West Hawaii SWAP Model Revision

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West Hawaii Groundwater Modeling & HDOH's Role

- Safe Drinking Water Branch Responsibilities
  1. Ensure quality of drinking water
  2. Groundwater protection
  3. Drinking water source contamination susceptibility assessments
  4. Well head protection
- Modeling is a powerful tool to:
  - Identify zones of contribution to drinking water wells
  - Evaluating any potential impact from contaminating sources within those zones of contribution

Why The Model Revision is Needed

1. New Research
   - Revised groundwater recharge assessments
   - UH Dept. of Geology and Geophysics geochemical study and sea surface temperature survey
   - Water resource engineering reports
   - Possibly new geophysics data
2. Increased groundwater resource utilization
3. Advances in groundwater modeling software capabilities, and
4. Increased modeling experience

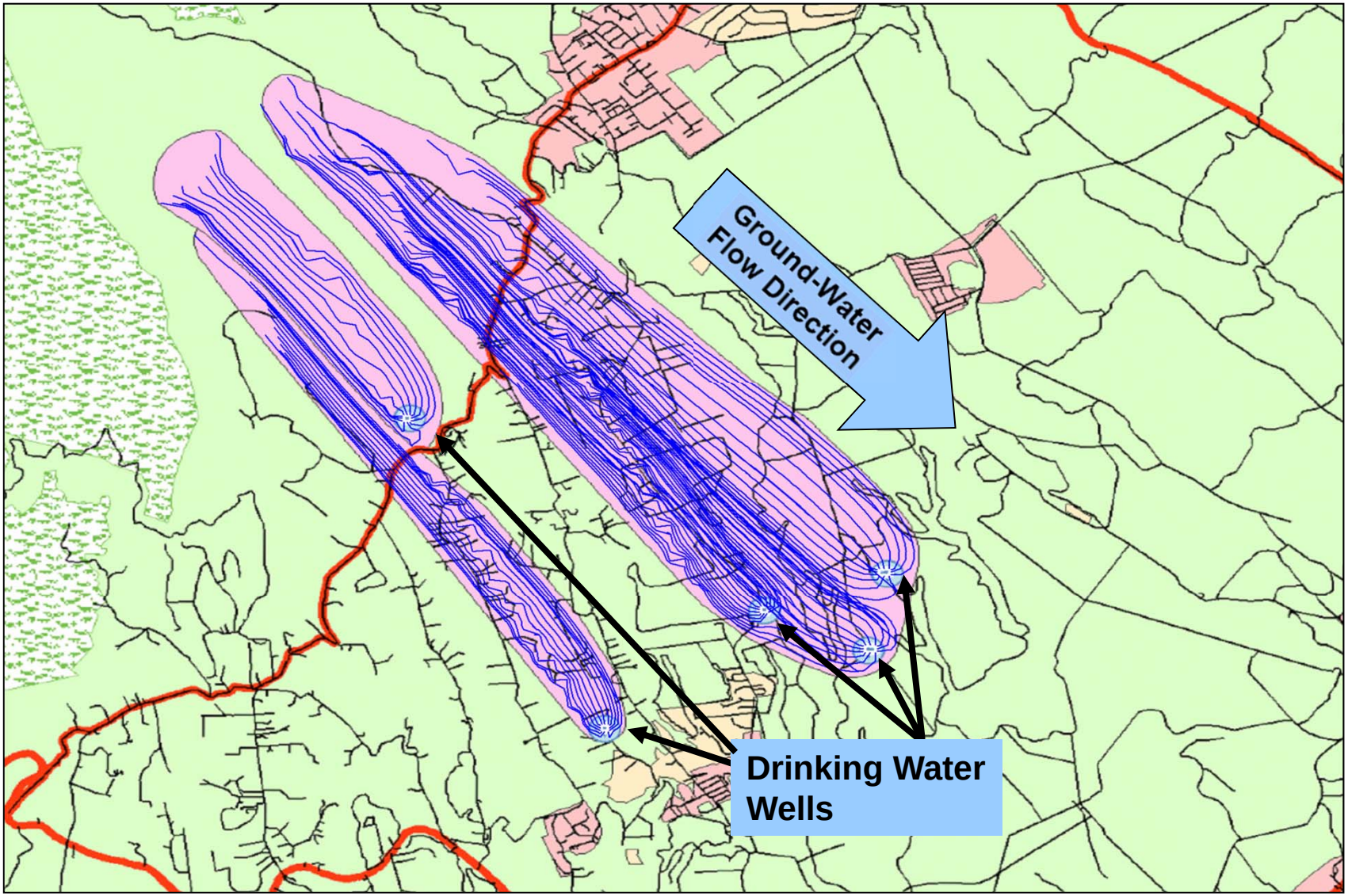
Hawaii’s Source Water Assessment Program

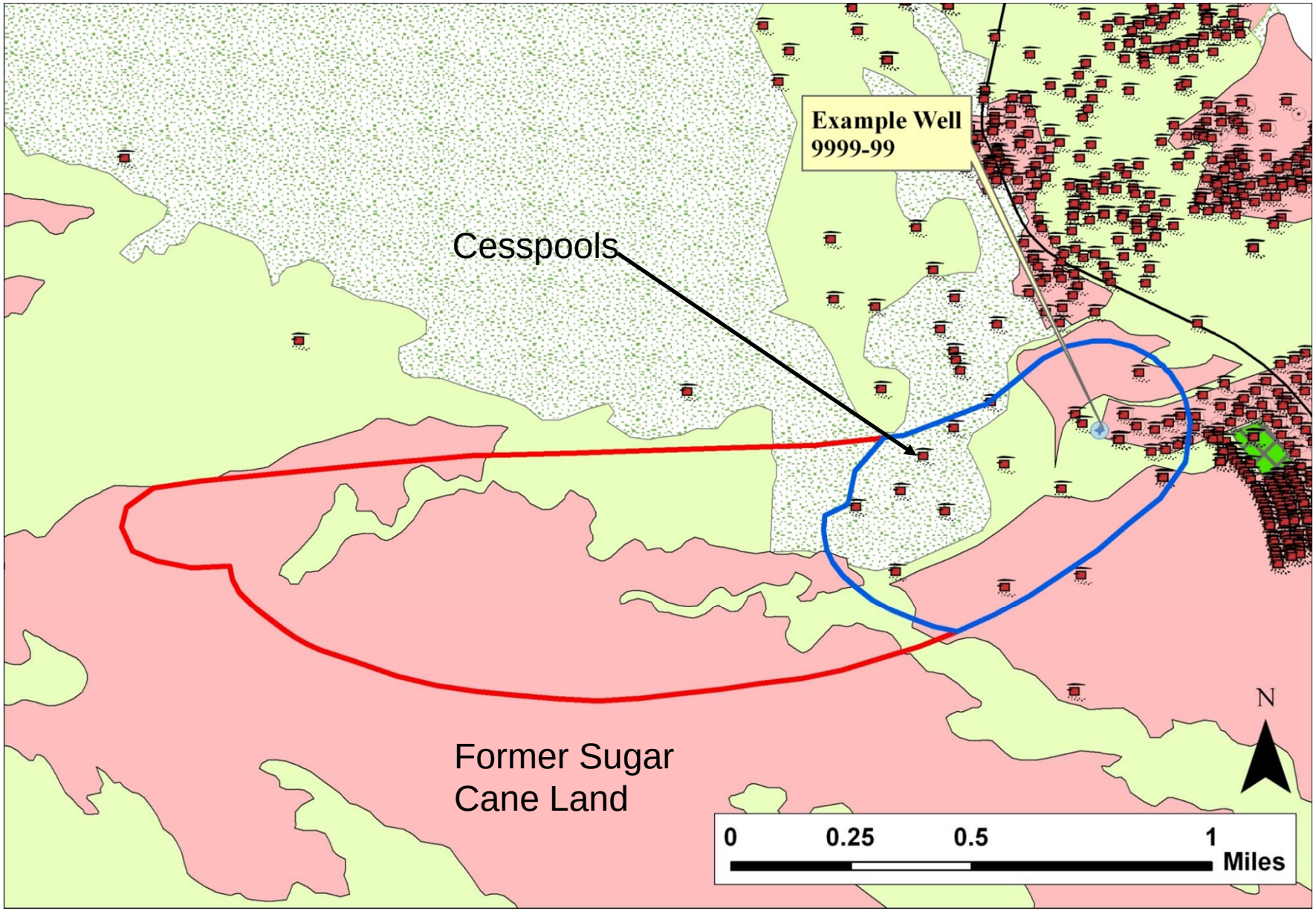
Hawaii's Source Water Assessment Program (SWAP)

