



Groundwater Recharge Estimates for the Kona Area

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



USGS Water Mission

- Provide scientific information to manage, protect, and enhance water resources
- Address water-related hazards
- Non-regulatory role
- Provide information that is reliable, impartial, and timely

Pacific Islands Water Science Center Core Capabilities

Hydrologic Data Collection

- Climate
- Streamflow and suspended sediment
- Groundwater levels and salinity
- Water quality

Research and Assessments

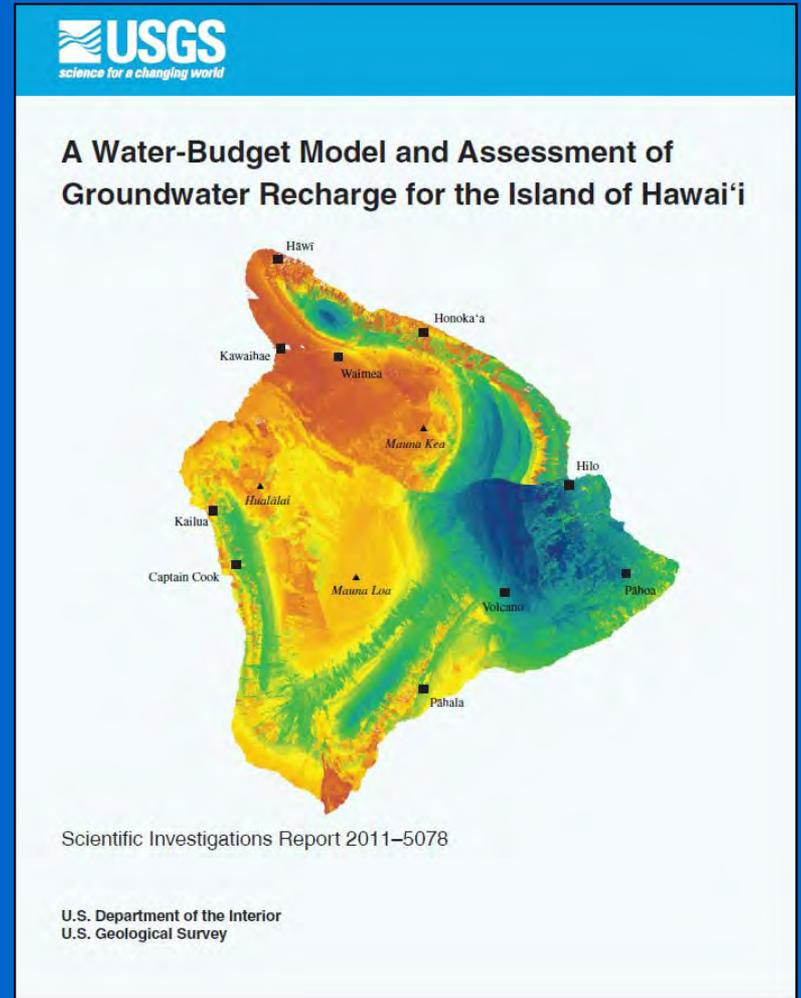
- Statistical analysis
- Hydraulic modeling
- Watershed modeling
- Groundwater flow and solute transport modeling

Information Services

- Flood-alert systems
- WaterWatch web pages
- NWISWeb database
- Publications and presentations

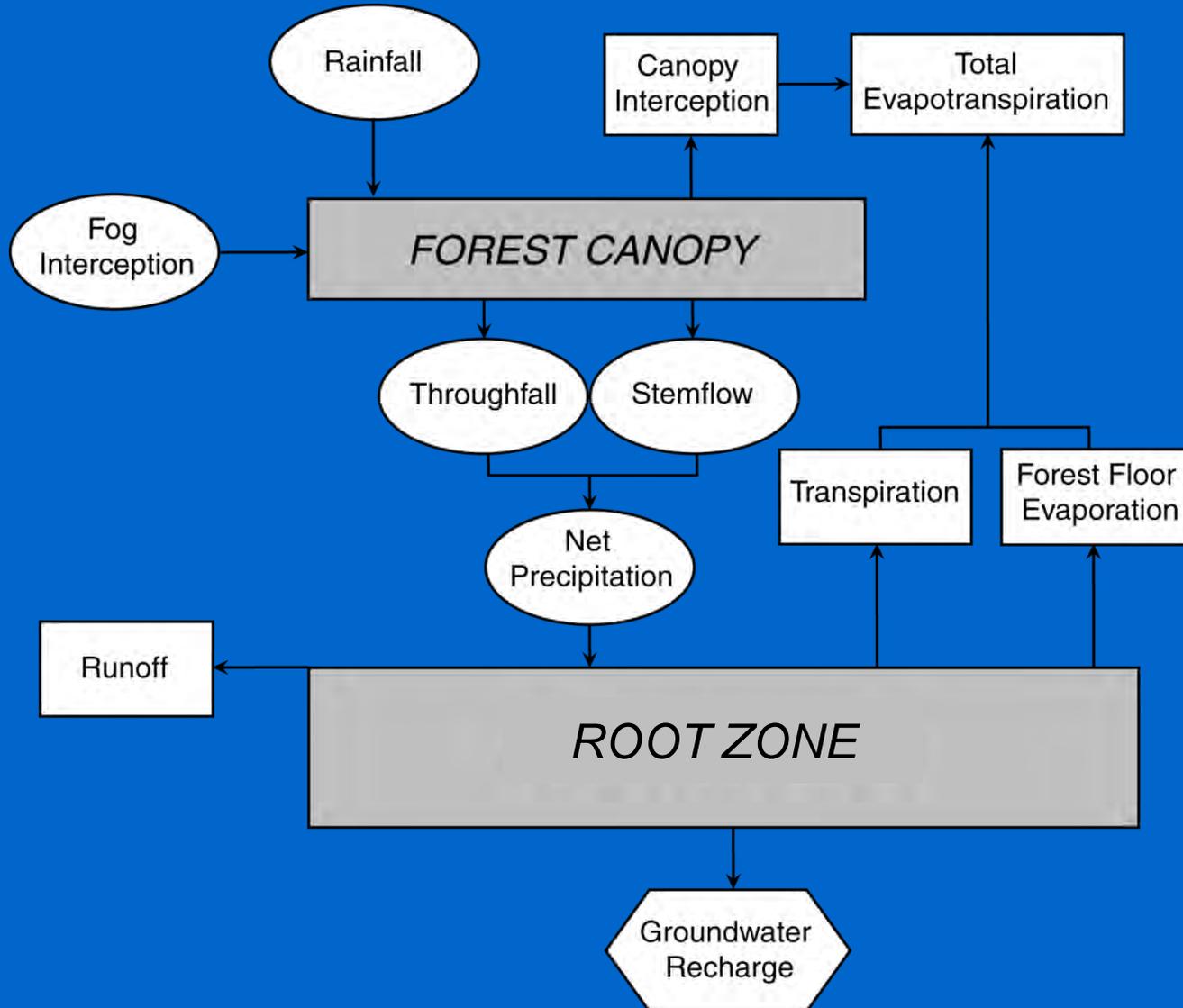
Groundwater Recharge Estimates

- Daily water-budget model
- Baseline recharge condition
 - Land use, 2008
 - Rainfall, 1916-83
- Rainfall scenarios
 - Drought, lowest 5-yr period
 - Climate change
- Land-cover scenarios
 - Replacement of alien forest with native
 - Future urbanization
- Kona-area submodel
 - 5-yr increments of rainfall, 1984-2008



