SGMA and Groundwater Modeling Myths

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Security and Sustainability Research Initiative

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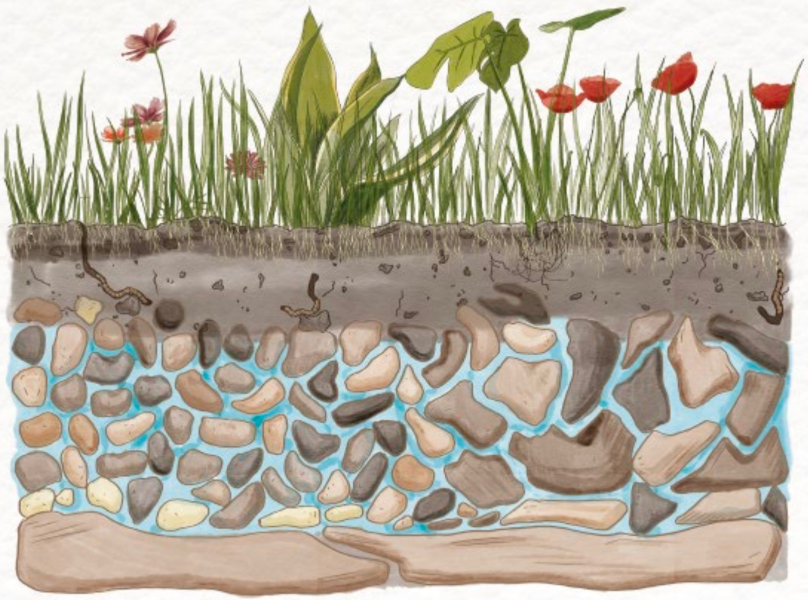
22 MARCH
WORLD WATER DAY
2022 Groundwater

World Water Day 2022 Factsheet

Groundwater: making the invisible visible



Some Groundwater Model Myths

1. The model is only as good as the data.
2. A corollary: we build the model by first determining the water budget (and parameters) and plugging into the model…
3. “A” groundwater budget exists.
4. If there’s no identifiable confining bed, the system is unconfined.

Myth 1: The model is only as good as the data

- A more accurate adage: *Better data always produces a better model.*
- Key distinguishing point: Groundwater models represent the physics of groundwater flow virtually perfectly. This can be leveraged to calculate/estimate unknowns using the knowns (e.g., calibration).
- ***An even better adage*****:** The model is only as good as the data, the model algorithm's representation of the physics, and the skill of the modeler.

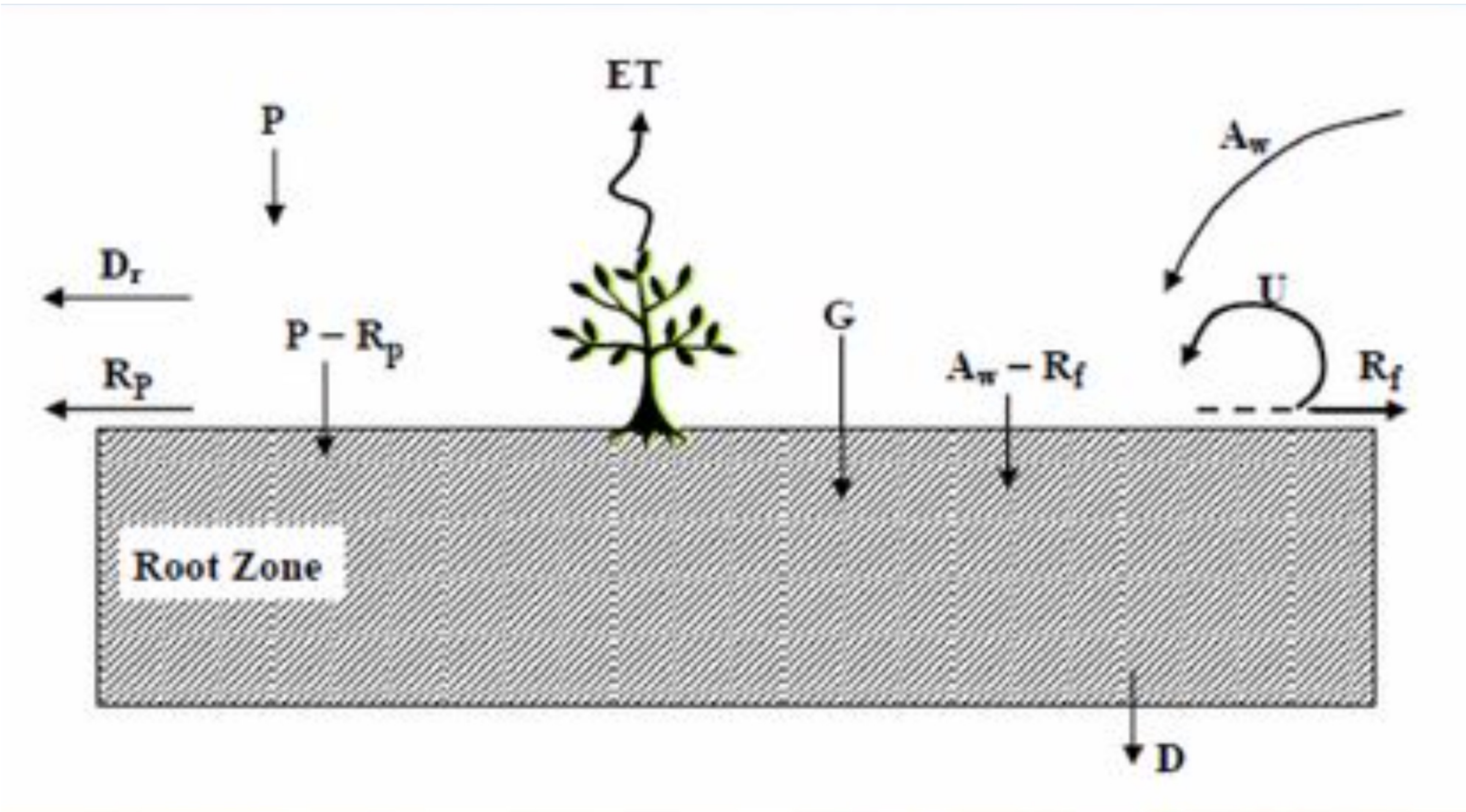
Myth 2: We build the model by first determining the water budget (and parameters)…

