



# BWS Watershed Program

Amy Tsuneyoshi

HWWA conference

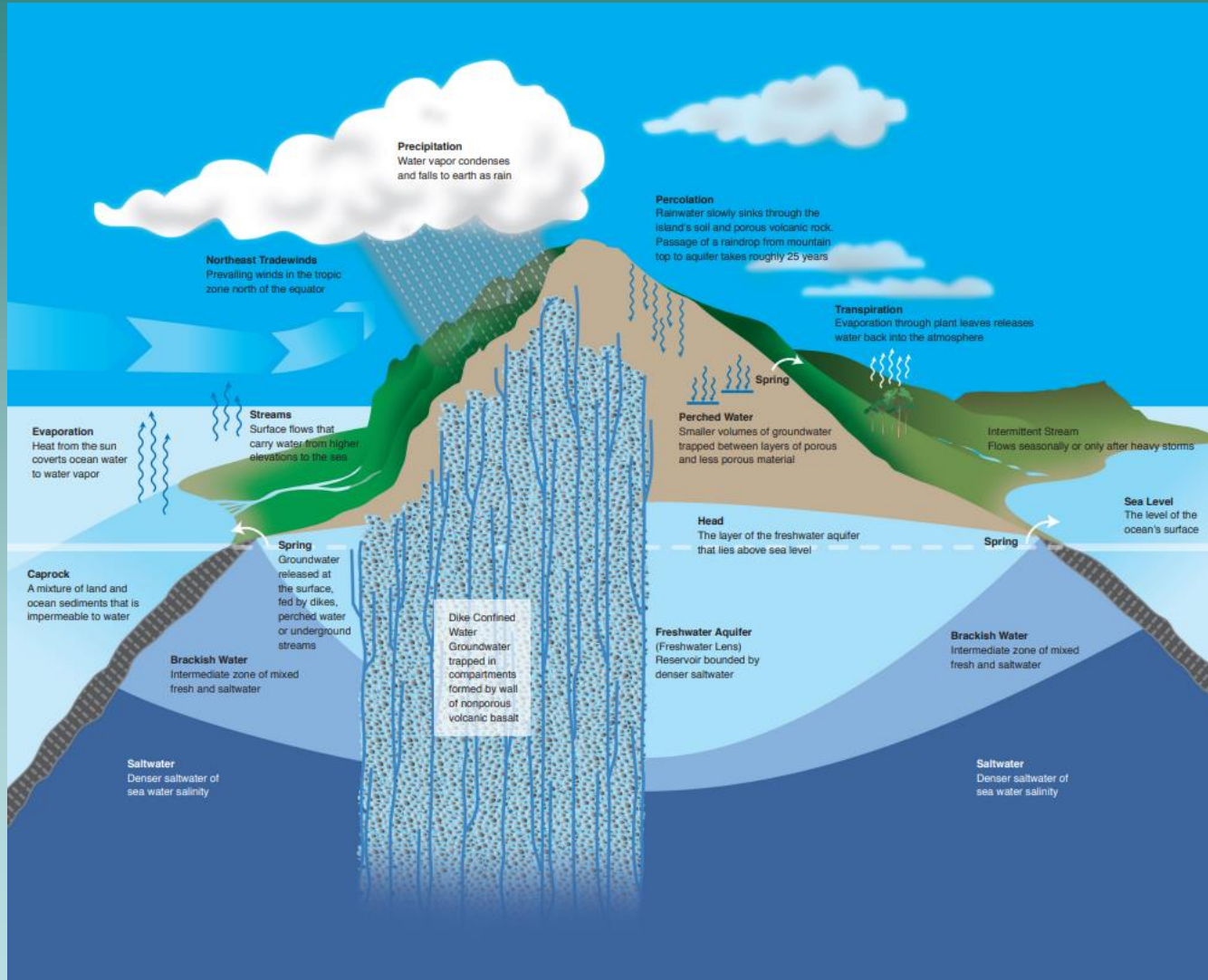
October 16, 2025

# WATER FOR LIFE

*Safe, dependable, and affordable water now and into the future*



Board of Water Supply  
City and County of Honolulu





## Background

- 2002 BWS Watershed Program created
- 2004 Honolulu Department of Human Resources adopts Watershed Resource Specialist series
- 2012 BWS Priority Watersheds
- 2013 Hired 2nd Watershed Resource Specialist  
Initiated Watershed Funding MOAs
- 2021 Hired 2 more Watershed Resource Specialists  
(total of 4)



