the district's open space network by providing visual relief from adjacent urban uses, as well as recreational value. The marina also has a cooling effect benefiting nearby commercial and residential uses. Given the activity that occurs within the Hawaiʻi Kai Marina, the management of this area and its adjacent uses are important to preserve the quality of the nearshore and coastal waters. DFM is working on a project to improve water quality and capture and treat runoff at Kuapā Pond, which is a priority area within the City's National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) program.[114]

Golf Courses

The three golf courses in East Honolulu are privately owned. The Hawaiʻi Kai Championship Golf Course and the Hawaii Kai Executive Golf Course are public, and the Waiʻalae Country Club is a members-only course. In some cases, golf courses are considered valuable open space and aesthetic resources. They also offer value by reducing flooding and non-point pollution by helping retain stormwater. However, they are highly water and land intensive, typically occupying 150 to 200 acres. Depending on location and design, new golf course development can have significant environmental impacts. New environmental management concepts for golf courses are emerging nationwide and opportunities exist for greater water conservation and alternative supply sources. The EHSCP did not support additional golf courses being developed in East Honolulu.

Upland Trails

Upland trail access for passive uses and resource gathering should be readily available to the public in accordance with Hawaiʻi Revised Statutes §115, §171, and §264. There are seventeen major trails in the mountainous areas of East Honolulu, however only five are actively maintained (see *Figure 2-25*). Four of the five are maintained by the DLNR Nā Ala Hele, the State of Hawaiʻi's trail and access program. Public

[114] DFM. (2016). Stormwater Management Program Plan. Permit No. HI S000002.

access to trails in East Honolulu is controversial because community residents and large landowners are concerned about impacts to adjacent residential homes such as loss of privacy, trespassing, litter, and parking congestion associated with the use of private roads by hikers and hunters.[115] Mountainous areas in the East Honolulu district are in the State Conservation District. The State Board of Land and Natural Resources has the authority to decide what uses are allowed in these areas. The EHSCP also states that action is needed to protect mauka resources, including control the number and range of feral animals and other alien species, prevent overuse and misuse of natural resources, and mitigate erosion.[116]

The majority of mauka Conservation land where trails are located in East Honolulu is owned by Kamehameha Schools. The Koʻolau Mountain Watershed Partnership (KMWP) plays an important role in managing these Conservation lands. In East Honolulu, KMWP's work is primarily focused within the Honolulu Watershed Forest Reserve and it conducts activities including invasive weed control and managing watershed fences as a means of ungulate control.

2.12 INFRASTRUCTURE AND UTILITIES

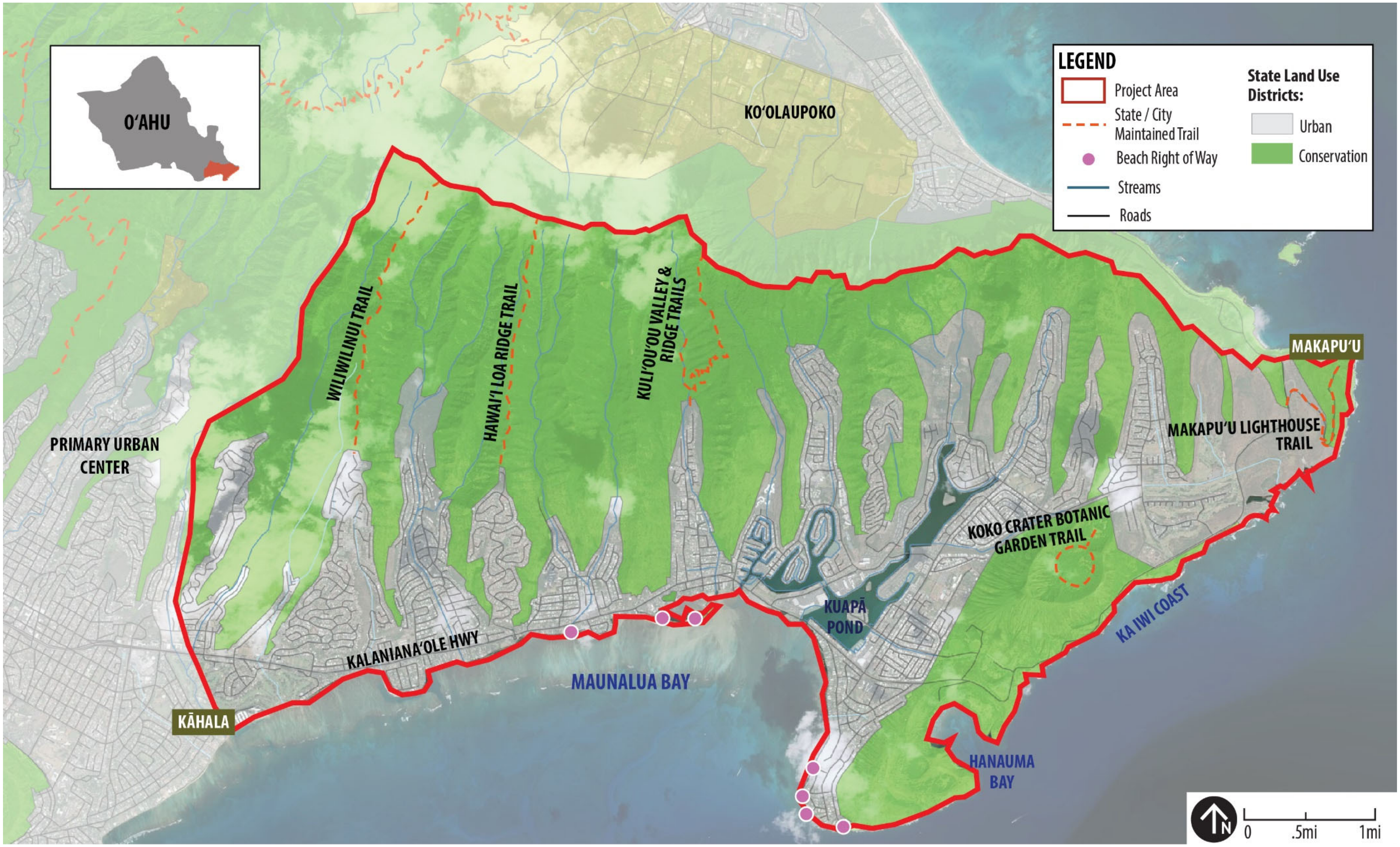
2.12.1 Roads and Highways

Kalanianaʻole Highway (State Highway 72) is the only major roadway arterial in East Honolulu. It links urban Honolulu to the communities of East Honolulu. It is also a scenic, secondary route for travel between Windward Coast communities and Honolulu. Portions of the highway were widened in the 1990's and upgraded so that the 4.2-mile stretch between ʻĀina Koa Avenue and Keahole Street consists of six lanes, with three lanes in each direction. One of the lanes is designed as a High Occupancy Vehicle contra-flow lane, thus providing four Honolulu-bound lanes during the morning peak between West Halemaʻumaʻu Street and ʻĀina Koa Avenue. According to the 2045 Oʻahu Regional Transportation Plan (2021), no major projects are planned for East Honolulu's roads for the immediate or long-term.

The EHSCP lists planning guidelines related to the dual use of roadways as drainage corridors, which includes streetscaping: *"Include more landscaping along roadways to improve aesthetics, to manage stormwater, sediment, and toxic pollutant runoff, and to filter oils and sediment from the roadway improving downstream water quality."* The 2016 Honolulu Complete Streets Manual similarly notes that while conventional stormwater controls aim to move water off-site and into storm drains as quickly as possible, stormwater management seeks to use and store water on-site for absorption and infiltration to clean it naturally and use it as a resource. Stormwater management tools include swales, planters, vegetated buffer strips, rain gardens, permeable paving, and others. Their use and application depends upon street context. DFM is currently developing design standards for these and other similar treatments.

[115] DPP (2022)
[116] Ibid.

Figure 2-25: East Honolulu Trails and Beach Rights of Way



2.12.2 Civic and Public Safety Facilities

The City and County of Honolulu operates ten Satellite City Halls island-wide. These facilities offer many essential services, such as bus pass sales, bicycle and auto registration, and driver's license renewals. A Satellite City Hall to serve East Honolulu was established in the Hawai'i Kai Corporate Plaza in 2002.There are also four libraries within East Honolulu.

The Honolulu Police Department (HPD) services East Honolulu out of the main station on Beretania Street. According to the EHSCP, 160 staff and officers are assigned to the area from Punahou Street to Makapu'u. Currently, the Honolulu Fire Department (HFD) operates fire stations in Hawai'i Kai and Wailupe Valley. The Hawai'i Kai station is equipped with a five-person engine and ladder trucks and a rescue boat. The Wailupe Valley station has a five-person engine. In addition, parts of the Kāhala area are also served by the Kaimukī station. Ambulance service, staffed by the City's Emergency Medical Services (EMS) Division, is currently provided from each of the fire stations.

Generally speaking, there are limited civic and public safety facilities within East Honolulu, and likely these do not have a great impact on water resources.

2.12.3 Electrical Power, Wastewater, and Solid Waste Handling

Electrical Power

Hawaiian Electric Company (HECO) forecasts that increased demand will create a need for additional island-wide power generation capacity by 2020. Growth policies in the O'ahu General Plan direct significant residential growth to the Primary Urban Center, 'Ewa, and Central O'ahu Development Plan Areas. Since East Honolulu's population is projected to remain stable, the EHSCP anticipates that the district will not be a major source of island wide future power demand. Thus, increasing the district's electrical power development was not recommended in the EHSCP. Nonetheless, HECO owns parcels of land throughout East Honolulu, 2.7 acres in total.

Wastewater

East Honolulu is divided into two wastewater service areas. The western portion of the region, from Kāhala to Niu Valley, is part of the East Māmala Bay service area. Wastewater from this service area is pumped to the Sand Island Wastewater Treatment Plant (WWTP) via several wastewater pump stations. From Kuli'ou'ou eastward, sewage is pumped to the privately operated East Honolulu WWTP. These wastewater treatment plants are described in further detail on the following page.

- **Sand Island Wastewater Treatment Plant:** The Sand Island WWTP is the primary treatment facility serving metropolitan Honolulu and the largest WWTP facility in the State of Hawai'i. The Sand Island WWTP currently has a design average daily flow rate of 90 MGD and peak wet weather hydraulic capacity of 271 MGD. According to the 2022 EHSCP, the wastewater generated in East Honolulu is only a very small portion of the total flow to Sand Island and was projected to increase by less than three percent between 1995 and 2000. The projected increase is expected to have a negligible impact on the capacity of the Sand Island WWTP.

- **East Honolulu Wastewater Treatment Plant:** The privately owned East Honolulu WWTP (also referred to as the Hawaiʻi Kai WWTP) opened in 1965 and is located on the mauka side of Kalanianaʻole Highway near Sandy Beach. The State Public Utilities Commission requires that the plant accept wastewater from public or private sources in the service area. The plant primarily collects wastewater from residential sources in the Hawaiʻi Kai, Kuliʻouʻou, Paikō, and Portlock communities, as well as some commercial users around Koko Marina. According to the 2022 EHSCP, the actual population served by the plant is approximately 37,000, or 74 percent of East Honolulu's 2010 population. The East Honolulu WWTP is a partial-tertiary treatment facility. The plant's design capacity is 5.2 MGD with average flows at approximately 4.5 MGD. The treated effluent is discharged via a 36-inch outfall, 1,400 ft off Sandy Beach at depths between 29 and 45 ft. The receiving waters are classified as "Class A" (generally dry, open coastal water) and "Class II" (marine bottom type) by the State DOH. Biosolids from the plant are dried and taken to a municipal landfill.

  Under the State of Hawaiʻi's rules and guidelines for wastewater systems and the treatment and use of reclaimed water, recycled water from the wastewater facility can be used for irrigation purposes. As of October 27, 1997, the State of Hawaiʻi authorized the Hawaiʻi Kai Golf Course to use this recycled water from the East Honolulu WWTP for irrigation. However, currently the effluent that is treated at the East Honolulu WWTP is too salty (due to high chloride levels) to be recycled and would require desalination.

  As previously mentioned, there have been several incidents of sewage discharge from the East Honolulu WWTP. In August 2015, a million gallons of treated but not yet disinfected sewage were discharged into the ocean near Sandy Beach after an underground electrical line failed, closing the beaches from the Halona Blowhole to Erma's Beach until bacteria levels were determined safe.[117] In East Honolulu, sewage discharges an ongoing cause for concern.

A substantial number of properties in East Honolulu dispose of wastewater via cesspools. As discussed in *Section 2.3.3*, there are an estimated 300 cesspools in East Honolulu. The improper disposal of untreated wastewater from cesspools can introduce excess nutrients and pathogens into water bodies, contributing to algal blooms, impaired water quality, and the degradation of aquatic habitats. This underscores the need to improve the district's aging wastewater infrastructure, as well as the

[117] Kuroiwa, Jared. (August 26, 2015). Sandy Beach reopens after large wastewater spill. KHON2. Available from: https://www.khon2.com/news/local-news/sandy-beach-reopens-after-large-wastewater-spill/1025551213.

need to reduce wastewater production. This can be accomplished, in part, through water conservation strategies such as low-flush toilets and leak detection and repair.

Solid Waste and Handling

In East Honolulu, there are presently no convenience centers where residents can dispose of large bulky items, although the Keehi Transfer Station will accept household rubbish and yard waste. The closest facilities for the disposal of bulky items are the Kapaʻa and Waimānalo convenience centers. There are no plans to locate a convenience center, transfer station, or landfill operation in East Honolulu.

2.12.4 Water Supply Infrastructure

In 2015, 96% of East Honolulu's potable water needs were met by BWS. East Honolulu is served by BWS's Metro Low hydraulic model sub-system (*Figure 2-26*). Within the Metro Low system, there are 52 wells, 2 shafts, and 44 source pumps. Within the boundaries of the East Honolulu planning district, there are an estimated 41 wells (listed in *Appendix C*). BWS has one monitoring well in the district.

East Honolulu's water supply is critically dependent on the integrity of the water transmission mains along Kalanianaʻole Highway, as transmission main breaks along this corridor could disrupt water service on a regional scale.

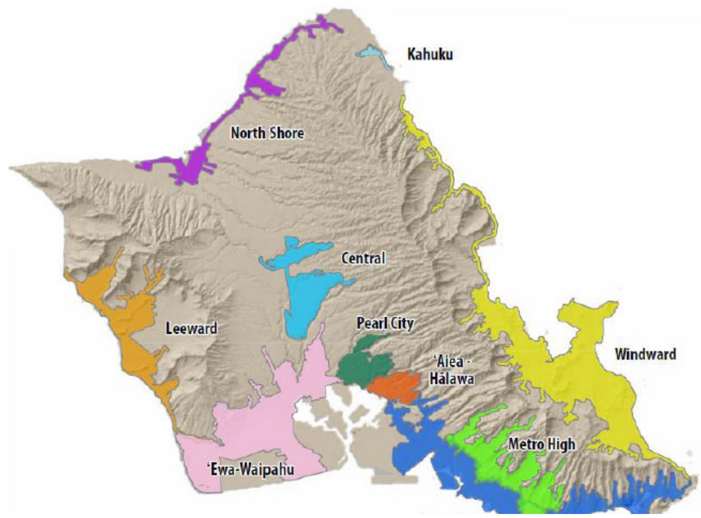


Figure 2-26: BWS Model Sub-Systems

2.13 RELEVANT PLANS

Chapter 1 provides an overview of Oʻahu's water management planning framework and references relevant County and State plans for water resource planning management. This section summarizes additional plans relevant to land use, watershed, and climate change and hazard mitigation planning in East Honolulu.

2.13.1 City and County Land Use Plans

The City's planning process is comprised of three tiers. As the first tier of planning, the General Plan establishes policy guidance for Oʻahu as a whole, with all subsequent plans and implementing regulations for the City and County of Honolulu required to be consistent with the General Plan. The second tier consists of eight regional Development Plans (DPs) and Sustainable Community Plans (SCPs). These plans relate to specific regions of the island. The third tier is comprised of the specific mechanisms to implement the two higher levels of the planning hierarchy. These include the implementing ordinances and regulations, the Subdivision Rules and Regulations, public facilities and infrastructure functional plans, and special area plans that give guidance for specific portions of the DP or SCP area.

<u>Oʻahu General Plan – Proposed Revised Version (DPP, 2021)</u>

The Oʻahu General Plan is intended to be a comprehensive statement of objectives and policies which express the long-term aspirations of Oʻahu residents and strategies to achieve them. In 2011, DPP initiated a review and update of the General Plan. The updated plan was recently finalized and adopted by the City Council on December 1, 2021 and signed by the Mayor on January 14, 2022. Objectives and policies from the 2021 General Plan that are relevant to the EHWMP are discussed in *Appendix A*.

<u>East Honolulu Sustainable Communities Plan (DPP, 2022)</u>

Oahu's eight regional plans provide the vision and implementing policies and guidelines for each of the island's planning areas. The Sustainable Communities Plans for East Honolulu, Koʻolau Poko, Koʻolau Loa, North Shore, and Waiʻanae implement the General Plan policy of sustaining their modest development patterns and rural character. The latest EHSCP was adopted in July 2022, and its vision extends to 2040. Policies within the EHSCP that are most relevant to the EHWMP are discussed in *Appendix A*.

2.13.2 Watershed-Based Plans

<u>Ocean Resources Management Plan (OP-CZM, 2020)</u>

One of the major planning initiatives of the Office of Planning Coastal Zone Management Program (OP-CZM), the Ocean Resources Management Plan (ORMP) has particular relevance for climate and coastal hazard management and adaptation. The ORMP is organized around three "Focus Areas": 1) Development and Coastal Hazards 2) Land-Based Pollution and 3) Marine Ecosystems. The three Focus Areas were developed out of the 2013 ORMP Management Priorities, as identified based on input from the public and agencies.

These Focus Areas are refinements of the 2013 ORMP Management Priorities (Appropriate Coastal Development, Management of Coastal Hazards, Watershed Management, Marine Resources, and Coral Reef). The remaining relevant Management Priorities: Ocean Economy, Cultural Heritage of the Ocean, Training, Education and Awareness, Collaboration and Conflict Resolution, and Community and Place-Based Ocean Management Practices apply broadly to all of the Focus Areas. The Focus Areas are a way to integrate ocean resource management and to provide guidance for ORMP agencies to manage ocean resources. Goals and management metrics identified in the ORMP that are relevant to the EHWMP are provided in *Appendix B*.

Hawaiʻi Watershed Guidance (OP-CZM and DOH, 2010)

OP-CZM and Hawaiʻi Department of Health (DOH) developed the Hawaiʻi Watershed Guidance (OP-CZM and DOH, 2010) to emphasize the six steps in watershed management, the nine elements of a watershed plan, and the management measures needed to demonstrate results. This guidance is intended to help those involved in managing Hawaiʻi's watersheds develop and implement watershed plans that have the greatest potential for achieving water quality goals.

Under this framework, the Hawaiʻi Watershed Guidance provides the following Guiding Principles for Watershed Management:

- **Risk-based:** Integrate risk reduction measures based on existing hazards and projected future impacts of climate change.
- **Community-based:** Consider unique social, economic, and environmental characteristics of the watershed.
- **Integrated:** Consider connections between land and sea as well as cumulative impacts of planned actions and other planning efforts.
- **Culture-based:** Build on Native Hawaiian knowledge, principles, and practices.
- **Collaborative:** Promote collaboration among stakeholders at all stages.

From this, a framework for developing watershed plans in Hawaiʻi was provided. This framework includes the nine key elements of successful watershed plans to achieve water quality improvements identified by the EPA. This framework has been key in the Oʻahu Watershed Management Planning process. These steps and sub-steps are listed below (EPA steps are marked with an asterisk (*)):

Six Steps of Watershed Planning and Implementation Process:

1. Build Partnerships
   a. Identify key stakeholders
   b. Identify issues of concern
   c. Develop preliminary goals
   d. Initiate outreach activities
2. Characterize the Watershed
   a. Gather existing data and create watershed inventory
   b. Identify data gaps and collect additional data if needed
   c. Analyze data
   d. Identify causes of water quality impairment and pollutant sources*
   e. Estimate pollutant loads
3. Set Goals and Identify Solutions
   a. Set overall goals and management objectives
   b. Develop indicators and targets
   c. Estimate load reductions expected of management measures*
   d. Identify critical areas

   e. Describe management measures needed to achieve load reductions*
4. Design an Implementation Program
   a. Develop an implementation schedule*
   b. Develop interim milestones to track implementation of management measures*
   c. Develop criteria to measure progress toward meeting watershed goals*
   d. Develop monitoring component*
   e. Develop information/education component*
   f. Develop evaluation process
   g. Identify technical and financial assistance needed to implement plan*
   h. Assign responsibility
5. Implement the Watershed Plan
   a. Prepare work plans
   b. Implement management strategies
   c. Conduct monitoring
   d. Conduct information and education activities
   e. Share results
6. Measure Progress and Make Adjustments
   a. Track progress
   b. Make adjustments

<u>The Rain Follows the Forest: A Plan to Replenish Hawaiʻi's Source of Water (DLNR, 2011)</u>

The Rain Follows the Forest (DLNR, 2011) is DLNR's plan to ensure mauka watersheds are fully functioning so that fresh water resources can be utilized and enjoyed by the people of Hawaiʻi in perpetuity. The Rain Follows the Forest (DLNR, 2011) identifies priority watersheds and outlines on-the-ground actions and projects required to protect and sustain Hawaiʻi's critical water sources.

As of 2011, only 10% of the priority watershed areas are protected. The Plan set a goal to double the amount of protected watershed areas in just 10 years. This would require approximately $11 million per year. This plan challenges Hawaiʻi's leaders to dedicate funding commensurate with the magnitude of the threats to Hawaiʻi's water supply.

The Rain Follows the Forest (DLNR, 2011) identifies an Action Plan focused on watershed partnerships. The Plan identifies watershed protection priority areas on each of Hawaiʻi's four counties. Hawaiʻi's 11 watershed partnerships provide a framework for large-scale protection. These voluntary alliances of public and private landowners and managers cooperate to protect over 2 million acres of forests that supply almost all of the hundreds of millions of gallons of fresh water needed in Hawaiʻi every year. Working across ownership boundaries, these partnerships leverage State efforts, pool funding, and provide a diverse range of local jobs.

Watershed partnership boundaries are based on priority areas identified by DLNR. Priority areas are based on climatic conditions (elevation, moisture zones, including fog and rain fall levels) as well as land cover types that provide high recharge and fog capture. On Oʻahu, The Watershed Protection Priorities are focused within the Koʻolau Mountain Range.

Appendix II of the Plan includes seven watershed protection and restoration actions to achieve the plan's overarching goal:

1. Remove all invasive hooved animals from priority I and II areas.
2. Remove or contain damaging invasive weeds that threaten priority I and II areas.
3. Monitor and control other forest threats including fires, predators, and plant diseases.
4. Restore and plant native species in priority areas and buffer areas.
5. Establish benchmarks and monitor success.
6. Educate Hawaiʻi's residents and visitors about the cultural, economic, and environmental important of conserving native forests.
7. Promote consistent and informed land use decision-making that protects watersheds.

Appendix III of the Plan lists Watershed Partnership projects. The Koʻolau Mountains Watershed Partnership (KMWP), which is applicable to the EHWMP, aims to: "Protect approximately 9,000 acres in the rainiest part of the island's Koʻolau range that provides drinking water for a majority of the State's residents." Its calls for phased fence construction and ongoing weed and pig removal, requiring a budget of approximately $1.3 million/year.

Watershed Based Plan for Reduction of Nonpoint Source Pollution in Wailupe Stream Watershed, Oʻahu (Mālama Maunalua, 2010)

The Watershed Based Plan for Reduction of Nonpoint Source Pollution in the Wailupe Stream Watershed, Oʻahu (Wailupe WBP) was developed under a DOH 319 grant to Mālama Maunalua. The plan includes four components: Watershed Characterization Report, Pollution Control Strategies Report, Implementation Strategy Report, and the Evaluation and Monitoring Report.

The Watershed Characterization Report summarizes the general environmental conditions of the watershed. In general, there is a lack of quantitative data about the nonpoint source pollutant (NPS) concentrations in runoff generated in the watershed. This report found that significant human induced alterations to the landscape have changed the rainfall runoff regime. Impervious surfaces such as roads, driveways, and rooftops prevent infiltration of rain into the ground and instead generate runoff. The upland watershed areas are dominated by invasive vegetation and contain feral ungulates, both of which increase erosion rates above background levels. The Wailupe Stream, while in a quasi-natural condition, is itself a source of sediment due in part to unstable and a degraded riparian zone.

Flooding is a concern particularly to those with property located in the 100-year floodway adjacent to the Wailupe Stream. The U.S. Army Core of Engineers is currently pursuing alternatives that would provide some level of flood protection while at the same time providing benefits to improve the quality of water the Wailupe Stream discharges into Maunalua Bay.

The Pollution Control Strategies Report identifies the sources and types of nonpoint source pollutants in the Wailupe watershed and recommends management strategies. For this discussion, the watershed was delineated into four management units (upland forest, steep slopes, urban footprint, and stream corridor) based on dominant land uses and types. Management measures were grouped into two major types; preventive and treatment controls. Preventive measures focus on controlling or eliminating pollution at the source. Treatment involves filtering, trapping, or bioremediating nonpoint source pollutants along the pollutant stream prior to reaching the receiving waters.

The Implementation Strategy identifies locations for management practices implementation and prioritizes installation within management units based on load reduction potential and relative cost. The Wailupe WBP identified the municipal separate storm sewer system (MS4) that is located within and services the urban center as a primary target for management efforts. Recommended management practices include retrofit installation of baffle boxes in the MS4 and construction of rain gardens and other practices that encourage infiltration to attenuate overland flow and trap NPS pollutants.

The Evaluation and Monitoring Plan describes three types of monitoring necessary to track management measures: implementation, baseline, and effectiveness. The monitoring of qualitative and quantitative data to these areas help determine their effectiveness and apply the findings to other watersheds. Implementation of the strategies presented in the Wailupe WBP is expected to reduce generation and transport of land-based pollutants, resulting in improved water quality and ecosystem health in Maunalua Bay. Recommended next steps include developing a comprehensive monitoring program, including management of a central database to document baseline data on key parameters.

Ka Iwi Coast Master Plan (DLNR, 1996)

The Ka Iwi State Scenic Shoreline Park is a scenic area along on Oahu's southeastern tip, which includes the Makapuʻu Lighthouse and other iconic destinations and trails and culturally significant resources and artifacts. The State Park spans along the Ka Iwi Coast from Kalolo Beach to Makapuʻu Lookout and is well-frequented by residents and visitors. The Ka Iwi Coast Master Plan (DLNR, 1996) was prepared in response to House Concurrent Resolution 261 H.D., S.D. 1 which directs DLNR to conduct a study of the establishment of a continuous scenic shoreline park from Koko Head to Makapuʻu with the basic objective of retaining the area makai of the highway in open space in perpetuity.

The Master Plan identified the following goals and objectives for the proposed park:

Goals:

- Preserve and enhance the natural, cultural, and scenic qualities of the Ka Iwi Site.
- Promote public education and appreciation of the Ka Iwi site's natural, cultural, and scenic qualities in a manner consistent with the preservation and enhancement of those qualities.
- Manage recreational activities in a manner consistent with the preservation and enhancement of the Ka Iwi site's natural, cultural and scenic qualities, and to promote public safety.

Objectives:

- Control park user volumes as a means of managing impacts on natural resources and park facilities.
- Ensure safe participation in park activities.
- Foster park user respect for natural resources and park facilities.
- Develop informational bases on which to formulate future park policy.
- Establish public education and awareness as a primary purpose of park usage.

The Plan notes that fertilizers used on golf courses and residential areas within East Honolulu, as well as runoff from the highway and other infrastructure, may be adversely affecting the nearshore water quality within the State Park. It recommends water quality and fishing impacts be continually monitored.

2.13.3 Climate Change and Hazard Mitigation Plans

Hawaiʻi Sea Level Rise Vulnerability and Adaptation Report (Climate Commission, 2017)

The Sea Level Rise Vulnerability and Adaptation Report (SLR Report), initially mandated by Act 83 in 2014 (Hawaiʻi Climate Change Adaptation Initiative) and expanded by Act 32 in 2017 (Hawaiʻi Climate Change Mitigation and Adaptation Initiative), provides the first statewide assessment of Hawaiʻi's vulnerability to sea level rise and recommendations to reduce exposure and sensitivity to sea level rise and increase capacity to adapt. Key findings of the report as it relates to East Honolulu are summarized in *Section 2.6*.

Guidance for Disaster Recovery Preparedness in Hawaiʻi (UH Sea Grant, 2019)

The Disaster Recovery Preparedness Guidance in Hawaiʻi was developed in partnership by UH Sea Grant, DLNR, the State Office of Planning, and Tetra Tech, Inc., with the purpose of supporting the implementation of resilience-focused rebuilding practices, policies, and regulations at the State and County level. This guidance document has a particular focus on developing pre-disaster recovery frameworks that incorporate opportunities to adapt to sea level rise. This guidance document is also intended to increase the capacity of coastal communities in Hawaiʻi to build back safer, stronger, smarter, and faster after natural disasters, while also conserving natural resources. The document does not recommend specific actions for East Honolulu, however the EHWMP does incorporate policies, projects, and programs to increase the district's resiliency to natural disasters and climate change impacts (see *Chapter 4*), as recommended by the Disaster Recovery Preparedness guidance.

Guidance for Addressing Sea Level Rise in Community Planning in Hawaiʻi (UH Sea Grant, 2020)

The Guidance for Addressing Sea Level Rise in Community Planning in Hawaiʻi was developed in partnership by UH Sea Grant, DLNR, the State Office of Planning, and Tetra Tech, Inc., as a companion document to Disaster Recovery Preparedness Guidance in Hawaiʻi and the Hawaiʻi Sea Level Rise

Viewer. Together, these resources serve as a toolkit to improve community resilience to coastal hazards and sea level rise. More specifically, this guidance document provides recommended practices, examples, and resources, to assist County governments in addressing sea level rise and coastal hazards as part of County planning and implementation framework. Similar to its companion document, Guidance for Addressing Sea Level Rise in Community Planning in Hawaiʻi does not recommend specific actions for East Honolulu, however the EHWMP does incorporate policies, projects, and programs to reduce the district's vulnerability to sea level rise and other coastal hazards (see *Chapter 4*). This guidance was also used to inform the water demand scenarios presented in *Chapter 3* (as it relates to the anticipated impacts of climate change on the district's future population and water use trends).

State of Hawaiʻi Multi-Hazard Mitigation Plan (Hawaiʻi Emergency Management Agency, 2018)

The State of Hawaiʻi Multi-Hazard Mitigation Plan (HMP) serves as a guide for State and local decision makers as they commit resources to reducing the effects of hazards on lives and property. It also provides assurance that the State will comply with all Federal statutes and regulations during the periods for which it receives grant funding, in compliance with the Code of Federal Regulations, and can maintain its eligibility to participate in FEMA funding programs. The HMP is intended to be a living document that is amended whenever necessary to reflect changes in State or Federal laws.

The 2018 update of the HMP includes significant updates from the latest 2013 update, particularly in the area of quantifying vulnerabilities and potential losses due to sea level rise. The HMP assesses risks and hazards, local capabilities, and mitigation strategies for the counties at-large. There are no specific recommendations for East Honolulu. There are mitigation actions which apply to BWS and watershed programs across the State, which are listed in *Table 2-14.*

Table 2-14: Relevant Hawaiʻi Multi-Hazard Mitigation Plan Actions

Action Title	Responsible Agencies	Description
Water Bags for Distribution	HI-EMA and BWS	HI-EMA will coordinate with BWS to purchase collapsible, 1-gallon water bags with an imprinted reminder to store 1-gallon of water per person per day for at least 14 days in preparation for an impending event. HI-EMA and BWS will coordinate with various partners to distribute the water bags at various events prior to the hurricane season.

Action Title	Responsible Agencies	Description
Increase water conservation, reuse, and recharge	CWRM, DOFAW, County water and wastewater departments, County planning departments	1) Implement the Hawaiʻi Water Conservation Plan; 2) Incentivize and promote reuse (e.g., grants, rebates, policies, etc.), and; 3) Protect and restore watersheds important to water supply (e.g., fencing, invasive species removal, replanting, etc.).
Support the Hawaiʻi Association of Watershed Partnerships	DOFAW	The Hawaiʻi Association of Watershed Partnerships protects and restores watersheds to ensure that water is captured efficiently to replenish and maintain our water supplies, which are especially important during drought periods. This Action will 1) seek dedicated, long-term funding for watershed protection, restoration, and maintenance and 2) support forest stewardship programs.
Develop water sources, including installation of water storage structures	DOFAW, CWRM, DOA, DHHL, County Water Supply Agencies	1) Encourage counties to develop emergency or backup water supplies; 2) Encourage County water departments to develop their own drought/water shortage plans; and, 3) Encourage counties to explore the use of alternative sources of water for non-potable uses (e.g., recycled wastewater, storm water).

2.14 SUMMARY OF CRITICAL WATER RESOURCE ISSUES AND AREAS OF CONCERN

This section synthesizes the findings of research and stakeholder consultation to identify eight critical water resource issues facing East Honolulu (*Table 2-15*). These issues provide the basis for the policies, projects, and strategies included in *Chapter 4*. The following discussion summarizes why each issue was identified as a priority issue to be addressed in the EHWMP and identifies special areas of concern where the issue is most prevalent in the East Honolulu district. Stakeholder input relevant to each of the eight critical water resource issues is also provided.

Table 2-15: East Honolulu Critical Water Resource Issues

Climate Change	Sea Level Rise	Nearshore Water Quality	Water Conservation Efforts
Protecting Traditional and Customary Practices	Flooding and Drainage	Access to Mauka and Makai Areas	Wildfires

2.14.1 Climate Change

Climate change is expected to impact nearly all components of watershed health over the coming decades. Climate change was identified as a EWHMP critical water resource issue due to the district's vulnerability to anticipated impacts such as sea level rise, coastal erosion, and saltwater intrusion into aquifers and drainage systems. Many of the impacts of climate change are interrelated. For the purposes of identifying critical issues and special areas of concern specific to water resources in East Honolulu, climate change, sea level rise, and wildfires are addressed as separate issues, each having unique implications for water resources and watershed health. Special areas of concern related to climate change are described below.

Special Areas of Concern for East Honolulu:

- Impacts to rainfall and drinking water supply.
- Greater frequency and intensity of storms.

Stakeholder Input Regarding Climate Change:

- Many stakeholders are concerned about future water supply and the uncertainty of climate change impacts on O'ahu's water supply.
- Changes in rainfall are of particular concern to East Honolulu, due to the dry climate.
- The EHWMP should address how climate change is impacting access to traditional and cultural practices.
- Climate change is interconnected with all of the EHWMP critical water resource issues and difficult to discuss in a silo.
- The active disaster management groups in East Honolulu focus on making residents aware of the likelihood of being impacted by natural disasters, focusing on earthquakes, hurricanes, tsunamis, and flood events. The disaster groups are less active in awareness surrounding climate change and sea level rise.

Climate change impacts to East Honolulu's water resources is further addressed in *Section 2.4.1.*

2.14.2 Sea Level Rise

Much of East Honolulu's development and infrastructure is located on the district's low-lying coastal plains that are expected to be impacted by sea level rise. Current science and policy are aligned in anticipating 3.2 ft of sea level rise in Hawai'i by the end of this century. By some predictions, an increase of up to 6 ft is "physically plausible", and this trend can be expected to continue for centuries into the future.[118] With 3.2 ft of sea level rise, waves and tides will reach farther inland at higher velocity. This will cause increased flooding, coastal erosion, and salt water intrusion into ground water and underground facilities, resulting in damage to coastal communities.

Special Areas of Concern for East Honolulu:

- Increased coastal flooding and erosion.
- Coastal areas (mostly) makai of the highway
- Areas near Kuapā Pond.
- Salt water intrusion into ground water.

Anticipated sea level rise impacts to East Honolulu's water resources are further discussed in *Section 2.6.3.*

Stakeholder Input Regarding Sea Level Rise:

- Community perceptions of sea level rise risk have increased since the release of the 2017 Hawai'i Sea Level Rise Vulnerability Assessment.
- Community groups are more concerned about the increase in the frequency and severity of storms and flooding than they are about incremental sea level rise.
- Beach access along Maunalua Bay is already limited and is a contentious issue – this is likely will increase as sea level and shoreline erosion also increase.
- The EHWMP should address how sea level rise is impacting access to traditional and cultural practices.
- The Mayor's directive mandates that City agencies plan for 3.2 ft of sea level rise by mid-century. Critical infrastucture, including the State highway, should be planning for up to 6 ft of sea level rise.
- Ground water inundation and salt water intrusion should be a top priority – when water pipes become damaged they contribute to nonpoint source pollution.
- Existing seawalls and armoring would likely not be able to deal with 1-2 ft of sea level rise and high tide flooding.
- BWS has identified 21 bridges that will be impacted by sea level rise throughout O'ahu.

[118] Sweet, W.V., R.E. Kopp, R.E. Weaver, J. Obeysekera, R.M. Horton, E.R. Thieler, and C. Zervas. 2017. *Global and Regional Sea Level Rise Scenarios for the United States.* Silver Spring, MD: NOAA Technical Report NOS CO-OPS 083.

2.14.3 Nearshore Water Quality

Nearshore water quality, particularly in Maunalua Bay, was the most often discussed critical water resource issue during stakeholder consultations. Nearshore waters throughout the East Honolulu district including Maunalua Bay, Hanauma Bay, and the Ka Iwi Coast have been subject to periodic water quality advisories and beach closures by DOH due to elevated levels of bacteria, sediments, and other pollutants generated through point and nonpoint sources.[119] Given the importance of nearshore water quality in ensuring human safety, marine ecosystem health, and access to recreational opportunities, it was identified as a critical water resource issue for the EHWMP.

Special Areas of Concern for East Honolulu:

- Maunalua Bay
- Polluted runoff from developed areas
- Erosion from natural and agricultural areas
- Contamination from sewage spills and cesspools

East Honolulu's nearshore water quality is further discussed in *Section 2.4.2*.

[119] Department of Health, Clean Water Branch: https://eha-cloud.doh.hawaii.gov/cwb/#!/landing

Stakeholder Input Regarding Nearshore Water Quality:

- A lot of community and government attention is given to nearshore water quality issues, but there is less attention given to the land uses and human activities that occur mauka that impact nearshore water quality. Funding primarily supports efforts that focus on marine restoration.
- One of the largest barriers to implementing green infrastructure projects is maintenance – there often is not enough funding to maintain projects after installation.
- There is a lack of funding and expertise to implement green infrastructure on a large scale.
- It is often easier to work with private landowners on green infrastructure projects than with government agencies. This makes it difficult to implement green infrastructure on a large scale. Community groups must also focus on smaller projects because of staff and grant constraints.
- Government agencies are currently focused on filtering out larger debris that enter nearshore waters (i.e., “low hanging fruit” projects). There is less focus on limiting the nutrients, metals, and other pollutants entering nearshore waters at this time.
- The EHWMP should address the different types of pollutants coming from upland areas – agricultural, conservation, and urban uses contribute different types of pollutants.
- Government agency priorities are within Central Oʻahu, where water aquifer sources are located.
- Cesspools contribute to nearshore water pollution, but there is limited information available on the cesspools present in East Honolulu. The latest study of active cesspools in Hawaiʻi was conducted in 2008. There may be opportunities to extrapolate data on water quality impacts of cesspools from other areas to the East Honolulu district.
- DFM hopes to implement a stormwater fee in the near future. With some exceptions, the fee will apply to all property owners (both government and private). The fee amount would be based on the amount of impervious area on the property.
- Private property owners are responsible for the debris that originate from their property, including grass clippings.
- With aging infrastructure, there are opportunities to apply LID and green infrastructure technologies as these are replaced and upgraded.
- Community groups are not working within or collecting data within Kuapā Pond, as the area is privately held and managed by the Hawaiʻi Kai Marina Association. However, it is a priority area for the City’s MS4.
- Mitigating land-based pollution is a difficult and complex undertaking. It is difficult to demonstrate the before and after effects of mitigation measures on nearshore water quality.
- Mālama Maunalua focuses on removing invasive alien algae in Maunalua Bay and has had success in partnering with schools in the East Honolulu district.
- Pulama Wai was a successful project in demonstrating the benefits of green infrastucture to the greater community.

Stakeholder Input Regarding Nearshore Water Quality (Continued):

- There is interest in developing erosion and nutrient models to better understand their sources and how those pollutants are contributing to nearshore water quality.
- Most watershed strategies to-date in Hawaiʻi have focused on mitigating surface pollutants, but do not address subsurface pollutants.
- DLNR DOFAW does not have many watershed protection projects in East Honolulu – they are more active in Central Oʻahu.
  - DLNR DOFAW has a small watershed fence in the upper Wailupe Valley.
  - DLNR DOFAW is considering projects in upper Pia and Hawaiʻi Loa.
- The EHWMP should include recommendations in regards to pollutants that originate from lawns, golf courses, washing cars, gardens (chemicals, soap, and fertilizers) and end up in our water system.

2.14.4 Water Conservation and Recycling

East Honolulu's water supply is provided almost entirely by aquifer sources outside the district. While the district's population is expected to remain flat, significant population growth and development is anticipated for other parts of the island. This, and the uncertainty around climate change impacts to water supply make water conservation and recycling critical to a sustainable future water supply.

<u>Special Areas of Concern for East Honolulu:</u>

- Single-family Homes
- Commercial Development
- Agricultural Land
- Golf Courses

Water supply and demand, as well as opportunities for water conservation and recycling, are further discussed in *Section 2.3.1*.

Stakeholder Input Regarding Water Conservation and Recycling:

- Water recycling is a topic both government and community members are interested in; it is often discussed from the treatment plant level, but not from the decentralized level.
- The EHWMP should consider microclimates within East Honolulu and what types of strategies are more applicable to drier versus wetter areas.
- The EHWMP should consider green infrastructure that can conserve water, improve water quality, reduce impervious surfaces, and mitigate other factors related to climate.
- Many people often don't see their water bills (especially renters) – this impacts their water usage and habits.
- Some community members are not in favor of extreme conservation measures and believe conservation regulations unfairly impact living in drier climates. Conversely, some government agencies do not believe the per capita water consumption goals identified in the 2016 WMP are ambitious enough.
- Since water and sewer rates are linked, this leads to high water bills for community members who have high irrigation demands.
- BWS should place water supply priority on residential uses versus commercial uses. There is dispute within the community on BWS supplying water to water bottle manufacturing companies.

2.14.5 Protecting Traditional and Customary Practices

In alignment with Ka Paʻakai criteria, the EHWMP must identify opportunities to protect Native Hawaiian traditional and customary practices. The East Honolulu district was urbanized in the mid to late twentieth century, at which time many cultural sites and fishponds were damaged or destroyed for development purposes. As coastlines developed with residential and other private land uses, access to fishing and other traditional subsistence activities was curtailed. Many non-profit and community-based organizations are working to restore cultural sites and traditional practices in the district. Several of efforts are highlighted as projects and strategies in *Chapter 4.*

Special Areas of Concern for East Honolulu:

- Maunalua Bay
- Ka Iwi Coast
- Hanauma Bay-Koko Crater
- Kuapā Pond
- Kānewai Spring
- Kānewai Fishpond
- Kalauhaʻihaʻi Fishpond
- Paikō Lagoon

Protecting traditional and customary practices is further discussed in *Section 2.9*.

Stakeholder Input Regarding Traditional and Customary Practices:

- The EHWMP should address both mauka and makai wahi pana.
- There is limited archecological data on mauka cultural sites.
- There are cultural sites in upper Wailupe that should be considered.
- Maunalua.net is the community caretaker for Pahua Heiau and Livable Hawaiʻi Kai Hui is the community caretaker for the Hawea Heiau.
- The EHWMP should identify the Keawāwa Wetland as a cultural resource – it is also owned by the Livable Hawaiʻi Kai Hui.
- The EHWMP should address access to Awāwāmalu and ways to better preserve and sustain this area.

2.14.6 Flooding and Drainage

Urbanization in low-lying areas combined with climate change impacts contributes to a greater risk of flooding. This is particularly true in the East Honolulu district, where development has occurred along both steep mountain ridges and coastal plains fed by steep, narrow drainageways. Several drainageways in the district are prone to flooding during intense rainstorms, including Niu Valley, Kuliʻouʻou Valley, and Hahaʻione Valley. Flooding and drainage was identified as a critical water resource issue due to its effects on nearshore water quality issues, infrastructure and development, and human safety.

Special Areas of Concern for East Honolulu:

- Flood prone and repetitive loss areas, including:
  - Coastal areas makai of the highway
  - Wailupe Valley, Niu Valley, Kuliʻouʻou Valley, Hahaʻione Valley, and Kamilo Iki
  - Kalanianaʻole Highway
- Drainageway improvement and maintenance

Flooding and drainage are further discussed in *Section 2.5.4*.

Stakeholder Input Regarding Flooding and Drainage:

- There is a lack of understanding around whose responsibility it is to clear debris from stream channels (i.e., whether it the responsibility of the government or of private property owners).
- DFM is piloting different technologies and devices to remove larger organic debris from storm drains, such as retractable screens.
- State highways are designed to be resilient to 50-year floods. Several recent floods have been 100-year floods. These type of storm events have the potential to overwhelm infrastructure and cut off community access.
- Some community groups are calling for detention basins in the upper stream basins.
- There is interest in converted parkways and constructed wetlands in some areas on East Honolulu.
- There is more attention focused on being prepared for large flood events than there is on flood mitigation.
- There is interest in retrofitting channelized streams, but for most of the streams in East Honolulu, there is limited to no space to expand the stream channels – development lines the upper banks of the stream in the riparian zone.
- Some residents drain their pools into the storm drain.
- The first response to flooding is often hardening – there are more environmentally sustainable solutions the City should explore.
- There is interest in seeing data on septic and sewer systems and how old inlets are.
- Most of East Honolulu is classified as Zone D (undetermined flood hazards) on FEMA's flood hazard maps, which there are no regulatory guidlines for. The City is interested in identifying the flood hazards in these areas that are currently undetermined.

2.14.7 Access to Mauka and Makai Areas

Finding the balance between providing access to natural and recreational resources, maintaining the environmental quality of the land, and ensuring human safety has been a pressing concern across O'ahu. Allowing recreational activities in natural areas supports health, quality of life and traditional customary practices, however it can also result in impacts such as erosion, spread of invasive species, pollution, and damage to sensitive ecosystems, often to the detriment of streams and nearshore waters. In other places, access has been limited through privatization and shoreline hardening.

Special Areas of Concern for East Honolulu:

- Public shoreline access
- Upland trail access

Accessing mauka and makai areas, and its impacts on East Honolulu's watersheds, is further described in *Section 2.11.2.*

Stakeholder Input Regarding Access to Mauka and Makai Areas:

- There are many community complaints around public access to upland hiking trails in East Honolulu neighborhoods – some of those being impacts on parking and litter.
- Shoreline access, particularly along Maunalua Bay, is a contentious issue.
- Most upland trails are located on land owned by Kamehameha Schools.
- There are jurisdictional issues around making hiking trail improvements. Many of the trail entrances are on BWS land, while the trails themselves are primarily owned by KS and managed by the DLNR Nā Ala Hele program.
- The district's upland trails are some of the most heavily used trails on Oʻahu – particularly on the Hawaiʻi Kai side of the district.
- Illegal use of upland trails is influenced by social media, which is extremely difficult for the State to manage.
- It is costly to maintain hiking trails, and the DLNR Nā Ala Hele program has very little operational budget.
- The southern Koʻolau Mountains suffer from widespread invasive species, which is partly due to the heavy use of upland trails in this area.
- Most valleys have a hiking trail, whether or not they properly managed.
- The Wiliwilinui Trail has a controlled parking lot that has a limited number of permitted vehicles allowed, which seems to help with overuse of trails, and erosion issues.
- Kuliʻouʻou is thought to be the highest used trail in East Honolulu.
- No capacity studies have been done in regards to upland hiking trails, but DLNR knows where the issues are.
- There is community desire for safe and accessible parking along the Ka Iwi shoreline – particularly at Awāwāmalu.

2.14.8 Wildfires

Wildfires occurring during dry conditions are a significant problem on all the major Hawaiian Islands. From 2006 to 2016, wildfires burned an average of 20,000 acres per year statewide, with some years reaching close to 45,000 acres.[120] More than 99% of known wildfires are attributed to human activities. Wildfires impact watershed health in numerous ways:[121]

- In addition to threatening properties and human safety, wildfires destroy native forests and change soil chemistry, potentially threatening native species and habitats.
- Heavy rains after fires can erode topsoil, leaving some areas denuded and unable to support vegetation.

[120] Hawaiʻi Wildfire Management Organization. (2016). Hawaiʻi Wildfire Management Organization. (2016). *Hawaiʻi has a Devastating Wildfire Problem*. Available from: https://static1.squarespace.com/static/5254fbe2e4b04bbc53b57821/t/58efdb3dc534a5631775e8f8/1492114284278/wildfire+impacts_final+2016.pdf.

[121] Ibid.

- Post-fire erosion can transport sediment into streams, ultimately depositing it in the ocean. This sedimentation can smother coral reefs, impacting water quality, fisheries, and long term ecosystem health.
- Burned soil from wildfires decreases ground water recharge, affecting drinking water supplies.

Special Areas of Concern for East Honolulu:

- Upland areas
- Ka Iwi Coast
- Kamilo Nui (Mariner's Ridge)

The impacts of wildfires on watershed health in East Honolulu is further discussed in *Section 2.5.2.*

Stakeholder Input Regarding Wildfires:

- Wildfires are a lesser known problem to the community but a significant risk.

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Chapter 3:
East Honolulu Water Demand Analysis

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3 EAST HONOLULU WATER DEMAND ANALYSIS

3.1 INTRODUCTION

This Chapter provides an overview of existing water use and water supply systems in the East Honolulu planning district and presents four future water demand scenarios for East Honolulu with associated projections and implications for water supply planning. The intent is to establish an understanding of how much water is used and supplied in the district today, and how much water may be needed in the future. This analysis informs the policies, projects, and strategies that are presented in *Chapter 4*.

Image: Agricultural lots in Kamilo Nui. Water efficiency is particularly important for agricultural water users, as they typically have a higher water demand than residential water users (photo credit: Aloha ʻĀina O Kamilo Nui website).

3.1.1 Key Terms and Definitions

In order to understand the content of this chapter, it is important to establish clear definitions of key terms and concepts related to water supply and demand. These are presented in *Table 3-1***.**

Table 3-1: Key Terms Related to Water Demand and Supply

Term	Definition
Aquifer Sector Areas (ASA)	CWRM defines six hydrologic regions, or ASAs, across Oʻahu. ASAs have broad hydrogeological similarities. They also maintain hydrographic, topographic, and historical boundaries where possible.
Aquifer System Areas (ASYA)	ASYAs are subdivisions of ASAs and serve as management boundaries for the regulation and allocation of ground water resources.
BWS Water Demand	BWS is the only drinking water purveyor in East Honolulu. The term "demand" is the sum of the five-year average of BWS metered consumption and water losses. The five-year average accounts for weather fluctuations to better represent metered consumption trends over time. Water losses are the difference between source production and metered consumption. Water loss is caused by leaks, use of unmetered fire hydrant water, system flushing, and meter calibration differences between source and customer meters. Assessing the BWS metered consumption and water loss data is an effective way to determine the total BWS water demand for the East Honolulu district, as BWS water systems extend beyond the City East Honolulu district boundaries, but BWS metered consumption data can be queried specially for customers within the boundaries of the East Honolulu district.
Caprock Ground Water	Brackish water or salt water from caprock aquifers; non-potable.
Ground Water	Water found below the surface of the ground. Originates from rain and feeds into aquifers, springs, wells, and water tunnels. Includes non-caprock and caprock water.
Metered Consumption	The amount of BWS water used as measured by BWS in water meters serving individual consumers (i.e., residences, businesses, agricultural operations).
Per Capita Water Demand	Per capita water demand is expressed in gallons per capita per day (GPCD) and is calculated by dividing the total water demand of an area by the population, including tourists served within that area. The BWS-served population excludes users served by military and private water systems, and absent residents.
Permitted Use	The quantity of water that CWRM allocates to an individual Water Use Permit. This quantity can legally be withdrawn by the permitted user.
Potable Water	Fresh water fit or suitable for drinking that meets the requirements of the Safe Drinking Water Act.
Pumpage	The quantity of ground water pumped from wells. Pumpage data comes from self-reported monthly pumpage from well owners to CWRM; consequently, reported pumpage may underrepresent actual pumpage.
Surface Water	Water in streams, lakes, or other surface waterbodies.
Sustainable Yield (SY)	Per the State Water Code, SY refers to the maximum rate at which water may be withdrawn from a water source without impairing the utility or quality of the water source as determined by CWRM. Each aquifer's SY is defined by CWRM in the WRPP.
Water Management Areas (WMA)	Per the State Water Code, CWRM can designate a WMA when it can be reasonably determined that water resources may be threatened by existing or proposed water use. Water Use Permits (WUP), issued by CWRM, are required for all water withdrawals within WMA's, except for domestic consumption by individual users and catchment systems. The Honolulu WMA includes the ground water systems that serve East Honolulu.

3.1.2 Methodology

The process to analyze East Honolulu's water demand and supply involved the following steps:

1) **Determine current water demand/supply:**
    a. Determine baseline year;
    b. Gather current population estimates;
    c. Identify current water sources and uses;
    d. Obtain relevant data and ensure its accuracy; and
    e. Calculate current water demand and supply.
2) **Project future water demand/supply:**
    a. Gather population estimates for the year 2040;
    b. Develop four growth scenario narratives; and
    c. Calculate water demand under each growth scenario.
3) **Assess future water demand/supply projections:**
    a. Determine the difference between water supply and demand under each growth scenario; and
    b. Determine opportunities and constraints for BWS to ensure sustainable water supply to East Honolulu through objectives, projects, and strategies.

To be consistent with recent WMPs, the EHWMP uses 2015 as the baseline year to analyze current water demand in East Honolulu (summarized in *Section 3.2* and *Section 3.3*). The EHWMP uses 2010 as the baseline year to analyze future water demand in East Honolulu (summarized in *Section 3.4*). These data sets represent the most recent data available when the water demand analysis for the EHWMP was conducted. The following sections present the findings of the analysis. A more detailed description of this Report's methodology and sources reviewed can be found in *Appendix C*.

Image: Hawai'i Kai Golf Course, the largest BWS water user in East Honolulu.

3.2 EAST HONOLULU WATER AVAILABILITY AND SUPPLY SYSTEMS

3.2.1 Potable Ground Water Availability

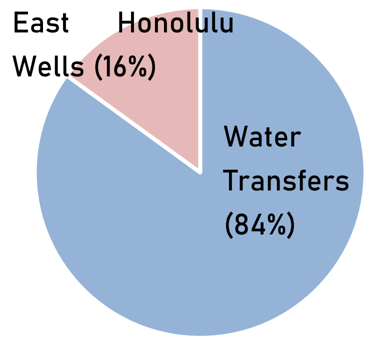


Figure 3-1: East Honolulu Potable Groundwater Supply

As discussed in *Section 2.3.1,* compared to other areas of Oʻahu, the East Honolulu planning district has limited ground water resources. This is largely due to the fact that the Waiʻalae-West and Waiʻalae-East have a relatively thin fresh water lens, and also in part due to the district's relatively low rainfall and dry climate. The majority of fresh water in East Honolulu exists between ʻAina Koa and Kuliʻouʻou. Ground water east of Hahaʻione is mostly brackish water. Because of this, approximately 84% of the district's potable ground water is supplied by water transferred from BWS's Honolulu and Windward water systems (*Figure 3-1*). In 2016, approximately 16%, or 1.32 MGD, of East Honolulu's potable water demand was provided by BWS and privately-owned wells within the district.

East Honolulu's Sustainable Yields by CWRM Aquifer System Areas

The estimate of available ground water for East Honolulu is based on sustainable yields (SY) of the aquifers it relies on. The State Water Code defines sustainable yield as the "maximum rate at which water may be withdrawn from a water source without impairing the utility or quality of the water sources."[1] Extracting amounts of ground water greater than the sustainable yield may damage the aquifer system. SYs are estimates and should not be considered exact in determining the amount of ground water that can be safely utilized.

The sustainable yield for the ASYAs in the Honolulu as provided in the 2019 Water Resource Protection Plan (WRPP) update are shown in *Table 3-2.* ASYAs within the East Honolulu district are outlined in red. See *Table 1-8* in *Chapter 1* for a tabulation of island-wide demand. The Waiʻalae-East ASYA has a sustainable yield of 2 million gallons per day (MGD); the Waiʻalae-West ASYA has a sustainable yield of 2.5 MGD (decreased from its previous sustainable yield of 4 MGD). The Honolulu ASA has a total sustainable yield of 48.5 MGD. The existing permitted allocation (53.134 MGD) exceeds the sustainable yield. This is the only ASA on the island where this is the case. However, existing water use (38.56 MGD) in the Honolulu ASA is still below the ASA's sustainable yield of 48.5 MGD.

[1] CWRM. (2019). Water Resources Protection Plan ("WRPP").

Table 3-2: Existing Demand by ASA, Honolulu Sector (2016)

Aquifer System	Sustainable Yield (SY) (MGD)[1]	Existing Permit Allocation (MGD)[2]	Unallocated SY (MGD)	Existing Water Use (MGD) 12 MAV[3]	SY minus Pumpage (MGD)	Existing Water Use as a % of SY
HONOLULU SECTOR						
Pālolo	5	5.646	-0.646	5.68	-0.68	113.6%
Nuʻuanu	14	15.165	-1.165	13.97	0.03	99.8%
Kalihi	9	8.776	0.224	5.50	3.50	61.1%
Moanalua	16	19.960	-3.960	11.50	4.50	71.9%
Waiʻalae-West	2.5	2.797	-0.297	1.75	0.75	70%
Waiʻalae-East	2	.79	1.210	0.16	1.84	7.8%
HONOLULU TOTAL	**48.5**	**53.134**	**-4.634**	**38.56**	**9.94**	**79.51%**

Table 3-2 Notes: Sustainable yields are from the 2019 Water Resource Protection Plan*;* Existing water usage is based on reported pumpage as of December 31, 2016.

3.2.2 Caprock Ground Water Availability

Basal (also referred to as caprock) ground water consists of non-potable brackish water and salt water. It is excluded from the potable ground water sustainable yield of the aquifer system area. There are two wells within the East Honolulu district (see *Table 3-5*) that have water use permits for caprock pumpage.

3.2.3 Surface Water Availability

Surface water sources include streams, lakes, and other surface water bodies. Surface water sources used to meet Hawaiʻi's water demand are listed in the 1992 CWRM Declarations of Water Use (1992).[2] As of the 1992 publication, there are no declared surface water use for the East Honolulu district. Surface water in East Honolulu is further discussed in *Section 2.4*.

3.2.4 Water Supply Systems and Permitted Use

East Honolulu is served almost entirely by domestic water supply systems owned and operated by BWS. This includes wells within the district, as well as transfers of water from the Honolulu and Windward water

[2] This database was populated based on water users' voluntary reporting conducted between 1989 and 1992; therefore, the data is outdated, incomplete, and does not provide an exact amount of available surface water.

systems. There is one privately owned well within the district that supplies domestic water and two caprock wells, as detailed below.

<u>Municipal – Honolulu Board of Water Supply Wells</u>

BWS supplies water to 97% of Oʻahu's population. In 2015, 96% of East Honolulu's water needs were met by BWS. East Honolulu is served by BWS's Metro Low hydraulic model sub-system, which includes 52 wells, 2 shafts, and 44 source pumps. BWS maintains a ground water monitoring program in which a series of index wells are monitored regularly to ensure that water levels are not decreasing, and that the chloride content of the water pumped from the aquifers is low and stable. BWS has one index monitoring well in the Waiʻalae West aquifer (Kapakahi Well, State Well No. 1746-003) and does not have any index monitoring well in the Waiʻalae East aquifer, due to its thin fresh water lens.

Within the boundaries of the East Honolulu planning district, there are an estimated 41 wells (listed in *Appendix C*). Notably, only 11 of these wells currently have a Water Use Permit (WUP). Of these wells, nine are owned by BWS. Seven of the nine BWS wells had a WUP in 2015. The total permitted usage of BWS wells in 2015 was 3.127 MGD (*Table 3-3*). One of these wells (Waiʻalae West) technically falls outside of the East Honolulu district boundary, but is still within the Waiʻalae West ASYA.