- Reality: The groundwater model is typically the main, and best way of *calculating* the groundwater budget.
- Why? Consider the typical groundwater budget and an apparent contradiction:
  - Dominated by pumpage and recharge!
  - Pumpage is mostly unmeasured.
  - Recharge is unobservable, and also unmeasured.
  - Yet we are able to build reliable groundwater models that produce reliable groundwater budgets.

How? (for the irrigated basin case)

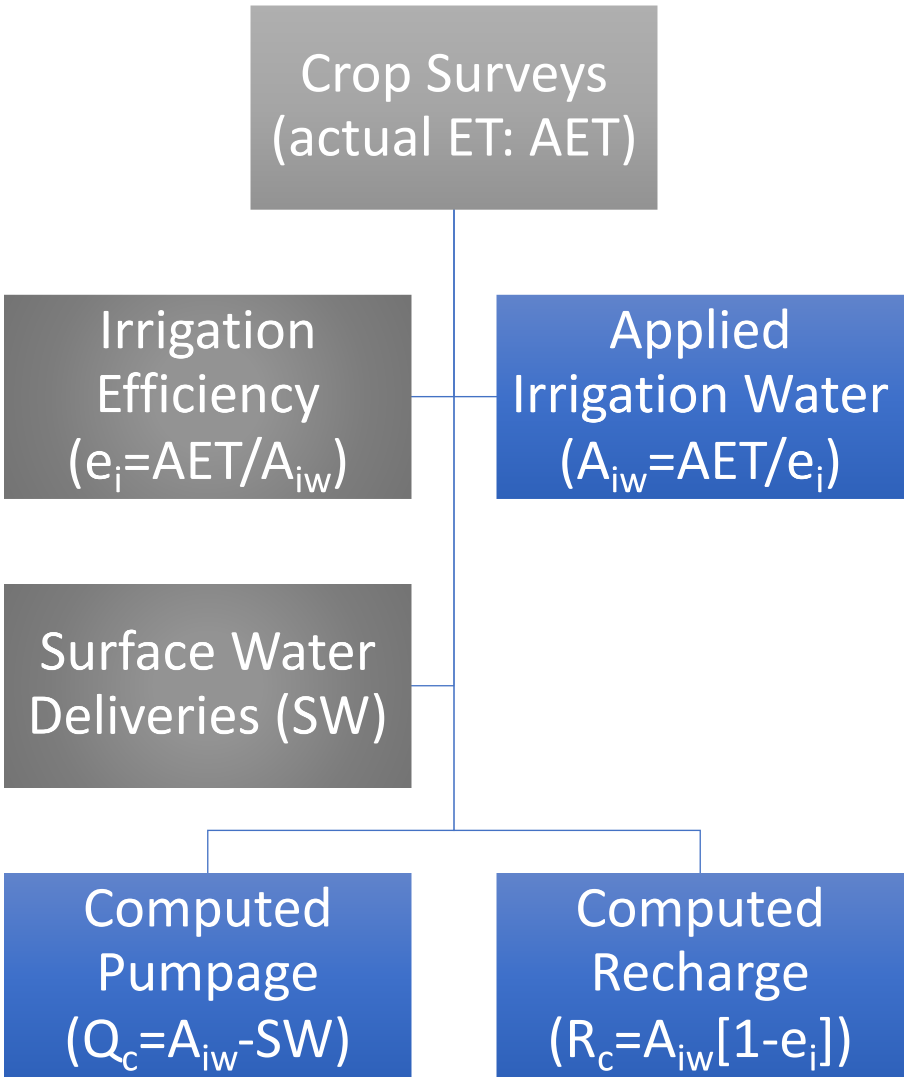
- By estimating pumpage and recharge using a crop-consumptive use analysis
- And validating or constraining that water budget using model computation of
  1. Hydraulic head
  2. Fluxes that can be compared to measured fluxes (e.g., spring or stream baseflow discharge; drain flows)