Available online at: <http://hi.water.usgs.gov/>

Water-Budget Conceptual Model

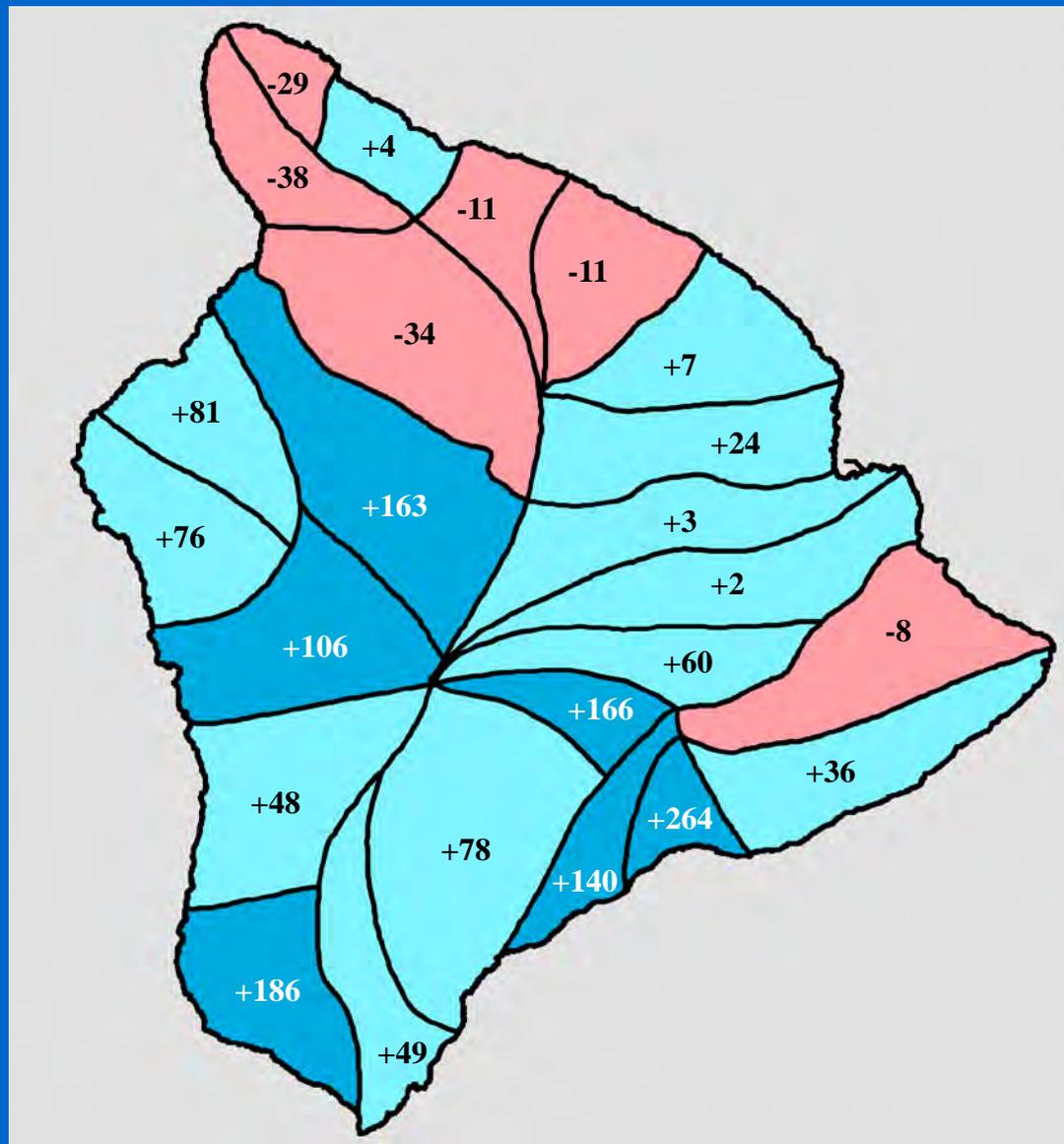


Recharge Difference Relative to WRPP

Keauhou Aquifer System

- USGS study = 152 Mgal/d
- WRRP = 86 Mgal/d
- Difference = +76%

Estimated baseline recharge relative to the Water Resources Protection Plan (WRPP) by aquifer system, in percent

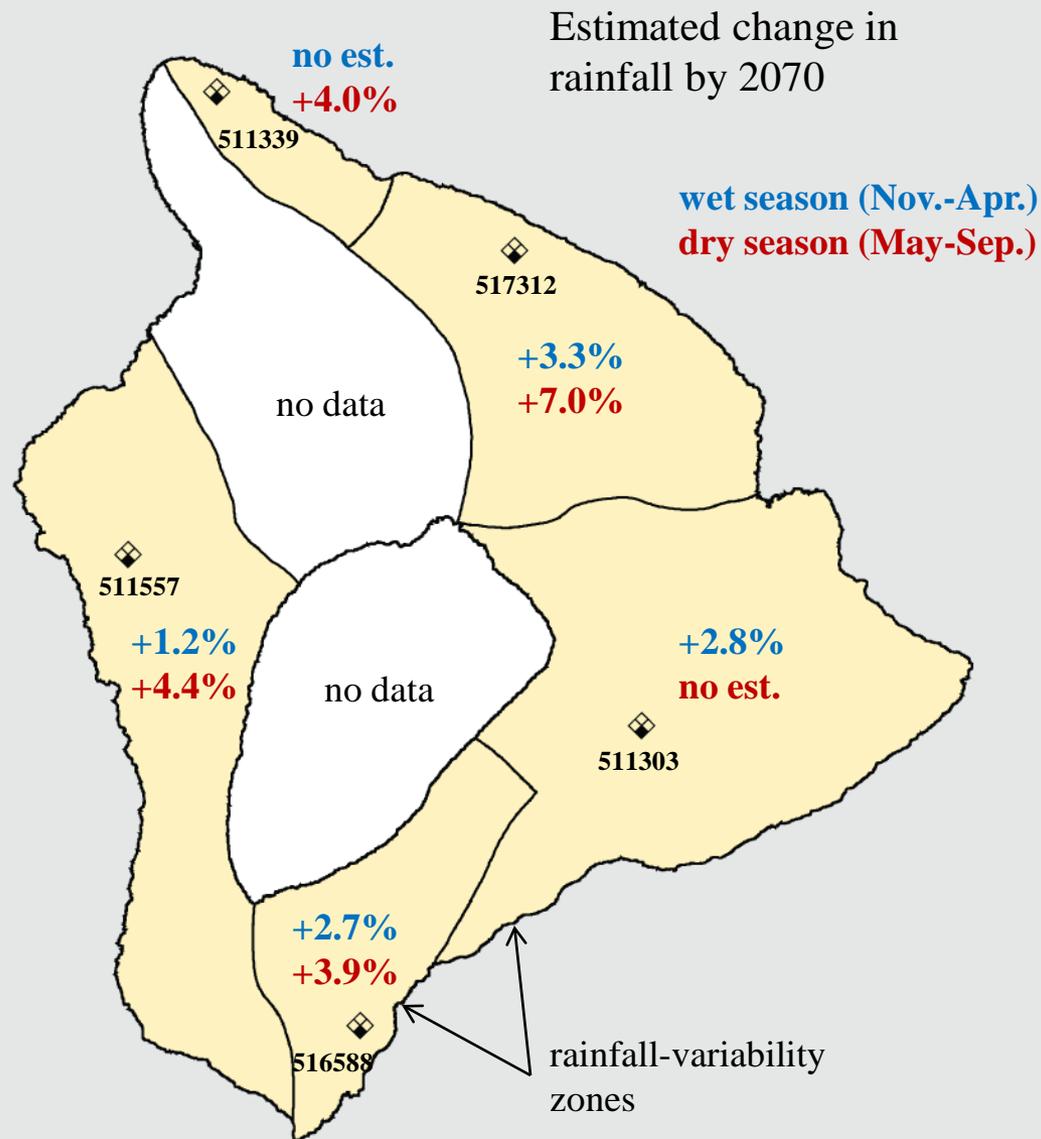


Reasons for Difference

	USGS study (2011)	WRPP (1990)
Time step	Daily	Annual
Fog interception	Included	Not included
Runoff	Subtracted baseflow	Did not subtract baseflow
Evapotranspiration	Calculated from soil moisture, land cover, and soil type	Equal to potential (maximum)

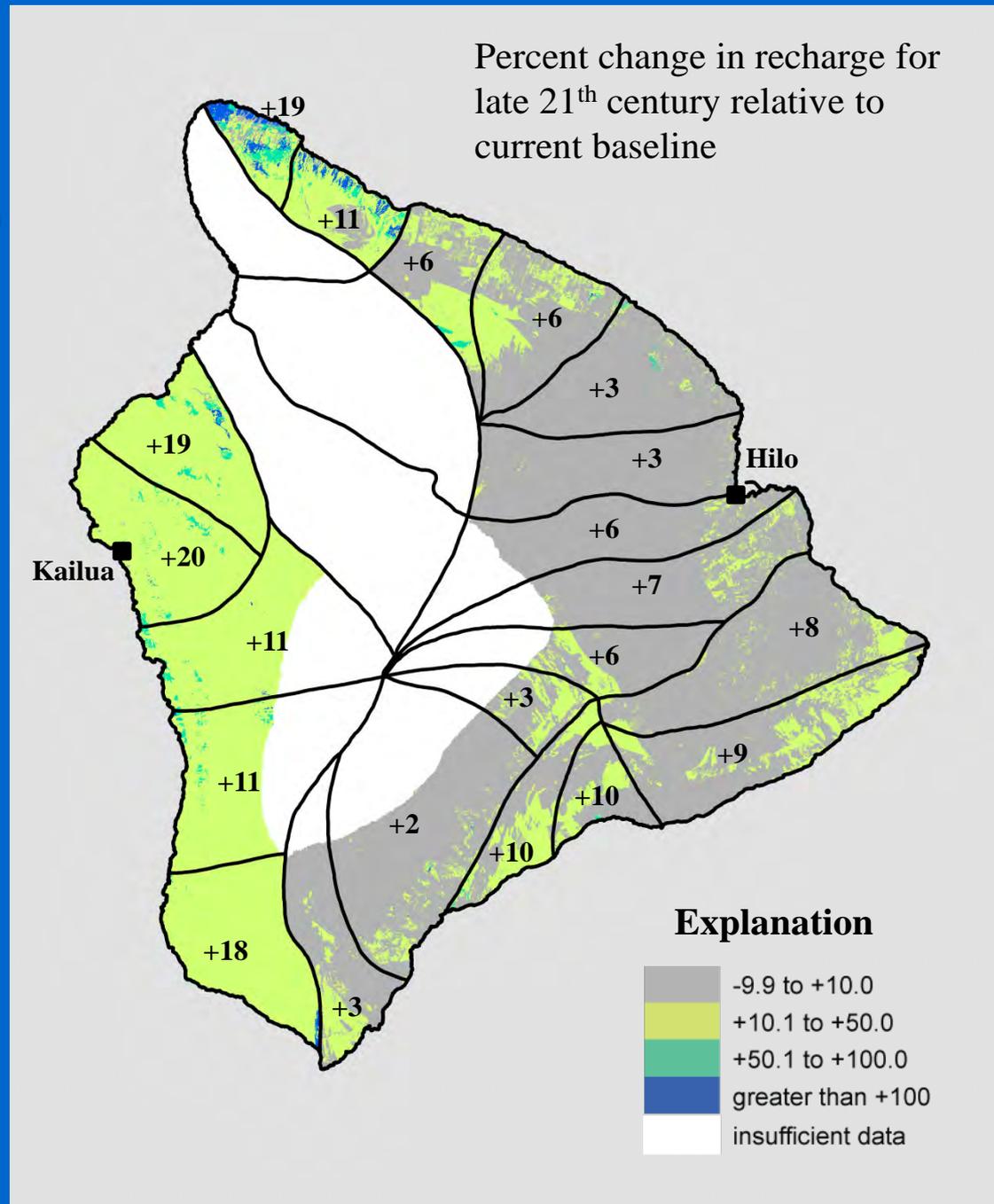
Effect of Climate Change on Rainfall

- Rainfall projections are available from statistical downscaling of climate models (Timm and Diaz, 2009)
- Based on historical relations between rainfall and other climate variables such as air temperature, and wind speed and direction
- Analysis does not include possible rise in the trade-wind inversion layer, and prediction for longer dry periods and bigger storms