- Reauthorization of the Safe Drinking Water Act in 1996 included a SWAP Mandate
  - The EPA required all states to conduct susceptibility to contamination assessments for public drinking water sources
- A modeling approach was selected
- SWAP is a "Living Document" making it a:
  - A Data Center for Hydrologic Information
  - A Foundation that can be used for Further Studies
    - On-site sewage disposal system risk assessment
    - Establishing site-specific groundwater contamination limits for the U.S. Navy Red Hill Fuel Storage Facility (TEC, Inc., 2007).
  - To remain a "Living Document" requires revisions

Well Capture Zones

Delineated using computer generated particles traveling backwards





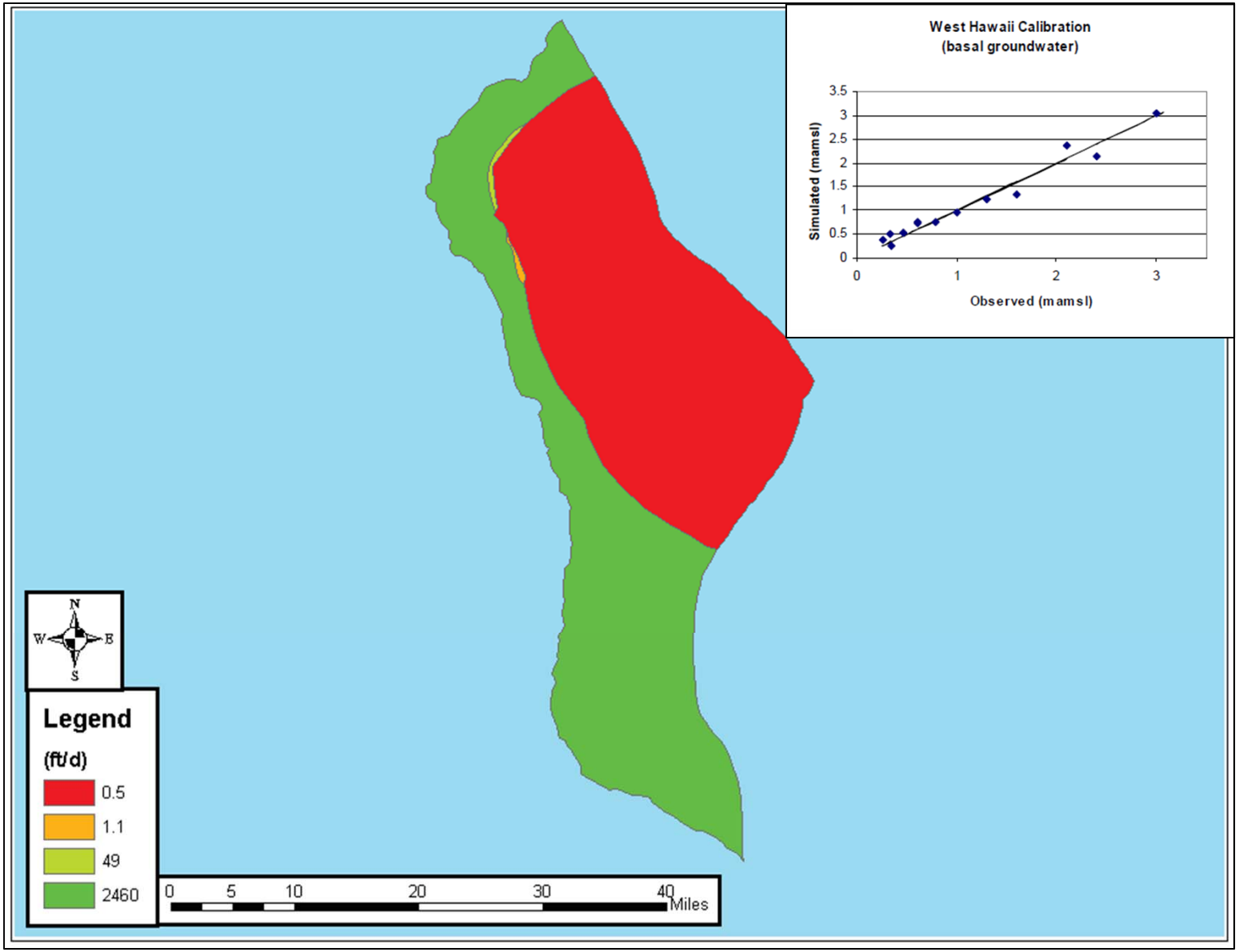
Assessed the well's susceptibility to contamination by inventorying potentially contaminating activities within the capture zone

Report: Zone B Score

Zone B PCA Scores

WELL USGS ID: 9999-99 **Zone B ID:** 8XB312 **TOTAL SCORE zone B:** 154

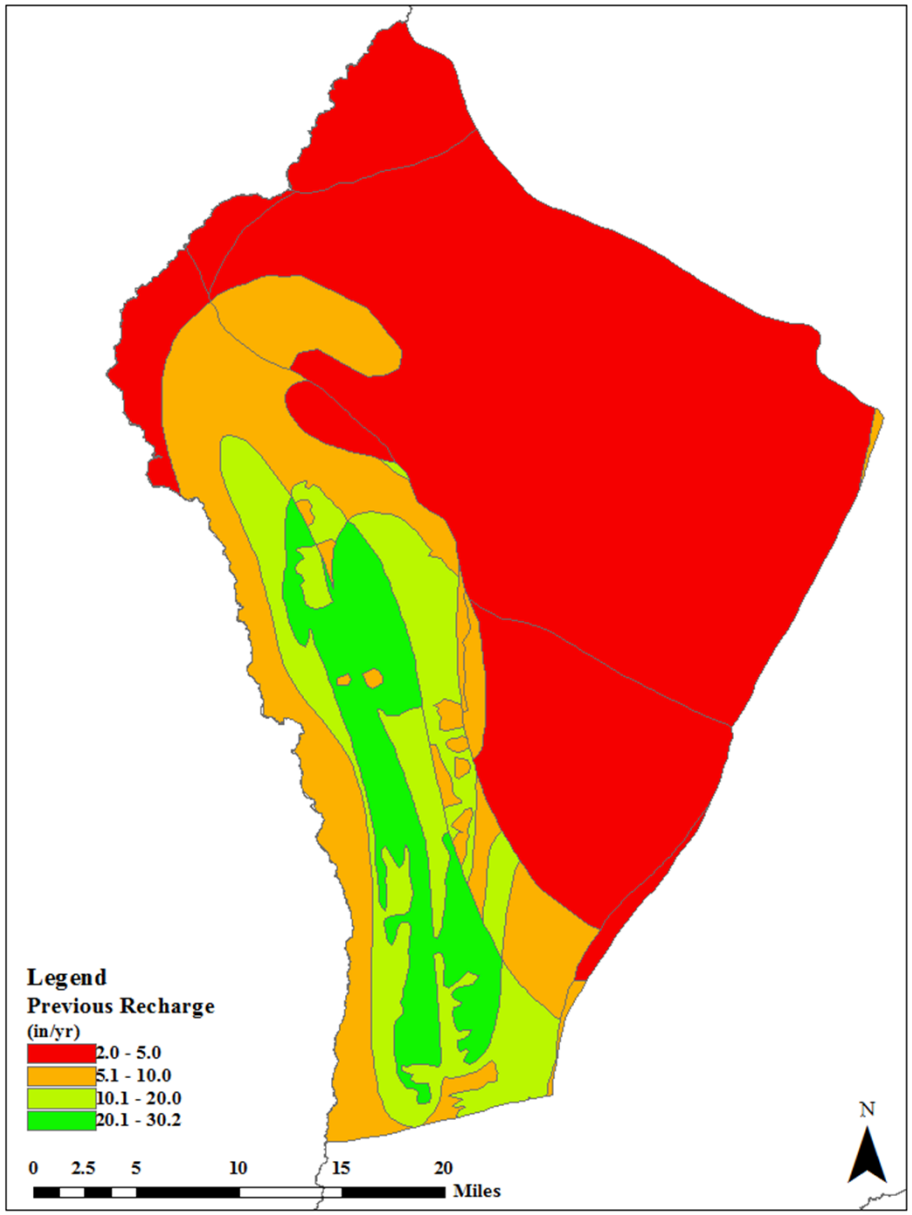
PCA	PCA Counts	PCA Scores	PCA	PCA Counts	PCA Scores
LQG RCRA:	0	0	Residencial Parcel:	120	6
CEG RCRA:	0	0	Above Ground Storage Tank:	0	0
DAG RCRA:	0	0	Herbicide Mixing and Loading:	0	0
SQG RCRA:	0	0	Military Installation:	0	0
other RCRA:	0	0	Leaky Underground Storage Tank:	0	0
Gas Station:	0	0	Illegal Dumping:	0	0
Dry Cleaner:	0	0	Other Crops using Soil Fumigants:	0	0
Road:	17	6	Auto Body and Repair Shop:	2	24
Golf Course:	0	0	Auto Junk Yard:	1	12
Recorded Spill:	0	0	Research Laboratory:	0	0
Septic Tank:	1	6	Utility Station:	1	12
Cesspool:	40	20	Confined Animal Feedlot:	0	0
Metal Plating:	0	0	Waste Transfer Station:	1	6
Airport:	0	0	Hospital and Clinic:	1	6
Sewer Plant:	0	0			
Sewer Line:	0	0	Cultivated Agriculture:	0.2 ha	6
Injection Well:	1	20	Diversified Agriculture:	0.0 ha	0
Cemetery:	1	6	Sugarcane:	36.1 ha	24