Table 3-3: BWS Potable Ground Water Permitted Uses and Pumpage in East Honolulu (2015) (MGD)

Aquifer System & State Well #	Permitted Use (MGD)[1]	Pumpage
WAIʻALAE-WEST		
Waiʻalae West (3-1747-005)[2]	0.160	0
Waiʻalae Nui (Proposed) (3-1747-003)	0.700	0
Aina Koa (3-1746-001)	0.480	0.471
Aina Koa II (3-1746-004)	0.997	0.942
Waiʻalae-West Aquifer System Total	**2.377**	**1.413**
WAIʻALAE-EAST		
Waiʻalae Iki (3-1746-002)	0.190	0
Kuliʻouʻou (3-1843-001)	0.300	0
Wailupe I (3-1745-001)	0.300	0
Pia (3-1744-004)	0	0
Waiʻalae-East Aquifer System Total	**0.79**	**0**
EAST HONOLULU TOTAL[3]	**3.127**	**1.72**

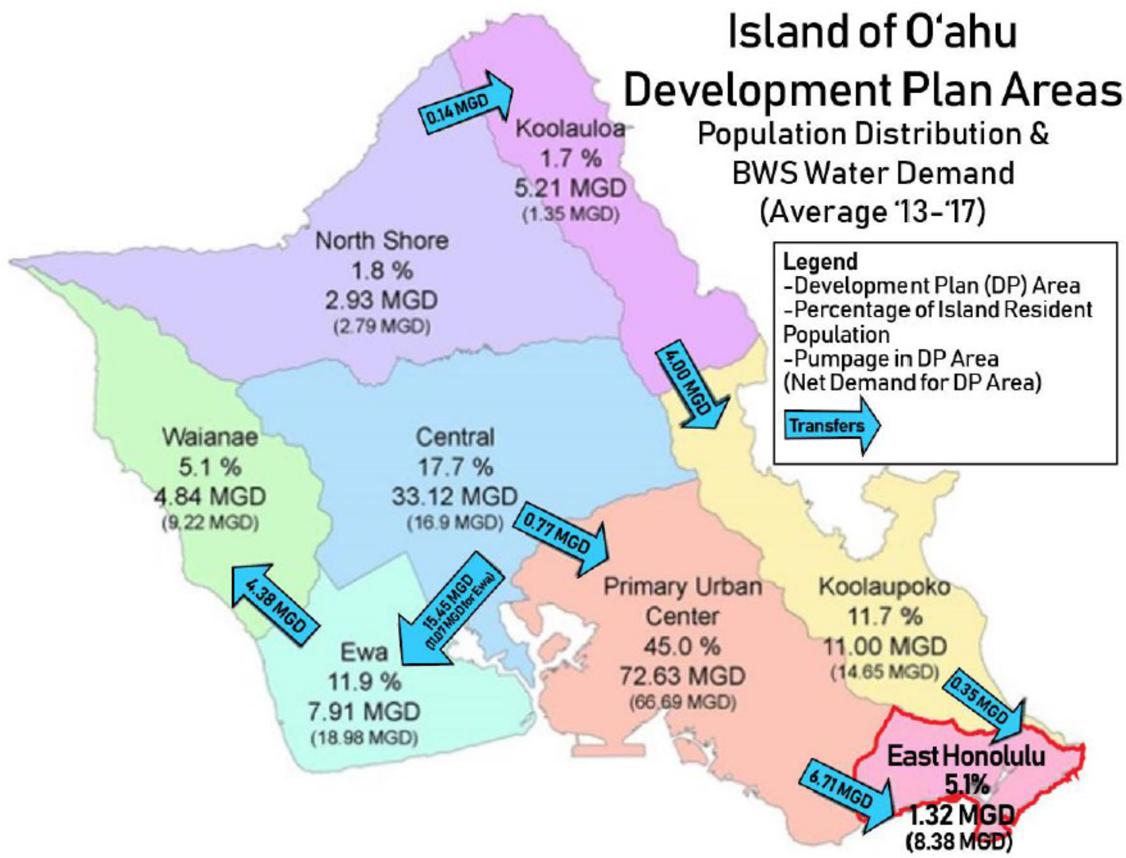
Table 3-3 Notes:

1 Permitted use amounts are from the CWRM Water Use Permit Index as of 2015. Permitted uses account for water withdrawals from potable ground water aquifer system areas.
2 Water pumped from Waiʻalae West is allocated to water users in the PUC. All other wells in the Waiʻalae East and West aquifers provide water to water users in East Honolulu.
3 East Honolulu's 2015 total pumpage (1.72 MGD) – as shown in *Table 3-2* – is slightly higher than the total district pumpage (1.32 MGD) shown in *Figure 3-2*. This is because *Table 3-2* is based solely on 2015, whereas *Figure 3-2* is based on the 2013-2017 five-year average.

BWS Water Transfers Between Planning Districts

The BWS water "system" is integrated and extends from Hau'ula around Makapu'u to Wai'anae. The integrated water system allows for transfer of ground water between planning districts. Existing and future water transfers through 2040 are set by the EHWMP and are based on estimates of population served and in-district water supply and demand. *Figure 3-2* summarizes BWS water transfers between 2013 to 2017 as a five-year average. According to the figure, total BWS water demand in East Honolulu (outlined in red) was 8.38 MGD. Approximately 80% of the district's total water demand (6.71 MGD) was supplied by water transferred from the Honolulu water system. An average of 0.35 MGD was transferred from Windward sources. 1.32 MGD was supplied by water pumped within East Honolulu.[3]

Figure 3-2: BWS Water Transfers Map (2013-2017 Average) (MGD)[4]



[3] Proportions of Honolulu and Windward transfers are subject to change from year to year. Data shown in *Figure 3-2* is based on averages from 2013 to 2017.

[4] BWS. (2016). WMP.

Private Potable Wells

In addition to BWS, private entities can also supply water. In 2015, there was one privately owned potable well with a WUP in the East Honolulu district, the Waiʻalae Golf Course well, which provides water for irrigation purposes.[5] The well is owned by Kamehameha Schools. The total permitted use of this well in 2015 was 0.460 MGD (*Table 3-4*).

Table 3-4: Private Potable Ground Water Permitted Uses in East Honolulu (2015)(MGD)

Aquifer System & State Well #	Permitted Use (MGD)[1]	Pumpage
30105 Waiʻalae-West		
Waiʻalae Golf Course (3-1646-001)	.460	0.296
EAST HONOLULU TOTAL	**.460**	**0.296**

Table 3-4 Notes::

1 Permitted use amounts are from the CWRM Water Use Permit Index as of 2015. Permitted uses account for water withdrawals from potable ground water aquifer system areas.

Private Caprock Wells

There are two private salt water caprock wells, the Kāhala Hilton 1 and Kāhala Hilton 2, which are both owned by the Kāhala Royal Corporation and are most likely used for the dolphin pools at the Kāhala Resort. In 2015, these two salt water wells had a combined permitted use of 2.88 MGD (*Table 3-5*). However, neither of these wells reported any pumpage in 2015.

Table 3-5: Caprock Ground Water Permitted Uses in East Honolulu (2015)(MGD)

Aquifer System & State Well #	Permitted Use (MGD)[1]	Pumpage
30105 Waiʻalae-West		
Kāhala Hilton 1 (3-1646-005) **Kāhala Hilton 2 (3-1646-006)**	2.88	0.00
EAST HONOLULU TOTAL	**2.88**	

Table 3-5 Notes: Caprock ground water consists of brackish and salt water and does not apply to the fresh water (potable) ground water sustainable yield of the aquifer system area.

1 Permitted use amounts are from the 2015 CWRM Water Use Permit Index.

[5] There were 20 private wells listed in the CWRM inventory of wells that had no WUP in 2015.

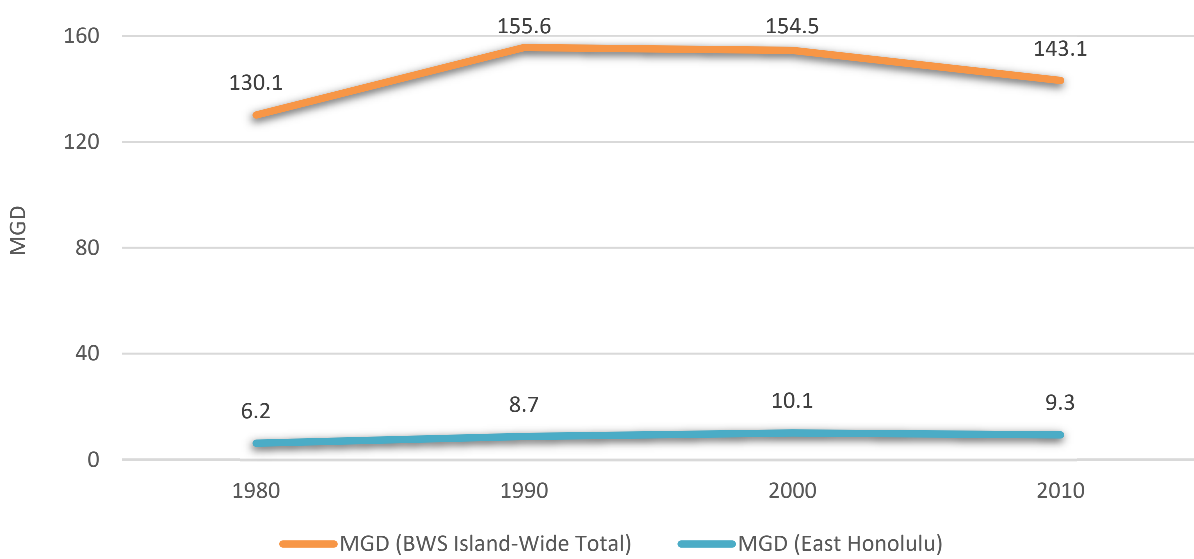
3.3 EAST HONOLULU WATER DEMAND

Water demand for East Honolulu is based on data from BWS and CWRM. It is important to note the distinctions between these sources. As defined in *Section 3.1.2*, BWS water demand is calculated based on a five-year average of metered consumption and water losses (Project #27 in *Chapter 4* provides further details on water losses). CWRM pumpage data is based on well pumpage reported monthly by users (including BWS) to CWRM in a given year. BWS water transfers from outside the district provide another source. This section describes historical and current water demand in East Honolulu based on these sources.

3.3.1 Historical Water Demand

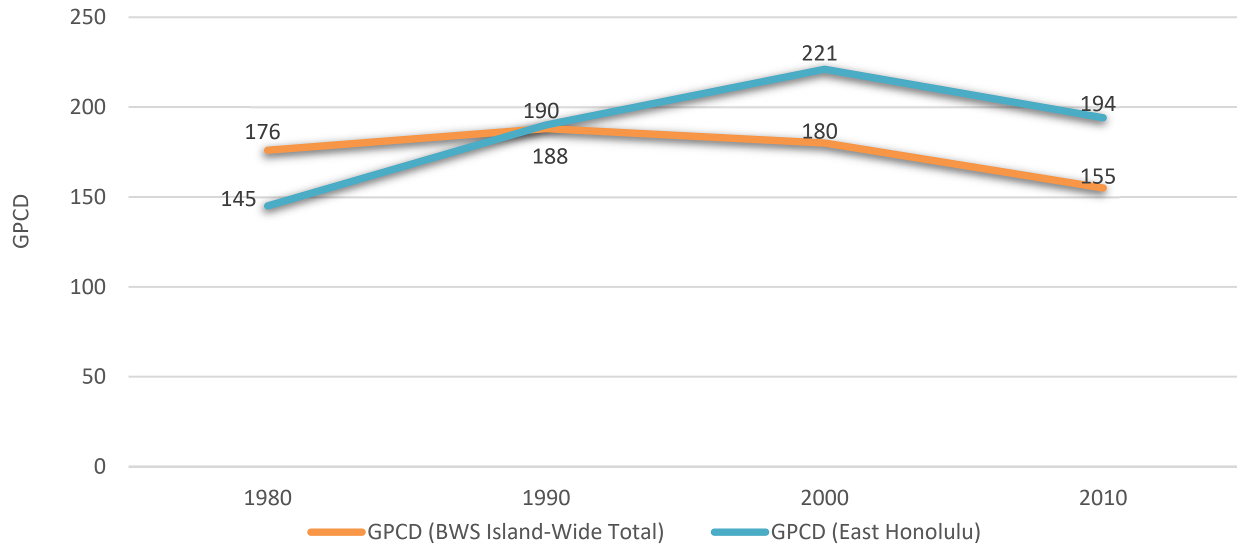
Historical BWS water demand data shows that from 1980 to 2000, district-wide BWS water demand increased from 130.1 MGD to 154.5 MGD (18.75%). Per capita water demand also increased significantly from 145 gallons per capita per day (GPCD) in 1980 to 221 GPCD in 2000. This is likely due to the district's development boom during latter half of the 20th century. Following the implementation of water conservation programs by BWS in the 1990's and 2000's, water demand has been steadily decreasing, both island-wide and in East Honolulu. East Honolulu's historical, district-wide water demand is shown in *Figure 3-3*. East Honolulu's historical, per capita water demand is shown in *Figure 3-4*. Data from BWS' entire system is shown for comparison.

Figure 3-3: Historical BWS Average Water Demand in East Honolulu (1980-2010) (MGD)[6]



[6] BWS (2016). WMP.

Figure 3-4: Historical Per Capita BWS Water Demand in East Honolulu (1980-2010) (GPCD)[7]



3.3.2 Existing Ground Water Demand

Existing water demand for East Honolulu is based on data from a number of different sources:

- Transfer data from BWS indicates how much water is transferred into the district from other areas, and how much is supplied from sources within the district, based on a five-year average of data collected for the years 2013-2017.
- Pumpage data from CWRM provides information on how much water was pumped in during the baseline year (2015) from permitted wells (both potable and caprock) and reported to CWRM.
- BWS water demand data provides information on how much water was produced from BWS sources, and how much use was recorded through BWS water meters. The data is presented as a five-year average for 2013-2017, accounting for water losses (i.e., the difference between production and metered use).

Based on these combined sources, the existing water demand for the East Honolulu district for baseline year 2015 is estimated as 7.336 MGD. This demand is provided entirely from potable ground water wells, because as previously noted, there are no surface water sources in the district, and there was no reported caprock pumpage in the district for the baseline year of 2015.

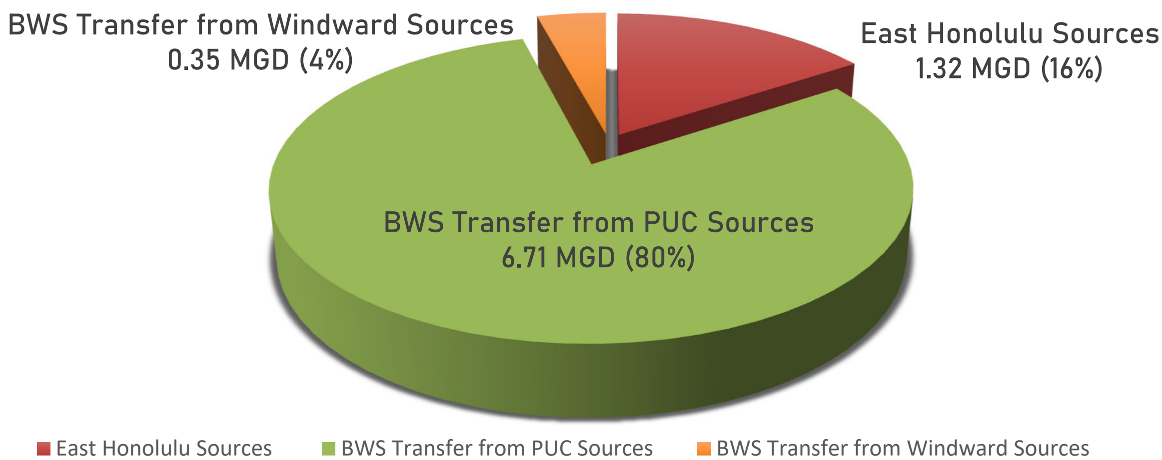
Water Transfers

As previously mentioned, according to the BWS Water Transfer map (2013 – 2017 average), the majority of East Honolulu's water demand is met by water transferred by BWS from Honolulu and Windward water

[7] BWS (2016). WMP.

systems, with only 16% of water supplied by in-district wells. *Figure 3-5* provides a snapshot of the East Honolulu district's water demand for 2015 based on the BWS Transfer Map.

Figure 3-5: Existing Water Demand (MGD) in East Honolulu based on BWS Transfer Map (2013-2017 Average)



Total Existing Water Demand in East Honolulu: 8.38

Figure 3-5 Notes: Transfers were calculated using 2013-2017 island-wide averages.

Reported Well Pumpage

Pumpage refers to the amount of water pumped from wells within the district that is reported to CWRM monthly. In 2015, a total of 1.72 MGD of water was reportedly pumped within East Honolulu (*Table 3-6*). The district's total pumpage is approximately 2.78 MGD lower than the district's total sustainable yield.

When considering the pumpage data, it is important to keep in mind that the data represent just one year and do not necessarily reflect long-term trends. Pumpage may fluctuate due to weather (i.e., more pumpage is required in relatively dry years and less is required in wet years). In some years, some sources may have been out of operation, requiring other sources to temporarily increase pumpage to compensate.

Table 3-6: Comparison of Ground Water Pumpage to Permitted Usage (PU) and Sustainable Yield (SY) in East Honolulu (MGD)

Aquifer System Area (ASYA)	BWS		Private		Total PU	Total Pumpage	SY[3]	Unallocated SY[4]	SY Minus Total Pumpage
	PU[1]	Pumpage[2]	PU[1]	Pumpage[2]					
HONOLULU SECTOR AREA									
Waiʻalae-West	2.337	.942	.46	.297	2.797	1.72	2.5	-.297	0.78
Waiʻalae-East	0.79	0.00	0.00	0.00	.79	0.00	2	1.210	2
TOTAL[5]	3.127	0.942	0.46	0.297	3.587	1.72	4.5	0.913	2.78

Table 3-6 Notes:

1 Permitted use amounts are from the CWRM Water Use Permit Index as of 2015. Permitted uses account for water withdrawals from potable ground water aquifer system areas.

2 BWS and private wells with WUPs are listed in *Table 3-4* and *Table 3-5*. Pumpage totals were derived from the reported monthly pumpage data reported to CWRM in 2015. See *Appendix C* for more detail on how pumpage data was derived.

3 The 2019 Water Resource Protection Plan decreased the sustainable yield of the Waiʻalae West aquifer from 4 MGD to 2.5 MGD.

4 The "Unallocated Sustainable Yield" for an aquifer system area is the sustainable yield minus the total permitted use for the entire aquifer system area.

5 East Honolulu's 2015 total pumpage (1.72 MGD) – as shown in *Table 3-3* – is slightly higher than the total district pumpage (1.32 MGD) shown in *Figure 3-2*. This is because *Table 3-3* is based solely on 2015, whereas *Figure 3-2* is based on the 2013-2017 five-year average.

BWS Water Demand

To determine water demand, BWS utilizes a five-year average, rather than data from a single year. This helps account for fluctuations due to weather and other causes and better represents metered consumption trends over time. Based on the average metered consumption from 2013 to 2017, the current BWS water demand for the East Honolulu district is 8.38 MGD.

BWS water demand in East Honolulu was also quantified for the subdistricts of Waiʻalae Nui, Wailupe, Niu, Kuliʻouʻou, Hahaʻione, Kamilo Iki, Koko Crater, Portlock, and Hanauma (*Table 3-7*). These subdistricts roughly correlate to the district's ten watershed boundaries. Note, *Table 3-7* represents total subdistrict water demand, not per capita calculations. The subdistricts with the highest overall demand in 2015 were Wailupe, Kamilo Iki, and Hahaʻione. Hanauma and Kuliʻouʻou had the lowest overall water demand in 2015.

Table 3-7: East Honolulu BWS Water Demand by Subdistrict (2013-2017 Average in MGD)

Sub-Area	Demand (MGD)	Percent
Wailupe	1.83	21.83%
Kamilo Iki	1.51	18.02%
Haha‘ione	1.13	13.53%
Koko Crater	1.07	12.77%
Kamilo Nui	0.73	8.67%
Wai‘alae Nui	0.60	7.14%
Niu	0.54	6.33%
Portlock	0.53	6.19%
Kuli‘ou‘ou	0.37	4.45%
Hanauma	0.07	0.78%
TOTAL	**8.38**	**100%**

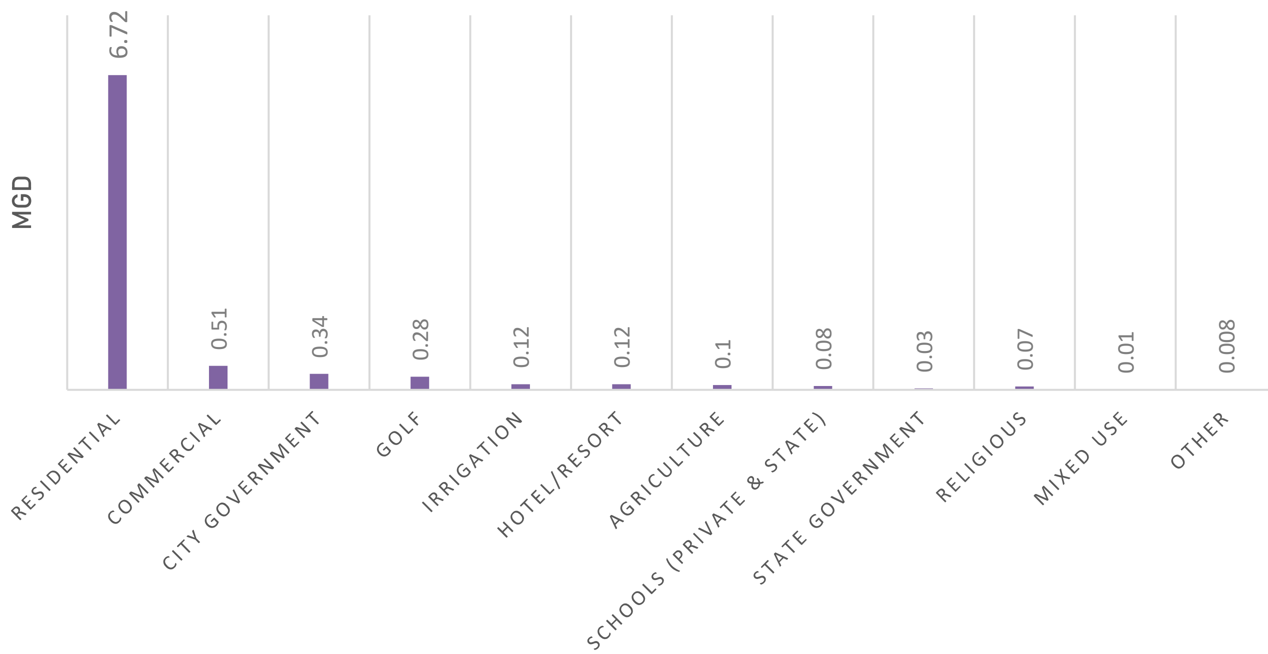
Table 3-7 Notes: Water demand is based on the average metered consumption from 2013 to 2017. Water demand accounts for estimated water losses.

3.4 EAST HONOLULU WATER USES

3.4.1 BWS Water Use Types

BWS classifies water users into the following categories: residential, commercial, City government, State government, Federal government, hotel/resort, golf, industrial, schools, irrigation, religious, agriculture, and other. *Figure 3-6* presents water demand in East Honolulu by BWS user type. Federal government and industrial users were not included in the figure because of their minimal use in East Honolulu (less than 0.0002 MGD).

Figure 3-6: BWS Potable Water Demand in East Honolulu by Use Type (Five-Year Average, 2013-2017 in MGD)



Based on the average metered consumption from 2013 to 2017, residential water use, including single-family, multi-family, and mixed residential uses, was by far the largest type of use in East Honolulu, with demand totaling 6.72 MGD, or about 80.12% of the total BWS demand. Of this, 82% of the demand was from single-family dwellings, which reflects the overall development pattern of the area (*Figure 3-7*). Commercial use represented the second highest type of demand with 0.51 MGD (6.06%), uses by City government were third, with 0.34 MGD (4.23%), and golf courses were fourth, with 0.28 MGD (3.63%). All other uses make up less than 2% of East Honolulu's share of water demand.

Table 3-8 lists the top ten largest water users in the East Honolulu district. The Hawaiʻi Kai Golf Course was the top BWS water user in the East Honolulu district in 2015. Other large water users include commercial establishments, as well as higher-density residential complexes.

Figure 3-7: Residential Water Demand in East Honolulu (2013-2017 Average) (MGD)

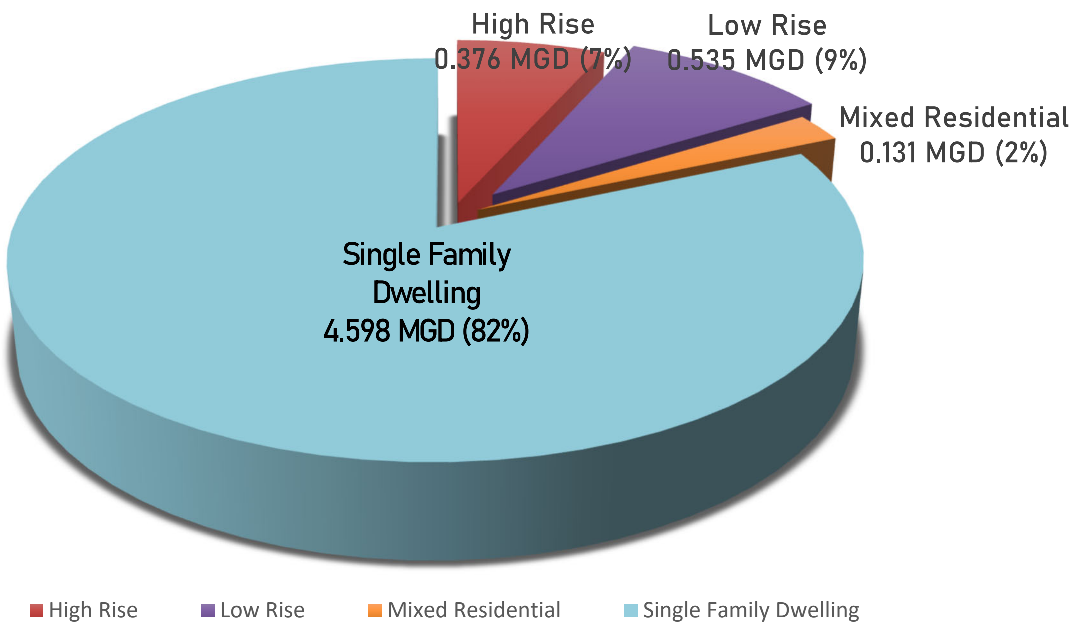


Table 3-8: Largest BWS Water Users in East Honolulu (2013-2017 Average)(MGD)

Water User	Use Type	Average Demand (MGD)
YHB Hawaiʻi Kai, LLC (Hawaiʻi Kai Golf Course)	Golf Course	0.284
Department of Parks and Recreation	City Government	0.177
Peninsula at Hawaiʻi Kai	Mixed Residential	0.133
Harvest Hawaiʻi LLC	Commercial	0.127
Resort Trust (The Kāhala Hotel and Resorts)	Hotel	0.096
Mauna Lani	High-Rise	0.092
Kāhala Nui	Low-Rise	0.084
Lalea at Hawaiʻi Kai	High-Rise	0.056
Kaluanui Maintenance Association	High-Rise	0.055
Kalele Kai Aoao	High-Rise	0.053
Kāhala Beach	Low-Rise	0.051
Hawaiʻi Kai Shopping Center	Commercial	0.032
Naniwa Gardens	High-Rise	0.031
Hawaiʻi Kai Towne Center	Commercial	0.031

3.4.2 CWRM Water Use Categories

CWRM's water use categories include Municipal, Military, Agriculture, Industrial, Irrigation, and other uses. Municipal uses include domestic uses (i.e., single-family homes, multi-family dwellings, and mixed-use buildings), as well as non-residential uses (e.g., commercial, resort, institutional, etc.). Until recently, CWRM used additional water use categories that included Domestic Residential and Domestic Non-Residential. The EHWMP is the first WMP to use the new, simplified municipal water use categories in its water demand analysis.

Table 3-9 below presents 2015 water use by CWRM category (includes all ground water sources). Refer to *Appendix D* for more details on calculations.

Table 3-9: Total East Honolulu Water Use by CWRM Category (2015)(MGD)

Category	Quantity (MGD)	Percent
Municipal (BWS)[1]	8.38	96.59%
Military	0	0%
Agriculture	0	0%
Industrial	0	0%
Irrigation[2]	0.296	3.41%
Other	0	0%
TOTAL	**8.676**	**100%**

Table 3-9 Notes:

1 Reflects the five-year average metered consumption of all BWS water in East Honolulu for 2015.

2 Reflects the 2015 pumpage of the private Waiʻalae Golf Course Well, which is used for irrigation purposes.

3.4.3 Land Use and Water Demand

Per capita water demand is often correlated with land use. The following land uses are associated with higher water usage, making them special areas of focus for water conservation efforts in East Honolulu:

- **Single-family Homes** typically have higher water demand given their relatively larger building footprint and need for irrigation (compared to multi-family dwelling units and apartments). Single-family homes make up the bulk of the district's residentially zoned areas (see *Figure 2-24* for East Honolulu zoning designations). Neighborhoods in the East Honolulu district, such as Kāhala, Waiʻalae Iki, and Hawaiʻi Loa, tend to have larger lot sizes and amenities such as pools, and also experience drier climates compared to other neighborhoods in the district. With no new housing or population growth anticipated for East Honolulu, conservation efforts will need to focus largely on existing homes. This includes incentives and rebates for retrofitting homes with low-flush toilets, flow constrictors, and other water-conserving devices. Education and incentives can also be used to encourage the use of indigenous, drought tolerant plants in landscaping, and installation of rain barrels to collect water for non-potable use.

- **Commercial Development** also has a relatively high water demand due to large building footprints. Several small commercial centers exist in East Honolulu, the largest of which is the Hawaiʻi Kai Towne Center. While no new commercial development is anticipated for the district, redevelopment or renovation of existing shopping centers may provide an opportunity to survey and audit water use for the presence of low flow fixtures and efficient water use. Chilled water air conditioning water efficiency is another area for potential conservation. There fixtures may be converted by way of plumbing code updates, financial incentives, and building renovations.

- **Agricultural Land** has relatively high water demand due to the need for irrigation, as well as activities such as washing produce. The Federal Food Safety Modernization Act (FSMA) enacted more stringent water quality standards for irrigation water used on food crops, which may increase potable water demand by Hawaiʻi's farms.[8] Notably, there are several nurseries in Kamilo Nui Valley that are not required to meet FSMA standards due to their annual food sales being less than $25,000. BWS provides subsidized agricultural rates to support local agriculture (applicable for farmers using more than 6,000 gallons of water per month). BWS is currently exploring ways to provide funding and support to farmers to help them decrease their water consumption, such as such as weather-based irrigation controllers, soil moisture sensors, sub-meters to monitor water use, identify leaks, right sizing water meters, mulches, and technical assistance to develop water and soil conservation plans for agricultural operations. BWS has initiated consultation with farmers in Hawaiʻi Kai and Kamilo Nui regarding potential incentives for conservation.

- **Golf Courses** have the benefits of preserving open space and providing natural flooding buffers, but they also use high amounts of water, largely for irrigation purposes. There are three 18-hole golf courses, totaling 328.9 acres, in the East Honolulu district. The EHSCP recommended using recycled water from the East Honolulu WWTP to irrigate the Hawaiʻi Kai Golf Course. While the State has previously authorized the Hawaiʻi Kai Golf Course to use recycled water from the WWTP for irrigation, this authorization has now lapsed. It has also not yet proven technically feasible to do so due to the high salinity levels of coastal wastewater treatment facilities.[9] Moreover, salt water infiltration is expected to worsen as sea level rises. See the Project #30 description in *Chapter 4* of the EHWMP for further discussion on these technical and economic challenges and potential ways to overcome these barriers.

[8] T. Yang and M. Swinburne. (2016). *New Produce Safety Regulations*. Public Health Reports. Doi: 10.1177/0033354916669495

[9] Ahuja et al. (2014). *Water Reclamation and Sustainability*. Elsevier.

3.5 FUTURE WATER DEMAND

The Statewide Framework for Updating the Hawaiʻi Water Plan (2000) requires that each County Water Use and Development Plan develop scenarios to project future water demand. The scenarios provide an estimate of how much water will be needed to ensure a sustainable water supply for future growth. They help provide indications as to if and when additional source development and infrastructure upgrades may be necessary, concurrent with the district's projected growth rate. The projections can also help to guide future land and water use decisions.

Four scenarios for East Honolulu are described in this Chapter, based on varying levels of projected demand: Low Demand, Mid Demand, High Demand, and Ultimate. The Low, Mid, and High scenarios project the future water demand for East Honolulu to the year 2040. The Low Demand scenario is identified as the "Base Case/Most Probable" scenario based on current trends and projections. In addition to the Low, Mid, and High Demand scenarios, an Ultimate demand scenario was developed that envisions East Honolulu in the year 2100 and identifies important planning considerations for the water needs of the district through the end of this century. Two climate-based projections are provided for the Ultimate Demand Scenario, one that incorporates a "dry" trend and another that assumes a "wet" trend for rainfall.

3.5.1 Planning Assumptions

Development of the four scenarios was informed by analysis of current data from BWS and CWRM, as well as a review of policies and projections contained in key planning documents and technical studies. These assumptions are reflected in some way throughout all the scenarios. Where the scenarios differ from the baseline assumptions contained in these plans, it is noted within the scenario description. Notably, given the already built-out nature of the East Honolulu district, and EHSCP policies containing future growth within the community growth boundary, the differences between the water demand projections for the Low Demand and High Demand Scenarios are minimal, especially when compared to those for other planning districts on Oʻahu. Key assumptions for the scenarios are summarized below.

East Honolulu Population and Development Potential

The EHSCP is the guiding policy document for the East Honolulu district through 2040. The EHSCP sets policies for land use, development, infrastructure, environment, and other aspects of the area. It also establishes projections for population, jobs, and housing, and articulates the desired community vision for the area. The EHSCP vision for East Honolulu notes that the population is expected to remain stable, and that there is limited development anticipated in the district:

> *"**The Vision to 2040 –** Through 2035 and 2040, East Honolulu is projected to experience population stabilization. According to projections by the Department of Planning and Permitting (DPP), East Honolulu's population is expected to remain stable at approximately 50,000. The region is expected to experience a growing elderly population and an associated decrease in average*

household size. Due to the expected population stabilization, there is not anticipated to be significant demand for additional commercial development or major investments in infrastructure and public facility capacity in East Honolulu. As a consequence, job growth in East Honolulu is expected to be minimal, remaining close to 2010 levels at approximately 10,400 jobs.

Beyond 2040 – *There will be little residential development capacity available in East Honolulu beyond 2040. Capacity will be limited to infill and redevelopment opportunities. After 2040, the potential impacts of climate change will become more evident, requiring East Honolulu to actively manage adaptation and improve resiliency to hurricane winds, coastal erosion, inundation, and flooding."*

The EHSCP indicates the East Honolulu district is already almost fully developed within the designated Community Growth Boundary, and proposes no changes to the Community Growth Boundary. The EHSCP states that there is sufficient capacity to accommodate the district's anticipated growth to 2040 and identifies about 300 new housing units as probable or possible under existing zoning. The EHSCP projections for population and housing are incorporated as baseline assumptions into the EHWMP scenarios, unless otherwise noted in the scenario description.

BWS-Served Population

The BWS-served population for East Honolulu in 2010 was 48,066 people (see *Table 3-10*). The 2016 WMP projects the district's BWS-served population in 2040 at 48,700 people (see *Table 3-11*). Note that the East Honolulu district population differs from the BWS-served population because BWS data excludes military users, private water systems, and absent residents, but includes visitors. The 2016 WMP's estimate of BWS-served population is incorporated into the EHWMP scenarios as the baseline, unless otherwise noted.

Per Capita Water Demand

According to the 2016 WMP, island-wide per capita BWS water demand has declined steadily over the past decades as a result of efficiencies and water conservation measures. While per capita demand in East Honolulu has steadily decreased since 2000, it still remains higher than the island-wide average. In 2010, East Honolulu's per capita water demand was 194 GPCD (see *Table 3-11*). While the 2016 WMP demand forecasted that the East Honolulu district would lower its per capita water use to 180 GPCD by 2040, preliminary census data shows that the district's per capita water demand had already dropped to 170 GPCD in 2020. This preliminary census data for per capita water demand is incorporated into the EHWMP scenarios as the baseline, unless otherwise noted in the scenario description.

Table 3-10: 2010 East Honolulu Population and Per Capita Water Demand

Resident Population	% of Oʻahu Population	Residents Absent	Visitors Present	De Facto Population	Private or Military	BWS Population Served	Total District Water Demand	Per Capita Water Demand
49,914	5%	2,744	896	48,066	0	48,066	9.348	194

Table 3-10 Notes: 2010 population estimates provided by the 2016 WMP.

Table 3-11: 2010 East Honolulu Population and Per Capita Water Demand (by Year)

	1980	1990	2000	2010	2020	2025	2030	2035	2040
	Given Data				Projected Data				
BWS Population Served[1]	42,829	45,646	45,702	48,066	47,962	47,910	47,858	47,806	47,800
Per Capita Water Demand (GPCD)[2]	144.80	190.20	221.30	194.48	170.00	170.00	170.00	170.00	170.00

Table 3-11 Notes:

1 Historic and future BWS-served population estimated provided by the 2016 WMP.
2 East Honolulu's per capita water demand (1980 to 2010) was provided by the 2016 WMP. Per capita water demand from 2020 to 2040 is based on preliminary census data, which shows the district's per capita water demand reducing to 170 GPCD in 2020.

<u>Water Sources and Supply</u>

The 2016 WMP emphasizes that water sources in East Honolulu are limited and can only meet a small portion of the district's water demand. This is supported by the 2019 Water Resources Protection Plan, which decreased the sustainable yield of the Waiʻalae West aquifer system area from 4 MGD to 2.5 MGD. Therefore, all the demand scenarios assume that source development potential within the district is limited, and that East Honolulu will need to continue to rely upon ground water transfers from the Honolulu and Windward water systems to provide the majority of its water.

<u>Water Uses</u>

In 2010, water demand data was only available for BWS water and one private irrigation well. There are are currently no Domestic (private), Military, or Industrial water sources in East Honolulu and there is no anticipated future need for these uses. It is assumed that BWS will continue to supply the majority (around 96%) of the district's water for both residential purposes and irrigation. Irrigation demand is anticipated to remain relatively stable through 2040, however as climate change affects rainfall patterns, this could lead to an increase or decrease in irrigation demand. This is discussed in the High and Ultimate demand scenarios.

Sea Level Rise

The City and County of Honolulu Mayor's Directive on Sea Level Rise (Directive 18-01) mandates that City agencies plan for 3.2 ft of sea level rise by the end of the century, and for up to 6 ft of sea level rise for the planning and design of critical infrastructure with low risk tolerance. The 2017 Hawaiʻi SLR Report and associated Sea Level Rise Viewer provide maps to indicate areas that may be impacted by sea level rise and other hazards. The report designates Sea Level Rise Exposure Areas (SLR-XA's), which represent the combined footprint of passive flooding (including ground water intrusion), annual high wave flooding, and coastal erosion expected to result from 1 foot, 3.2 ft, and 6 ft of sea level rise.

The Ultimate Demand Scenarios assume that the East Honolulu district will be impacted by 3.2 ft of sea level rise or more by 2100, and that this may impact population, infrastructure, and development patterns within district's low lying coastal areas from Kāhala to Portlock. Areas within the SLR-XA with 3.2 ft of sea level rise may experience periodic flooding and inundation, eventually becoming uninhabitable.

Climate Change

As described in *Section 2.6*, climate change impacts to the East Honolulu district are anticipated to impact rainfall patterns within the East Honolulu district and island-wide. However, the direction of the changes remain uncertain, with one model predicting increased rainfall (the dynamical downscaling scenario, also referred to as the "wet" scenario) and one predicting a dramatic decrease in rainfall (the statistical downscaling scenario, also referred to as the "dry" scenario) (see Chapter 2 for details on each scenario). To acknowledge this uncertainty, the Ultimate Demand Scenario includes a "Wet" Scenario and "Dry" Scenario. Both the High Demand Scenario and the Ultimate (Dry Rainfall) Scenario also incorporate an increase in irrigation demand in the event that rainfall decreases. Historic and projected rainfall (through 2099) in both the Wet and Dry Scenarios are provided in *Table 3-12* and *Table 3-13*.

Table 3-12: East Honolulu Historical and Projected Wet Season Precipitation (in.) (Wet Scenario)[10]

Historical Wet Averages (1978-2007)	Statistically Downscaling Mid-Century Wet Season (2040-2069)			Statistical Downscaling End of Century Wet Season (2070-2099)			Dynamical Downscaling End of Century Wet Season (2080-2099)		
	RCP 4.5 (in.)	RCP 8.5 (in.)	Percent Change*	RCP 4.5 (in.)	RCP 8.5 (in.)	Percent Change*	RCP 4.5 (in.)	RCP 8.5 (in.)	Percent Change*
30	26.7	26.7	-11%	26.1	26.0	-13% to -14%	57.2	62.1	7% to 13%

[10] Brown and Caldwell. (2016). *Impacts of Climate Change on Honolulu Water Supplies and Planning Strategies for Mitigation: Technical Memo #1 – Understanding Future Climate, Demand, and Land Use Projections for the Island of Oʻahu*. Prepared for: Water Research Foundation, Honolulu Board of Water Supply.

Table 3-13: East Honolulu Historical and Projected Dry Season Precipitation (in.) (Dry Scenario)[11]

Historical Dry Averages (1978-2007)	Statistically Downscaling Mid-Century Dry Season (2040-2069)			Statistical Downscaling End of Century Dry Season (2070-2099)			Dynamical Downscaling End of Century Dry Season (2080-2099)		
	RCP 4.5 (in.)	RCP 8.5 (in.)	Percent Change*	RCP 4.5 (in.)	RCP 8.5 (in.)	Percent Change*	RCP 4.5 (in.)	RCP 8.5 (in.)	Percent Change*
15.1	12.0	10.9	-21% to -28%	11.8	9.2	-22% to -39%	15.4	20.3	2% to 35%

3.5.2 Water Demand Scenario Descriptions

This section describes the four scenarios used for projecting the future water demand for the East Honolulu district. The scenarios are summarized in *Table 3-14.*

Low Demand Scenario (Base Case/Most Probable Scenario)

The Low Demand Scenario incorporates the "most probable" water demand scenario described in the BWS's 2016 WMP. The scenario utilizes the 2016 WMP estimate of 47,800 for the district's total BWS-served population.

<u>Low Demand Scenario</u>

2040 East Honolulu BWS-Served Population: 47,800

Per Capita Water Demand: 170 GPCD

(based on East Honolulu's decreasing per capita water use)

While the 2016 WMP demand forecasted that the East Honolulu district would lower its per capita water use to 180 GPCD by 2040, preliminary census data shows that the district's per capita water demand had already dropped to 170 GPCD in 2020. This Most Probable (Low) Demand Scenario assumes that East Honolulu's per capita demand will remain at 170 GPCD in 2040. This represents a 12% decrease in per capita water demand from the 2010 baseline of 194 GPCD. This scenario assumes that water conservation efforts will continue to be promoted by BWS and implemented at residential and commercial levels to maintain consumption at 170 GPCD. *Figure 3-8* illustrates the approach used to calculate the projected BWS water demand in this scenario.

The Statewide Framework for Updating the Hawaii Water Plan (2000) requires that each County Water Use and Development Plan identify a base case scenario which is assumed to be the most probable future scenario. In the EHWMP, the base case scenario is the Low Demand scenario since it incorporates the

[11] Brown and Caldwell (2016).

"most probable" water demand scenario described in the 2016 WMP, which is in turn based on current City policies and growth projections.

Figure 3-8: Low Demand (Most Probable) Scenario Approach

Mid Demand Scenario

The Mid Demand scenario reflects the "high range" scenario in the 2016 WMP. Like the Low Demand Scenario, this scenario utilizes the 2016 WMP's BWS-served population estimate for East Honolulu to the year 2040.

Mid Demand Scenario

2040 East Honolulu BWS-Served Population: 47,800

Per Capita Water Demand: 194 GPCD

(based on the 2010 per capita water demand)

However, this scenario assumes that that the per capita demand of the existing BWS-served population of the East Honolulu will hold steady at the baseline 2010 level (194 GPCD) throughout the planning period. The assumption is that the level of conservation for existing BWS customers has reached saturation and little additional water savings will be possible without stronger regulations and/or incentives to compel existing users to change their water use behaviors or retrofit existing fixtures. *Figure 3-9* illustrates the approach used to calculate the projected BWS water demand for the East Honolulu district in this scenario.

Figure 3-9: Mid-Demand Scenario Approach

High Demand Scenario

High Demand Scenario

2040 East Honolulu BWS-Served Population: 53,000 (incorporates a 10%% increase due to infill development and tourism)

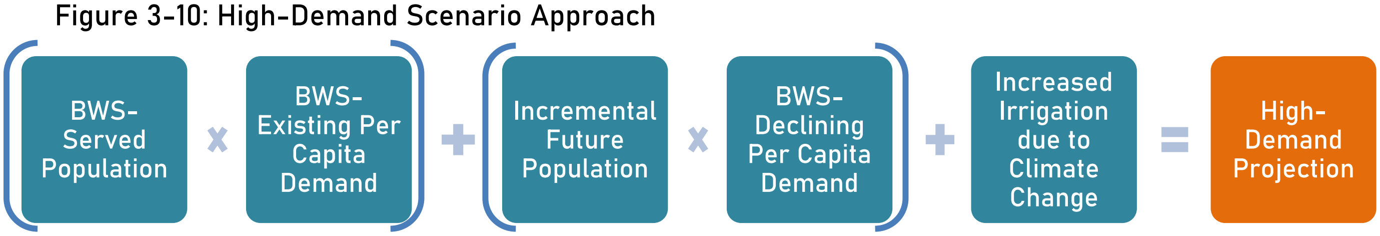
Per Capita Water Demand: 180 GPCD for the added population, 194 GPCD for the existing population

The High Demand Scenario reflects a future where the population of the East Honolulu has grown at a faster rate than current DPP projections. In this scenario, the East Honolulu district experiences incremental population growth through infill development and densification of neighborhoods such as Hawai'i Kai. Moreover, this scenario anticipates a surge in tourism, with an increased use of facilities at Hanauma Bay, Koko Marina, and others. As a result, the High Demand Scenario assumes that the BWS-served population for East Honolulu will increase approximately 10%, to about 53,000 by 2040.

This scenario also assumes that new development and infill within the district will be subject to more stringent water conservation requirements. Thus, it is assumed that the additional 5,200 individuals in the East Honolulu district will have a lower per capita water demand of 180 GPCD, in accordance with the 2016 WMP. However, because much of the existing population resides in homes that were built in prior decades when water conservation requirements were less stringent, this scenario assumes that per capita water demand of the existing BWS-served population (47,800) will remain at the 2010 level of 194 GPCD.

This scenario also anticipates increasing impacts from climate change, including increased heat and decreased rainfall. To account for this, the High Demand scenario assumes there will be an 18% increase in irrigation water demand due to increased evapotranspiration as a result of increased heat.[12] This scenario also acnkolwedges that the district will likely be increasingly impacted by flooding and sea level rise; however, the impacts are unlikely to extend beyond a small number of properties as of 2040, and thus will not likely impact the BWS-served population. *Figure 3-10* illustrates the approach used to calculate the projected BWS water demand for the East Honolulu district in this scenario.

Figure 3-10: High-Demand Scenario Approach



[12] Increased irrigation demand assumes an 18% decrease in average annual rainfall. Rainfall estimates are based on statistical downscaling for mid-century, as provided in Brown and Caldwell (2016). 18% represents an average of estimates between the dry and wet seasons, as provided in *Table 3-11* and *Table 3-12*.

Ultimate Demand Scenario

Ultimate Demand Scenario

2100 East Honolulu Population: 42,600

(incorporates a net population decrease due to climate change and sea level rise)

Per Capita Water Demand: 170 GPCD (based on East Honolulu's decreasing per capita water use)

The Ultimate Demand Scenario imagines a future for the East Honolulu district in the year 2100. Between 2010 and 2040, this scenario follows the storyline for population growth and water consumption described in the High Demand Scenario (i.e., a healthy economy, growing population, and an uptick in tourism). In addition, the Ultimate Demand Scenario assumes that by 2100, mean sea level will rise by 3.2 ft, causing more pronounced nuisance flooding with the additional impacts of high wave run-up and coastal erosion. Over time, these impacts could leave development within the 3.2 ft SLR-XA permanently inundated or uninhabitable.[13] GIS analysis indicates there are 1,184 parcels (and about 5,200 residents) within East Honolulu that are located within the 3.2 ft SLR-XA and may become chronically inundated by 2100. This primarily includes low-lying areas makai of the highway, as well as some areas surrounding Kuapā Pond and within Kuliʻouʻou valley (see *Figure 2-20).*

Critical infrastructure, such as the State highway and water supply facilities, will also be impacted by increased flooding and salt water intrusion into ground water and drainage systems. Higher frequency and severity of storms will likely result in increased flooding and storm surge, which could damage properties, raise insurance rates and decrease property values in vulnerable areas. Depending on impacts to beaches and coastal destinations, tourism may also experience a decline.

Adaptation measures such as seawalls, raising roads, and pumping sea water out of inundated coastal areas may mitigate some of these anticipated impacts in East Honolulu. However, the City and County's approach to adaptation is yet to be determined and will be subject to many complex factors and tradeoffs, including where to direct limited funding for the greatest public good. The reality is likely that in some areas subject to repeated losses and flooding, retreat of development away from coastal hazard areas will be necessary. Over time, this could reduce the population of parts of the island, including the East Honolulu district. If displaced residents leave the district, this could commensurately reduce water demand.

[13] Passive flooding impacts associated with 3.2 feet of sea level rise is equal to the Mean Higher High Water (MHHW) + 3.2ft of sea level rise. MHHW is the average of the higher of the two high tides of each day averaged over a 19-year tidal epoch. Thus, passive flooding describes a daily flooding scenario.

Taking all of these factors into account, this Ultimate Scenario assumes that by the year 2100, the BWS-served population in the East Honolulu district will decrease by 10%, with a BWS-served population of 42,600. The Ultimate Scenario assumes by 2100, some impacted residents would either retreat to inland areas or move out of the district. The per capita demand for the BWS-served population from 2040 through 2100 is assumed to remain steady at 170 GPCD, matching the Most Probable (Low) Demand scenario. Additional water conservation practices and technologies to reduce per capita demand further could be pursued, but are not factored into the analysis.

The Ultimate Scenario was also sub-categorized into a “Dry Scenario” and “Wet Scenario” to reflect two alternative methodologies for modeling the effects of climate change on future rainfall. The Dry Scenario, based on the statistical downscaling method, projects that in 2100, rainfall in East Honolulu (during the dry season) could decrease by 22 to 39% (see *Table 3-13*).[14] To account for this, the Ultimate Demand (Dry) Scenario assumes there will be a 22% increase in demand for irrigation water.

The Wet Scenario is based on the dynamical downscaling method, and projects that rainfall in East Honolulu will substantially increase by 30 to 50% over current levels, leading to increased flooding.[15] It is uncertain how this would impact irrigation demand, as the increased rainfall will likely occur as heavy rainfall and flooding events (sometimes called “rain bombs” or cloudburst events). Thus, no changes to irrigation demand are assumed in the Ultimate Demand (Wet) Scenario.

[14] Brown and Caldwell. (2016). *Impacts of Climate Change on Honolulu Water Supplies and Planning Strategies for Mitigation: Technical Memo #1 – Understanding Future Climate, Demand, and Land Use Projections for the Island of O‘ahu*. Prepared for: Water Research Foundation, Honolulu Board of Water Supply.

[15] Brown and Caldwell (2016)

Table 3-14: Overview of Water Demand Scenarios for East Honolulu

	2040 Demand Scenarios				2100 Ultimate Demand Scenario
	Baseline (2010)	Low	Mid	High	
Municipal - BWS	• Actual BWS-served population: 48,100 • Actual per capita demand: 194 GPCD	"Most Probable" scenario from BWS's 2016 WMP. •BWS-served population: 47,800 • Per capita demand: 170 GPCD	"High-Range" scenario from 2016 WMP. • BWS-served population: 47,800 • Per capita demand: 194 GPCD	Higher densification in existing residential areas due to multi-generational living/ADU's, redevelopment/infill. Moderate increase in tourism; onset of climate change impacts. • BWS-served population: 53,000 • Per capita demand: 194 GPCD for existing population; 180 GPCD for "incremental increase in population" • Decreased evapotranspiration from climate change causes a 18% increase in irrigation	Follows Low Demand Scenario for urban growth until 2040. Climate change impacts increase and likely reduce population due to retreat from low-lying coastal areas. Conservation policy/practices continue to become more stringent and kick in as properties are redeveloped and renovated. • BWS-served population: 42,600 (appx. 10% loss from baseline population) • Per capita demand after 2040: 170 GPCD • Climate change: Increased flooding may result in localized property loss and some population loss (appx. 10%); Dry Rainfall Scenario incorporates a 22% increase in irrigation demand at residential and commercial levels (no changes in the Wet Rainfall Scenario)
Agriculture & Irrigation	One private well with reported pumpage	Status quo: No anticipated increase from 2010 demand	Status quo: No anticipated increase from 2010 demand	No anticipated increase from 2010 demand EXCEPT: • Decreased evapotranspiration from climate change causes an 18% increase in irrigation	No anticipated increase from 2010 demand EXCEPT: • Dry Scenario: Decreased evapotranspiration from climate change causes a 22% increase in irrigation • Wet Scenario: No changes.
Domestic - Private	None	None	None	None	None
Military, Industrial, and Other	None	None	None	None	None

3.5.3 Summary of Water Demand Projections

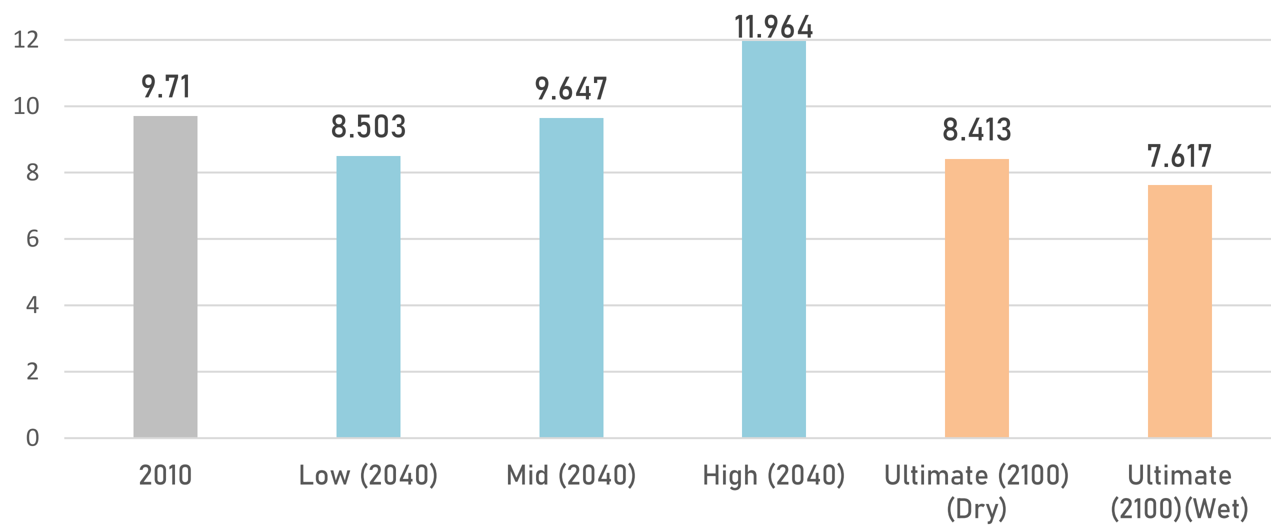
The projected future water demand according to the Low, Mid, High, and Ultimate scenarios was assessed for two water use categories: municipal (BWS) and irrigation (see *Table 3-14*). Note that the water demand projections only include potable ground water. Caprock ground water was excluded from future water demand projections, as it is too brackish for drinking and irrigation purposes. Surface water was also excluded, given its limited availability in East Honolulu. Water demand was projected by multiplying the BWS-served population by the per capita water demand, and then adding irrigation demand (see *Figures 3-8* through *3-10* in the previous section).

In the Low, Mid, and High scenarios, the total projected water demand ranges from 8.503 MGD in the Low scenario to 11.964 MGD in the High Scenario (*Figure 3-11*). The Low Demand Scenario, which is the base case/most probable scenario, projects 12.43% less total water demand for the East Honolulu in the year 2040 than the 2010 baseline because of the continued implementation of conservation measures that will lower per capita demand. The Mid Demand Scenario results in a projected demand of 0.64% less than the 2010 baseline, due to the slight decrease in BWS-served population (from 48,100 in 2010 to 47,800 in 2040). The High Demand Scenario, which incorporates a larger BWS-served population and increased irrigation demand due to climate change, results in a projected demand of nearly 12 MGD, a 23.21% increase over 2010.

The total projected demand in the Ultimate Demand Scenario is 8.413 MGD in the Dry Scenario and 7.617 MGD in the Wet Scenario. The projected demand in both of the Ultimate Demand Scenarios is lower than in the baseline 2010 Demand and the High Demand Scenario due to the following assumptions:

- East Honolulu’s population decreases after the year 2040 as a result of sea level rise impacts to coastal areas;
- Tourism slows after 2040 as a result of sea level impacts; and
- Per capita demand decreases after 2040 to 170 GPCD for the total BWS-served population.

Figure 3-11: Total Future Water Demand Scenarios for East Honolulu (MGD)



Water Demand Projections by Water Use Category

In all the scenarios, BWS is assumed to supply approximately 96% of the district's water. Irrigation water demand remains the same in the Low, Mid, and Ultimate (Wet) Demand Scenarios as it is in the 2010 Baseline, because these scenarios do not account for any changes in rainfall (*Table 3-15*). Irrigation water demand increases in the High and Ultimate (Dry) Demand Scenario, as these scenarios account for increased heat and reduced rainfall.

The EHWMP Water Use and Development Plan in *Chapter 5* focuses on water supply for the Low Demand Scenario (Most Probable) and the Ultimate (Dry) Demand Scenario. These two scenarios are summarized in *Figure 3-12* and *Figure 3-13* on the following page.

Table 3-15: Water Demand Projections by Water Use Category (MGD)

	Baseline (2010)	2040 Scenarios			2100 Scenarios	
		Low	Mid	High	Ultimate (Dry)	Ultimate (Wet)
BWS	9.33	8.126	9.27	11.52	7.68	7.24
Irrigation	.377	.377	.377	.444	.463	.377
Domestic (Private)	0	0	0	0	0	0
Military, Industrial, and Other	0	0	0	0	0	0
Total	9.71	8.503	9.647	11.964	8.413	7.617
% Change from 2010	-	-12.43%	-0.64%	23.21%	-13.36%	-25.44%

Table 3-15 Notes: The Ultimate Dry Scenario assumes 30% of water use is allocated towards irrigation and applies an applied an 22% increase, using statistical downscaling model.