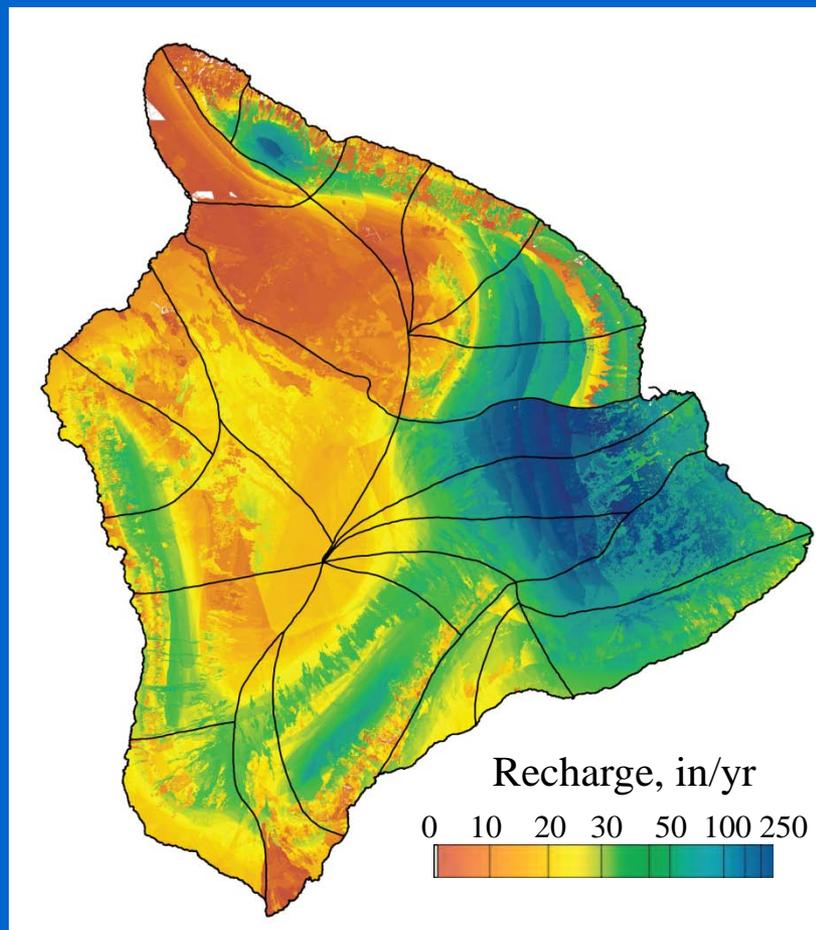
Effect of Climate Change on Groundwater Recharge

- Statistical downscaling projections for particular rainfall gages were applied to rainfall-variability zones in water-budget model
- Pan-evaporation input was adjusted based on an inverse relation with rainfall

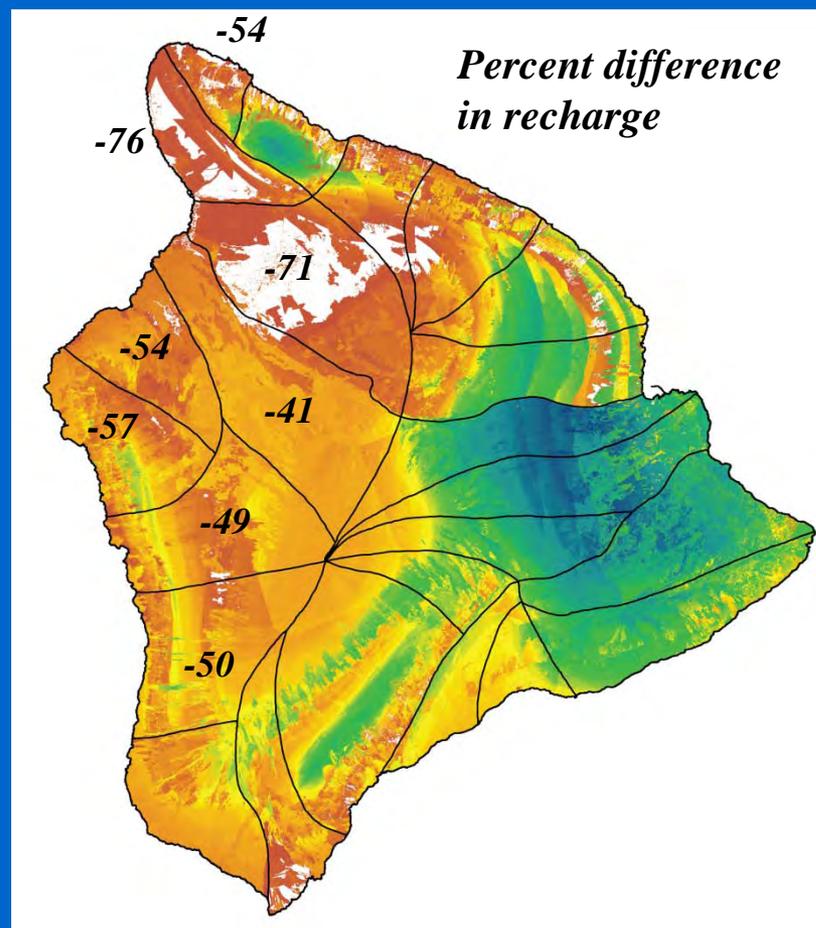


Effect of Historical Drought Periods

Baseline Recharge
(1916-1983 mean rainfall)



Drought-Period Recharge
(lowest 5-year rainfall period)



Kona-Area Submodel, 1984-2008

- Estimates of mean annual recharge in 5-year increments: 1984-88, 1989-93, 1994-98, 1999-2003, and 2004-08

Keauhou Aquifer System	1913-1983	1984-2008	Difference
Rainfall, in inches	339	254	-25%
Recharge, in Mgal/d	152	103	-32%