## BWS Priority Watersheds

### PURPOSE:

Prioritize watersheds from a water supply perspective

Focus funding and implementation efforts



## BWS Priority Watersheds

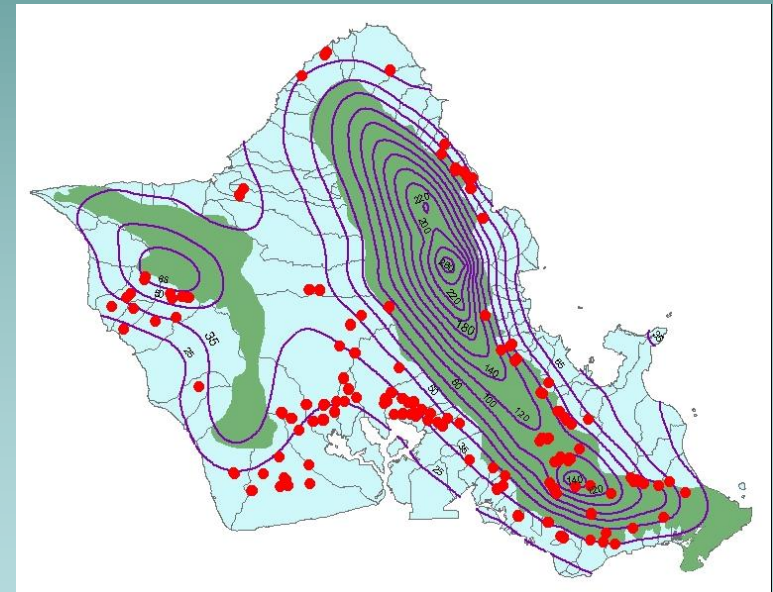
METHOD: Identify INPUTS and OUTPUTS

### Groundwater Recharge (INPUT)

- General soil/rock/vegetation type (ability to capture water for recharge)
- Rainfall (potential amount for recharge)

### Production (OUTPUT)

- Production amount compared with Sustainable Yield
- Chloride concentrations



## BWS Priority Watersheds

Potentially High Recharge Watersheds – Koolau	Potentially High Production / High Chloride Watersheds – Koolau
Waimea	Waikele
Kawainui (North)	Waiawa
Kawaiiki	Kapakahi
Opaeula	Waimalu
Helemano	Kalauao
Poamoho	Aiea
Kaukonahua	Halawa
Waikele	Moanalua
Waiawa	Kalihi
Waimalu	Kapalama
Kalauao	Nuuanu
Halawa	Makiki
Moanalua	Manoa-Palolo
Nuuanu	Ala Wai
Makiki	Waialaenui
Manoa-Palolo	Wailupe
Malaekahana	Kuliouou
Kahawainui	Punaluu
Wai'ele	
Koloa	
Kaipapau	
Maakua	
Waipuhi	
Kaluanui	
Punaluu	
Kahana	
Waikane	
Waiahole	
Kaalaea	
Waihee	
Kahaluu	
Kawainui (South)	

Potentially High Recharge Watersheds – Waianae	Potentially High Production / High Chloride Watersheds – Waianae
Kaupuni	Makaha
Makaha	Kamaileunu
Keaau	Kaupuni
Makua	Makaiwa
Kawaihapai	Kaloi
Pahole	Honouliuli
Makaleha	
Waialua	
Kaukonahua	

## BWS Priority Watersheds

Priority Watersheds (Wai'anae)	Priority Watersheds (Ko'olau)
Kaupuni (Wai'anae Kai)	Waikele (Kipapa)
Mākaha	Waiawa
	Waimalu
	Kalauao ('Aiea)
	Hālawa
	Moanalua
	Nu'uano
	Makiki
	Mānoa-Pālolo
	Punalu'u



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## BWS Priority Watersheds

Link to the poster



<https://www.boardofwatersupply.com/watershedstudies>

**Prioritizing Watersheds From a Water Supply Perspective: Balancing Recharge, Production, Water Quality and Stakeholder Needs for Protection and Restoration Efforts**

Nancy L. Matsumoto and Amy K. Tsunoyoshi  
Honolulu Board of Water Supply  
(Information as of July 2013)

**1. Background**

The Honolulu Board of Water Supply (BWS) recently prioritized watershed areas on Oahu from its water supply perspective, to meet two objectives. First, as a member of both the Koolaua and Waianae Mountain Watershed Partnerships (KMWP and WMWP), the BWS prioritization results serve as input with respect to prioritizing watersheds for future cooperative protection / restoration work. Second, the BWS prioritization results serve as guidance for its own watershed management programs, to focus funding and implementation efforts.

**2. Methods for Prioritizing Watersheds**

There are many methods to prioritize watersheds, depending on stakeholder needs. Some examples include: prioritization based on the presence of a single plant or animal species that is targeted for either protection or eradication; prioritization based on the degree of water quality impairment along a river / stream channel; prioritization using risk assessment formulas that include the vulnerability of the watershed to water quality impairment and its current degree of impairment; prioritization based on a matrix of weighted parameters, such as vegetation type, soil type, human uses, hydrology, and animal species.