Crop Consumptive Use Approach to Computing Pumpage and Recharge



Source: E. C. Dogrul, DWR IDC-2015

Crop Consumptive Use Approach to Computing Pumpage and Recharge



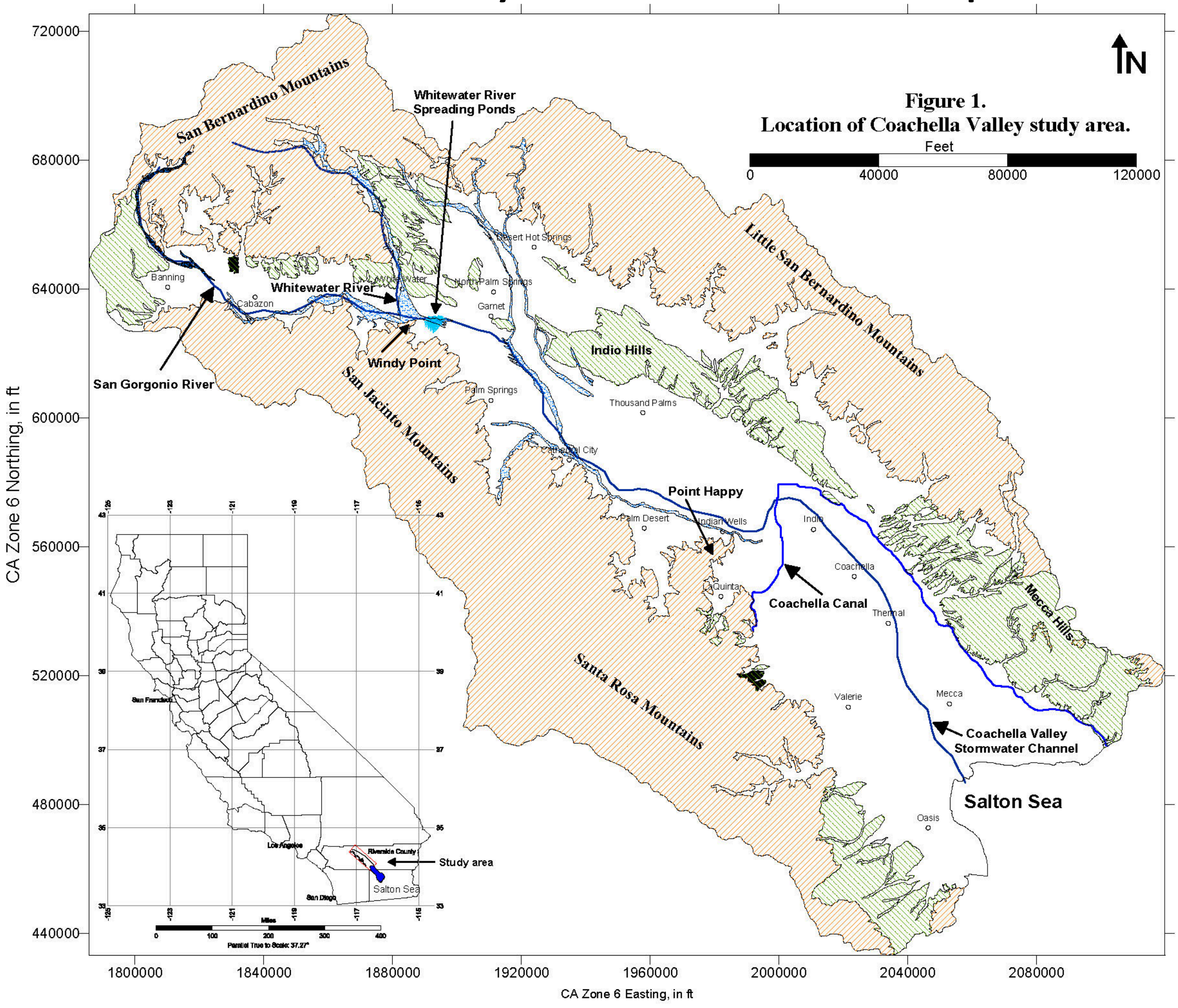
Essential Data

AET: From CA CIMIS stations and crop coefficients; or satellite methods.

e_i: AET/A_{iw}. Fraction of the applied irrigation water (A_{iw}) evapotranspired by the crop (including plant transpiration and soil evaporation). Comes from knowledge of local irrigation practices; input from knowledgeable agricultural engineers very important.