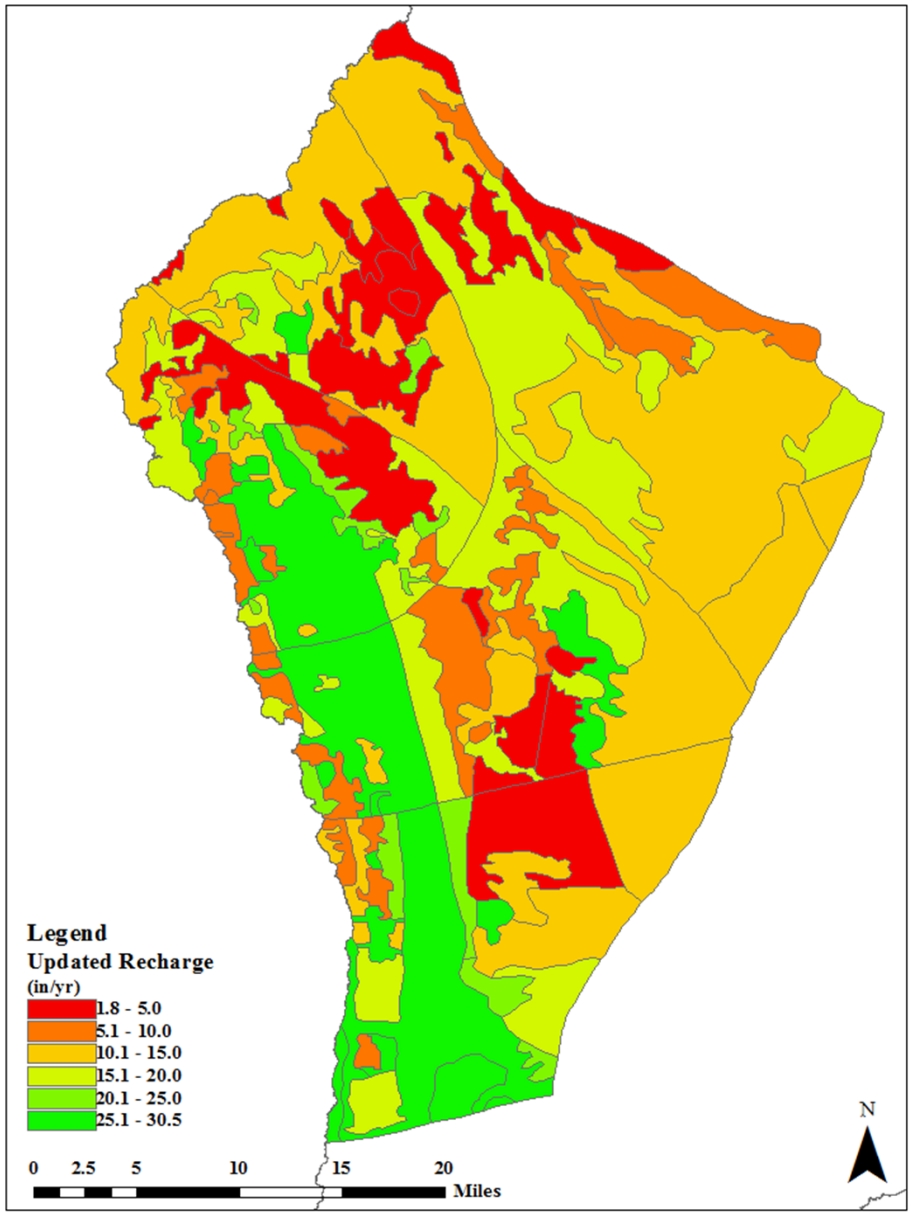


The 2004 SWAP Model for West Hawaii

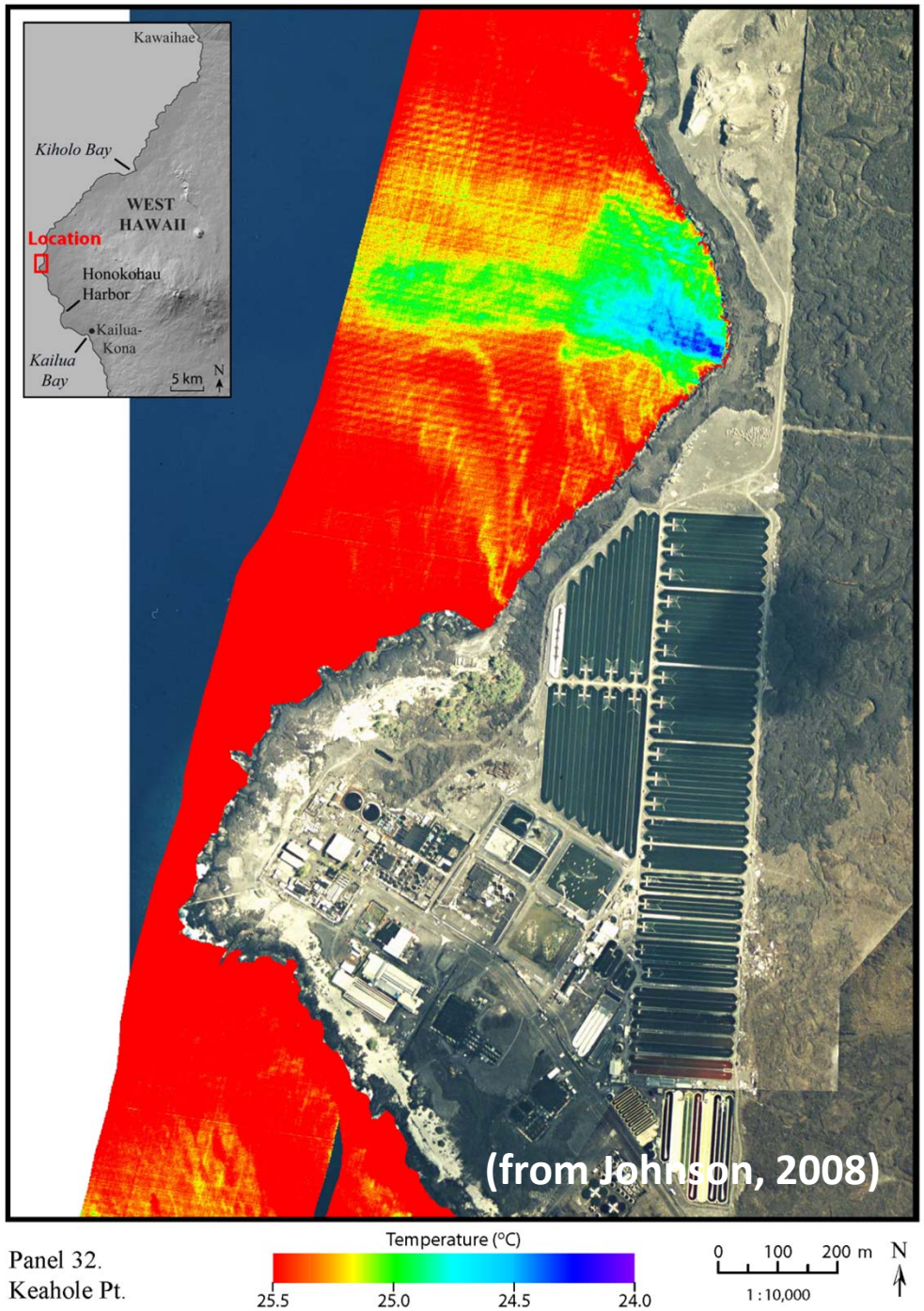
Only two major hydrologic regions, however calibration was good

New Research





Recharge for the 2004 SWAP model (left) used data from Oki (1999) and a simple recharge model developed by UH. New model uses the recharge estimates of Engott (2009) (right).