The KMWP and WMWP were planning to use the last method, the matrix of weighted parameters, to take into account their range of stakeholder needs. The BWS therefore prioritized the watersheds on Oahu from a water supply perspective, understanding that this prioritization would be folded into the partnership's larger prioritizations, and also serve as a stand-alone prioritization for any sole BWS watershed protection / restoration work.

**3. Watershed Prioritization Parameters**

The BWS focused on two types of parameters, using fundamental concepts of water budgetting – groundwater recharge ("water in") and groundwater production ("water out").

Groundwater recharge parameters included:

- General soil / rock / vegetation type in each watershed (the ability to capture precipitation for groundwater recharge); and
- Relative rainfall amounts across watersheds (potential groundwater recharge amounts).

Groundwater production parameters included:

- Production amounts compared to the sustainable yield defined for watershed regions (how heavily groundwater is being extracted compared to its potential supply, and how much a particular aquifer is relied upon for water supply); and
- Relative chloride concentrations (where impacted a particular aquifer might be due to groundwater extraction).

**4. General Soil / Rock / Vegetation Type**

The U.S. National Resources Conservation Service (NRCS) produced the reference book titled, *Land Erosion Research and Major Land Resource Areas of the United States: the Conterminous and the Pacific Basin*. In this book, general soil, rock and vegetation types for the major islands of Hawaii are described.

On Oahu, the high mountainous areas of the Waianae and Koolaua ranges are described as serving "primarily as areas of groundwater recharge" or as "watersheds for adjacent areas". The soil, rock and to some degree, vegetation cover are similar across these areas, and are classified very rarely, essentially called "Steep Mountain Slopes".

This map shows the "Steep Mountain Slopes" highlighted in green. It should be noted that the KMWP and WMWP partnership boundaries (shown on this map as thin red lines) correspond fairly well to the "Steep Mountain Slopes".

Also, like contour lines (shown on the map as thin purple lines) correspond to several locations in the "Steep Mountain Slopes". While this factor did not refine the prioritization of watersheds, it emphasized that steep mountain slopes may contain dike complexes, which are important components of capturing groundwater for recharge.

In addition to the *Land Erosion* book, the NRCS consistently publishes soil survey results for their ongoing studies completed across the United States. The latest soil survey information for Oahu is extremely detailed, and shows various soil and soil types along much of the steep mountain slopes of the Waianae and Koolaua ranges.

These rock and soil types are relatively well-defined and therefore more suitable for groundwater recharge, compared to the dike areas with lower elevations. All of these classifications and their locations support the *Land Erosion* descriptions of the "Steep Mountain Slopes".

**5. Rainfall Amounts**

The University of Hawaii recently issued a *Rainfall Atlas of Hawaii* presenting mean rainfall for the major islands over the 30-year period, 1978 - 2007. Historic rainfall measurements taken at over 1,000 stations were used to develop the *Rainfall Atlas* maps. To the left is a map based on the *Atlas* showing average annual rainfall across Oahu for that 30-year period.

As expected, there are higher amounts of rainfall along the steep mountain slopes of the Waianae and Koolaua ranges compared to rainfall at lower elevations, which reflects the steepness of the higher mountain slopes to capture precipitation. This supports the previously discussed classification of the "Steep Mountain Slopes" as serving "primarily as areas of groundwater recharge".

**6. Groundwater Production Amounts**

The BWS is the primary groundwater supplier for Oahu. Maps such as the following, which display the Board's groundwater sources (as the red dots) show production occurring across much of the island. One other significant groundwater producer in the U.S. Navy, whose largest production occurs in the Waianae and Red Hill fields.

Groundwater production on Oahu is limited according to "Sustainable Yield". Sustainable Yield may be defined as the maximum groundwater extraction rate that can be sustained without degrading the subject aquifer. Sustainable Yield values are defined by the State Commission on Water Resource Management for the Hydrologic Units (aquifers) across Oahu.

The Commission produced a map that conveniently groups Sustainable Yield values according to BWS production sectors, as shown by the different colors on the map.

The BWS reviewed groundwater production from its sources and the Navy's sources for Calendar Year 2011, and compared production to the Sustainable Yield values by sector. Based on this analysis, it appears that groundwater production is well below the Sustainable Yield values by sector, although the Pearl Harbor, Honolulu and Waianae sectors are starting to near this gap.

**7. Chloride Concentrations**

In order to more realistically evaluate a source's potential for chloride degradation, one should consider both the measured chloride concentration and the source's rate of groundwater production. In other words, a source might exhibit high chloride concentrations, but if this source is rarely used, it might not be as significant in terms of prioritizing the source's watershed.

The BWS accounted for both chloride concentrations and production rates by applying mathematical "indexing" or weighting. In other words, each source's production rate was multiplied by its latest known chloride concentration. Based on this indexing, the highest indexed sources are associated mainly with the BWS Pearl Harbor and Honolulu production sectors.