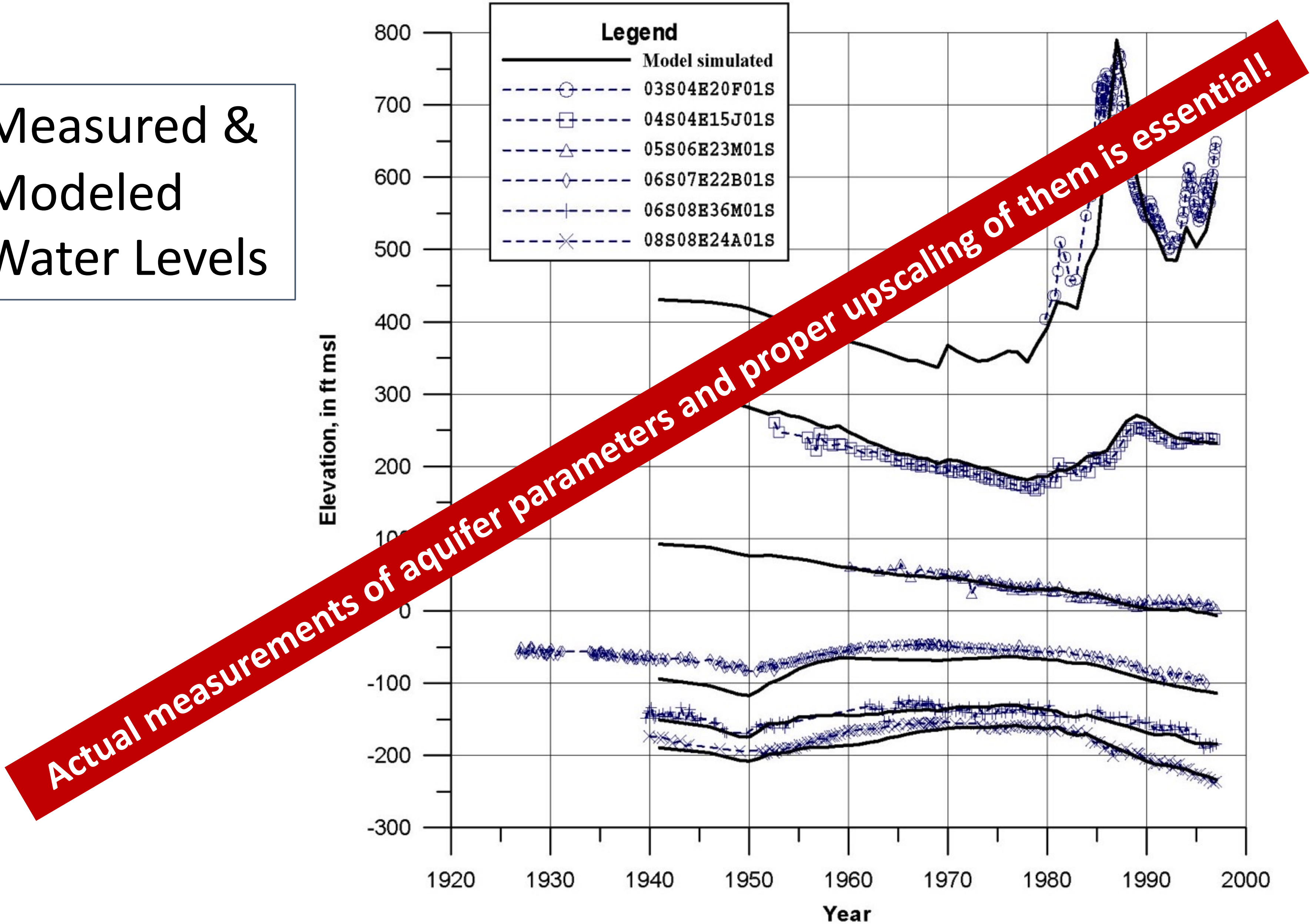
SW: In CA comes from DWR or local irrigation or water district data.