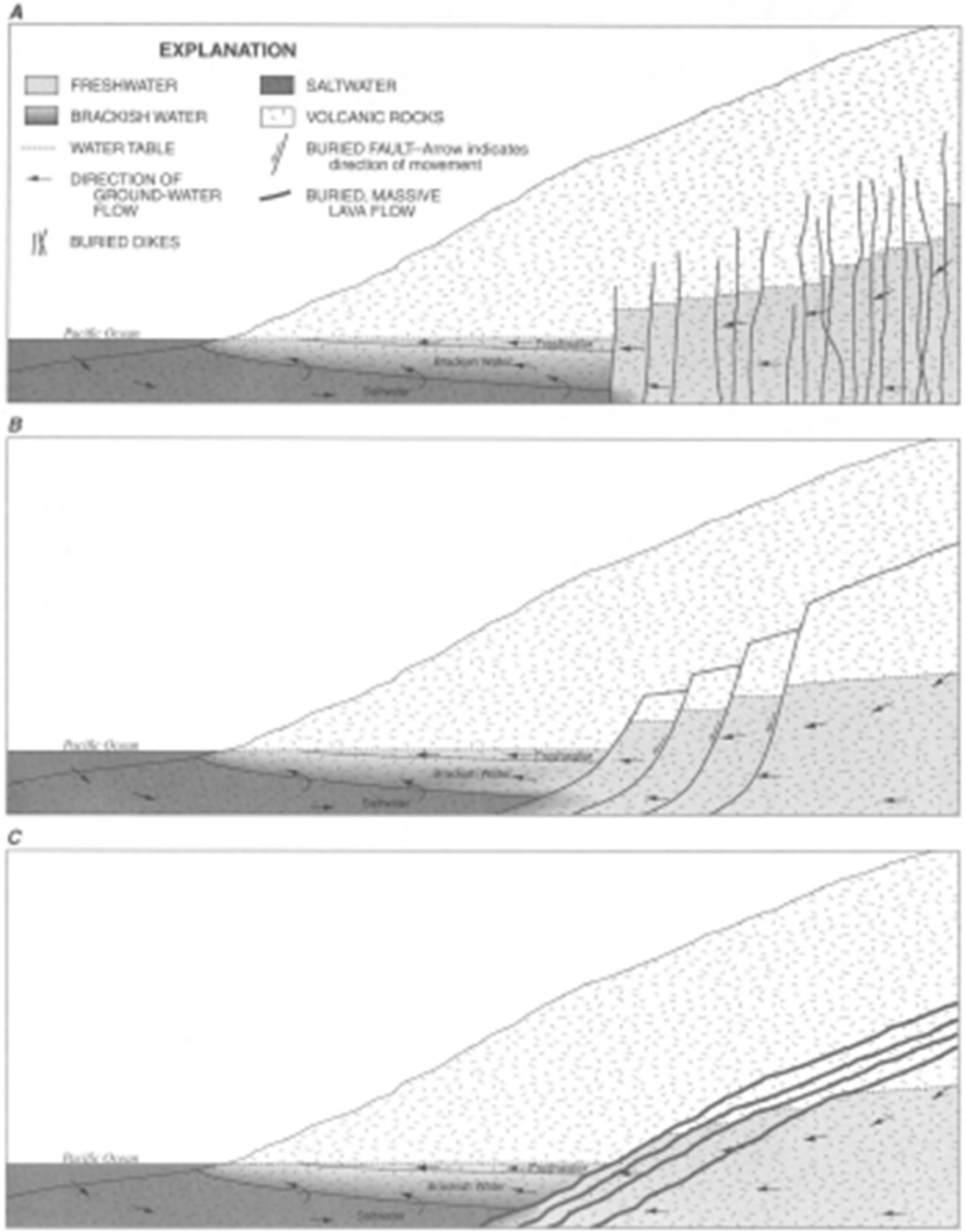


Panel 32.
Keahole Pt.

Coastal Thermal Imaging

- Night-time survey from an aircraft with thermal infrared sensors
- Normal sea surface temperature ~25.5 ^{o}C
- Groundwater Temperature ~24 ^{o}C
- Cooler colors show areas of greater coastal groundwater discharge