Figure 3-12: Summary of the Low (Most Probable) Demand Scenario Projections

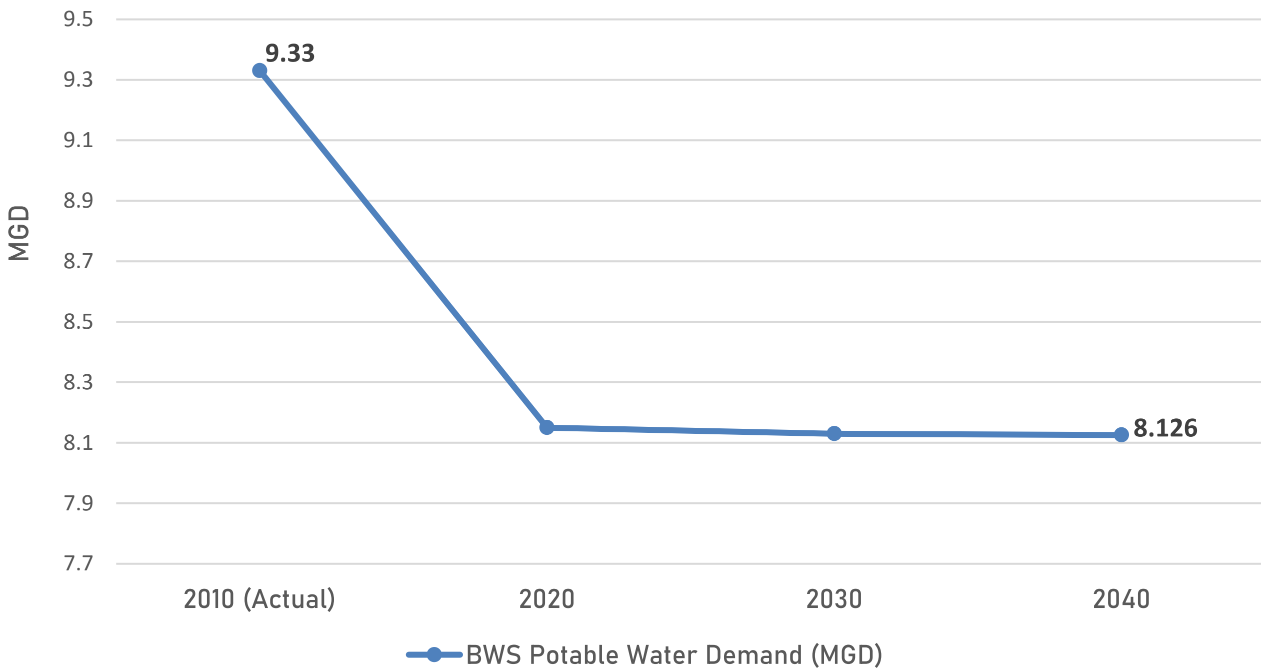
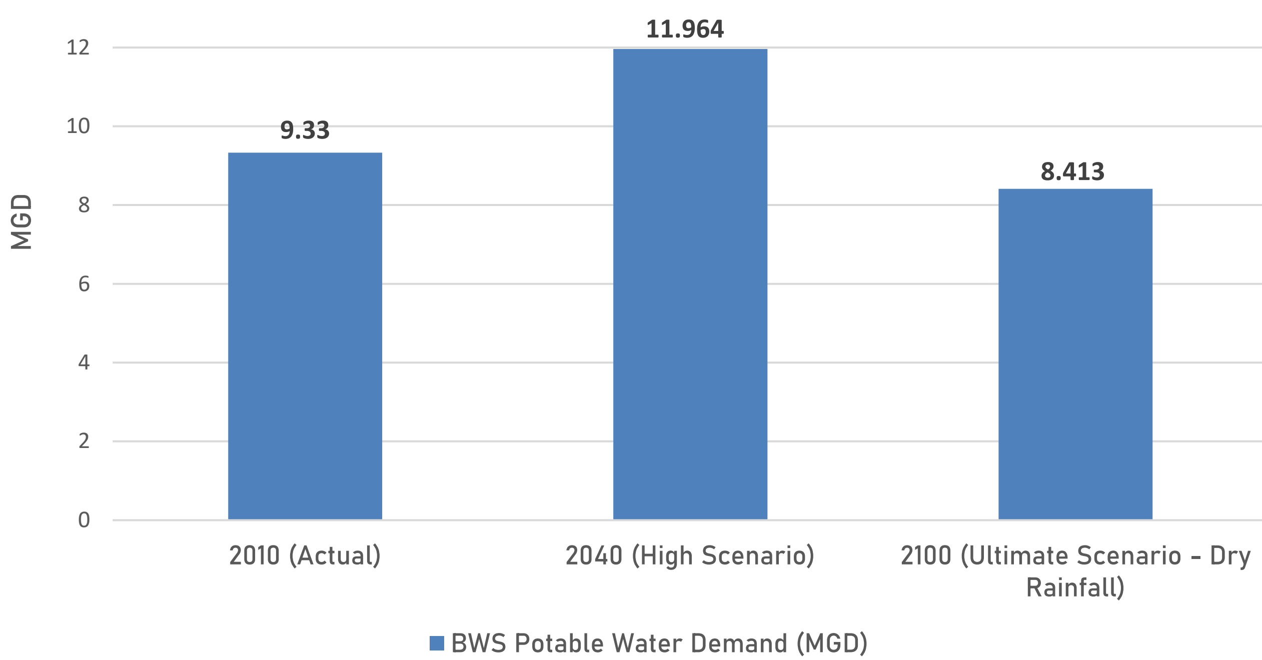


Figure 3-13: Summary of the High and Ultimate Demand (Dry Scenario) Projections

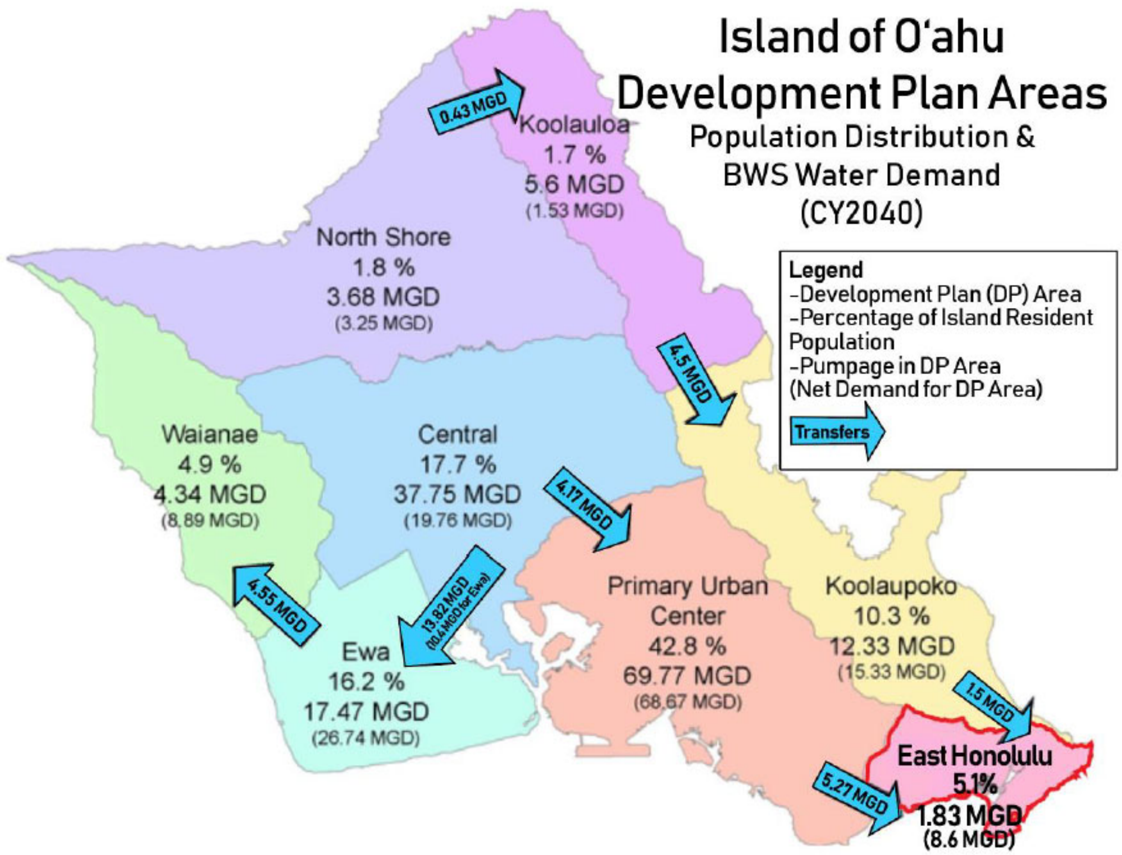


3.6 FUTURE WATER SUPPLY

2040 Water Supply

Future water supply in East Honolulu will continue to depend on BWS transfers of water from other areas. Water transfers are estimated through 2040. According to *Figure 3-14*, in 2040 the East Honolulu planning district will have a BWS water demand of 8.6 MGD (based on the Base Case/Most Probable Demand Scenario). This demand will be accommodated by 1.83 MGD of in-district pumpage, 5.27 MGD of water transferred from the Honolulu water system, and 1.5 MGD of water transferred from the Windward water system. CWRM may also take regulatory actions that could reduce the amount of water which can be transferred from the Windward water system.

Figure 3-14: 2040 BWS Water Transfer Map (MGD)



When comparing the transfer map to the estimated BWS water supply shown in *Figure 3-14* to the projected water demand shown in *Table 3-16*, it becomes evident that the Mid and High Demand Scenarios exceed the estimated supply. This means that East Honolulu will need to pursue both new source development and conservation efficiencies to mitigate the uncertainties of climate change and regulatory actions to restore Windward stream flows. Within the 2040 projected water supply constraints, the overall water demand in the preliminary Mid Demand Scenario would need to be reduced by 0.67 MGD (7.23%), and the overall water demand in the preliminary High Demand Scenario would need to be reduced by 2.92 MGD (25.35%). See *Table 3-16* for further detail.

Table 3-16: Adjusted Water Demand Scenarios to Meet 2040 Water Supply

	2040 Scenarios		
	Low	Mid	High
Preliminary Per Capita Water Demand	170 GPCD	194 GPCD	194 (existing) / 180 (additional population)
Total BWS Demand	8.126	9.27 MGD	11.52
Total BWS Supply	8.6 MGD		
Additional Supply Needed to Meet Demand	none	0.67 MGD	2.92 MGD
Target Per Capita Water Demand to Meet 2040 Supply	n/a	180 GPCD	160 (existing)/145 (additional population)
% Reduction in Total Demand	n/a	-7.23%	-25.35%

2100 Water Supply

There are many uncertainties when projecting 2100 water supply. In the Dry Scenario, there could be a substantial decrease to the sustainable yield of Oʻahu's ground water aquifer systems. As shown in *Figure 1-14*, these impacts range by aquifer sector, from a potential decrease of 14% in Honolulu Aquifer Sector's SY, to a decrease up to 69% in Waiʻanae Aquifer Sector's SY. Given these potential reductions to the island's SY's, under the Dry Scenario we assume that East Honolulu's water availability will be reduced to 5.54 MGD due to anticipated changes in water transfers. Further discussion regarding the ways in which the district's water demand would need to be reduced under the realization of the Ultimate Dry Scenario, as well as water conservation strategies to accomplish this, is provided in *Section 5.2.2*.

Conversely, if the Wet Scenario is realized, it is assumed that there will be no changes to water availability in 2100, given that expected increases in rainfall are likely to come in form of heavy rainfall and flooding, which does necessarily increase aquifer recharge or ground water availability. As such, the EHWMP estimates that water supply for East Honolulu remains at 8.6 MGD under the Ultimate Wet Scenario.

3.7 IMPLICATIONS FOR WATER SUPPLY PLANNING

The water demand projections in this Chapter are used to inform the water supply analysis in the Water Use and Development Plan contained in *Chapter 5*. That Chapter also includes a more detailed discussion on planning for future water supply in the East Honolulu planning district.

The data presented in this Chapter on 2015 water use in the East Honolulu and the projections for future water demand reveal important observations. Gains in water conservation and efficiencies, initiated in 1990, have continued for three decades and are expected to continue to have a positive effect on water demand and source production in the near term. From 2000 to 2010, East Honolulu lowered its per capita water demand by 12.2%. 2015 estimates indicate decreased per capita water demand is likely to continue in East Honolulu. Despite these positive gains, East Honolulu's per capita water demand is still 25% higher than the island-wide per capita average (based on 2010 data).

While the Low Demand Scenario is considered the most probable scenario for East Honolulu, there are many factors that could influence the district's future water demand, such climate-induced changes in air temperature and rainfall, as well as retreat from low-lying coastal areas. The policies and programs identified in *Chapter 4* reflect this range of possibilities and are intended to help increase the district's resilience in the face of uncertainties, including both extreme droughts and heavy rainfall events.

As discussed in the previous section, if the Mid, High, or Ultimate (Dry) Demand Scenario were to be realized in East Honolulu, measures would need to be taken to ensure water shortage conditions are avoided. This could include building more wells in Waiʻalae East aquifer (such as the Pia Well), increasing the amount of water transferred from outside planning districts, or greater implementation of water conservation measures. Among these options, enhancing conservation measures is the most economically feasible and environmentally sustainable option. Per capita water demand would need to be greatly reduced in the High and Ultimate (Dry Rainfall) Demand Scenarios to meet the projected water supply in 2040 and 2100, respectively.

As discussed in *Chapter 3*, water demand and water conservation are influenced by various factors, such as land use, income, individual behaviors, plumbing codes, and climate. Conservation strategies can be adapted to East Honolulu's unique geographic setting and scaled up or down to be implemented at both residential and commercial levels. Conservation strategies could include increasing water efficiency through water fixture retrofits, rainwater harvesting, leak detection and repair, improving stormwater retention, recharge, and reuse with green infrastructure, and encouraging water reuse and on-site non-potable water reuse. *Chapter 4* discusses these conservation strategies and others in greater detail.

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Chapter 4: policies, programs & strategies

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4 Policies, Programs and Strategies

4.1 INTRODUCTION AND METHODOLOGY

The first phase of the EHWMP planning process involved the identification of critical water resource issues for East Honolulu (see *Chapter 2*). The second phase analyzed the district's existing and future water supply and demand (see *Chapter 3*). This Chapter synthesizes these findings into an overall policy and action framework for addressing water resource issues and meeting the water resource needs of the East Honolulu district over the next twenty years. This framework includes the following components:

1. EHWMP Goal, Objectives, and Sub-Objectives
2. EHWMP Watershed Management Projects
3. EHWMP Watershed Management Strategies and Programs

These components incorporate overarching guidance from the Oʻahu Watershed Management Plans, as well as district-specific analysis and community outreach, as described further below.

Methodology

In order to provide planning consistency, all of the Oʻahu Watershed Management Plans share the same goal and five major objectives. These are based on the framing Federal, State and City laws and policies and on a community engagement process that is documented in Chapter 1. More detailed sub-objectives or policies are derived from an analysis of district-specific watershed issues and stakeholder values. These are intended to reflect the unique resources and needs for the East Honolulu planning district.

Image: Stakeholders in East Honolulu discuss watershed projects.

4.2 EHWMP GOALS, OBJECTIVES, AND SUB-OBJECTIVES

4.2.1 EHWMP Goals

The EHWMP adopts the overall goal of the Oʻahu Watershed Management Plans, which is:

> *"To formulate an environmentally holistic, community-based, and economically viable watershed management plan that will provide a balance between: (1) the preservation and management of Oʻahu's watersheds, and (2) sustainable ground water and surface water use and development to serve present users and future generations."*

4.2.2 EHWMP Objectives and Sub-Objectives

The five major objectives that are common to all of the Oʻahu Watershed Management Plans are:

1. Promote sustainable watersheds.
2. Protect and enhance water quality and quantity.
3. Protect Native Hawaiian rights and traditional and customary practices.
4. Facilitate public participation, education, and project implementation.
5. Meet future water demands at reasonable cost.

These are incorporated as the objectives of the EHWMP. Sub-objectives (or policies) specific to East Honolulu were identified through the EHWMP planning process. The sub-objectives provide the framework for identifying specific water supply and watershed management projects and programs to address East Honolulu's water resource needs, which are described in the next section. The five major objectives and related sub-objectives specific to East Honolulu are listed below. A brief description of East Honolulu-specific issues and community values related to each sub-objective is also provided.

OBJECTIVE #1: PROMOTE SUSTAINABLE WATERSHEDS

Sub-Objective 1.1: **Increase native reforestation and implement measures to slow the spread of invasive species and ungulates to improve the overall health of East Honolulu's forest reserves and increase recharge into the East and West Waiʻalae aquifers.** Forests reserves, rich in native flora and fauna, are vital to watershed health. A forest's canopy can improve ground water recharge by capturing precipitation and fog drip, allowing water to percolate into the ground and feed the island's drinking water supply. The spread of invasive species and ungulates pose a large threat to East Honolulu's watersheds, as non-native plants reduce ground water recharge and increase soil erosion and sediment runoff. Invasive plant species also crowd out and outcompete native plant species, which negatively impacts water availability, water quality, and forest health.

Native reforestation has been proven to reduce sediment transfer and stormwater runoff and increase drought tolerance. Native plants, when compared to non-native species, also typically require less water and pesticides to establish and maintain. Increased management and restoration efforts are needed to address the degraded condition of most of the East Honolulu forest reserves. The spread of invasive species can be slowed through improved management of mauka hiking trails and implementation of fencing projects and hunting programs to control feral ungulates.

Sub-Objective 1.2: **Implement preventative measures that reduce wildfire risks.** Wildfires can damage watershed health by destroying native forests, changing soil chemistry, threatening native species and habitat. Moreover, burned soil from wildfires decreases ground water recharge, affecting drinking water supply. Wildfires occurring during dry conditions represent a significant problem on all the major Hawaiian Islands. From 2006 to 2016, wildfires burned an average of 20,000 acres per year statewide, with some years reaching close to 45,000 acres. More than 99% of known wildfires are attributed to human activities. Due to East Honolulu's dry climate, the district is particularly susceptible to wildfires. Resilience to wildfires can be improved through fire break and other measures.

Sub-Objective 1.3: **Enhance ecosystem diversity within East Honolulu's streams and nearshore waters.** Channelization of the district's streams and increased runoff has impacted the amount of flora and fauna that can be found in East Honolulu. For example, shrimp were once abundant in Maunalua Bay. Today, Maunalua Bay is considered an impaired water body, suffering from widespread growth of invasive algae. There are opportunities to protect and restore ecosystem diversity in surface waters in both mauka and makai areas of East Honolulu through restoring streams and fishponds, enhancing stormwater retention and infiltration to reduce runoff, community cleanups, and species-targeted interventions such as invasive algae removal and coral restoration.

Sub-Objective 1.4: **Prepare for the anticipated impacts of sea level rise on existing ecosystems, properties and infrastructure through remediation, adaptation, and other measures.** Climate change is expected to increase the frequency and intensity of storms, increasing Hawaiʻi's risk and vulnerability to damaging winds, flooding, wave action, and other storm-related impacts. At least 3.2 ft of sea level rise is expected by the end of this century, which would chronically flood miles of East Honolulu's coastline. Coastal flooding and erosion will directly impact development along the East Honolulu coastline, including infrastructure for water supply, drainage, and treatment. Eventually, some areas may become infeasible to inhabit, necessitating relocation or retreat of coastal development and infrastructure. Government agencies must work collaboratively to explore opportunities to mitigate hazards and protect, elevate, or retreat infrastructure and development vulnerable to the sea level rise. Existing disaster prepardness community groups can also be further supported in their outreach efforts.

Sub-Objective 1.5: **Conserve natural shorelines to protect beaches, coastal ecosystems, recreational and cultural resources, and public shoreline access.** Natural shorelines and coastal ecosystems are vital components of watershed health. However, much of the shoreline along Maunalua Bay has become armored over recent decades. Shoreline armoring to protect coastal properties from coastal erosion and sea level rise negatively impacts coastal ecosystems, recreational and cultural resources, and public shoreline access. Updates to City and State shoreline regulations have been called for to better provide guidance for management of vulnerable coastal areas. Programs and strategies to enhance access to the shoreline and nearshore waters, particularly along Maunalua Bay, should also be explored.

OBJECTIVE #2: PROTECT AND ENHANCE WATER QUALITY AND QUANTITY

Sub-Objective 2.1: **Encourage the use of xeriscaping and other low impact development strategies to reduce irrigation water demand from current aquifer sources and mitigate flooding impacts, with a focus on large landscaped areas such as parks, schools, golf courses, roadway landscaping, farms and large residential lots.** East Honolulu's per capita water demand is approximately 20% higher than the island-wide average. While climate change impacts to the island's drinking water supply are uncertain, the district should be prepared for decreased water supply in the future and plan to adopt measures to lower its water demand. Greater implementation of existing BWS conservation programs (such as Water Sensible Rebate and WaterSmart programs) can improve water efficiency and likely reduce the district's water usage. Programs that focus on water reuse, stormwater retention, recharge, and reuse, and on-site non-potable reuse should also be established and implemented.

Sub-Objective 2.2: **Improve the water quality of Maunalua Bay by capturing and infiltrating stormwater runoff and reducing the transfer of sediment and other pollutants from mauka areas to the Bay.** The impaired water quality of Maunalua Bay was one of the most discussed water resource issues among East Honolulu stakeholders during the EHWMP process. Nearshore waters throughout the East Honolulu district including Maunalua Bay, Hanauma Bay, and the Ka Iwi Coast have been subject to periodic water quality advisories and beach closures by the State Department of Health due to elevated levels of bacteria, sediments, and other pollutants generated through point and nonpoint sources. The Bay's degraded water quality is largely due to polluted runoff from developed areas. Nearshore water quality impacts from runoff and debris can be addressed through improvements that enhance stormwater retention and infiltration and filter out debris and pollutants before stormwater enters coastal waters. This includes improvements to municipal storm drain systems as well as to privately owned properties, through strategies such as green infrastructure and low impact development.

Erosion from natural and agricultural areas also brings sediment and pollutants into nearshore waters. Agricultural best practices and efforts to control ungulate populations and install fencing to keep them out of sensitive upland areas may have significant downstream benefits on water quality.

Sub-Objective 2.3: **Improve the water quality of Maunalua Bay by increasing the amount of fresh water that enters the Bay.** Many of the district's fresh water resources, particularly fishponds, have been damaged or destroyed as the district developed. The loss of fresh water entering Maunalua Bay has contributed to an increase in invasive species and decline of ecosystem diversity in the Bay. Restoring fresh water connections from mauka to makai through restoration of fishponds and coastal springs would have multiple benefits including enhancing water quality, improving nearshore habitat, and restoring cultural and traditional resources.

Sub-Objective 2.4: **Reduce the impacts from extreme rain events and flooding.** Urbanization and climate change have contributed to an increase in flooding. Debris-clogged bridges and culverts also play a part in the district's flooding problems. Flooding can cause health and safety concerns, as well as property damage; Nearly 400 homes were damaged in the April 2018 flooding event in East Honolulu, which was equivalent to a 25-50 year storm. Maintenance and improvement of natural and manmade drainageways and wastewater systems can mitigate potential damages and pollution caused by flooding. The EHSCP also calls for policies to map and identify repetitive loss areas, to restrict development in those areas, and implement a "build back better and smarter" strategy to mitigate future damages.

Sub-Objective 2.5: **Reduce ground water contamination through cesspool conversion and wastewater system improvements in East Honolulu.** Studies have indicated many of Honolulu's cesspools are partially inundated with ground water. Contamination from sewage spills and cesspools can also result in elevated levels of bacteria and contaminants in nearshore waters. As sea level rises, salt water has the potential to intrude into coastal aquifers and underground infrastructure, such as sewer lines, cesspools, and drainage systems. Act 125 (SLH 2017) requires all cesspools in Hawaiʻi to be upgraded or converted, or the property must connect to a sewer system before January 1, 2050. Cesspool conversion can be a costly and timely effort for many residents. Resources should be provided to assist low income residents with cesspool conversion. Leaking sewer lines should also be repaired or replaced.

Sub-Objective 2.6: **Maintain and improve the water supply of aquifers serving East Honolulu by maximizing ground water infiltration and encouraging urban recharge.** While climate change impacts to the island's rainfall and drinking water supply are uncertain, the district should be prepared for decreases in water supply of aquifers. Programs and strategies for increased ground water infiltration in the Conservation and Urban Land Use Districts should be implemented to support recharge of aquifers and preserve limited drinking water supplies. In addition to retention and infiltration retrofit projects, xeriscaping and green infrastructure improvements should be encouraged.

Sub-Objective 2.7: **Re-evaluate aquifer sustainable yields to support ground water dependent ecosystems.** Driven by gravity, all aquifer ground water flows to the ocean, emerging as stream flow, springs, and estuaries. Fresh water mixing with salt water creates brackish water environments that support unique ecosystems and fisheries. Ground water flow to the coast is estimated as the difference between recharge and sustainable yield. Should CWRM consider increasing ground water flows to enhance ground water dependent ecosystems, sustainable yields could be decreased based upon site specific ecosystem studies. As an alternative, developing capture zone delineations that supply ground water flow to high value coastal ecosystems and managing cesspools discharges and pumping wells can benefit resources such as the Kalauhaʻihaʻi Fishpond.

OBJECTIVE #3: PROTECT NATIVE HAWAIIAN RIGHTS AND TRADITIONAL AND CUSTOMARY PRACTICES

Sub-Objective 3.1: **Restore fishponds and springs for cultural and educational use.** East Honolulu is an area once known for its fishing resources and large fishponds. When the district was urbanized in the mid to late twentieth century, many fishponds were damaged or destroyed. As coastlines developed with residential and other private land uses, access to fishing and other traditional subsistence activities were curtailed. Where feasible, fishponds and fresh water spring flows to coastal areas should be restored.

Sub-Objective 3.2: **Provide support to community organizations that are stewarding cultural and natural resources.** Community groups in East Honolulu are actively stewarding cultural sites throughout the region, including the Kalauhaʻihaʻi Fishpond, Kānewai Spring, Paikō Lagoon, Keawāwa Wetland, Hāwea Heiau, and the Ka Iwi Coast mauka lands. Cultural and educational activities should be supported at these sites and others.

Sub-Objective 3.3: **Improve public shoreline access to allow for the practice of cultural traditions and subsistence activities.** Many residents and community groups have commented on the lack of public shoreline access in East Honolulu, particularly along Maunalua Bay. Shoreline access is limited due to the development along Kalanianaʻole Highway and the proliferation of seawalls. Shoreline access is likely to decrease as sea levels rise and more coastlines become armored or eroded. Going forward, shoreline development regulations and climate adaptation policy will need to consider the need for safe access to nearshore waters for recreational, cultural, and subsistence purposes.

Sub-Objective 3.4: **Increase community awareness of Maunalua's unique history of water through educational programs**. Maunalua encompasses the area from southeast Oʻahu at Koko Head to Kupikipikio on the slopes of Diamond Head. The area has a unique history that includes Keahupua O Maunalua (also referred to as the Kuapā Fishpond), once the largest fishpond in the Hawaiian Islands. However, awareness of Maunalua's history is not as prevalent today due to the destruction of many cultural sites and the urbanization that took place in the mid to late twentieth century. Educational programs, including signage, can be used to help perpetuate Maunalua's history.

OBJECTIVE #4: FACILITATE PUBLIC PARTICIPATION, EDUCATION AND PROJECT IMPLEMENTATION

Sub-Objective 4.1: **Promote public participation in planning of watershed management projects and programs.** Community involvement is needed to protect and manage water resources in East Honolulu. Successful watershed management projects and programs should embrace public participation and integrate local knowledge and support. Public participation may also increase awareness of resources, resulting in behavioral change and actions that are more environmentally sensitive.

Sub-Objective 4.2: **Provide educational opportunities for the community to learn about protecting and preserving water resources in East Honolulu with a particular emphasis on youth education.** The effectiveness of watershed projects is dependent upon the community being educated to steward water resources, particularly younger generations. Community education and involvement can increase public awareness that may result in behavioral change and actions that are more environmentally favorable.

Sub-Objective 4.3: **Collaborate among government agencies, landowners, and other stakeholders to implement mutually beneficial projects and strategies, obtain community support, and secure the necessary funding and legislation.** Successful watershed management requires collaboration among community groups, agencies, and organizations to work towards common objectives. Watershed funding tends to be short term, so it is difficult to work towards long-term goals. Watershed organizations, both public and private, need longer-term funding. Implementing policy and climate adaptation initiatives through a collaborative framework such as One Water will allow agencies to address water resources and infrastructure needs in an integrated, holistic manner.

OBJECTIVE #5: MEET PUBLIC WATER DEMANDS AT REASONABLE COST

Sub-Objective 5.1: **Maintain and improve the reliability, adequacy, and efficiency of the potable water system.** The BWS water supply system is aging and needs regular repairs and upgrades. Potable water is being lost through leakages and water main breaks. A reliable water delivery system can minimize the frequency, magnitude and duration of water shortages and ensure a consistent supply of high-quality water to customers. Going forward, this will involve considering potential impacts on water infrastructure due to climate change, and identifying solutions to enhance the resilience of the BWS system as a whole.

Sub-Objective 5.2: **Adapt to and plan for drought and its impacts on water supply in East Honolulu.** Oʻahu has experienced decreasing rainfall over the past few decades and some climate change forecasts predict an increasingly dry future. A drying trend from climate change will affect aquifer recharge, thus impacting water supply in the future. There is a need to continuously update our understanding of climate change and its impacts on future water supply, while also taking sufficient actions and precautions to address drought.

Sub-Objective 5.3: **Implement conservation measures that improve water efficiency and decrease per capita water demand among residential, commercial, and agricultural water users.** Programs and strategies for increased water conservation, recycled water, stormwater capture and reuse, and low impact development need to be implemented to preserve limited drinking water supplies. Educational programs that promote conservation as a way of life can help effect a generational change in thinking. Programs may also include rebate, retrofit, and incentive programs to encourage hardware and behavioral modifications from customers. Given the East Honolulu district's high irrigation water demand, special attention should be given to xeriscaping and low impact development strategies.

Sub-Objective 5.4: **Through a One Water framework, promote an integrated demand-side management water conservation program with stormwater management and recycled water for all land uses to extend limited water supply and system capacity.** Various State agencies and City departments manage water resources on Oʻahu, including BWS, CWRM, and DFM. While these entities have overlapping goals, they are often siloed in implementing their mandates. The City and County of Honolulu is implementing a One Water Framework for cross-agency collaboration in managing water resources. In East Honolulu, this framework will provide a pathway to use stormwater and recycled water programs as means of decreasing the impacts stormwater runoff and improving water conservation.

4.3 EHWMP WATERSHED MANAGEMENT PROJECTS AND STRATEGIES

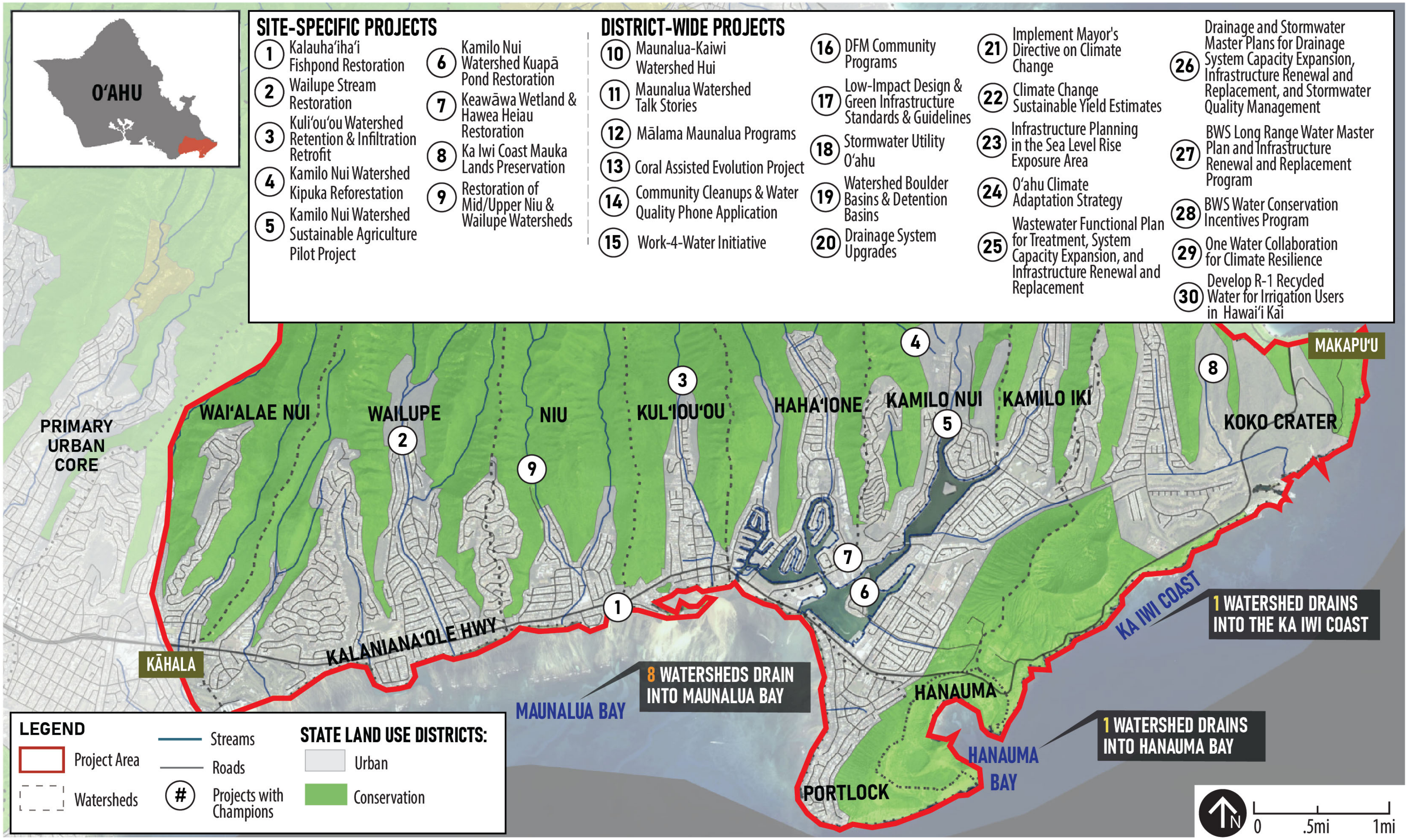
4.3.1 Overview of EHWMP Watershed Management Projects

This section of the EHWMP identifies recommended projects and strategies to address water resource issues and meet the objectives and subobjectives of the EHWMP. Projects are those that have an identified champion, which constitutes a designated lead agency or organization that is proposing, planning, or already implementing the project. Projects with champions include:

1. Kalauhaʻihaʻi Fishpond Kalauhaʻihaʻi Fishpond Restoration
2. Wailupe Stream Restoration
3. Kuliʻouʻou Watershed Retention and Infiltration Retrofit
4. Kamilo Nui Watershed Kipuka Reforestation
5. Kamilo Nui Watershed Sustainable Agriculture Pilot Project
6. Kamilo Nui Watershed Kuapā Pond Restoration
7. Keawāwa Wetland and Hawea Heiau Restoration
8. Ka Iwi Coast Mauka Lands Preservation
9. Restoration of Mid/Upper Niu and Wailupe Watersheds
10. Maunalua-Ka Iwi Watershed Hui
11. Maunalua Watershed Talk Stories
12. Mālama Maunalua Programs
13. Coral Assisted Evolution Project
14. Community Cleanups and Water Quality Phone Application
15. Work-4-Water Initiative
16. DFM Community Programs
17. Low Impact Design and Green Infrastructure Standards and Guidelines
18. Stormwater Utility Oʻahu
19. Watershed Boulder Basins and Detention Basins
20. Drainage System Upgrades
21. Implement Mayor's Directive on Climate Change and Sea Level Rise
22. Climate Change Sustainable Yield Scenarios
23. Infrastructure Planning in the Sea Level Rise Exposure Area
24. Oʻahu Climate Adaptation Strategy
25. Wastewater Long Range Master Plan for Treatment, System Capacity Expansion, and Infrastructure Renewal and Replacement
26. Drainage and Stormwater Master Plans for Drainage System Capacity Expansion, Infrastructure Renewal and Replacement, and Stormwater Quality Management
27. BWS Long Range Water Master Plan and Infrastructure Renewal and Replacement Program
28. BWS Water Conservation Incentives Program
29. One Water Collaboration for Climate Resilience
30. Develop R-1 Recycled Water for Irrigation Users in Hawaiʻi Kai

Figure 4-1 graphically illustrates the approximate location of specific "projects with champions" in East Honolulu. District-wide programs and projects with champions are listed at the top of the map. *Section 4.3.1* of this Chapter includes project descriptions for each of the EHWMP project.

Figure 4-1: East Honolulu Watershed Management Projects with Champions



*Note, project locations are approximate.

4.3.2 Overview of EHWMP Watershed Management Strategies and Programs

The EHWMP watershed management strategies and programs are actions that would help to implement EHWMP objectives but that do not currently have a championing agency or organization. Strategies and programs for East Honolulu include:

A. Southern Koʻolau Mountains Native Species Reforestation Program
B. Stream Restoration, Dechannelization and Maintenance
C. Stream Debris Educational Program
D. Coordinated Pig Hunting Program
E. Trail Educational Program
F. Trail Erosion Mitigation
G. Kuliʻouʻou Ridge Trail Entrance Improvements
H. Firebreak Plan
I. Golf Course Xeriscaping and Water Efficiency Plan
J. Lateral Shoreline Access Plan
K. Awāwāmalu Access Improvements
L. Agricultural Water Use Plans
M. Grey Water Reuse Plan
N. Climate Adaptation Neighborhood Plans
O. Climate Change and Resilience Education
P. Restoration of Fresh water Spring Flows to Nearshore Coastal Waters
Q. Strengthening of Codes and Standards for Building Resilience
R. Build Back Better and Smarter
S. Restrictions on Shoreline Armoring
T. Redevelopment District

Policy Alignment

Table 4-1 shows how the objectives, sub-objectives, projects, and strategies relate to one another and to the water resources issues and community values identified for East Honolulu. For each sub-objective, one or more projects or strategies are identified as implementing actions. Several projects and strategies support more than one sub-objective and are thus listed multiple times in the table.

4.3.3 Watershed Management Project Descriptions

This section provides additional detail on the recommended EHWMP watershed management projects. Descriptions for each project include:

- Location
- Project Champion and Partners
- Project Goals
- EHWMP Objectives Addressed
- EHWMP Sub-Objectives Addressed
- Background
- Project Status
- Ka Paʻakai Analysis*
- Estimated Cost

*Background information on the Ka Paʻakai Analysis is provided in *Section 2.9*. Potential impacts to traditional and customary practices were considered for each project and strategy presented in this Chapter. These analyses should be considered preliminary, and it should be noted that individual projects may require further site-specific study and analysis to fulfill the Ka Paʻakai requirement.

Table 4-1: Relationship of EHWMP Objectives, Issues, Sub-Objectives, Projects and Strategies

Community Value / Water Resource Issue	Sub-Objective	Projects with Champions	Strategies
OBJECTIVE #1: PROMOTE SUSTAINABLE WATERSHEDS			
Issue: Invasive plants are wide spread in the Southern Koʻolau Mountains. Invasive groundcover reduces ground water recharge and increase soil erosion and sediment runoff.	**1.1:** Increase native reforestation and implement measures to slow the spread of invasive species and ungulates to improve the overall health of East Honolulu's forest reserves and increase recharge into the East and West Waiʻalae aquifers.	**#4:** Kamilo Nui Watershed Kipuka Reforestation **#9:** Restoration of Mid/Upper Niu and Wailupe Watersheds	**A:** Southern Koʻolau Mountains Native Species Reforestation Program **D:** Coordinated Pig Hunting Program
Issue: East Honolulu is prone to wildfires due to its dry climate. Wildfires negatively impact watershed health.	**1.2:** Implement preventative measures that reduce wildfire risks.		**H:** Firebreak Plan
Issue: Urban land uses and stream channelization have significantly impacted ecosystem diversity within surface waters.	**1.3:** Enhance ecosystem diversity within East Honolulu's streams and nearshore waters.	**#1:** Kalauhaʻihaʻl Fishpond Restoration **#2:** Wailupe Stream Restoration **#3:** Kuliʻouʻou Watershed Retention and Infiltration Retrofit **#13:** Coral Assisted Evolution Project **#14:** Community Cleanups and Water Quality Phone Application	**B:** Stream Restoration, Dechannelization and Maintenance **P:** Restoration of Fresh water Spring Flows to Nearshore Coastal Waters
Value: Community prioritizes being prepared for climate change impacts and natural disasters.	**1.4:** Prepare for the anticipated impacts of sea level rise on existing ecosystems, properties and infrastructure through remediation, adaptation, and other measures.	**#21:** Implement Mayo''s Directive on Climate Change **#23:** Infrastructure Planning in the Sea Level Rise Exposure Area **#24:** Oʻahu Climate Adaptation Strategy **#26:** Drainage and Stormwater Master Plans for Drainage System Capacity Expansion, Infrastructure Renewal and Replacement, and Stormwater Quality Management **#29:** One Water Collaboration for Climate Resilience	**N:** Climate Adaptation Neighborhood Plans **Q:** Strengthen Building Codes and Standards for Building Resilience **R:** Build Back Better and Smarter **T:** Redevelopment District
Issue: Shoreline armoring negatively impacts coastal ecosystems, recreational and cultural resources, and public shoreline access.	**1.5:** Conserve natural shorelines to protect beaches, coastal ecosystems, recreational and cultural resources, and public shoreline access.	**#23:** Infrastructure Planning in the Sea Level Rise Exposure Area	**J:** Lateral Shoreline Access Plan **S:** Restrictions on Shoreline Armoring

Table 4-1: Relationship of EHWMP Objectives, Issues, Sub-Objectives, Projects and Strategies

Community Value / Water Resource Issue	Sub-Objective	Projects with Champions	Strategies
OBJECTIVE #2: PROTECT AND ENHANCE WATER QUALITY AND QUANTITY			
Issue: Irrigation is a large contributor to water demand for single-family home development, particularly in East Honolulu, which has a relatively dry climate.	**2.1:** Encourage the use of xeriscaping and other low impact development strategies to reduce irrigation water demand from current aquifer sources and mitigate flooding impacts, with a focus on large landscaped areas such as parks, schools, golf courses, roadway landscaping, farms and large residential lots.	**#17:** Low Impact Design and Green Infrastructure Standards and Guidelines **#30:** Develop R-1 Recycled Water for Irrigation Users in Hawaiʻi Kai	**L:** Agricultural Water Use Plans **I:** Golf Course Xeriscaping and Water Efficiency Plan **M:** Grey Water Reuse Plan
Value: Water quality of Maunalua Bay was one of the most discussed water resource issues among residents. **Issue:** Maunalua Bay is considered an impaired water body; stormwater contributes to the degraded quality of the Bay.	**2.2:** Improve the water quality of Maunalua Bay by capturing and infiltrating stormwater runoff and reducing the transfer of sediment and other pollutants from mauka areas to the Bay.	**#2:** Wailupe Stream Restoration **#3:** Kuliʻouʻou Watershed Retention and Infiltration Retrofit **#4:** Kamilo Nui Watershed Kipuka Reforestation **#5:** Kamilo Nui Watershed Sustainable Agriculture Pilot Project **#6:** Kamilo Nui Watershed Kuapā Pond Restoration **#11:** Restoration of Upper Niu and Wailupe Watersheds **#12:** Mālama Maunalua Programs **#16:** DFM Community Programs **#17:** Low Impact Design and Green Infrastructure Standards and Guidelines **#18:** Stormwater Utility Oʻahu **#19:** Watershed Boulder Basins and Detention Basins **#20:** Drainage System Upgrades **#26:** Drainage and Stormwater Master Plans **#29:** One Water Collaboration for Climate Resilience	**A:** Southern Koʻolau Mountains Native Species Reforestation **D**: Coordinated Pig Hunting Program **C:** Stream Debris Educational Program **E:** Trail Education Program **F:** Trail Erosion Mitigation **G:** Kuliʻouʻou Ridge Trail Entrance Improvements

Table 4-1: Relationship of EHWMP Objectives, Issues, Sub-Objectives, Projects and Strategies

Community Value / Water Resource Issue	Sub-Objective	Projects with Champions	Strategies
Value: Water quality of Maunalua Bay was one of the most discussed water resource issues among East Honolulu stakeholders. **Issue:** Maunalua Bay is considered an impaired water body; many former fresh water sites in the district have been destroyed.	**2.3:** Improve the water quality of Maunalua Bay by increasing the amount of fresh water that enters the Bay.	**#1:** Kalauhaʻihaʻi Fishpond Restoration **#3:** Kuliʻouʻou Watershed Retention and Infiltration Retrofit	**P:** Restoration of Fresh water Spring Flows to Nearshore Waters
Issue: The district's drainageways are prone to clogging during heavy rain events; flooding causes property damage; climate change is likely to increase the frequency of flooding (over 400 homes damaged in the 2018 floods).	**2.4:** Reduce impacts from extreme rain events and flooding.	**#3:** Kuliʻouʻou Watershed Retention and Infiltration Retrofit **#19:** Watershed Boulder Basins and Detention Basins **#20:** Drainage System Upgrades **#25:** Wastewater Long Range Master Plan for Treatment, System Capacity Expansion, and Infrastructure Renewal and Replacement **#26:** Drainage and Stormwater Master Plans for Drainage System Capacity Expansion, Infrastructure Renewal and Replacement, and Stormwater Quality Management	**C:** Stream Debris Educational Program **R:** Build Back Better and Smarter
Issue: Cesspools, leaking sewer lines, and salt water intrusion into the sewer system are contributors to contamination of ground water, streams, and nearshore waters. East Honolulu has over 300 cesspools, many of which are likely to become inundated with sea level rise.	**2.5:** Reduce ground water contamination through cesspool conversion and wastewater system improvements in East Honolulu.	**#15:** Work-4-Water Initiative **#25:** Wastewater Long Range Master Plan for Treatment, System Capacity Expansion, and Infrastructure Renewal and Replacement	**R:** Build Back Better and Smarter

Table 4-1: Relationship of EHWMP Objectives, Issues, Sub-Objectives, Projects and Strategies

Community Value / Water Resource Issue	Sub-Objective	Projects with Champions	Strategies
Issue: Water sources are limited in East Honolulu. Approximately 97% of the district's water are provided by aquifers outside the district, and the remainder is provided from the Wai'alae East aquifer, in the East Honolulu district.	**2.6:** Maintain and improve the water supply of aquifers serving East Honolulu by maximizing ground water infiltration and encouraging urban recharge.	**#2:** Wailupe Stream Restoration **#3:** Kuliʻouʻou Watershed Retention and Infiltration Retrofit **#4:** Kamilo Nui Watershed Kipuka Reforestation **#5:** Kamilo Nui Watershed Sustainable Agriculture Pilot Project **#7:** Keawāwa Wetland and Hawea Heiau Restoration **#12:** Mālama Maunalua Programs **#16:** DFM Community Programs **#17:** Low Impact Design and Green Infrastructure Standards and Guidelines **#18:** Stormwater Utility Oʻahu **#22:** Climate Change Sustainable Yield Scenarios **#28:** BWS Water Conservation Incentives Program **#26:** Drainage and Stormwater Master Plans for Drainage System Capacity Expansion, Infrastructure Renewal and Replacement, and Stormwater Quality Management **#30:** Develop R-1 Recycled Water for Irrigation Users in Hawaiʻi Kai	**A:** Southern Koʻolau Mountains Native Species Reforestation **B:** Stream Restoration, Dechannelization and Maintenance
Issue: Sustainable yields may vary over time with changing climatic conditions. There is a need for measuring the district's sustainable yield, pumpage, and water transfers from the Honolulu and Windward water systems.	**2.7:** Re-evaluate aquifer sustainable yields to support ground water dependent ecosystems.	**#22:** Climate Change Sustainable Yield Scenarios	

Table 4-1: Relationship of EHWMP Objectives, Issues, Sub-Objectives, Projects and Strategies

Community Value / Water Resource Issue	Sub-Objective	Projects with Champions	Strategies
OBJECTIVE #3: PROTECT NATIVE HAWAIIAN RIGHTS AND TRADITIONAL AND CUSTOMARY PRACTICES			
Value: East Honolulu values is an area once known for its fishing resources and large fishponds. The community values this history. **Issue:** Nearly all the district's fishponds were destroyed in the 20th century.	**3.1:** Restore fishponds and springs for cultural and educational use.	**#1**: Kalauhaʻihaʻi Fishpond Restoration	**P:** Restoration of Fresh water Spring Flows to Nearshore Waters
Value: The community values the preservation of cultural sites and has led grassroots efforts to protect and maintain them.	**3.2:** Provide support to community organizations that are stewarding cultural and natural resources.	**#1:** Kalauhaʻihaʻi Fishpond Restoration **#7:** Keawāwa Wetland and Hawea Heiau Restoration **#8:** Ka Iwi Coast Mauka Lands Preservation **#11:** Maunalua Watershed Talk Stories **#12:** Mālama Maunalua Programs	
Issue: Lack of public shoreline access, particularly along Maunalua Bay. This hinders access to recreational, cultural, and subsistence opportunities.	**3.3:** Improve public shoreline access to allow for the practice of cultural traditions and subsistence activities.	**#23:** Infrastructure Planning in the Sea Level Rise Exposure Area	**J:** Lateral Shoreline Access Plan **K:** Awāwāmalu Access Improvements **S:** Restrictions on Shoreline Armoring

Table 4-1: Relationship of EHWMP Objectives, Issues, Sub-Objectives, Projects and Strategies

Community Value / Water Resource Issue	Sub-Objective	Projects with Champions	Strategies
Value: The community wishes to perpetuate the area's unique history.	**3.4:** Increase community awareness of Maunalua's unique history of water through educational programs.	**#11:** Maunalua Watershed Talk Stories	
OBJECTIVE #4: FACILITATE PUBLIC PARTICIPATION, EDUCATION AND PROJECT IMPLEMENTATION			
Issue: Community involvement is needed to protect and manage water resources in East Honolulu. Certain measures to lower the district's water demand will only be effective if the community is engaged and changes their behavior.	**4.1:** Promote public participation in planning of watershed management projects and programs.	**#2:** Wailupe Stream Restoration **#11:** Maunalua Watershed Talk Stories **#14:** Community Cleanups and Water Quality Phone Application **#26:** Drainage and Stormwater Master Plans for Drainage System Capacity Expansion, Infrastructure Renewal and Replacement, and Stormwater Quality Management	
Issue: The effectiveness of watershed projects is dependent upon younger generations being educated to steward water resources.	**4.2:** Provide educational opportunities for the community to learn about protecting and preserving water resources in East Honolulu with a particular emphasis on youth education.	**#1:** Kalauhaʻihaʻl Fishpond Restoration **#7:** Keawāwa Wetland and Hawea Heiau Restoration **#8:** Ka Iwi Coast Mauka Lands Preservation **#11:** Maunalua Watershed Talk Stories **#12:** Mālama Maunalua Programs **#14:** Community Cleanups and Water Quality Phone Application **#16:** DFM Community Programs **#28:** BWS Water Conservation Incentives Program	**C:** Stream Debris Educational Program **E:** Trail Educational Program **O:** Climate Change and Resilience Education

Table 4-1: Relationship of EHWMP Objectives, Issues, Sub-Objectives, Projects and Strategies

Community Value / Water Resource Issue	Sub-Objective	Projects with Champions	Strategies
Issue: Implementation of most watershed projects require collaboration amongst community groups, agencies, and organizations to work towards common objectives.	**4.3:** Collaborate among government agencies, landowners, and other stakeholders to implement mutually beneficial projects and strategies, obtain community support, and secure the necessary funding and legislation.	**#10:** Maunalua-Ka Iwi Watershed Hui **#15:** Work-4-Water Initiative **#21:** Implement Mayor's Directive on Climate Change **#24:** Oʻahu Climate Adaptation Strategy **#29:** One Water Collaboration for Climate Resilience	
OBJECTIVE #5: MEET PUBLIC WATER DEMANDS AT REASONABLE COST			
Issue: BWS water supply system is aging and needs repairs and upgrades.	**5.1:** Maintain and improve the reliability, adequacy, and efficiency of the potable water system.	**#27:** BWS Long Range Water Master Plan and Infrastructure Renewal and Replacement Program	
Issue: The timing and severity of climate change impacts to water supply is yet to be determined. However, it is imperative that governments have the best available science to base their policy decisions on.	**5.2:** Adapt to and plan for drought and its impacts on water supply in East Honolulu.	**#10:** Maunalua-Ka Iwi Watershed Hui **#28:** BWS Water Conservation Incentives Program	**I:** Golf Course Xeriscaping and Water Efficiency Plan **N:** Climate Adaptation Neighborhood Plans
Issue: In 2010, East Honolulu's per capita water demand was approximately 25% higher than the island-wide average. The majority of land use is residential single-family homes.	**5.3:** Implement conservation measures that improve water efficiency and decrease per capita water demand among residential, commercial, and agricultural water users.	**#28:** BWS Water Conservation Incentives Program	**M:** Grey Water Reuse Plan

Table 4-1: Relationship of EHWMP Objectives, Issues, Sub-Objectives, Projects and Strategies

Community Value / Water Resource Issue	Sub-Objective	Projects with Champions	Strategies
Issue: Other than single-family homes, the top water users in East Honolulu are golf courses, commercial users, and farms. Solutions are needed to promote conservation, stormwater management, and reuse for these users.	**5.4:** Through a One Water framework, promote an integrated demand-side management water conservation program with stormwater management and recycled water for all land uses to extend limited water supply and system capacity.	**#5:** Kamilo Nui Watershed Sustainable Agriculture Pilot Project **#25:** Wastewater Long Range Master Plan for Treatment, System Capacity Expansion and Infrastructure Renewal and Replacement **#28:** BWS Water Conservation Incentives Program **#29:** One Water Collaboration for Climate Resilience	**I:** Golf Course Xeriscaping and Water Efficiency Plan **L:** Agricultural Water Use Plans **M:** Grey Water Reuse Plan

Project #1: Kalauhaʻihaʻi Fishpond Restoration

Location

Niu

Project Champion & Partners

DLNR Engineering Branch and Maunalua Fishpond Heritage Center

Project Goals

- Restore the artesian water flow to the Kalauhaʻihaʻi Fishpond.

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #2:** Protect and Enhance Water Quality and Quantity.
    - **Sub-Objective 1.3:** Enhance ecosystem diversity within East Honolulu's streams and nearshore waters.
    - **Sub-Objective 2.3:** Improve the water quality of Maunalua Bay by increasing the amount of fresh water that enters the Bay.
    - **Sub-Objective 2.7:** Re-evaluate aquifer sustainable yields to support ground water dependent ecosystems.
- **Objective #3:** Protect Native Hawaiian Rights and Traditional and Customary Practices.
    - **Sub-Objective 3.1:** Restore fishponds and springs for cultural and educational use.
    - **Sub-Objective 3.2:** Provide support to community organizations that are stewarding cultural and natural resources.
- **Objective #4:** Facilitate Public Participation, Education and Project Implementation.
    - **Sub-Objective 4.2:** Provide educational opportunities for the community to learn about protecting and preserving water resources in East Honolulu with particular emphasis on youth education.

Image: Kalauhaʻihaʻi Fishpond (Photo credit: Chris Cramer)

Background

Kalauhaʻihaʻi Fishpond is a spring-fed fishpond in Niu, Oʻahu. The fishpond is said to have been historically owned by King Kamehameha I and Queen Kaʻahumanu and provided subsistence fishery for Native Hawaiians. In Hawaiian history it is believed to be the site where the ʻai kapu (Hawaiian system of laws governing contact between men and women) was broken by Queen Kaʻahumanu for the Island of Oʻahu in 1819. In the 1820's, the fishpond was given to Captain Alexander Adams, who later passed on the land to his descendants. Until the mid-1990's, cold, fresh water poured from a lava tube in the pond through a stone ʻauwai (irrigation channel) to the sea. The pond and nearshore teemed with native fish, shrimp, and limu. The last owner and keeper of the fishpond lived in a glass floored home over the fishpond.

According to local accounts, during a State highway widening project in the early 1990's, contractors broke the lava tube that conveyed spring water from mauka areas to the pond. Concrete was poured to plug the leak, sealing off the water source. The pond subsequently dried up, and the lack of fresh water also impacted the nearshore ecosystem. The fishpond is currently owned by DLNR and is set to be managed by the MFHC under a 30-year lease of the property. Since 2013, the MFHC has led an effort to restore the fishpond with the help of school and community volunteers. Following the securing of initial funds through State Representative Mark Hashem, the landowner DLNR is now in the midst of a multi-phase project to restore the artesian water flow to the Kalauhaʻihaʻi Fishpond.

Image: Kalauha'iha'i Lava Tube break in 1993 (Photo credit: T. Hara)

Water restoration will be achieved by installing a trench collection system. This system will collect groundwater mauka of Kalanianaʻole Highway and transport it to the Kalauhaʻihaʻi Fishpond via a 120' long-trench. The trench collection system was selected as the best alternative to restore groundwater flow as it provides multiple points where water is collected and does not require electrical power.

Another strategy to improve water flow to the fishpond is to establish a protective water recharge capture zone around and mauka of the fishpond and lagoon aligning with the Kuliʻouʻou watershed boundary supplying ground water flow to the coast. Ground water recharge in the Waiʻalae East aquifer is estimated by USGS in 2017 as approximately 10 MGD minus the sustainable yield of 2 MGD. BWS has reduced its Kuliʻouʻou Well pumping by two-thirds of the 0.3 MGD permitted use through water conservation in Kuliʻouʻou valley. Converting the remaining cesspools and managing chemical use within the capture zone will reduce nutrient and contaminant movement to the nearshore.

Preliminary Ka Paʻakai Analysis

The proposed project is expected to enhance, protect and restore traditional and customary practices.

Project Status

The DLNR has preliminarily determined that the installation of the trench collection system would have minimal or no significant effect on the environment and can therefore qualify for an Environmental Assessment exemption. The DLNR submitted a Proposed Environmental Assessment exemption notice to BWS in August 2023. Pending permits and approvals, Construction is expected to begin in late 2024, with project completion expected within 6 months.

Estimated Cost

$1,500,000 has been released by the Legislature for the project to date. The project is in the final permitting and implementation phases.

Project #2: Wailupe Stream Restoration

Location

Wailupe Stream

Project Champion & Partners

Maunalua-Ka Iwi Watershed Hui

Project Goals

- Establish a City-community partnership to coordinate stream maintenance and restoration.
- Engage homeowners and community groups in the process of stream restoration.

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #1:** Promote Sustainable Watersheds.
  - **Sub-Objective 1.3:** Enhance ecosystem diversity within East Honolulu's streams and nearshore waters.
- **Objective #2:** Protect and Enhance Water Quality and Quantity.
  - **Sub-Objective 2.2:** Improve the water quality of Maunalua Bay by capturing and infiltrating stormwater runoff and reducing the transfer of sediment and other pollutants from mauka areas to the Bay.
  - **Sub-Objective 2.6:** Maintain and improve the water supply of aquifers serving East Honolulu by maximizing ground water infiltration and encouraging urban recharge.
- **Objective #4:** Facilitate Public Participation, Education, and Project Implementation.
  - **Sub-Objective 4.1:** Promote public participation in planning of watershed management projects and programs.

Background

The Wailupe Stream Restoration project is identified in the 2019 Maunalua Watershed Priority Projects Report by the Maunalua-Ka Iwi Watershed Hui. The Report identified projects within three priority watersheds – Wailupe, Kuliʻouʻou, and Kamilo Nui. These watersheds were selected because they represent the highest potential pollution reduction benefit for Maunalua Bay. The EHWMP defines stream restoration as an effort to rehabilitate or enhance the ecological functions of a stream ecosystem. Stream restoration projects can include but are not limited to enhancing riparian zones through native vegetation, reducing debris and sediment/nutrient runoff, restoring natural stream patterns through de-channelization, and erosion control techniques to address eroding stream banks.

The Priority Projects Report recommended restoration of Wailupe Stream through implementation of a Regenerative Stormwater Conveyance (RSC) system, combined with a neighborhood outreach program. RSC is considered an innovative approach to provide stormwater treatment, infiltration, and conveyance. It consists of rock weirs constructed with boulders, riffle pools, vegetation, and an engineered filtration media usually consisting of a mix of sand, woodchips or compost. RSCs are also used for flood control and are typically designed to accommodate flows associated with up to 100-year floods. The Priority Projects

Report recommends establishing the RSC in partnership with the City and County of Honolulu, as the City has an existing mandate to "stabilize" and "maintain" the Wailupe Stream.

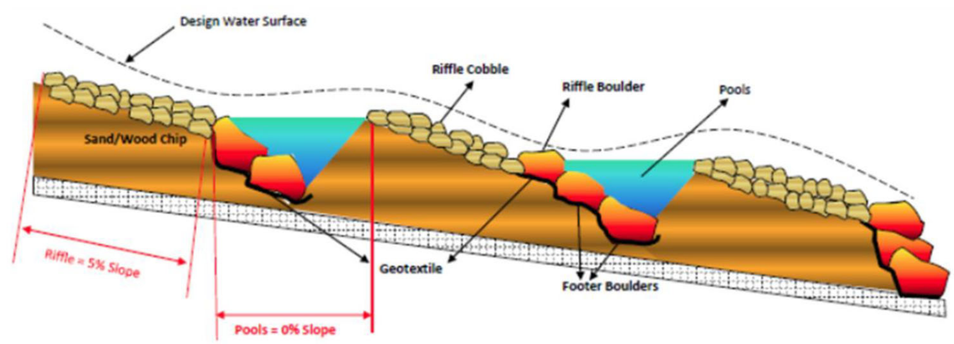


Image: RSC system (Credit: Anne Arundel County)

The Report notes that the entire portion of the Wailupe Stream that traverses through residential areas would benefit from an RSC system. However, prioritization of stream sections could consider alignment with the City and County's maintenance schedule and departmental priorities, as well as homeowners' willingness to participate. The design will require further surveying, mapping, and field investigation, and could incorporate taro, native plants, and other elements supporting environmental restoration and traditional cultural practices. Implementation of an RSC system would benefit from a parallel neighborhood outreach program. The Priority Projects Report recommended engaging stakeholders including neighborhood residents and landowners, the ʻĀina Haina Community Association, schools, and other community organizations.

Preliminary Ka Paʻakai Analysis

The project will enhance, protect and restore traditional and customary practices and riparian resources, while incorporating cultural features such as native plants and taro. RSC methodologies have commonalities with traditional practices such as loʻi kalo (wetland taro) farming, which utilizes a stream's riparian floodplain to grow kalo (taro) by diverting water using a series of manowai (rock weirs constructed within the stream to slow the water), poʻowai (riffle pools above the manowai),ʻahuauwai (ditches to transport water into the loʻi). The hoʻi wai returns the water back into the stream.

Project Status

Field observations have been completed and stakeholders and potential contractors identified by the Maunalua-Ka Iwi Watershed Hui. The hui must next work with the City to identify priority areas to implement the RSC, then obtain funding to permit and construct the proposed project.

Estimated Cost

Cost is dependent upon the selected locations and phasing for the project, which will be determined in consultation with the City.

Project #3: Kuliʻouʻou Watershed Retention and Infiltration Retrofit

Location

Kuliʻouʻou Stream (slightly mauka of the Kuliʻouʻou neighborhood)

Project Champion & Partners

Maunalua-Ka Iwi Watershed Hui and DFM

Project Goals

- Implement two flood control structures within Kuliʻouʻou Stream to retain and infiltrate stormwater.
- Implement 1,000 ft of stream restoration within Kuliʻouʻou Stream, including Regenerative Stormwater Conveyance (RSC) system.
- Redirect the hardened outfall at the mouth of Kuliʻouʻou Stream into Paikō lagoon, to enhance both the Kuliʻouʻou Stream and Paikō lagoon ecosystems.