Coachella Valley Groundwater Model Example

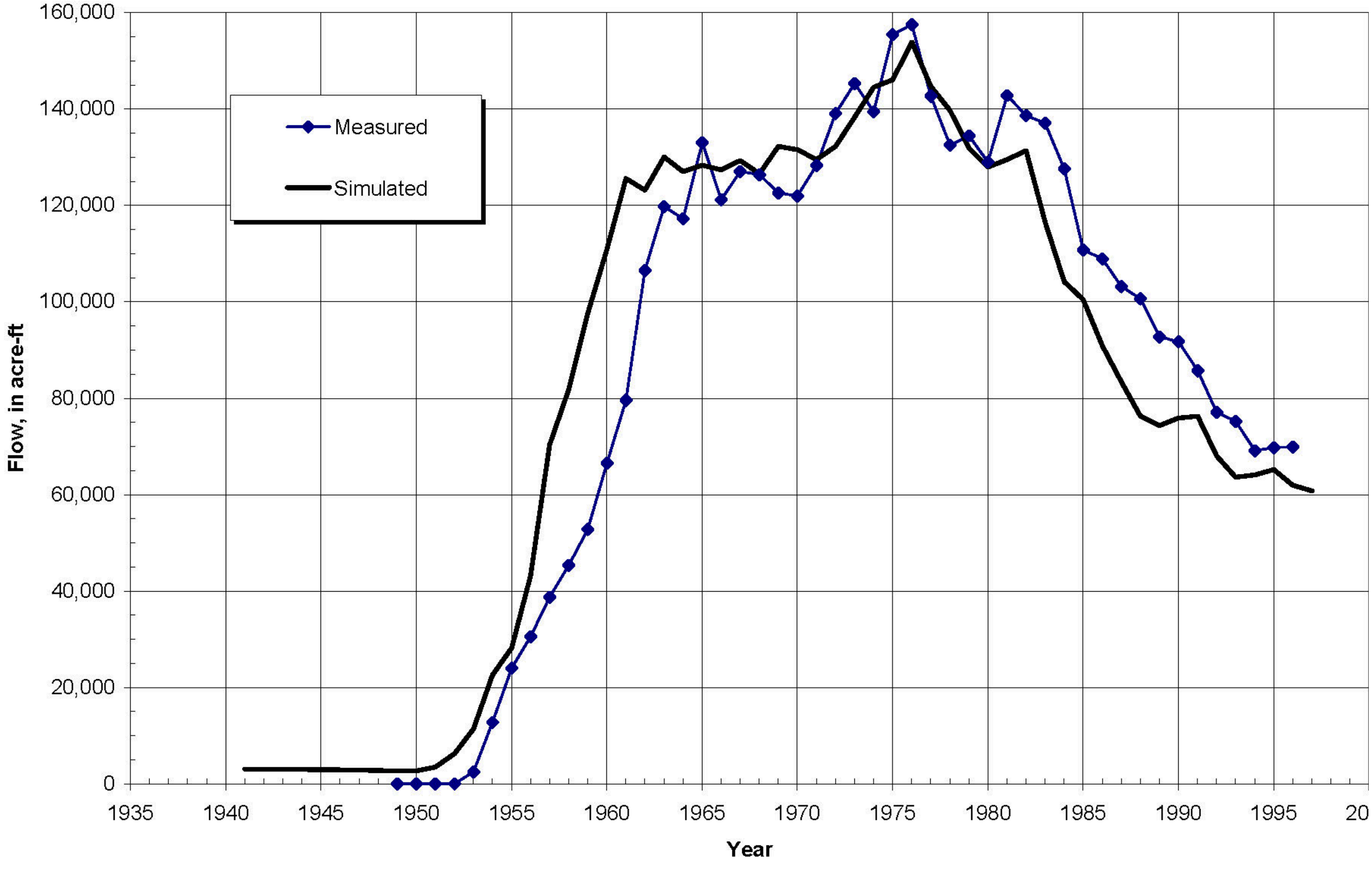


Coachella Valley Groundwater Model Example

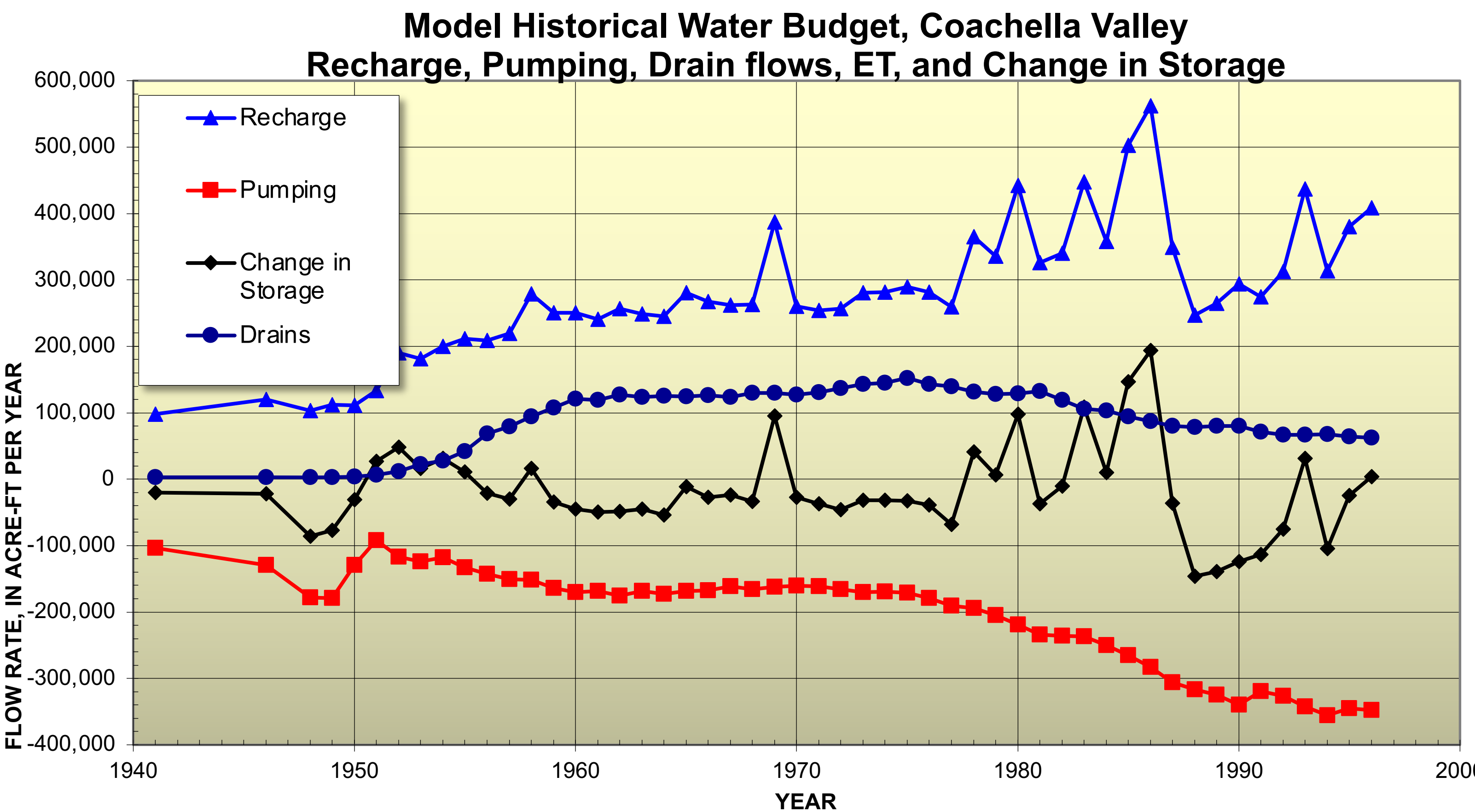
Measured & Modeled Water Levels



Modeled & Measured Drain Flows, Coachella V.

