

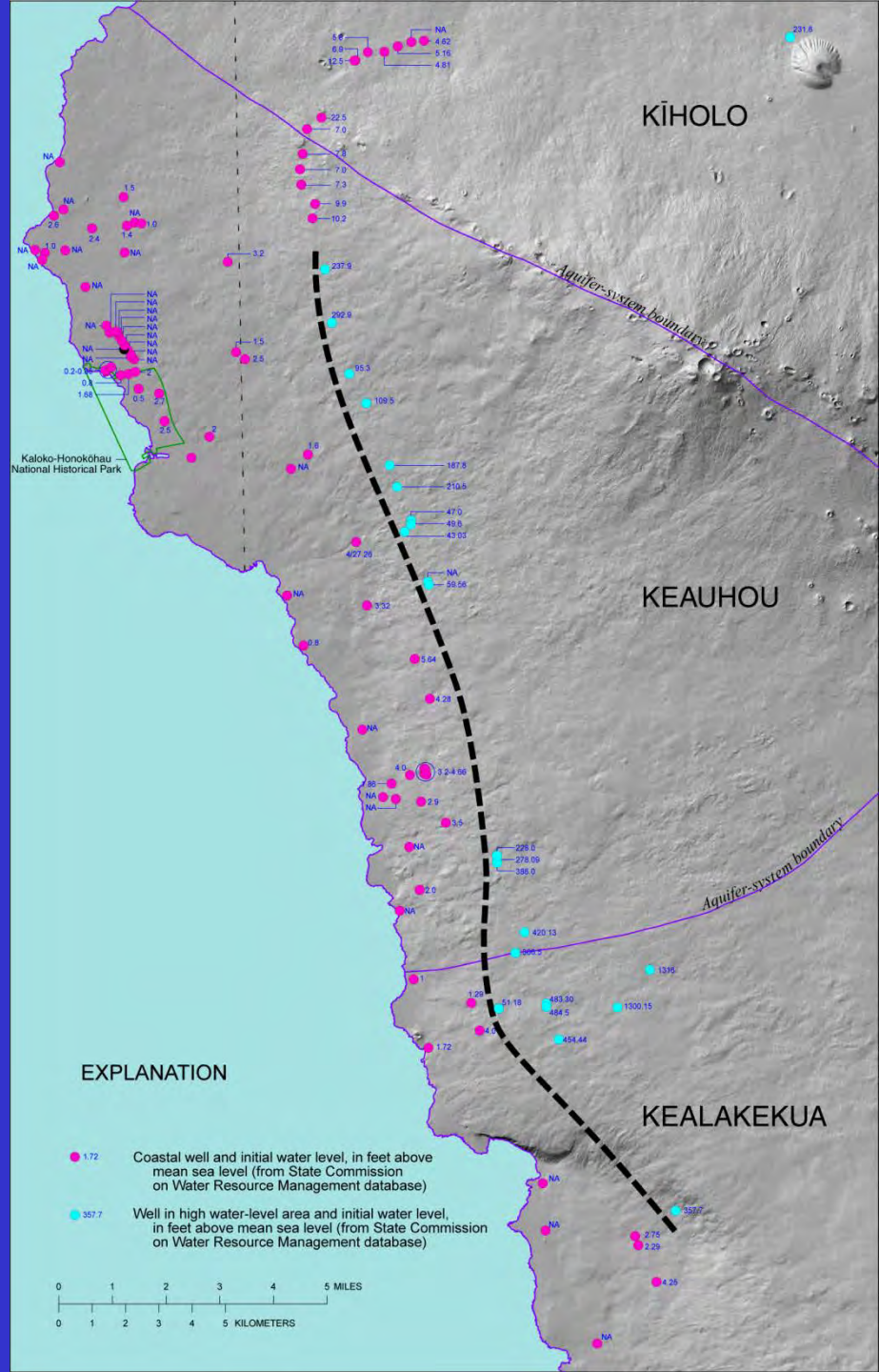
Use of Water Isotopes to Evaluate High-Level Groundwater Contribution to Coastal Groundwater, Kona, Hawai'i

Commission on Water Resource Management
Kona, Hawai'i
9/17/2014

Delwyn S. Oki, Fred D Tillman, Adam G. Johnson
U.S. Geological Survey

Groundwater Levels

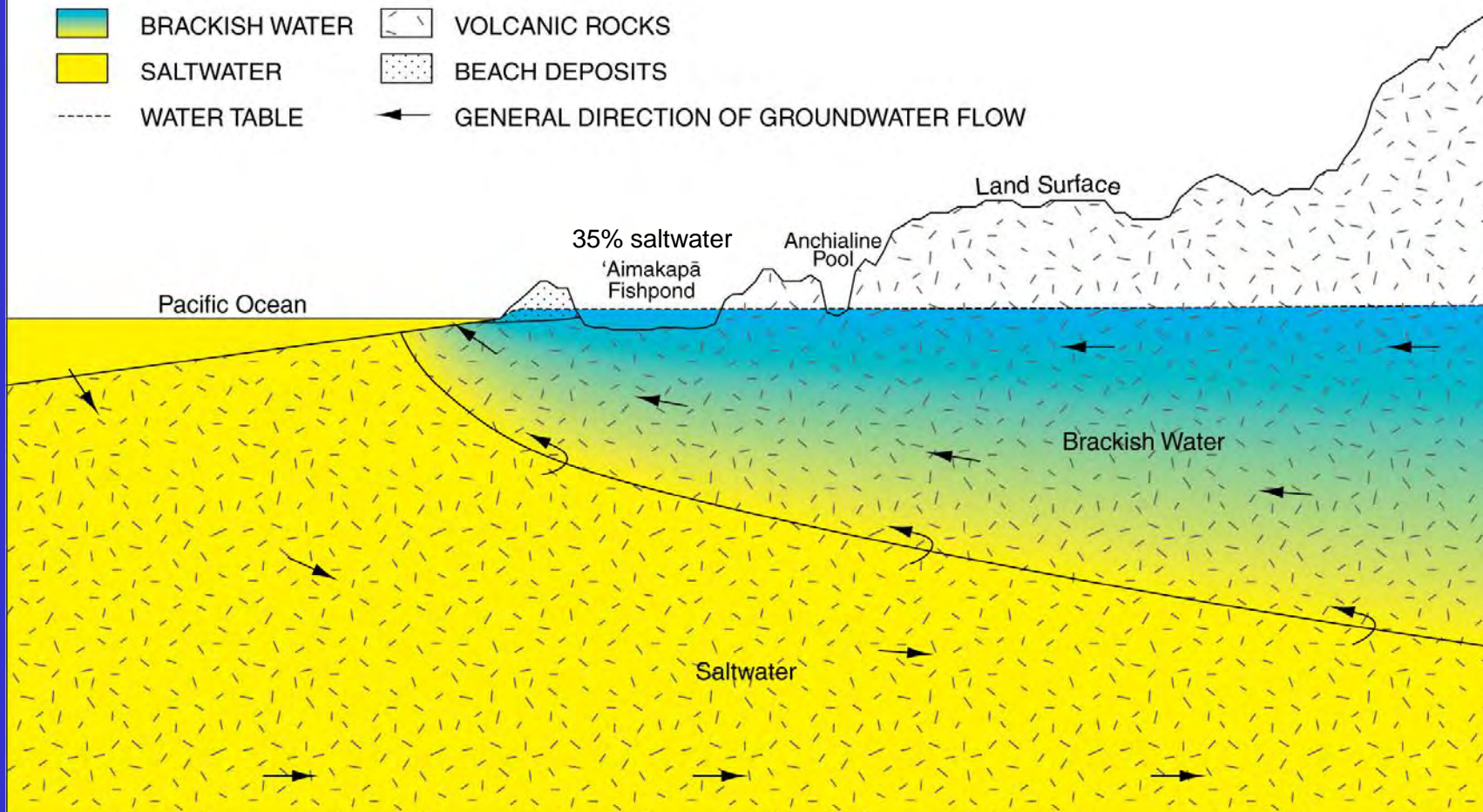
- Well in coastal system (water table generally less than 3 feet)
- Well in inland system (water table greater than 40 feet)