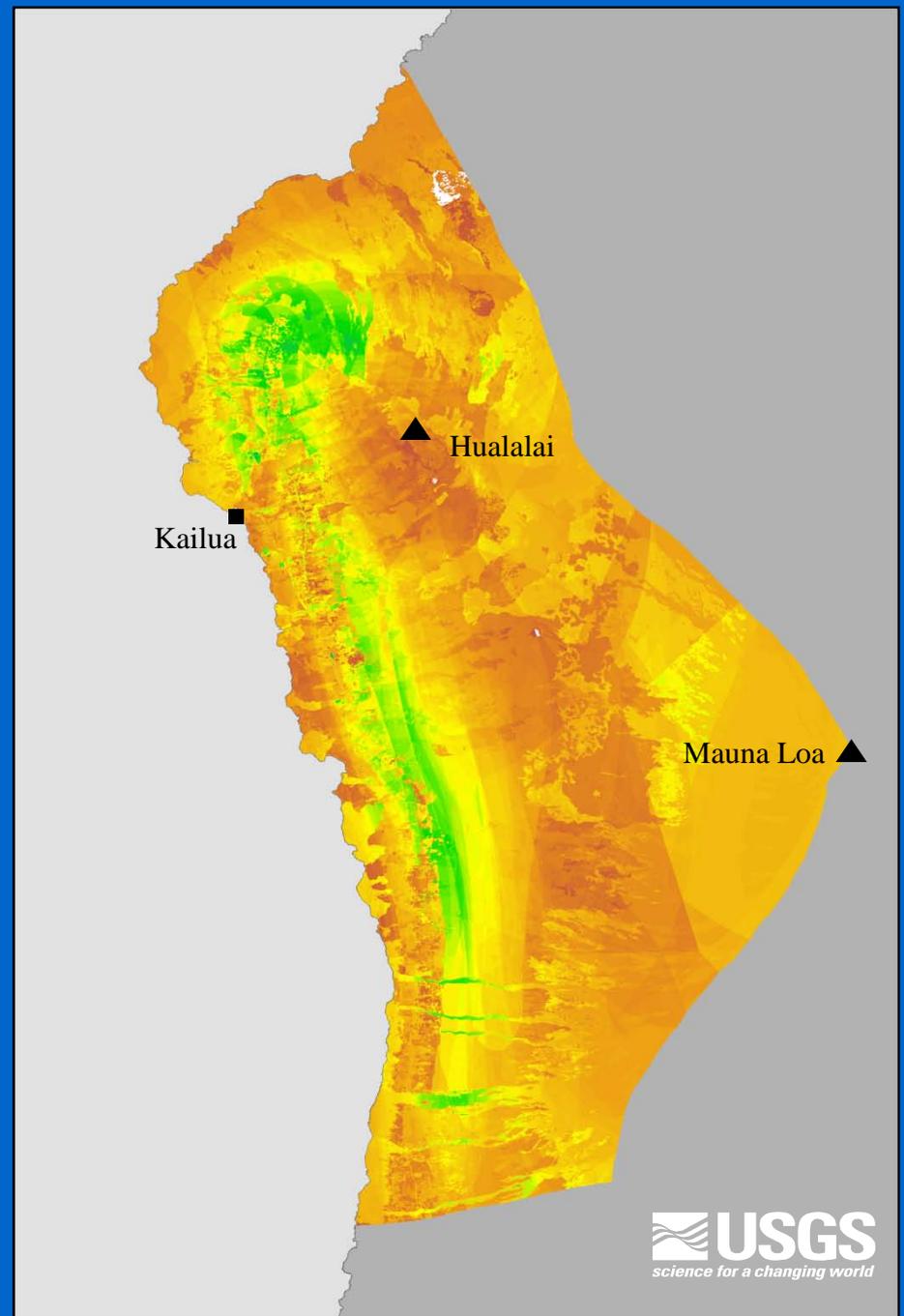
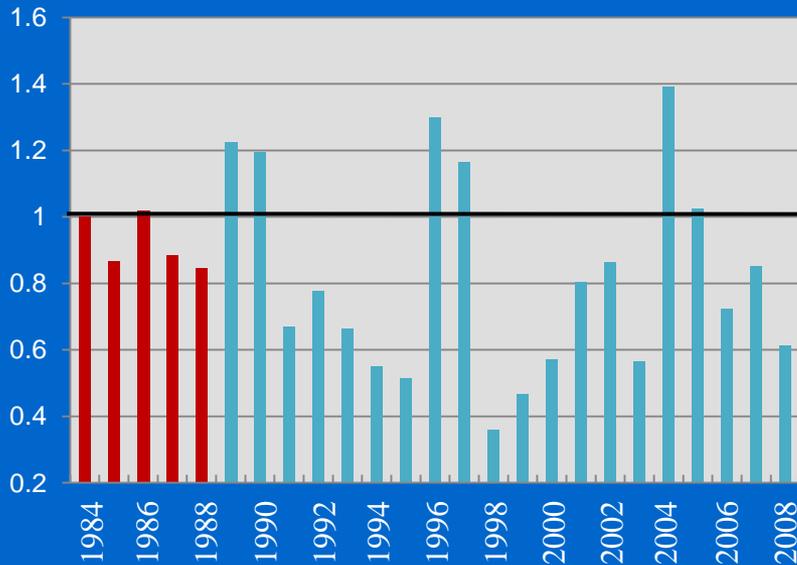
- Rainfall in the recently released Rainfall Atlas of Hawaii (1978-2007) is 15% less than the long-term average rainfall for the period 1913-83

Kona-Area Recharge, 1984-1988

Recharge (in./yr)



Annual rainfall (% of mean)

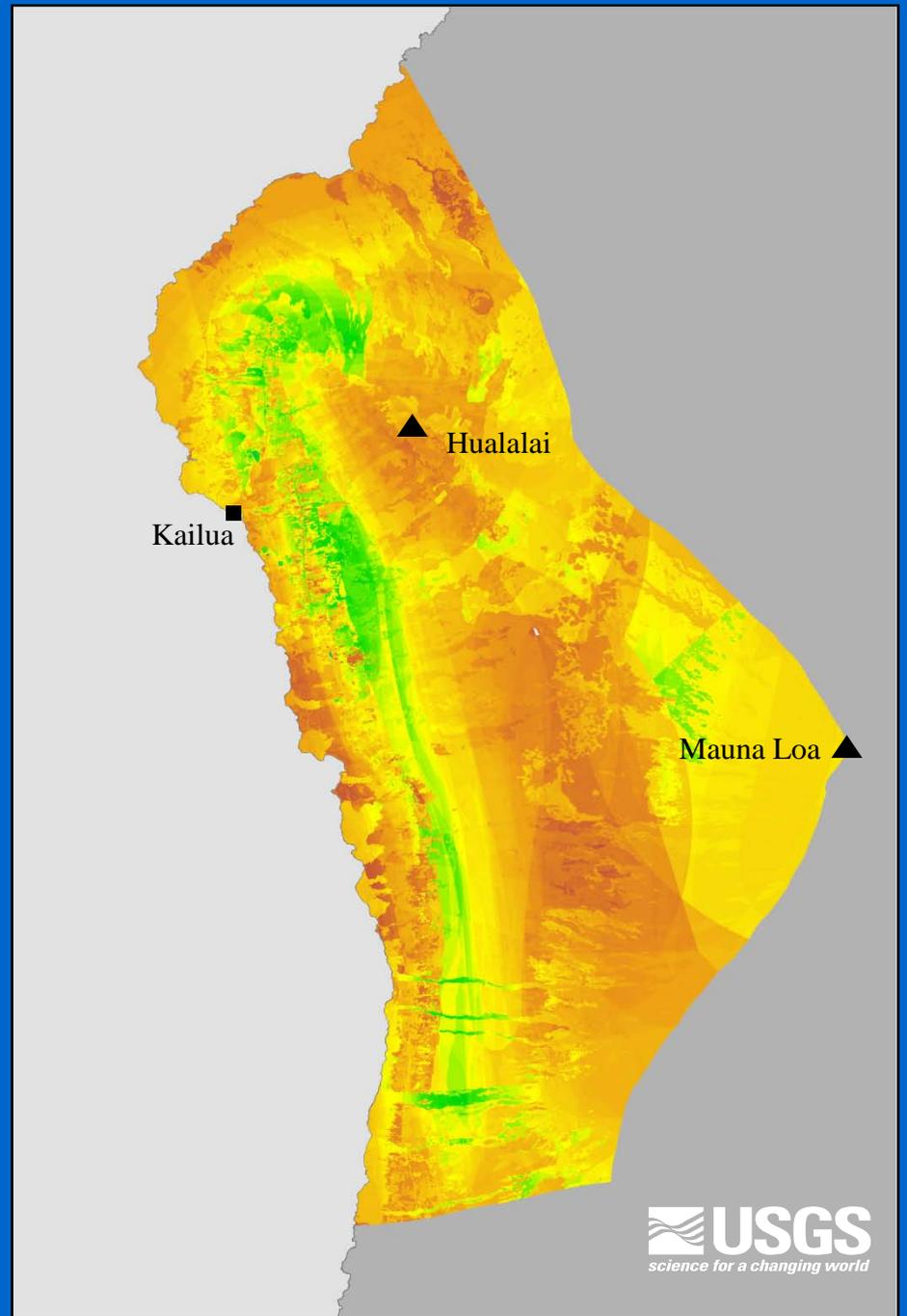
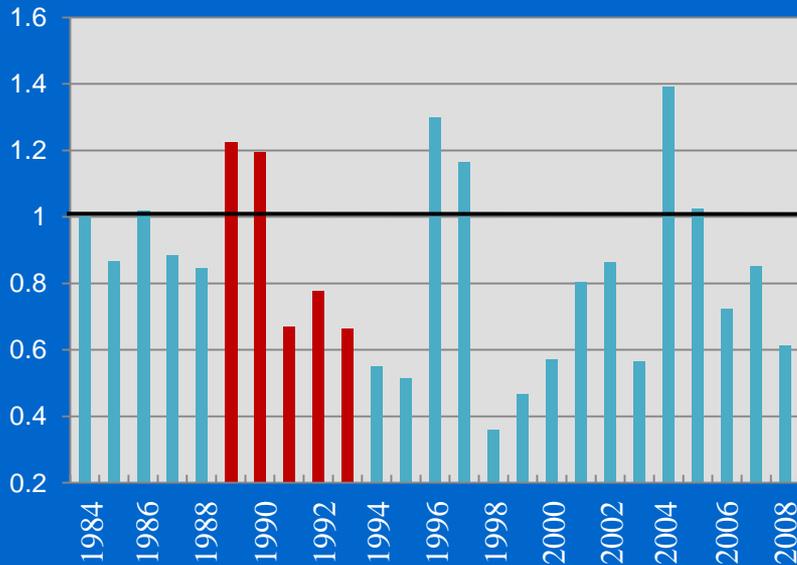


Kona-Area Recharge, 1989-1993

Recharge (in./yr)



Annual rainfall (% of mean)