Modeling Challenges

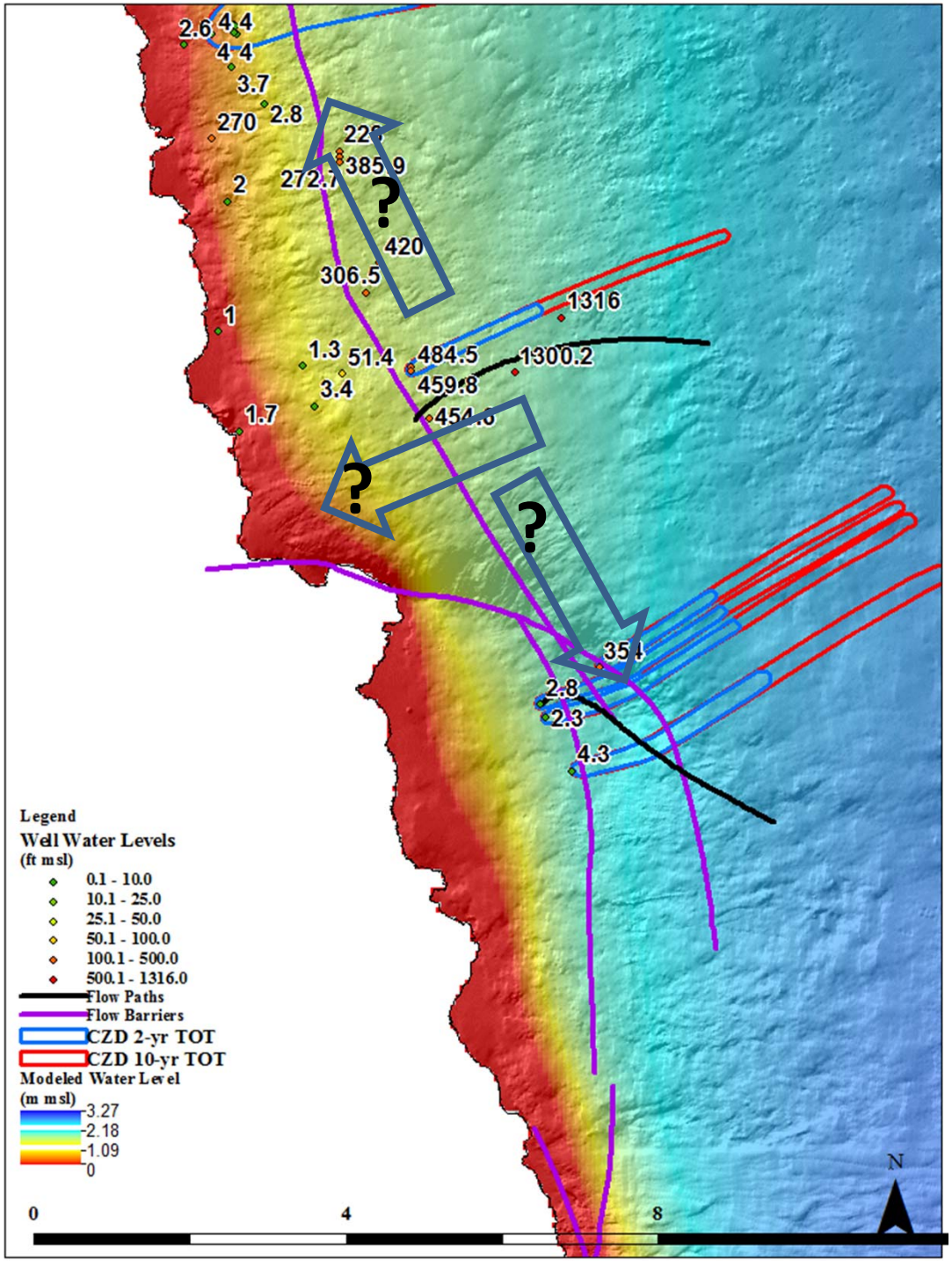


The High Level Water Debate

Three different hypothesis' for the existence of the high level water

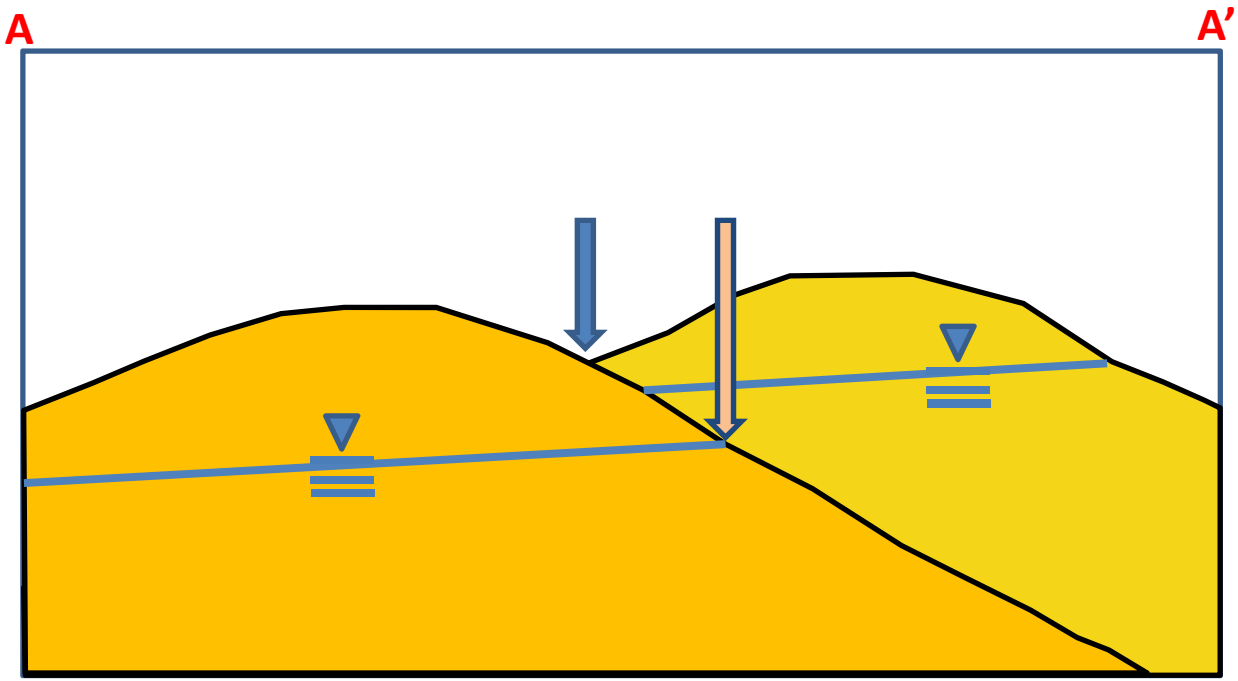
Each has a different implication for direction and velocity of groundwater flow.

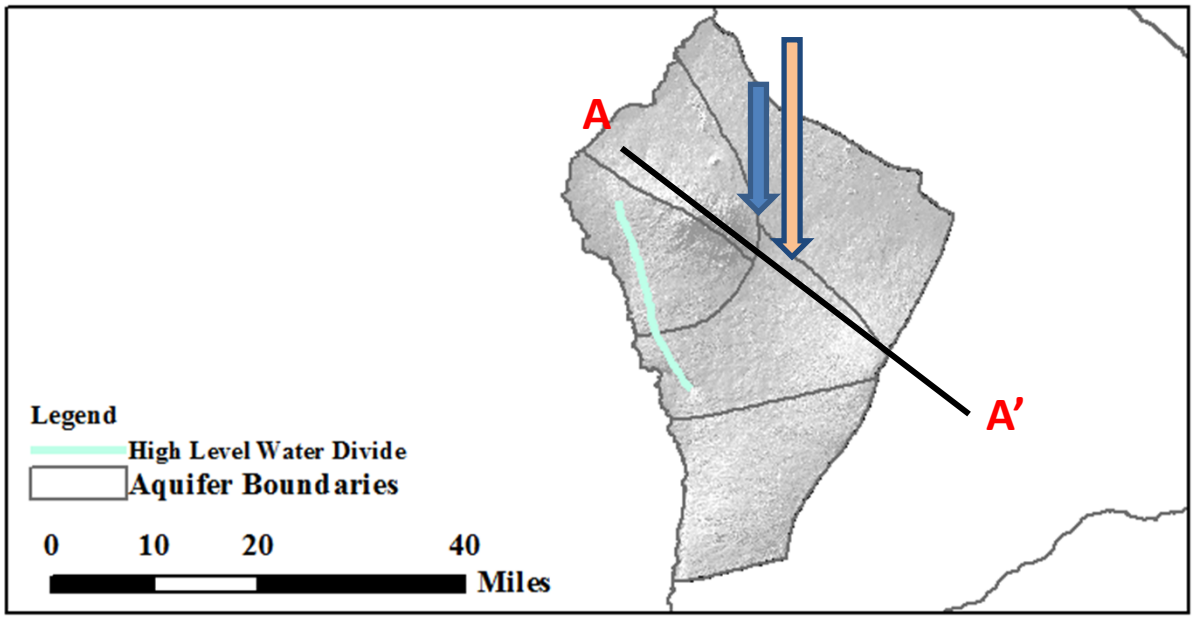
From Oki, 1999



How Do the Hydraulic Barriers Affect Direction of Groundwater Flow?

- Dike complex could favor mauka to makai flow
- On-echelon faults could favor a flow component parallel to barriers





Aquifer Boundaries

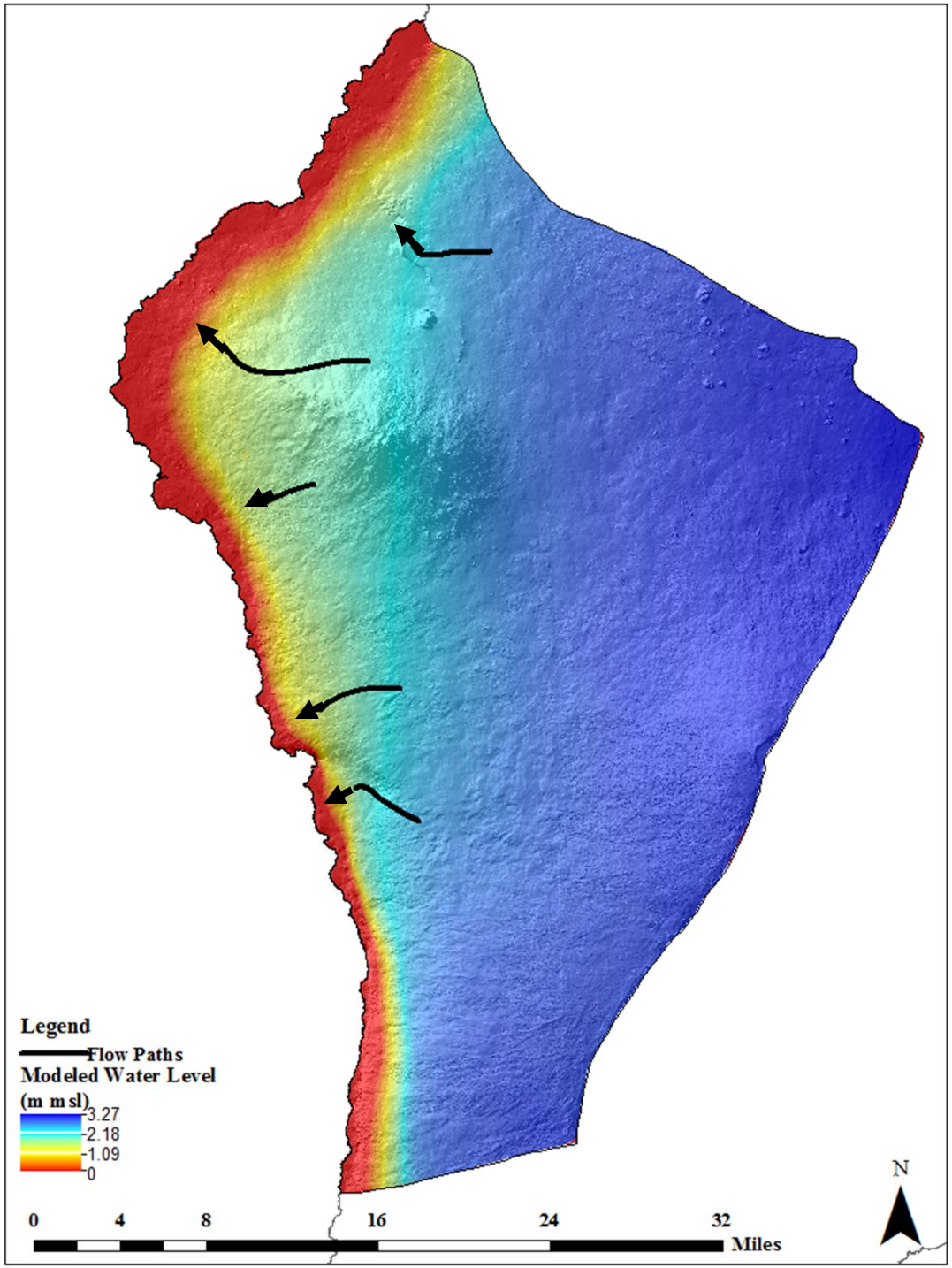
- Aquifer boundaries are intended to segregate groundwater flow systems
- As such would steer groundwater flow directions
- Currently delineated along contacts between volcanos (blue arrow)
- However, actual aquifer boundary would occur at the water table not at the ground surface (brown arrow)