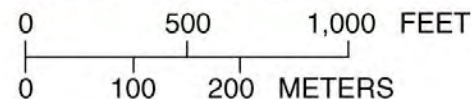
Coastal Groundwater System

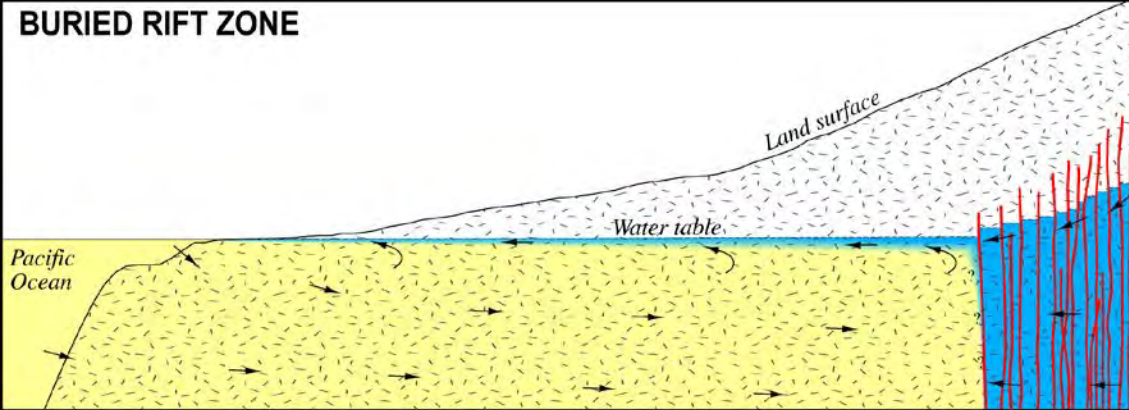
EXPLANATION

- BRACKISH WATER
- SALTWATER
- WATER TABLE
- VOLCANIC ROCKS
- BEACH DEPOSITS
- GENERAL DIRECTION OF GROUNDWATER FLOW



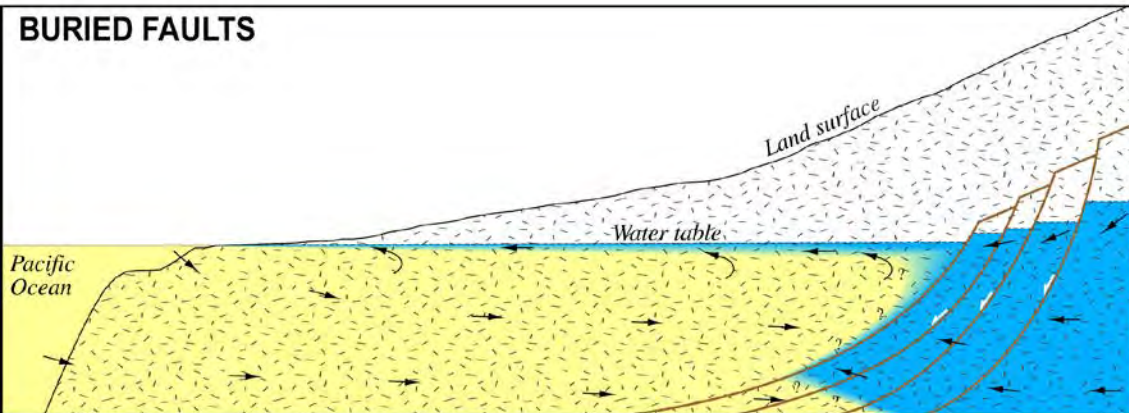
Vertical scale greatly exaggerated



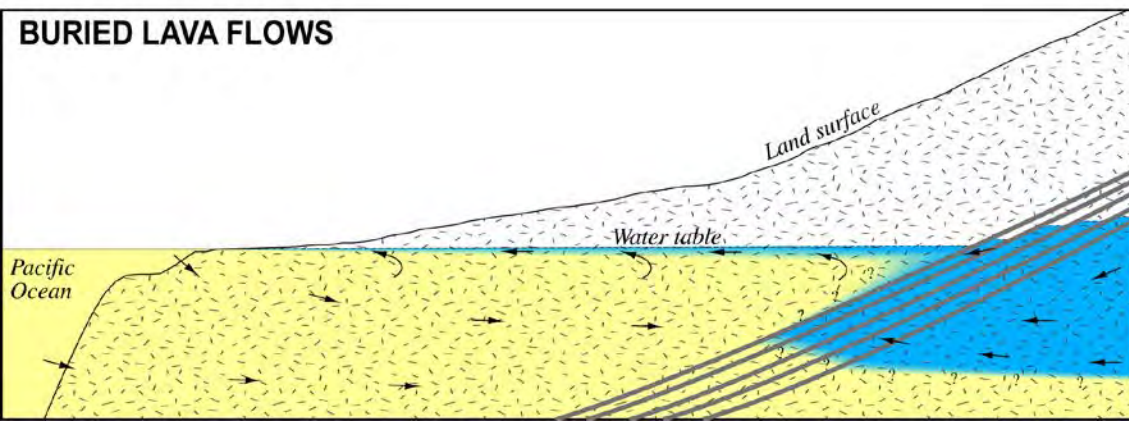


Origin of High Water Levels

Intrusive, low-permeability dikes

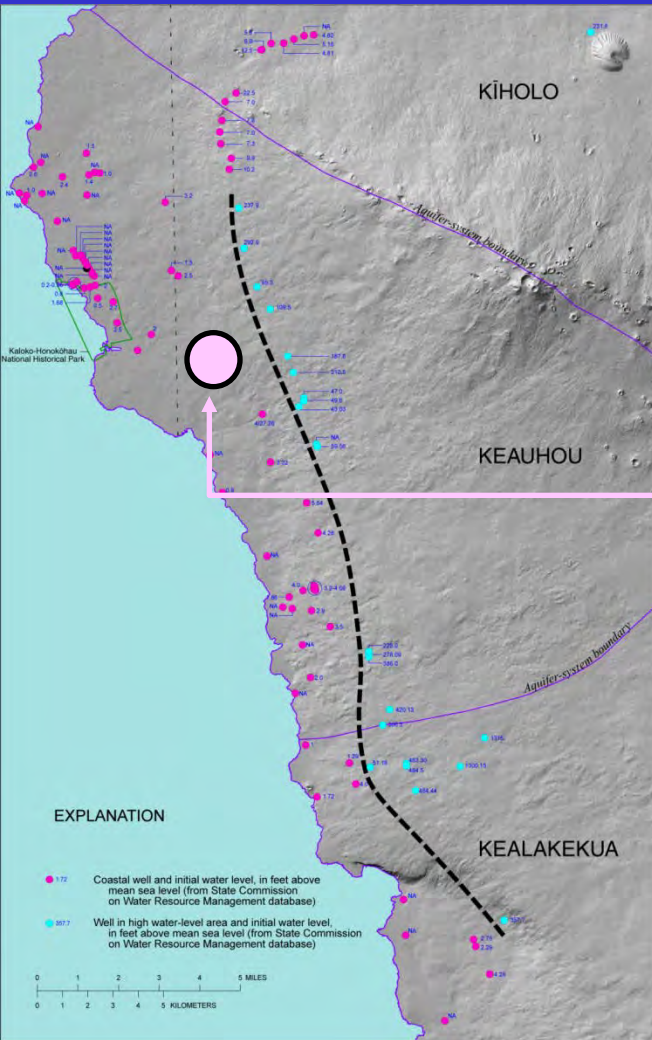