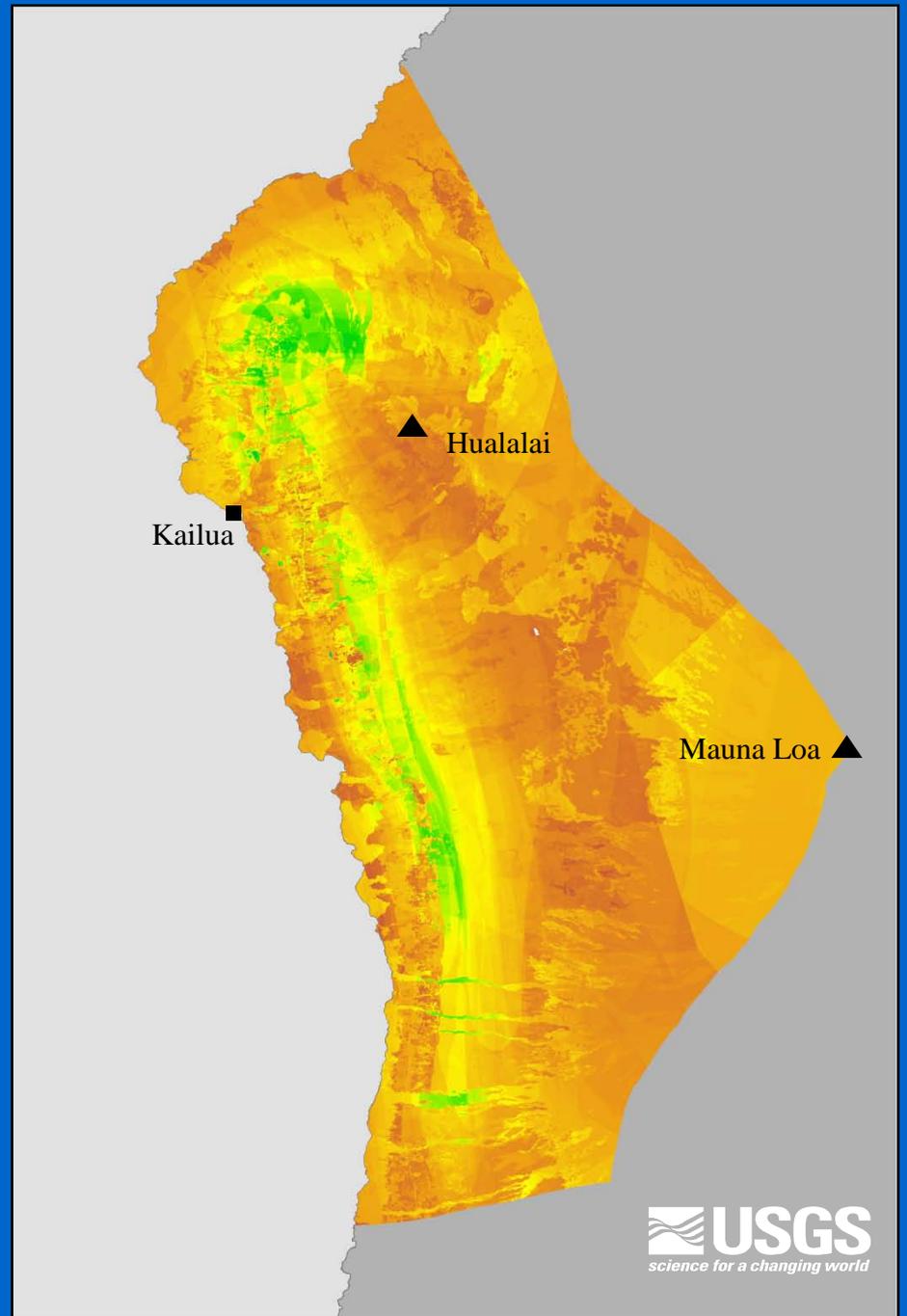
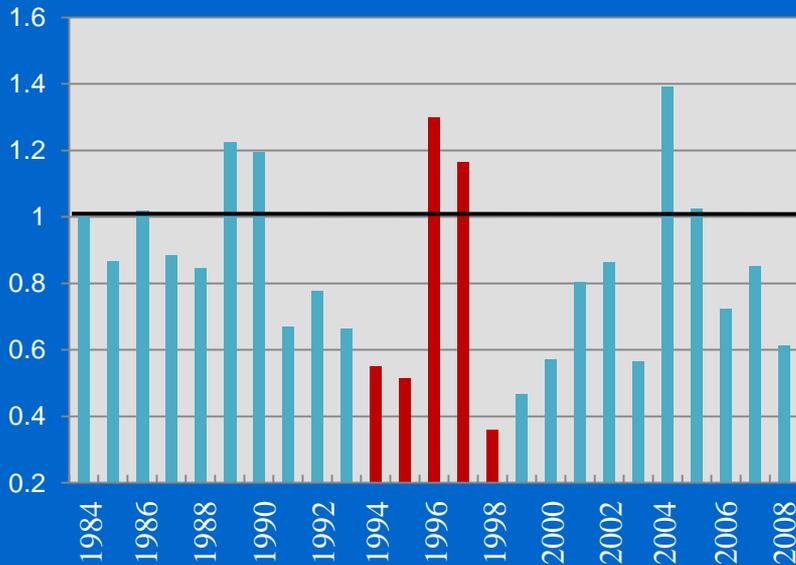
Kona-Area Recharge, 1994-1998

Recharge (in./yr)

0 10 20 30 40 50 100 320

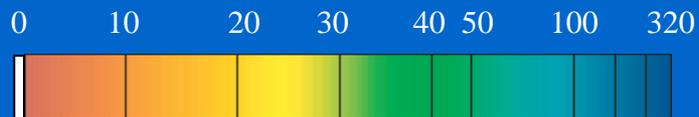


Annual rainfall (% of mean)

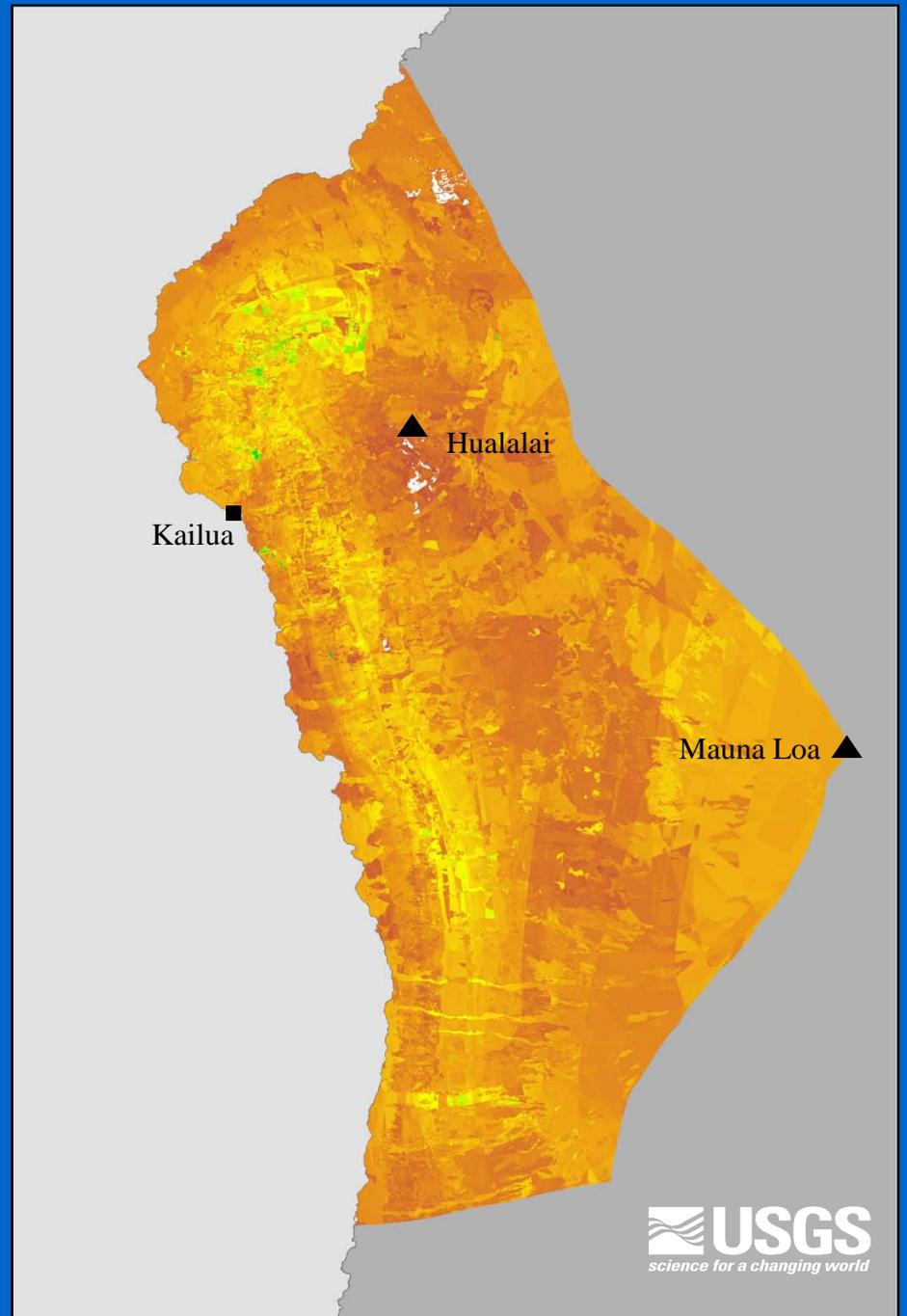
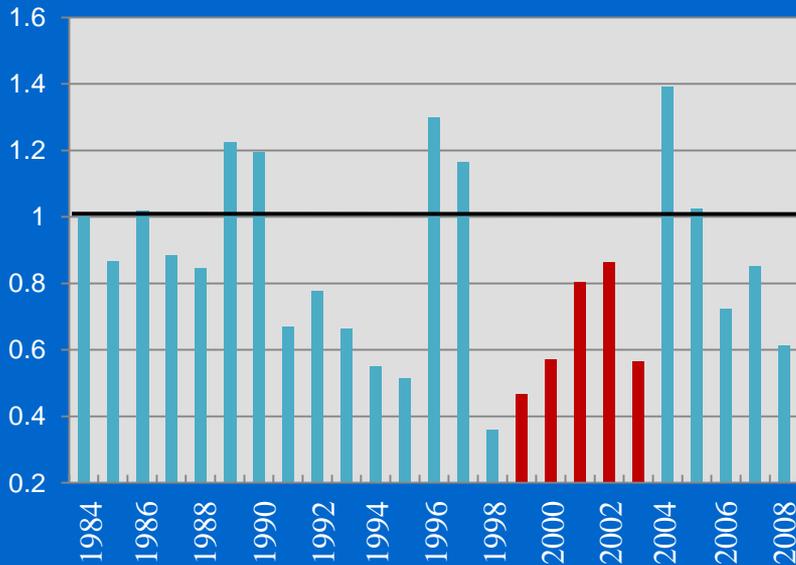