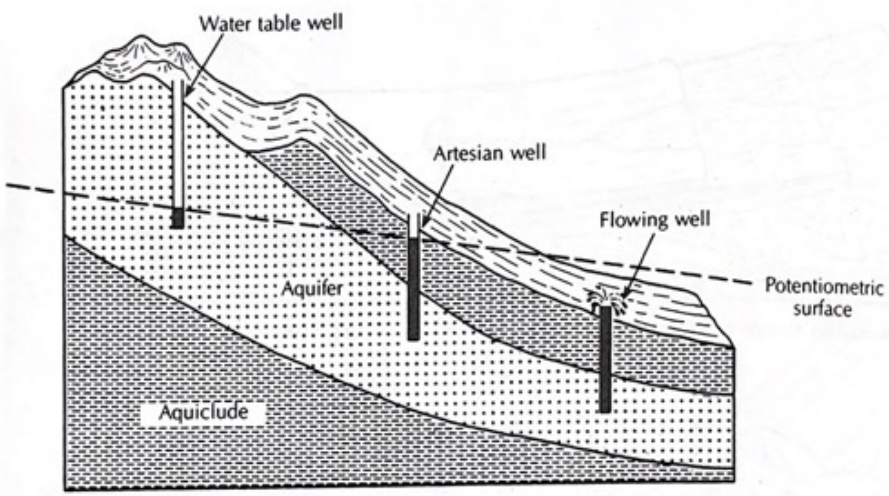


Myth 3: “A” groundwater budget exists; Reality: The terms are transient and interdependent



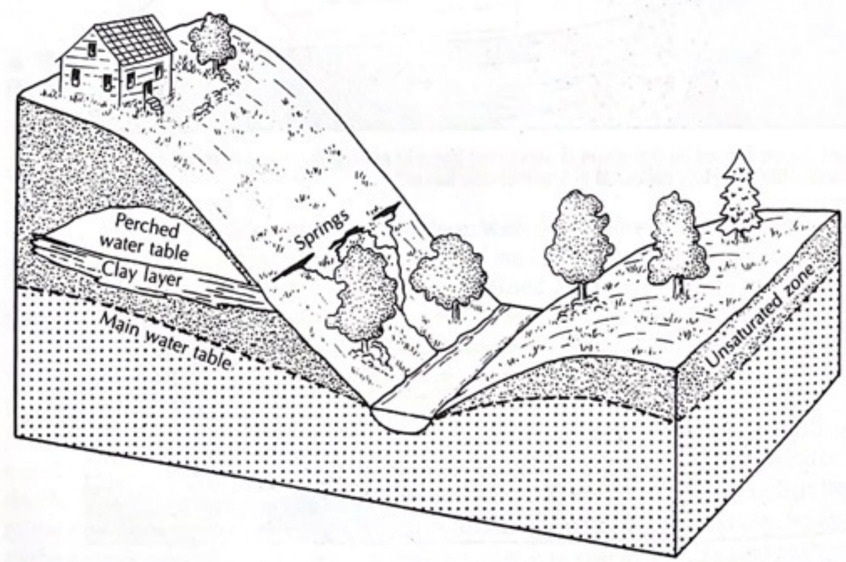
Myth 4: If there's no identifiable confining bed, the system is unconfined

Classic "confined" (Fetter, 2018)