Faults draped with younger lava flows

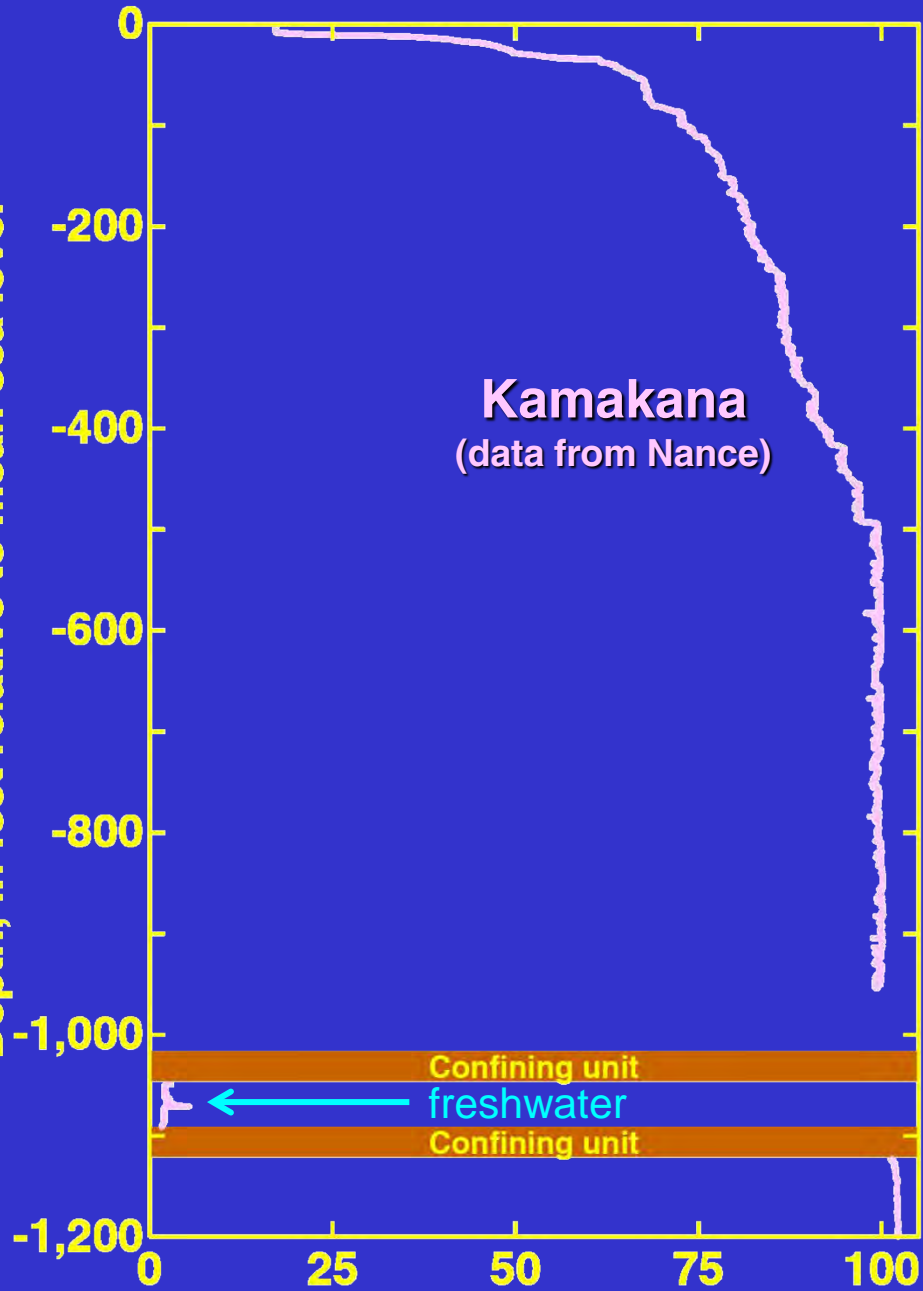


Low-permeability layers (ash, lava flows, weathered rock)

Salinity Profile



Depth, in feet relative to mean sea level

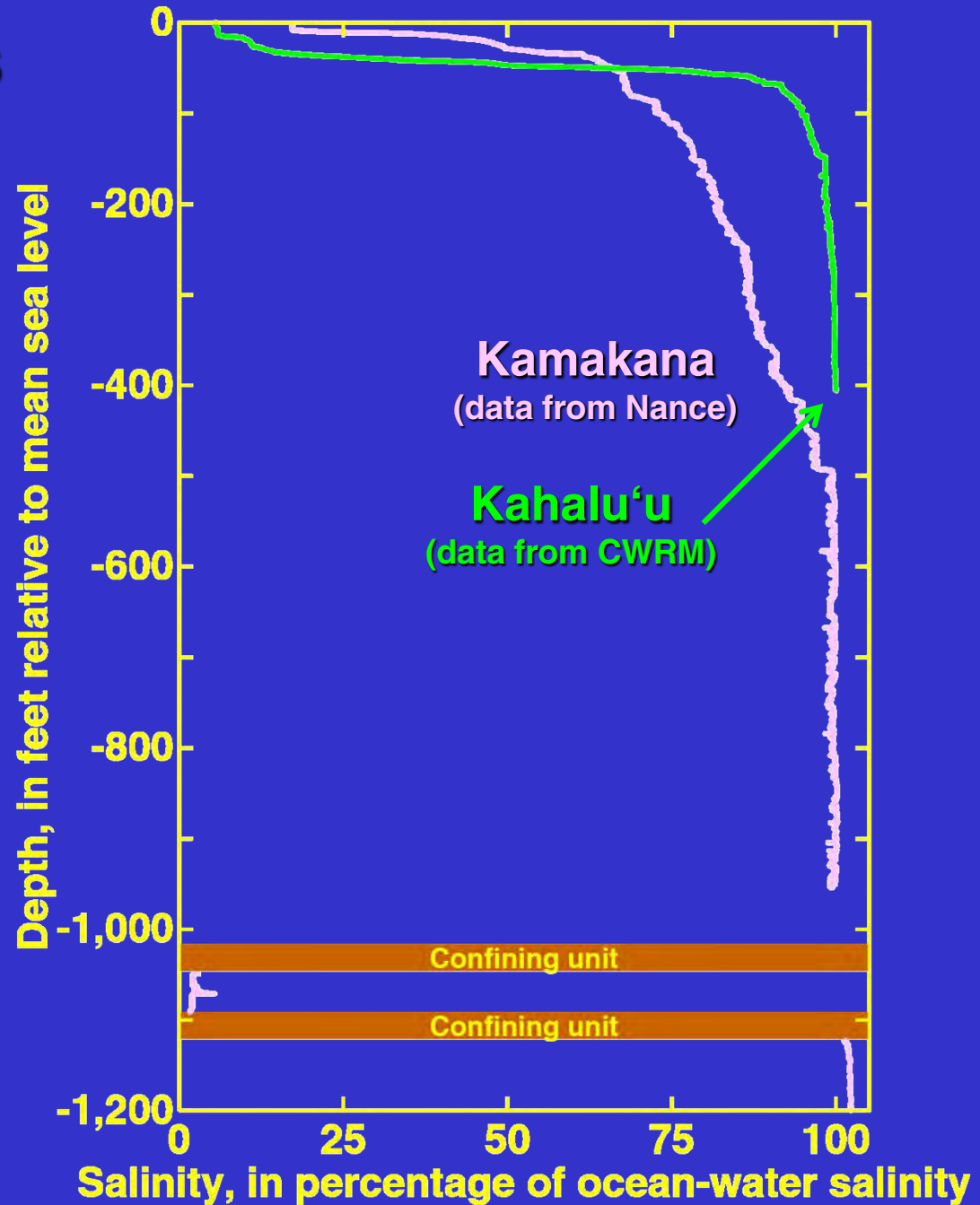
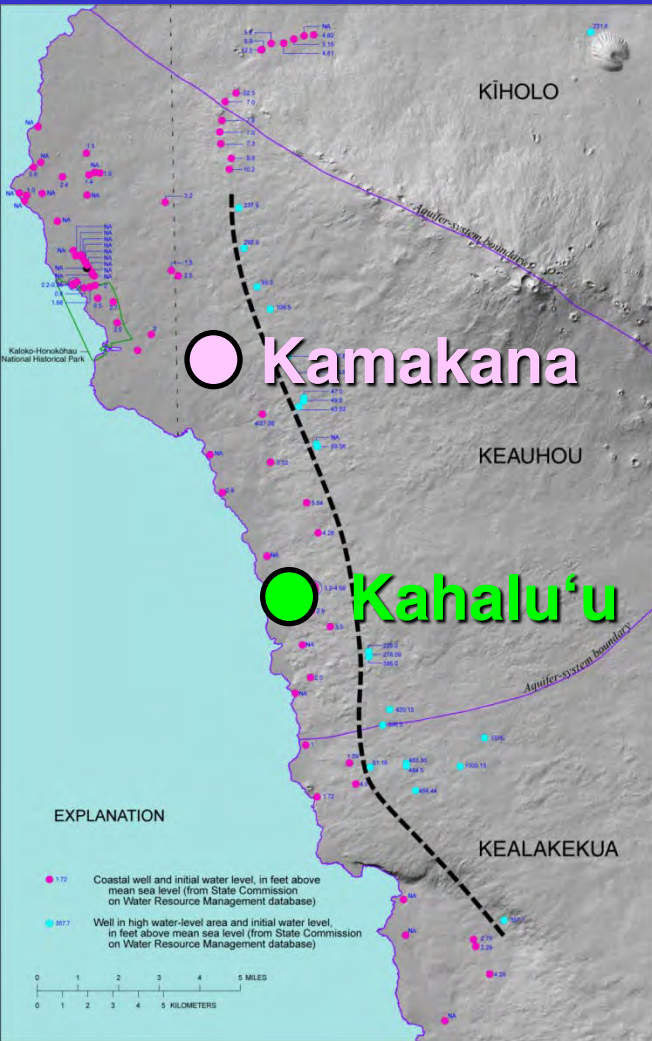


Kamakana
(data from Nance)

Confining unit
freshwater
Confining unit

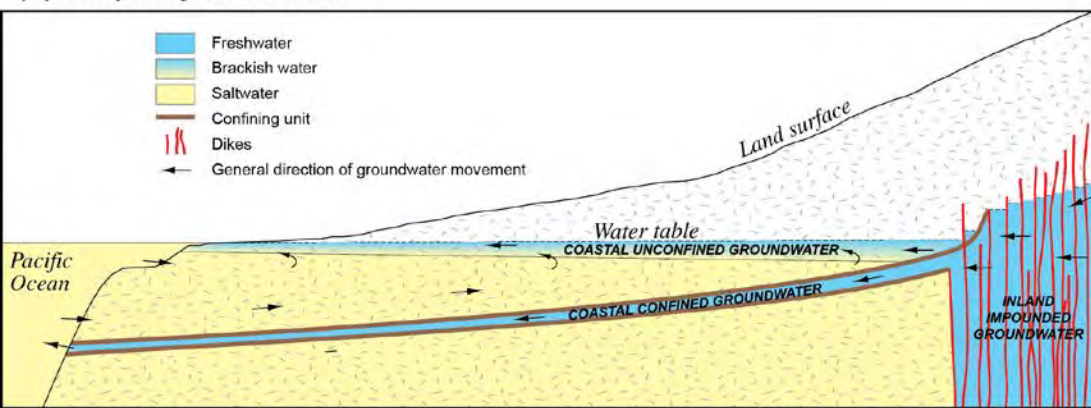
Salinity, in percentage of ocean-water salinity