**8. Prioritization and Recommendations**

Based on our review of the above-mentioned parameters, the BWS began prioritizing the watersheds on Oahu. First, for convenience the watersheds were separated into the Waianae and Koolaua mountain ranges. Next, four lists of watersheds were generated, which were subsequently further prioritized:

- Some notes regarding how these four lists were generated.
- The NRCS "Steep Mountain Slopes" and soil survey classifications were extensive and did not sufficiently narrow the list of watersheds on Oahu; therefore, rainfall was relied upon as the primary parameter.
- Rainfall isobars of 50 inches and above for the Waianae range and 120 inches and above for the Koolaua range were used to define the watersheds with the potentially highest recharge. These isobars were chosen based on several factors.
- First, these isobar patterns roughly correspond with the boundaries of the "Steep Mountain Slopes", particularly along the Koolaua range. Second, using 50 inch isobar / data, we calculated land area and rainfall volume for each watershed isobar. Based on these calculations, the areas that fell within the above-mentioned isobars plus those in a value center approximately one-third of the total rainfall for their respective mountain range, while encompassing slightly less than 17 percent of the total land area of Oahu. Finally, these isobars were used to define watersheds with higher-value isobars tend to capture too few watersheds to be beneficial, while lower-value isobars tend to capture too many watersheds to be practical.
- With respect to potentially high production / high chloride watersheds, we selected watersheds having sources within the Pearl Harbor, Honolulu and Waianae sectors, based on their relatively high production compared to their Sustainable Yields. As a cross-check and to further refine the list of watersheds, watersheds having sources exceeding a 1.0 index (i.e., production > chloride) were selected. These comprised roughly the top quarter of all sources indexed. It happened that these sources were already in the Pearl Harbor and Honolulu sectors noted earlier for high index values.
- Because these four lists were still rather extensive, further prioritization was done by selecting those watersheds that are present on both the "Potentially High Recharge" and "Potentially High Production / High Chloride" lists of their respective mountain range.
- Following are location maps for the "Real Priority" lists, one list for Waianae watershed and one list for Koolaua watersheds.

**9. Final Priority Lists**

Two maps showing the final priority lists for Waianae and Koolaua watersheds.

**10. Summary**

It should be noted that, in addition to all the prioritization parameters covered, the demand from major agricultural irrigation systems was also considered. The Waianae, Waialae and Waianae irrigation systems encompass about 10 miles, 23 miles, and 15 miles of transmission dikes, respectively. The systems draw a mixture of groundwater and surface water from the following watersheds:

- Waianae Irrigation System: Koolaua, Waianae, Waialae, Waianae.
- Waianae Irrigation System: Koolaua, Waianae, Waialae, Waianae.

Because all of these watersheds already appear on the "Potentially High Recharge" lists (Waianae appears on both the "Potentially High Recharge" and "Potentially High Production / High Chloride" lists), the watersheds were incorporated into the final prioritization recommendations.

**11. Recommendations**

One recommended strategy for future watershed protection / restoration work is as follows:

- First priority: Focus efforts on watersheds that appear on both "Potentially High Recharge" and "Potentially High Production / High Chloride" lists.
- Second priority: Focus efforts on other watersheds appearing on only the "Potentially High Recharge" lists, particularly those associated with the Waianae, Waialae, and Waianae irrigation systems.
- Third priority: Focus efforts on other watersheds appearing on only the "Potentially High Production / High Chloride" lists of certain high recharge watersheds are infeasible for protection / restoration work, due to factors such as difficult site access or a high degree of protection measures already in place.

The reasoning behind these levels of prioritization is that most of the factors affecting the "potentially high recharge" watersheds such as rainfall, cover results in altered (i.e., a long period of time is needed to develop a good forest canopy), while the primary factor affecting the "high production / high chloride" watersheds (i.e., production rates) can be altered to some degree if needed, by shifting pumping patterns.

Finally, this effort was limited to identifying entire watersheds, although it is understood that the focus for future projects will be in the higher-elevation portions of these watersheds, above the target subjects mentioned previously. Selecting specific project sites is left to future efforts.





## BWS Watershed Funding

Initiated in FY14

BWS Funding Memoranda of Agreements (MOA)

Government to Government agreements

5-year terms



## BWS Watershed Funding

Projects are discussed with measurable deliverables

Proposals are submitted annually for BWS approval in the next FY budget

Projects are awarded (subject to available funding) and typically accomplished within 1 year