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #1:** Promote Sustainable Watersheds.
  - **Sub-Objective 1.3:** Enhance ecosystem diversity within East Honolulu's streams and nearshore waters.
- **Objective #2:** Protect and Enhance Water Quality and Quantity.
  - **Sub-Objective 2.2:** Improve the water quality of Maunalua Bay by capturing and infiltrating stormwater runoff and reducing the transfer of sediment and other pollutants from mauka areas to the Bay.
  - **Sub-Objective 2.3:** Improve the water quality of Maunalua Bay by increasing the amount of fresh water that enters the Bay.
  - **Sub-Objective 2.6:** Maintain and improve the water supply of aquifers serving East Honolulu by maximizing ground water infiltration and encouraging urban recharge.

Background

The Kuliʻouʻou Watershed Retention and Infiltration and Retrofit project was identified in the Maunalua Watershed Priority Projects Report (previously described in Project #2). This proposed project involves three main components: 1) retrofitting a flood control structure mauka of the Kuliʻouʻou neighborhood to retain and infiltrate stormwater; 2) 1,000 ft of stream restoration through implementation of an RSC system and an additional retention and infiltration system; and 3) redirecting the hardened outfall at the mouth of Kuliʻouʻou Stream into Paikō lagoon to enhance both the Kuliʻouʻou Stream and Paikō lagoon ecosystems.

The use of bulkheads or sheet pile construction at the mouth at Kuliʻouʻou Stream will guide the stream flow to the desired discharge points. While sheet piles and bulkheading are considered 'hard engineering' measures, the Priority Projects report suggests they are worth exploring, given their ability to mitigate the amount of pollution entering Maunalua Bay from the stream and ditch outfalls.

Preliminary Ka Pa'akai Analysis

The proposed project is expected to enhance, protect and restore traditional and customary practices and riparian and nearshore water resources.

Project Status

In many ways, this project is "shovel ready" as field observations have been completed and stakeholders and potential contractors have been identified by the Maunalua-Ka Iwi Watershed Hui. To proceed, the Maunalua-Ka Iwi Watershed Hui must work with the City to permit the project and acquire needed funding.

Estimated Cost

Cost will be dependent upon permitting required as well as the selected contractor, which is still being determined.

Image: Kuli'ou'ou Channelized Stream

Project #4: Kamilo Nui Watershed Kipuka Reforestation

Location

Kamilo Nui (mauka of farm lots)

Project Champion & Partners

Maunalua-Ka Iwi Watershed Hui and DFM

Project Goals

- Retain and infiltrate stormwater to reduce pollutants entering Maunalua Bay.
- Enhance ecosystem diversity within the Kamilo Nui watershed.

Objectives & Sub-Objectives Addressed

- **Objective #1:** Promote Sustainable Watersheds.
  - **Sub-Objective 1.1:** Increase native reforestation and implement measures to slow the spread of invasive species and ungulates to improve the overall health of East Honolulu's forest reserves and increase recharge into the East and West Waiʻalae aquifers.
- **Objective #2:** Protect and Enhance Water Quality and Quantity.
  - **Sub-Objective 2.2:** Improve the water quality of Maunalua Bay by capturing and infiltrating stormwater runoff and reducing the transfer of sediment and other pollutants from mauka areas to the Bay.
  - **Sub-Objective 2.6:** Maintain and improve the water supply of aquifers serving East Honolulu by maximizing ground water infiltration and encouraging urban recharge.

Background

The Kamilo Nui Watershed Kipuka Reforestation project was identified in the Maunalua Watershed Priority Projects Report (previously described in Project #2). Kipuka refers to an "island" of forest that is spared when surrounded by a lava flow. It represents an important ecological preserve that can provide the seed bank and genetic stock for forests to regrow on former lava flow. The kipuka concept has been adopted in some reforestation projects to allude to an "island" of native plants and trees surrounded by invasive trees and grasses.

The Maunalua Watershed Priority Projects Report recognized the value of mauka reforestation efforts in reducing erosion and improving water quality in the makai areas around Maunalua Bay. The report recommended starting with a small reforestation effort, which will focus on establishing kipuka to reseed and repopulate native plants within certain areas of Kamilo Nui. Field observations identified several large wiliwili trees that could become the centerpieces for a small restoration site mauka of the Kamilo Nui farm lots.

Preliminary Ka Paʻakai Analysis

The proposed project is expected to enhance, protect and restore native forest resources.

Project Status

Field observations have been completed and stakeholders and potential contractors have been identified by the Maunalua-Ka Iwi Watershed Hui. To proceed, the Maunalua-Ka Iwi Watershed Hui must determine the number and size of kipuka areas, establish an agreement with the affected landowner(s), identify and obtain any required permits, and acquire funding for implementation.

Estimated Cost

Cost will be dependent upon the number and size of kipuka areas, as well as the agreement reached with the landowner(s).

Image: Kipuka (credit: 2019 Maunalua Watershed Priority Projects Report).

Project #5: Kamilo Nui Watershed Sustainable Agriculture Pilot Project

Location

Kamilo Nui (mauka of the spillway that drains into Kuapā Pond)

Project Champion & Partners

Maunalua-Ka Iwi Watershed Hui and DFM

Project Goals

- Retain and infiltrate stormwater to reduce the amount of pollutants which enter Maunalua Bay.
- Enhance ecosystem diversity within Kuliʻouʻou Stream and Paikō lagoon.

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #2:** Protect and Enhance Water Quality and Quantity.
    - **Sub-Objective 2.2:** Improve the water quality of Maunalua Bay by capturing and infiltrating stormwater runoff and reducing the transfer of sediment and other pollutants from mauka areas to the Bay.
    - **Sub-Objective 2.6:** Maintain and improve the water supply of aquifers serving East Honolulu by maximizing ground water infiltration and encouraging urban recharge.

Background

The Kamilo Nui Watershed Sustainable Agriculture project was identified in the 2019 Maunalua Watershed Priority Projects Report. The proposed sustainable agriculture pilot project would focus on integrating stormwater best management practices (BMPs) into agricultural practices within the properties located just above the spillway that drains into Kuapā Pond.

The Priority Projects Report also suggests harvesting rainwater for irrigation. Since there is already sufficient elevation gain (head pressure) in the valley to allow for a simple lined reservoir or basin, gravity could feed the farm plots below with irrigation water.

Preliminary Ka Paʻakai Analysis

The proposed project is expected to enhance, protect and restore mauka and makai resources.

Project Status

In many ways, this project is "shovel ready" as field observations have been completed and stakeholders, and potential contractors have been identified by the Maunalua-Ka Iwi Watershed Hui. To proceed, the Maunalua-Ka Iwi Watershed Hui must work with the landowners to acquire permissions, permits, and obtain needed funding.

Estimated Cost

Unknown.

Image: Kamilo Nui – the relatively broad and flat nature of the valley makes it ideal for implementing stormwater best management practices and pollution reduction projects (Credit: Google Earth).

Project #6: Kamilo Nui Watershed Kuapā Pond Restoration

Location

Kuapā Poʻahud (Hawaiʻi Kai Marina)

Project Champion & Partners

Maunalua-Ka Iwi Watershed Hui and DFM

Project Goals

- Improve the water quality of Kuapā Pond.
- Enhance ecosystem diversity within Kuapā Pond by increasing fish and bird habitat.

Image: Example of a Floating Wetland Treatment with Native Hawaiian plants (Credit: 2019 Maunalua Watershed Priority Projects Report).

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #2:** Protect and Enhance Water Quality and Quantity.
    - **Sub-Objective 2.2:** Improve the water quality of Maunalua Bay by capturing and infiltrating stormwater runoff and reducing the transfer of sediment and other pollutants from mauka areas to the Bay.

Background

The Kamilo Nui Watershed Kuapā Pond Restoration project was identified in the 2019 Maunalua Watershed Priority Projects Report. Kuapā Pond is a traditional fishpond and wetland that was later dredged to create the Hawaiʻi Kai marina. There are two artificial spoil islands in Kuapā Pond that were created by the dredging operations. This project proposes outplanting these islands with native wetland plants such as makaloa or other native salt tolerant sedges. It also proposes reshaping these islands to create small artificial intertidal zones in the islands' interiors to serve as a fish and bird habitats as well as provide nutrient sinks to improve the water quality of Kuapā Pond. This project also recommends retrofitting the private docks within Kuapā Pond with a combination of floating wetlands and/or oyster cages. Substantial work has been done on the continental U.S. with the use of oysters for restoration projects, including a homeowner participation and community-based restoration program.

Preliminary Ka Paʻakai Analysis

The proposed project is expected to improve ecosystem health and diversity.

Project Status

In many ways, this project is "shovel ready" as field observations have been completed and stakeholders and potential contractors have been identified by the Maunalua-Ka Iwi Watershed Hui. To proceed, the Maunalua-Ka Iwi Watershed Hui must acquire needed permits and funding.

Estimated Cost

Unknown.

Project #7: Keawāwa Wetland & Hawea Heiau Restoration

Location

Keawāwa Wetland (Kamilo Nui Watershed)

Image: Keawāwa Wetland Workday (Credit: Livable Hawaiʻi Kai Hui)

Project Champion & Partners

Livʻahuble Hawaiʻi Kai Hui (LHKH) and Maunalua.Net

Project Goals

- Improve the ecosystem health of Keawāwa Wetland.
- Community involvement in restoring natural and cultural resources.

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #2:** Protect and Enhance Water Quality and Quantity.
  - **Sub-Objective 2.6:** Maintain and improve the water supply of aquifers serving East Honolulu by maximizing ground water infiltration and encouraging urban recharge.
- **Objective #3:** Protect Native Hawaiian Rights and Traditional and Customary Practices.
  - **Sub-Objective 3.2:** Provide support to community organizations that are stewarding cultural and natural resources.
- **Objective #4:** Facilitate Public Participation, Education, and Project Implementation.
  - **Sub-Objective 4.2:** Provide educational opportunities for the community to learn about protecting and preserving water resources in East Honolulu with particular emphasis on youth education.

Background

The Keawāwa Wetland is located on the 5-acre Hāwea Heiau complex and is managed by the Liʻahuable Hawaiʻi Kai Hui (LHKH). Hāwea Heiau is managed by Maunalua.Net. These organizations have been actively involved in restoring these areas for cultural and educational purposes. LHKH is seeking to enhance restoration efforts through the following activities: 1) planting native trees; 2) resʻahuing ʻŌpaeʻula (Hawaiian red shrimp) habitat in partnership with the U.S. Fish and Wildlife Service; 3) rechanneling stormwʻahuter from Hawaiʻi Kai Drive that currently drains into the wetland and implementing a rain garden to infiltrate the runoff; 4) conducting a water quality study; and 5) obtaining an easement for land behind the Oʻahu Club, which is part of the wetland.

Preliminary Ka Paʻakai Analysis

The proposed project is expected to enhance, protect, and restore natural and cultural resources.

Project Status

This project is already underway by LHKH and Maunalua.Net.

Estimated Cost

Unknown.

Project #8: Ka Iwi Coast Mauka Lands Preservation

Location

Ka Iwi Coast Mauka Lands

Project Champion & Partnerʻahu

Livable Hawaiʻi Kai Hui (LHKH)

Project Goals

- Protect the natural and cultural resources along the Ka Iwi Coast.
- Increase community involvement in restoring natural and cultural resources.

Image: Guided hikes during the 2019 Ka Iwi Explorations (Credit: Ka Iwi Coast Coalition)

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #3:** Protect Native Hawaiian Rights and Traditional and Customary Practices.
  - **Sub-Objective 3.2:** Provide support to community organizations that are stewarding cultural and natural resources.
- **Objective #4:** Facilitate Public Participation, Education, and Project Implementation.
  - **Sub-Objective 4.2:** Provide educational opportunities for the community to learn about protecting and preserving water resources in East Honolulu with particular emphasis on youth education.

Background

The Ka Iwi Coast Mauka Lands consist of 181 acres of land that was preserved in perpetuity in 2016. In 2017, the land was transferred from the Trust for Public Land to LHKH, who then formed the Ka Iwi Coalition to steward the land. The coalition annually hosts the "Ka Iwi Explorations", which includes guided hikes and educational activities. This group seeks to enhance the restoration of the Ka Iwi Coast Mauka lands by developing a cultural plan for one of the parcels that has many archeological sites, and creating a hui of agencies and organizations to oversee the cultural management of the Ka Iwi Coast.

Preliminary Ka Paʻakai Analysis

The proposed project is expected to enhance, protect, and restore natural and cultural resources.

Project Status

This project is already underway by LHKH's Ka Iwi Coalition.

Estimated Cost

Unknown.

Project #9: Restoration of Mid/Upper Niu and Wailupe Watersheds

Location

Upper Watersheds of Wailupe and Niu

Project Champion & Partners

State Department of Land and Natural Resources, Division of Forestry and Wildlife (DLNR-DOFAW), Koʻolau Mountains Watershed Partnership (KMWP), and Protect & Preserve Hawaiʻi (PPH)

Project Goals

- Decrease erosion from mauka to makai areas in East Honolulu.

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #1:** Promote Sustainable Watersheds.
    - **Sub-Objective 1.1:** Increase native reforestation and implement measures to slow the spread of invasive species and ungulates to improve the overall health of East Honolulu's forest reserves and increase recharge into the East and West Waiʻalae aquifers.
- **Objective #2:** Protect and Enhance Water Quality and Quantity.
    - **Sub-Objective 2.2:** Improve the water quality of Maunalua Bay by capturing and infiltrating stormwater runoff and reducing the transfer of sediment and other pollutants from mauka areas to the Bay.
- **Objective #4:** Facilitate Public Participation, Education, and Project Implementation.
    - **Sub-Objective 4.1:** Promote public participation in planning of watershed management projects and programs.

Background

KMWP is a voluntary alliance of public and private landowners and partners working to protect nearly 100,000 acres of forested mauka areas in the Koʻolau Mountains. Many of the areas KMWP manages are identified as Priority 1 watersheds by BWS. KWMP's methods for watershed protection include ungulate-proof fencing, weed removal, restoration work, and long-term monitoring. In East Honolulu, KMWP has plans to implement ungulate-proof fences in the upper watersheds of Wailupe and Niu (also known as Pia).

PPH is a community-based conservation group that is working to restore 330 acres of forest in the Pia Valley (located in the Niu watershed). PPH's methods for watershed protection include removing invasive species and reestablishing native dry-land forest, creating habitat for native species while serving as a means to involve the Pia Valley community through volunteer, cultural, and educational experiences.

KMWP and PPH are currently working together to implement the objectives and policies documented in the Pia Valley Forest Stewardship Plan. The long-term goal of this joint project is to improve drought resilience and watershed efficiency through community driven restoration activities and transition the site into a more functionally diverse multi-strata native dryland forest ecosystem. This will be achieved by activating PPH's volunteer network to work within KMWP's native forest restoration area.

Preliminary Ka Pa'akai Analysis

The project is expected protect, enhance, and restore natural resources.

Project Status

This project is being planned by DLNR-DOFAW and KMWP.

Estimated Cost

Unknown.

Image: PPH volunteer workday in (Credit: PPH)

Project #10: Maunalua-Ka Iwi Watershed Hui

Location

District-Wide

Project Champion & Partners

Maunalua-Ka Iwi Watershed Hui and BWS

Project Goals

- Improve coordination between government agencies and community organizations/leaders regarding watershed projects.

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #4:** Facilitate Public Participation, Education, and Project Implementation.
  - **Sub-Objective 4.3:** Collaborate among government agencies, landowners, and other stakeholders to implement mutually beneficial projects and strategies, obtain community support, and secure the necessary funding and legislation.
- **Objective #5:** Meet Public Water Demands at a Reasonable Cost.
  - **Sub-Objective 5.2:** Adapt to and plan for drought and its impacts on water supply in East Honolulu.

Background

The Maunalua-Ka Iwi Watershed Hui (also referred to as "hui") is a community partnership consisting of a dedicated group of locally based stakeholders and volunteers. The Maunalua-Ka Iwi Watershed Hui includes representatives of nonprofits, landowners, cultural practitioners, citizens, kupuna, and government agencies. The Watershed Hui published the Maunalua Watershed Priority Projects Report in 2019, which identifies three priority watersheds in the East Honolulu district: Wailupe, Kuliʻouʻou, and Kamilo Nui. The hui meets regularly to coordinate efforts.

Improved coordination between government agencies and the Maunalua-Ka Iwi Watershed Hui is needed assist in the implementation of the watershed projects outlined in the Priority Projects Report and in this EHWMP. Similar to the Neighborhood Board process, BWS and other government agencies could be invited to the hui's meetings to provide a status update on the priority projects and discuss next steps. The project team participated in several Watershed Hui meetings as part of the EHWMP process.

In addition to the projects identified in this Plan, members of the hui are engaged in many ongoing and developing projects to improve regional watershed health throughout the district via their respective agencies and organizations. These efforts are continuously evolving and growing. At the time of publication, the following additional projects and ongoing efforts were identified by the hui in the East Honolulu District:

- Restoration of Sandy Beach (West End)
- Āwawamalu Beach Sand Dune/Native Vegetation Restoration
- Āwawamalu Beach Cleanups
- Maunalua - Makapuʻu Scenic Byway Restoration

- Regional Albizia Eradication
- Waiʻalae Nui Forest Restoration and Watershed Management
- East Honolulu Goat Control
- Kuliʻouʻou Ridge Trail Restoration Project
- Green Infrastructure Installation
- Watershed Restoration of Niu, Wailupe and Kuliʻouʻou watersheds
- Koʻolau Mountains Watershed Partnership Programs and Collaborative Watershed Management

The inclusion of the Maunalua Ka Iwi Watershed Hui as an identified project in the EHWMP is meant to acknowledge and support these and other current and future efforts of the hui as a collective.

Preliminary Ka Paʻakai Analysis
The project is expected to improve community engagement and foster public-private partnerships to protect water resources.

Project Status
This is an ongoing project by the Maunalua-Ka Iwi Watershed Hui.

Estimated Cost
Unknown.

Project #11: Maunalua Watershed Talk Stories

Location

District-Wide

Project Champion & Partners

Maunalua.Net

Project Goals

- Perpetuate the cultural and historical knowledge of Maunalua.
- Improve the community's understanding of the history of water in Maunalua, and how water resources can be protected.

Top Image: Maunalua Talk Story (credit: Livable Hawaiʻi Kai Hui webpage)

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #3:** Protect Native Hawaiian Rights and Traditional and Customary Practices.
  - **Sub-Objective 3.2:** Provide support to community organizations that are stewarding cultural and natural resources.
  - **Sub-Objective 3.4:** Increase community awareness of Maunalua's unique history of water through cultural and educational programs.
- **Objective #4:** Facilitate Public Participation, Education, and Project Implementation.
  - **Sub-Objective 4.1:** Promote public participation in planning of watershed management projects and programs.
  - **Sub-Objective 4.2:** Provide educational opportunities for the community to learn about protecting and preserving water resources in East Honolulu with particular emphasis on youth education.

Background

Maunalua.Net is a non-profit organization dedicated to sharing the history of Maunalua. The organization's website features the history of wahi pana throughout Maunalua. In addition to being the caretaker for the Hāwea Heiau, the organization also engages the community at regularly talk story gatherings. The talk story sessions are held monthly at the Hāwea Heiau. With additional support, the talk story sessions could be expanded to include discussion of the district's historic water resources.

Preliminary Ka Paʻakai Analysis

The proposed project is expected to help perpetuate the cultural and historical knowledge of Maunalua.

Project Status

This is an ongoing project by Maunalua.Net.

Estimated Cost

Unknown.

Project #12: Mālama Maunalua Programs

Location

District-Wide

Project Champion & Partners

Mālama Maunalua

Project Goals

- Improve the water quality of Maunalua Bay through community-led habitat restoration, science, planning, education, and outreach programs.

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #2:** Protect and Enhance Water Quality and Quantity.
  - **Sub-Objective 2.2:** Improve the water quality of Maunalua Bay by capturing and infiltrating stormwater runoff and reducing the transfer of sediment and other pollutants from mauka areas to the Bay.
  - **Sub-Objective 2.6:** Maintain and improve the water supply of aquifers serving East Honolulu by maximizing ground water infiltration and encouraging urban recharge.
- **Objective #4:** Facilitate Public Participation, Education, and Project Implementation.
  - **Sub-Objective 4.2:** Provide educational opportunities for the community to learn about protecting and preserving water resources in East Honolulu with particular emphasis on youth education.

Background

Mālama Maunalua, founded in 2005, is one of the largest community organizations in East Honolulu. The organization is committed to restoring the health of Maunalua Bay through habitat restoration, science, planning, education, and outreach. Mālama Maunalua has a variety of ongoing community programs which could be continued and enhanced in future years through additional funding and government support. These programs, as well as future initiatives, are outlined below:

Image: 2019 Plant a Tree, Save the Sea Festival (Credit: Mālama Maunalua)

- **Huki Project** was first launched in 2007. During the "huki's", volunteers work together to remove invasive introduced algae from select plots of Pāiko beach. Today, over 28 acres of the Maunalua Bay is maintained by Mālama Maunalua and over 3.5 million pounds of algae have been removed from the Bay. Mālama Maunalua leads an Adopt a Plot program in addition to the hukis where volunteers can help clear and maintain these plots on their own time.

- **Plant a Tree, Save the Sea** is an ong‘ing’project where free 'ōhi'a, koa, lime, lemon, ‘a‘ali‘i, and ‘ulu trees are provided to Maunalua residents. This project’s objectives are to prevent soil erosion and runoff into the Bay, which collects silt that invasive algae species cling to. These invasive algae species, particularly leather mudweed, further trap sediment and mud, which suffocates coral and contributes to the loss of habitat for fish and other sea life in the Bay. Trees also help combat climate change by absorbing carbon dioxide. As part of this program, Mālama Maunalua holds a festival during which residents are provided trees and opportunities to learn about the organization’s restoration work.
- **Follow the Drop Mobile App** was developed by 3R Water, Inc., who has partnered with Mālama Maunalua on a pilot project to test its mobile application and to support the City’s future stormwater utility incentive program. The pilot is currently underway and is anticipated to last 12 months. The pilot project will include assessing the annual average stormwater runoff in the ‘Āina Haina watershed and the potential for stormwater reduction through green infrastructure. Following this baseline analysis, residential and commercial property owners will be surveyed to support the future stormwater utility incentive program. The pilot project will also include workforce development training for contractors to become certified under the National Green Infrastructure Certification Program.

Preliminary Ka Pa‘akai Analysis

The proposed project is expected protect, enhance, and restore natural resources and improve water quality in Maunalua Bay.

Project Status

These are ongoing projects by Mālama Maunalua.

Estimated Cost

Unknown.

Project #13: Coral Assisted Evolution Project

Location

District-Wide

Project Chamʻahuions & Partners

Hawaiʻi Institute of Marine Biology (HIMB), National Oceanic and Atmospheric Administration (NOAA), Hawaiʻi State Department of Aquatic Resources (DLNR-DAR), and Mālama Maunalua

Project Goals

- Improve coral reef resiliency to thermal stress in Maunalua Bay.

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #1:** Promote Sustainable Watersheds.
    - **Sub-Objective 1.3:** Enhance ecosystem diversity within East Honolulu's streams and nearshore waters.

Background

Rising ocean temperatures and acidification due to climate change pose major threats to coral reefs. When ocean temperatures rise, coral expel the algae they rely on for food. This causes their skeletons to lose color and appear "bleached." Coral can recover if the water cools, but will die if high temperatures persist. Bleaching can be determinantal to watershed health, because as reefs degrade, fish are left without habitats and coastlines are less protected from storm surges.

It was estimated that nearly half of Hawaiʻi's coral reefs were bleached during heat waves in 2014 and 2015. Recent reports by the United Nations Intergovernmental Panel on Climate Change (IPCC) predicts that if humans do not make drastic changes in reducing carbon emissions, 99 percent of the world's coral reefs will be gone in one more generation.[137]

The Coral Assisted Evolution Project is an effort to develop corals that can withstand ocean water that is becoming warmer and more acidic, conditions that make coral vulnerable to bleaching. It is being led by HIMB's Gates Lab, in partnership with NOAA, DLNR-DAR, and Mālama Maunalua and funded through a $1 million grant from the National Fish and Wildlife Fund and HIMB. During this three-year project, the team will identify existing coral stocks that are more resilient to thermal stress, grow them within *in situ* nurseries, and propagate them along the south and east shores of Oʻahu. This project is focusing its efforts at three sites, one of which is in East Honolulu: Kāneʻohe Bay, Maunalua Bay, and near Daniel K. Inouye International Airport.

[137] IPCC. (2018). *Special Report – Global Warming of 1.5 ºC.*

Preliminary Ka Paʻakai Analysis

The proposed project is expected to protect natural resources and support resilience to climate change.

Project Status

This is an ongoing project by Mālama Maunalua, HIMB, NOAA, and DLNR-DAR

Estimated Cost

Unknown

Image: Gates Coral Lab members placing fragments of more resilient corals at a nursery site in Kāneʻohe Bay (Credit: UH News)

Project #14: Community Cleanups and Water Quality Mobile Application

Location

District-Wide

Project Champion & Partners

808 Cleanups (Champion); Surfrider Foundation Blue Water Task Force; Water.App

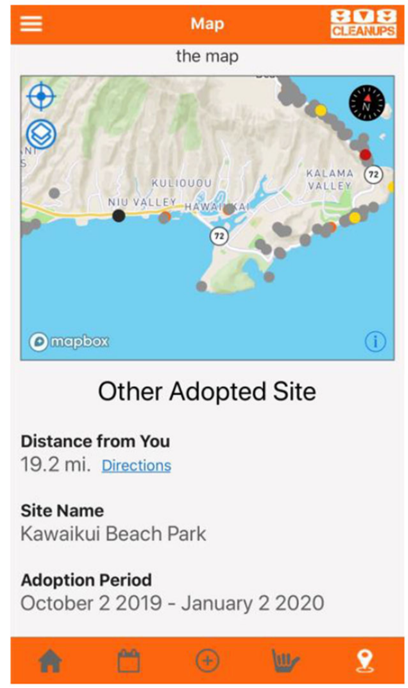


Image: Map on 808 Cleanups Mobile App

Project Goals

- Improve stream water quality.
- Decrease debris transfer to nearshore areas.
- Improve public knowledge of water quality.
- Increase community involvement in water resource protection.

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #1:** Promote Sustainable Watersheds.
  - **Sub-Objective 1.3:** Enhance ecosystem diversity within East Honolulu's streams and nearshore waters.
- **Objective #4:** Facilitate Public Participation, Education, and Project Implementation.
  - **Sub-Objective 4.1:** Promote public participation in planning of watershed management projects and programs.
  - **Sub-Objective 4.2:** Provide educational opportunities for the community to learn about protecting and preserving water resources in East Honolulu with particular emphasis on youth education.

Background

There are various community groups that coordinate beach and stream cleanups and monitor water quality through public technology platforms. One such organization is 808 Cleanups, a volunteer-led initiative that began in 2014. The organization focuses on beach, park, underwater, hike, and stream cleanups, as well as graffiti removal, invasive plant removal, and outreach and education. They hold weekly cleanups along the Ka Iwi Coast. The organization often partners with schools, as well as with Surfrider Foundation, Sustainable Coastlines, and other non-profits to host cleanups and conduct water quality testing.

In May 2019, 808 Cleanups launched a mobile application that allows the community to post about adopted sites and report litter, debris, and water quality issues. Cleanups in combination with water quality monitoring provide an opportunity for the community to learn about watershed issues and take part in citizen science. To enhance this program, 808 Cleanups could partner with other organizations such as Surfrider Blue Water Task Force and Water.App to increase its reach and scale up community engagement.

Surfrider's Blue Water Task Force is a volunteer-run water testing, education, and advocacy program. As of December 2019, Surfrider's Blue Water Task Force had collected water quality samp'ahu from 26 beaches on O'ahu, eight of which are within East Honolulu. Water.App has not yet been launched but plans to focus on collecting and making public data regarding drinking water quality.

Preliminary Ka Pa'akai Analysis

The proposed project is expected to enhance, protect, and restore riparian and nearshore resources.

Project Status

This project is underway by 808 Cleanups and Surfrider Blue Water Task Force.

Estimated Cost

Unknown.

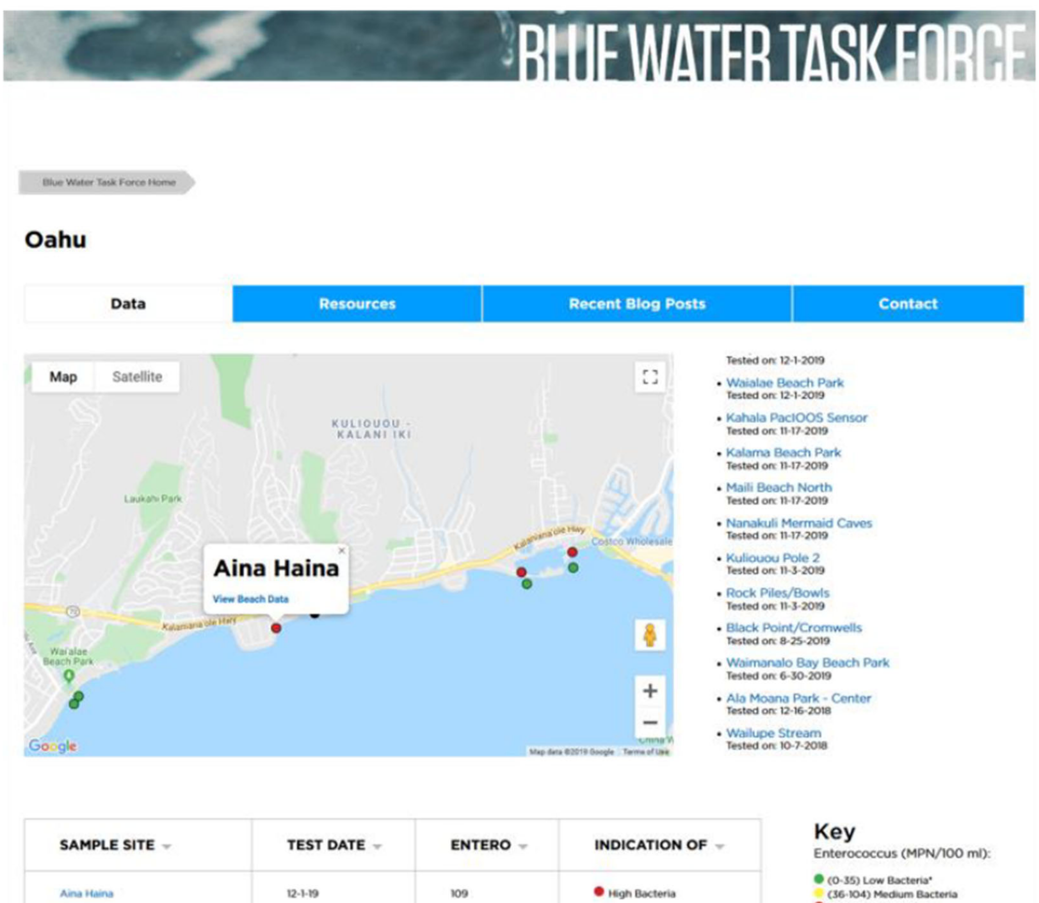


Image: Map on Surfrider's Blue Water Task Force Website showing water testing sites (Credit: Surfrider Foundation Website)

Project #15: Work-4-Water Initiative

Location

State-Wide

Project Champion & Paʻahutners

University of Hawaiʻi at Mānoa Water Resources Research Center (WRRC), UH Sea Grant College Program, Wastewater Alternatives and Innovations (WAI), UH Community Colleges (UHCC), State Department of Health Wastewater Branch (DOH-WWB)

Project Goals

- Improve water quality and reduce the public and environmental health risks associated with sewage pollution (53 million gallons per day) from the State's estimated 88,000 cesspools.
- Enhance the local economy by creating shovel-ready projects to convert 400 cesspools in Hawaiʻi's most at-risk areas.
- Develop training courses in wastewater management to meet workforce demand while creating long-term, well-paid jobs that are not dependent on tourism.
- Create a proof-of-concept model and blueprint for Hawaiʻi to fulfill its mandate under Act 125 to convert the islands' remaining cesspools by 2050.
- Contribute to State revenue through job creation and income tax revenues.

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #2:** Protect and Enhance Water Quality and Quantity.
    - **Sub-Objective 2.5:** Reduce ground water contamination through cesspool conversion and wastewater system improvements in East Honolulu.
- **Objective #4:** Facilitate Public Participation, Education, and Project Implementation.
    - **Sub-Objective 4.3:** Collaborate among government agencies, landowners, and other stakeholders to implement mutually beneficial projects and strategies, obtain community support, and secure the necessary funding and legislation.

Background

It is estimated that $2 billion will be needed to replace the approximately 88,000 cesspools remaining in Hawaiʻi by 2050 as mandated by the State Department of Health. To meet that goal, the replacement rate must also be scaled up to approximately 3,000 cesspools per year. The current replacement rate is 100-200 cesspools per year.[138]

The Work-4-Water Initiative is intended to jump-start the mandated replacement of cesspools, while simultaneously training and employing a specialized, non- tourism-based workforce. Through education courses, hands-on training, job creation and pilot testing of more than 400 cesspool conversion sites, the

[138] DOH. (2020). *Cesspools in Cesspools in Hawaiʻi*. Available at: https://health.hawaii.gov/ wastewater/cesspools/

plan will create shovel-ready projects for employment, stimulating the economy and improving water quality and public health for residents and visitors alike.

The DOH-WWB has designated approximately 24,000 cesspools (27% of the state's total) as the highest risk to public health and the highest priority for replacement.[139] On Oʻahu, there are four areas designated for priority upgrades: Diamond Head (240 cesspools); ʻEwa (1,100 cesspools); Waialua (1,080 cesspools); and Waimānalo (530 cesspools). There are many cesspools in the Diamond Head priority upgrade area that drain into Maunalua Bay, thereby impacting water quality in East Honolulu.

The Work-4-Water Initiative will be completed through the steps described below:

1. **Identify sites on each island with willing homeowners and community groups in priority areas.** Selection criteria will include a diversity of site conditions including soil type, lot size, lot slope, and proximity to coastal/water resources.
2. **Select onsite treatment and disposal technologies for each site in each priority area.**
3. **Conduct engineering site investigations and prepare required design submittals to the DOH-WWB for the sites** with selected treatment and disposal technologies; to be completed by engineering firms under sub-contract from UH-WRRC.
4. **Hire two additional personnel for DOH-WWB** to process IWS applications for cesspool replacement projects and maintain IWS database.
5. **Survey the condition of the state's estimated 88,000** cesspools in tandem with the University of Hawaiʻi campuses and DOH-WWB to develop a georeferenced database for planning, tracking, permitting, and maintenance records on IWS systems statewide.
6. **Issue contracts for installation of full-scale demonstration technologies at selected sites,** with little to no cost for qualified homeowners.
7. **Install upgrades at selected sites.**
8. **Inspect, monitor, and collect samples at least biannually** for existing technologies and at least quarterly for newer technologies from project installed units using UH personnel (students and faculty). Provide any necessary maintenance functions for a minimum of three years from installation, covered through a minimal monthly maintenance fee to the homeowner (using UH students under guidance of licensed wastewater operators).
9. **Develop protocols and submittal documents for DOH-WWB approval** of new IWS technologies. Develop design criteria and regulatory language for new technologies approved by DOH-WWB.
10. **Rapidly develop and implement new training programs for contractors** and certificate programs for other personnel (design, inspection, operation and maintenance/repair) at each of the participating UHCC campuses.
11. **Research and identify the best management model for the long-term regulation of IWS in Hawaiʻi by DOH-WWB** and submit a report to the Governor's Office and the State of Hawaiʻi Legislature. Research the number of workers needed for each category of an IWS program,

[139] DOH (2017). *Report To The 29th Legislature of State of Hawaiʻi: 2018 Regular Session. Relating to Cesspools and Prioritization for Replacement*. Available at: https:// health.hawaii.gov/opppd/files/2017/12/Act-125-HB1244-HD1-SD3-CD1-29th-Legislature-Cesspool- Report.pdf

including, but not limited to: design; permitting; operation; maintenance; and, inspection. Create and implement a new education module on IWS technologies for licensed operators.

12. **Create and implement a statewide public education and community outreach program to communicate the need for, and benefits of, cesspool upgrades.** The HSG-developed program will educate homeowners on how technologies work, how to maintain systems, information on service providers, and specialized requirements. Create a variety of multimedia communication tools on different platforms, including websites, YouTube videos, "Voice of the Sea" television and online episodes, community presentations, fact sheets, pamphlets, and coloring books.
13. **Investigate and develop partnerships with new and existing manufacturers to produce IWS technologies** and equipment locally, reducing shipping costs of materials and developing advanced manufacturing business opportunities and workforce within Hawaiʻi.

Preliminary Ka Paʻakai Analysis

The proposed project is expected to help protect valuable fresh water, ground water, and nearshore water resources.

Project Status

This project is an ongoing effort by WAI, who is currently focusing their efforts on Maui and Hawaiʻi island. With additional funding, they hope to expand their efforts to Oʻahu and Kauaʻi.

Estimated Cost (Statewide)

Description	Amount (USD)
Design and Permitting	$2,000,000
Inspection and Compliance	$700,000
Installation and System Construction	$16,000,000
Research and Analysis	$1,500,000
Outreach and Database Development	$1,000,000
Workforce Development and Training	$1,800,000
	TOTAL: $23,000,000

Project #16: DFM Community Programs

Location

Island-Wide

Project Champion & Partners

DFM

Project Goals

- Improve water quality through ongoing community-led cleanups of streams and streets.
- Educate students about the impacts of runoff, and how to mitigate them.

Image: 2019 Adopt-A-Stream Cleanup in Hawaiʻi Kai (Credit: DFM Website)

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #2:** Protect and Enhance Water Quality and Quantity.
    - **Sub-Objective 2.2:** Improve the water quality of Maunalua Bay by capturing and infiltrating stormwater runoff and reducing the transfer of sediment and other pollutants from mauka areas to the Bay.
    - **Sub-Objective 2.6:** Maintain and improve the water supply of aquifers serving East Honolulu by maximizing ground water infiltration and encouraging urban recharge.
- **Objective #4:** Facilitate Public Participation, Education, and Project Implementation.
    - **Sub-Objective 4.2:** Provide educational opportunities for the community to learn about protecting and preserving water resources in East Honolulu with particular emphasis on youth education.

Background

DFM has implemented various programs that educate and engage residents, businesses, and schools in improving the water quality in their communities. These initiatives, described below, could be enhanced through partnership with community organizations.

- **Adopt-A-Stream/Adopt-A-Block Programs** provide a platform for residents and businesses to engage in cleanups along certain stretches of streams or streets on Oʻahu. Any group of people may apply to Adopt-A-Block or Adopt-A-Stream if they are committed to ongoing cleanups for a two-year period. DFM has currently designated 51 steams and 60 street blocks on Oʻahu as adoptable. In the East Honolulu district, there are 10 adoptable steams and one adoptable street block. While streams have formerly been adopted in Hawaiʻi Kai, according to the DFM website, no streams or blocks are currently adopted in East Honolulu.
- **Stormwater Public School Curriculum** is a recent initiative by DFM, in which students learn about stormwater runoff impacts on water quality, and how stormwater can be better managed through

green infrastructure. Students also work with representatives from DFM to develop a stormwater runoff plan for their school.

Preliminary Ka Paʻakai Analysis
The proposed project is expected to educate young people about protecting natural resources.

Project Status
This is an ongoing project by DFM.

Estimated Cost
Unknown

Image: DFM at Noelani Elementary (Credit: DFM Website)

Project #17: Low Impact Design and Green Infrastructure Standards & Guidelines

Location

Island-Wide

Project Champion & Partners

DFM

Project Goals

- Capture and infiltrate stormwater runoff.
- Increase watershed recharge to reduce stormwater runoff.

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #2:** Protect and Enhance Water Quality and Quantity.
    - **Sub-Objective 2.1:** Encourage the use of xeriscaping and other low impact development (LID) strategies to reduce irrigation water demand from current aquifer sources and mitigate flooding impacts, with a focus on large landscaped areas such as parks, schools, golf courses, roadway landscaping, farms and large residential lots.
    - **Sub-Objective 2.2:** Improve the water quality of Maunalua Bay by capturing and infiltrating stormwater runoff and reducing the transfer of sediment and other pollutants from mauka areas to the Bay.
    - **Sub-Objective 2.6:** Maintain and improve the water supply of aquifers serving East Honolulu by maximizing ground water infiltration and encouraging urban recharge.

Background

The need to slow, capture, and infiltrate stormwater in East Honolulu was discussed at length during the EHWMP planning process. Stormwater management regulations and guidelines for private development in the City and County of Honolulu are found in these primary sources:

- The CCH Rules Related to Water Quality (amended 9/17/18, effective 12/24/18) and Water Quality Rules (WQR) (Administrative Rules Title 20 Chapter 3) establish requirements for regulated projects and activities both during and after construction. The 2018 update of the WQR specifies that regulated new development and redevelopment projects (including "priority uses" as well as projects >1 acre) include low impact development (LID) site design strategies, source control best management practices (BMPs), and post-construction treatment control BMPs to reduce the pollution associated with stormwater runoff.
- The CCH Stormwater BMP Guide for New and Redevelopment (2017) provides planning and design guidelines to support implementation of the Water Quality Rules. It includes minimum design and technical criteria for the analysis and design of storm drainage facilities and water quality, as well as guidance for stormwater quality during the planning phase, and operations and maintenance guidance. Additional guidance details and specifications for low impact development BMPs were released in March 2019 to provide supplemental guidance in implementation of LID and green infrastructure.

The EHSCP recommends requiring the use of LID in any significant new construction or redevelopment to hold stormwater on-site instead of discharging it into storm drains or stream channels. The EHSCP also promotes LID and other green infrastructure along natural gulches and drainage ways to restore ecological function to these areas, with a particular focus along stream channels.

While some of these guidelines (such as CCH Stormwater BMP Guide for New and Redevelopment) have limited applicability for East Honolulu because they only apply to new or redevelopment, the use of these guidelines, in tandem with the anticipated Oʻahu Stormwater Utility (see *Project #18*: **Stormwater Utility Oʻahu**), may be a catalyst to incentivize property owners to implement LID and green infrastructure, which has the potential to reduce the amount of impervious surfaces in East Honolulu and improve the district's nearshore water quality.

Preliminary Ka Paʻakai Analysis

The proposed project is expected to enhance nearshore water quality through reducing runoff.

Project Status

This project is an ongoing effort by DFM.

Estimated Cost

Unknown.

Project #18: Stormwater Utility Oʻahu

Location

Island-Wide

Project Champion & Partners

DFM, BWS

Project Goals

- Incentivize private property owners to implement permeable pavement, green infrastructure, and LID to help manage and treat stormwater runoff.
- Help fund DFM system maintenance and replacement.
- Help fund community projects that mitigate stormwater runoff and improve water quality.

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #2:** Protect and Enhance Water Quality and Quantity.
    - **Sub-Objective 2.2:** Improve the water quality of Maunalua Bay by capturing and infiltrating stormwater runoff and reducing the transfer of sediment and other pollutants from mauka areas to the Bay.
    - **Sub-Objective 2.6:** Maintain and improve the water supply of aquifers serving East Honolulu by maximizing ground water infiltration and encouraging urban recharge.

Background

The City and County of Honolulu is studying the formation of a stormwater utility for Oʻahu. The stormwater utility will create a dedicated fee for cleaner water and a healthier ocean environment, based on an equitable fee structure. There are more than 2,000 stormwater utilities across 39 U.S. states, and more are being formed each year. They play an important role in the communities they serve, focusing on managing impacts of stormwater runoff on the community and the environment. Stormwater utilities provides municipalities with dedicated, fee-based funding available exclusively for stormwater management purposes.

As empowered by the State Legislature in 2015, the City will develop a Stormwater Enterprise Fund. This dedicated funding will support implementation of the Stormwater Management Program Plan that the City is required to develop and implement for its Municipal Separate Storm Sewer System (MS4) and National Pollutant Discharge Elimination System (NDPES) permit to discharge stormwater into streams and the ocean. The City will first establish the Fund as a collection mechanism, and then establish a stormwater utility, which would impose fees for impervious area and further incentivize the use of green infrastructure and LID. BWS will coordinate with DFM to provide rebates for rain barrels to reuse captured stormwater. While the fee structure of the utility is still being debated, it may be based on the percentage of impervious surface on a property. Unless exempt, State and Federal agencies will also have to pay into the utility. The utility is needed to provide funds for maintenance and replacement of DFM's system, however the utility could also support community projects that mitigate stormwater runoff and improve water quality.

As of September 2020, the City had completed two rounds of community engagement. DFM is proceeding with revisions to the stormwater utility study in light of the COVID-19 pandemic crisis. Revisions are expected to include a proposal to delay the implementation of fees and include an equity plan for kūpuna, low-income families, and non-profits.

Preliminary Ka Pa'akai Analysis

The proposed project is expected to protect and improve surface and nearshore water quality.

Project Status

This project is an ongoing effort by DFM.

Estimated Cost

Unknown.

Image: Graphic from the Stormwater O'ahu Utility Website.

Project #19: Watershed Boulder Basins and Detention Basins


Image: Detention Basin in the Waiʻalae Iki Stream (Credit: DFM)

Location

District-Wide

Project Champion & Partners

DFM and BWS

Project Goals

- Capture and slow stormwater runoff.

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #2:** Protect and Enhance Water Quality and Quantity.
  - **Sub-Objective 2.2:** Improve the water quality of Maunalua Bay by capturing and infiltrating stormwater runoff and reducing the transfer of sediment and other pollutants from mauka areas to the Bay.
  - **Sub-Objective 2.4:** Reduce impacts from extreme rain events and flooding.

Background

There are concrete lined boulder basins, which are managed by DFM, within every stream in the East Honolulu district. Boulder basins are situated upstream of where a waterway enters developed areas. Boulder basins can prevent large debris and boulders from entering concrete stream channels. There may be opportunities for DFM to expand the capacity of existing boulder basins or create additional basins to prevent debris from entering stream channels during heavy rain events. Detention basins are engineered impoundments or excavated basins designed to capture and slow stormwater.

Detention basins provide an opportunity for stormwater management where there is channelization or limited space for natural stream drainageways. Detention basins can also help to reduce the amount of pollutants that enter streams and ground water. As they can impact natural stream flows, detention basins are most appropriate for already urbanized areas where there are limited options for natural stream flows or nature-based engineering solutions.

Preliminary Ka Paʻakai Analysis

As these solutions may impact stream flows, they should be done in consultation with cultural practitioners. The environmental impacts of such activities should also be assessed.

Project Status

Boulder and detention basins are already being managed by DFM; proposals for additional basins would need to be studied and budgeted for.

Estimated Cost

Unknown.

Project #20: Drainage System Upgrades

Image: Article about automatic retractable screens in Kailua (Credit: DFM Website).

Location

Island-Wide

Project Champion & Partners

DFM and BWS

Project Goals

- Capture debris and pollutants before they enter nearshore water.

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #2:** Protect and Enhance Water Quality and Quantity.
  - **Sub-Objective 2.2:** Improve the water quality of Maunalua Bay by capturing and infiltrating stormwater runoff and reducing the transfer of sediment and other pollutants from mauka areas to the Bay.

Background

DFM has implemented technologies in the City's drainage system over the past decade that have helped to capture debris and pollutants before they enter nearshore waters. These technologies include automatic retractable screens and baffle boxes. DFM has installed retractable screens in Downtown Honolulu, Waikīkī, and Kailua to date. In addition to litter and debris, these screens can also remove some organics from the storm drain system. Unlike temporary socks or other devices placed in storm drains, retractable screens are designed to remain in place permanently and have a spring mechanism that allows them to open during heavy rains for proper drainage. They also make curbside debris removal easier for street sweepers. To date, DFM has only implemented one baffle box, and it is considered a pilot at this time. With additional funding, these technologies could be scaled up and implemented in other areas including the East Honolulu district.

Preliminary Ka Paʻakai Analysis

The proposed project is expected to reduce debris and pollutants which enter the storm drain system and nearshore waters.

Project Status

This an ongoing project by DFM.

Estimated Cost

Unknown.

Project #21: Implement Mayor's Directive on Climate Change

Location

Island-Wide

Project Champion & Partners

DPP, BWS, ENV, DFM, DDC, and OCCSR

Project Goals

- Increase resilience to climate change and sea level rise through City land use plans, infrastructure plans, programs, standards and capital improvement programs.

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #1:** Promote Sustainable Watersheds.
    - **Sub-Objective 1.4:** Prepare for the anticipated impacts of sea level rise on existing ecosystems, properties and infrastructure through remediation, adaptation, and other measures.
- **Objective #4:** Facilitate Public Participation, Education, and Project Implementation.
    - **Sub-Objective 4.3:** Collaborate among government agencies, landowners, and other stakeholders to implement mutually beneficial projects and strategies, obtain community support, and secure the necessary funding and legislation.

Background

Impacts from global climate change will create new challenges in Hawaiʻi, including sea level rise, coastal erosion, and increased frequency and severity of storm surges, floods, heat and droughts. The Honolulu Climate Change Commission, established by City Charter, is charged with gathering the latest science and information on climate change impacts to Hawaiʻi and providing advice and recommendations to the City.

3.2 ft of sea level rise would result in 9,400 acres of land unusable on Oʻahu. Of the 9,400 acres, more than half of the land is designated as State Urban lands. Approximately 3,880 structures and 17.7 miles of major coastal roads would be chronically flooded. Total structure and land loss would equate to more than $12.9 billion. Approximately 13,300 residents living near the shoreline would be displaced and in need of new homes. A more detailed economic loss analysis is needed of Oʻahu's critical infrastructure, including water, wastewater and storm drainage systems, facilities and streets.

The Honolulu Climate Change Commission's 2018 Guidance provides various recommendations to mitigate impacts of sea level rise, including the following:

- Set as a planning benchmark up to 3.2 ft of global mean sea level (GMSL) rise by mid-century as it will be an area experiencing chronic high tide flooding
- Set as a planning benchmark up to 6 ft of GMSL rise in the later decades of the century, especially for critical infrastructure with long expected lifespans and low risk tolerance, as it will be an area experiencing chronic high tide flooding
- Revise the SMA boundary to include parts of the 3.2 ft of Sea Level Rise Exposure Area (SLR-XA) that are not currently in the SMA.

- Disclosure of all lands in the 3.2 ft and 6 ft SLR-XA on all real estate sales, City Property Information Sheets, and all other real estate transactions.
- Adopt the 3.2 ft SLR-XA and 6 ft SLR as a vulnerability zone (hazard overlay) for planning purposes by the City, for example in the general plan, all development plans, and sustainable community plans.
- All ordinances related to land development, such as policy plans and regulations should be reviewed and updated, as necessary.
- Relevant City departments and agencies be supported with adequate resources and capacity to implement these recommendations and proactively plan for sea level rise, as it will rapidly become a major challenge to City functions.

In response to the Commission's recommendations, a Climate Change and Sea Level Rise Mayor's Directive was issued in 2018 (Mayoral Directive 18-2). The Directive requires all City departments to take several actions, including:

- Use the most current versions of the Commission's Guidance and accompanying Brief, and the Hawaiʻi Sea Level Rise Vulnerability and Adaptation Report (2017) and associated Sea Level Rise Viewer as resources for managing assets, reviewing permitting requests, and assessing project proposals;
- Consider how sea level rise and associated climate change risks will impact the City's residents and visitors, infrastructure, communities, policies and programs, investments, natural resources, cultural and recreational sites, and fiscal security;
- Use the Guidance, Brief, and State Report in their plans, programs, and capital improvement decisions, to mitigate impacts to infrastructure and facilities subject to sea level rise exposure, which may include the elevation or relocation of infrastructure and critical facilities, the elevating of surfaces, structures, and utilities, and/or other adaptation measures;
- Work cooperatively to develop and implement land use policies, hazard mitigation actions, and design and construction standards that mitigate and adapt to the impacts of climate change and sea level rise; and
- Work cooperatively to propose revisions to amend shoreline rules and regulations to incorporate sea level rise into the determination of shoreline setbacks and Special Management Area (SMA) considerations.

Table 4-2 provides a timeline for the employment of different sea level rise adaptation measures on Oʻahu. The table highlights three benchmarks through 2100:

- **First Phase:** Current.
- **Second Phase:** Nuisance flooding (24x per year) at 1.7 ft by 2044-2045.
- **Third Phase:** Benchmark of adapting to high tide flooding associated with 3.2 ft of SLR by end of century.
- **Fourth Phase:** Benchmark of up to 6 ft of global SLR.

While the timeline assumes each Phase is a quarter of a century (25 years), the duration may vary according to the timing of the observed impacts (e.g., when nuisance flooding reaches 24x per year, it is time to move to the second phase).

Table 4-2: Sea Level Rise Adaptation Timeline (Brown & Caldwell [modified], 2019, unpublished)

ADAPTATION MEASURES		**FIRST PHASE**	**SECOND PHASE**	**THIRD PHASE**	**FOURTH PHASE**
Research and Monitoring	Environmental baseline data Refine research on SLR-XA that will be impacted Expand and continuously monitor tidal and ground water well network				
Policy/Regulation	Develop and enact climate change and SLR policies				
	Amend land use plans, zoning ordinances, Flood Insurance Rate Maps, Building Codes, long-range infrastructure facilities plans and CIP				
	Adopt County framework for interagency coordination				
	Consolidate and streamline SLR environmental and permit and review process				
Financing	Authorize CIP appropriations for SLR adaptation measures				
	Develop alternative funding strategies				
	Develop, establish, and authorize funding strategies				
Planning and Engineering Feasibility Studies	Implement long-range infrastructure facilities plans and CIP				
	Conduct risk assessments, identify priorities, and develop strategies and drainage master plans				
	Install interim flood mitigation measures				
	Conform existing and new development consistent with drainage master plans				
	Mitigate coastal erosion impact areas				

ADAPTATION MEASURES		FIRST PHASE	SECOND PHASE	THIRD PHASE	FOURTH PHASE
	Initiate district areas EIS and long-lead permitting/approvals				
	Revise and adjust CIP sequencing for site-specific actions				
	Incorporate SLR CIP design and construction improvements in annual budgets				
Public Outreach	Continuous engagement Develop outreach strategies for specific CIP projects Conduct project-specific stakeholder and community meetings				
Design	Design of highest priority adaptation projects by district				
Construction	Construct highest priority adaptation projects by district.				

Preliminary Ka Paʻakai Analysis

The proposed project is expected to protect vital natural resources and subsistence activities.

Project Status

In accordance with the Mayor's Climate Change Directive and guidance documents, the following initiatives and projects have been scoped for the watershed management plans:

- Work-4-Water Initiative (Project #15)
- Wastewater Long Range Master Plan for Treatment, System Capacity Expansion, and Infrastructure Renewal and Replacement (Project #25)
- Drainage and Stormwater Master Plans for Drainage System Capacity Expansion, Infrastructure Renewal and Replacement, and Stormwater Quality Management (Project #26)
- BWS Long Range Water Master Plan and Infrastructure Renewal and Replacement Program (Project #27)
- One Water Collaboration for Climate Resilience (Project #29)

Estimated Cost

Implementing climate change adaptation measures is expected to cost billions of dollars over the next several decades.

Project #22: Climate Change Sustainable Yield Scenarios

Location

Island-Wide

Project Champion & Partners

BWS and CWRM

Project Goals

- Develop climate change sustainable yield scenario estimates for Oʻahu's aquifers, considering the Wet and Dry rainfall scenarios, to better plan water for long-term water resource management.
- Support improvements to UH's climate models of future rainfall forecasts to 2100.

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #2:** Protect and Enhance Water Quality and Quantity.
    - **Sub-Objective 2.6:** Maintain and improve the water supply of aquifers serving East Honolulu by maximizing ground water infiltration and encouraging urban recharge.
    - **Sub-Objective 2.7:** Re-evaluate aquifer sustainable yields to support ground water dependent ecosystems.

Background

Section 2.6 discusses climate change impacts to future rainfall and sustainable yields. Two leading models, statistical downscaling and dynamical downscaling, are used to project annual rainfall in Hawaiʻi through 2100. The statistical downscaling model (or the "Dry" scenario) projects a generally drier climate, while the dynamical downscaling model (or the "Wet" scenario) projects a generally wetter climate. Climate scientists support either model as representative of future uncertainty to evaluate risk tolerance.

To plan for reductions in ground water aquifer recharge under the Dry Scenario, *Chapter 5* presents strategies to ensure adequate water availability through aggressive water conservation and the development of alternative water supplies, such as stormwater capture, on-site reuse, desalination, and indirect and direct potable reuse. To support this planning and better understand climate change impacts to aquifers' sustainable yields, investments are needed in climatic and hydrologic modeling, scenario modeling, and evaluation of adaptive management strategies.

Preliminary Ka Paʻakai Analysis

The proposed project is expected to protect and enhance ground water resources through climate research, modeling, and management.

Project Status

This project is an ongoing effort by BWS and CWRM.

Estimated Cost

Unknown.

Project #23: Infrastructure Planning in the Sea Level Rise Exposure Area

Location

Island-Wide

Project Champion & Partners

City and County of Honolulu One Water Panel, a multi-agency panel convened by the Office of Climate Change, Sustainability and Resiliency (OCCSR)

Project Goals

- Develop clear policy and facilitate inter-agency coordination around the construction and maintenance of development and infrastructure within the sea level rise exposure area (SLR-XA).

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #1:** Promote Sustainable Watersheds.
  - **Sub-Objective 1.5:** Conserve natural shorelines to protect beaches, coastal ecosystems, recreational and cultural resources, and public shoreline access.
- **Objective #3:** Protect Native Hawaiian Rights and Traditional and Customary Practices.
  - **Sub-Objective 3.3:** Improve public shoreline access to allow for the practice of cultural traditions and subsistence activities.

Background

Image: Coastal development in Wailupe.

Sea level rise and other climate change-related impacts will result in increasing stresses on infrastructure and development within vulnerable coastal areas. Potentially affected areas in the City and County of Honolulu (City) have been identified as the sea level rise exposure area (SLR-XA) in the Hawaiʻi Sea Level Rise Vulnerability and Adaptation Report (2017) and associated Sea Level Rise Viewer. As impacts increase in frequency and intensity, infrastructure and development within the SLR-XA is expected to be subject to repeated losses and damages, over time becoming more costly to maintain and repair. Eventually, some areas will become infeasible to continue to inhabit, necessitating relocation or retreat of coastal development and infrastructure.

As described in the project write-up for the Mayor's Directive on Climate Change (Project #21), the Mayor's Directive requires use of the Honolulu Climate Change Commission's Guidance and accompanying Brief, and the Hawaiʻi Sea Level Rise Vulnerability and Adaptation Report (2017) and associated Sea Level Rise Viewer as resources for agency plans, programs, and capital improvement decisions, to mitigate impacts to infrastructure and facilities subject to sea level rise exposure, which may include the elevation or relocation of infrastructure and critical facilities, the elevating of surfaces, structures, and utilities, and/or other adaptation measures. It also calls for agencies to work cooperatively to develop and implement land use policies, hazard mitigation actions, and design and construction standards that mitigate and adapt to the impacts of climate change and sea level rise, and to amend shoreline rules and regulations to incorporate sea level rise into the determination of shoreline setbacks and Special Management Area (SMA) considerations.

The Honolulu Climate Change Commission's Guidance sets as a planning benchmark up to 3.2 ft of ground mean sea level (GMSL) rise by mid-century. However, for critical infrastructure with low risk tolerance and an expected lifespan into the second half of the century, it sets up to 6 ft of ground mean sea level rise (SLR) as the planning scenario.

Preliminary Ka Paʻakai Analysis
The proposed project is expected to protect valuable shoreline resources and subsistence activities.

Project Status
Because infrastructure is closely linked to other types of development, accounting for up to 6 ft of SLR in infrastructure planning will require close coordination between multiple agencies and jurisdictions responsible for infrastructure, land use, coastal management, and climate adaptation. It will also require changes in regulations, policy, and planning to support the needed changes.

This points to the need for a broader inter-agency climate adaptation planning effort, along with the development of regulatory tools and guidance that will collectively direct decisions about maintenance, protection, and/or relocation of coastal development and infrastructure. Toward this end, the following initiatives are in various stages of development at the City:

- Preparation of a City and County of Honolulu Climate Adaptation Plan, to provide a framework for identifying climate adaptation strategies island-wide.
    - Status: Currently under development.
- Updates to regulations for the Special Management Area (SMA) (ROH Chapter 23) and shoreline setback area (ROH Chapter 25), to incorporate climate change considerations and integration of the SLR-XA.
    - Status: In 2022, the City and County of Honolulu approved Bill 41 and 42 (2022) and updated its SMA regulations to incorporate sea level rise considerations and adopted erosion-based shoreline setback regulations that require a shoreline setback area of 60 feet plus 70 times the annual erosion rate.
- Incorporation of climate change impacts and considerations into land use planning efforts such as City and County Development Plans (DP's), Sustainable Communities Plans (SCP's), and Transit Oriented Development (TOD) area plans.
    - Status: Policies for sea level rise and coastal development are included in the current drafts of the Primary Urban Center DP and East Honolulu SCP. Updates of the North Shore

SCP and Waiʻanae SCP are in process. TOD Area Plans are being reviewed and updated to incorporate updated SLR projections in accordance with the Mayor's Directive.