Salinity Profiles



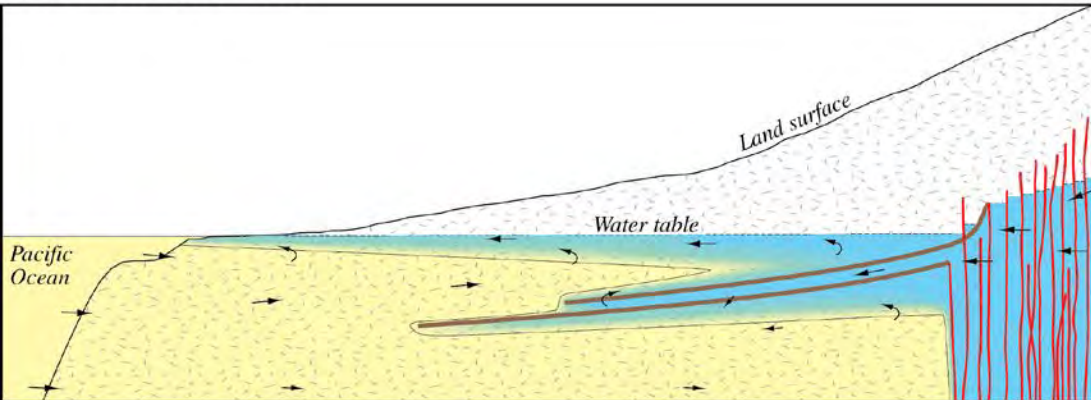
Connection between groundwater bodies

(A) Completely disconnected



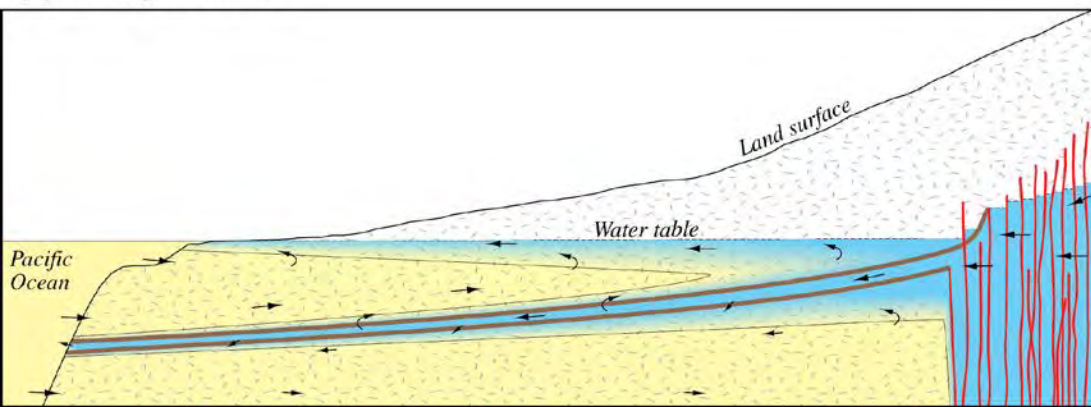
A. Zero high-level groundwater discharges to freshwater lens

(B) Completely connected



B. All of the high-level groundwater discharges to freshwater lens

(C) Partially connected



C. Some of the high-level groundwater discharges to freshwater lens

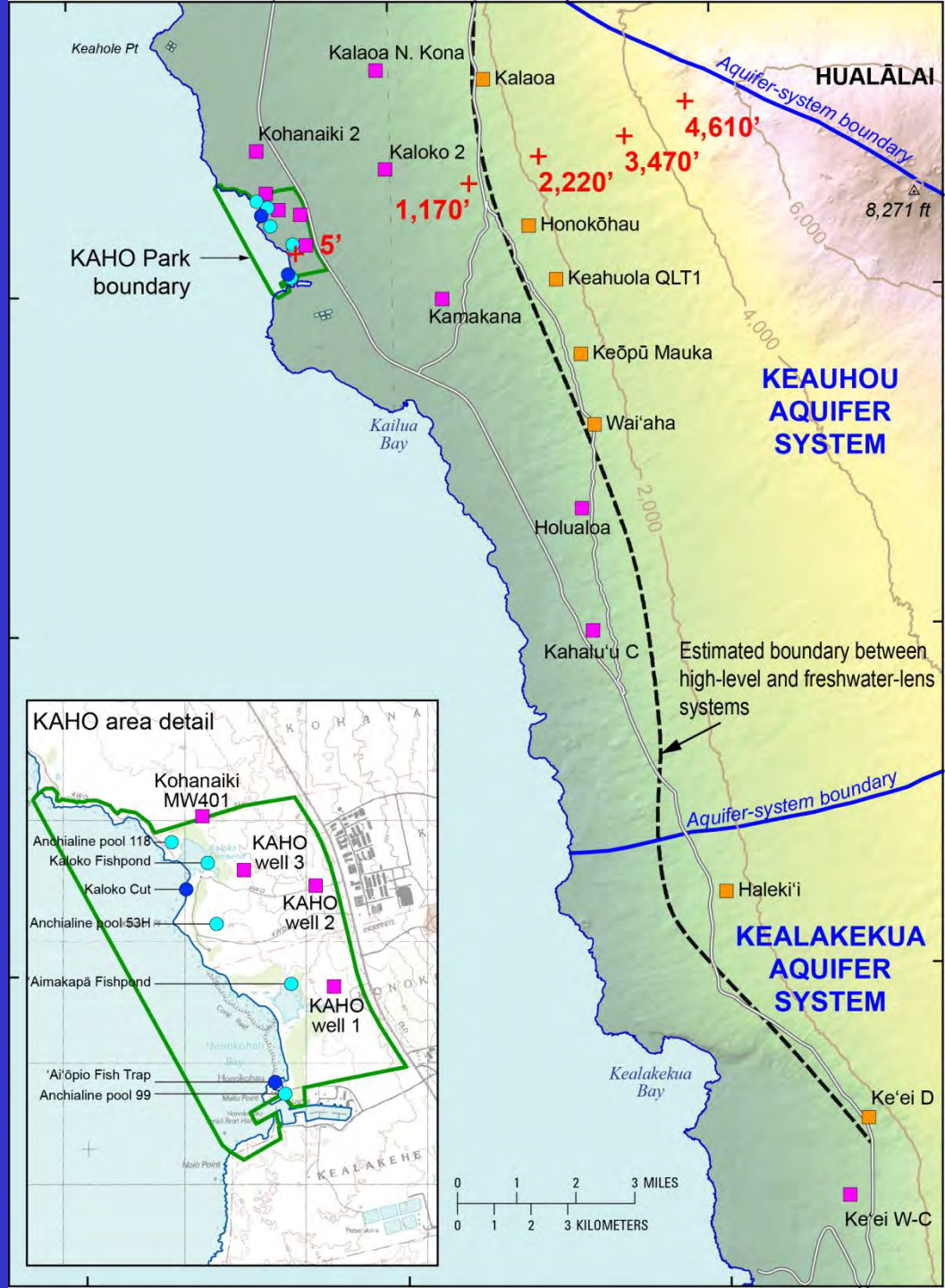
Groundwater Tracer Study

- Multi-agency funding
 - Commission on Water Res. Management
 - National Park Service
 - USGS
- Evaluate connection between high-level and coastal systems
- Use geochemical tracers
 - Stable water isotopes
 - Major ions
 - Trace elements
 - Rare earth elements
 - Strontium isotopes