Modeling Approach

Modeling Approach
Stepped Method

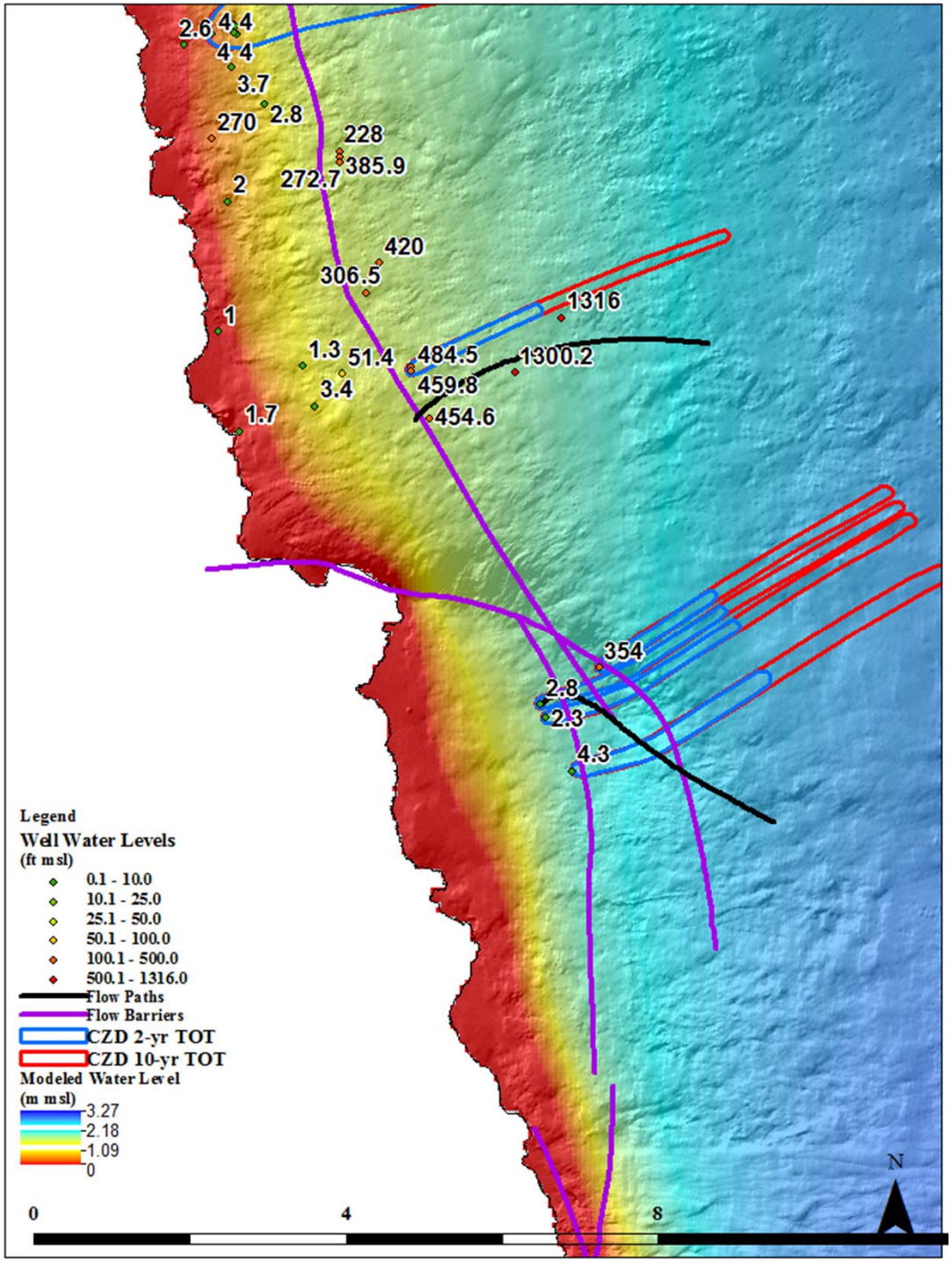
1. Develop model with uniform hydraulic characteristics
2. Incorporate known or inferred barriers
3. Break model into hydrologic regions
4. Minimize water level and Oxygen-18 isotope error after each step

KEEP THE MODEL AS SIMPLE AS POSSIBLE AND STILL ANSWER THE PERTINENT QUESTIONS!



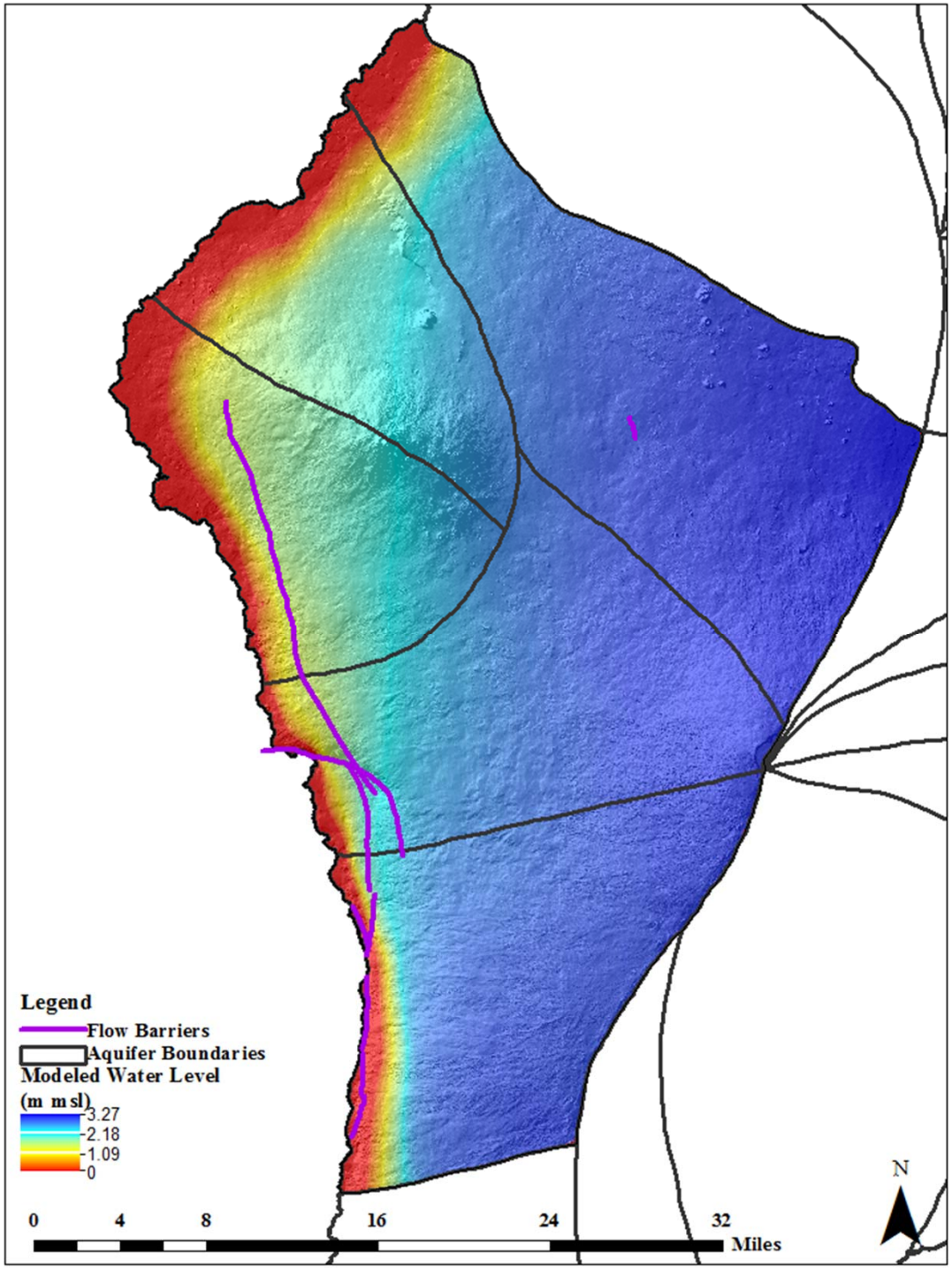
Modeling Approach

- Develop model with uniform hydraulic characteristics:
  - Identifies groundwater flow paths governed by
    - distribution of recharge
    - Near shore bathymetry



Modeling Approach

- Incorporate known or inferred barriers
- Check - are modeled flow paths consistent with:
  - Barriers?
  - Topography?
  - Aquifer boundaries?