- Incorporation of climate change impacts and considerations into functional planning for infrastructure, including the Watershed Management Plans.
    - Status: The WMP's and other functional plans are incorporating climate change data and including policies, projects, and strategies to address climate change related impacts, as discussed further below and throughout the Plan.
- Update of relevant codes to elevate buildings within flood hazard zones to base flood elevation (BFE) plus additional freeboard.
    - Status: Completed. The City has adopted the 2018 International Building Code (IBC), which contains freeboard requirements above BFE.
- Launch of the Climate Ready Oʻahu Web Explorer, an online mapping tool with data representing best available science for a variety of climate change stressors and other regulatory layers.
    - Status: Completed. The tool was launched in 2020.
- Development of climate adaptation design guidelines to require new development and redevelopment to consider and incorporate climate mitigation and adaptation measures.
    - Status: In process. The Honolulu Climate Adaptation Principles for Urban Development document was released in December 2020. Additional resilience design guidelines are under development by the City Department of Design and Construction (DDC).
- Establishment of a One Water policy and multi-agency panel to guide climate adaptation efforts and inter-agency coordination around resilient infrastructure planning.
    - Status: Ordinance 20-47 was adopted in December 2020 establishing a One Water policy and providing for the formation of a One Water panel for interagency coordination. The One Water panel started convening regularly in March 2021 and completed a Memorandum of Understanding around inter-agency coordination. A One Water Plan is contracted and will be forthcoming. See Project #29 for more details on the One Water framework.

In addition, the State is in the process of preparing guidance to support updates to planning and regulatory standards to incorporate climate change:

- Resilience-Focused Disaster Reconstruction Planning to increase the capacity of coastal communities in Hawaiʻi to build back safer, stronger, smarter, and faster after a damaging disaster while conserving natural resources. The project will produce guidelines and support implementation of resilience focused rebuilding practices, policies and regulations at the state and County level.
    - Status: Forthcoming. Fact sheet available online.
- Guidance for Disaster Recovery Preparedness to establish resilience-focused recovery practices before a disaster hits to enable communities to recover quickly while also adapting to sea level rise and protecting sensitive coastal environments.
    - Status: Completed.
- Guidance for Addressing Coastal Hazards and Sea Level Rise in Community Planning to build capacity, particularly in County government, to address climate change, sea level rise, and coastal hazards through appropriate entry points in the County general and community planning process.

    - Status: Completed.
- Assessing the Feasibility of Managed Retreat from Vulnerable Coastal Areas, to highlight the factors and considerations involved in retreating infrastructure and other types of development from the coast.
    - Status: Completed.
- An Analysis of Legal and Financial Mechanisms for Managed Retreat in Hawaiʻi, to determine feasible and appropriate strategies to facilitate managed retreat from vulnerable coastal areas.
    - Status: Ongoing.

These efforts will help to establish a regulatory framework for infrastructure and land use planning in vulnerable coastal areas. In addition, site-specific studies will be needed to determine feasible and appropriate neighborhood and site-specific engineering solutions for protection, accommodation, and/or retreat. Until such a framework is established, decisions about further investments in coastal infrastructure will need to be approached at the agency level in a way that incorporates the Hawaiʻi SLR Viewer projections and other available data, anticipates future policy changes, and seeks coordination with other agencies and users of the area.

In support of efforts to incorporate sea level rise and other climate change impacts into infrastructure planning, the following initiatives and projects have been scoped for the watershed management plans:

- Work-4-Water Initiative (Project #15)
- Wastewater Long Range Master Plan for Treatment, System Capacity Expansion, and Infrastructure Renewal and Replacement (Project #25)
- Drainage and Stormwater Master Plans for Drainage System Capacity Expansion, Infrastructure Renewal and Replacement, and Stormwater Quality Management (Project #26)
- BWS Long Range Water Master Plan and Infrastructure Renewal and Replacement Program (Project #27)
- One Water Collaboration for Climate Resilience (Project #29)

Estimated Cost

Implementing climate change adaptation measures including moving, elevating, or hardening infrastructure is expected to cost billions over the next several decades.

Project #24: Climate Ready Oʻahu

Location

Island-Wide

Project Champion & Partners

OCCSR

Project Goals

- Implement Climate Ready Oʻahu, which outlines island-wide policies and programs to better prepare Oʻahu for sea level rise and other climate change related impacts.

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #1:** Promote sustainable watersheds.
  - **Sub-Objective 1.4:** Prepare for the anticipated impacts of sea level rise on existing ecosystems, properties and infrastructure through remediation, adaptation, and other measures.
- **Objective #4:** Facilitate public participation, education, and project implementation.
  - **Sub-Objective 4.3:** Collaborate among government agencies, landowners, and other stakeholders to implement mutually beneficial projects and strategies, obtain community support, and secure the necessary funding and legislation.

Background

Honolulu was selected in 2016 to join the third cohort of 100 Resilient Cities (100RC), an initiative launched by the Rockefeller Foundation. That same year, Oʻahu voters amended the City Charter, which catalyzed the development of the Office of the Climate Change, Sustainability, and Resiliency (OCCSR), an office dedicated to tackling the issues of climate change, increase the sustainability of City operations, and work with communities to create a more resilient island home.

After 18 months of community engagement and public outreach — with input from all 33 neighborhood boards on Oʻahu, 219 organizations, and more than 2,300 individuals —OCCSR released the Oʻahu Resilience Strategy. The Strategy consists of 44 actions that represent not only the City and County of Honolulu's blueprint for resilience but the community's vision.

Two major actions outlined in the Resilience Strategy are the preparation of: 1) a Climate Action Plan and 2) a Climate Adaptation Strategy. The Climate Action Plan was adopted in 2021. It provides a list of programs, policies, and actions for Oʻahu to reduce greenhouse gas (GHG) emissions by 45 percent over the next five years and achieve carbon neutrality by 2045.

The Climate Ready Oʻahu climate adaptation strategy is currently in preparation, and includes an island-wide risk assessment; an evaluation of climate impacts on important infrastructure, assets, and populations; guidance to inform community plan updates, functional plans, and disaster mitigation plans; adaptation strategies for City departments to implement; and recommendations for integrating climate risks into decision-making processes.

Together these plans set a path for Oʻahu to both mitigate its contribution to local and global climate change and adapt to the inevitable impacts of climate change. Residents and community organizations from East Honolulu should be active in implementing the actions outlined in the Climate Action Plan and Climate Adaptation Strategy at a local scale.

Preliminary Ka Paʻakai Analysis
The proposed project is expected to help the community prepare for climate change impacts.

Project Status
This project is an ongoing effort by OCCSR.

Estimated Cost
Implementing climate change adaptation measures is expected to cost billions over the next several decades.

Image: Planning process to develop Climate Ready Oʻahu (Climate Ready Oʻahu Website).

Project #25: Wastewater Long Range Master Plan for Treatment, System Capacity Expansion, and Infrastructure Renewal and Replacement

Location

Island-Wide

Project Champion & Partners

City and County of Honolulu Department of Environmental Services (ENV)

Project Goals

- Develop/update a Wastewater Long Range Plan that increases resilience of the municipal wastewater system in accordance with the Mayor's Climate Change and Sea Level Rise Directive 18-02.
- Protect public health and safety and the environment.
- Comply with the EPA Consent Decree, Clean Water Act and DOH Wastewater Regulations Chapter 11-62 HAR.
- Eliminate sewer system overflows.
- Proactively invest in infrastructure renewal and replacement, capacity expansion, and maintenance of the wastewater system.
- Develop an infrastructure vulnerability assessment to natural and man-made disasters and climate change and sea level rise.

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #2:** Protect and Enhance Water Quality and Quantity.
    - **Sub-Objective 2.5:** Reduce ground water contamination through cesspool conversion and wastewater system improvements in East Honolulu.
- **Objective #5:** Meet Public Water Demands at a Reasonable Cost.
    - **Sub-Objective 5.4:** Through a One Water framework, promote an integrated demand-side management water conservation program with stormwater management and recycled water for all land uses to extend limited water supply and system capacity.

Background

ENV collects and treats approximately 110 MGD of wastewater from approximately 147,000 customer accounts and serves approximately 780,000 residential, commercial and industrial customers on Oʻahu. Through a system of 2,100 miles of pipelines, assisted by gravity and 72 pump stations, the wastewater is delivered to nine wastewater treatment plants (WWTP), which are distributed across Oʻahu.

ENV serves approximately one-third of the residents in East Honolulu. Generally speaking, wastewater produced in the Waiʻalae Nui, Wailupe, and Niu watersheds are collected by ENV facilities and treated at the Sand Island WWTP, which currently has a design average daily flow rate of 90 MGD and peak wet weather hydraulic capacity of 271 MGD. Wastewater produced in other areas of the East Honolulu district are collected by the Hawai'i American Water Company and treated at the East Honolulu WWTP.


Image: Sand Island Wastewater Treatment Plant (Credit: DFM Website)

Article VI, Chapter 8, Section 6-803 Revised Charter of the City and County of Honolulu requires ENV to "prepare a functional plan for wastewater to emphasize source reduction and reuse where appropriate. The plan shall be for a thirty-year period with review and revisions every five years. The wastewater functional plan shall be reviewed and approved for consistency with the general plan and development plans by the planning commission." In fulfillment of this requirement, ENV prepares a series of infrastructure facilities plans for each of the 9 sewer collection systems and WWTPs on the island, including the Sand Island WWTP. A facility plan was not developed for the East Honolulu WWTP, as this is a privately-owned and operated facility.

The facility plans identify needed improvements to the existing wastewater collection system and treatment facilities to meet future flow demands and permit compliance. They take into account regulatory considerations, future population and land use patterns, policies established by the Development Plans and Sustainable Communities Plans, existing and emerging technologies for wastewater disposal and reuse, and community concerns.

Preliminary Ka Pa'akai Analysis
The proposed project is expected to help conserve valuable ground water and fresh water resources through wastewater management.

Project Status
Consent decree: On December 17, 2010, a Consent Decree, subsequently amended, was entered among the City and County of Honolulu, the United States Environmental Protection Agency, the Hawai'i Department of Health, and several non-governmental organizations. One of the main goals of the 2010 consent decree was to eliminate sanitary sewer overflows and construct secondary treatment at the Sand Island WWTP by 2035. The annual report for year twelve of the 2010 Consent Decree is available on ENV's website: https://www.honolulu.gov/cms-env-menu/site-env-site-articles-2/47764-consent-decree.html.

Estimated Cost
Unknown.

Project #26: Drainage and Stormwater Master Plans for Drainage System Capacity Expansion, Infrastructure Renewal and Replacement, and Stormwater Quality Management

Location

Island-Wide

Project Champion & Partners

DDC and DFM

Project Goals

- Develop and update a Drainage and Stormwater Management Long Range Master Plan that increases resilience of the drainage system in accordance with the Mayor's Climate Change and sea level rise Directive 18-02.
- Protect water quality, public health, safety, property and the nearshore environment
- Reduce flooding and stormwater quality impacts.
- Proactive investment in infrastructure renewal and replacement, capacity expansion, and maintenance of the drainage system.
- Develop an infrastructure vulnerability assessment to natural and man-made disasters and climate change and sea level rise.

EHWMP Policies & Sub-Objectives Addressed

- **Objective #1:** Promote a Sustainable Watershed
  - **Sub-Objective 1.4:** Improve disaster preparedness and resiliency to climate change.
- **Objective #2:** Protect and Enhance Water Quality and Quantity.
  - **Sub-Objective 2.2:** Improve the water quality of Maunalua Bay by capturing and infiltrating stormwater runoff and reducing the transfer of sediment and other pollutants from mauka areas to the Bay.
  - **Sub-Objective 2.4:** Reduce impacts from extreme rain events and flooding.
  - **Sub-Objective 2.5:** Reduce ground water contamination through cesspool conversion and wastewater system improvements in East Honolulu.
  - **Sub-Objective 2.6:** Reduce ground water contamination through cesspool conversion and wastewater system improvements in East Honolulu.

Background

Many drainage systems in urban Honolulu were constructed many decades ago and most are not designed to accommodate the 1% or the 100-year storm occurrence. Research scientists state that today's 100-year storm will not be tomorrow's 100-year storm given climate change forecasts that storm intensity will increase with warming. Drainage systems will be overwhelmed with greater storm occurrence and will need to be expanded over time. The challenge is that urban development has encroached into stream floodways leaving little room for expansion. Retention basins and green infrastructure can offset and supplement drainage system capacity improvements, such as what the Army Corps of Engineers has proposed for the Ala Wai watershed.

Article VI, Chapter 5, Section 6-503 of the Revised Charter of City and County of Honolulu mandates DDC to direct and perform the planning, engineering, design, and construction of City facilities including buildings, roads, bridges and walkways, and drainage and flood improvements, and to advise and assist the respective departments on matters related to the planning and engineering, design, construction, improvement, repair renovation and maintenance of city facilities under their jurisdiction.

DDC has identified areas prone to flood damage and is evaluating, programming, design and construction of drainage improvement projects for repetitive flooding areas, repairing existing drainage infrastructure and expanding drainage capacity where deficient as funding is available. In East Honolulu, the Wailupe Stream is identified as a priority area. The Wailupe watershed was also identified as a priority watershed in the 2006 Conservation Action Plan co-developed by Mālama Maunalua and in the 2019 Priority Projects Plan.[140]

Article VI, Chapter 9, Section 6-903 Revised Charter of City and County of Honolulu directs DFM to maintain, oversee and monitor drainage and flood control systems, administer City storm water permits, programs and management plans, and enforce City ordinances and rules relating to storm water quality.

DFM is responsible for the maintenance of roadways and drainage systems to ensure drains are not clogged with trash and debris and stream mouths along the coast are not blocked from the sand embankments from wave action. Water quality of streams and nearshore waters is important for public health and habitat environment. Sediment transport limits or Total Maximum Daily Load (TMDL) is the calculation of the maximum amount of a pollutant allowed to enter a waterbody to meet State water quality standards.

DFM and DOH have entered into a consent decree for the National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) to implement a broad program to address water quality in receiving waters. DFM is developing a comprehensive Storm Water Management Plan consisting of the following major themes:

Water Quality and Nearshore Protection: The NPDES MS4 stormwater management program plan establishes the elements to treat and mitigate runoff to streams and nearshore waters:

- MS4 Retrofit Plan, Street Sweeping & Drain Cleaning Prioritization Plan, Dewatering Facilities Expansion Plans
- Water Quality Rules, New Development/Re-development Manual
- Green Infrastructure Plan, Green Workforce Development Plan

[140] Mālama Maunalua. (2006). Maunalua Bay Conservation Action Plan; Maunalua Watershed Hui. (2019). *Maunalua Watershed Priority Projects Plan*.

Drainage and Flooding: The Asset Management Plan provides condition assessments, prioritization for the maintenance, repair and replacement of storm drains, catch basins and outfalls that capture and convey stormwater from properties to streams and nearshore waters.

- Department of Public Works Standard details and specification revisions
- Asset Renewal and Replacement Prioritization and Functional Plan
- Regional Drainage and Flood Management Studies
- Stream Maintenance Prioritization Plan and required personnel needs and succession plans

Climate Change, Sustainability and Sea Level Rise: The Stormwater Strategic Plan provides an overarching framework integrating stormwater into the following strategies, plans and regulations:

- Oahu Resilience Strategy, Emergency & Disaster Response Plans and Climate Adaptation and Climate Action Plans
- Watershed Management Plans, Urban Forest Master Plan
- Land Use, Zoning and Building Code Review, Complete Streets Design Manual

Budgeting and Finance: The Long-Range O&M and CIP Financial Plan provides the project prioritization and programming with funding strategies:

- Stormwater Fees and Billing System, Stormwater Utility Credits and Rebates Manual, Impervious Cover Aerial Imagery and GIS property boundary revisions
- Partnerships and Grants Program Plan, Community Engagement and Outreach Plan
- Community Re-investment Plan, Stormwater Utility Hardship Plan

Preliminary Ka Paʻakai Analysis

The proposed project is expected to protect valuable fresh water, ground water, and nearshore water resources.

Project Status

The Storm Water Management Program Plan was finalized by DFM in September 2021 and is available at www4.honolulu.gov/docushare/dsweb/View/Collection-8762.

Estimated Cost

DFM's annual operating budget is approximately $90 million. Costs for implementing the Storm Water Management Program Plan are unknown.

Project #27: BWS Long Range Water Master Plan and Infrastructure Renewal and Replacement Program

Location

Island-Wide

Project Champion & Partners

BWS

Project Goals

- Improve investment in water infrastructure and maintenance of the water system.
- Provide safe, dependable, and affordable water service to its customers.

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #5:** Meet Public Water Demands at a Reasonable Cost.
- **Sub-Objective 5.1:** Maintain and improve the reliability, adequacy, and efficiency of the potable water system.

Background

BWS builds, operates, and maintains a complex system of pipes, source and booster pumps, wells, tunnels, shafts, and water storage reservoirs on Oʻahu. The BWS Long Range Water Master Plan and Infrastructure Renewal and Replacement Program is focused on improving the efficiency of BWS' water distribution system.

The 2016 WMP defines an island-wide goal for "non-revenue" water, which is the percent of water produced but not sold and therefore not used by metered customers. Non-revenue water is caused by a combination of real water losses in the BWS system (due to main breaks, pipes leaking, fire-fighting, etc.) and apparent losses from differences in source and revenue meter calibration and timing differences in meter reading. The goal is for non-revenue water to be less than 8.1%, based on a 2012 American Water Works Association nationwide benchmarking survey of large utilities. In 2016, island-wide non-revenue water for BWS was 10.5% as a 5-year average, and in 2021, non-revenue water increased to approximately 14%, indicating a need for improvement in this area.

Pipelines make up more than 75 percent of the BWS's facility assets. Approximately 10 percent of the BWS pipelines and reservoirs are over 70 years old, with 2 percent of each older than 85 years. These pipelines are exposed to stressors such as high salinity ground water, corrosive soils, and other conditions that can impact their lifespan. East Honolulu stakeholders have expressed concern about the perceived high frequency of water main breaks in the district.

To reduce BWS main breaks, the BWS Renewal and Replacement (R&R) program aims to annually replace 21 miles of pipeline by 2030, funding dependent. Under the program, pipeline projects are prioritized by total risk based on a statistical model that determines the likelihood and consequence of failure.

Reservoirs, pump stations, and water treatment facility projects are prioritized by condition assessment. By reducing main breaks and water loss, BWS can reduce pumpage, which benefits aquifer health and reduces pumping power costs.

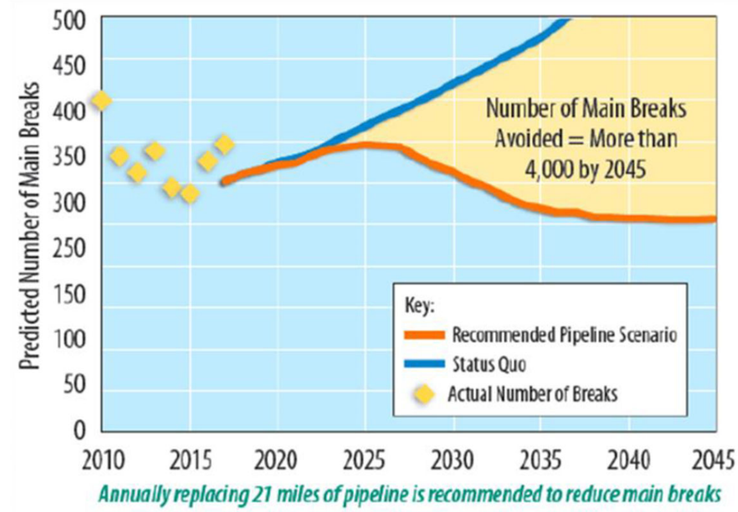


Image: Number of main breaks are predicted to increase (blue line) if BWS maintains status quo with pipeline replacement. By replacing more high-risk pipelines sooner, more than 4,000 water main breaks will be avoided by 2045 (Credit: BWS WMP)

Preliminary Ka Paʻakai Analysis

The proposed project is expected to help protect and conserve ground water resources.

Project Status

This project is an ongoing BWS project. BWS' goal is to reduce main breaks and to replace 21 miles of pipeline every year for the next 10 years.

Estimated Cost

Only a portion of high priority pipelines will be upgraded with the existing annual CIP budget. To fund additional infrastructure improvement projects, BWS has recently increased their water rates, which are incrementally increasing over a 5-year period (2018 through 2022). Rate increases are expected to generate about an additional $60 million to support the BWS Infrastructure Renewal and Replacement Program, and other CIP projects.

Project #28: BWS Water Conservation Incentives Program

Location

Island-Wide

Project Champion & Partners

BWS

Project Goals

- Educate water users to modify their behaviors toward an ethic of conservation ethic.
- Incentivize BWS customers to improve water efficiency and conservation through water fixture retrofits.
- Decrease per-capita water usage of BWS customers – in East Honolulu, BWS seeks to maintain per capita water demand at 170 GPCD tthrough 2040.

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #2:** Protect and Enhance Water Quality and Quantity.
    - **Sub-Objective 2.6:** Maintain and improve the water supply of aquifers serving East Honolulu by maximizing ground water infiltration and encouraging urban recharge.
- **Objective #4:** Facilitate Public Participation, Education, and Project Implementation.
    - **Sub-Objective 4.2:** Provide educational opportunities for the community to learn about protecting and preserving water resources in East Honolulu with particular emphasis on youth education.
- **Objective #5:** Meet Public Water Demands at a Reasonable Cost.
    - **Sub-Objective 5.1:** Maintain and improve the reliability, adequacy, and efficiency of the potable water system.
    - **Sub-Objective 5.2:** Adapt to and plan for drought and its impacts on water supply in East Honolulu.
    - **Sub-Objective 5.3:** Implement conservation measures that improve water efficiency and decrease per capita water demand at the household level.
    - **Sub-Objective 5.4:** Through a One Water framework, promote an integrated demand-side management water conservation program with stormwater management and recycled water for all land uses to extend limited water supply and system capacity.

Background

The BWS Conservation Incentives Program is focused on reducing water waste by influencing water conservation behaviors through outreach and education and providing tools and incentives to reduce per capita demand across the BWS customer base. Specific programs that have been major contributors to water conservation savings are summarized below (and further described in *Section 5.4.1*).

- **Water Conservation Week Art Contests:** An annual poster and poetry contest is open to all Oʻahu K-12 students to demonstrate the importance of water conservation. The winning posters and poems are featured in a water conservation calendar, which is distributed by BWS to schools and the public.

- **Water Sensible Rebate Program:** This program offers a number of rebates for Oʻahu residents, including rebates for water-efficient laundry machines and rain catchment barrels.
- **WaterSmart Programs:** WaterSmart is an online and mobile platform where participating BWS residential customers can access detailed information about their water use and customized water-saving tips and recommendations for their household.
- **Rain Barrel Catchment Program:** BWS conducts Rain Barrel Water Catchment workshops year round to promote rain barrel water catchment as an alternative and effective method for conserving water. Attendees learn how to install and maintain rain barrels at their homes to collect and use rainwater for non-potable purposes, such as garden irrigation. It is estimated the BWS rain barrel program saves about 253,000 gallons of potable water a year island-wide.

All of the initiatives discussed above have the potential to be marketed and implemented at a greater scale in East Honolulu, which benefits from highly engaged community members and organizations such as the Maunalua-Ka Iwi Watershed Hui and Mālama Maunalua. Given the high per capita use of water in East Honolulu due in part to landscaping irrigation, there is a particular opportunity to promote the Rain Barrel Catchment Program. BWS could work with the district's community organizations to host water catchment workshops within East Honolulu.

Image: 2019 Water Conservation Poster Contest (source: BWS website).

Preliminary Ka Paʻakai Analysis

The proposed project is expected to reduce aquifer pumpage and increase ground water flow to nearshore waters.

Project Status

This project is an ongoing effort by BWS.

Estimated Cost

Funded through existing BWS programs and initiatives.

Project #29: One Water Collaboration for Climate Resilience

Location

Island-Wide

Project Champion & Partners

City Administration, OCCSR, DPP, DDC, BWS, DFM, ENV, DPR and DTS

Project Goals

- Develop collaborative actions between separate but interconnected entities among City and later State agencies to coordinate planning and infrastructure investment for climate resiliency.

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #1:** Promote Sustainable Watersheds.
  - **Sub-Objective 1.4:** Prepare for the anticipated impacts of sea level rise on existing ecosystems, properties and infrastructure through remediation, adaptation, and other measures.
- **Objective #2:** Protect and enhance water quality and quantity.
  - **Sub-Objective 2.2:** Improve the water quality of Maunalua Bay by capturing and infiltrating stormwater runoff and reducing the transfer of sediment and other pollutants from mauka areas to the Bay.
- **Objective #4:** Facilitate public participation, education, and project implementation.
  - **Sub-Objective 4.3:** Collaborate among government agencies, landowners, and other stakeholders to implement mutually beneficial projects and strategies, obtain community support, and secure the necessary funding and legislation.
- **Objective #5:** Meet future water demands at reasonable cost.
  - **Sub-Objective 5.4**: Through a One Water framework, promote an integrated demand-side management water conservation program with stormwater management and recycled water for all land uses to extend limited water supply and system capacity.

Background

Research has shown that climate change will impact fresh water supplies, making water management (the management of fresh water, wastewater, sea water, and stormwater) a key facet of planning for resiliency and adaptation. As climate pressures are compounded over time, integrated water management should be addressed comprehensively and incorporated throughout agency planning efforts. A nationally acclaimed technique for encouraging integrated water management is the ‘One Water’ model, which envisions water being managed in a sustainable, inclusive manner while recognizing the intrinsic value of water in every form- stormwater, wastewater, sea water and drinking water alike. One Water can be defined as "an integrated planning and implementation approach to managing finite water resources for long-term resilience and reliability, meeting both community and ecosystem needs".[141]

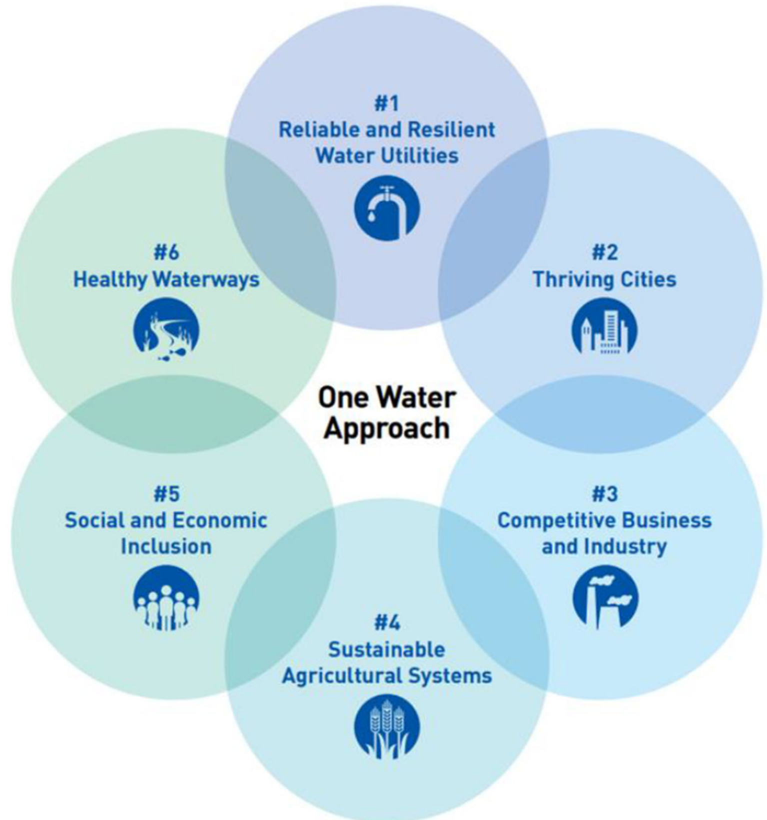


Image: One Water Approach (credit: One Water for America Policy Framework)

Water, wastewater, stormwater and transportation infrastructure agencies on O'ahu are efficient at completing their individual goals and tasks prescribed for each agency but are not necessarily designed to elicit collaboration or the sharing of innovative ideas and practices. In order to elevate O'ahu's resilience as the climate changes, seas rise, populations grow and natural resources decline, agencies can no longer plan and operate in siloes. Climate change is a generational existential threat and agencies must work together to resolve these challenges.

A One Water collaborative approach considers the water cycle as an integrated system, recognizing the interconnectedness of surface water, ground water, stormwater, wastewater, sea water and energy, including streets where infrastructure exists. Like the ahupua'a system, each process of the watershed has a specialized, valued role, but ultimately it works as an integrated system to provide for both the

[141] City and County of Honolulu Climate Change Commission. (2020). One Water for Climate Resiliency White Paper. Prepared by One World One Water. Available at www.resilientoahu.org/onewater.

needs of the community and the environment. Only by holistically working together can the mutual benefits be identified and collectively enhanced. The One Water Collaboration for Climate Resilience Framework defines and guides collaborative actions between separate but interconnected entities among City and later State agencies to coordinate planning and infrastructure investment for climate resiliency. These priority actions are described in the "Project Status" section below.

Ka Paʻakai Analysis

The proposed project is expected to help conserve valuable ground water and fresh water resources.

Preliminary Project Status

This project is an ongoing effort by BWS, DFM, ENV, and other agencies which manage water resources. Status on each of the priority actions is provided below.

- **Issue an Ordinance for One Water Framework for Climate Resilience:** Ordinance 20-47 was adopted in December 2020 establishing a One Water policy and providing for the formation of a One Water panel for interagency coordination.
- **Establish a One Water Panel to consult on City projects and programs:** The One Water panel was established following the passage of Ordinance 20-47 and started convening in March 2021.
- **Develop interagency Memorandum of Understanding (MOA):** The One Water panel completed an MOU around inter-agency coordination at the end of 2021.
- **Establish a One Water component in the broader planning framework:** Ordinance 20-47 lays the groundwork for this, with work continuing through the efforts on the One Water Panel.
- **Coordinate on budgets and CIP checklist for One Water climate resiliency:** Not yet initiated.
- **Develop a coordinating mechanism around developers seeking information about capacity and resilience:** Not yet initiated.
- **Identify and implement One Water demonstration projects**, including the Ala Wai Stormwater Management Plan, Māpunapuna Sea Level Rise Adaptation, University Avenue Complete Streets, cesspool conversions, and on-site water reuse: These are in various stages of planning and implementation by different agencies.

Estimated Cost

Unknown.

Project #30: Develop R-1 Recycled Water for Irrigation Users in Hawaiʻi Kai

Location

Ka Iwi, Oʻahu

Project Champion & Partners

Hawaiʻi American Water Co, Hawaiʻi Kai Golf Course, BWS, DPR

Project Goals

- Develop R-1 recycled water to replace potable irrigation of large landscaped areas in Hawaiʻi Kai, such as the Hawaiʻi Kai Golf Course and Sandy Beach Park.

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #5:** Meet Public Water Demands at a Reasonable Cost.
  - **Sub-Objective 5.2:** Adapt to and plan for drought and its impacts on water supply in East Honolulu.
  - **Sub-Objective 5.3:** Implement conservation measures that improve water efficiency and decrease per capita water demand at the household level.
  - **Sub-Objective 5.4:** Through a One Water framework, promote an integrated demand-side management water conservation program with stormwater management and recycled water for all land uses to extend limited water supply and system capacity.

Background

Approximately 3.6 MGD of treated effluent from the East Honolulu WWTP is being discharged through an ocean outfall instead of being reused for irrigation in a relatively dry part of the island with high irrigation demand. The WWTP is adjacent to the Hawaiʻi Kai Golf Course and Sandy Beach Park, both of which have significant irrigation demand and are obvious customers for recycled water.

The East Honolulu WWTP is a privately owned utility and operated by Hawaiʻi American Water Company, and previously provided the golf course with disinfected secondary effluent (R-2 recycled water) for irrigation that resulted in public complaints about odors and public health concerns. R-1 recycled water is tertiary treated disinfected water and is approved for irrigation by DOH Reuse Rules. A preliminary R-1 Upgrade Conceptual Plan was prepared for Hawaii American Water Company to evaluate the feasibility of converting the East Honolulu WWTP to a R-1 recycled water facility to produce 200,000 GPD for irrigation.[142] A distribution pipeline to the golf course irrigation pond still exists. The estimated conversion cost was $2.8 million and the monthly operating and maintenance costs was $36,000 (2016 dollars).

However, the chloride content of the wastewater was deemed too salty for turf irrigation. Average chloride content ranged from 1,564 to 2,920 mg/l in 2015. Turf grass can withstand about 500 to 1,000 mg/l chlorides depending on grass type and soils. The Hawaiʻi Kai sewer system is in low lying areas

[142] Limtiaco Consulting Group. (2016). *Hawaiʻi Kai WWTP R1 Upgrade Conceptual Plan*.

subject to saltwater infiltration and rehabilitating and replacing aging sewer pipe is a significant additional cost. Further, sea level rise will increase saltwater infiltration and chloride content.

Project Status

Due to the high chloride content of effluent at the East Honolulu WWTP, this project is currently not cost effective. However, there are various options to consider to move the project forward: 1) Extract lower chloride wastewater effluent during low tide cycles and blend the R-1 water with potable water within the golf course ponds to meet chloride targets and 2) Install brackish water reverse osmosis desalination membranes and blend the brine concentrate with the remaining treated effluent to ocean outfall, environmental permitting dependent.

Preliminary Ka Pa'akai Analysis

The proposed project is not expected to adversely impact any traditional and customary native Hawaiian practices and will reduce the discharge of treated effluent to coastal waters.

Estimated Cost

Needed treatment plant upgrades will cost $2,800,000 (2016 dollars). The cost of replacing sewer pipes or the cost of brackish water desalination has not been evaluated.

Image: Aerial View of the East Honolulu WWTP (Credit: Google Earth).

4.3.4 Watershed Management Strategies Descriptions

The EHWMP watershed management strategies and programs are actions that would help to implement EHWMP objectives but that do not currently have a championing agency or organization. The strategies identified for this EHWMP are summarized in this section, with the following information provided:

- Description
- Possible Champion or Partners
- EHWMP Objectives and Sub-Objectives Addressed
- Ka Paʻakai Analysis

Strategy A: Southern Koʻolau Mountains Native Species Reforestation

Description

It was noted several times during the EHWMP planning process that the Southern Koʻolau Mountains suffer widespread impacts from invasive species. In general, native Hawaiian plants, when planted in the appropriate habitat, require less irrigation and handle drought conditions better than most introduced plant species. Native plants also provide ecological benefits such as preventing soil erosion and stabilizing stream banks. While native plant reforestation may not be feasible for large swaths of land, native out plantings for small areas may be an effective strategy. Landscaping urbanized areas with native plants is also beneficial for water conservation as native plants tend to require less water than non-native plants. The importance of native forests is discussed in the EHSCP's planning guidelines, which states the City should, "Maintain, protect, and/or restore upland native forests in the State Conservation District."[143]

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #1:** Promote Sustainable Watersheds.
    - **Sub-Objective 1.1:** Increase native reforestation and implement measures to slow the spread of invasive species and ungulates to improve the overall health of East Honolulu's forest reserves and increase recharge into the East and West Waialae aquifers.
- **Objective #2:** Protect and Enhance Water Quality and Quantity.
    - **Sub-Objective 2.2:** Improve the water quality of Maunalua Bay by capturing and infiltrating stormwater runoff and reducing the transfer of sediment and other pollutants from mauka areas to the Bay.
    - **Sub-Objective 2.6:** Maintain and improve the water supply of aquifers serving East Honolulu by maximizing ground water infiltration and encouraging urban recharge.

Potential Champions or Partners

KMWP, DOFAW, DPR, Trees for Honolulu's Future, Maunalua-Ka Iwi Watershed Hui, and local arborists and botanists

[143] DPP. (2022). EHSCP.

Preliminary Ka Paʻakai Analysis

The proposed strategy is expected to improve the overall health of the forests and encourage aquifer recharge, which will result in the enhancement of water resources for traditional and customary practices. It could also increase native plant populations that could be accessed for gathering.

Strategy B: Stream Restoration, Dechannelization and Maintenance

Description

Stream channel degradation is a major threat to water quality, instream habitat, and overall stream health. Stream restoration is defined in *Project #2***: Wailupe Stream Restoration** of the EHWMP. A district-wide stream restoration effort could include a broad range of measures, including removing invasive species and out planting with native plants, stream cleanups, and installing signage to discourage dumping debris into streams. The DFM Stormwater Quality Branch has an "Adopt-A-Stream" program where community members can steward a designated stretch of a stream. Most of their past work has focused on stream cleanups. Other local nonprofits such as 808 Cleanups have similar cleanup efforts.

A stream restoration program could also include de-channelization of certain streams in the district to improve freshwater flow to nearshore areas and decrease the impacts of clogged drainageways and culverts. This would likely be a long, costly, and controversial effort, as there is existing development along many of the district's stream banks.

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #1:** Promote Sustainable Watersheds.
    - **Sub-Objective 1.3:** Enhance ecosystem diversity within East Honolulu's streams and nearshore waters.
- **Objective #2:** Protect and Enhance Water Quality and Quantity.
    - **Sub-Objective 2.6:** Maintain and improve the water supply of aquifers serving East Honolulu by maximizing ground water infiltration and encouraging urban recharge.

Potential Champions or Partners

DFM, Mālama Maunalua, 808 Cleanups, Surfrider Foundation, and private property owners

Preliminary Ka Paʻakai Analysis

The proposed strategy is expected to improve riparian resources and ecosystems important to traditional and customary practices.

Strategy C: Stream Debris Educational Program

Description

It was suggested by community stakeholders that outreach and educational signage could be used to increase community awareness about whose responsibility it is to clear debris from stream channels. A stream debris educational program has the potential for decreased dumping and debris, mitigating flood hazards, and improving nearshore water quality.

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #2:** Protect and Enhance Water Quality and Quantity.
    - **Sub-Objective 2.2:** Improve the water quality of Maunalua Bay by capturing and infiltrating stormwater runoff and reducing the transfer of sediment and other pollutants from mauka areas to the Bay.
- **Objective #4:** Facilitate Public Participation, Education, and Project Implementation.
    - **Sub-Objective 4.2:** Provide educational opportunities for the community to learn about protecting and preserving water resources in East Honolulu with particular emphasis on youth education.

Potential Champions or Partners

DFM, 808 Cleanups, Surfrider Foundation, LHKH

Preliminary Ka Paʻakai Analysis

The proposed strategy is expected to improve stream health and nearshore water quality, which are important to subsistence activities.

Strategy D: Coordinated Pig Hunting Program

Description

Feral pigs can significantly degrade native forest ecosystems. The rooting and digging activities of pigs are known to cause soil compaction, erosion, and nutrient runoff. Pigs can also spread invasive species when seeds are dispersed through their feces. Moreover, the erosion caused by pigs and other ungulate species can be transferred to nearshore waters, damaging the district's water quality.

A coordinated pig hunting program could be an effective strategy to reduce pig populations in East Honolulu watersheds. The program could include increasing the number of permits for hunters, facilitated working groups with hunters, and developing meaningful and mutually beneficial working relationships with hunters. Pig hunters could help identify pig behavior and migration patterns and take part in watershed protection fencing efforts and out planting in pig eroded areas.

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #1:** Promote Sustainable Watersheds.
    - **Sub-Objective 1.1:** Increase native reforestation and implement measures to slow the spread of invasive species and ungulates to improve the overall health of East Honolulu's forest reserves and increase recharge into the East and West Waialae aquifers.
- **Objective #2:** Protect and Enhance Water Quality and Quantity.
    - **Sub-Objective 2.2:** Improve the water quality of Maunalua Bay by capturing and infiltrating stormwater runoff and reducing the transfer of sediment and other pollutants from mauka areas to the Bay.

Potential Champions or Partners

DLNR-DOFAW, KWMP, DLNR Nā Ala Hele

Preliminary Ka Paʻakai Analysis

The proposed strategy is expected to improve the overall health of watersheds and encourage aquifer recharge.

Strategy E: Trail Education Program

Description

East Honolulu has some of the most heavily used hiking trails on all of Oʻahu. There are seventeen major trails with access to the mountainous areas of East Honolulu, however only five trails are actively maintained (see more detail in Chapter 2 of the EHWMP). Overuse of hiking trails can lead to an increase in the spread of alien plant species and erosion. Hiking trail use has also led to community complaints of trespassing, litter, and parking congestion near trail heads. A coordinated trail education program could include educational signage to increase awareness about the impacts of trail use on watershed health, as well as outreach to schools, neighborhood organizations, recreational groups, and tourism associations.

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #2:** Protect and Enhance Water Quality and Quantity.
    - **Sub-Objective 2.2:** Improve the water quality of Maunalua Bay by capturing and infiltrating stormwater runoff and reducing the transfer of sediment and other pollutants from mauka areas to the Bay.
- **Objective #4:** Facilitate Public Participation, Education, and Project Implementation.
    - **Sub-Objective 4.2:** Provide educational opportunities for the community to learn about protecting and preserving water resources in East Honolulu with particular emphasis on youth education.

Potential Champions or Partners

DLNR Nā Ala Hele, BWS, Hawaiian Trail and Mountain Club, Sierra Club

Preliminary Ka Paʻakai Analysis

The proposed strategy is expected to improve the overall health of the forests and encourage aquifer recharge. It is also intended to teach the community about the importance forests play in watershed health.

Strategy F: Trail Erosion Mitigation

Description: Where trail grade exceeds 20 percent, improvements such as steps help prevent erosion while also aiding hikers.[144] The suggestion to implement steps on trails in the East Honolulu planning district originated from the DLNR Nā Ala Hele Program. A coordinated program to replace trail ropes with steps would likely involve 1) identification of suitable areas; 2) funding allocation; 3) permitting and constuction; and 4) ongoing maintenance. This program could be done in partnership with Sierra Club, Hawaiian Trail and Mountain Club, and other non profits that support forest health and hiking safety. For example, steps were recently built along the Kuliʻouʻou Ridge Trail, one of the heaviest used trails on Oʻahu. Some of these efforts in the past have been led by non-profits. Since 1998, Sierra Club has led hikes and service projects to improve the safety and accessibility of Wiliwilinui Ridge Trail. They are responsible for some of the steps found along the Kuliʻouʻou and Wiliwilinui Ridge Trails.

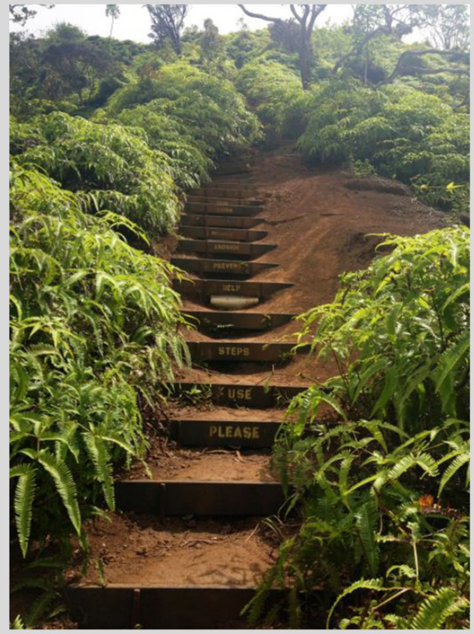


Image: Steps along Kuliʻouʻou Ridge Trail (Credit: DLNR).

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #2**: Protect and Enhance Water Quality and Quantity.
  - **Sub-Objective 2.2:** Improve the water quality of Maunalua Bay by capturing and infiltrating stormwater runoff and reducing the transfer of sediment and other pollutants from mauka areas to the Bay.

Potential Champions or Partners

DLNR Nā Ala Hele, Sierra Club, Hawaiian Trail and Mountain Club

Preliminary Ka Paʻakai Analysis

The proposed strategy is expected to improve the overall health of the forests and encourage aquifer recharge.

Strategy G: Kuliʻouʻou Ridge Trail Entrance Improvements

Description

The Kuliʻouʻou Ridge Trail is one of the most heavily used trails in East Honolulu. It was suggested by DLNR Nā Ala Hele that parking lot improvements at trail heads can help to mitigate the overuse of trails and erosion issues. A controlled parking lot (allowing a limited number of permitted vehicles) was recently

[144] U.S. Forest Service ("USFS"). (2018). *Trails Manual and Specifications*.

implemented at the Wiliwilinui Ridge Trail head, and anecdotally, this has helped to decrease erosion along the trail. The Kuliʻouʻou Ridge Trail entrance is located on BWS land, which provides an opportunity for BWS and DLNR Nā Ala Hele to work together to implement these improvements. Parking lot improvements could also incorporate permeable pavement techniques to encourage infiltration and aquifer recharge.

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #2:** Protect and Enhance Water Quality and Quantity.
  - **Sub-Objective 2.2:** Improve the water quality of Maunalua Bay by capturing and infiltrating stormwater runoff and reducing the transfer of sediment and other pollutants from mauka areas to the Bay.

Potential Champions or Partners

BWS and DLNR Nā Ala Hele

Preliminary Ka Paʻakai Analysis

The proposed strategy is expected to improve forest health and improve aquifer recharge. However, the implementation of any hard surface should be considered in concert with green infrastructure, as to minimize potential runoff.

Strategy H: Firebreak Plan

Description

U.S. wildfires are burning more than twice the area than they did in 1970 and are a major threat to Hawaiʻi. Development that is located within the wildland-urban interface (properties within ½ mile of the zone where wildland and human development intersects) are particularly susceptible to wildfires. About 80% of the land within the East Honolulu district falls within the wildland-urban interface. The likelihood of wildfires can decrease through the implementation of fire break walls. A firebreak is a gap in vegetation or other combustible material that acts as a barrier to slow or stop the progress of a wildfire. A firebreak may occur naturally where there is a lack of vegetation or fuel, such as a stream. Firebreaks may also be man-made, and many of these also serve as roads and trails. In May, 2019 the Kamilo Nui Firewise Community coordinated a group of volunteers to build a firebreak around Kamilo Nui -Mariner's Cove. The City could work with community groups, like the Kamilo Nui Firewise Community, to identify appropriate firebreak locations, and help to fund and implement such efforts.

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #1:** Promote Sustainable Watersheds.
  - **Sub-Objective 1.2:** Implement preventative measures that reduce wildfire risks.

Potential Champions or Partners

BWS, DOFAW, Honolulu Fire Department, Kamilo Nui Firewise Community

Preliminary Ka Paʻakai Analysis

The proposed strategy is expected to improve forest health and aquifer recharge and contribute to human safety.

Strategy I: Golf Course Xeriscaping and Water Efficiency Plan

Description

The Hawaiʻi Kai Golf Course is the largest BWS water user in the East Honolulu district, with a 2015 water demand of 0.284 MGD. While the Waiʻalae Golf Course has a private well, it also has a high water demand of 0.297 MGD. Using recycled water at the Hawaiʻi Kai Golf Course is unlikely in the near future because of the high salinity of available water (requiring expensive brackish water desalination). However, if water resources become limited with the realization of the Dry scenario, desalinated recycled water may be required.

Image: BWS Hālawa Xeriscape Garden

Xeriscaping is another viable strategy for water conservation at both golf courses. Xeriscaping is a drought-tolerant landscaping technique that can be attractive and uses less water than traditional landscaping. There are various xeriscape gardens in Hawaiʻi, including the BWS Hālawa Xeriscape Garden (see image to the right). The desire for more xeriscaping in East Honolulu was expressed many times during EHWMP stakeholder consultations. Xeriscaping practices should be paired with water-efficient irrigation systems, such as automatic timers, moisture sensors, rain shutdown devices, and low output irrigation equipment such as spray sprinkler heads, micro-spray sprinkler heads, emitters, and dripper lines.

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #2:** Protect and Enhance Water Quality and Quantity.
  - **Sub-Objective 2.1:** Encourage the use of xeriscaping and other low impact development strategies to reduce irrigation water demand from current aquifer sources and mitigate flooding impacts, with a focus on large landscaped areas such as parks, schools, golf courses, roadway landscaping, farms and large residential lots.
- **Objective #5:** Meet Future Water Demands at Reasonable Cost.
  - **Sub-Objective 5.2:** Adapt to and plan for drought and its impacts on water supply in East Honolulu.
  - **Sub-Objective 5.4:** Through a One Water framework, promote an integrated demand-side management water conservation program with stormwater management and recycled water for all land uses to extend limited water supply and system capacity.

Potential Champions or Partners

BWS, Hawaiʻi American Water Company, Waiʻalae Golf Course, Hawaiʻi Kai Golf Course

Preliminary Ka Paʻakai Analysis

The proposed strategy is expected to improve watershed health by conserving water and using it more efficiently.

Strategy J: Lateral Shoreline Access Plan

Description

Due to the proliferation of private development along the shoreline, particularly along Maunalua Bay, shoreline access is a major issue in East Honolulu. Many properties have seawalls and other shoreline armoring, which further hinders shoreline access. These issues are likely to increase as sea level rises and coastal erosion increases. Some community stakeholders noted during the EHWMP planning process that they have completely lost access to some coastal areas such as Portlock. Improving shoreline access is also discussed in the EHSCP, which states, *"Existing mauka-makai beach access and rights-of-way in East Honolulu should remain and new shoreline access ways should be provided as the opportunities arise."* In particular, at least three public access points should be acquired along Portlock Road to meet the City's standard of public shoreline access at approximately one quarter mile intervals."[145] The City should work with community groups to identify appropriate locations for additional lateral beach access ways. In return, community groups can help to monitor future shoreline access in the district and alert the City when issues arise and when improvements need to be made.

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #1:** Promote Sustainable Watersheds.
  - **Sub-Objective 1.5:** Conserve natural shorelines to protect beaches, coastal ecosystems, recreational and cultural resources, and public shoreline access.
- **Objective #3:** Protect Native Hawaiian Rights and Traditional and Customary Practices.
  - **Sub-Objective 3.3:** Improve public shoreline access to allow for the practice of cultural traditions and subsistence activities.

Potential Champions or Partners

OP-CZM, DPP, DPR, Mālama Maunalua, Surfrider Foundation, Livable Hawaiʻi Kai Hui, and private property owners

Preliminary Ka Paʻakai Analysis

The proposed strategy is expected to improve shoreline access, which will allow for greater access to subsistence and gathering activities.

[145] DPP. (2022). EHSCP.

Strategy K: Awāwāmalu Access Improvements

Description

It was expressed by various stakeholders that access to Awāwāmalu (near Ka Iwi Scenic Shoreline) is particularly difficult to access due to lack of parking. Improved parking at this site would allow for enhanced access for locals to recreational and cultural resources along the Ka Iwi Coast.

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #3:** Protect Native Hawaiian Rights and Customary Practices.
  - **Sub-Objective 3.3:** Improve public shoreline access to allow for the practice of cultural traditions and subsistence activities.

Potential Champions or Partners

City Department of Parks and Recreation, Livable Hawaiʻi Kai Hui, Surfrider Foundation

Preliminary Ka Paʻakai Analysis

The proposed strategy is expected to improve access to natural resources, which otherwise may be inaccessible. However, the implementation of any hardened surface should be considered in concert with green infrastructure to minimize potential runoff.

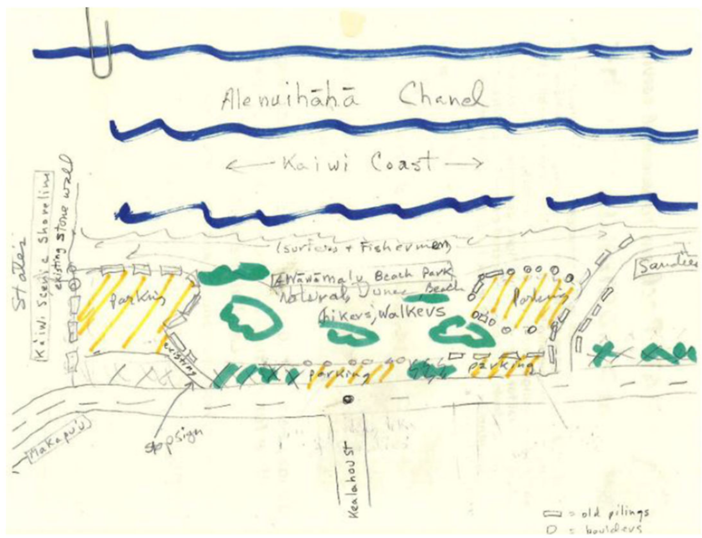


Image: Drawing of Awāwāmalu submitted by a community member at EHWMP's Community Meeting #1

Strategy L: Agricultural Water Use Plans

Description

Agricultural users have higher water demand compared to residential users. At a meeting with local farmers during the EHWMP planning process, it was suggested that farms develop individual water use plans to measure how much water they are using and implement improvements to water efficiency. Given rising water fees, particularly for large water users, this strategy is of special interest to farmers that could see dramatic increases in their water bills in the coming years. This could be a community-driven effort, with support of BWS and Kamehameha Schools, the landowner of many agricultural lots in East Honolulu.

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #2:** Protect and Enhance Water Quality and Quantity.
  - **Sub-Objective 2.1:** Encourage the use of xeriscaping and other low impact development strategies to reduce irrigation water demand from current aquifer sources and mitigate flooding impacts, with a focus on large landscaped areas such as parks, schools, golf courses, roadway landscaping, farms and large residential lots.
- **Objective #5:** Meet Future Water Demands at Reasonable Cost.

- **Sub-Objective 5.4:** Through a One Water framework, promote an integrated demand-side management water conservation program with stormwater management and recycled water for all land uses to extend limited water supply and system capacity.

Potential Champions or Partners

BWS, Aloha Aina O Kamilo Nui, UH CTAHR, local farmers

Preliminary Ka Paʻakai Analysis

The proposed strategy is expected to improve watershed health by using water more efficiently.

Strategy M: Grey Water Reuse Plan

Description

DOH defines grey water as wastewater discharged from "showers and bathtubs, hand-washing lavatories, wastewater that has not contacted toilet waste, sinks (not used for disposal of hazardous, toxic materials, food preparation, or food disposal) and clothes-washing machines (excluding wash water with human excreta)." Grey water from sinks, tub and shower drains, and clothes washers are estimated to be 50 to 80 percent of the total residential wastewater generated. Grey water reuse can help to lower per capita water demand by conserving potable water for drinking purposes. An on-site recycling system would capture and reuse water that would otherwise flow down the drain into the sewer system or an individual wastewater system. The captured water could then be used for non-potable uses such as flushing toilets, irrigation, or even supplying cooling systems.

BWS provided nearly 90 percent of the potable water needs in the East Honolulu in 2015. Of the potable water demand, residential use, including single-family, multi-family, and mixed residential uses, accounted for approximately 80 percent (5.64 MGD). Commercial use was the second highest type of demand, accounting for 6 percent (0.427 MGD). Uses by the City government and golf courses nearly tied for third, which each accounted for approximately 4 percent. Therefore, conservation through grey water reuse for residential, commercial, City government, and golf course uses can potentially have a large impact on potable water demand in East Honolulu. The use of recycled water at the district's golf courses is discussed in the draft EHSCP's planning guidelines, which encourages *"the use of tertiary-treated recycled water for the irrigation of golf courses and landscaped areas where this would not adversely affect potable ground water supply."*[146]

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #2:** Protect and Enhance Water Quality and Quantity.
  - **Sub-Objective 2.1:** Encourage the use of xeriscaping and other low impact development strategies to reduce irrigation water demand from current aquifer sources and mitigate flooding impacts, with a focus on large landscaped areas such as parks, schools, golf courses, roadway landscaping, farms and large residential lots.

[146] DPP. (2022). EHSCP.

- **Objective #5:** Meet Future Water Demands at Reasonable Cost.
  - **Sub-Objective 5.3:** Implement conservation measures that improve water efficiency and decrease per capita water demand at the household level.
  - **Sub-Objective 5.4:** Through a One Water framework, promote an integrated demand-side management water conservation program with stormwater management and recycled water for all land uses to extend limited water supply and system capacity.

Potential Champions or Partners

DOH, BWS, ENV, Mālama Maunalua, Livable Hawaiʻi Kai Hui, private property owners

Preliminary Ka Paʻakai Analysis

The proposed strategy is expected to reduce the use of ground water for non-potable uses, thus resulting in the enhancement of available water resources for traditional and customary practices.

Strategy N: Climate Adaptation Neighborhood Plans

Description

It has been well-documented that climate change will impact Hawaiʻi's land and people in drastic ways. The East Honolulu district will be particularly vulnerable to increased flooding and erosion, impacts to rainfall, heat, and water supply, and greater frequency and intensity of storms. However, even in the relatively small district of East Honolulu, each community will be impacted by climate change differently. Sierra Club has expressed interest in facilitating planning process with neighborhoods on Oʻahu to develop neighborhood-scale climate change adaptation plans. This effort could be supported by government agencies supporting resilience work, such as OCCSR, as well as local disaster preparedness groups. This effort would support the planning guidelines established by the EHSCP to *"Prepare for the anticipated impacts of sea level rise on existing communities and facilities through remediation, adaptation, and other measures."*[147]

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #1:** Promote Sustainable Watersheds.
  - **Sub-Objective 1.4:** Prepare for the anticipated impacts of sea level rise on existing ecosystems, properties and infrastructure through remediation, adaptation, and other measures.
- **Objective #5:** Meet Public Demands at Reasonable Cost.
  - **Sub-Objective 5.2:** Adapt to and plan for drought and its impacts on water supply in East Honolulu.

Potential Champions or Partners

Sierra Club, OCCSR, ʻĀina Haina Prepared, Hawaiʻi Kai Strong

[147] DPP. (2022). EHSCP.

Preliminary Ka Pa'akai Analysis

The proposed strategy is expected help prepare the community for climate change impacts.

Strategy O: Climate Change and Resilience Education

Description

In order to promote water conservation and protection of watersheds, education and outreach are needed to increase community awareness about climate change impacts to East Honolulu's water supply and ecosystems. While BWS, DFM, OCCSR, Mālama Maunalua, and other agencies and community organizations have community education and outreach programs, there have been limited educational efforts focused on climate change and resilience in East Honolulu. These government organizations could partner with community organizations to implement an education and outreach program, focused on climate change and resilience, with residents, businesses, and schools.

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #4:** Facilitate Public Participation, Education, and Project Implementation.
  - **Sub-Objective 4.2:** Provide educational opportunities for the community to learn about protecting and preserving water resources in East Honolulu with particular emphasis on youth education.

Potential Champions or Partners

OCCSR, BWS, Livable Hawai'i Kai Hui, Sierra Club

Preliminary Ka Pa'akai Analysis

The proposed strategy is expected to help prepare the community for climate change impacts.

Strategy P: Restoration of Fresh water Spring Flows to Nearshore Coastal Waters

Description

East Honolulu was historically rich in fishponds and fresh water ponds. However, most natural springs and fishponds were damaged or destroyed in the 20th century due to urbanization. The lack of fresh water flow to Maunalua Bay is a contributing factor to the Bay's water quality. BWS, DLNR, and other government agencies should collaborate with community organizations to identify potential areas where hydrologic connections between natural springs and coastal nearshore waters, which have been cut off or diverted over time, can be restored. Restoring Kalauha'iha'i Fishpond (Project #1) has been identified by the community as a priority.

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #1:** Promote Sustainable Watersheds.
  - **Sub-Objective 1.3:** Enhance ecosystem diversity within East Honolulu's streams and nearshore waters.
- **Objective #2:** Protect and Enhance Water Quality and Quantity.

- **Sub-Objective 2.3:** Improve the water quality of Maunalua Bay by increasing the amount of fresh water that enters the Bay.
- **Objective #3:** Protect Native Hawaiian Rights and Customary Practices.
  - **Sub-Objective 3.1:** Restore fishponds and springs for cultural and educational use.

Potential Champions or Partners

Maunalua Fishpond Heritage Center, Livable Hawaiʻi Kai Hui

Preliminary Ka Paʻakai Analysis

The proposed strategy is expected to improve the quality of nearshore waters and restore traditional practices such as fishponds.

Strategy Q: Strengthen Building Codes and Standards for Building Resilience

Description

Existing standards and regulations for land use, hazard mitigation, and design and construction should be replaced or updated in order to reduce existing and future building vulnerability to coastal hazards and climate impacts. Ways in which codes and standards should be updated was outlined in the 2018 report, Building Code Amendments to Reduce Existing and Future Building Stock Vulnerability to Coastal Hazards and Climate Impacts in the City and County of Honolulu, prepared by for the State Office of Planning (OP) by Martin & Chock, Inc. As a first step to implementing the report's recommendations, the City and County of Honolulu adopted the International Building Code in 2018. The State OP, DPP, and other relevant agencies should continue work together to implement this report's recommendations.

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #1:** Promote Sustainable Watersheds.
  - **Sub-Objective 1.4:** Prepare for the anticipated impacts of sea level rise on existing ecosystems, properties and infrastructure through remediation, adaptation, and other measures.

Potential Champions or Partners

State Office of Planning, DPP, OCCSR

Preliminary Ka Paʻakai Analysis

The proposed strategy is expected to help prepare the community for climate change impacts, and help protect coastal resources.

Strategy R: Build Back Better & Smarter

Description

"Build Back Better and Smarter" is a concept that guides post-disaster reconstruction and recovery. It aims to utilize post-disaster reconstruction as an opportunity to improve the resiliency of impacted buildings and communities. To achieve these goals, careful planning must occur long before disasters occur. This should include mapping repetitive loss areas and incorporating adaptive design and resiliency strategies into the location, structure, and operations plans for any reconstruction to mitigate future damage costs. UH Sea Grant is currently undergoing the Resilience-Focused Disaster Reconstruction Planning project. This effort includes establishing guidelines for incorporating resilience focused rebuilding practices into State and County plans, policies, ordinances, and regulations and creating a framework for Pre-Disaster Recovery Plans that can be applied at the State and local level. Once finalized, County agencies should work to integrate these guidelines into their respective plans and policies.