Sample Sites

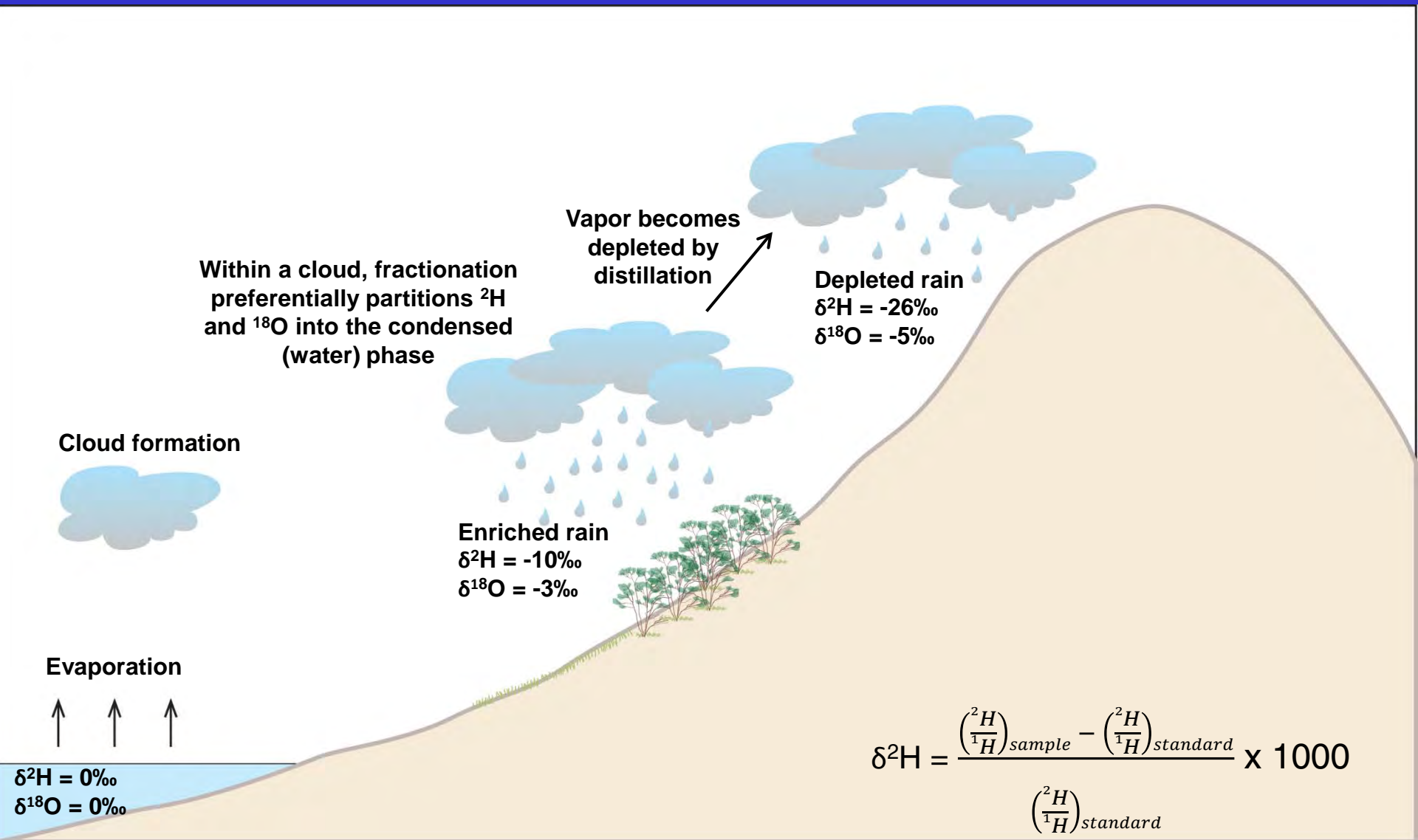
- 7 wells, high-level system
- 11 wells, freshwater-lens
- 5 ponds/pools
- 2 ocean sites
- + 5 precipitation collectors



Water Isotopes--Background

- Isotopes of an element have same number of protons but different number of neutrons
- Hydrogen has two main isotopes
 - ^1H (protium) has one proton and no neutrons
 - ^2H (deuterium) has one proton and one neutron
- Oxygen has two main isotopes
 - ^{16}O has 8 protons and 8 neutrons
 - ^{18}O has 8 protons and 10 neutrons

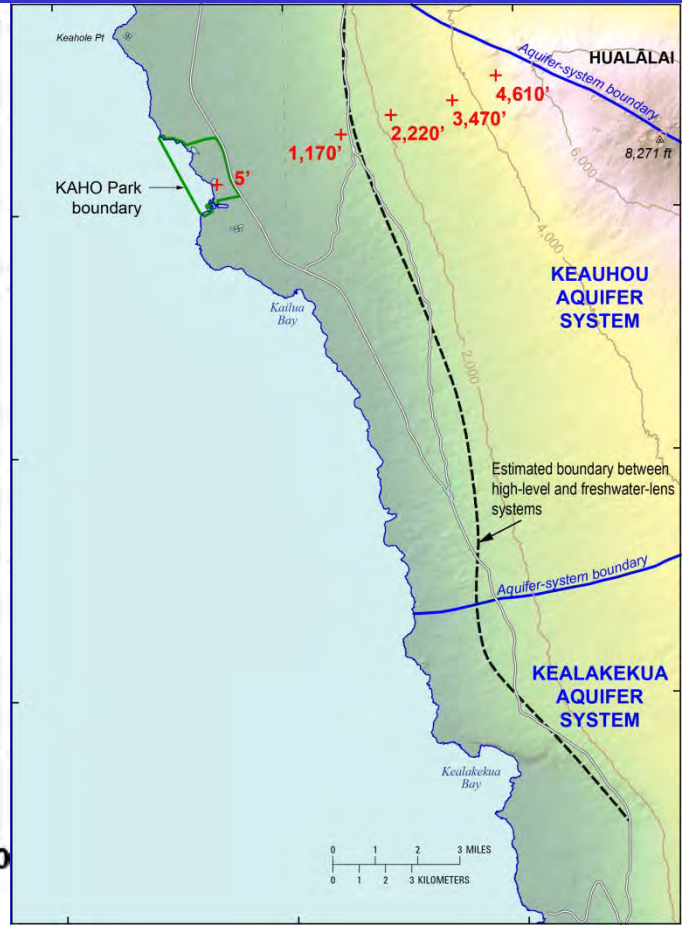
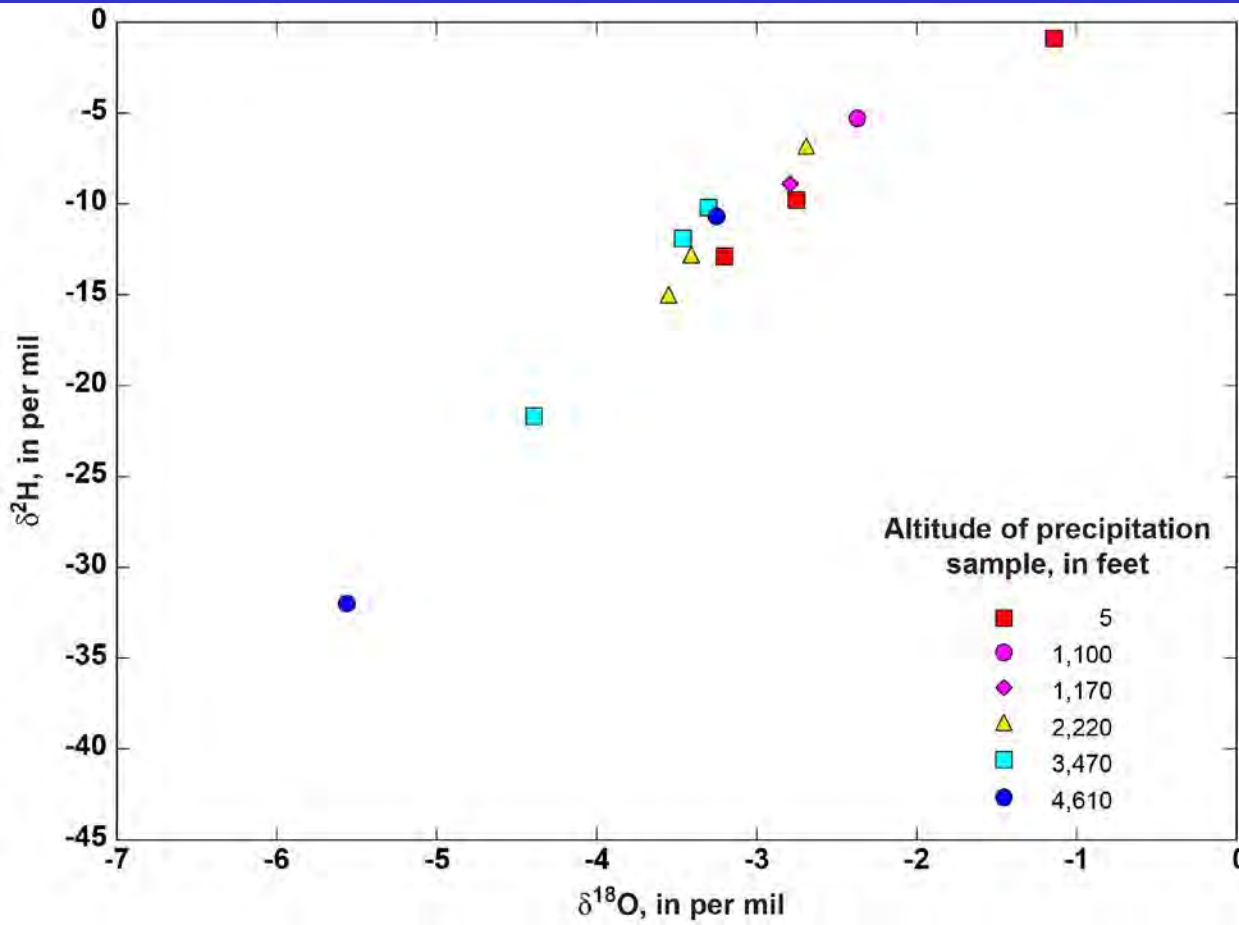
Water Isotopes--Rain



$$\delta^2\text{H} = \frac{\left(\frac{^2\text{H}}{^1\text{H}}\right)_{\text{sample}} - \left(\frac{^2\text{H}}{^1\text{H}}\right)_{\text{standard}}}{\left(\frac{^2\text{H}}{^1\text{H}}\right)_{\text{standard}}} \times 1000$$