Reports are submitted per project/FY funding



## Watershed Funding FY14 to FY26

FY14	\$40,000
FY15	\$230,000
FY16	\$237,721
FY17	\$504,018
FY18	\$505,840
FY19	\$672,075
FY20	\$801,615

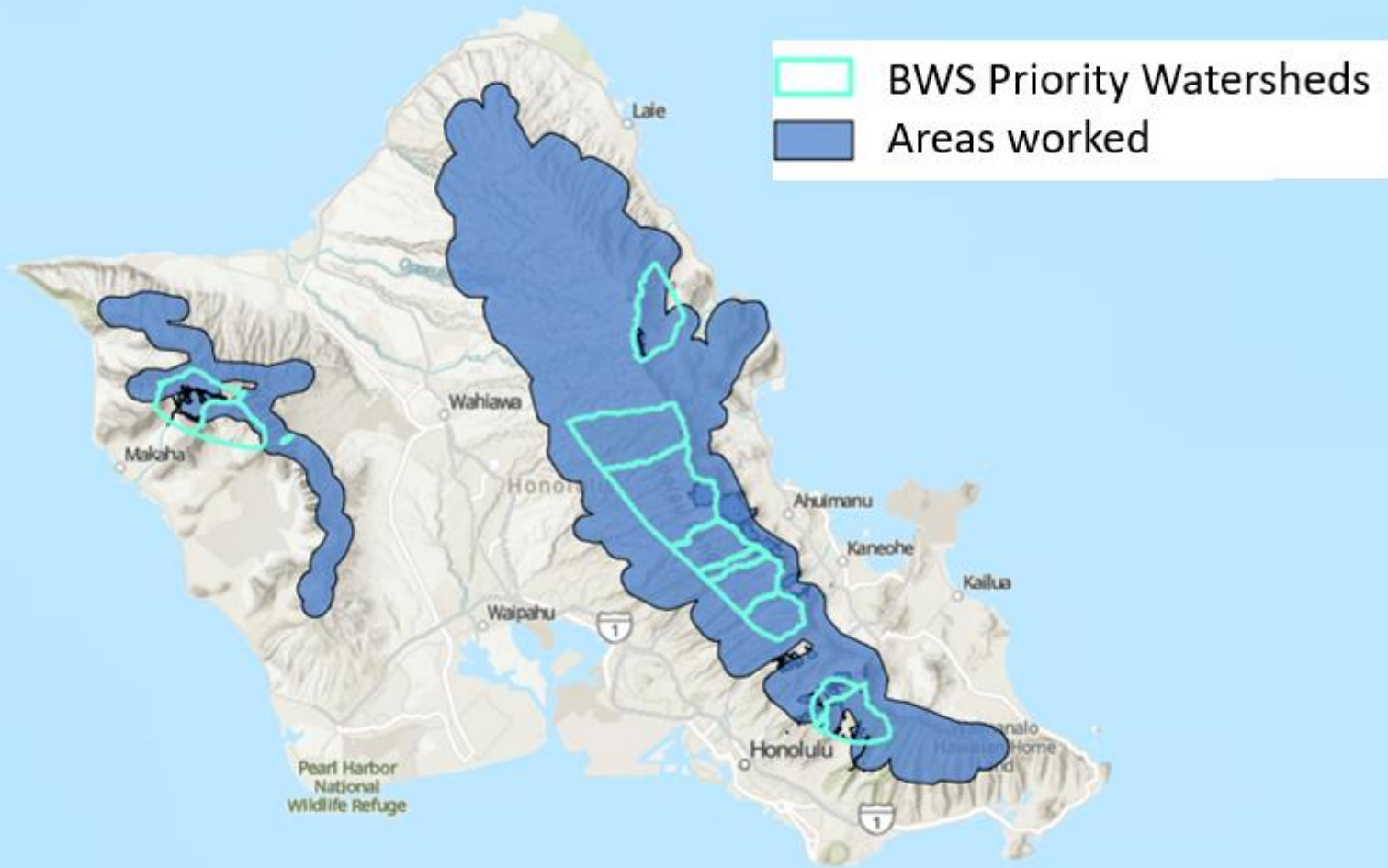
FY21	\$914,128
FY22	\$855,089
FY23	\$1,021,276
FY24	\$1,084,646
FY25	\$1,272,781
FY26	\$1,426,778

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## Benefits to BWS

Watershed protection and natural resource management activities help to:

- improve the forest's ability to capture and retain rainfall
- reduce erosion and sedimentation
- improves ground water recharge.



## Benefits to BWS

BWS funding can be used to match additional funding (State/Federal) to increase watershed management activities.

Increased outreach about the importance of watershed protection and ground water recharge to school groups and the public by our partners.