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #1:** Promote Sustainable Watersheds.
    - **Sub-Objective 1.4:** Prepare for the anticipated impacts of sea level rise on existing ecosystems, properties and infrastructure through remediation, adaptation, and other measures.
- **Objective #2:** Protect and Enhance Water Quality and Quantity.
    - **Sub-Objective 2.4:** Reduce impacts from extreme rain events and flooding.
    - **Sub-Objective 2.5:** Reduce ground water contamination through cesspool conversion and wastewater system improvements in East Honolulu.

Potential Champions or Partners

DPP, OCCSR, UH Sea Grant

Preliminary Ka Paʻakai Analysis

The proposed strategy is expected to help prepare the community for climate change impacts and natural hazards.

Strategy S: Restrictions on Shoreline Armoring

Description

While shoreline armoring provides short-term protection against coastal erosion and sea level rise, it can also lead to permanent beach loss, and sometimes can be more costly and less effective over the long term than other adaptation techniques, such as managed retreat. Where possible, conserving natural and dynamic shorelines should be encouraged, and shoreline armoring should be discouraged, except as a last resort, when it supports significant public benefits. While the State OP-CZM is primarily responsible for establishing shoreline armoring restrictions (HRS §205A), counties also have a role in enforcing these restrictions and encouraging lateral shoreline access.

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #1:** Promote Sustainable Watersheds.
    - **Sub-Objective 1.5:** Conserve natural shorelines to protect beaches, coastal ecosystems, recreational and cultural resources, and public shoreline access.
- **Objective #3:** Protect Native Hawaiian Rights and Customary Practices.
    - **Sub-Objective 3.3:** Improve public shoreline access to allow for the practice of cultural traditions and subsistence activities.

Potential Champions or Partners

DPP, OCCSR, State DLNR-OCCL, OP-CZM

Preliminary Ka Paʻakai Analysis

The proposed strategy is expected to help protect coastal resources and shoreline access.

Strategy T: Redevelopment District

Description

As means of being better prepared for climate change impacts, a community-based redevelopment district, similar to a business improvement district, could be formed in East Honolulu. The purposes of this redevelopment district would be to fund the protection, adaptation, and/or relocation of residential and commercial structures, public facilities, and natural and cultural resources vulnerable to sea level rise impacts, including coastal flooding, inundation, and erosion. To achieve this, the City would first need to work with community residents, businesses, and organizations in East Honolulu to identify the best area to establish the redevelopment district and determine an appropriate fee structure.

EHWMP Objectives & Sub-Objectives Addressed

- **Objective #1:** Promote Sustainable Watersheds.
    - **Sub-Objective 1.4:** Prepare for the anticipated impacts of sea level rise on existing ecosystems, properties and infrastructure through remediation, adaptation, and other measures.

Potential Champions or Partners

DPP, OCCSR

Preliminary Ka Paʻakai Analysis

The proposed strategy is expected to help prepare the community for climate change impacts and natural hazards.

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East Honolulu Watershed Management Plan

Chapter 5: Implementation

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5 Implementation

5.1 INTRODUCTION

This final chapter EHWMP provides guidance on implementing the policies, projects, programs and strategies identified in *Chapter 4*. Implementation guidance is provided in three sections:

5.2 Water Use and Development Plan includes a suite of management strategies to meet future water demand and supply scenarios for East Honolulu.

5.3 Watershed Management – Critical Watersheds and Catalyst Projects presents "priority watersheds" and "catalyst projects" for East Honolulu that were identified through consultation with stakeholders and agencies as critical to furthering the EHWMP's Goals and Objectives.

5.4 Implementation and Funding describes needs for the planning, funding and implementation of critical watershed management projects and strategies in East Honolulu.

5.2 WATER USE AND DEVELOPMENT PLAN

Chapter 3 describes East Honolulu's ground water and surface water availability, as well as the district's historical, existing, and projected future water demand. It includes four scenarios based on varying levels of projected water demand: Most Probable (Low) Demand Scenario (2040), Mid Demand Scenario (2040), High Demand Scenario (2040), and Ultimate Demand Scenario (2100).

As described in *Chapter 3*, the Most Probable (Low) Demand Scenario for the year 2040 and the Ultimate Demand Scenario for the year 2100 represent the range of plausible futures for the purposes of water resources planning in the East Honolulu district. This section presents a suite of management strategies focused on meeting the future water demand projections for these two scenarios. Collectively, these management strategies are referred to as the "Water Use and Development Plan."

Key Takeaway:

There will be adequate water supply in East Honolulu in 2040 under the Most Probable Scenario, but water conservation is required. Greater water use reduction would be required to meet the Mid, High, and Ultimate Demand (Dry) Scenarios.

The East Honolulu planning district has very limited ground water resources. Two new wells are planned to bring an additional 0.7 MGD of new water sources to the Waiʻalae-West and Waiʻalae-East ASYAs by 2040 (see *Section 5.2.3* for further detail). However, there are island-wide water supply challenges that make it critical for each district to do its part to ensure a sustainable water supply for Oʻahu. Meeting future water demand in East Honolulu rests on three approaches: 1) reducing water transfers from Honolulu and Windward water systems through limited source development within the Waiʻalae-West and Waiʻalae-East ASYAs; 2) water conservation to manage per-capita demand; and 3) preservation of existing sources and water system infrastructure to maintain reliable service. The strategies for each scenario are described further below.

5.2.1 Most Probable (Low) Water Demand Scenario (2040)

Scenario Overview

The Most Probable (Low) Demand Scenario is based on population projections provided in the EHSCP[148], which anticipates that the district's population will remain stable through 2040 and that there will be no significant new commercial, residential, or public infrastructure development. The scenario utilizes the 2016 WMP estimate of 47,800 for the district's total BWS-served population. While the 2016 WMP demand forecasted that the East Honolulu district would lower its per capita water use to 180 GPCD by 2040, preliminary census data shows that the district's per capita water demand had already dropped to 170 GPCD in 2020. This Most Probable (Low) Demand Scenario assumes that East Honolulu's per capita demand will remain at 170 GPCD in 2040. This represents a 12% decrease in per capita water demand from the 2010 baseline of 194 GPCD. This scenario assumes that water conservation efforts will continue to be promoted by BWS and implemented at residential and commercial levels to maintain consumption at 170 GPCD. For a more detailed description of the Most Probable (Low) Demand Scenario, refer to EHWMP *Chapter 3.*

> Low Demand Scenario
>
> 2040 East Honolulu BWS-Served Population: 47,800
>
> Per Capita Water Demand: 170 GPCD
> (based on East Honolulu's decreasing per capita water use)

Water Source Adequacy

Based on the Most Probable (Low) Demand Scenario as described in *Chapter 3*, the district's overall water demand in 2040 is projected to be 8.503 MGD. This represents a 12.43% decrease from the 2010 baseline of 9.71 MGD. It is assumed in this scenario that water transfers from Honolulu and Windward water systems will continue to provide up to 6.1 MGD of water to East Honolulu, which amounts to 70.9% of the

[148] DPP. (2022). EHSCP.

district's projected 2040 water supply. The remaining 2.5 MGD of the district's 2040 water demand is anticipated to be provided by wells within Waiʻalae-West and Waiʻalae-East ASYAs.

Table 5-1 presents water demand by CWRM water use category for the years 2010 (Baseline) and 2040 (Low Demand Scenario). The table indicates that there will be enough water available to meet the projected 2040 demand for this scenario across all water sources and use categories. In fact, when comparing anticipated 2040 water supply to water demand, there is nearly 4 MGD of "unallocated" water supply. However, there are some external factors that could impact the district's future water supply. These are described in *Section 5.2.3*, which discusses island-wide water management strategies.

Table 5-1: 2040 East Honolulu Water Demand & Supply (Most Probable (Low) Demand Scenario)

Water Use Category / Water System	2010	2040
DEMAND (MGD)		
Municipal Water Systems (BWS)		
Potable Ground Water Demand[1]	9.33	8.126
Irrigation and Agriculture (Private)		
Potable Ground Water Demand[2]	0.377	0.377
Other		
Caprock Water Demand[3]	-	-
TOTAL WATER DEMAND	**9.71**	**8.503**
SUPPLY (MGD)		
Municipal Potable Supply (BWS) for East Honolulu	**10.03**	**8.6**
Total Permitted Use of Potable Ground Water in Waiʻalae-West ASYA[4]	2.18	1.5
Total Permitted Use of Potable Ground Water in Waiʻalae-East ASYA[5]	0.79	1.0
BWS Water Transfers from Honolulu Sources[6]	6.71	5.27
BWS Water Transfers from Windward Sources[7]	0.35	0.83
Private Water Supply for East Honolulu	**0.460**	**0.460**
Total Permitted Use of Potable Ground Water[8]	0.460	0.460
Other Private Water Supply	**2.88**	**2.88**
Total Permitted Use of Caprock Water[9]	2.88	2.88
TOTAL WATER SUPPLY	**13.37**	**12.41**
UNALLOCATED WATER SUPPLY = SUPPLY – DEMAND	**3.65**	**3.907**

Table 5-1 Notes:

1 Baseline (2010) municipal potable ground water demand reflects the five-year average metered consumption for 2010 of all BWS water in East Honolulu. 2040 Municipal potable ground water demand reflects the Most Probable Demand Scenario, as discussed in Chapter 3 of the EHWMP.

2 Baseline (2010) Irrigation and Agriculture potable ground water demand reflects the five-year average metered consumption for 2010 of the private Waiʻalae Golf Course Well. 2040 Irrigation and Agriculture potable ground water demand reflects the Most Probable Demand Scenario, as discussed in Chapter 3 of the EHWMP.

3 The district's caprock water demand is based on reported pumpage from East Honolulu's two caprock wells: Kāhala Hilton 1 and Kāhala Hilton 2 (i.e. the salt water "dolphin ponds"). However, these wells had no reported pumpage in 2010. Thus, the district's caprock water demand is unknown. Notably, caprock water use is not expected to increase over the coming decades.

4,5 Permitted use amounts are sourced from the CWRM Water Use Permit Index. Baseline (2010) permitted uses are from the 2010 Water Use Permit Index. 2040 permitted uses are from the 2010 Water Use Permit Index. The permitted users of municipal water include Waiʻalae Nui, Ainakoa, Ainakoa II, Waiʻalae Iki, Kuliʻouʻou, Wailupe I, and Pia Wells. The Waiʻalae Nui, Ainakoa, Ainakoa II, and Pia Wells are located within the East Honolulu portion of the Waiʻalae-West ASYA. The only municipal well within the Waiʻalae-West ASYA that falls outside the East Honolulu planning district boundary is the Waiʻalae-West Well, which has a permitted use of 0.16 MGD. The Waiʻalae Iki, Kuliʻouʻou, and Wailupe I Wells are located within the Waiʻalae-East ASYA.

6,7 Baseline (2010) BWS water transfers from the Honolulu and Windward water systems reflect 2013 to 2017 averages. 2040 estimates reflect the 2040 water transfer map suggested by BWS.

8 Waiʻalae Golf Well, privately owned by Kamehameha Schools.

9 Kāhala Hilton 1 and Kāhala Hilton 2 Wells, privately owned by the Kāhala Royal Corporation.

Water Conservation Strategies

Table 5-1 demonstrates that there should be sufficient water supply to meet the district's demand in 2040 under the Most Probable (Low) Demand Scenario. The BWS's 2016 WMP originally forecasted the per capita demand in East Honolulu to decrease from 194 GPCD in 2010 to 180 GPCD in 2020, and remain at 180 GPCD through 2040. However, review of preliminary census data indicated that per capita water in East Honolulu had already reached 170 GPCD in 2020. This represents a 10% decrease from the district's 2010 (baseline) per capita water demand.

To maintain 170 GPCD in the Most Probable (Low) Water Demand Scenario, as shown in *Figure 5-1*: , the district must continue to implement water conservation strategies through 2040, keeping water demand steady even as temperatures increase and rainfall becomes more variable due to climate change.

Figure 5-1: Summary of 2010-2040 Decline in East Honolulu Per Capita Water Demand (Based on Historic Data and the Most Probable Demand Scenario)

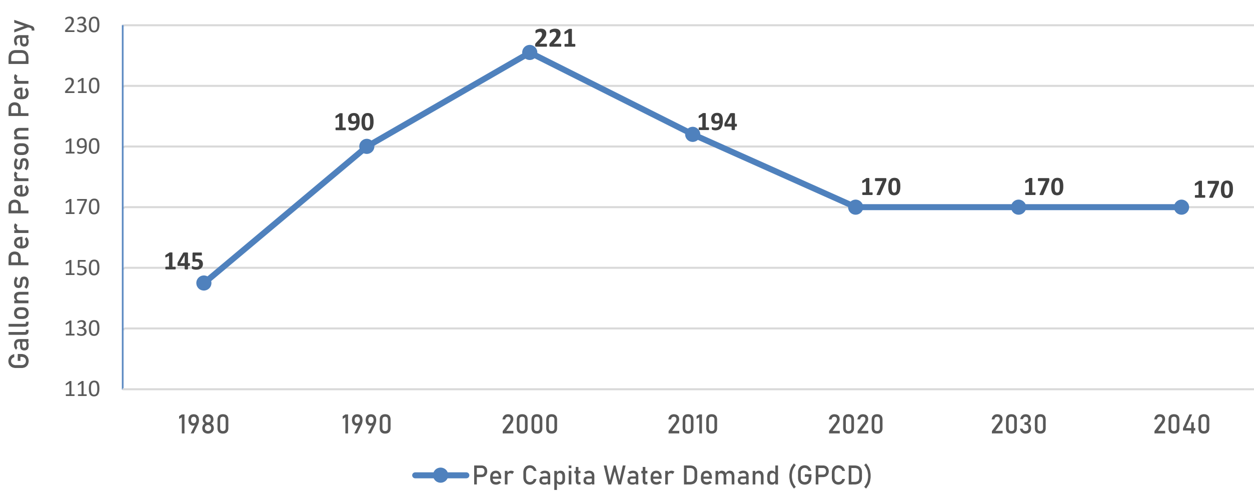


Figure 5-1: ***Notes:*** 1980 to 2010 per capita demand is based on estimates provided in the 2016 WMP. 2020 to 2040 per capita demand is based the Most Probable (Low) Demand Scenario, which uses preliminary 2020 census data.

Water conservation is the most cost-effective strategy to reduce water demand and allow for capital improvement funding to be used toward maintaining water sources, transmission, and storage. Since there is limited (0.7 MGD) water supply expansion planned within East Honolulu, water conservation is also the primary way for the East Honolulu district to achieve the projected water demand for 2040. Given this, one of the two catalyst projects identified for the district is to “Increase water efficiency in East Honolulu.” As will be further discussed in *Section 5.4*, this catalyst project will be implemented primarily through implementation of two existing BWS programs: 1) the BWS Infrastructure Renewal and Replacement Program, which improves water efficiency by reducing water losses within BWS facilities; and 2) the BWS Water Conservation Program, which aims to increase water efficiency among BWS water users through education and behavior changes and incentives for high efficiency plumbing fixtures and on-site reuse.

Several of the “Projects with Champions” and “Programs and Strategies” identified in *Chapter 4* also support water conservation in East Honolulu. These include:

Projects with Champions

- Project #5: Kamilo Nui Watershed Sustainable Agriculture Pilot Project
- Project #12: Mālama Maunalua Programs
- Project #17: Low Impact Design and Green Infrastructure Standards and Guidelines
- Project #18: Stormwater Utility Oʻahu
- Project #27: BWS Long Range Water Master Plan and Infrastructure Renewal and Replacement Program
- Project #28: BWS Water Conservation Incentives Program

Strategies and Programs

- Strategy I: Golf Course Xeriscaping and Water Efficiency Plan
- Strategy L: Agricultural Water Use Plans
- Strategy M: Grey Water Reuse Plan
- Strategy N: Climate Adaptation Neighborhood Plans
- Strategy O: Climate Change and Resilience Education

In addition to these district-specific projects, strategies, and programs, there are island-wide programs policies and programs which have the potential for lowering water demand across the island’s eight planning districts. Information on these and other island-wide initiatives is provided in *Section 5.2.3*.

5.2.2 Ultimate Demand Scenario (2100)

Scenario Overview

Ultimate Demand Scenario

2100 East Honolulu Population: 42,600

(incorporates a net population decrease due to climate change and sea level rise)

Per Capita Water Demand: 170 GPCD

(based on East Honolulu's decreasing per capita water use)

The Ultimate Demand Scenario imagines a future for the East Honolulu district in the year 2100. Between 2010 and 2040, this scenario utilizes the population growth and water consumption projections for the High Demand Scenario as described in *Chapter 3*, which assumes robust tourism and some population increase. However, moving beyond 2040 the Ultimate scenario takes into account statewide projections that sea level will rise 3.2 ft over current levels by 2100.[149] This means that over time, East Honolulu will be exposed to more frequent and pronounced nuisance flooding, storm events, high wave run-up, and coastal erosion, eventually leading to permanent inundation of over 1,100 parcels of land and potentially displacing over 5,000 residents. In some areas subject to repeated damages and flooding, retreat of development away from hazard-prone areas will likely be necessary.

Taking all of these factors into account, this Ultimate Scenario assumes that by 2100, the BWS-served population in East Honolulu will decrease by 10%, resulting in a BWS-served population of 42,600. The per capita demand for the BWS-served population from 2040 through 2100 is assumed to remain steady at 170 GPCD, matching the Most Probable (Low) Demand scenario.

The Ultimate Scenario was also sub-categorized into a "Dry Scenario" and "Wet Scenario" to reflect two alternative methodologies for modeling the effects of climate change on future rainfall. The Dry Scenario, based on the statistical downscaling method, projects that in 2100, rainfall in East Honolulu (during the dry season) could decrease by 22 to 39% (see *Table 3-13*).[150] To account for this, the Ultimate Demand (Dry) Scenario assumes there will be a 22% increase in demand for irrigation water.

The Wet Scenario is based on the dynamical downscaling method, and projects that rainfall in East Honolulu will substantially increase by 30 to 50% over current levels.[151] It is uncertain how this would impact irrigation demand, as the increased rainfall will likely occur as heavy rainfall and flooding events (sometimes called "rain bombs" or cloudburst events). Thus, no changes to irrigation demand are

[149] Hawai'i Climate Change Mitigation and Adaptation Commission. (2017). Hawai'i Sea Level Rise Vulnerability and Adaptation Report. Available at: https://climateadaptation.hawaii.gov/wp-content/uploads/2017/12/SLR-Report_Dec2017.pdf.

[150] Brown and Caldwell. (2016). Impacts of Climate Change on Honolulu Water Supplies and Planning Strategies for Mitigation: Technical Memo #1 – Understanding Future Climate, Demand, and Land Use Projections for the Island of Oahu. Prepared for: Water Research Foundation, Honolulu Board of Water Supply.

[151] Brown and Caldwell (2016)

assumed in the Ultimate Demand (Wet) Scenario. *Chapter 3* includes a more detailed description of the Ultimate Demand Scenario.

Water Source Adequacy

As evidenced by the description of the Ultimate Demand Scenario, there are many uncertainties when projecting water demand in 2100. Neither of the methodologies used to forecast future rainfall (statistical nor dynamical downscaling) are currently considered more valid than the other. Only with additional research and monitoring – likely to occur over the coming decades – will BWS and other governing agencies know whether the Dry or Wet Scenario is more likely to be realized. Thus, for long range planning, BWS must be prepared for a range of possibilities. The EHWMP illustrates the range of possibilities through the Ultimate Dry and Wet Demand scenarios. As presented in *Chapter 3*, the Ultimate Demand (Dry) Scenario would result in a total district water demand of 8.413 MGD, where the Ultimate Demand (Wet) Scenario would yield a total district water demand of 7.617 MGD (includes both BWS and private water users). The total water demand in the Wet Scenario is approximately 9% lower than the Dry Scenario. Because of the stark differences between the projected water supply and demand between the Wet and Dry Scenarios, water adequacy must be discussed separately for these two subcategories of the Ultimate Demand Scenario.

There are also many uncertainties when projecting 2100 water supply. In the Dry Scenario, there could be a substantial decrease to the sustainable yield (SY) of O‘ahu's ground water aquifer systems. As shown in Figure 1-13: Range of Sustainable Yields based on UH Statistical and Dynamical Rainfall Models to 2100 *Figure 1-13*, these impacts range by aquifer sector, from a potential decrease of 14% in Honolulu Aquifer Sector's SY, to a decrease up to 69% in Wai‘anae Aquifer Sector's SY. Given these potential reductions to the island's ground water aquifer systems, under the Dry Scenario we assume that East Honolulu's water availability will be reduced due to anticipated changes in water transfers, including:

- A 50% reduction in water transfers between BWS's Honolulu Water System and East Honolulu (2.5 MGD).
- A return to 2010 levels of water transfer between BWS's Windward Water System and East Honolulu (0.35 MGD).

Availability of water within East Honolulu (from the Wai‘alae-West and Wai‘alae-East ASYAs) are expected to remain consistent through 2100 (even under the Dry Scenario), providing 2.5 MGD of water to the district. With these factors in mind, this analysis estimates that water supply for East Honolulu is 5.54 MGD under the Dry Scenario (see *Table 5-2*). In the original description for the Ultimate Demand Scenario, the EHWMP assumed that residents would continue to use approximately 170 gallons per day. However, given the reduced water supply anticipated in the Dry Scenario, further reductions to per capita demand are needed for the district's total water demand to meet the estimated water supply of 5.54 MGD. As shown in as shown in *Table 5-2*, this would require East Honolulu to reduce its per capita water demand by approximately 25%, from 170 GPCD to 130 GPCD by 2100. These estimates align with the PUC WMP water demand analysis, which estimates that under the Dry Scenario, the PUC will need to lower its per capita demand from 140 GPCD (2040 Most Probable Water Demand estimates) to 100 GCPD by 2100.

Thus, in both the PUC and East Honolulu under the Dry Scenario, per capita water demand will need to be lowered by 40 GPCD (from 2040 to 2100), to ensure there is adequate water availability.

Conversely, if the Wet Scenario is realized, it is assumed that there will be no changes to water availability in 2100, given that expected increases in rainfall are likely to come in form of flooding, which does necessarily increase aquifer recharge or ground water availability. As such, this analysis estimates that water supply for East Honolulu is 8.6 MGD under the Wet Scenario.

As shown in *Table 5-2*, if the Wet Scenario is realized, it is anticipated that there would be sufficient water supply to meet East Honolulu's water demand. The data presented does not account for private water sources, given the uncertainty of these sources in 2100. These projections assume that under the Wet Scenario, increased rainfall would provide for greater ground water recharge of the island's ground water aquifers. This scenario also assumes that the overall increase in the SY of the island's aquifers would lend itself to more municipal water withdrawals.

Table 5-2: 2100 East Honolulu Water Demand & Supply (Ultimate Dry and Wet Scenarios)

	2100 Scenarios	
	Wet	Dry
Total BWS Demand[1]	7.24	7.68
Estimated BWS Supply[2]	8.6 MGD	5.54 MGD
Additional Supply Needed to Meet Demand[3]	none	1.06 MGD
Target Per Capita Water Demand to Meet Estimated 2100 Supply[4]	no change	130 GPCD
% Reduction in Per Capita Demand to Meet Estimated 2100 Supply	no change	-23.52%

Table 5-2 Notes:

1 2100 BWS Water Demand = (BWS-served population X per capita water demand) + increased irrigation due to climate change. Taking into account all the factors presented in the Ultimate Demand Scenario (such as potential population displacement due to sea level rise and other climate change impacts), this study assumes that by the year 2100, the BWS-served population in the East Honolulu district will decrease by 10%, with a BWS-served population of 42,700. To account for decreased rainfall and increased heat within the Dry Scenario, a 22% increase in irrigation demand is incorporated in the Ultimate (Dry) Demand Scenario. There are no changes to irrigation demand assumed in the Ultimate (Wet) Demand Scenario, since it is uncertain how increased rainfall would impact irrigation demand, as the increased rainfall may occur primarily as heavy rain events.

2 2100 BWS Supply includes both municipal water transfers to East Honolulu from the BWS's Honolulu and Windward water systems, as well as ground water supply within East Honolulu (based on the CWRM Water Use Permit Index for the Waiʻalae Nui, Ainakoa, Ainakoa II, Waiʻalae Iki, Kuliʻouʻou, Wailupe I, and Pia Wells).

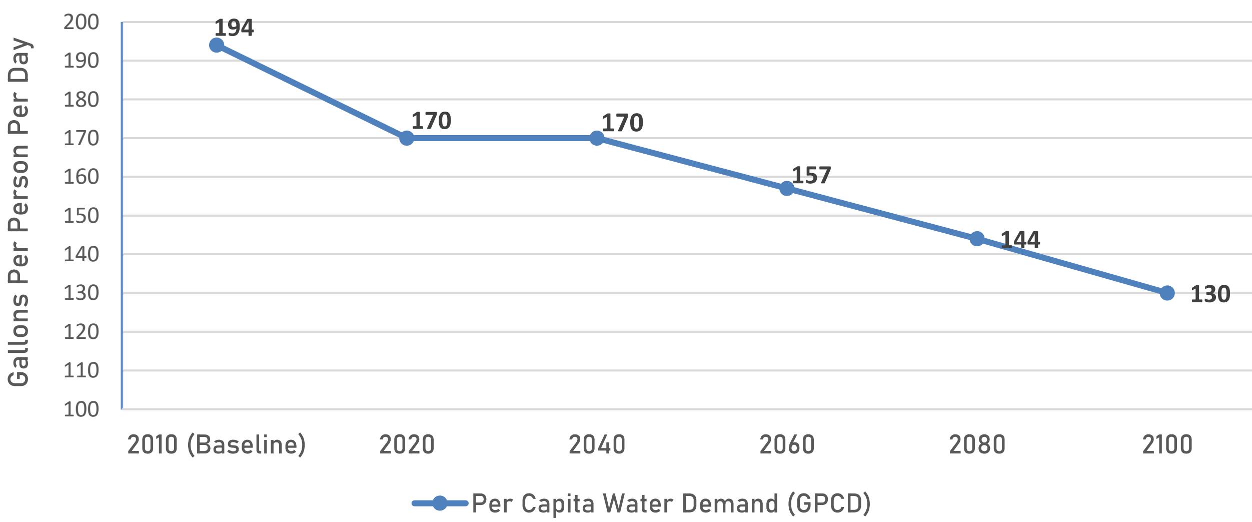
3 Additional Supply Needed to Meet Demand = Estimated BWS Water Supply – BWS Water Demand.

4 The "Target Per Capita Water Demand" reflects further per capita water use reductions needed to ensure water source adequacy in 2100. No additional per capita water reductions are needed (assuming per capita water usage is 170 GPCD in East Honolulu by 2100). To compensate for a projected water deficiency of 1.06 MGD in the Ultimate (Dry) Demand Scenario, this study estimates that East Honolulu residents would need to further reduce their per capita water usage from 170 GPCD to 130 GPCD by 2100.

<u>Additional Water Conservation Strategies for 2100</u>

The realization of the Ultimate (Dry) Scenario would call for even greater water conservation efforts to be employed in East Honolulu, and likely throughout Hawaiʻi. As shown in *Figure 5-2*, the district would need to decrease its per capita water demand from 194 GPCD (Baseline) to 130 GPCD in 2100, representing a 33% decrease over a ninety-year period. In addition to continuing conservation strategies to hold a per capita water of demand of 170 GPCD from 2020 to 2040, BWS water users would need to continually decrease their per capita water usage by approximately 7 GPCD every ten years (see *Figure 5-2*). To achieve this, implementation of aggressive conservation strategies and programs would be needed. Potential conservation programs to be pursued are identified in Section 5.4.1 (see Catalyst Project #2, "Improving Water Efficiency throughout East Honolulu").

Figure 5-2: Summary of Needed 2010-2100 Decline in East Honolulu Per Capita Water Demand (Ultimate Dry Demand Scenario)



5.2.3 Island-Wide Water Management Strategies

5.2.3.1 Island-Wide Water Supply Considerations and Challenges

The discussion provided in the below subsections underscore East Honolulu's dependence on the Honolulu and Windward water systems. Potential threats to the water source adequacy of these regions, such as ground water pollution or climate change impacts, could potentially decrease water availability in East Honolulu. Some of these considerations for Honolulu and Windward water supply, as well as potential vulnerabilities, are discussed below.

Updated Sustainable Yields

As discussed in *Section 2.3.1,* the State's 2019 WRPP is relevant to future water planning for East Honolulu, as it lowered the SY for the Waiʻalae West ASYA's SY from 4 MGD to 2.5 MGD. Currently, both the existing permitted use levels for all wells within the Waiʻalae West ASYA (2.337 MGD) as well the reported pumpage (.942 MGD) fall below the updated SY of 2.5 MGD. Since two new water sources are planned in the Waiʻalae-West ASYA, BWS will redistribute permitted uses among existing and planned sources in the Waiʻalae West ASYA to stay within the revised SY of 2.5 MGD. Due to the uncertainty in climate modeling (i.e., whether the Dry or Wet Scenario is more likely to be realized), 2100 estimates for the aquifers' SY are unknown. The range of estimates developed by the UH Statistical and Dynamical Rainfall Models is provided in *Figure* 1-13.

Water Transfers

Given the limited availability of water sources in East Honolulu, the district's water supply is dependent upon water transfers. As shown in *Table 5-1*, BWS water transfers from the Honolulu and Windward water systems currently account for approximately 70% of East Honolulu's municipal water supply. Water transfers from the Honolulu and Windward water systems are set by BWS through 2040. Given the anticipated changes in rainfall in the latter half of the century, particularly under the Dry Scenario, the amount of water that is transferred between BWS water systems is likely to change beyond 2040. See *Section 5.2.2* for a more detailed explanation of how water transfers may be impacted in 2100 under the realization of the Dry and Wet Scenarios.

Ground Water Contamination

An increasing threat to Oʻahu's water supply is ground water contamination. These threats have been recently been brought to national attention with the fuel leaks at Red Hill. As of December 3, 2021, BWS shut down its Hālawa Shaft, as well as its Hālawa and ʻAiea Wells in order to reduce likelihood of fuel contamination after news that leaks in the Red Hill Fuel Facility had contaminated the Red Hill Well, which receives water from the Halāwa Shaft. The Hālawa Shaft provides about 20% of the water for urban Honolulu and the closing of that facility has put notable strains on the other pumping stations to make up for the deficit. In spring of 2022, BWS urged residents to reduce water usage by 10% or risk "mandatory water conservation" during summer months. BWS has cited the potential for introducing progressive restrictions such as water allotments, rate surcharges, flow restrictors, and conditions on redevelopment building permit approvals.

This situation has caused a strain on other water facilities which are experiencing higher levels of water withdrawals to compensate for the loss of water supply from the Hālawa Shaft, however over the long term, the Red Hill situation is not expected to significantly impact the amount of water being transferred from the Honolulu water system to East Honolulu. Replacement wells are currently being sited within the Waimalu ASYA where the three existing sources were shut down. There are two planned future sources in East Honolulu (Waiʻalae Nui and Pia Well) which were planned prior to the Red Hill event.

While this incident is just one example of ground water contamination, it has brought public attention to the vulnerabilities and interconnectedness of Oʻahu's water supply. Further research and monitoring will be needed to prevent and detect future incidents of ground water contamination. Additional examples of island-wide ground water contamination threats, such as agricultural pollution and cesspools, are described in *Section 2.3.2.*

Sea Level Rise and Climate Change

Another factor in the vulnerability of Oʻahu's water supply is climate change. Anticipated impacts such as sea level rise, high tide flooding, coastal erosion, increased frequency and intensity of storms, rainfall shortages, higher temperatures, and increased frequency and intensity of wildfires – are discussed at length in *Chapter 2*. Impacts of climate change on irrigation and domestic water demands have been considered in the High Demand and Ultimate Demand Scenarios as described in *Chapter 3*.

Given the threat that sea level rise and climate change poses to the livelihood of all people and to residents' access to clean drinking water, there is an urgent need for inter-agency coordination to implement sea level rise and climate change adaptation measures. Implementing these measures is addressed in several of the projects and strategies identified in the EHWMP, including:

- Project #21: Implement Mayor's Directive on Climate Change
- Project #22: Sustainable Yield Estimates
- Project #23: Infrastructure Planning in the Sea Level Rise Exposure Area
- Project #24: Oʻahu Climate Adaptation Strategy
- Project #26: Drainage and Stormwater Master Plans for Drainage System Capacity Expansion, Infrastructure Renewal and Replacement, and Stormwater Quality Management
- Project #29: One Water Collaboration for Climate Resilience
- Project #30: Develop R-1 Recycled Water for Irrigation Users in Hawaiʻi Kai
- Strategy N: Climate Adaptation Neighborhood Plans
- Strategy Q: Strengthen Building Codes and Standards for Building Resilience
- Strategy R: Build Back Better and Smarter
- Strategy T: Redevelopment District

5.2.3.2 Island-Wide Water Conservation Initiatives

In addition to the projects described for EHWMP Catalyst Project #2 ("Improving Water Efficiency in East Honolulu") in *Section 5.4.1*, there are island-wide BWS initiatives which could be further expanded to support water efficiency and conservation in East Honolulu. These existing and future programs are listed below.

Existing BWS Programs to be Expanded:

- Utility-side water system water loss control
- Water loss control programs (such as leak detection and pressure management)

- Water conservation public education programs
- Water Shortage Response and Recovery Plan for Drought, Contamination and Long-term Infrastructure Disruptions
- Participation in the Participation in the State of Hawaiʻi Water Audit Program and the Hawaiʻi Water Audit Validation Effort
- Cost-benefit methodology and integration into water resource planning
- Conservation-oriented tiered water rate structure
- Low-flow fixtures ordinances
- Residential customer programs
- Rebates for rain barrels, water-efficient clothes washers, and weather-based irrigation controllers
- Irrigation efficiency incentives
- Alternative water ordinance if available and incentives

Future BWS Programs to Pursue:

- Advanced Metering Infrastructure (AMI) tied to existing Automatic Meter Reading (AMR)
- Incentive programs for homeowner associations and multi-family facilities
- Incentive programs for businesses
- On-site plumbing water loss control
- On-site non-potable reuse
- Air conditioning condensate reuse ordinance
- Commercial, Industrial, and Institutional ordinances
- Water use benchmarking and budgeting
- Landscape transformation ordinances and incentives

5.3 WATERSHED MANAGEMENT – PRIORITY WATERSHEDS AND CATALYST PROJECTS

Chapter 4 identifies a comprehensive suite of approaches to watershed management that are in keeping with overall goal of the EHWMP to be holistic, ahupuaʻa oriented, community based, and economically viable. It describes “Projects with Champions” and “Watershed Management Programs and Strategies” that support the EHWMP.

In order to focus implementation efforts on the projects and locations that offer the greatest opportunity for advancement of the EHWMP goals and policies, this section of the EHWMP identifies “priority watersheds” and “catalyst projects.” Each catalyst project consists of a suite of projects and strategies that have been identified by stakeholders and agencies as critical to watershed management in East Honolulu. Catalyst projects also provide energy, connectivity, and inspiration for other watershed projects and programs within East Honolulu.

Two catalyst projects have been identified within the East Honolulu planning district: 1) improving the water quality in Maunalua Bay; and 2) improving water efficiency throughout East Honolulu. Efforts associated with the first catalyst project are focused on "priority watersheds" identified within the district, as described in the next section. Efforts for the second catalyst project are intended to be district-wide.

5.4 PRIORITY WATERSHEDS FOR IMPROVEMENT OF WATER QUALITY IN MAUNALUA BAY

The implementation of the first catalyst project will be focused on the district's priority watersheds. In line with the five major objectives of the Oʻahu Water Management Plan, a Priority Watershed possess one or more of the following qualities:

- Provides exceptional opportunities to promote sustainable watersheds;
- Requires protection or enhancement of water quality and quantity;
- Provides special opportunities to protect native Hawaiian rights and traditional practices;
- Presents special opportunities for organizing and implementing important watershed management actions; or
- Provides or may provide important ground water or surface water supplies to meet current and future demand.

The EHWMP identifies six priority watersheds within the East Honolulu planning district: 1) Wailupe; 2) Niu; 3) Kuliʻouʻou; 4) Hahaʻione; 5) Kamilo Nui and 6) Kamilo Iki. These priority watersheds are shown in *Figure 5-3*.

Figure 5-3: EHWMP Priority Watersheds for Improvement of Water Quality in Maunalua Bay

A profile of each Priority Watershed is provided below. These profiles were developed based on information provided in three key sources:

- **Atlas of Hawaiian Watersheds and Their Aquatic Resources (DLNR, Division of Aquatic Resources and Bishop Museum, 2008)** provides comprehensive environmental and land use information for watersheds across Hawaiʻi including watershed size, elevation, land use designations, vegetative covering, stream conditions, and protection/management status.
- **Hawaiʻi Statewide GIS Program (2022)** provides spatial data on administrative boundaries, land use, zoning, environmental conditions, climate change impacts, and other topics. This resource was used to generate data on the 3.2-foot sea level rise exposure area (SLR-XA) in each watershed.
- **Maunalua Watershed Priority Projects Report (Maunalua Watershed Hui, 2019)** provides information on existing conditions and recommended projects to improve the health of the Wailupe, Kuliʻouʻou, and Kamilo Nui watersheds.

Unless otherwise noted, all information provided in the profile of Priority Watersheds originates from the sources identified above.[152]

Wailupe Watershed

With 3,245 sq acres, Wailupe is the second largest watershed in the East Honolulu district. The Wailupe watershed has a maximum elevation of 2,612 ft. The Wailupe watershed is classified by the DLNR Department of Aquatic Resources (DLNR-DAR) as "cluster 5", meaning the watershed is medium in size, steep in the upper watershed, with little embayment. Existing State land use designations are: 0% Agricultural; 66.2% Conservation; 0% Rural; and 33.8% Urban. The majority (61.4%) of the Wailupe watershed is covered by scrub and shrub, while the remaining land in is covered by low-density development (14.5%), high-density development (8.9%), evergreen forest (8.9%), grassland (3.9%), bare land (1.9%), and water (0.4%).

An estimated 62.6% of the Wailupe watershed is classified as "protected but unmanaged" and the other 37.4% is classified as "unprotected." This classification is based on four categories of biodiversity protection and management created by the Hawaiʻi Gap Analysis Program (GAP): 1) permanent biodiversity protection; 2) managed for multiple uses; 3) protected but unmanaged; and 4) unprotected.

The Wailupe watershed is highly prone to erosion due to the spread of invasive trees and plants such as mango, strawberry guava, lantana, and ironwood. The roads and trails that traverse the valley are the primary sources of sediment that are transferred to Maunalua Bay during heavy rain events. Stormwater runoff is also generated by development in ʻĀina Haina, as well as the valley's "bare patches", where the thin top layer of soil and vegetation have eroded and exposed underlying organic material. These bare patches are typically found below the valley's Western ridge.

The watershed includes one intermittent stream, the Wailupe Stream. When flowing the entirety of its reach (typically during the wet season), the Wailupe Stream runs a total distance of 8.4 miles. The Wailupe

[152] The Atlas of Hawaiian Watersheds currently does not include publicly available information for the Kuliʻouʻou or Hahaʻione watersheds. Thus, information was gleaned from GIS analysis to develop these watershed profiles.

Stream is the only stream in the planning district that has not been converted into a concrete lined channel. In 2019, the City and County of Honolulu Department of Facility Maintenance (DFM) began installing boulders along the Wailupe Stream’s banks to stabilize and protect steam embankments.

The Wailupe Stream has experienced high amounts of incision, likely because of the historical straightening of the original path of the stream to provide a direct path to the ocean. It is also likely attributable to the down cutting of the stream due to scouring from increased runoff volumes. In addition to negative impacts to fish ecosystems, stream incision can reduce ground water aquifer levels.

Wailupe Stream drains into Maunalua Bay near the Wailupe Peninsula. The shoreline of the Wailupe watershed along Maunalua Bay is highly developed with residential properties and is vulnerable to erosion and coastal flooding. Approximately 45 square acres of the Wailupe watershed falls within the 3.2 ft SLR-XA.

Niu Watershed

Niu, also known as “Pia”, has an area of 1,709 square acres and a maximum elevation of 2,500 ft. The Niu watershed is classified by DAR as “cluster 5”, meaning the watershed is medium in size, steep in the upper watershed, with little embayment. The percentage of the watershed’s State land use designations are: 0% Agricultural; 78.5% Conservation; 0% Rural; and 21.5% Urban.

The majority (70.1%) of Niu is covered by scrub/shrub, while the remaining land is covered by low-density development (9.5%), high-density development (6.9%), evergreen forest (5.9%), grassland (5.6%), bare land (1.7%), and water (0.1%). According to the Hawaiʻi GAP, 35.1% of Niu is classified as “protected but unmanaged” and the other 34.9% is classified as “unprotected.”

Niu includes one intermittent stream, the Pia Stream. When flowing the entirety of its reach (typically during the wet season), the stream runs a total distance of 6.9 miles. Pia Stream drains into Maunalua Bay near Niu Beach. The Niu shoreline is highly developed with residential properties. Compared to other areas of East Honolulu, Niu is less vulnerable to sea level rise and erosion, with only 13 acres lying within the 3.2 ft SLR-XA.

Kuliʻouʻou Watershed

Kuliʻouʻou has an area of 1,152 square acres. Although the watershed is unclassified by DAR, it would likely be classified as “cluster 4” or “cluster 5”, due to the watershed’s size, steep topography, and small embayment. The percentage of the watershed’s State land use designations are: 0% Agricultural; 72.5% Conservation; 0% Rural; and 27.5% Urban.

The majority (50.4%) of Kuliʻouʻou is covered by scrub/shrub, while the remaining land is covered by low-density development (13.6%), high-density development (12%), evergreen forest (11.5%), grassland (8.6%), cultivated landscaping (2.1%), bare land (1.5%), and water (0.3%). Hawaiʻi GAP Program classifications for Kuliʻouʻou is not available.

The East and West ridges of Kuliʻouʻou are currently undeveloped. The area immediately mauka of the Kuliʻouʻou Valley neighborhood is heavily forested with a mixture of native and non-native plants and trees. The native species become prominent at higher elevations. There are two heavily traversed trails in Kuliʻouʻou, one along Kuliʻouʻou Stream, and the other along the Eastern ridgeline. The ridgeline trail is severely eroded in places, however there has been recent trail maintenance, including the installation of stairs and water bars.

Kuliʻouʻou Stream is the watershed's only intermittent stream and runs approximately 7 miles when flowing the entirety of its reach. Generally, Kuliʻouʻou Stream is lined with forest cover, including invasive guava and java plum trees, as well as Christmas berry and low-lying ferns. Compared to the Wailupe watershed, the riparian areas along Kuliʻouʻou Stream appear to be more ecologically intact. However, where Kuliʻouʻou Stream emerges from the forest, it is immediately channelized and directed into a series of pipes and concrete lined channels. The concrete channels create an environment that is difficult for native species, such as the Oʻopu (fish), hihiwai (snails), and opae (shrimp), who migrate from the ocean up fresh water streams in order to complete their life cycles, to survive in.

The stream typically has a small base flow, which is present even in times of severe drought. This may indicate that ground water is draining out of surrounding aquifers and being converted into surface water where it flows down a concrete lined channel to the ocean. This loss of ground water also likely contributes to the loss of fresh water springs in the watershed. During low or zero flow conditions, pools of stagnant water, which include urban pollutants, gather along the reach of Kuliʻouʻou Stream.

Kuliʻouʻou Stream drains into Maunalua Bay along a heavily developed shoreline near the Paikō Lagoon Wildlife Sanctuary. Many of the properties fronting the lagoon have seawalls to protect against coastal erosion. Compared to the district's other watersheds, Kuliʻouʻou is the most susceptible to sea level rise and erosion, as nearly 58 square acres of the Kuliʻouʻou watershed falls within the 3.2 ft SLR-XA.

<u>Hahaʻione Watershed</u>

Hahaʻione has an area of 1,382 square acres. Although the watershed is unclassified by DAR, it would likely be classified as "cluster 4" or "cluster 5", due to the watershed's size, steep topography, and small embayment. The percentage of the watershed's State land use designations are: 0% Agricultural; 72.1% Conservation; 0% Rural; and 27.9% Urban.

The majority (49.2%) of Hahaʻione is covered by scrub/shrub, while the remaining land is covered by high-density development (14.5%), low-density development (12.8%), grassland (6.5%), evergreen forest (6.5%), water (5.2%), bare land (5.0%), and unconsolidated shoreline (0.3%). Hawaiʻi GAP Program classifications for Hahaʻione is not available.

Hahaʻione Stream is the watershed's sole intermittent stream and runs approximately 5.2 miles when flowing the entirety of its reach. The stream drains into the manmade channels of Hawaiʻi Kai Marina. The area surrounding the Hawaiʻi Kai Marina is heavily developed with residential and commercial properties. Approximately 32 square acres of the Hahaʻione watershed falls within the 3.2 ft SLR-XA.

Kamilo Nui Watershed

The Kamilo Nui watershed has an area of 1,280 square acres and a maximum elevation of 2,372 ft. Although the watershed is unclassified by DAR, it would likely be classified as "cluster 4" or "cluster 5", due to the watershed's size, steep topography, and small embayment. The percentage of the watershed's State land use designations are: 0% Agricultural; 67% Conservation; 0% Rural; and 33% Urban. While not technically classified by the State land use designations as Agricultural, there is a small-scale agricultural operation in Kamilo Nui Valley (approximately 100 acres).

The majority (54.8%) of Kamilo Nui is covered by scrub/shrub, while the remaining land in Kamilo Nui is covered by low-density development (13.8%), high-density development (12.5%), grassland (7.7%), evergreen forest (6.1%), water (3.3%), bare land (1.3%), and unconsolidated shoreline (0.5%). According to the Hawaiʻi GAP Program, an estimated 14.8% of Kamilo Nui is classified as "protected but unmanaged" and the other 85.2% is classified as "unprotected."

The upper portions of Kamilo Nui are characterized by dryland plants, including haole koa, kiawe, and invasive grasses. Few native trees, including the ʻaʻaliʻi and wiliwili trees, remain. The surrounding hillsides are undeveloped, however there was significant alteration caused by Henry J. Kaiser's former use of the area as a cement manufacturing operation.

Kamilo Nui Stream is the watershed's sole intermittent stream, and it runs a total distance of 6 miles when flowing the entirety of its reach. The stream consists of a series of rivulets which enter the valley from the surrounding gulches. These side channels flow down through the valley and drain into Kuapā Pond and the Hawaiʻi Kai Marina. The primary road in the Valley, Kamilonui Place, is a significant source of stormwater during heavy rain events. Erosion occurs along the streambeds, and due to the unstable nature of the underlying fill material, the stream flow paths are highly variable, shifting each time it rains.

One of the two agricultural areas in East Honolulu is located in Kamilo Nui Valley, directly mauka of Kuapā Pond. Generally, these agricultural areas are seen as an asset to the region's watershed health, as conservation tillage, soil remediation, and other sustainable agricultural practices have been used to reduce and treat stormwater pollution.

The Kamilo Nui watershed has a small shoreline (approximately 0.15 miles) fronting Maunalua Bay. Only 6 square acres of the Kamilo Nui watershed falls within the 3.2 ft SLR-XA.

Kamilo Iki Watershed

The Kamilo Iki watershed has an area of 1,517 square acres and a maximum elevation of 1,588 ft. Although the watershed is unclassified by DAR, it would likely be classified as "cluster 4" or "cluster 5", due to the watershed's size, steep topography, and small embayment. The percentage of the watershed's State land use designations are: 0% Agricultural; 67% Conservation; 0% Rural; and 33% Urban.

The majority (45.5%) of Kamilo Iki is covered by scrub/shrub, while the remaining land in Kamilo Iki is covered by high-density development (20.3%), low-density development (15%), grassland (8.6%), cultivated land (1.7%), water (6%), bare land (1.5%), and evergreen forest (1.4%). According to the Hawaiʻi

GAP Program, an estimated 10.7% of Kamilo Iki is classified as “protected but unmanaged” and the other 89.3% is classified as “unprotected.” Based on this data, Kamilo Iki is the most developed of the district’s six Priority Watersheds.

Kamilo Iki Stream is the watershed’s sole intermittent stream and runs a total distance of 6.3 miles when flowing the entirety of its reach. The stream drains into Kuapā Pond, which eventually drains into the ocean. Kuapā Pond fronts a highly developed area with heavy commercial uses, such as the Koko Marina Center. The Kamilo Iki watershed does not include any shoreline along Maunalua Bay, as the boundaries of the watershed fall along the highway. 19 square acres of the watershed falls within the 3.2 ft SLR-XA.

5.4.1 Action Plan for EHWMP Catalyst Projects

This section includes a high-level action plan for implementing the EHWMP’s two catalyst projects: 1) improving the water quality in Maunalua Bay; and 2) improving water efficiency throughout East Honolulu. Key issues and goals are identified for each catalyst project, as well as an action plan with relevant “Projects with Champions” that support implementation.

i. Catalyst Project #1: Improving Water Quality in Maunalua Bay

This EHWMP strives to incorporate principles from the traditional ahupuaʻa model of resource management, applied in a modern context. The ahupuaʻa approach recognizes the ecological and hydrological connections between mauka and makai resources and the complex interactions and dependencies that exist among environmental, economic, and sociocultural uses. The ahupuaʻa approach can provide a model for how economic, social, and environmental goals can be achieved. The catalyst project to improve water quality in Maunalua Bay incorporates the ahupuaʻa approach, calling for mauka management strategies to improve makai water quality.

Key Issues: As discussed in Chapter 2 and 3, while East Honolulu’s ground water quality is generally good (as it the case with most of Oʻahu), nearshore water quality in Maunalua Bay continues to be poor due to drainage and runoff from the district’s residential and commercial development, as well as erosion from natural and agricultural areas. These persistent pollutants have damaged the Bay’s shallow and fragile reef system, in turn impacting recreational, subsistence, and cultural uses of the Bay. NOAA’s classification of Maunalua Bay as an “impaired open coastal water body” underscores the need to improve the water quality of the region. More detailed information about nearshore water quality issues can be found in *Section 0*.

Fresh water flow to Maunalua Bay is essential to improve the Bay’s water quality and supports ground water dependent ecosystems and traditional and customary practices, such as fishponds and estuaries. Natural ground water recharge from rainfall in the Waiʻalae East aquifer is estimated by USGS in 2017 at approximately 10 MGD. Accounting for sustainable yield and pumping, about 9 MGD currently flows to the nearshore.

<u>Catalyst Project #1 Goals</u>: The following goals are identified for water quality improvements in Maunalua Bay. These are based on the anticipated outcomes for the Projects with Champions that comprise this catalyst project:

- <u>Goal #1:</u> Reduce the amount of invasive algae (Gorilla Ogo, Prickly Seaweed, and Leather Mudweed) found in Maunalua Bay.
- <u>Goal #2:</u> Increase the amount of healthy, living coral reef in Maunalua Bay.
- <u>Goal #3:</u> Decrease the amount of impervious surfaces within the district's priority watersheds (Wailupe, Niu, Kuliʻouʻou, Hahaʻione, Kamilo Nui, and Kamilo Iki).
- <u>Goal #4:</u> Decrease the number of cesspools located within the district's priority watersheds.
- <u>Goal #5:</u> Increase the amount of fresh water that enters Maunalua Bay through stormwater retention and water conservation.
- <u>Goal #6:</u> Decrease the amount of stormwater runoff, erosion, and debris that enters Maunalua Bay.

<u>Relevant Project with Champions</u>: *Chapter 4* identifies Projects with Champions to achieve the EHWMP goals and objectives, including promoting sustainable watersheds, protecting and enhancing water quality, protecting native Hawaiian and traditional and customary practices, and facilitating public participation, education, and project implementation. Projects with Champions are defined as efforts with a designated lead agency or organization that is proposing, planning, or already implementing the project.

Eighteen of the identified Projects with Champions, if successfully implemented, would support the achievement of the Catalyst Project #1 goals through measures such as reducing stormwater and pollutants entering the Bay, removing invasive species, enhancing community awareness and involvement, and improving habitat for coral reefs. These Projects with Champions are shown in *Figure 5-4*. Ten of these projects are site specific, and eight are district-wide efforts. The action plan for each of the Projects with Champions is provided in *Table 5-3*. This table summarizes the goals, catalyst project alignment, champions and partners, status, estimated cost, and target implementation timing for each of the Projects with Champions to support water quality improvements in Maunalua Bay. Further background about these Projects with Champions can be found in *Section 4.3.3.*

<u>Relevant Strategies and Programs</u>: *Chapter 4* also identifies Strategies and Programs that help to implement EHWMP goals and objectives, but that do not currently have a championing agency or organization. Nine of the identified Strategies and Programs, if successfully implemented, would support the achievement of the Catalyst Project #1 goals through measures such as native species reforestation, stream restoration, trail erosion mitigation, restoration of fresh water spring flows to Maunalua Bay, and others. Further details about these relevant Strategies and Programs are provided in *Table 5-3*. Note, no details regarding the Programs' and Strategies' status, estimated costs, or next steps are provided in the Action Plan for Catalyst Project #1, since these Strategies and Programs do not have existing champions. Further details about these Strategies and Programs can be found in *Section 4.3.4.*

Potential funding sources to support both catalyst projects can be found in the last section of this Chapter.