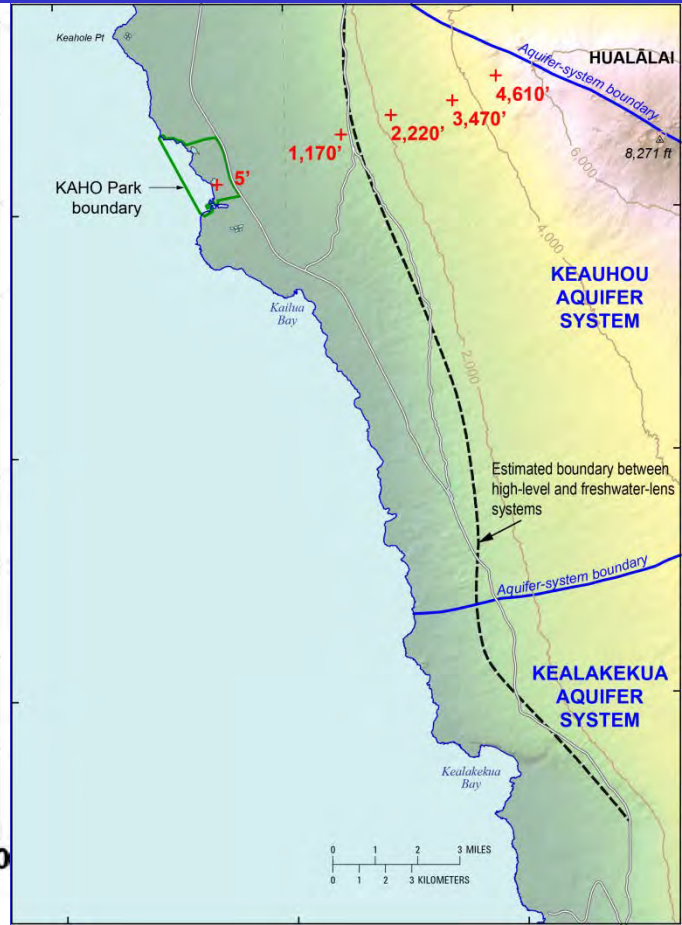
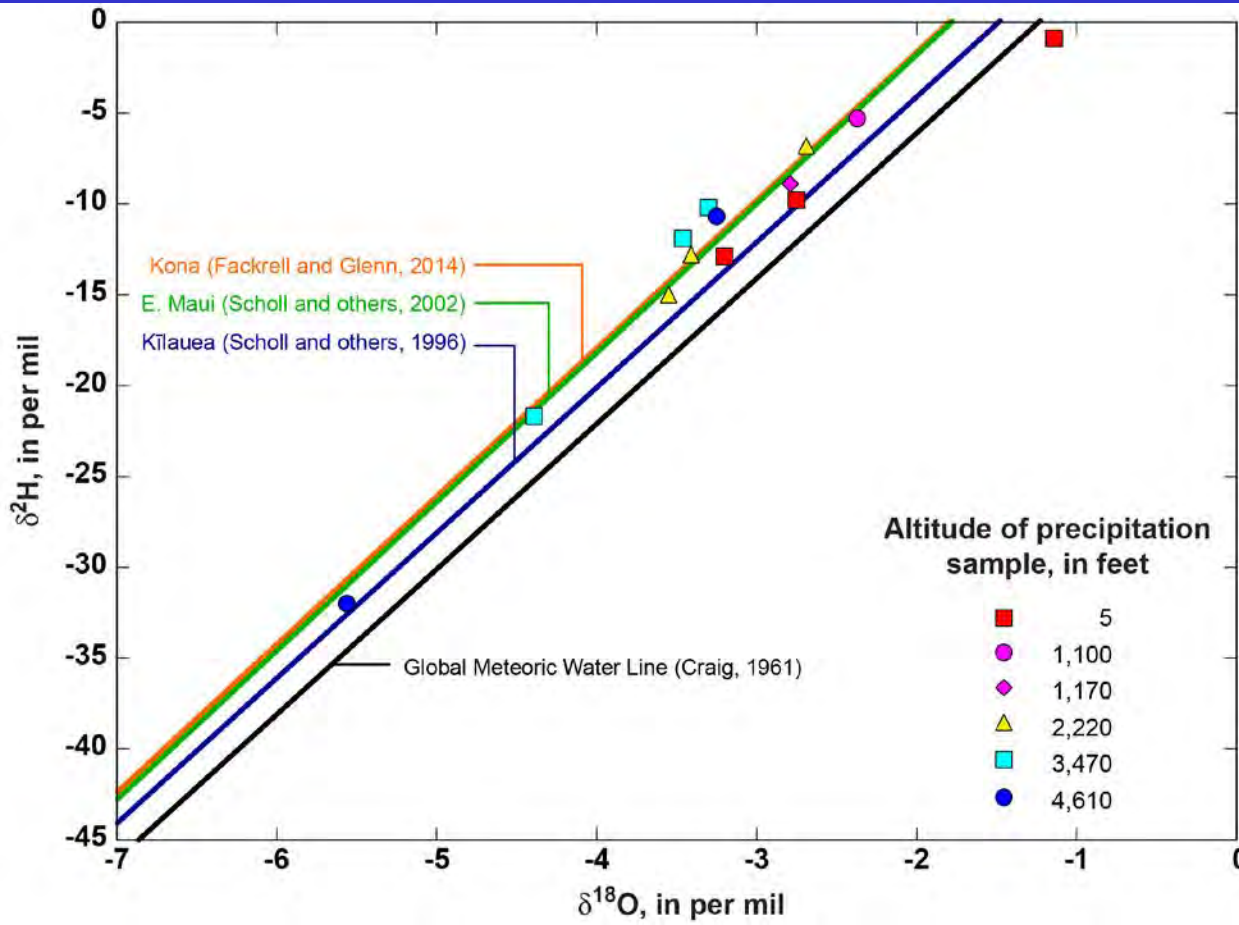
Precipitation

- Hualālai transect
- 5 to 4,610 feet altitude
- Collection period 09/2012 to 03/2014