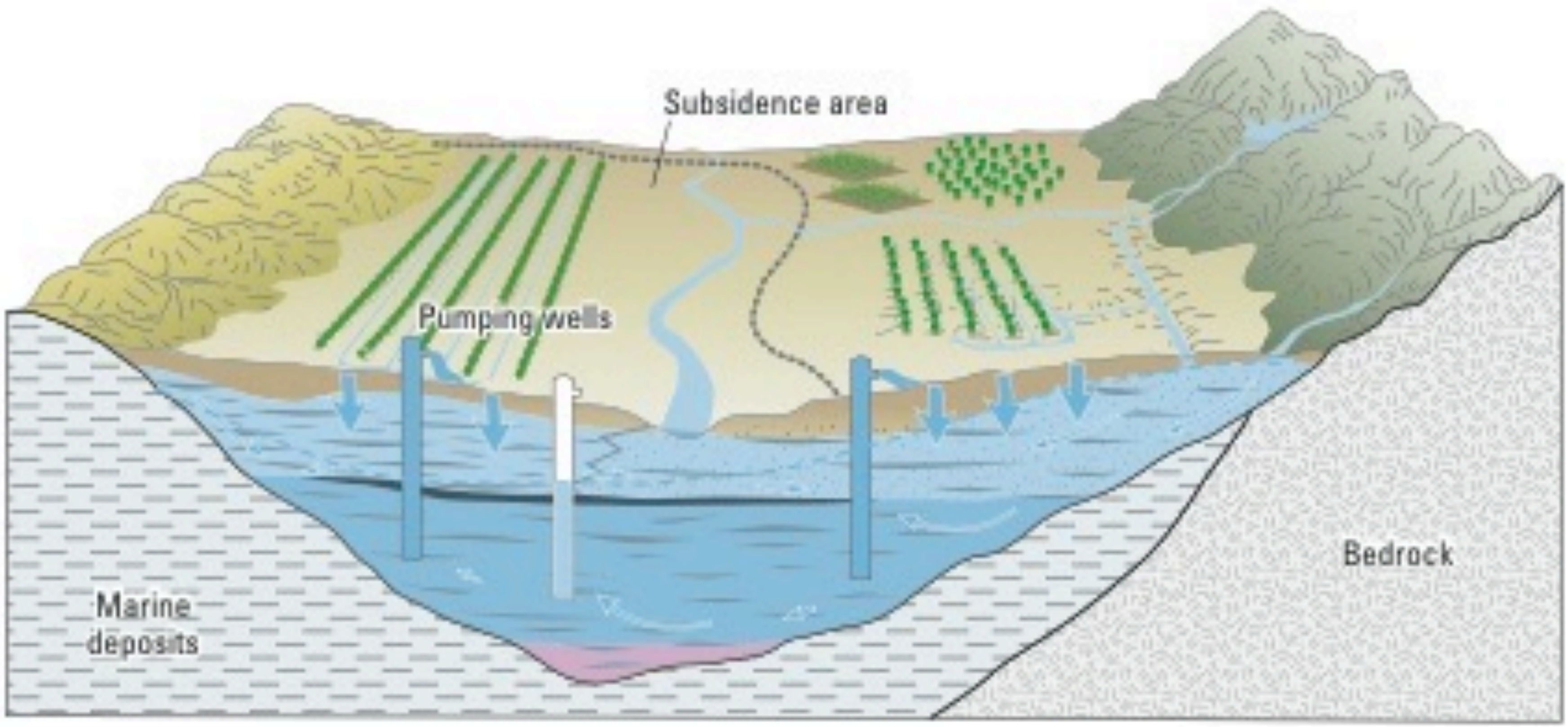
▲ FIGURE 3.22
Artesian and flowing well in confined aquifer.

Classic "unconfined" (Fetter, 2018)

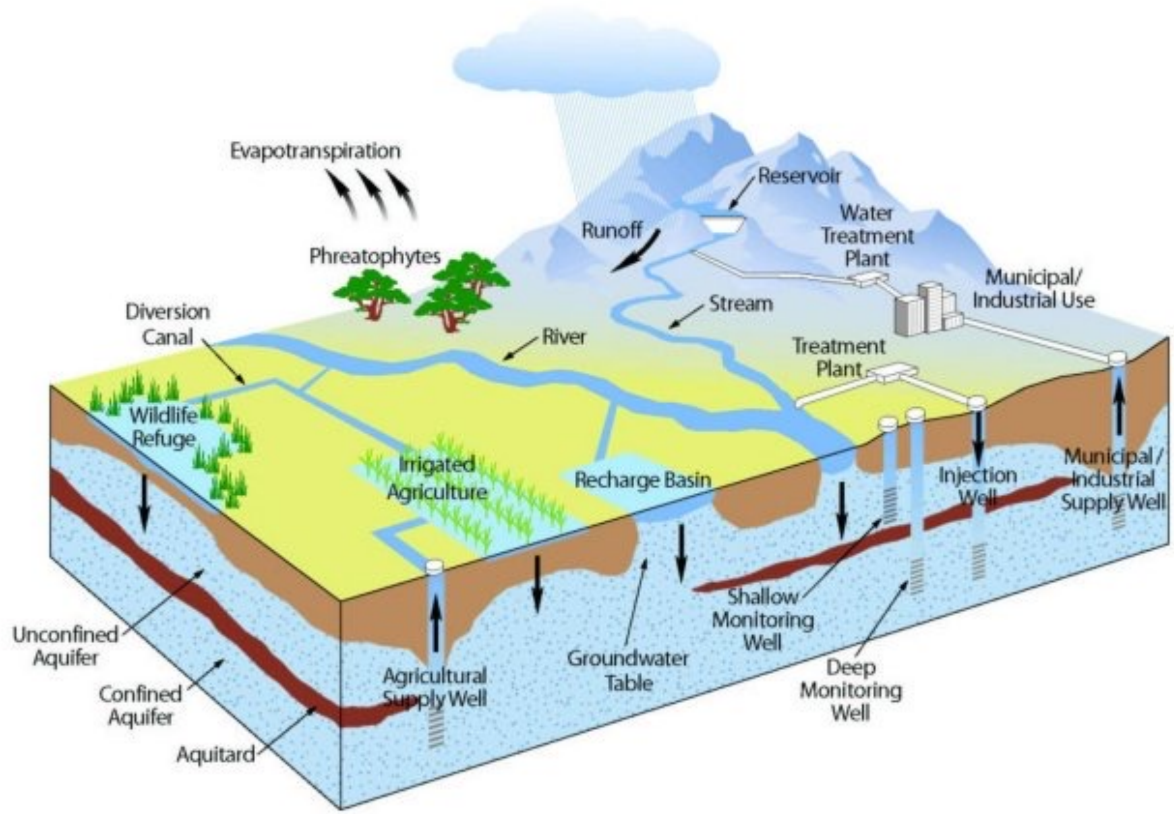


▲ FIGURE 3.23
Perched aquifer formed above the main water table on a low-permeability layer in the unsaturated zone.