Figure 5-4: EHWMP Projects with Champions to Support the Improvement of Water Quality in Maunalua Bay

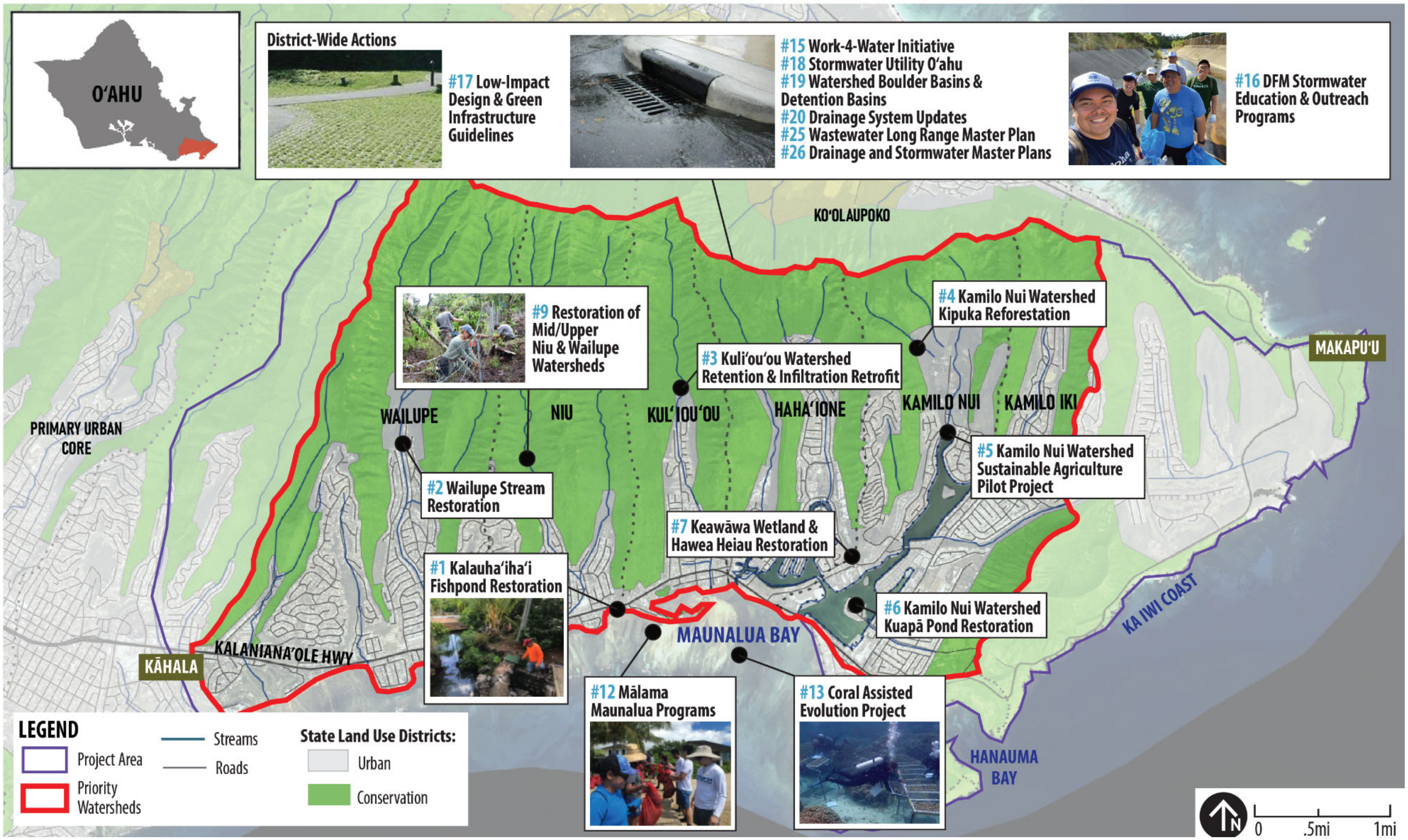


Table 5-3: Action Plan for Catalyst Project #1 – Improving Water Quality in Maunalua Bay

Project with Champion or Strategy	Goals & Alignment with Improving Water Quality in Maunalua Bay	Existing or Potential Champions & Partners	Status	Estimated Project Costs	Target Implementation
ONGOING EFFORTS					
Project #7: Keawāwa Wetland and Hawea Heiau Restoration	*Project Goal:* Improve the ecosystem health and diversity of the Keawāwa Wetland and promote community-led efforts to restore the district's natural and cultural resources. *Catalyst Project Alignment:* Enhanced ecosystem diversity and stormwater practices in Hahaʻione and Kamilo Nui watersheds will help retain and infiltrate stormwater entering Maunalua Bay.	Livable HawaiʻI Kai Hui (LHKH), Maunalua.Net, and the U.S. Fish and Wildlife Service (USFWS)	*To Date:* LHKH and Maunalua.Net have been actively involved in restoring Keawāwa Wetland and the Hawea Heiau for cultural and educational purposes. *Next Steps:* Restoration to be further enhanced through 1) planting native trees; 2) ʻŌpaeʻula (Hawaiian red shrimp) habitat restoration in partnership with the USFWS; 3) rechanneling stormwater from Hawaiʻi Kai Drive that currently drains into the wetland and implementing a rain garden to infiltrate the runoff; 4) conducting a water quality study; and 5) obtaining an easement for land behind the Oʻahu Club, which is part of the wetland.	Unknown.	Ongoing Effort
Project #17: Low Impact Design and Green Infrastructure	*Project Goal:* Require the use of low impact development (LID) standards (found in the CCH *Rules Related to Water Quality* and the CCH *Stormwater BMP*	City and County of Honolulu (CCH), Department of Facilities	*To Date:* CCH published *Rules Related to Water Quality* published in 2018 and the *Stormwater BMP Guide for New and Redevelopment* in 2017.	Unknown – costs accrue to project developers when construction or	Ongoing Effort

Table 5-3: Action Plan for Catalyst Project #1 – Improving Water Quality in Maunalua Bay

Project with Champion or Strategy	**Goals & Alignment with Improving Water Quality in Maunalua Bay**	**Existing or Potential Champions & Partners**	**Status**	**Estimated Project Costs**	**Target Implementation**
Standards and Guidelines	*Guide for New and Redevelopment*) in all new construction or redevelopment. *Catalyst Project Alignment:* LID and green infrastructure help to capture and infiltrate stormwater runoff entering Maunalua Bay.	Maintenance (DFM)	*Next Steps:* DFM to further promote the City's low impact development standards in tandem with the anticipated Oʻahu Stormwater Utility (see Project #18).	redevelopment occurs.	
Project #16: DFM Community Programs	*Project Goal:* Expand DFM's existing community programs to enhance public participation in watershed improvements. *Catalyst Project Alignment:* DFM's Adopt-A-Stream/Adopt-A-Block Programs improve water quality through community cleanups of streams and streets. The Stormwater Public School Curriculum educates students about the impacts of runoff, and how to mitigate them.	DFM	*To Date:* DFM has established two community programs: 1) Adopt-A-Stream/Adopt-A-Block Programs; and 2) Stormwater Public School Curriculum. *Next Steps:* DFM to expand existing programs to reach an increased numbers of volunteers and students through enhanced partnerships with community organizations and schools.	Unknown.	Ongoing Effort
Project #12: Mālama Maunalua Community Programs	*Project Goal:* Improve the water quality of Maunalua Bay through community-led habitat restoration, science, planning, education, and outreach programs.	Mālama Maunalua	*To Date:* Mālama Maunalua has established three key ongoing initiatives: 1) Huki Project; 2) Plant and Tree, Save the Sea; and 3) Follow the Drop Mobile App.	Unknown.	Ongoing Effort

Table 5-3: Action Plan for Catalyst Project #1 – Improving Water Quality in Maunalua Bay

Project with Champion or Strategy	Goals & Alignment with Improving Water Quality in Maunalua Bay	Existing or Potential Champions & Partners	Status	Estimated Project Costs	Target Implementation
	<u>*Catalyst Project Alignment:*</u> Mālama Maunalua's initiatives improve water quality of Maunalua Bay through removing invasive species within the Bay (Huki Project) and programs (such as Follow the Drop Mobile App) that support improved stormwater management.		<u>*Next Steps:*</u> Mālama Maunalua to secure funding to expand existing community programs.		
<u>Project #13:</u> Coral Assisted Evolution Project	<u>*Project Goal:*</u> Identify existing coral stocks that are more resilient to thermal stress, grow them within *in situ* nurseries, and propagate them in Maunalua Bay. <u>*Catalyst Project Alignment:*</u> This project can improve the quality Maunalua Bay by enhancing the health and resilience of the bay's coral reefs to thermal stress.	Hawaiʻi Institute of Marine Biology (HIMB), NOAA, DAR, and Mālama Maunalua	This is an ongoing project by Mālama Maunalua, HIMB, NOAA, and DAR. Project funding will expire in 2022.	Project is funded through a $1 million grant from the National Fish and Wildlife Fund and HIMB.	Ongoing Effort

Table 5-3: Action Plan for Catalyst Project #1 – Improving Water Quality in Maunalua Bay

Project with Champion or Strategy	Goals & Alignment with Improving Water Quality in Maunalua Bay	Existing or Potential Champions & Partners	Status	Estimated Project Costs	Target Implementation
Project #26: Drainage and Stormwater Master Plans	*Project Goal:* Implement DFM's *Stormwater Management Program Plan*, which increases resilience of the drainage system in accordance with the Mayor's Climate Change and sea level rise Directive 18-02. *Catalyst Project Alignment:* Drainage system improvements are needed to slow, capture, and filter stormwater runoff that enters Maunalua Bay.	CCH Department of Design and Construction (DDC) and DFM	*To Date:* The Storm Water Management Program Plan was finalized by DFM in September 2021. *Next Steps:* DFM to work with DCC and other partner agencies to implement the *Stormwater Management Program Plan.*	Unknown.	Ongoing Effort
SHORT-TERM (2-5 YEARS TARGET IMPLEMENTATION)					
Project #1: Kalauhaʻihaʻi Fishpond Restoration	*Project Goal:* Return water flow to the Kalauhaʻihaʻi Fishpond. *Catalyst Project Alignment:* Increased flow of fresh water to Maunalua Bay will improve the health of nearshore ecosystems.	DLNR Engineering Branch and Maunalua Fishpond Heritage Center	*To Date:* The DLNR has selected trench collection system as the best alternative to restore groundwater flow to the fishpond. The DLNR submitted a Proposed Environmental Assessment exemption notice to BWS in August 2023. *Next Steps*: The DLNR will secure final permitting. Pending permits and approvals, construction is expected to begin in late 2024.	$1,500,000 has been released by the Legislature for the project to date.	2025

Table 5-3: Action Plan for Catalyst Project #1 – Improving Water Quality in Maunalua Bay

Project with Champion or Strategy	Goals & Alignment with Improving Water Quality in Maunalua Bay	Existing or Potential Champions & Partners	Status	Estimated Project Costs	Target Implementation
Project #4: Kamilo Nui Watershed Kipuka Reforestation	*Project Goal:* Reforest the area near Kamilo Nui Farm with kipuka, to reseed and repopulate native plants in Kamilo Nui Valley. *Catalyst Project Alignment:* Enhanced vegetation cover and diversity surrounding Kuliʻouʻou Stream and Paikō lagoon will help prevent erosion and reduce stormwater entering Maunalua Bay.	Maunalua Watershed Hui	*To Date:* Field observations have been completed and stakeholders / potential contractors have identified by the Hui. *Next Steps:* The Hui to determine the number and size of kipuka areas, establish an agreement with the affected landowner(s), identify and obtain any required permits, and acquire funding for implementation.	Cost will be dependent upon the number and size of kipuka areas, as well as the agreement reached with the landowner(s).	2025
Project #5: Kamilo Nui Watershed Sustainable Agriculture Pilot Project	*Project Goal:* Integrate stormwater best management practices within the agricultural properties located above the spillway that drains into Kuapā Pond. *Catalyst Project Alignment:* Enhanced stormwater practices in Kamilo Nui will help retain and infiltrate stormwater entering Maunalua Bay.	Maunalua Watershed Hui	*To Date:* Field observations have been completed and stakeholders / potential contractors have identified by the Hui. *Next Steps*: The Hui to work with the landowners to acquire permissions, permits, and obtain needed funding.	Unknown.	2027
Project #9: Restoration of	*Project Goal:* Implement ungulate-proof fences in the	DLNR's Division of Forestry and Wildlife (DLNR-	*To Date:* This project is being planned by DLNR-DOFAW and KMWP.	Unknown.	2025

Table 5-3: Action Plan for Catalyst Project #1 – Improving Water Quality in Maunalua Bay

Project with Champion or Strategy	Goals & Alignment with Improving Water Quality in Maunalua Bay	Existing or Potential Champions & Partners	Status	Estimated Project Costs	Target Implementation
Mid/Upper Niu and Wailupe Watersheds	upper watersheds of Wailupe and Niu (also known as Pia). *Catalyst Project Alignment:* Watershed protections fences help to decrease the amount of erosion which travels to Maunalua Bay.	DOFAW) and Koʻolau Mountains Watershed Partnership (KMWP)	*Next Steps:* DLNR-DOFAW and KMWP to work together to secure funding to construct and install planned fences in the upper watersheds of Wailupe and Niu.		
Project #18: Stormwater Utility Oʻahu	*Project Goal:* Establish a stormwater utility to provide DFM with dedicated, fee-based funding exclusively for stormwater management purposes. *Catalyst Project Alignment:* The Stormwater Utility will fund needed drainage system improvements to slow, capture, and filter stormwater runoff. It will also provide funding to community projects with similar goals of improving stormwater management.	DFM and BWS	*To Date:* As of September 2020, the City had established a stakeholder advisory group and completed two of three rounds of community engagement. In December 2020, the City released a Feasibility Study on the proposed stormwater utility, which summarized community input and provided recommendations on developing a revised stormwater utility. *Next Steps:* DFM to continue technical analysis and needed GIS parcel mapping, release the revised stormwater utility, complete the last round of community engagement, and receive needed Council approval of the proposed utility.	Unknown – the proposed stormwater utility will be applied to property owners based on size of property, amount of impervious surfaces, etc.	2023

Table 5-3: Action Plan for Catalyst Project #1 – Improving Water Quality in Maunalua Bay

Project with Champion or Strategy	Goals & Alignment with Improving Water Quality in Maunalua Bay	Existing or Potential Champions & Partners	Status	Estimated Project Costs	Target Implementation
Project #25: Wastewater Long Range Master Plan for Treatment, System Capacity Expansion, and Infrastructure Renewal and Replacement	*Project Goal:* Develop/Update a Wastewater Long Range Plan for the Sand Island WWTP that increases resilience of the wastewater system in accordance with the Mayor's Climate Change and Sea Level Rise Directive 18-2. *Catalyst Project Alignment:* Increasing the resilience of the WWTP will reduce environmental and public health risks of potential sewage contamination to Maunalua Bay.	CCH Department of Environmental Services (ENV)	*To Date:* ENV announced plans to update the Facility Plan for the Sand Island WWTP in 2017. As part of the project, the consultant has evaluated alternatives and performed preliminary engineering for upgraded infrastructure to meet the 2035 consent decree requirements. *Next Steps:* ENV to work with the consultant to complete updates to the Sand Island WWTP Facility Plan.	Unknown.	2025
Project #15: Work-4-Water Initiative	*Project Goal:* Create shovel-ready projects to convert 400 cesspools in the most at-risk areas on Oʻahu, Maui, Kauaʻi and Hawaiʻi Island. *Catalyst Project Alignment:* Cesspool conversion is needed to reduce potential water contamination to Maunalua Bay and reduce the public and environmental health risks associated with sewage pollution.	Wastewater Alternatives and Innovations (WAI)	*To Date:* WAI and project partners have begun research, analysis, outreach, and workforce development and training. *Next Steps*: The project team must secure funding to support design, permitting, inspection, compliance, installation, and system construction)	$23 million total project budget.	2025

Table 5-3: Action Plan for Catalyst Project #1 – Improving Water Quality in Maunalua Bay

Project with Champion or Strategy	Goals & Alignment with Improving Water Quality in Maunalua Bay	Existing or Potential Champions & Partners	Status	Estimated Project Costs	Target Implementation
Strategy A: Southern Koʻolau Mountains Native Species Reforestation	*Project Goal:* Facilitate the removal of invasive species and enhance native outplanting in upland areas of the Southern Koʻolau Mountains. *Catalyst Project Alignment:* Native outplanting has been found to prevent soil erosion and stabilize stream banks, thereby helping to reduce the transfer of sediment from mauka areas to Maunalua Bay.	KMWP, DOFAW, DPR, Protect and Preserve Hawaiʻi, Trees for Honolulu's Future, Maunalua Watershed Hui, and local arborists and botanists	N/A	N/A	N/A
Strategy B: Stream Restoration, Dechannelization and Maintenance	*Project Goal:* Establish a district-wide stream restoration effort, which could include removing invasive species and outplanting with native plants, stream cleanups, and others. A stream restoration program could also include de-channelization of certain streams in the district. *Catalyst Project Alignment:* Stream channel degradation is a major threat to instream habitat, and overall health and water	DFM, Mālama Maunalua, 808 Cleanups, Surfrider Foundation, Protect and Preserve Hawaiʻi, and private property owners	N/A	N/A	N/A

Table 5-3: Action Plan for Catalyst Project #1 – Improving Water Quality in Maunalua Bay

Project with Champion or Strategy	Goals & Alignment with Improving Water Quality in Maunalua Bay	Existing or Potential Champions & Partners	Status	Estimated Project Costs	Target Implementation
	quality of streams and nearshore waters.				
Strategy C: Stream Debris Educational Program	*Project Goal:* Facilitate an educational campaign to further community understanding regarding the responsibility of property owners to clear debris from stream channels. *Catalyst Project Alignment:* The program has the potential for decreased dumping and debris, and would help to improve the quality of Maunalua Bay.	DFM, BWS, 808 Cleanups, Surfrider Foundation, LHKH	N/A	N/A	N/A
Strategy D: Coordinated Pig Hunting Program	*Project Goal:* Establish a coordinated pig hunting program to increase the number of permits for hunters, facilitate working groups with hunters, and develop meaningful and mutually beneficial working relationships with hunters.	DLNR-DOFAW, KWMP, DLNR Nā Ala Hele	N/A	N/A	N/A

Table 5-3: Action Plan for Catalyst Project #1 – Improving Water Quality in Maunalua Bay

Project with Champion or Strategy	Goals & Alignment with Improving Water Quality in Maunalua Bay	Existing or Potential Champions & Partners	Status	Estimated Project Costs	Target Implementation
	Catalyst Project Alignment: Feral pigs are known to increase erosion, nutrient runoff, and the spread of invasive species. Better managing pig populations would help reduce the transfer of sediment and other pollutants from mauka areas to Maunalua Bay.				
Strategy E: Trail Education Program	*Project Goal:* Establish a coordinated trail education program, including educational signage to increase awareness about the impacts of trail use on watershed health, as well as outreach to schools, neighborhood organizations, recreational groups, and tourism associations. *Catalyst Project Alignment:* Better management and use of the district's hiking trails could would help reduce trail erosion and the transfer of sediment from mauka areas to Maunalua Bay.	DLNR Nā Ala Hele, BWS, Hawaiian Trail and Mountain Club, Sierra Club	N/A	N/A	N/A

Table 5-3: Action Plan for Catalyst Project #1 – Improving Water Quality in Maunalua Bay

Project with Champion or Strategy	**Goals & Alignment with Improving Water Quality in Maunalua Bay**	**Existing or Potential Champions & Partners**	**Status**	**Estimated Project Costs**	**Target Implementation**
<u>Strategy F:</u> Trail Erosion Mitigation	<u>*Project Goal:*</u> Establish a coordinated program to replace trail ropes with steps, where trail grade exceeds 20 percent. <u>*Catalyst Project Alignment:*</u> Certain trail improvements, such as steps, can help prevent erosion, and thus the transfer of sediment from mauka areas to Maunalua Bay.	DLNR Nā Ala Hele, Sierra Club, Hawaiian Trail and Mountain Club	N/A	N/A	N/A
<u>Strategy R:</u> Build Back Better and Smarter	<u>*Project Goal:*</u> County agencies to integrate post-disaster reconstruction and recovery guidelines developed by UH Sea Grant into their respective plans and policies. <u>*Catalyst Project Alignment:*</u> The adaptive design and resiliency strategies that are part of recovery strategies can be developed in a way that provide water quality benefits. For example, some recovery strategies promote cesspool conversion and stormwater infrastructure improvements,	DPP, OCCSR, UH Sea Grant	N/A	N/A	N/A

Table 5-3: Action Plan for Catalyst Project #1 – Improving Water Quality in Maunalua Bay

Project with Champion or Strategy	Goals & Alignment with Improving Water Quality in Maunalua Bay	Existing or Potential Champions & Partners	Status	Estimated Project Costs	Target Implementation
	both of which improve nearshore water quality.				
MID-TERM PROJECTS (5-10 YEARS TARGET IMPLEMENTATION)					
Project #6: Kamilo Nui Watershed Kuapā Pond Restoration	*Project Goals:* - Outplanting the two artificial islands within Kuapā Pond with native plants. - Reshaping these islands to create small artificial intertidal zones to serve as a fish and bird habitats. *Catalyst Project Alignment:* Enhanced ecosystem diversity in Kamilo Nui will help retain and infiltrate stormwater entering Maunalua Bay.	Maunalua Watershed Hui	*To Date:* Field observations have been completed and stakeholders / potential contractors have identified by the Hui. *Next Steps*: The Hui to acquire permits and obtain needed funding.	Unknown.	2030
Project #19: Watershed Boulder Basins and Detention Basins	*Project Goal:* Expand the capacity of DFM's existing boulder basins and/or create additional boulder basins within East Honolulu or create additional basins to further slow stream water and prevent debris from entering	DFM and BWS	*To Date:* Boulder and detention basins in East Honolulu are already being managed by DFM. *Next Steps*: Proposals for expansion or addition of basins would need to be studied and budgeted for.	Unknown.	2030

Table 5-3: Action Plan for Catalyst Project #1 – Improving Water Quality in Maunalua Bay

Project with Champion or Strategy	Goals & Alignment with Improving Water Quality in Maunalua Bay	Existing or Potential Champions & Partners	Status	Estimated Project Costs	Target Implementation
	stream channels during heavy rain events. *Catalyst Project Alignment:* Boulder and detention basins help slow and capture debris before entering Maunalua Bay.				
Project #20: Drainage System Upgrades	*Project Goal:* Improve drainage systems with technologies such as automatic retractable screens and baffle boxes. *Catalyst Project Alignment:* Drainage system improvements are needed to slow, capture, and filter stormwater runoff that enters Maunalua Bay.	DFM	*To Date:* DFM has installed retractable screens in Downtown Honolulu, Waikīkī, and Kailua. No such technologies have been implemented in East Honolulu to date. *Next Steps*: DFM to acquire needed permits and obtain funding.	Unknown.	2030
Strategy G: Kuliʻouʻou Ridge Trail Entrance Improvements	*Project Goal:* Implement parking lot improvements at the Kuliʻouʻou Ridge Trail Head to better manage trail use. Parking lot improvements could incorporate permeable pavement techniques to offset the impacts of impervious surfaces. *Catalyst Project Alignment:* Better management and use of	BWS and DLNR Nā Ala Hele	N/A	N/A	N/A

Table 5-3: Action Plan for Catalyst Project #1 – Improving Water Quality in Maunalua Bay

Project with Champion or Strategy	Goals & Alignment with Improving Water Quality in Maunalua Bay	Existing or Potential Champions & Partners	Status	Estimated Project Costs	Target Implementation
	Kuliʻouʻou Ridge Trail, one of the island's heaviest used trails, help reduce trail erosion and the transfer of sediment from mauka areas to Maunalua Bay.				
LONG-RANGE PROJECTS (10-20 YEARS TARGET COMPLETION)					
Project #2: Wailupe Stream Restoration	*Project Goal:* Establish a partnership to maintain and restore Wailupe Stream through implementation of a Regenerative Stormwater Conveyance (RSC) system (described in *Project #2*: **Wailupe Stream Restoration**). *Catalyst Project Alignment:* Stream restoration in combination with RSC system would help to slow, capture, and infiltrate stormwater runoff entering Maunalua Bay.	Maunalua Watershed Hui	*To Date:* Field observations completed and stakeholders / potential contractors identified. *Next Steps*: Hui to work with the City to identify priority areas to implement the RSC, then obtain funding to permit and construct the proposed project.	Cost is dependent upon the locations and phasing for the project, to be determined in consultation with the City.	2035
Project #3: Kuliʻouʻou Watershed Retention and Infiltration Retrofit	*Project Goals:* -Implement two flood control structures within Kuliʻouʻou Stream to retain and infiltrate stormwater.	Maunalua Watershed Hui	*To Date:* Field observations have been completed and stakeholders / potential contractors have identified by the Hui.	Cost will be dependent upon permitting required as well as the selected contractor,	2035

Table 5-3: Action Plan for Catalyst Project #1 – Improving Water Quality in Maunalua Bay

Project with Champion or Strategy	**Goals & Alignment with Improving Water Quality in Maunalua Bay**	**Existing or Potential Champions & Partners**	**Status**	**Estimated Project Costs**	**Target Implementation**
	-Implement 1,000 ft of stream restoration within Kuliʻouʻou Stream. - Redirect the hardened outfall at the mouth of Kuliʻouʻou Stream into Paikō lagoon. *Catalyst Project Alignment:* Stream restoration in combination with the flood control structures/RSC system would help to slow, capture, and infiltrate stormwater runoff entering Maunalua Bay.		*Next Steps*: The Hui to work with the City to permit the project and acquire needed funding.	which is still being determined.	
Strategy P: Restoration of Fresh water Spring Flows to Nearshore Coastal Waters	*Project Goal:* Identify areas where hydrologic connections between natural springs and coastal nearshore waters can be restored. *Catalyst Project Alignment:* The lack of fresh water flow to Maunalua Bay is a contributing factor to the Bay's impaired water quality.	Maunalua Fishpond Heritage Center, Livable Hawaiʻi Kai Hui	N/A	N/A	N/A

ii. Catalyst Project #2: Improving Water Efficiency throughout East Honolulu

Key Issue: Given the limited availability of ground water supply in East Honolulu aquifers, the district's dependence on transfers from the Honolulu and Windward water systems for 80% of its demand, shifting rainfall trends, increasing heat, and the potential of climate change reducing aquifer yields 26% by the end of the century, it is imperative that East Honolulu become as water efficient as possible or risk potential water shortages. East Honolulu's per capita water demand is currently 17% higher than the island-wide average. This can be attributed to large residential landscaped areas, water features, parks, and a golf course irrigated with potable water. There have been some attempts to explore alternatives to potable water for irrigation, particularly for the golf course. However, brackish ground water wells near the coast were found to be too salty to be used for irrigation, especially in the eastern end of the district. While reuse of the Hawaii Kai WWTP effluent is technically possible, the effluent requires costly desalination because of salt water intrusion into the collection system, which is expected to worsen with sea level rise.

The most viable and cost-effective strategy to ensure a sustainable water supply for East Honolulu is through increased water conservation, efficiency measures, and water loss control. This requires all water users including government agencies, commercial businesses, and residents to take action to lower per capita water usage. If climate change leads to substantial decreases in rainfall across Oʻahu resulting in lower aquifer yields, the Honolulu and Windward water systems will be impacted. This would likely reduce available water transfers into East Honolulu, (i.e., if the "Ultimate Dry Scenario" is realized). In that scenario, further action will be needed beyond 2040 to ensure adequate water for East Honolulu in 2100. If the Ultimate Wet Scenario is realized, per capita demand can potentially remain status quo, although more flooding events may occur. More detailed information about East Honolulu's availability of water supply through 2040 and beyond can be found in EHWMP *Chapter 3* and in *Section 5.2*.

Catalyst Project #2 Goals: Two goals have been identified for improving water efficiency throughout East Honolulu. Goal #1 is to maintain per capita water demand of 170 GPCD (through 2040) for BWS water users in East Honolulu through a combination of reducing potable water use, improving efficiency with incentives-based water fixtures, on-site reuse, and sustainability best practices. Goal #1 is based on the analysis provided in *Section 5.2.2*, which estimates that if the "Dry Scenario" is realized, East Honolulu residents will need to lower per capita water usage to 130 GPCD by 2100 to ensure water source adequacy. Goal #2 is to reduce water loss in the BWS water distribution system and on-site private plumbing systems through leak detection, repair, and replacement. Reducing water use and water loss will reduce City water and sewer bills and energy costs from pumping.

- **Goal #1:** Maintain East Honolulu's per capita water demand at 170 GPCD through 2040.
- **Goal #2:** Reduce per capita water demand to 130 GPCD by 2100 in the Ultimate Dry Scenario.

Relevant Projects with Champions: Three of the Projects identified in *Chapter 4*, if successfully implemented, would support the achievement of the Catalyst Project #2 goals. These projects include the

BWS Long Range Water Master Plan and Infrastructure and Renewal Program (Project #27), the BWS Water Conservation Incentives Program (Project #28), and Developing R-1 Recycled Water for Irrigation Users in Hawaiʻi Kai (Project #30). Projects #27 and #28 will be implemented district-wide, while Project #30 will be implemented in Hawaiʻi Kai.

<u>BWS Long Range Water Master Plan and Infrastructure and Renewal Program</u>
The BWS Long Range Water Master Plan is focused on improving the efficiency of BWS' water distribution system. The 2016 WMP defines an island-wide goal for "non-revenue" water, which is the percent of water produced but not sold and therefore not used by metered customers. The goal is for non-revenue water to be less than 8.1%, based on a 2012 American Water Works Association nationwide benchmarking survey of large utilities (see Project #27 in *Chapter 4* for more details).

The BWS Infrastructure and Renewal Program aims to increase island-wide annual pipeline replacement from six miles in 2016 to 21 miles depending on available funding. This will result in fewer water main breaks, with a goal of less than 300 per year. In Fiscal Year 2017, there were 346 main breaks island-wide. Targeting the highest risk pipes, BWS expects to reduce water loss from breaks and leaks. Improving water distribution efficiency can help achieve BWS' non-revenue water goals by "freeing-up" existing water system capacity and deferring major capital improvement funds for source, transmission, and storage projects.

BWS' leak detection team uses satellite leak detection technology to detect 350' radius zones of chlorinated water and sounding equipment called correlators to pinpoint leaks. 700 leaks were detected in 2021. However, there is no proactive leak detection and repair program to incentivize private landowners to detect leaks in private property piping. Reducing private property pipe leaks on the customer side of the water meter will significantly reduce customer water bills and per capita demand.

The BWS Water Conservation Program is focused on reducing water waste by influencing water conservation behaviors through outreach and education and providing tools and incentives to reduce per capita demand across the BWS customer base. Specific programs that have been major contributors to water conservation savings are summarized below.

<u>Public Education and Outreach</u>
The primary objective of public education and outreach is to influence consumer water use habits. A variety of programs target homes, schools and businesses including Public Service Announcements, features in the newspaper, water saving tips, xeriscape demonstrations, detect-a-leak week, imagine a day without water, educational booths, water waste hotline, and a water conservation poster and poetry contest that has been held for more than 40 years.

This program is based on 7 easy tips to conserve water.

- Tip #1 - Water lawns just 1-2 times per week
- Tip #2 – Don't water lawns between 9 AM and 5 PM
- Tip #3 – Check for plumbing leaks
- Tip #4 – Install water-efficient fixtures

- Tip #5 – Take shorter showers
- Tip #6 – Put a nozzle on your garden hose
- Tip #7 – Don't let the faucet run and run

During droughts, BWS reminds the top 100 water users on their system to conserve water and be more efficient in their water use, including City and State agencies charged with managing public parks, schools, golf courses, roadway landscaping, and other governmental facilities.

Water Sensible Conservation Incentives Program

The Water Sensible conservation incentives program was initiated in 2018 and provides prescriptive and custom rebates for residential and commercial uses. It targets residential, commercial, and institutional properties to reduce water consumption and reduce their bills. The incentives offset the capital costs of replacing existing fixtures and equipment to shorten the pay-back period for realizing savings to BWS customers.

Leak Detection, Repair, and Maintenance

Water losses can be separated into two categories: 1) Real losses (i.e., physical losses) include pipe leakage, main breaks, storage leaks, and overflows from water tanks; 2) Apparent losses (i.e., commercial losses) include unauthorized consumptions (thefts) and customer meter inaccuracies/data handling errors. Water loss audits measure water distribution system efficiencies to inform leak detection surveys. The BWS leak detection team locates distribution system leaks and effects repairs to reduce water loss between wells and property meters. If main break density increase, the pipe segment is scheduled for replacement.

The action plan for each of the Projects described above is provided in *Table 5-4*. This table summarizes the goals, catalyst project alignment, project champions, status, estimated project costs, and implementation timing for each of the identified Projects. Further background about these Projects with Champions can be found in *Section 4.3.3.*

Relevant Strategies and Programs: Five of the Strategies and Programs identified in *Chapter 4*, if successfully implemented, would support the achievement of the Catalyst Project #2 goals through measures such as golf course xeriscaping, agricultural water use plans, grey water reuse programs, and others. Further details about these relevant Strategies and Programs are provided in *Table 5-4*. Further details about these Strategies and Programs can be found in *Section 4.3.4.*

Table 5-4: Action Plan for Catalyst Project #2 – Improving Water Efficiency throughout East Honolulu

Project with Champion or Strategy	Goals & Alignment with Improving Water Efficiency throughout East Honolulu	Existing or Potential Champions & Partners	Status	Estimated Project Costs	Target Implementation
ONGOING EFFORTS					
Project #27: BWS Long Range Water Master Plan and Infrastructure Renewal and Replacement Program	*Project Goal:* Annually replace 21 miles of pipeline by 2030. *Catalyst Project Alignment:* By replacing high-risk water pipes, more than 4,000 water main breaks could be avoided by 2045, providing for greater efficiency within BWS' water distribution system.	BWS	This project is an ongoing effort. BWS' goal is to reduce main breaks by replacing 21 miles of pipeline every year for the next 10 years (funding dependent).	Program is funded through BWS' annual Capital Improvements Program (CIP) budget ($80M) and increased water rates (expected to generate additional $60M).	Ongoing Effort
Project #28: BWS Water Conservation Incentives Program	*Project Goal:* Further promote and expand the existing BWS Water Conservation Incentives Program. *Catalyst Project Alignment:* Implementing these conservation programs at larger scale will help incentivize BWS customers to implement water efficiency and conservation measures.	BWS	This project is an ongoing effort. BWS is impacting water conservation behaviors to reduce water waste and provide tools and incentives to reduce water use across the BWS customer base.	Funded through existing BWS programs and initiatives.	Ongoing Effort

Table 5-4: Action Plan for Catalyst Project #2 – Improving Water Efficiency throughout East Honolulu

Project with Champion or Strategy	Goals & Alignment with Improving Water Efficiency throughout East Honolulu	Existing or Potential Champions & Partners	Status	Estimated Project Costs	Target Implementation
SHORT-TERM (2-5 YEARS TARGET IMPLEMENTATION)					
Strategy I: Golf Course Xeriscaping and Water Efficiency Plan	*Project Goal:* Implement xeriscaping (drought-tolerant landscaping technique) at golf courses located in East Honolulu. Xeriscaping to be paired with water-efficient irrigation systems, such as automatic timers and moisture sensors. *Catalyst Project Alignment:* Golf courses are among BWS's highest water users. The Hawaiʻi Kai Golf Course alone has a water demand of 0.284 MGD (based on 2015 data). Xeriscaping is a viable strategy for water conservation at both the Hawaiʻi Kai Golf Course and the Waiʻalae Golf Course.	BWS, Waiʻalae Golf Course, and Hawaiʻi Kai Golf Course	N/A	N/A	N/A
Strategy N: Climate Adaptation Neighborhood Plans	*Project Goal:* East Honolulu communities to develop neighborhood-scale climate change adaptation plans. *Catalyst Project Alignment:* Climate adaptation plans could be one of the many tools use to prepare communities in East Honolulu to the impacts of decreased rainfall and increased drought by promoting water conservation programs.	Sierra Club, OCCSR, ʻĀina Haina Prepared, and Hawaiʻi Kai Strong	N/A	N/A	N/A

Table 5-4: Action Plan for Catalyst Project #2 – Improving Water Efficiency throughout East Honolulu

Project with Champion or Strategy	Goals & Alignment with Improving Water Efficiency throughout East Honolulu	Existing or Potential Champions & Partners	Status	Estimated Project Costs	Target Implementation
Strategy O: Climate Change and Resilience Education	*Project Goal:* Establish an educational program to increase community awareness about climate change impacts to water supply and ecosystems. *Catalyst Project Alignment:* The proposed educational strategy would be used in part to promote water conservation and protection of watersheds.	OCCSR, BWS, Livable Hawaiʻi Kai Hui, Sierra Club	N/A	N/A	N/A
MID-TERM PROJECTS (5-10 YEARS TARGET IMPLEMENTATION)					
Strategy L: Agricultural Water Use Plans	*Project Goal:* Develop individual water use plans to measure how much water farm are using and ways to improve water efficiency. *Catalyst Project Alignment:* Agricultural users have a high-water demand, compared to residential users. Improving water efficiency at agricultural sites is a critical component to reducing East Honolulu's per capita water demand.	BWS, Kamehameha Schools, Aloha ʻĀina O Kamilo Nui, UH CTAHR, local farmers	N/A	N/A	N/A
Strategy M: Grey Water Reuse Plan	*Project Goal:* Incentivize private property owners and government agencies to implement on-site recycling systems to capture and reuse water that could be used for be used for non-potable uses such as flushing toilets, irrigation, or even supplying cooling systems.	DOH, BWS, ENV, Mālama Maunalua, Livable Hawaiʻi Kai Hui, private property owners	N/A	N/A	N/A

Table 5-4: Action Plan for Catalyst Project #2 – Improving Water Efficiency throughout East Honolulu

Project with Champion or Strategy	Goals & Alignment with Improving Water Efficiency throughout East Honolulu	Existing or Potential Champions & Partners	Status	Estimated Project Costs	Target Implementation
	Catalyst Project Alignment: Grey water from sinks, tub and shower drains, and clothes washers are estimated to be 50 to 80 percent of the total residential wastewater generated. Grey water reuse can help to lower per capita water demand by conserving potable water for drinking purposes.				
LONG-RANGE PROJECTS (10-20 YEARS TARGET COMPLETION)					
Project #30: Develop R-1 Recycled Water for Irrigation Users in Hawaiʻi Kai	*Project Goal:* Develop R-1 recycled water to replace potable irrigation of large landscaped areas in Hawaiʻi Kai, such as the Hawaiʻi Kai Golf Course and Sandy Beach Park. *Catalyst Project Alignment:* The East Honolulu WWTP treats approximately 3.6 MGD of effluent. The WWTP is adjacent to the Hawaiʻi Kai Golf Course and Sandy Beach Park, both of which have significant irrigation water demand. Utilizing R-1 recycled water from the WWTP for large landscaped areas in Hawaiʻi Kai could significantly reduce the region's irrigation water demand.	Hawaiʻi American Water Company, Hawaiʻi Kai Golf Course, BWS, DPR Project Goals	*To-Date:* A preliminary R-1 Upgrade Conceptual Plan evaluated the feasibility of converting the WWTP so that it could produce 200,000 GPD of R-1 recycled water. *Next Steps*: Assess options for reducing the WWTP's high chloride content.	The estimated conversion cost is \$2.8M and the monthly operating and maintenance costs is \$36,000 (2016 dollars).	N/A

5.5 IMPLEMENTING ENTITIES AND FUNDING

This section describes entities and funding sources that can support implementation of the EHWMP.

5.5.1 Implementing Entities

The following section discusses the opportunities and challenges regarding the coordination of the entities responsible for the implementation of the projects, programs, and strategies provided in the EHWMP.

5.5.1.1 Entities by Jurisdiction

The public agencies and community non-profits responsible for implementing the individual EHWMP projects, programs, and strategies are identified in Chapter 4. A combined list of implementing entities is provided below, categorized by the entity type and jurisdiction.

Public Agencies (Federal)

- Environmental Protection Agency (EPA)
- Federal Emergency Management Agency (FEMA)
    - National Flood Insurance Program (NFIP)
    - National Oceanic and Atmospheric Agency (NOAA)
- National Science Foundation (NSF)
- U.S. Army Corps of Engineers (USACE)
- U.S. Fish and Wildlife Service (USFWS)
    - Partners for Fish and Wildlife
    - Pacific Islands Coastal Program
- U.S. Geological Survey (USGS)
- U.S. Navy Region Hawaiʻi

Public Agencies (State)

- Board of Land and Natural Resources (BLNR), Department of Agriculture (DOA)
    - Agribusiness Development Corporation (ADC)
- Department of Education (DOE)
- Department of Health (DOH)
    - Environmental Management Division
        - Wastewater Branch
        - Clean Water Branch
        - Safe Drinking Water Branch
- Department of Land and Natural Resources (DLNR)
    - Commission on Water Resource Management (CWRM)
    - Department of Aquatic Resources (DAR)
    - Division of Conservation and Resource Enforcement (DOCARE)
    - Division of Forestry and Wildlife (DOFAW)
    - Engineering Branch

    - State Historic Preservation Division (SHPD)
    - Office of Conservation and Coastal Lands (OCCL)
- Office of Hawaiian Affairs (OHA)
- Office of Planning and Sustainable Development (OPSD)
    - Hawaiʻi Coastal Zone Management Program (OP-CZM)
- University of Hawaiʻi (UH)
    - Water Resources Research Center (WRRC)
    - Hawaiʻi Institute of Marine Biology (HIMB)
    - Sea Grant Program
    - Community Colleges (UHCC)

Public Agencies (City and County of Honolulu)

- Board of Water Supply (BWS)
- Department of Design and Construction (DDC)
- Department of Emergency Management (DEM)
- Department of Environmental Services (ENV)
    - Wastewater Branch
- Department of Facility Maintenance (DFM)
- Department of Planning and Permitting (DPP)
- Department of Parks and Recreation (DPR)
- Department of Transportation Services (DTS)
- Office of Climate Change, Sustainability and Resiliency (OCCSR)

Private Organizations

- Kamehameha Schools (KS)
- Water.App

Non-Profits and Community Organizations

- 808 Cleanups
- Liveable Hawaiʻi Kai Hui (LHKH)
- Koʻolau Mountains Watershed Partnership (KMWP)
- Mālama Maunalua
- Maunalua.Net
- Maunalua Ka Iwi Watershed Hui (MKWH)
- Maunalua Fishpond Heritage Center (MFHC)
- Surfrider Foundation Blue Water Taskforce
- Wastewater Alternatives and Innovations (WAI)

5.5.1.2 Challenges and Barriers

Uncertainties and complexities around watershed management, coupled with the need for improved communication and coordination between government agencies, organizations, and the public are the greatest challenges to overcome in implementing watershed management projects, programs, and strategies. Some illustrative examples of the challenges and barriers include:

- Watershed management projects often cross jurisdictional boundaries, requiring interagency and intergovernmental coordination;
- Government agencies have limited legal and jurisdictional authorities and are often siloed, lacking an effective framework to collaborate with other agencies that have overlapping interests and jurisdictions;
- Climate change projections, policies, and planning frameworks vary at City, State, and Federal levels, resulting in inconsistencies across agencies.
- Lands that require management actions, or would reap the most benefit from such actions, are not under the control of agencies or non-profit organizations that champion resource management or ecosystem restoration projects; and,
- Decision makers and the general public are not adequately aware of the complex interactions between land and water resources and uses, as well as the importance of those resources.

5.5.1.3 Opportunities for Cross-sector Coordination

Complex issues such as watershed management require cross-sector collaboration between Federal, State, and City agencies, as well as private and non-profit organizations. In order to ensure consistency across City agencies, the projects, programs, and strategies identified in this plan should be incorporated into City long-range plans, functional plans, and capital improvement plans. In addition, existing working groups at the City and district level may provide a platform or a model to emulate in furthering the implementation of the EHWMP. These are described below.

City and County of Honolulu One Water Panel: As discussed in *Chapter 4*, the "One Water" framework is an integrated approach to planning for water resources, considering long-term resilience and reliability, as well as community and ecosystem needs. Under the One Water approach, all water, including drinking water, grey water, wastewater, and stormwater, is considered to have value and is managed in a sustainable, inclusive, and integrated way. Institutionalizing this One Water Approach within City (and eventually State) agencies to support climate resilience is included as EHWMP Project #27.

On Oʻahu, a One Water Panel has been established by City ordinance in Chapter 2, ROH, to facilitate cross-agency collaboration in implementing the One Water Approach. Currently, the Panel is comprised of City agencies including OCCSR, DPP, DDC, BWS, DFM, ENV, DPR, DTS, and the City Administration, however the intent is to expand it to involve other stakeholders including State agencies. The Panel's interagency collaboration efforts are focused on climate change adaptation and infrastructure resiliency strategies to address sea level rise exposure, coastal erosion, storm surge, drought, and flooding to vulnerable infrastructure and facilities.

<u>Maunalua Watershed Hui:</u> The Maunalua Watershed Hui is an East Honolulu-based community partnership consisting of nonprofits, landowners, cultural practitioners, citizens, kupuna, and government agencies with an interest in the health of Maunalua Bay and its watersheds. The hui meets quarterly to coordinate efforts between stakeholders, and also produces research and publications such as the 2019 Watershed Hui Priority Projects Report, which proved instrumental to the EHWMP planning process in identifying projects, strategies, and priority watersheds for implementation of Catalyst Project #1. BWS attended and presented on the EHWMP status at several Maunalua Watershed Hui meetings, and as a result gathered significant input on the Plan. Hui members also shared information about the EHWMP and opportunities for public input with their networks. Convening regional stakeholders with common interests through groups such as the Maunalua Watershed Hui facilitates collaboration and sharing of knowledge and resources, builds community capacity to address needs and issues, increases effectiveness of community efforts, and reduces duplication.

Project #20 in the EHWMP recognizes the value of Maunalua Watershed Hui as a platform to improve coordination between the community organizations and public agencies responsible for watershed management in East Honolulu. As EHWMP implementation progresses, BWS and other implementing agencies should keep the hui apprised of agency efforts and stay apprised of local watershed initiatives. This will help break down the barriers between government agencies and community groups who share responsibility to champion and implement watershed projects and programs.

<u>Koʻolau Mountain Watershed Partnership (KWMP)</u>**:** KWMP is a is a voluntary alliance of major public and private landowners, that since 1999 has worked to improve health of the Koʻolau Mountains through watershed fencing, invasive species control, and monitoring of activities in mauka watersheds. Supporting the KWMP in furthering their restoration work in the Upper Niu and Wailupe watersheds is highlighted in EHWMP Project #9. Given the critical role the KWMP plays in forest management, they will likely play a significant role in the various EHWMP projects, strategies, and programs focused on restoration of the upper watersheds.

5.5.2 Potential Funding Sources

Many of the agencies and nonprofits listed under Implementing Entities (see *Section 5.5.1*) have one or more funding programs that could provide funds or resources to support implementation of the EHWMP's projects, programs, and strategies. However, City and State agencies are not solely responsible for implementing the EHWMP. Funding will likely come through a combination of CIP appropriations, grants, fees, dedicated funds, donations from private foundations, and volunteer time/in-kind donations. Three potential funding sources which may be particularly relevant to the EHWMP are discussed below.

Clean Water Act Section 319 Grants: These grants address the need for greater Federal leadership to support State and local efforts to mitigate nonpoint source ground water pollution. Government agency and nonprofit recipients receive grant money to support a wide variety of activities including technical assistance, financial assistance, education, training, technology, demonstration projects, and monitoring to implement projects that mitigate nonpoint-source ground water pollution. The State of Hawaiʻi Polluted Runoff Control Program typically issues a request for proposals (RFP) for the grant on an annual basis. Government agencies are eligible to apply for the grant outside of the RFP period. Examples of watershed improvement projects in Hawaiʻi that have been awarded the Clean Water Act Section 319 Grant include:

- Watershed Implementation Project for the Ahupuaʻa of Waipā
- Expanding Water Quality Improvement Projects at Heʻeia Fishpond
- Waikele Watershed and Total Maximum Daily Load Implementation Plan
- Operations and Maintenance Plan for Hakioawa Watershed, Kahoʻolawe Island

National Fish and Wildlife Foundation (NFWF): NFWF supports more than 70 grant programs to restore the nation's wildlife and habitats. In particular, the America the Beautiful Grant Challenge is intended to provide funding opportunities for advancing conservation and restoration projects that focus on conserving and restoring rivers, coasts, wetlands, and watersheds.

NFWF's Coral Reefs Grant Program works to support reef resiliency by reducing impacts from unsustainable fishing and land-based pollution. Grants have assisted broad-scale coral reef management by establishing new techniques for assessing and monitoring reef health and new fishery management models. Site-specific initiatives have developed and implemented watershed management plans, reduced sediment erosion through stream bank stabilization, provided incentives or best management practices on agricultural lands, and supported capacity-building of management and conservation organizations to sustain outcomes.

Examples of watershed improvement projects in Hawaiʻi that have been awarded the funding from NFWF include:

- Pelekane Bay Watershed Restoration and Recovery
- Expanding Stream Gulch Restoration Actions to Improve Coral Reef Health in Wahikuli
- Implementing a Storm water Management Plan in the Pōhākea Watershed
- Evaluating Watersheds for Regional Decision Making in North Kīhei, US Geological Survey
- Reducing Land-based Sources of Pollution at Three Priority Sites in Maui Nui

***Stormwater Utility Oʻahu (Forthcoming Funding Opportunity)*:** The City and County of Honolulu is in the process of developing a stormwater utility, which would impose fees for impervious area and further incentivize the use of green infrastructure and LID. While the fee structure of the utility is still being considered, it may be based on the percentage of impervious surface on a property. The fee will likely be applied to all property owners, unless specifically exempt. By law, City agencies will also have to pay into the utility. The Stormwater Utility is included as Project #18 in the EHWMP.

Once established, the Stormwater Utility will provide funds for maintenance and replacement of the City's stormwater drainage system. The Stormwater Utility could also support community projects that mitigate stormwater runoff and improve water quality. More information on the background, benefits, and potential financial uses of the forthcoming Stormwater Utility is provided in *Chapter 4*.

State of Hawaiʻi DOH Drinking Water State Revolving Fund: The program was established by the 1997 State Legislature as the result of the 1996 Federal amendments to the Safe Drinking Water Act. The program provides low interest loans to regulated water system operators in Hawaiʻi. The loans can be used for infrastructure construction and improvement projects, such as replacing water pipelines. The main goal of the program is to achieve or maintain compliance with drinking water standards, and protect public health and the environment. Active BWS projects funded by the program include the Kalihi Pump Station Renovation; Diamond Head Line Booster; Punaluʻu Wells II Renovation; Lunalilo Home Road Water System Improvements; Anoi Road Water System Improvements; and others.

CHAPTER 5 REFERENCES

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AP APPENDICES

APPENDIX A: RELEVANT POLICIES FROM CITY AND COUNTY LAND USE PLANS

Oʻahu General Plan (DPP, Adopted July, 2022)

I. Population

Objective A: To plan for anticipated population growth in a manner that acknowledges the limits of Oʻahu's natural resources, that protects the environment, and that minimizes social, cultural, and economic disruptions.

Objective B: To establish a pattern of population distribution that will allow the people of Oʻahu to live, work, and play in harmony.

Policy 3: Manage land use and development in the urban-fringe and rural areas so that:

a. Development is contained within growth boundaries; and
b. Population densities in all areas remain consistent with the character and the culture and environmental qualities desired for each community.

Appendix Table A: Distribution of 2040 Oʻahu Population by Planning District

Location	% Distribution of 2040 Oʻahu Population
Policy 1 Area	
Primary Urban Center	43%
Policy 2 Areas	
ʻEwa	16%
Central Oʻahu	18%
Policy 3 Areas	
East Honolulu	5%
Koʻolau Poko	10%
Koʻolau Loa	1%
North Shore	2%
Waiʻanae	5%

Policy 4: Direct growth according to Policies 1, 2, and 3 above by providing development capacity and needed infrastructure to support distribution of Oʻahu's resident population that is consistent with *Appendix Table A.*

II. Economy

Objective B: To maintain a successful visitor industry that creates meaningful employment, enhances quality of life, and celebrates our unique sense of place, natural beauty, Native Hawaiian culture, and multi-cultural heritage.

Policy 5: Provide related public expenditures for rural and urban fringe areas that are highly impacted by the visitor industry.

Policy 9: Preserve the well-known and widely publicized scenic qualities of Oʻahu for residents and visitors alike.

Policy 11: Consider small-scale community-oriented visitor accommodations in non-resort areas with attention to community-input, compatibility of uses, infrastructure adequacy, and the ability to enforce effectively.

Objective C: To ensure the long-term viability and continues productivity of agriculture on Oʻahu.

Policy 9: Prohibit the urbanization of agricultural land located outside the City's growth boundaries,

Policy 10: Support and encourage technologies and agricultural practices that conserve and protect water, soil, air quality, and drainage areas, and that promote public health and safety.

Policy 11: Support and encourage the availability and use of non-potable water for irrigation, where feasible.

Policy 12: Encourage both public and private investments to improve and expand agricultural infrastructure, such as irrigations systems, agricultural processing centers, and distribution networks.

Objective D: To use the economic resources of the sea in a sustainable manner.

Policy 1: Encourage the fishing industry to maintain its viability at a level that does not degrade or damage marine ecosystems.

Policy 2: Encourage the ongoing development of aquaculture, ocean research, and other ocean related industries.

Policy 3: Encourage the expansion of ocean recreation activities for residents and visitors in a sustainable manner.

III. Natural Environment and Resource Stewardship

Objective A: To protect and preserve the natural environment.

Policy 1: Protect Oahu's natural environment, especially the shoreline, valleys, ridges and watershed, from incompatible development.

Policy 2: Seek the restoration of environmentally damaged areas and natural areas.

Policy 3: Protect, restore, and enhance stream flows and stream habitats to support aquatic and environmental processes and riparian, scenic, recreational, and Native Hawaiian cultural resources.

Policy 4: Require development projects to give due consideration to natural features and hazards such as slope, inland and coastal erosion and flood hazards water recharge areas, and existing vegetation, as well as to plan for coastal hazards that threaten life and property.

Policy 5: Require sufficient setbacks from Oʻahu shorelines to minimize threats to life and property and to minimize the future need for protective structures or relocation of structures.

Policy 6: Design and maintain surface drainage and flood-control systems in a manner which will help preserve natural and cultural resources.

Policy 7: Protect the natural environment from damaging levels of air, water, and noise pollution.

Policy 8: Protect plants, birds, and other animals that are unique to the State of Hawaiʻi and Oʻahu, and protect their habitats.

Policy 10: Increase public awareness, appreciation, and protection of Oʻahu's land, air, and water resources.

Policy 12: Plan and prepare for the impacts of climate change on the natural environment, including strategies and adaptation.

Objective B: To preserve and enhance natural landmarks and scenic views of Oʻahu for the benefit of both residents and visitors as well as future generations.

Policy 1: Protect the Island's significant natural resources: its mountains and craters; forests and watershed areas; marshes, rivers, and streams; shorelines, fishponds, and bays; and reefs and offshore islands.

IV. Housing

Objective C: To provide residents with a choice of living environments which are reasonably close to employment, recreation, and commercial centers and which are adequately served by transportation networks and public utilities.

Policy 4: Encourage that residential development in suburban areas where existing roads, utilities, and other community facilities are not being used to capacity, and in urban areas where higher densities can be readily accommodated.

Policy 6: Discourage residential development in areas where the topography makes construction difficult or hazardous and where providing and maintaining roads, utilities, and other facilities would be extremely costly or environmentally damaging.

V. Transportation and Utilities

Objective B: Provide an adequate supply of water and environmentally sound systems of waste disposal for O'ahu's existing population and for future generations, and support a one water approach that uses and manages freshwater, wastewater, and stormwater resources in an integrated manner.

Policy 1: Develop and maintain and adequate, safe and reliable supply of water in a cost-effective way that supports the long-term sustainability of the resource.

Policy 2: Help to develop and maintain an adequate, safe, and reliable supply of water for agricultural and industrial needs in a cost-effective way that supports the long-term health of the resource and considers the impacts of climate change, including possible decreases in water supply due to drought.

Policy 3: Use new technologies which will ensure that water and waste disposal services are provided at reasonable cost.

Policy 4: Encourage the increased availability and use of recycled or brackish water to meet non-potable demands.

Policy 5: Pursue strategies to reduce the per capita consumption of water and the per capita production of waste.

Policy 7: Pursue programs to expand recycling and resource recovery from Oahu's solid-waste and wastewater streams.

Policy 8: Support initiatives that educate the community about the importance of conserving resources and reducing waste streams through reduction, reuse, and recycling.

VII. Physical Development and Urban Design

Objective A: To coordinate changes in the physical environment of O'ahu to ensure that all new developments are timely, well-designed, and appropriate for the areas in which they will be located.

Policy 2: Coordinate the location and timing of new development with the availability of adequate water supply, sewage treatment, drainage, transportation, and other public facilities and services.

Policy 11: Implementing siting and design solutions that seek to reduce exposure to natural hazards, including those related to climate change and sea level rise.

Objective B: To plan and prepare for the long-term impacts of climate change.

Policy 1: Integrate climate change adaptation into the planning, design, and construction of all significant improvements to the development of the built environment.

Policy 3: Prepare for the anticipated impacts of sea level rise on existing communities and facilities through remediation, adaptation, and other measures.

Objective E: To maintain those development characteristics in the urban-fringe and rural areas which make them desirable places to live.

Policy 1: Develop and maintain urban-fringe as predominantly residential areas characterized by generally low-rise, lower-density development which may include significant levels of retail and service commercial uses as well as satellite institutions and public uses geared to serving the needs of households.

VIII. Public Safety and Community Resilience

Objective B: To protect residents and visitors and their property against natural disasters and other emergencies, traffic, and fire hazards, and unsafe conditions.

Policy 2: Require all developments in areas subject to floods and tsunamis, and coastal erosion to be located and constructed in a manner that will not create any health or safety hazards or cause harm to natural and public resources.

Policy 3: Participate with State and Federal agencies in the funding and construction of flood-control projects, and prioritize the use of ecologically sensitive flood-control strategies when feasible.

Policy 8: Foster disaster-ready communities and households through implementation of resilience and hubs and other resiliency strategies.

Policy 9: Plan for the impacts of climate change and sea level rise on public safety, in order to minimize potential future hazards.

IX. Health and Education

Objective A: To protect the health and well-being of residents and visitors.

Policy 3: Coordinate City and County health codes and other regulations with State and Federal health codes to facilitate the enforcement of air-, water-, and noise-pollution controls.

X. Culture and Recreation

Objective B: To protect, preserve and enhance Oahu’s cultural, historic, architectural, and archaeological resources.

Policy 7: Encourage the protection of areas that are historically important to Native Hawaiian cultural practices and to the cultural practices of other ethnicities, in order to further preserve and continue these practices for future generations.

Objective D: To provide a wide range of recreational facilities and services that are readily available to residents and visitors alike, and to balance access to natural areas with the protection of those areas.

Policy 5: Encourage the State to develop, improve and maintain a system of natural resource-based parks, such as beach, shoreline, and mountain parks.

Policy 8: Encourage ocean and water-oriented recreation activities that do not adversely impact the natural environment and cultural assets, or result in overcrowding or overuse of beaches, shoreline areas and the ocean.

East Honolulu Sustainable Communities Plan (DPP, 2021)

East Honolulu's Role in Oahu's Development Pattern:

- Limit the potential for substantial new housing in the region so that significant residential growth is directed instead to the Primary Urban Center, ʻEwa, and Central Oʻahu Development Plan Areas.
- Revitalize existing commercial centers while limiting the expansion of commercial and other economic activities in the region to promote the development and growth of employment in the Primary Urban Center, Central Oʻahu, and ʻEwa while reorienting existing commercial centers to better serve their neighborhood community needs;
- Maintain the region's predominantly low-rise, low-density form of residential development.
- Redesign and repurpose infrastructure and programs to become a more age-friendly community with a focus on complete streets.
- Avoid flood damage, slippage and other problems associated with development of steep slopes and sites with expansive soils.
- Create resilient, disaster-ready communities that are strategically and physically prepared for disasters and environmental stressors:
  - Improve evacuation area designations and procedures;
  - Increase cooperation with neighborhood emergency preparedness groups;
  - Create a City-community liaison to leverage non-profit and volunteer assets;
  - Seek to harden emergency shelters to be capable to minimally withstand winds from a Category 3 hurricane.
- Address, minimize risks from, and adapt to the impacts of climate change and sea level rise:
  - Integrate climate change adaptation into the planning, design, and construction, of all significant improvements to and development of the built environment; and
  - Prepare for the anticipated impacts of sea level rise on existing communities and facilities through remediation, adaptation, and other measures.
- Utilize the design capacity of Kalanianaʻole Highway, the region's key component of transportation, as a means to manage urban growth.

- Preserve scenic views of ridges, upper valley slopes, shoreline areas from Kalanianaʻole Highway and from popular hiking trails, and along the Ka Iwi Scenic Shoreline.
- Promote access to mountain and shoreline resources for recreational purposes and traditional hunting, fishing, gathering, religious, and cultural practices.
- Adopt and implement the ahupuaʻa concept to improve downstream water quality through improved upland management and the implementation of LID standards when properties or infrastructure are redeveloped.

Key Elements of the Vision:

- Community Growth Boundary, and Agriculture and Preservation Lands;
- Adoption of the Concept of the Ahupuaʻa in Land Use and Natural Resource Management;
- Ka Iwi Scenic Shoreline;
- Ridge-and-valley Neighborhoods;
- Mauka-Makai recreational access;
- Protection and preservation of natural areas;
- Housing stability and Age-Friendly Communities;
- Commercial Centers Refocused; and
- Climate Change Adaptation.

3.1 Open Space Preservation and Development

General Policies:

- Provide and maintain recreational access to shoreline and mountain areas;
- Provide and maintain fire safety buffers where developed areas border "wildlands" either in preservation areas within the Community Growth Boundary or in the State Conservation District;
- Create a linear system of landscaped pathways and bikeways along roadways and drainage channels to visually enhance the different communities, create more complete streets, and assist with stormwater retention; and
- Prevent development of areas susceptible to natural hazards such as soil movement, rock falls, coastal erosion, and sea level rise.

Planning Guidelines:

3.1.2.1 Mountain Areas

- **Access** – Make access to mountain areas (including provision of parking areas) readily available for passive uses and resource gathering, in accordance with HRS 115, 171, and 264.
- **Access Easements –** Acquire and maintain public access easements, or encourage the transfer of easements to the State or NGOs that preserve access to open space areas.
- **Parking –** Provide public parking for trail users near the trailhead.
- **Native Forests –** Maintain, protect, and/or restore upland native forests in the State Conservation District.
- **Impact –** Avoid disturbances caused by utility corridors and other uses on areas with high concentrations of native species.
- **Habitat –** Identify and protect endangered species habitats and other important ecological zones from threats such as fire, alien species, feral animals, and human activity.

- **Alien Species –** Control the number and range of feral animals and other alien species which could lead to the destruction of habitats of native or endangered species and erosion.
- **Resource Management –** Create a City Resource Management Program to address the demands from outdoor recreational activities and the associated stresses to the natural and built environment.
- **More Trails –** Balance trail demands across East Honolulu and alleviate congestion through the opening and sanctioning of additional trails, particularly in Mariners Ridge, Niu Valley, and Kamilo Nui Valley.

3.1.2.2 Shoreline Areas

- **Makai Views –** Maintain makai view channels along Kalanianaʻole Highway between Waiʻalae and Koko Head. Avoid obstructions such as walls and landscaping, designed to screen out traffic noise.
- **Natural Landscape –** Maintain the natural landscape quality of the Ka Iwi Scenic Shoreline viewshed as a high priority. Any modification to this shoreline area will be done in a manner that preserves the aesthetic values of the undeveloped xerophytic landscape (plants adapted to a dry environment).
- **Ka Iwi Scenic Shoreline –** Protect and preserve the long-term recreational and scenic value of the shoreline between Koko Head and Makapuʻu Head through the maintenance of the Ka Iwi Scenic Shoreline park.
- **Lateral Access –** Improve, protect, and maintain lateral shoreline access along reaches of the beach from Maunalua Bay to Waiʻalae Beach Park where feasible.
- **Shoreline Access –** Pursue opportunities to secure additional pedestrian rights-of-way from the nearest street or highway to the shoreline in sections that have high recreational value, but no similar public access within at least a quarter of a mile.
- **Feedback –** Encourage citizen reporting of shoreline access issues to the DLNR Office of Conservation and Coastal Lands.
- **Vegetation –** Encourage landowners along the shoreline to maintain vegetation so as to not encroach into the public right-of-way, particularly as the shoreline erodes pushing the right-of-way inland.
- **Sea Level Rise Impact on Lateral Access –** Include sea level rise and shoreline erosion projections when establishing protections for lateral shoreline access.
- **Codify Access –** Recognize and codify mauka-makai shoreline access into the Revised Ordinances of Honolulu (ROH).
- **Setbacks –** Increase minimum setbacks for structures near the shoreline and implement other management strategies to protect unstable sandy beach areas to account for anticipated impacts from climate change and coastal erosion. Revise and amend shoreline rules and regulations to incorporate seal lever rise into the determination of shoreline setbacks and Special Management Area (SMA) considerations.
- **Armoring –** Conserve and enhance a natural, dynamic shoreline wherever possible. Permitting permanent shoreline armoring is discouraged and should only be considered as a last resort

where it supports significant public benefits and will result in insignificant negative impacts to coastal resources and natural shoreline processes.

- **Protect Infrastructure –** Identify critical public and private infrastructure subject to sea level rise exposure and to mitigate these impacts through elevation, relocation, or other adaptation measures.
- **Sea Level Rise Impact on New Projects –** Analyze the potential impact of sea level rise for new public and private projects in shoreline areas. If it is likely that sea level rise will increase the risk of flooding during the lifespan of the project, incorporate, where appropriate and feasible, measures to reduce risks and increase resiliency to impacts of sea level rise.
- **Current Information –** Use the most current versions of the City Climate Change Commission's **Sea Level Rise Guidance**, **Climate Change Brief**, and the State of Hawaiʻi **Sea Level Rise Vulnerability and Adaptation Report** and associated Viewer for managing assets, reviewing permitting requests, and assessing project proposals.
- **Building Codes –** Work cooperatively to develop design and construction standards that mitigate and adapt to the impacts of climate change and sea level rise.
- **Hazard Assessment –** Incorporate assessments of all hazards into the land development application process.
- **Redevelopment District –** Consider forming a community-based redevelopment district, similar to a business improvement district, that would protect, adapt, and relocate residential and commercial structures, public facilities, and natural and cultural resources vulnerable to sea level rise impacts, including coastal flooding, inundation, and erosion.
- **"Build Back Better and Smarter" –** Map repetitive loss areas and develop and implement a "build back better and smarter" strategy to mitigate future damage costs.
- **Disaster Plans –** Develop short- and long-term resiliency and recovery plans to:
    - Develop a network of Community Resilience Hubs;
    - Designate evacuation routes;
    - Increase coordination with neighborhood emergency preparedness groups and create a liaison between City agencies and NGOs;
    - Encourage residents to have their own emergency supplies and be knowledgeable about what they will do in the event of a disaster;
    - Expedite the recovery of East Honolulu; and
    - Outline the vision and methods for how East Honolulu can "build back better and smarter" following disasters.

3.1.2.3 Agricultural Areas

- **Accessory Uses –** Design and locate buildings and other facilities that are accessory to an agricultural operation in a way that minimizes the impact on nearby urban areas and the street system.
- **Existing Uses –** Encourage continued use of small lots for agricultural uses, and promote compatibility of nearby residential areas with those uses. Maintain the existing buffer between agricultural lands and residential development.

- **Kamilo Nui Valley –** Designate undeveloped areas in Kamilo Nui Valley which are on the ewa side of the existing farm lots for agricultural use.

3.1.2.4 Runoff, Natural Gulches, and Drainage Corridors

- **Drainage Ways –** Preserve and restore the aesthetic values and biological functions of significant streams, wetlands, natural gulches and other drainage ways by requiring setbacks as part of the open space system. These include:
    - Perennial streams identified in the Hawaiʻi Stream Assessment prepared by the State Commission on Water Resource Management;
    - Wetlands identified by the Army Corps of Engineers and/or identified on the Fish and Wildlife Service's National Wetland
    - Inventory maps;
    - Other drainage ways identified by the Department of Design and Construction or the Department of Planning and Permitting; and
    - For other streams, including intermittent streams, require applicant for development show that the open space system will not be significantly impacted and that biological values will not be significantly disturbed if setbacks are not provided.
- **Low Impact Development –** Implement low impact development standards and other green infrastructure to restore ecological function to the area, particularly along and adjacent to stream channels, and reduce the amount of stormwater, sediment, and toxic pollutant runoff entering Maunalua Bay.
- **Green Incentives –** Provide incentives for owners of existing homes, particularly those adjacent to drainage ways, to develop rain gardens, permeable driveways, and other strategies that hold stormwater on-site instead of discharging it into storm drains or streams.
- **Preservation –** Preserve the remaining natural gulches within the Community Growth Boundary that are necessary to provide flood protection in a way which protects aesthetic values and biological functions and avoids degradation of stream, coastline and near shore water quality.
- **Remediation –** Clean up contaminated areas that pose hazards to soil and downstream water quality, particularly any properties adjacent or directly upland of a stream channel.
- **Recreation Corridors –** Incorporate landscaped pathways and bikeways adjacent to stream channels and drainage corridors, where appropriate and feasible.
- **Retention –** Retain stormwater, sediment, and toxic pollutant runoff through the installation of linear landscaping features and permeable pavement along roadways, particularly Kalanianaʻole Highway, which should be used to visually enhance the different communities.
- **Preservation Lands –** Use preservation lands located within the Community Growth Boundary to prevent further degradation of nearshore water quality.
- **Natural Improvements –** Identify potential natural improvements to park and preservation lands within the Community Growth Boundary to improve its ecological function and retain an open, undeveloped character, particularly on lands near Hawaiʻi Kai Marina and Maunalua Bay, including along Keāhole Street.