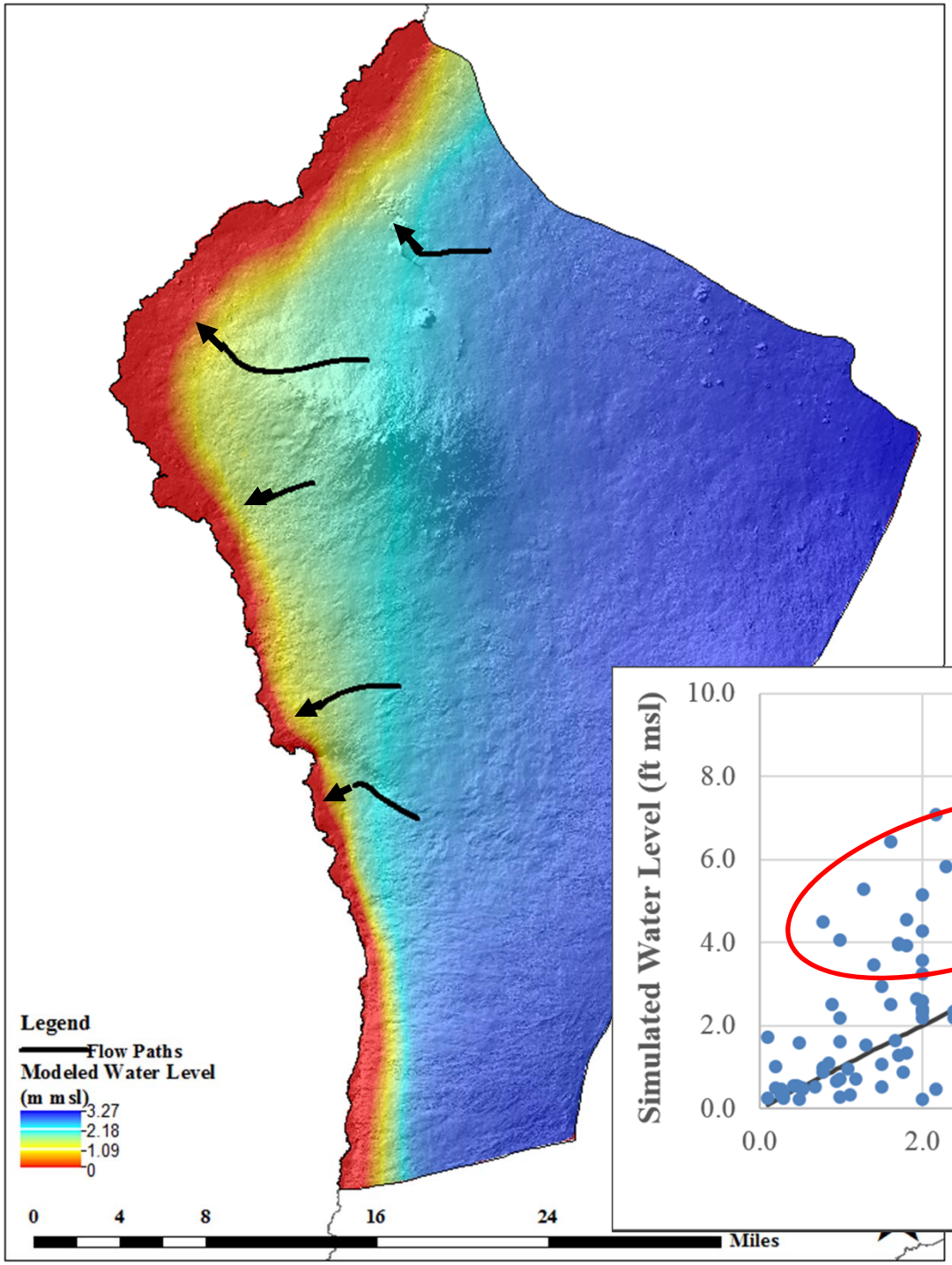
Modeling Approach

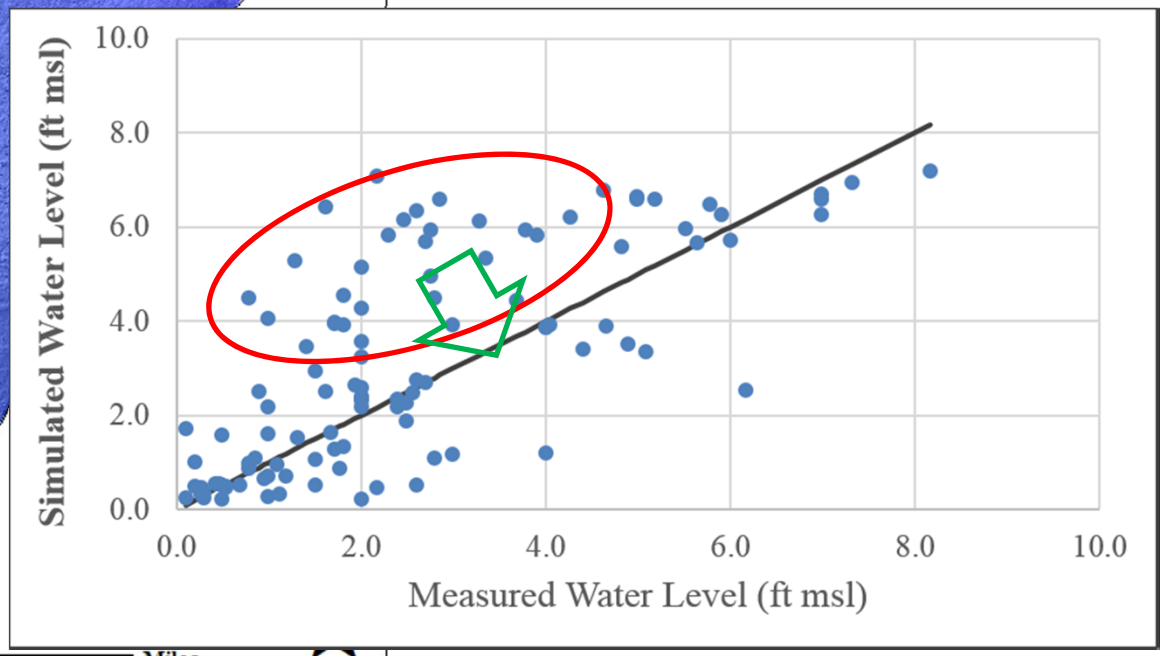
- Parse model into hydrologic flow regions
  - 1st pass - use delineated aquifer boundaries
  - Investigate various sub-terrain mountain contacts
  - Incorporate new data as it becomes available (geophysics?)