Kona-Area Recharge, 1999-2003

Recharge (in./yr)

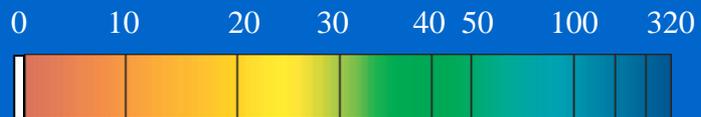


Annual rainfall (% of mean)

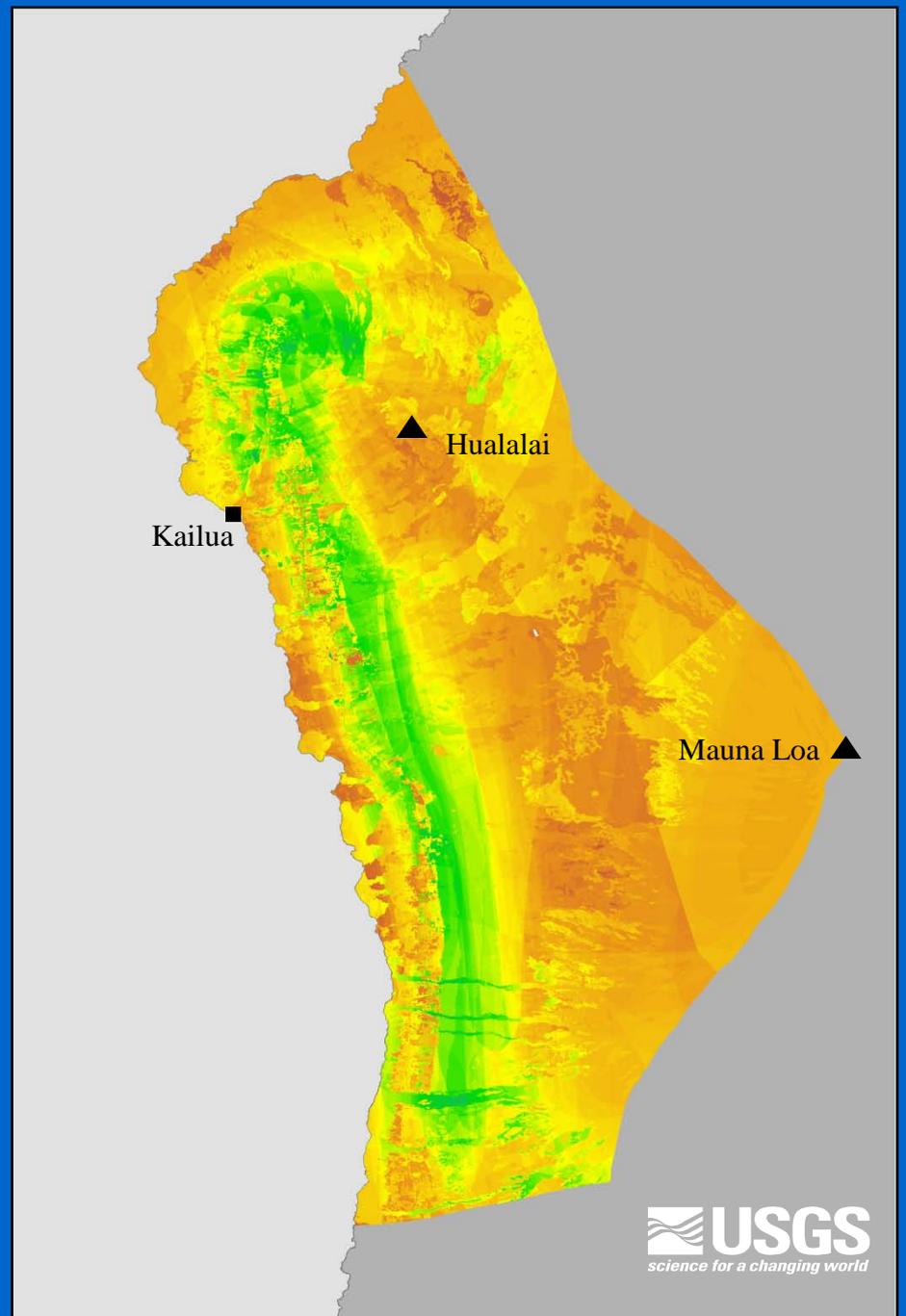
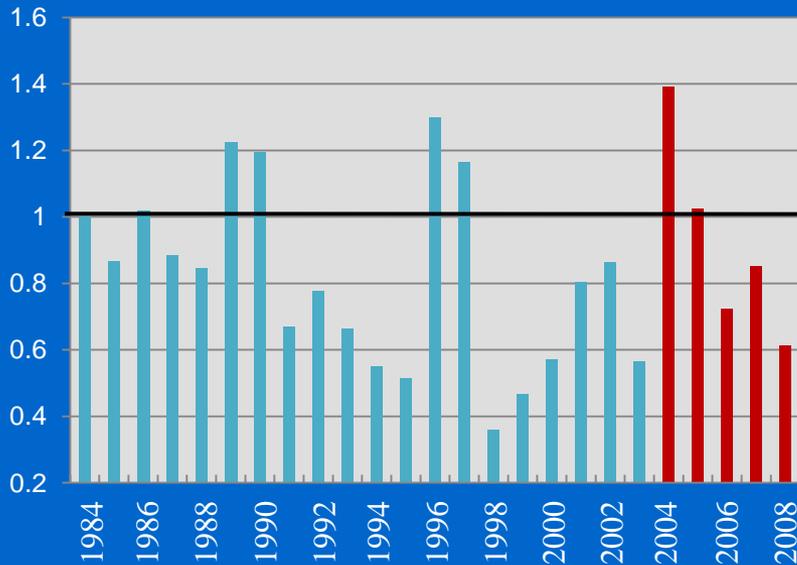


Kona-Area Recharge, 2004-2008

Recharge (in./yr)

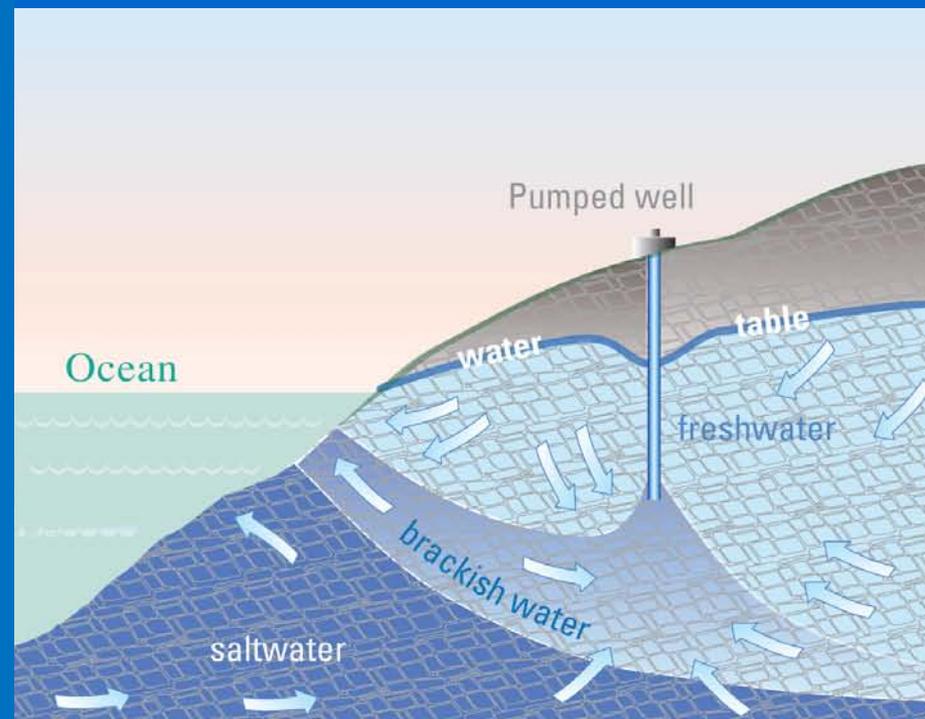
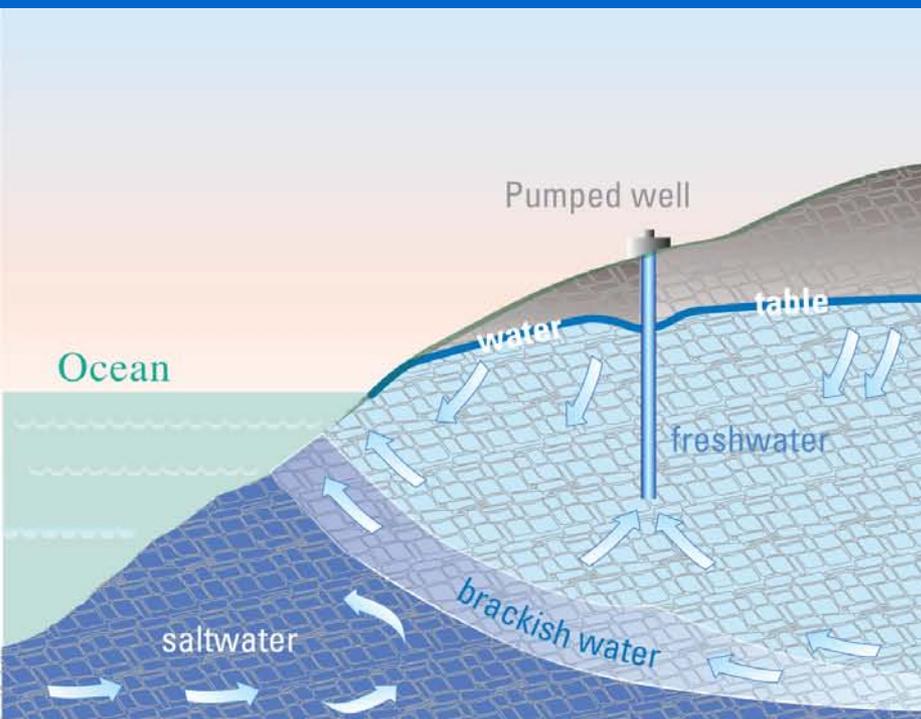