3.1.2.5 Natural Resources and Preserves

- **Encroachment –** Avoid encroachment or intensification of residential or other urban uses near preservation lands.
  - Prohibit the reduction in preservation zoning in the vicinity of the Paikō Lagoon or intensification of residential use in this zone.
  - Designate any property with an existing residential use for low-density residential use and to an appropriate residential zone.
- **Management –** Implement management programs in areas where intense human activity threatens the sustainability of the resources. This could include, for example, impact monitoring studies, limits on the number of visitors, and admission fees such as at Hanauma Bay.
- Biological Study – Conduct a biological study to determine if Rim Island 2 is eligible for declaration as a recognized endangered species habitat.

3.1.2.6 Marina

- **Screening –** Install and maintain landscaping, where appropriate, to screen areas of the marina not intended for public views and to intercept stormwater, sediment, and toxic pollutant runoff.
- **Best Management Practices –** Utilize BMPs for marina uses to mitigate degradation of water quality to both the marina and Maunalua Bay.

3.2 Island-Based Parks and Recreational Areas

General Policies:

- Increase the inventory of island-based parks, where feasible and supportive of open space general policies and guidelines, by expanding the boundaries of existing parks and/or creating new parks.
- Maintain and enhance, to the extent possible, existing island-based parks by utilizing land area that has not been fully developed for recreation use.
- Expand access to existing park lands by improving neighborhood linkages along shared paths for people walking and biking, and blending park boundaries through the transition of park space to adjacent paths or greenways.
- Preserve the Ka Iwi Scenic Shoreline as one of Oʻahu's last undeveloped, rugged coastlines.
- Prohibit alterations to the shoreline to avoid disrupting natural processes and the potentially adverse impacts armoring has on adjacent areas.

Planning Guidelines:

3.2.3.1 Passive or Nature Parks

- **Ka Iwi and Koko Crater –** Preserve and enhance the Ka Iwi Scenic Shoreline's coastal-oriented recreational and educational resources by implementing, when funding is available, the following:
  - Maintain and facilitate access to the important fishing resources.
  - Develop new walking/hiking trails within Koko Crater Botanical Garden for better viewing of plant collections.
  - Prohibit access to any trails or paths outside Koko Crater Botanical Garden from within the garden.
  - Protect the fragile topography of Koko Crater by restricting recreational uses such as horseback riding to areas apart from the conservation plant collections.

  - Continue to develop Koko Crater Botanical Garden as a conservation site of global importance for rare and endangered species from Hawaiʻi and other tropical dryland areas.
  - Maintain Koko Crater Botanical Garden with drought-tolerant plant species.
  - Minimize adverse lighting impacts on aquatic life and avifauna, as well as adverse aesthetic impacts, particularly from stationary point lookouts and along significant viewplanes.
- **Preservation and Recreation –** Maintain the Ka Iwi Scenic Shoreline in a manner that preserves the area's natural scenic quality and provides educational and passive recreation opportunities.
- **Management –** Protect fragile natural resources, such as the wildlife at Hanauma Bay Nature Park, from overuse through continued management and control of visitor numbers and impacts.

3.2.3.2 Active Recreation Areas

- **Acquisition –** Expand the Koko Head Regional Park boundary to include Golf Course 5 and 6 properties, thereby increasing East Honolulu's active recreation areas.
- **Lighting –** Reduce light pollution's adverse impact on wildlife and human health, and its unnecessary consumption of energy by using, where sensible, fully shielded lighting fixtures using lower wattage.

3.2.3.3 Golf Courses

- **Retention –** Optimize the function of golf courses as passive drainageways, maximizing their potential to retain or detain stormwater runoff.
- **Irrigation –** Use of non-potable water for irrigation of large landscaped areas in accordance with the BWS Rules and Regulations. If non-potable water is either unavailable or infeasible, a report of the investigation should be coordinated and submitted to the BWS prior to considering the use of potable water.

3.3 Community-Based Parks

General Policies:

- Provide adequate parks to meet residents' recreational needs.
- Observe the DPR standard for community-based parks of a minimum of two acres of community-based parks per 1,000 residents, with one acre for district parks and a total of one acre for community parks, neighborhood parks, and mini-parks.
- Expand active recreational facilities at Koko Head District Park by incorporating and developing the adjacent Job Corps Center site.
- Modify recreational facilities in existing parks and increase access to public school facilities in areas where there is limited opportunity to expand park space to respond to changing demographic profiles or recreational needs.
- Expand access to existing park lands by improving neighborhood linkage for non-motorized transportation modes and disguising park boundaries through the transition of park space to paths or greenways.

- Continue efforts to co-locate Neighborhood or Community Parks with elementary or intermediate schools and coordinate the design of facilities when efficiencies in the development and use of athletic, recreation, meeting, and parking facilities can be achieved.

Planning Guidelines:

- **Connectivity –** Provide and improve linkages with bikeways and walking paths off-site with the redevelopment of existing parks.
- **Residents' Needs –** Modify community-based parks in areas where recreational needs of residents are not being adequately met.

3.4 Historic and Cultural Resources

General Policies:

- Emphasize physical references to East Honolulu's history and cultural roots.
- Protect existing visual landmarks and support the creation of new, culturally appropriate landmarks.
- Preserve significant historic features from earlier periods.
- Retain, whenever possible, significant vistas associated with archaeological features.

Planning Guidelines:

- **Preservation and Protection –** Determine the appropriate preservation methods on a site-by-site basis in consultation with the State Historic Preservation Officer.
    - Require preservation in-situ only for those features that the State Historic Preservation Officer has recommended such treatment.
    - Recommend in-situ preservation and appropriate protection measures for sites that have high preservation value because of their good condition or unique features.
- **Compatible Setting –** Determine the appropriate treatment for a historic site by the particular qualities of the site and its relationship to its physical surroundings in consultation with the State Historic Preservation Officer. The context of a historic site is usually a significant part of its value and care should be taken in the planning and design of adjacent uses to avoid conflicts or abrupt contrasts that detract from or destroy the physical integrity and historic or cultural value of the site. Include sight lines that are significant to the original purpose and value of the site in criteria for adjacent use restrictions.
- **Accessibility –** Determine the degree of access that would best promote the preservation of the historic, cultural and educational value of the site in consultation with the State Historic Preservation Officer, Hawaiian cultural organizations, and the landowner, recognizing that economic use is sometimes the only feasible way to preserve a site. Public access to a historic site can take many forms, from direct physical contact and use to limited visual contact. In some cases, however, it may be highly advisable to restrict access to sites to protect their physical integrity or sacred value.

3.5 Residential Use

<u>*General Policies:*</u>

- Modify residential neighborhood street design, where appropriate and feasible, to provide greater emphasis on safe, accessible, convenient and comfortable pedestrian routes, bus stops, bike routes, and landscaping, even if this requires somewhat slower travel speeds, less direct routes and fewer on-street parking spaces for automobiles. Revision of City street standards, subdivision regulations, and use of traffic calming measures may be required in order to support these policies and the policies identified in the *Complete Streets Design Manual* (2016).
- Suggest the formation a community-based redevelopment district that would protect, adapt, and relocate residential and commercial structures, public facilities, and natural and cultural resources vulnerable to sea level rise impacts,including coastal flooding, inundation, and erosion.
- Adopt maps and regulations to incorporate the guidance from the City Climate Commission and *Hawaiʻi Sea Level Rise Vulnerability and Adaptation Report* on vulnerability to coastal erosion and flooding and other science based projections of climate change impacts into land use regulations and permit processes.
- Encourage new structures to be designed to withstand the anticipated impacts of sea level rise over the building's lifespan.

<u>*Planning Guidelines:*</u>

- **Low Impact Development and Stormwater Retention –** Follow low impact development standards as properties are redeveloped to encourage the capture of stormwater, sediment, and toxic pollutant runoff on-site and reduce pollutant loads into downstream water bodies. Provide incentives for owners of existing homes to develop rain gardens, permeable driveways, and other strategies that hold stormwater on-site instead of discharging it into storm drains or streams.

3.6 Non-Residential Use

<u>*General Policies:*</u>

- **Sea Level Rise –** Protect, adapt, or relocate commercial structures, public facilities, and natural and cultural resources vulnerable to sea level rise impacts, including coastal flooding, inundation, and erosion as feasible.

<u>*Planning Guidelines:*</u>

- **Appropriate Scale and Architectural Style –** Maintain consistency between the building mass of a commercial center and its urban and natural setting.
  - Provide a landscaped screen of trees and hedges for parking areas in setbacks with shade trees throughout the parking lot for aesthetics and stormwater retention.
- **Environmental Compatibility –** Encourage energy-efficiency features, such as the use of solar panels for generating electricity and heating water, and passive solar design, such as the use of window recesses and overhangs and orientation of openings to allow natural cross-ventilation.
  - Incorporate resource conservation measures, such as water constrictors and facilities for the sorting of waste materials for recycling, in the design of new development.

- Require the use of low impact development standards for an significant new construction or redevelopment in order to hold stormwater on-site instead of discharging it into storm drains or stream channels.
- Provide incentives for owners to develop rain gardens, permeable parking lots and driveways, and other strategies that hold stormwater on-site instead of discharging it into storm drains or streams.

4.1 Transportation Systems

Planning Guidelines:

- **Streetscape** – Roadway design should be altered to encourage greater bicycle and pedestrian use and support users of all ages.
  - Include more landscaping along roadways to improve aesthetics, to manage stormwater, sediment, and toxic pollutant runoff, and to filter oils and sediment from the roadway improving downstream water quality.

4.2 Water Allocation and Systems Development

General Policies

- Integrate management of all potable and non-potable water sources, including groundwater, stream water, stormwater, and effluent, following State and City legislative mandates.
- Adopt and implement water conservation and stormwater management practices, in the design of redevelopment projects and the modification of existing uses, including landscaped areas.

Planning Guidelines:

- **Development and Allocation of Potable Water –** BWS will coordinate development of potable water sources and allocation of all potable water intended for urban use on Oʻahu.
- **Certification of Capacity –** BWS will certify that adequate potable and non-potable water is available in order for a new residential or commercial development to be approved.
- **Water Conservation Measures –** Conserve potable water by implementing the following measures, as feasible and appropriate:
  - Encourage the use of low-flush toilets, flow constrictors, and other water-conserving devices in commercial and residential redevelopments.
  - Encourage the use of indigenous, drought-tolerant plants and drip irrigation systems in landscaped areas and promote stormwater retention and infiltration on-site.
  - Encourage timely leak repair for distribution systems.
  - Encourage the use of tertiary-treated recycled water for the irrigation of golf courses and other landscaped areas where this would not adversely affect potable groundwater supply.
  - Require the use of low impact development standards for any significant new construction or redevelopment in order to hold stormwater on-site instead of discharging it into storm drains or stream channels.

    - Provide incentives for owners of existing homes to develop rain gardens, permeable driveways, and other strategies that hold stormwater on-site instead of discharging it into storm drains or streams.

4.3 Wastewater Treatment

General Policies

- Connect all wastewater produced by urban uses in East Honolulu to a publicly regulated or municipal sewer service system.
- Implement, where feasible, water recycling as a water conservation measure.
- Connect homes to one of the two existing sewer systems. Support conversion efforts and upgrades to individual wastewater systems where connections are not feasible.

Planning Guidelines:

- **Water Recycling –** Encourage or require, as feasible and appropriate, the use of recycled water from the East Honolulu WWTP as a source for irrigating golf courses and other uses compatible with the Board of Water Supply's rules and guidelines for the treatment and use of recycled water.
- **Private Operation of the East Honolulu WWTP –** Unless there is a compelling reason and a mutually satisfactory agreement between the City and the private operator to incorporate this treatment plant within the municipal wastewater treatment system, keep the East Honolulu WWTP under private operation and under the regulatory supervision of the State Public Utilities Commission and the State Department of Health.
- **Water Quality –** Reduce groundwater contamination that may be exacerbated by climate change and sea level rise through cesspool conversion and wastewater system improvements in East Honolulu.

4.6 Drainage Systems

General Policies

- Complete the proposed study of local flooding and drainage problems as soon as possible.
- Include a phased plan and implementation program for drainage system improvements.
- Promote drainage system design that emphasizes control and minimization of non-point source pollution.
- Keep drainage ways clear of debris to avoid the flooding problems that have occurred in the past.
- Join with Federal, State, and City agencies and local landowners and stakeholder organizations to create a Watershed Partnership to effectively manage the East Honolulu ahupuaʻa to retain stormwater and keep sediment and pollutants from entering streams and being transported to the ocean.
- Improve downstream water quality, particularly in sources leading to Maunalua Bay, through the restoration of channelized streams and wetlands, the installation of upland detention basins, implementation of low impact development standards, and the encouragement of planting and maintenance of vegetation along drainage ways. Where possible, drainage ways should also provide passive recreation benefits
- Identify repetitive loss areas from flooding and implement greater restrictions to rebuilding in these areas.

Planning Guidelines

- **Debris Basins –** Conduct maintenance of large-capacity boulder and debris basins in upper valleys above urbanized areas to prevent the blocking of downstream channels during major storm events.
- **Recreational Areas –** Integrate planned improvements to the drainage system into the regional open space network by emphasizing the creation of passive recreational areas, and recreational access for pedestrians and bicycles without jeopardizing public safety.
- **Drainage Improvements –** Design and execute drainage improvements in a manner which protects natural resource and aesthetic values of the stream to the greatest extent possible.
- **Drainage Management –** Keep drainage corridors clear of debris to avoid the flooding problems that have occurred in the past.

4.8 Civic and Public Safety Facilities

General Policies

- Analyze the possible impact of sea level rise for new public and private projects in shoreline areas and require, where appropriate and feasible, measures to reduce vulnerability and increase resiliency.
- Identify critical public and private infrastructure and important cultural and natural resources vulnerable to historic coastal hazards and impacts of climate change, and, working with local landowners, stakeholders, and State and Federal agencies, begin the work of protecting, adapting, or relocating the highest priority projects.
- Coordination between community organizations, businesses, residents, homeowners, and City, State and Federal agencies determine how to:
  - Mitigate the anticipated threats from sea level rise,
  - Plan for future infrastructure improvements, and
  - Maintain existing connections, especially along Kalanianaʻole Highway where future flooding is anticipated to occur.

Planning Guidelines

- **Staffing capacity –** Approve new development only if adequate staffing and facilities for fire, ambulance and police protection will be provided. If the development of any new substation is warranted, potentially near an entry to Hawaiʻi Kai, there is a preference that it be co-located with other emergency medical and transportation services.
- **Community Resilience Hub –** Establish and operate a center in East Honolulu in accordance with the recommendations of the Oʻahu Resilience Strategy. In addition to post-disaster response and recovery operations, the centers will provide year-round community services.

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APPENDIX B: RELEVANT POLICIES FROM STATE WATERSHED PLANS AND GUIDANCE

Hawaiʻi Watershed Guidance (OP, 2010) Management Measures	Applicability
Agriculture Management Measures	
Erosion and Sediment Control: - Apply any combination of conservation structural and management practices based on U.S. Department of Agriculture – Natural Resources Conservation Service standards and specifications to minimize the delivery of sediment from agricultural lands to surface waters, or - Design and install a combination of management and structural practices to settle the settleable solids and associated pollutants in runoff delivered from the contributing area for storms of up to and including a 10-year, 24-hour frequency.	Applicable to activities that cause erosion on agricultural land and on land that is converted from other land uses to agriculture.
Wastewater Runoff: Limit the discharge from the confined animal facility to surface waters by: 1. Containing both the wastewater and the contaminated runoff from confined animal facilities that is caused by storms up to and including a 25-year, 24- hour frequency storm event. Storage structures should be of adequate capacity to allow for proper wastewater utilization and constructed so they prevent seepage to groundwater. 2. Managing stored contaminated runoff and accumulated solids from the facility through an appropriate waste utilization system.	Applicable to all new confined animal facilities regardless of size and to all existing confined animal facilities that contain specific amounts of animal units.
Nutrients: Develop, implement, and periodically update a nutrient management plan to: (1) apply nutrients at rates necessary to achieve realistic crop yields, (2) improve the timing of nutrient application, and (3) use agronomic crop production technology to increase nutrient use efficiency. When the source of the nutrients is other than commercial fertilizer, determine the nutrient value. Determine and credit the nitrogen contribution of any legume crop. Soil and/or plant tissue testing should be used at a suitable interval.	Applicable to activities associated with the application of nutrients, including both manures and commercial fertilizers, to agricultural lands.

Hawaiʻi Watershed Guidance (OP, 2010) Management Measures	Applicability
Pesticides: To eliminate the unnecessary release of pesticides into the environment and to reduce contamination of surface water and groundwater from pesticides: 1. Use integrated pest management strategies where available that minimize chemical uses for pest control. 2. Manage pesticides efficiently by: a. calibrating equipment; b. using appropriate pesticides for given situation and environment; c. using alternative methods of pest control; and d. minimizing the movement of pest control agents from target area. 3. Use anti-backflow devices on hoses used for filling tank mixtures. 4. Enhance degradation or retention by increasing organic matter content in the soil or manipulating soil pH.	Applicable to activities associated with the application of pesticides to agricultural lands.
Grazing: Protect range, pasture and other grazing lands: 1. By implementing one or more of the following to protect sensitive areas (such as streambanks, wetlands, estuaries, ponds, lake shores, near coastal waters/ shorelines, and riparian zones): a. Exclude livestock, b. Provide stream crossings or hardened watering access for drinking, c. Provide alternative drinking water locations, d. Locate salt and additional shade, if needed, away from sensitive areas, or e. Use improved grazing management (e.g., herding) to reduce the physical disturbance and reduce direct loading of animal waste and sediment caused by livestock; and 2. By achieving either of the following on all range, pasture, and other grazing lands not addressed under (1): a. Implement range and pasture conservation and management practices that apply the progressive planning approach of USDA-NRCS following the standards and specifications contained in the FOTG that achieve an acceptable level of treatment to reduce erosion, and/or c. Maintain range, pasture, and other grazing lands in accordance with activity plans established by the Division of Land Management of DLNR, federal agencies managing grazing land, or other designated land management agencies.	Applicable to activities on range, irrigated and non-irrigated pasture, and other grazing lands used by domestic livestock.

Hawaiʻi Watershed Guidance (OP, 2010) Management Measures	Applicability
Irrigation Water: To reduce nonpoint source pollution of surface waters caused by irrigation: 1. Operate the irrigation system so that the timing and amount of irrigation water applied match crop water needs. This will require, as a minimum: (a) the measurement of soil-water depletion volume and the volume of irrigation water applied; (b) uniform application of water; and (c) application rate which does not exceed infiltration rate in the field. 2. When chemigation is used, include backflow preventers for wells, minimize the harmful amounts of chemigated waters that discharge from the edge of the field, and control deep percolation. In cases where chemigation is performed with furrow irrigation systems, a tailwater management system may be needed. The following limitations and special conditions apply: 1. In some locations, irrigation return flows are subject to other water rights or are required to maintain stream flow. In these special cases, on-site reuse could be precluded and would not be considered part of the management measure for such locations. 2. By increasing the water use efficiency, the discharge volume from the system will usually be reduced. While the total pollutant load may be reduced somewhat, there is the potential for an increase in the concentration of pollutants in the discharge. In these special cases, where living resources or human health may be adversely affected and where other management measures (nutrients and pesticides) do not reduce concentrations in the discharge, increasing water use efficiency would not be considered part of the management measure. 3. The time interval between the order for and the delivery of irrigation water to the farm may limit the irrigator's ability to achieve the maximum on-farm application efficiencies that are otherwise possible. 4. In some locations, leaching is necessary to control salt in the soil profile. Leaching for salt control should be limited to the leaching requirement for the root zone. 5. Where leakage from delivery systems or return flows supports wetlands or wildlife refuges, it may be preferable to modify the system to achieve a high level of efficiency and then divert the "saved water" to the wetland or wildlife refuge. This will improve the quality of water delivered to wetlands or wildlife refuges by preventing the introduction of pollutants from irrigated lands to such diverted water. 6. In some locations, sprinkler irrigation is used for crop cooling or other benefits (e.g., watercress). In these special cases, applications should be limited to the amount necessary for crop protection, and applied water should not contribute to erosion or pollution.	Applicable to activities on irrigated lands, including agricultural crop and pasture land (except for isolated fields of less than 10 acres in size that are not contiguous to other irrigated lands); orchard land; specialty cropland; and nursery cropland.

Hawaiʻi Watershed Guidance (OP, 2010) Management Measures	Applicability
Forestry Management Measures	
Preharvest Planning Perform advance planning for forest harvesting that includes the following elements, where appropriate: 1. Identify the area to be harvested including location of waterbodies and sensitive areas such as wetlands, threatened or endangered aquatic species habitats, or high erosion hazard areas (landslide-prone areas) within the harvest unit. 2. Time the activity for the season or moisture conditions when the least impact occurs. 3. Consider potential water quality impacts and erosion and sedimentation control in the selection of silvicultural and regeneration systems, especially for harvesting and site preparation. 4. Reduce the risk of occurrence of landslides and severe erosion by identifying high erosion-hazard areas and avoiding harvesting in such areas, to the extent practicable. 5. Consider additional contributions from harvesting or roads to any known existing water quality impairments or problems in watersheds of concern. Perform advance planning for forest road systems that includes the following elements, where appropriate: 1. Locate and design road systems to minimize, to the extent practicable, potential sediment generation and delivery to surface waters. Key components are: locate roads, landings, and skid trails to avoid, to the extent practicable, steep grades and steep hillslope areas, and to decrease the number of stream crossings; avoid, to the extent practicable, locating new roads and landings in Streamside Management Zones (SMZs); and determine road usage and select the appropriate road standard. 2. Locate and design temporary and permanent stream crossings to prevent failure and control impacts from the road system. Key components are: size and site crossing structures to prevent failure; for fish-bearing streams, design crossings to facilitate fish passage. 3. Ensure that the design of road prism and the road surface drainage are appropriate to the terrain and that road surface design is consistent with the road drainage structures. 4. Use suitable materials to surface roads planned for all-weather use to support truck traffic. 5. Design road systems to avoid high erosion or landslide hazard areas. Identify these areas and consult a qualified specialist for design of any roads that must be constructed through these areas. Each State should develop a process (or utilize an existing process) that ensures that the management measures in this chapter are implemented. Such a process should include appropriate notification, compliance audits, or other mechanisms for forestry activities with the potential for significant adverse nonpoint source effects based on the type and size of operation and the presence of stream crossings or SMZs.	Applicable to lands where silvicultural or forestry operations are planned or conducted.

Hawai'i Watershed Guidance (OP, 2010) Management Measures	Applicability
Streamside Management Zone Establish and maintain a streamside management zone along surface waters, which is sufficiently wide and which includes a sufficient number of canopy species to buffer against detrimental changes in the temperature regime of the waterbody, to provide bank stability, and to withstand wind damage. Manage the SMZ in such a way as to protect against soil disturbance in the SMZ and delivery to the stream of sediments and nutrients generated by forestry activities, including harvesting. Manage the SMZ canopy species to provide a sustainable source of large woody debris needed for instream channel structure and aquatic species habitat.	Applicable to lands where silvicultural or forestry operations are planned or conducted.
Road Construction/ Reconstruction 1. Follow preharvest planning when constructing or reconstructing the roadway. 2. Follow designs planned under Management Measure A for road surfacing and shaping. 3. Install road drainage structures according to designs planned under Management Measure A and regional storm return period and installation specifications. Match these drainage structures with terrain features and with road surface and prism designs. 4. Guard against the production of sediment when installing stream crossings. 5. Protect surface waters from slash and debris material from roadway clearing. 6. Use straw bales, silt fences, mulching, or other favorable practices on disturbed soils on unstable cuts, fills, etc. 7. Avoid constructing new roads in SMZs, to the extent practicable.	Applicable to lands where silvicultural or forestry operations are planned or conducted.

Hawaiʻi Watershed Guidance (OP, 2010) Management Measures	Applicability
Road Management 1. Avoid using roads, where possible, for timber hauling or heavy traffic during wet periods on roads not designed and constructed for these conditions. 2. Evaluate the future need for a road and close roads that will not be needed. Leave closed roads and drainage channels in a stable condition to withstand storms. 3. Remove drainage crossings and culverts if there is a reasonable risk of plugging or failure from lack of maintenance. 4. Following completion of harvesting, close and stabilize temporary spur roads and seasonal roads to control and direct water away from the roadway. Remove all temporary stream crossings. 5. Inspect roads to determine the need for structural maintenance. Conduct maintenance practices, when conditions warrant, including cleaning and replacement of deteriorated structures and erosion controls, grading or seeding of road surfaces, and, in extreme cases, slope stabilization or removal of road fills, where necessary to maintain structural integrity. 6. Conduct maintenance activities, such as dust abatement, so that chemical contaminants or pollutants are not introduced into surface waters, to the extent practicable. 7. Properly maintain permanent stream crossings and associated fills and approaches to reduce the likelihood that (a) stream overflow will divert onto roads, and (b) fill erosion will occur if the drainage structures become obstructed.	Applicable to lands where silvicultural or forestry operations are planned or conducted.
Timber Harvesting The timber harvesting management measure consists of implementing the following: 1. Timber harvesting operations with skid trails or cable yarding follow layouts. 2. Install landing drainage structures to avoid sedimentation, to the extent practicable. Disperse landing drainage over side slopes. 3. Construct landings away from steep slopes and reduce the likelihood of fill slope failures. Protect landing surfaces used during wet periods. Locate landings outside of SMZs. Minimize size of landing areas. 4. Protect stream channels and significant ephemeral drainages from logging debris and slash material. 5. Use appropriate areas for petroleum storage, draining, dispensing. Establish procedures to contain and treat spills. Recycle or properly dispose of all waste materials in accordance with State law.	Applicable to lands where silvicultural or forestry operations are planned or conducted.

Hawaiʻi Watershed Guidance (OP, 2010) Management Measures	Applicability
For cable yarding: 1. Limit yarding corridor gouge or soil plowing by properly locating cable yarding landings. 2. Locate corridors for SMZs following Management Measure B. 3. Cable yarding should not be done across perennial or intermittent streams, except at improved stream crossings. For ground skidding: 1. Within SMZs, operate ground skidding equipment only at stream crossings, to the extent practicable. In SMZs, fell and endline trees to avoid sedimentation. 2. Use improved stream crossings for skid trails which cross flowing drainages. Construct skid trails to disperse runoff and with adequate drainage structures. 3. On steep slopes, use cable systems rather than ground skidding where ground skidding may cause excessive sedimentation. 4. Ground skidding should not be done across perennial or intermittent streams, except at improved stream crossings.	
Site Preparation and Forest Regeneration Confine on-site potential nonpoint source pollution and erosion resulting from site preparation and the regeneration of forest stands. The components of the management measure for site preparation and regeneration are: 1. Select a method of site preparation and regeneration suitable for the site conditions. 2. Conduct mechanical tree planting and ground-disturbing site preparation activities on the contour of erodible terrain. 3. Do not conduct mechanical site preparation and mechanical tree planting in SMZs. 4. Protect surface waters from logging debris and slash material. 5. Suspend operations during wet periods if equipment used begins to cause excessive soil disturbance that will increase erosion. 6. Locate windrows at a safe distance from drainages and SMZs to control movement of the material during high runoff conditions. 7. Conduct bedding operations in high water-table areas during dry periods of the year. Conduct bedding in erodible areas on the contour. 8. Protect small ephemeral drainages when conducting mechanical tree planting.	Applicable to lands where silvicultural or forestry operations are planned or conducted.
Fire Management Prescribe fire or suppress wildfire in a manner which reduces potential nonpoint source pollution of	Applicable to lands where silvicultural or forestry

Hawaiʻi Watershed Guidance (OP, 2010) Management Measures	Applicability
surface waters: 1. Prescribed fire should not cause excessive sedimentation due to the combined effect of removal of canopy species and the loss of soil-binding ability of subcanopy and herbaceous vegetation roots, especially in SMZs, in streamside vegetation for small ephemeral drainages, or on very steep slopes. 2. Prescriptions for fire should protect against excessive erosion or sedimentation, to the extent practicable. 3. All bladed firelines, for prescribed fire and wildfire, should be plowed on contour or stabilized with water bars and/or other appropriate techniques if needed to control excessive sedimentation or erosion of the fireline. 4. Wildfire suppression and rehabilitation should consider possible nonpoint source pollution of watercourses, while recognizing the safety and operational priorities of fighting wildfires.	operations are planned or conducted.
Re-vegetation of Disturbed Areas Reduce erosion and sedimentation by rapid revegetation of areas disturbed by harvesting operations or road construction: 1. Revegetate disturbed areas (using seeding or planting) promptly after completion of the earth-disturbing activity. Local growing conditions will dictate the timing for establishment of vegetative cover. 2. Use mixes of species and treatments developed and tailored for successful vegetation establishment for the region or area. 3. Concentrate revegetation efforts initially on priority areas such as disturbed areas in SMZs or the steepest areas of disturbance near drainages.	Applicable to lands where silvicultural or forestry operations are planned or conducted.
Forest Chemical Management Use chemicals when necessary for forest management in accordance with the following to reduce nonpoint source pollution impacts due to the movement of forest chemicals off-site during and after application: 1. Conduct applications by skilled and, where required, licensed applicators according to the registered use, with special consideration given to impacts to nearby surface and groundwater. 2. Carefully prescribe the type and amount of pesticides appropriate for insect or herbaceous species. 3. Establish and identify buffer areas for surface waters. (This is especially important for aerial applications.) 4. Prior to applications of pesticides and fertilizers, inspect the mixing and loading process and the calibration of equipment, and identify the appropriate weather conditions, the spray area, and buffer areas for surface waters.	Applicable to lands where silvicultural or forestry operations are planned or conducted – in particular, to all fertilizer and pesticide applications (including biological agents) conducted as part of normal silvicultural activities.

Hawaiʻi Watershed Guidance (OP, 2010) Management Measures	Applicability
Wetlands Forest Management Plan, operate, and manage normal, ongoing forestry activities (including harvesting, road design and construction, site preparation and regeneration, and chemical management) to adequately protect the aquatic functions of forested wetlands.	Applicable for forested wetlands where silvicultural or forestry operations are planned or conducted - specifically to forest management activities in forested wetlands and to supplement the previous management measures by addressing the operational circumstances and management practices appropriate for forested wetlands.
Urban Areas	
New Development 1. By design or performance: a. Construction has been completed and the site is permanently stabilized, reduce the average annual total suspended solid (TSS) loadings by 80%. For the purposes of this measure, an 80% TSS reduction is to be determined on an average annual basis,* or b. Reduce the post-development loadings of TSS so that the average annual TSS loadings are no greater than predevelopment loadings. 2. To the extent practicable, maintain post-development peak runoff rate and average volume at levels that are similar to predevelopment levels. Sound watershed management requires that both structural and nonstructural measures be employed to mitigate the adverse impacts of storm water. Both the Watershed Protection and Site Development Management Measure can be effectively used in conjunction with New Development to reduce both the short- and long-term costs of meeting the treatment goals of this management measure.	Applicable to control urban runoff and treat associated pollutants generated from new development, redevelopment, and new and relocated roads, highways, and bridges.

Hawaiʻi Watershed Guidance (OP, 2010) Management Measures	Applicability
Watershed Protection Develop a watershed protection program to: 1. Avoid conversion, to the extent practicable, of areas that are particularly susceptible to erosion and sediment loss; 2. Preserve areas that provide important water quality benefits and/or are necessary to maintain riparian and aquatic biota; and 3. Site development, including roads, highways, and bridges, to protect to the extent practicable the natural integrity of waterbodies and natural drainage systems.	Applicable to new development or redevelopment including construction of new and relocated roads, highways, and bridges that generate nonpoint source pollutants.
Site Development Plan, design, and develop sites to: 1. Protect areas that provide important water quality benefits and/or are particularly susceptible to erosion and sediment loss; 2. Limit increases of impervious areas, except where necessary; 3. Limit land disturbance activities such as clearing and grading, and cut and fill to reduce erosion and sediment loss; and 4. Limit disturbance of natural drainage features and vegetation.	Applicable to site development activities including those associated with roads, highways, and bridges.
Existing Development Develop and implement watershed management programs to reduce runoff pollutant concentrations and volumes from existing development: 1. Identify priority local and/or regional watershed pollutant reduction opportunities, e.g., improvements to existing urban runoff control structures; 2. Contain a schedule for implementing appropriate controls; 3. Limit destruction of natural conveyance systems; and 4. Where appropriate, preserve, enhance, or establish buffers along surface waterbodies and their tributaries.	Applicable to all urban areas and existing development in order to reduce surface water runoff pollutant loadings from such areas.

Hawai'i Watershed Guidance (OP, 2010) Management Measures	Applicability
New Onsite Disposal Systems 1. Ensure that new Onsite Disposal Systems (OSDS) are located, designed, installed, operated, inspected, and maintained to prevent the discharge of pollutants to the surface of the ground and to the extent practicable reduce the discharge of pollutants into groundwater that are closely hydrologically connected to surface waters. Where necessary to meet these objectives: (a) discourage the installation of garbage disposals to reduce hydraulic and nutrient loadings; and (b) where low-volume plumbing fixtures have not been installed in new developments or redevelopments, reduce total hydraulic loadings to the OSDS by 25%. Implement OSDS inspection schedules for preconstruction, construction, and post-construction; 2. Direct placement of OSDS away from unsuitable areas. Where OSDS placement away from unsuitable areas is not practicable, ensure that the OSDS is designed or sited at a density so as not to adversely affect surface waters or groundwater that is closely hydrologically connected to surface water. Unsuitable areas include, but are not limited to, areas with poorly or excessively drained soils; areas with shallow water tables or areas with high seasonal water tables; areas overlaying fractured bedrock that drain directly to groundwater; areas within floodplains; or areas where nutrient and/or pathogen concentrations in the effluent cannot be sufficiently treated or reduced before the effluent reaches sensitive waterbodies; 3. Establish protective setbacks from surface waters, wetlands, and floodplains for conventional as well as alternative OSDS. The lateral setbacks should be based on soil type, slope, hydrologic factors, and type of OSDS. Where uniform protective setbacks cannot be achieved, site development with OSDS so as not to adversely affect waterbodies and/or contribute to a public health nuisance; 4. Establish protective separation distances between OSDS system components and groundwater which is closely hydrologically connected to surface waters. The separation distances should be based on soil type, distance to groundwater, hydrologic factors, and type of OSDS.	Applicable to all new OSDSs, including package plants and small-scale or regional treatment facilities not covered by NPDES regulations, in order to manage the siting, design, installation, and operation and maintenance of all such OSDSs.
Operating Onsite Disposal Systems 1. Establish and implement policies and systems to ensure that existing OSDS are operated and maintained to prevent the discharge of pollutants to the surface of the ground and to the extent practicable reduce the discharge of pollutants into groundwaters that are closely hydrologically connected to surface waters. Where necessary to meet these objectives, encourage the reduced use of garbage disposals, encourage the use of low-volume plumbing fixtures, and reduce total phosphorus loadings to the OSDS by 15% (if the use of low-level phosphate detergents has not been required or widely adopted by OSDS users). Establish and implement policies that require an OSDS to be repaired, replaced, or modified where the OSDS fails, or threatens or impairs surface waters; 2. Inspect OSDS at a frequency adequate to ascertain whether OSDS are failing;	Applicable to all operating OSDSs.

Hawaiʻi Watershed Guidance (OP, 2010) Management Measures	Applicability
Consider replacing or upgrading OSDS to treat influent so that total nitrogen loadings in the effluent are reduced by 50%. This provision applies only where conditions indicate that nitrogen-limited surface waters may be adversely affected by significant groundwater nitrogen loadings from OSDS, and where nitrogen loadings from OSDS are delivered to groundwater that is closely hydrologically connected to surface water.	
Pollution Prevention Implement pollution prevention and education programs to reduce nonpoint source pollutants generated from the following activities, where applicable: a. The improper storage, use, and disposal of household hazardous chemicals, including automobile fluids, pesticides, paints, solvents, etc.; b. Lawn and garden activities, including the application and disposal of lawn and garden care products, and the improper disposal of leaves and yard trimmings; c. Turf management on golf courses, parks, and recreational areas; d. Improper operation and maintenance of onsite disposal systems; e. Discharge of pollutants into storm drains including floatables, waste oil, and litter; f. Commercial activities including parking lots, gas stations, and other entities not under NPDES purview; g. Improper disposal of pet excrement.	Applicable to reduce the generation of polluted runoff in all areas within the coastal nonpoint pollution control program management area.
Golf Course Management 1. Develop and implement grading and site preparation plans to: a. Design and install a combination of management and physical practices to settle solids and associated pollutants in runoff from heavy rains and/or from wind; b. Prevent erosion and retain sediment, to the extent practicable, onsite during and after construction; c. Protect areas that provide important water quality benefits and/or are environmentally-sensitive ecosystems; d. Avoid construction, to the extent practicable, in areas that are susceptible to erosion and sediment loss; e. Protect the natural integrity of waterbodies and natural drainage systems by establishing streamside buffers; f. Follow, to the extent practicable, the amended U.S. Golfing Association (USGA) guidelines for the construction of greens. 2. Develop nutrient management guidelines appropriate to Hawaii for qualified superintendents to implement so that nutrients are applied at rates necessary to establish and maintain vegetation without causing leaching into ground and surface waters. 3. Develop and implement an integrated pest management plan. Follow EPA guidelines for the proper storage and disposal of pesticides.	Applicable to all golf courses in Hawaii that are in operation, under construction, or to be built in the future.

Hawaiʻi Watershed Guidance (OP, 2010) Management Measures	Applicability
Planning, Siting, and Development Roads and Highways Plan, site, and develop roads and highways to: 1. Protect areas that provide important water quality benefits or are particularly susceptible to erosion or sediment loss; 2. Limit land disturbance such as clearing, grading and cut and fill to reduce erosion and sediment loss; and 3. Limit disturbance of natural drainage features and vegetation.	Applicable to site development and land disturbing activities for new, relocated, and reconstructed (widened) roads (including residential streets) and highways in order to reduce the generation of nonpoint source pollutants and to mitigate the impacts of urban runoff and associated pollutants from such activities.
Bridges Site, design, and maintain bridge structures so that sensitive and valuable aquatic ecosystems and areas providing important water quality benefits are protected from adverse effects.	Applicable to new, relocated, and rehabilitated bridge structures in order to control erosion, streambed scouring, and surface runoff from such activities.
Operational and Maintenance, Roads & Highways Incorporate pollution prevention procedures into the operation and maintenance of roads, highways, and bridges to reduce pollutant loadings to surface waters.	Applicable to existing, restored, and rehabilitated roads, highways, and bridges. This management measure does not apply to urban City and County of Honolulu due to overlap with NPDES storm water regulations.
Runoff Systems for Roads, Highways, and Bridges	Applicable to existing, resurfaced, restored, and

Hawaiʻi Watershed Guidance (OP, 2010) Management Measures	Applicability
Develop and implement runoff management systems for existing roads, highways, and bridges to reduce runoff pollutant concentrations and volumes entering surface waters. 1. Identify priority and watershed pollutant reduction opportunities (e.g., improvements to existing urban runoff control structures); and 2. Establish schedules for implementing appropriate controls	rehabilitated roads, highways, and bridges that contribute to adverse effects in surface waters. This management measure does not apply to urban City and County of Honolulu due to overlap with NPDES storm water regulations.
Marinas and Recreational Boating	
Marina Flushing Site and design marinas such that tides and/or currents will aid in flushing of the site or renew its water regularly.	Applicable to the siting and design of new and expanding marinas.
Water Quality Assessment Assess water quality as part of marina siting and design.	Applicable to the siting and design of new and expanding marinas.
Habitat Assessment Site and design marinas to protect against adverse effects on coral reefs, shellfish resources, wetlands, submerged aquatic vegetation, or other important riparian and aquatic habitat areas as designated by local, State, or federal governments.	Applicable to the siting and design of new and expanding marinas where site changes may have an impact on important marine species, coral reefs, wetlands, or other important habitats.
Shoreline Stabilization Where shoreline erosion is a serious nonpoint source pollution problem, shorelines may need to be stabilized. Vegetative methods are strongly preferred. Structural methods may be necessary where vegetative methods	Applicable to siting and design of new and expanding marinas where site changes

Hawai'i Watershed Guidance (OP, 2010) Management Measures	Applicability
cannot work and where they do not interfere with natural beach processes or harm other sensitive ecological areas.	may result in shoreline erosion.
<u>Storm Water Runoff</u> - Implement effective runoff control strategies which include the use of pollution prevention activities and the proper design of hull maintenance areas. - Reduce the average annual loadings of total suspended solids (TSS) in runoff from hull maintenance areas by 80%. For the purposes of this measure, an 80% reduction of TSS is to be determined on an average annual basis.	Applicable to new and expanding marinas, and to existing marinas for at least the hull maintenance areas.
<u>Fueling Station Design</u> Design fueling stations to allow for ease in cleanup of spills.	Applicable to new and expanding marinas where fueling stations are to be added or moved.
<u>Sewage Facility Management</u> Install pumpout, dump station, and restroom facilities where needed at new and expanding marinas to reduce the release of sewage into surface waters. Design these facilities to allow ease of access and post signage to promote use by the boating public.	Applicable to new and expanding marinas in areas where adequate marine sewage collection facilities do not exist.
<u>Solid Waste Management</u> Properly dispose of solid wastes produced by the operation, cleaning, maintenance, and repair of boats to limit entry of solid wastes into surface waters.	Applicable to the operation and maintenance of new and expanding marinas.
<u>Fish Waste Management</u> Promote sound fish waste management through a combination of fish-cleaning restrictions, public education, and proper disposal of fish waste.	Applicable to marinas where fish waste is determined to be a source of water pollution.

Hawaiʻi Watershed Guidance (OP, 2010) Management Measures	Applicability
Liquid Material Management Provide and maintain appropriate storage, transfer, containment, and disposal facilities for liquid material, such as oil, harmful solvents, antifreeze, and paints, and encourage recycling of these materials.	Applicable to the operation and maintenance of marinas where liquid materials used in the maintenance, repair, or operation of boats are stored.
Petroleum Control Reduce the amount of fuel and oil from boat bilges and fuel tank air vents entering marina and surface waters.	Applicable to boats that have inboard fuel tanks.
Boat Cleaning For boats that are in the water, perform cleaning operations to minimize, to the extent practicable, the release to surface waters of harmful cleaners, solvents and paint from in-water hull cleaning.	Applicable to marinas where boat topsides are cleaned and marinas where hull scrubbing in the water has been shown to result in water or sediment quality problems.
Public Education Public education/outreach/training programs should be instituted for boaters, as well as marina owners and operators, to prevent improper disposal of polluting material.	Applicable to all environmental control authorities in areas where marinas are located.
Maintenance of Sewage Facilities Ensure that sewage pumpout facilities are maintained in operational condition and encourage their use.	Applicable to marinas where marine sewage disposal facilities exist.
Boast Operation Restrict boating activities where necessary to decrease turbidity and physical destruction of shallow-water habitat.	Applicable in non-marina surface waters where evidence indicates that boating activities are impacting shallow-water habitats.

Hawaiʻi Watershed Guidance (OP, 2010) Management Measures	Applicability
Hydromodification	
Physical and Chemical Characteristics of Surface Waters 1. Evaluate the potential effects of proposed channelization and channel modification on the physical and chemical characteristics of surface waters in coastal areas; 2. Plan and design channelization and channel modification to reduce undesirable impacts; and 3. Develop an operation and maintenance program for existing modified channels that includes identification and implementation of opportunities to improve physical and chemical characteristics of surface waters in those channels.	Applicable to public and private channelization and channel modification activities to prevent the degradation of physical and chemical characteristics of surface waters from such activities.
Instream and Riparian Habitat Restoration - Evaluate the potential effects of proposed channelization and channel modification on instream and riparian habitat in coastal areas; - Plan and design channelization and channel modification to reduce undesirable impacts; and - Develop an operation and maintenance program with specific timetables for existing modified channels that includes identification of opportunities to restore instream and riparian habitat in those channels.	Applicable to any proposed channelization or channel modification project to determine changes in instream and riparian habitats and to existing modified channels to evaluate possible improvements to these environments.
Protection of Surface Water Quality and Instream and Riparian Habitat from Dams Develop and implement a program to manage the operation of dams in coastal areas that includes an assessment of: Surface water quality and instream and riparian habitat and potential for improvement and significant nonpoint source pollution problems that result from excessive surface water withdrawals.	Applicable to dam operations that result in the loss of desirable surface water quality, and of desirable instream and riparian habitat.

Hawaiʻi Watershed Guidance (OP, 2010) Management Measures	Applicability
Eroding Streambank and Shorelines 1. Where streambank or shoreline erosion is a serious nonpoint source pollution problem, streambanks and shorelines may need to be stabilized. Vegetative methods are strongly preferred. Structural methods may be necessary where vegetative methods cannot work and where they do not interfere with natural processes or harm other sensitive ecological areas. 2. Protect streambank and shoreline features with the potential to reduce nonpoint source pollution. 3. Protect streambanks and shorelines from erosion due to uses of either the shorelands or adjacent surface waters. 4. Where artificial fill is eroding into adjacent streams or coastal waters, it should be removed.	Applicable to eroding shorelines in coastal bays and to eroding streambanks in coastal streams.
Wetlands, Riparian Areas, and Vegetated Treatment Systems	
Protection of Wetlands and Riparian Areas Protect from adverse effects wetlands and riparian areas that are serving a significant nonpoint source pollution abatement function and maintain this function while protecting the other existing functions of these wetlands and riparian areas as measured by characteristics such as vegetative composition and cover, hydrology of surface water and groundwater, geochemistry of the substrate, and species composition.	Applicable to protecting wetlands and riparian areas from adverse nonpoint source pollution impacts.
Restoration of Wetlands and Riparian Areas Promote the restoration of the pre-existing functions in damaged and destroyed wetlands and riparian systems in areas where the systems will serve a significant nonpoint source pollution abatement function.	Applicable to restoring the full range of wetland and riparian functions in areas where the systems have been degraded and destroyed, and where they can serve a significant nonpoint source pollution abatement function.

Hawaiʻi Watershed Guidance (OP, 2010) Management Measures	Applicability
Vegetated Treatment Systems Promote the use of engineered vegetated treatment systems such as constructed wetlands or vegetated filter strips where these systems will serve a significant nonpoint source pollution abatement function.	Applicable in cases where engineered systems of wetlands or vegetated treatment systems can treat polluted runoff.

Ocean Resources Management Plan (OP-CZM, 2020) Focus Areas Goals	Metrics for Measuring Success
Focus Area I: Development and Coastal Hazards	
Goal: Develop a statewide integrated shoreline management strategy to address the compounding impacts to Hawai'i's shorelines of coastal development, climate change and sea level rise, erosion, and other chronic coastal hazards. ***Proposed Components for Goal Success (Relevant to the EHWMP):*** - Inventory and analyze critical infrastructure assets along the shoreline threatened by chronic and episodic coastal hazards and future sea level rise projections. Conduct vulnerability assessments and assess options for protection, accommodation, and retreat of public infrastructure as sea levels rise. - Identify suitable geographic scale for shoreline adaptation planning based on coastal processes. - Determine barriers to proactive shoreline adaptation and actionable policy strategies to surmount them. - Examine barriers to beach nourishment, including impacts to coastal habitats (offshore sand sources, sandy beach ecosystems), cost, and regulatory requirements (i.e. dewatering of sand). - Study the feasibility of utilizing 'nature-based solutions' on Hawai'i's high-energy shorelines to manage and mitigate erosion. - Study the impacts of sea level rise projections on cultural and archeological resources, such as gathering sites, loko i'a, fishponds or fish traps, heiau, place of worship, shrine, and ki'I pohaku, petroglyphs. - Incorporate a managed retreat or strategic relocation analysis in all action team projects/studies to help develop criteria for this adaptation strategy as identified in *Assessing the Feasibility and Implication of Managed Retreat Strategies for Vulnerable Coastal Areas in Hawai'i*.	- Number of Public Access Sites Created or Enhanced from OP-CZM Funding or Staff (Data Source: OP-CZM) - Number of County General Plans and County Development Plans that include a climate change adaptation component (Data Source: County Planning Departments) - Number of shoreline erosion studies and maps completed or updated for the main Hawaiian Islands (Data Source: OP-CZM) - Number of counties that have updated shoreline setback rules in the last five years (Data Source: County Planning Departments)

Ocean Resources Management Plan (OP-CZM, 2020) Focus Areas Goals	Metrics for Measuring Success
Focus Area II: Land-Based Pollution	
Goal: Design management strategies and programs to recognize and incorporate the connection of land and sea, facilitating the broad adoption of green infrastructure practices to reduce polluted runoff from within watersheds. ***Proposed Components for Goal Success (Relevant to the EHWMP):*** - Increase the shared understanding of green stormwater infrastructure among homeowners, government officials, practitioners, and private industry, through continuing outreach efforts. - Sponsor symposia and trainings on green stormwater infrastructure installation and maintenance for professionals, homeowners, and advocates. - Identify adaptations needed to implement green stormwater infrastructure successfully in Hawai'i's unique conditions (topography, climate, soils, development patterns). - Compare and contrast the efficacy, cost, and lifespan of green stormwater infrastructure, and traditional water management techniques (through such process as phytoremediation and filtration) compared to the 'grey' infrastructure (engineered assets) currently utilized in Hawai'i in order to dispel misconceptions about green options. - Evaluate the use of green stormwater infrastructure along Hawai'i's shoreline and throughout the coastal zone, with the dual-benefit of controlling erosion and other shoreline processes while mitigating the impacts of land-based pollution and inland flooding. - Expand use of NOAA's Coastal Change Analysis Program (C-CAP) sea level rise and land cover data in conducting stormwater assessments and modeling.	- Number of fenced acres in DLNR priority watersheds (Data Source: DLNR-DOFAW) - Miles of fencing inspected and maintained at DLNR priority watersheds (Data Source: DLNR-DOFAW) - Number of impaired streams reported and Total Maximum Daily Loads (TMDLs) mandated and created in the latest State of Hawaiʻi Water Quality Monitoring and Assessment Report (Data Source: DOH-CWB) - Percentage of wastewater recycled annually (Data Source: DOH-WWB) - Number of pollutant load reductions achieved (Data Source: DOH-CWB) - Number of "hits" to Department of Health Water Quality website (Data Source: DOH-CWB) - Average score on DOT-HARBOR's environmental knowledge survey(s), as reported in the Small Municipal Separate Storm Sewer Systems (MS4) Annual Compliance Report for Honolulu - Harbor and Kalaeloa Barbers Point (Data Source: DOT-HARBORS)

Ocean Resources Management Plan (OP-CZM, 2020) Focus Areas Goals	Metrics for Measuring Success
Focus Area III: Marine Ecosystems	
Goal #1: Promote fishing practices that adopt the wisdom of both traditional ecological knowledge and scientific ecological knowledge to improve fish stocks. **Goal #2:** Effectively manage networks of healthy coral reefs while improving the health of reef ecosystems at priority sites identified by the State of Hawai'i coral program. **Goal #3:** Minimize the likelihood of aquatic alien species introduction and spread into and within hawai'i from sources associated with vessels. ***Proposed Components for Goal Success (Relevant to the EHWMP):*** - Support DLNR-DAR capacity to work with communities that wish to pursue fishing practices that adopt the wisdom of traditional and scientific ecological knowledge. - Identify management gaps that inform existing efforts to prevent further damage to fragile nearshore ecosystems, and collaboratively seek and obtain funding for implementation. - Identify management gaps that will support expansion of efforts to restore and enhance coral reef priority areas, and collaboratively seek and obtain funding for implementation. - Supplement DLNR-DAR education and outreach efforts to build a greater public awareness for responsible behavior affecting aquatic resources such as nearshore fisheries and coral reef, including the impact of aquatic alien species on native ecosystems. - Identify management gaps to develop capacity to address aquatic alien species introduction and spread into and within Hawai'i from sources associated with vessels, and collaboratively seek and obtain funding for implementation.	- Number of Makai Watch trainings provided to community groups (Data Source: DLNR-DAR) - Area surveyed for aquatic alien/invasive species (Data Source: DLNR-DAR) - Area of aquatic alien species treated (Data Source: DLNR-DAR) - Number of ballast water risk assessments conducted (Data Source: DLNR-DAR) - Miles of beaches conserved or restored through projects employing nature-based practices. (Data Source: Hawai'i Sea Grant and DLNR-OCCL) - Number of impaired coastal waters listed in the most recently published State of Hawai'I Water Quality Monitoring and Assessment Report (Data Source: DOH-CWB) - Number of shoreline postings due to sewage or other water pollution (Data Source: DOHCWB)

APPENDIX C: WELLS IN EAST HONOLULU

Appendix Table C-1 identifies wells located in the East Honolulu planning district which have a state well number and also have a WUP. This table also identifies the wells' permitted water use based on the 2015 Water Use Permit Index. *Appendix Table C-2* identifies wells located in the East Honolulu planning district which have a state well number but do not have a current WUP. As shown in *Appendix Table C-2,* certain well names are associated with multiple state well numbers. This may indicate that some of the wells are no longer in use. Since the wells listed in *Appendix Table C-2* do not have a WUP, these wells do not include a permitted water use. Well data shown in both tables was provided by CWRM in 2019.

Appendix Table C-1: East Honolulu Wells with a Water Use Permit

Aquifer System & Well Name	State Well #	Well Owner	2015 Permitted Use (MGD) [1]
WAIʻALAE-WEST 30105			
Waiʻalae Golf Course	3-1646-001	Waiʻalae Country Club	0.460
Kāhala Hilton 1	3-1646-005	Kāhala Hotel and Resort	2.88
Kāhala Hilton 2	3-1646-006	Kāhala Hotel and Resort	
Aina Koa	3-1746-001	BWS	0.480
Aina Koa II	3-1746-004	BWS	0.997
Waiʻalae Nui (Proposed)	3-1747-003	BWS	0.700
Waiʻalae West	3-1747-005	BWS	0.160
WAIʻALAE-EAST 30106			
Pia	3-1744-004	BWS	0.0
Wailupe I	3-1745-001	BWS	0.300
Waiʻalae Iki	3-1746-002	BWS	0.190
Kuliʻouʻou	3-1843-001	BWS	0.300

Appendix Table D-1 Notes:

1 Permitted use amounts are from the CWRM Water Use Permit Index as of 2015. Permitted uses account for water withdrawals from potable ground water aquifer system areas.

Appendix Table C-2: East Honolulu Wells Without a Water Use Permit

Aquifer System & Well Name	State Well #	Well Owner
WAIʻALAE-WEST 30105		
Kapakahi	3-1746-003	BWS
Waiʻalae Golf	3-1646-002	Kamehameha Schools
Waiʻalae Golf	3-1646-004	Kamehameha Schools
WAIʻALAE-EAST 30106		
Koko Head	3-1642-001	Evershine II LP
Koko Head	3-1642-002	Ammai LLC
Paiko Spring	3-1643-001	DLNR, Oʻahu Land Division
Koko Head	3-1645-001	DOT, Highways Division
Waiʻalae Golf	3-1646-003	Kahala Hotel & Resort
Kalama Valley	3-1740-001	Steven Yip
Kalama Valley	3-1740-002	Gregory A Heller Trust
Kalama Valley	3-1740-003	Atsugi Kokusai Kanko Inc.
Kalama Valley	3-1740-004	Glenn Shigezawa
Kalama Valley	3-1740-005	E & K Wong Trust
Kamilo Iki Valley	3-1741-001	Jon Kagamida
Kamilo Iki Valley	3-1741-002	Takemoto-Luke Trust
Hahaʻione Valley	3-1742-001	Naniwa Gardens
Kuliouou	3-1743-001	Jack Takeda
Niu Valley	3-1744-001	Karl Kiyokawa
Niu Valley	3-1744-002	Brian Lau Trust
Niu Valley	3-1744-003	DOT, Highways Division
Kalama Valley	3-1840-001	Mark Hervey
Kalama Valley	3-1840-002	DOT, Highways Division
Kalama Valley	3-1840-003	Lawrence Egan Trust
Kalama Valley	3-1840-004	Raylene Nolan
Kalama Valley	3-1840-005	DOT, Highways Division
Kalama Valley	3-1840-006	Robert J White Trust
Kalama Valley	3-1840-007	DOT, Highways Division
Hawaiʻi Kai GC	3-1840-008	Atsugi Kokusai Kanko Inc.
Kamilo Vui Valley	3-1841-001	Katsumi Higa Trust
Kamilo Nui Valley	3-1842-001	Sandra Matsui Trust
Wailupe II	3-1845-001	BWS

APPENDIX D: WATER DEMAND ANALYSIS METHODOLOGY AND ASSUMPTIONS

Appendix D provides a detailed methodology for how the existing permitted use and pumpage of water was calculated. As a rule of thumb, figures were rounded to the third decimal place throughout the Chapter.

Identifying Permitted Uses of Water in East Honolulu

Step 1: The 2015 WUP Index was provided by CWRM. The WUP Index is categorized by ASA. Two ASAs are applicable to East Honolulu: Waiʻalae West and Waiʻalae East.

Step 2: The wells listed in the WUP Index classified as Waiʻalae West and Waiʻalae East were identified. The total permitted use of these wells were summed (shown in *Table 3-3* of the EHWMP).

Identifying Active Wells and Pumpage in East Honolulu

Step 1: An index of existing wells in Hawaiʻi from April 2018 was provided by CWRM. This dataset was imported into GIS.

Step 2: The "Overlay Layers" function in GIS was used to overlay East Honolulu planning district boundaries on well data. The end result of this analysis was an inventory of wells located only within East Honolulu (not Statewide, as data originally provided).

Step 3: Pumpage data from 2015 was provided by CWRM (potable). Wells located within East Honolulu (identified in Step 2) were extracted and copied into a separate tab.

Step 4: In 2015, there were ten wells that reported pumpage to CWRM. The pumpage was zero for seven of the ten wells that reported its pumpage. For the three wells with pumpage above zero in 2015 were: ʻĀinakoa, ʻĀinakoa II, and Waiʻalae Golf. The 12-month moving average (12 MAV) was calculated for each well (see *Appendix Table D*). 12 MAV was calculated by pumpage by totaling the pumpage in MGD for the 12 month period (1/1/15 to 12/31/15), then dividing total by 12 (i.e. pumpage was averaged).

Step 5: The 12 MAV of each well was summed together, equaling 1.72 MGD (see *Appendix Table D*). This provided the quantity for potable groundwater pumpage used within East Honolulu.

Appendix Table D-1: 2015 Monthly Pumpage within East Honolulu, by Well (MGD)

Well	Start Date	End Date	Pumpage (MGD)
ʻĀinakoa	1/1/2015	1/31/2015	0.479
	2/1/2015	2/28/2015	0.474
	3/1/2015	3/31/2015	0.479
	4/1/2015	4/30/2015	0.473
	5/1/2015	5/31/2015	0.479
	6/1/2015	6/30/2015	0.471
	7/1/2015	7/31/2015	0.478
	8/1/2015	8/31/2015	0.473
	9/1/2015	9/30/2015	0.475
	10/1/2015	10/31/2015	0.471
	11/1/2015	11/30/2015	0.454
	12/1/2015	12/31/2015	0.443
		12 MAV	**0.47075**
ʻĀinakoa II	1/1/2015	1/31/2015	1.013
	2/1/2015	2/28/2015	0.98
	3/1/2015	3/31/2015	0.949
	4/1/2015	4/30/2015	0.966
	5/1/2015	5/31/2015	0.932
	6/1/2015	6/30/2015	0.922
	7/1/2015	7/31/2015	0.883
	8/1/2015	8/31/2015	0.955
	9/1/2015	9/30/2015	0.885
	10/1/2015	10/31/2015	0.887
	11/1/2015	11/30/2015	0.919
	12/1/2015	12/31/2015	1.014
		12 MAV	**0.942083333**
Waiʻalae Golf	1/3/2015	2/2/2015	0.131
	3/3/2015	4/1/2015	0.287
	4/2/2015	5/1/2015	0.421
	5/2/2015	6/1/2015	0.471
	6/2/2015	7/1/2015	0.536
	7/2/2015	7/31/2015	0.548
	8/1/2015	9/2/2015	0.356
	9/3/2015	10/1/2015	0.182
	10/2/2015	11/2/2015	0.237
	11/3/2015	12/1/2015	0.161
	12/2/2015	12/31/2015	0.226
		12 MAV	**0.296333333**
TOTAL		**12 MAV**	**1.709166667**