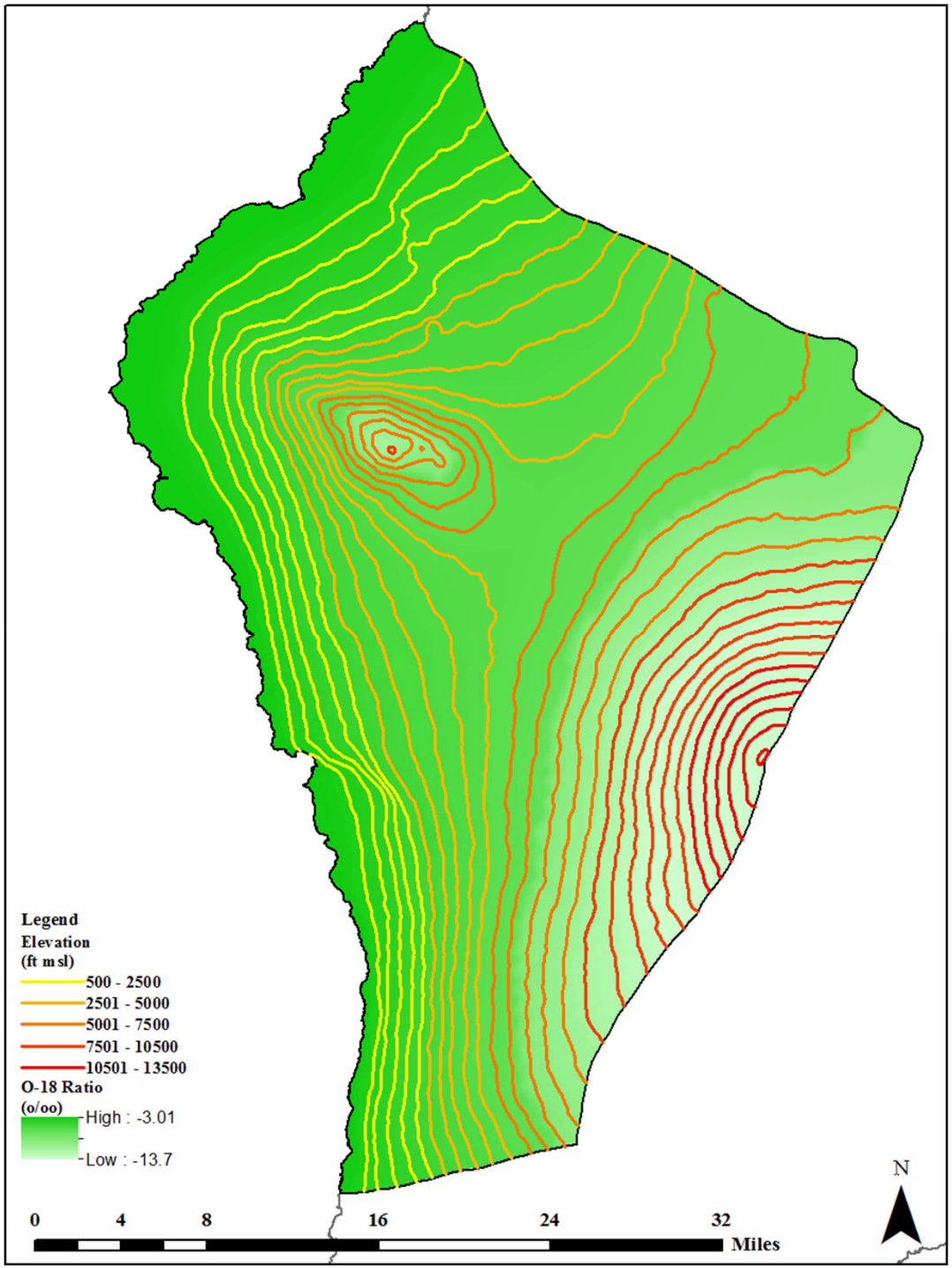
Model Validation

Validating the Model

- Classical approach
- Compare simulated and observed water levels
- Basal water level calibration below

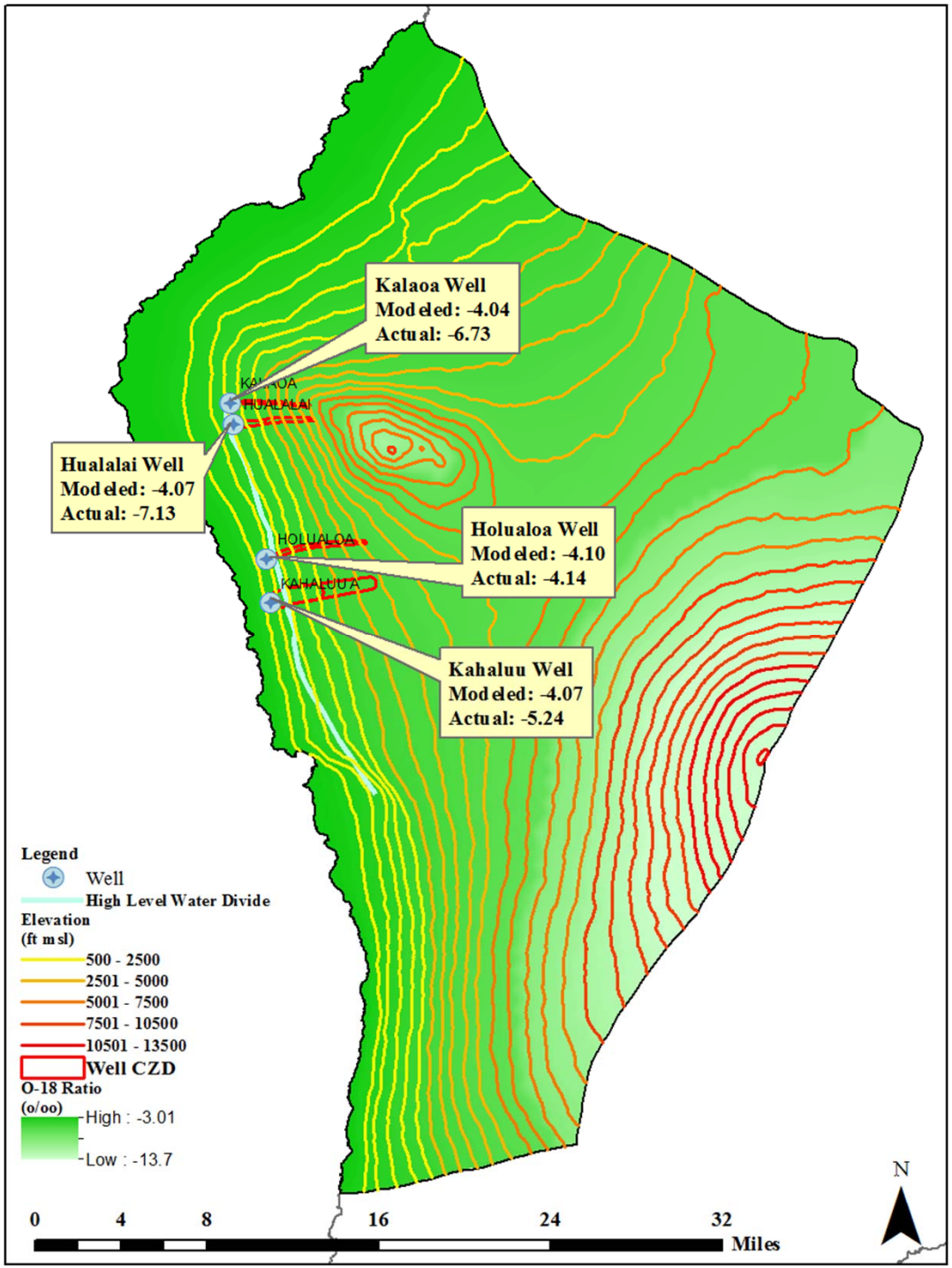






Oxygen-18 Isotope as a Tracer

- Heavy Isotope of Oxygen
- Less negative numbers indicate enrichment in ^{18}O ($\delta^{18}O$)
- Predicable correlation with elevation
  - Elevation >2000m
    - $\delta^{18}O$=-0.0032h-0.45 (Scholl et al. 1996)
  - Elevation <2000m
    - $\delta^{18}O$=-0.0013h-3.03 (Fackrell, 2014)



Oxygen-18 Isotope as a Model Validation Parameter

- From work done by Fackrell, UH Dept. of Geology & Geophysics
- Compared model calculated $\delta^{18}O$ values with those measured
- Reasonably close for those wells makai of the high level water boundary
- Poor match for those wells mauka of the high level water boundary
  - Indicates a higher elevation source of recharge than that modeled

In Summary

Summary

- The SWAP requires groundwater flow models that accurately replicate groundwater flow paths and velocity
- The complex hydrogeology of West Hawaii make meeting those requirements challenging
- Significant new scientific research has been done since the original SWAP models were done prior to 2004

Summary (Cont.)

- The SWAP model for West Hawaii will be updated to include:
  - The results of recent and on-going scientific research
  - Incorporate stable isotope geochemistry in the model validation process
  - Attempt to test various explanations for the existence of the high level water in West Hawaii

Thank You!