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**O'ahu Invasive Species Committee**  
**BWS was founding member**  
**Formed in 2001**  
**Funding MOA expires 2028**



Photos courtesy of OISC

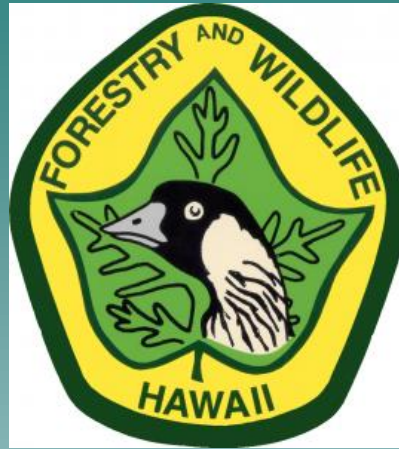
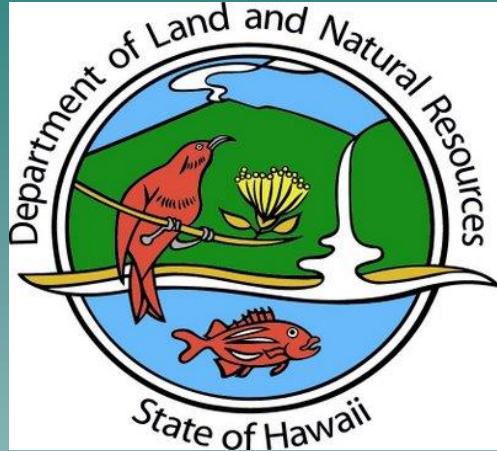


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**Department of Land and  
Natural Resources (DLNR)  
Division of Forestry and  
Wildlife (DOFAW)**

**Funding MOA expires 2028**



Photos courtesy of DLNR/WMWP





## **Ko'olau Mountains Watershed Partnership**

**BWS was a founding member**

**Formed in 1999**

**Funding MOA expires 2030**



Photos courtesy of KMWP



## Wai'anāe Mountains Watershed Partnership

BWS was a founding member

Formed in 2010

Funding MOA expires 2030



Photos courtesy of WMWP





**‘A‘ohe Hana Nui ke Alu ‘ia.**

**No task is too big when done together by all.**

- Mary Kawena Pukui

## **Wai‘anae Mountains Watershed Partnership**

• Yumi Kam

• WMWP Program Manager



WMWP is a voluntary partnership between major landowners and stakeholders in the Waianae Mountains. The partnership was formed on April 22, 2010 with 7 original partners signing a Memorandum of Understanding.

Partners:

- Department of Land and Natural Resources
- Gill Ewa Lands
- Honolulu Board of Water Supply
- Ka'ala Farms Inc.
- Ka'ala Ranch
- MA'O Organic Farm
- Oahu Army Natural Resources Program
- Navy Region Hawaii

Associate Partners:

- Malama Learning Center
- Oahu Invasive Species Committee
- Oahu Plant Extinction Prevention Program
- US Fish and Wildlife

47,121 acres of mauka conservation land in the Wai'anae Mountains

WMWP is a project under the University of Hawaii on behalf of the College of Natural Sciences for the Pacific Cooperative Studies Unit