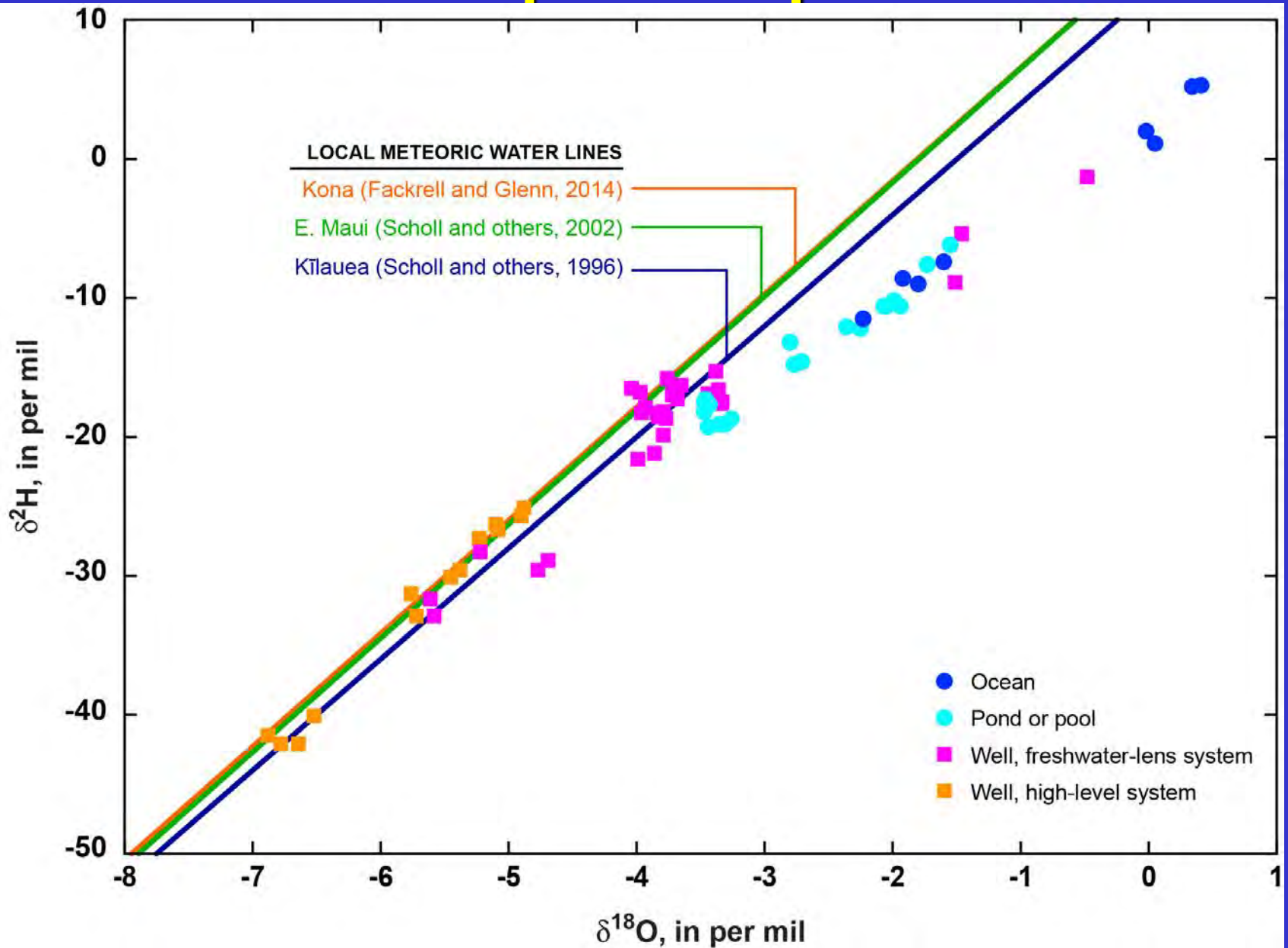


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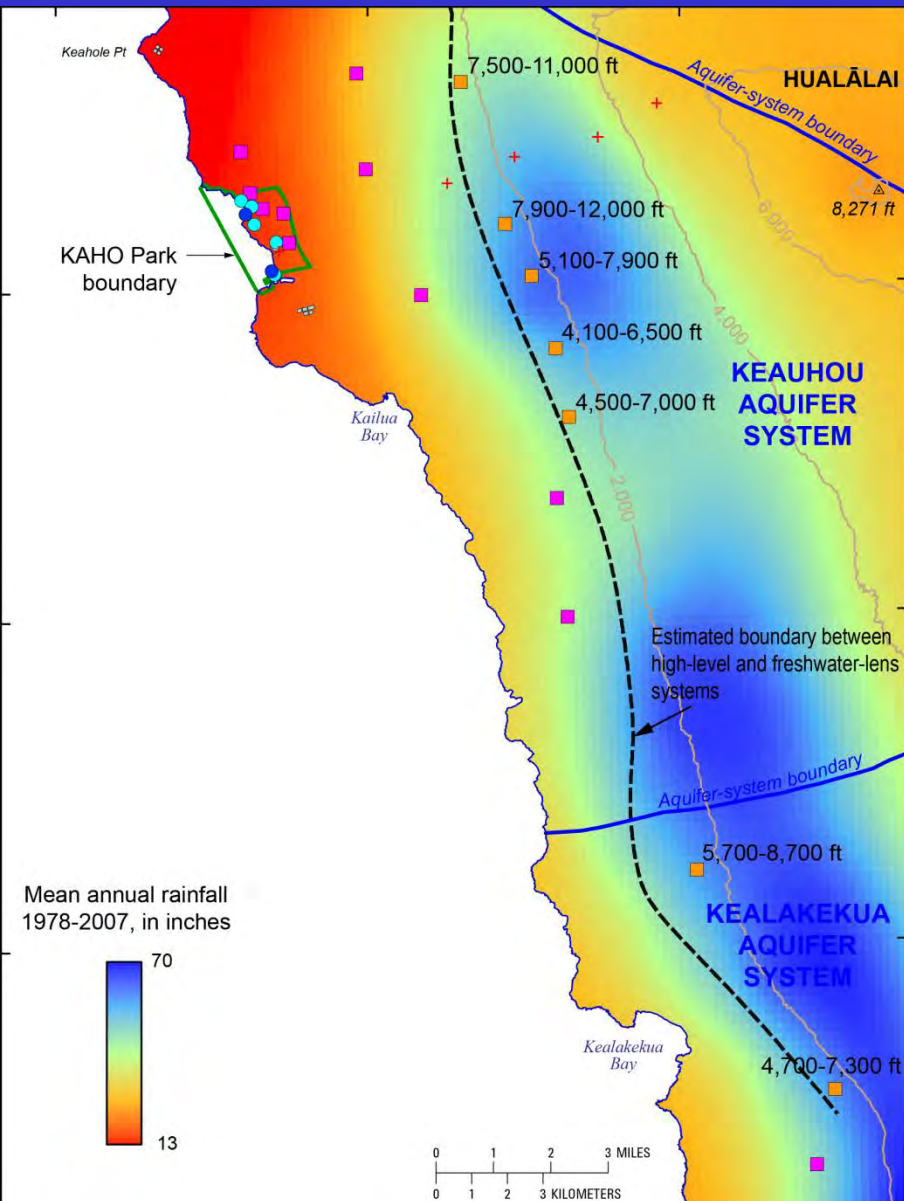