Annual rainfall (% of mean)



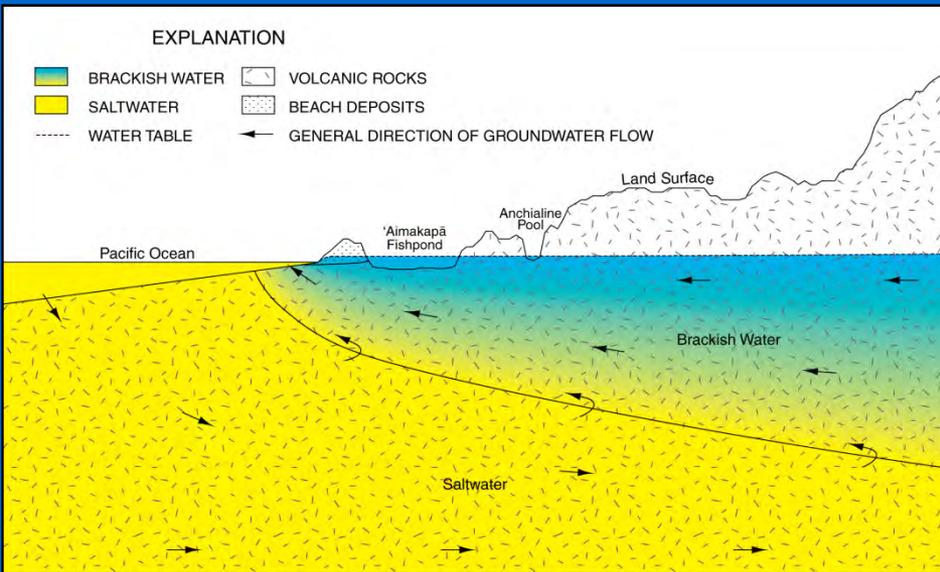
Groundwater Availability Limited by Salinity of Drinking Water from Pumped Wells

State Water Commission has established sustainable yield estimates to help protect water resources from saltwater intrusion caused by over-pumping

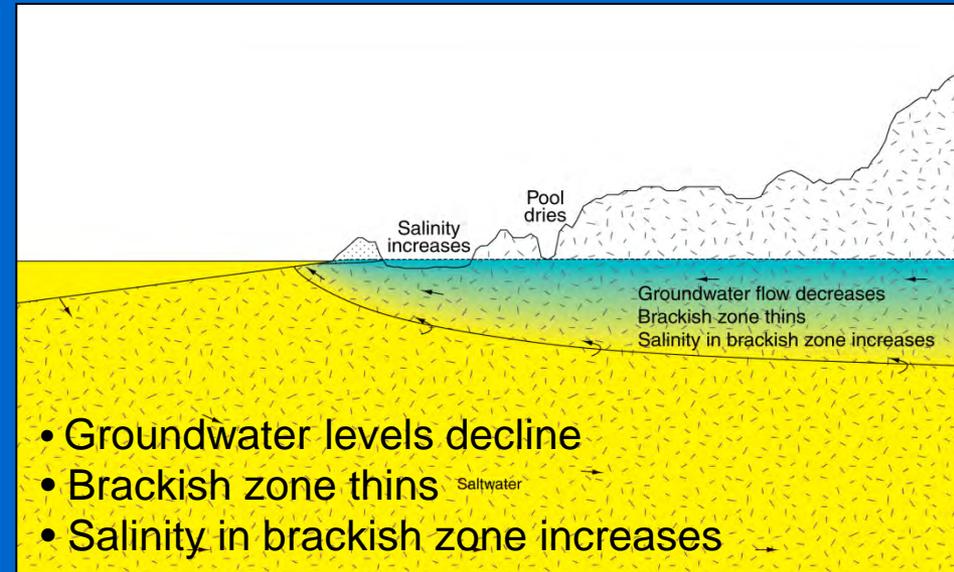


Hydrologic Effects of Groundwater Withdrawals on Non-Drinking Water Resources

Current condition

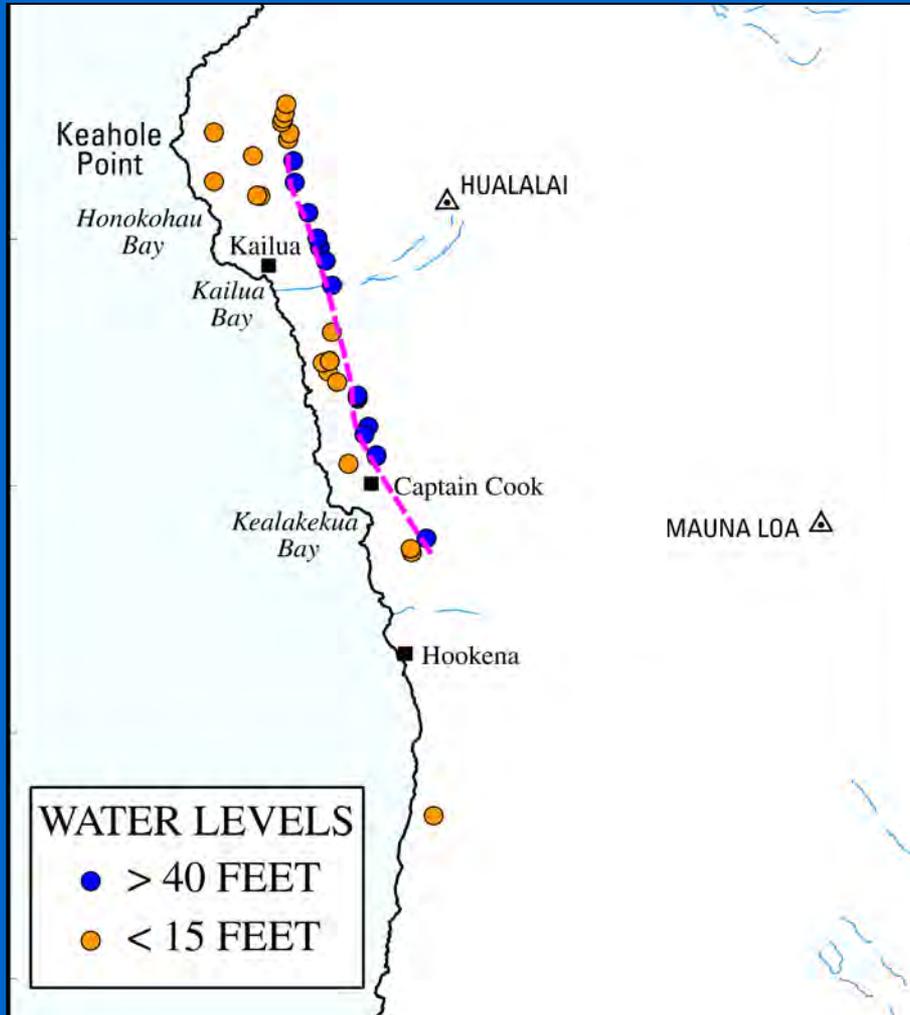


Increased withdrawal



- Terrestrial aquatic ecosystems, such as anchialine pools and wetlands, may dry up or become shallower as groundwater levels decline.
- In the nearshore marine environment, coral, limu, and fishpond productivity may be affected by a reduction in fresh groundwater discharge.