# Wai'anae Mountains Watershed Partnership

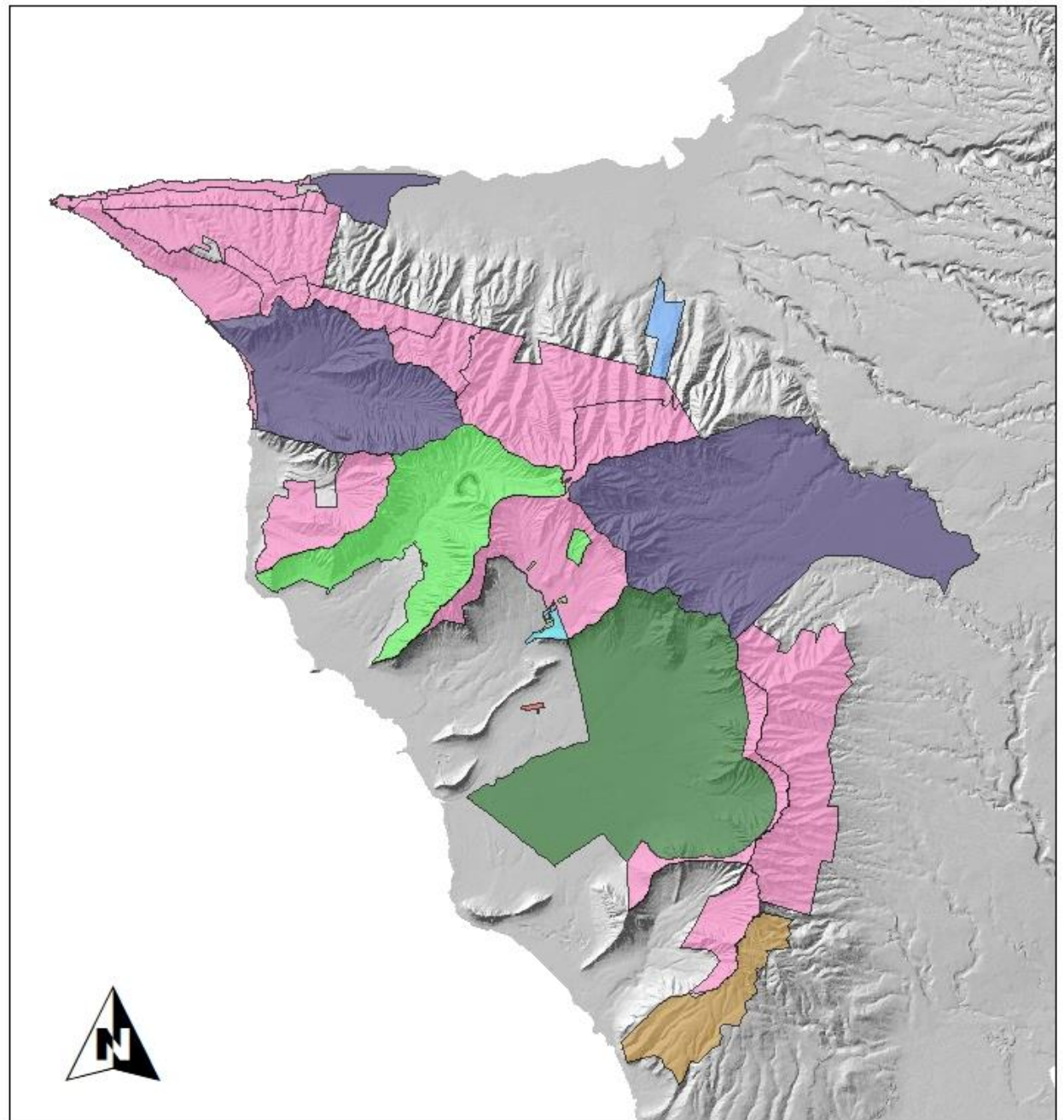
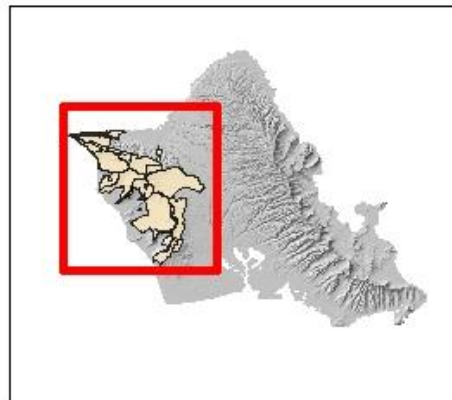
## Legend

### WMWP

### Landowners

- Army
- County (HBWS)
- Gill Ewa Lands
- Kaala Farms
- Kaala Ranch
- Mao Organic Farms
- Navy
- State (DLNR)

0 2.5 5 Miles





# Waianae Kai Forest Reserve – Wildfire Fuel Load Reduction, Vegetative Fire Break Installation, Native Plant Restoration