Sample Isotopes

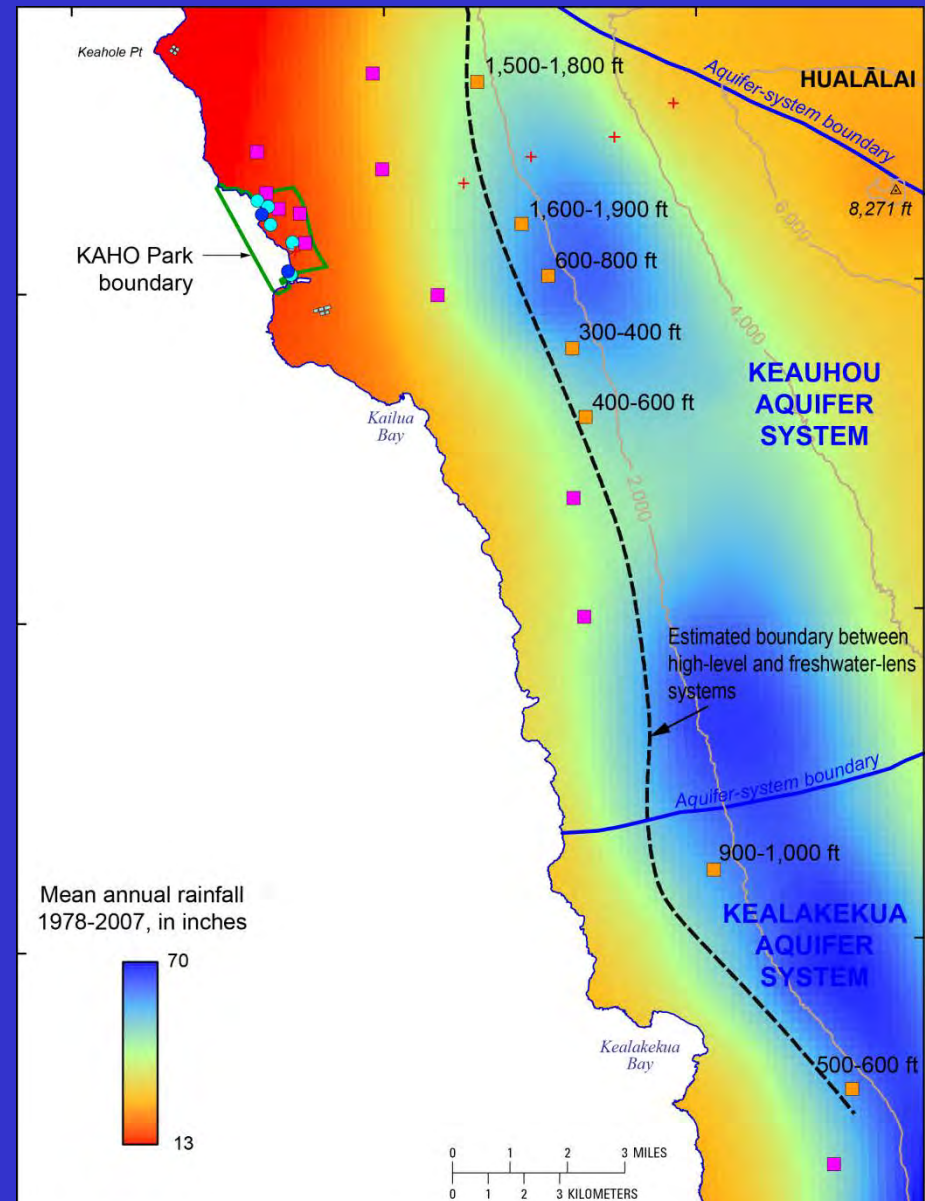


Aggregate Recharge Altitude

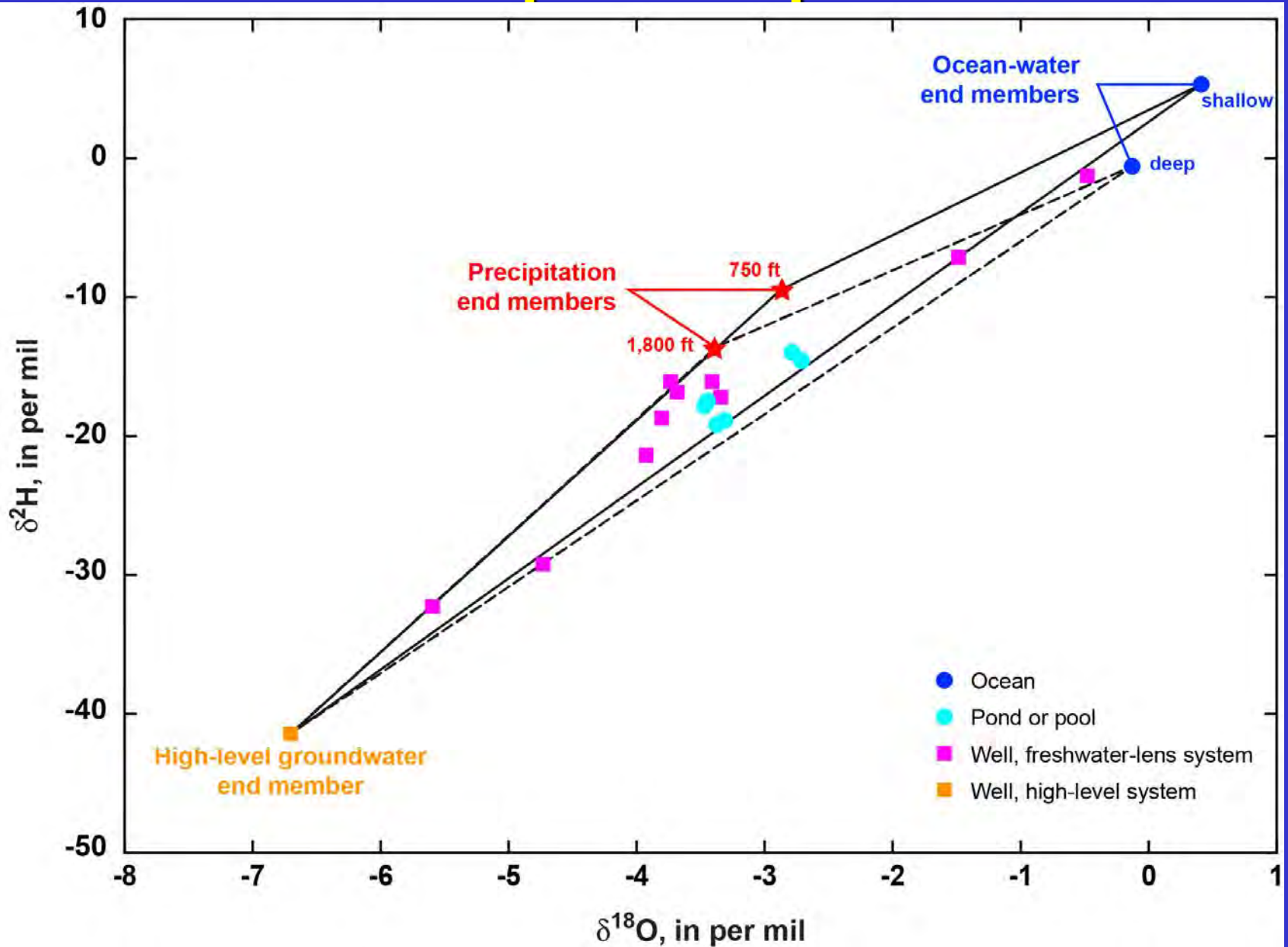
Trade-wind relations



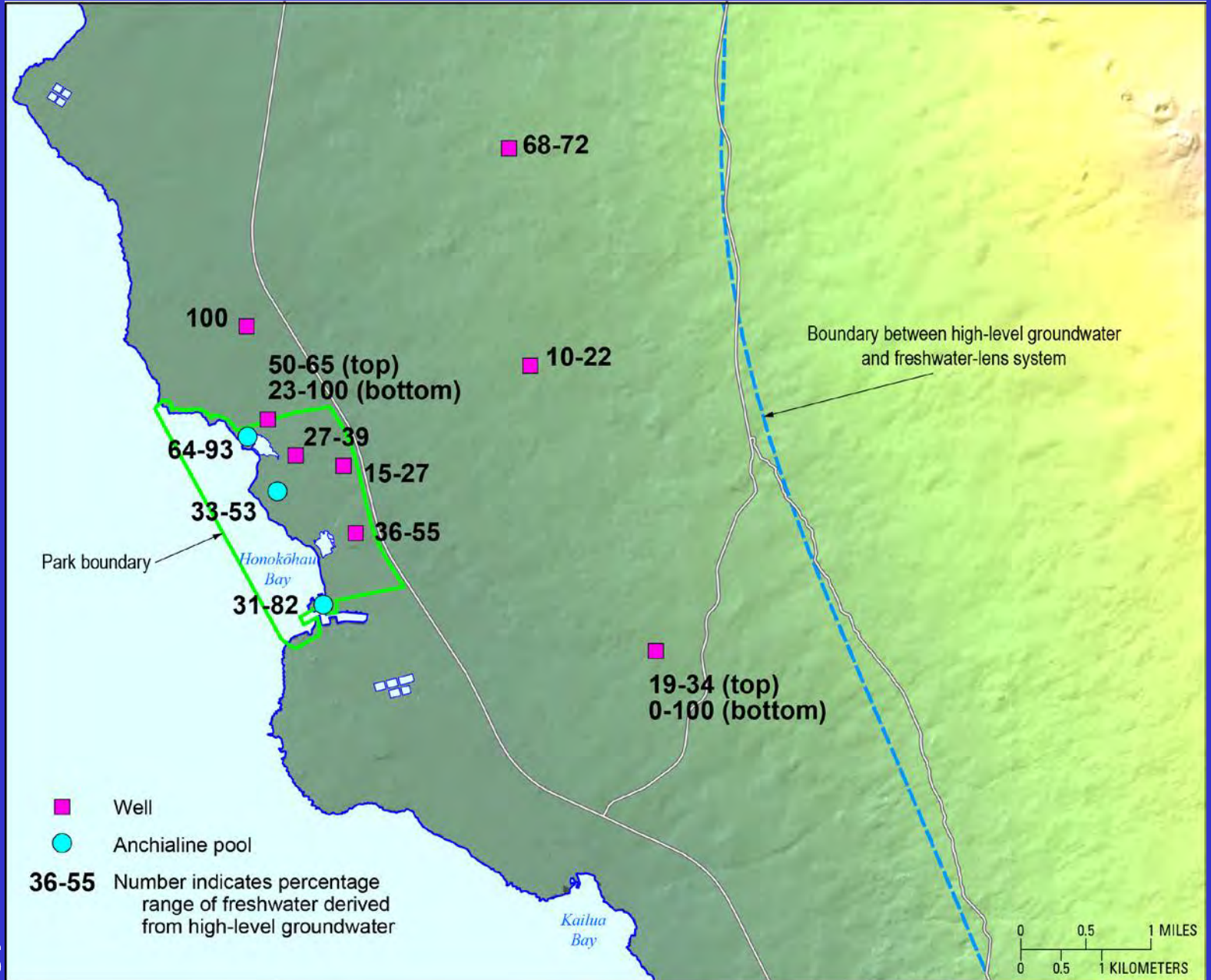
Rain-shadow relations



Sample Isotopes



Percentage of Freshwater from High-Level System



Data Needs

- Additional wells would help to constrain the spatial extent of deep freshwater and conceptual model of the groundwater system
- Geophysical studies could provide insight into the hydrogeological setting
- Long-term collection of rainfall isotope data would better constrain the isotope-altitude relation

Summary

- Existing information is consistent with some degree of hydrologic connection between the high-level and coastal groundwater systems
- The isotopic composition of the freshwater component of groundwater in the Park indicates about 25-70 percent high-level groundwater (about 10-15 percent may be from irrigation or septic systems)
- Additional wells and data would improve our understanding of the Kona groundwater system

Recent and Planned Publications



Prepared in cooperation with the Hawai'i Commission on Water Resource Management and the National Park Service

Water-Chemistry Data Collected in and near Kaloko-Honokōhau National Historical Park, Hawai'i, 2012–2014



Open-File Report 2014–1173

U.S. Department of the Interior
U.S. Geological Survey

- Hunt, C.D., Jr., 2014, Baseline water-quality sampling to infer nutrient and contaminant sources at Kaloko-HonokMhau National Historical Park, Island of Hawai'i, 2009: U.S. Geological Survey Scientific Investigations Report 2014-5158.
- Tillman, F.D, Oki, D.S., Johnson, A.G., 2014, Water-chemistry data collected in and near Kaloko-HonokMhau National Historical Park, Hawai'i, 2012-2014: U.S. Geological Survey Open-File Report 2014-1173, 14 p.
- Tillman, F.D, Oki, D.S., Johnson, A.G., Barber, L.B., and Beisner, K.R., submitted, Investigation of geochemical indicators to evaluate the connection between inland and coastal groundwater systems near Kaloko-HonokMhau National Historical Park, Hawai'i.
- Oki, D.S., in progress, Numerical simulation of groundwater, Kaloko-HonokMhau National Historical Park, Hawai'i.