Measured Groundwater Levels



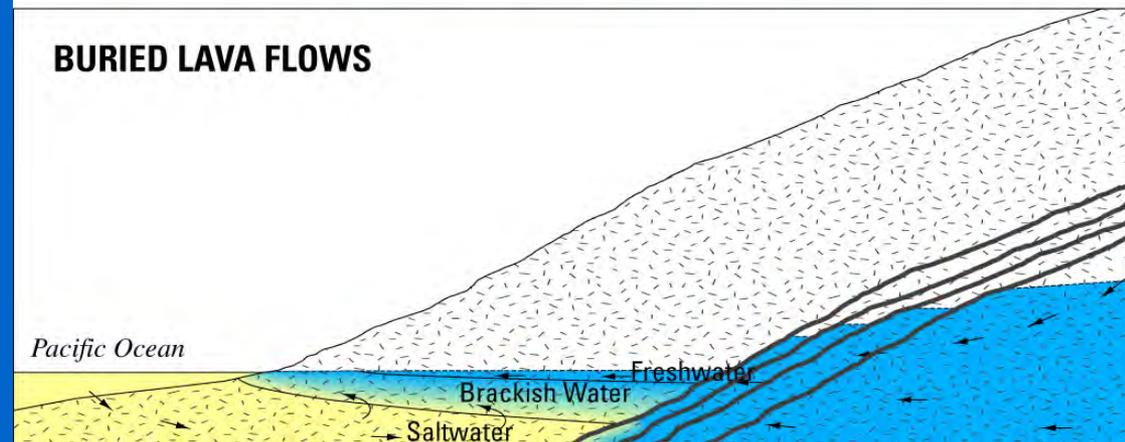
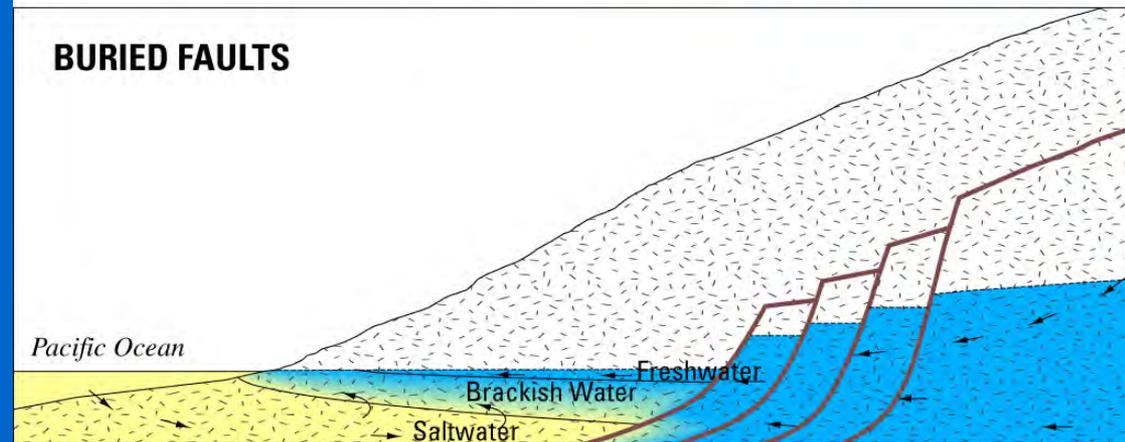
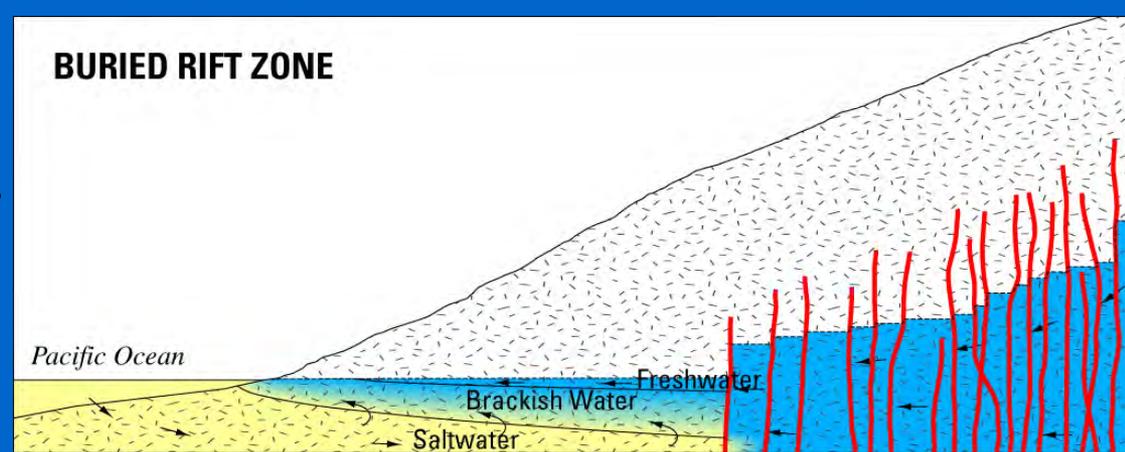
- Low water levels—coastal groundwater system
- High water levels—inland areas above 1,600 feet elevation
- High-level water created by low-permeability subsurface geologic feature
- Structural origin of geologic feature is uncertain
- Southern extent of high water levels unknown

Origin of High Water Levels

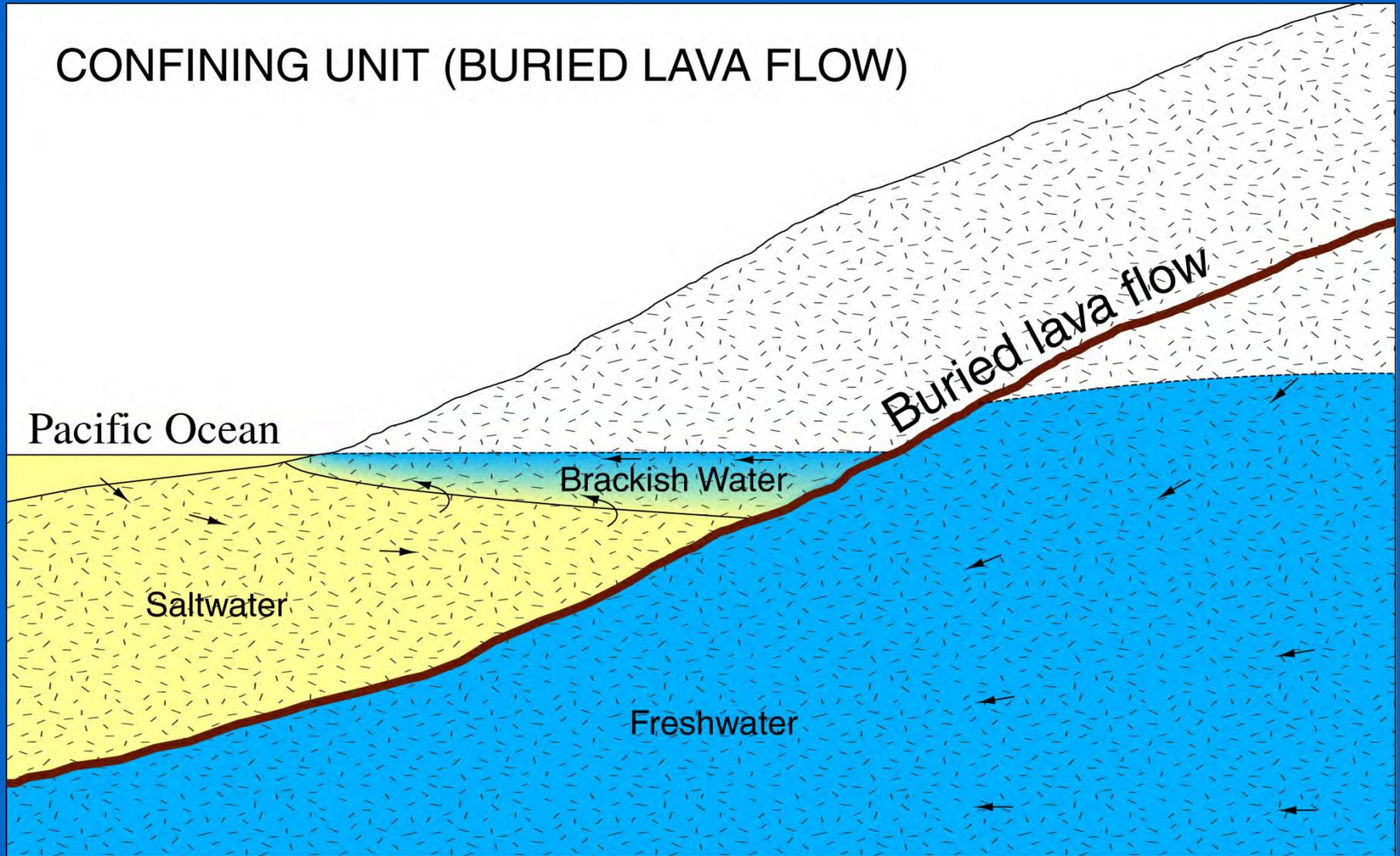
Intrusive, low-permeability dikes

Faults draped with younger lava flows

Low-permeability lava flows



Alternative Conceptual Model



Implications of Conceptual Models

- If high-level groundwater discharges to downgradient coastal lens
 - Withdrawals of high-level groundwater will affect coastal system
- If high-level groundwater discharges completely beneath coastal lens to offshore areas
 - Any withdrawals of high-level groundwater will not affect coastal system

USGS Study to Evaluate Connection Between High-Level and Coastal Groundwater Systems

- Sample existing wells (high-level and coastal), anchialine pools, fishponds, and ocean
- Compare concentrations of silica and other natural tracers, such as ratios of stable isotopes to identify:
 - Geochemical connection or lack of a connection between the two systems
 - Altitude and seasonality of groundwater recharge to the two systems
 - Extent of groundwater-ocean water mixing in the coastal system
- Funding source: CWRM, NPS, and USGS
- Study period: May 2012 – September 2014

Questions?