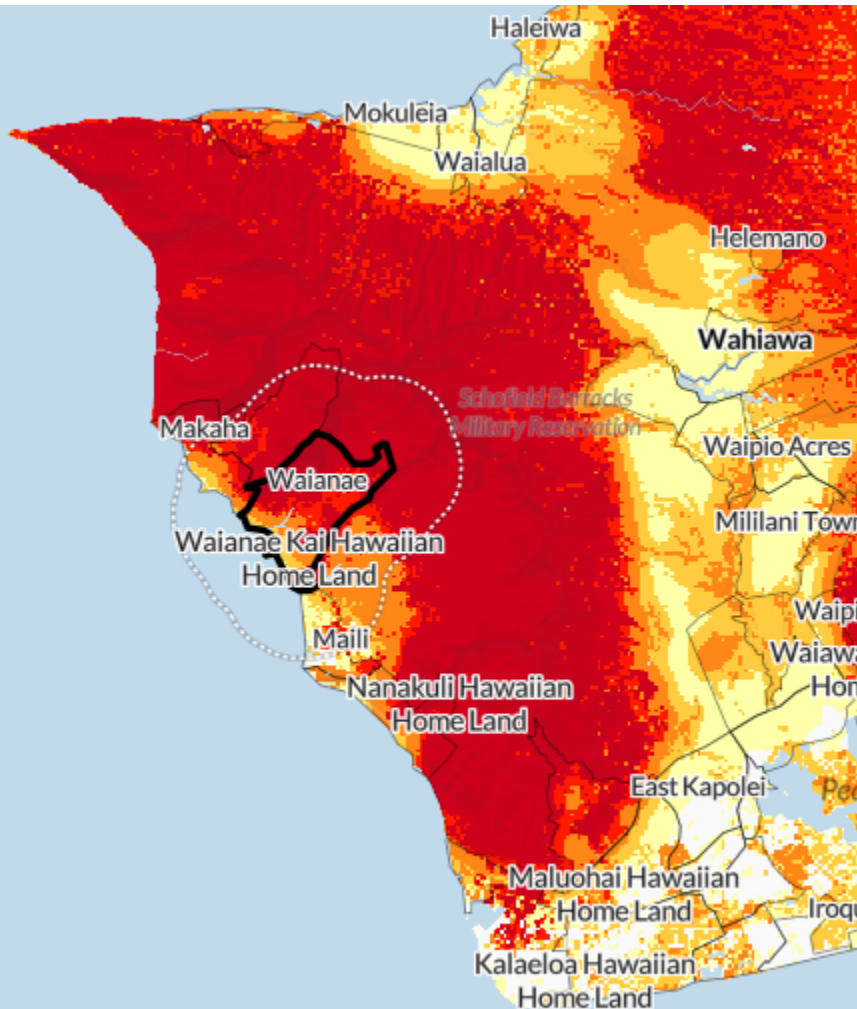




## Homes in Waianae have, on average, greater risk than 100% of communities in the US.

Wildfirerisk.org

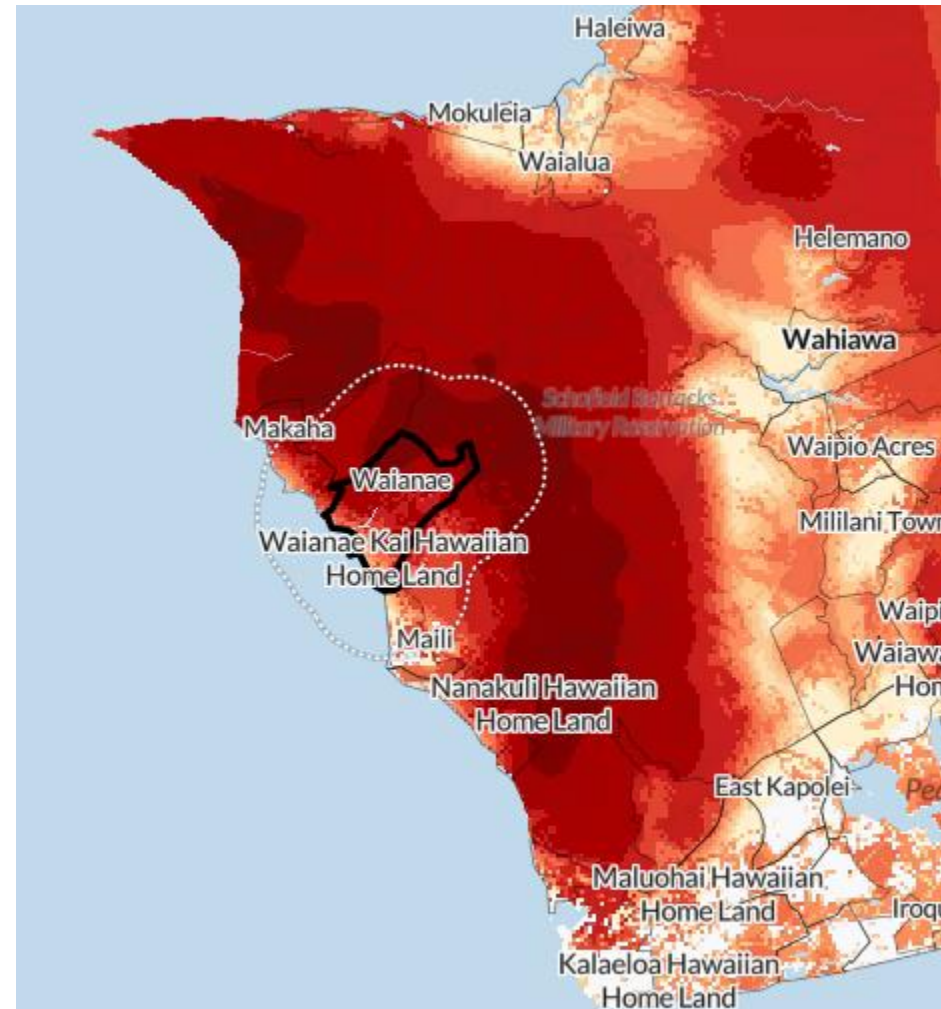
Risk to homes measures the relative consequence of wildfire to residential structures everywhere on the landscape, whether a home actually exists there or not.



## Waianae has, on average, greater wildfire likelihood than 100% of communities in the US.

Wildfirerisk.org

Wildfire likelihood is the probability of wildfire burning in any given year.









# Waianae Kai Forest Reserve – Wildfire Fuel Load Reduction, Vegetative Fire Break Installation, Native Plant Restoration





# Nurseries and Propagation





# Makaha Valley – Fuel Load Reduction, Fire Break Installation









# Makaha Valley

## Weed Control, Ecosystem Restoration, Erosion Management



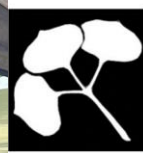












O'ahu  
Army  
Natural  
Resources  
Program



Mālama  
Learning  
Center