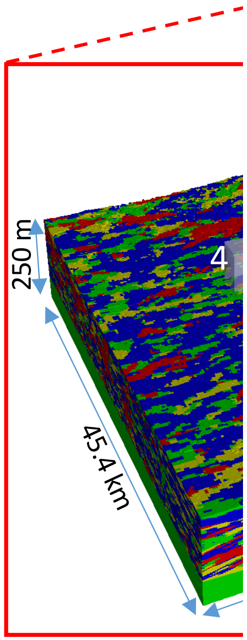
San Joaquin Valley Groundwater (from Faunt, 2009)

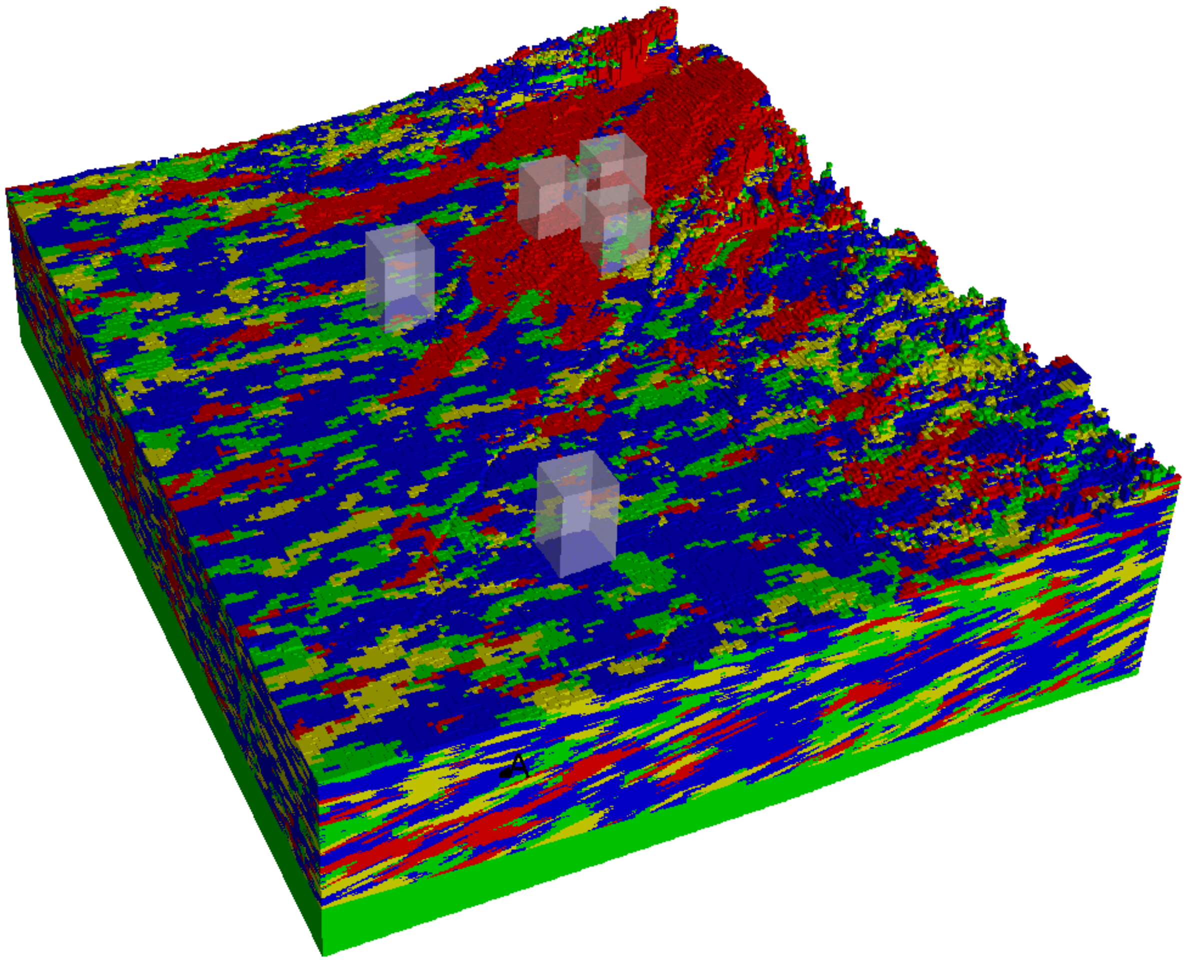


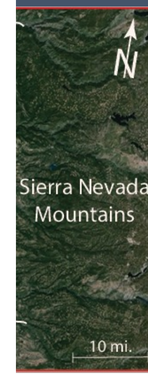
Typical Concept of Aquifer Recharge



ParFlo
American-Co







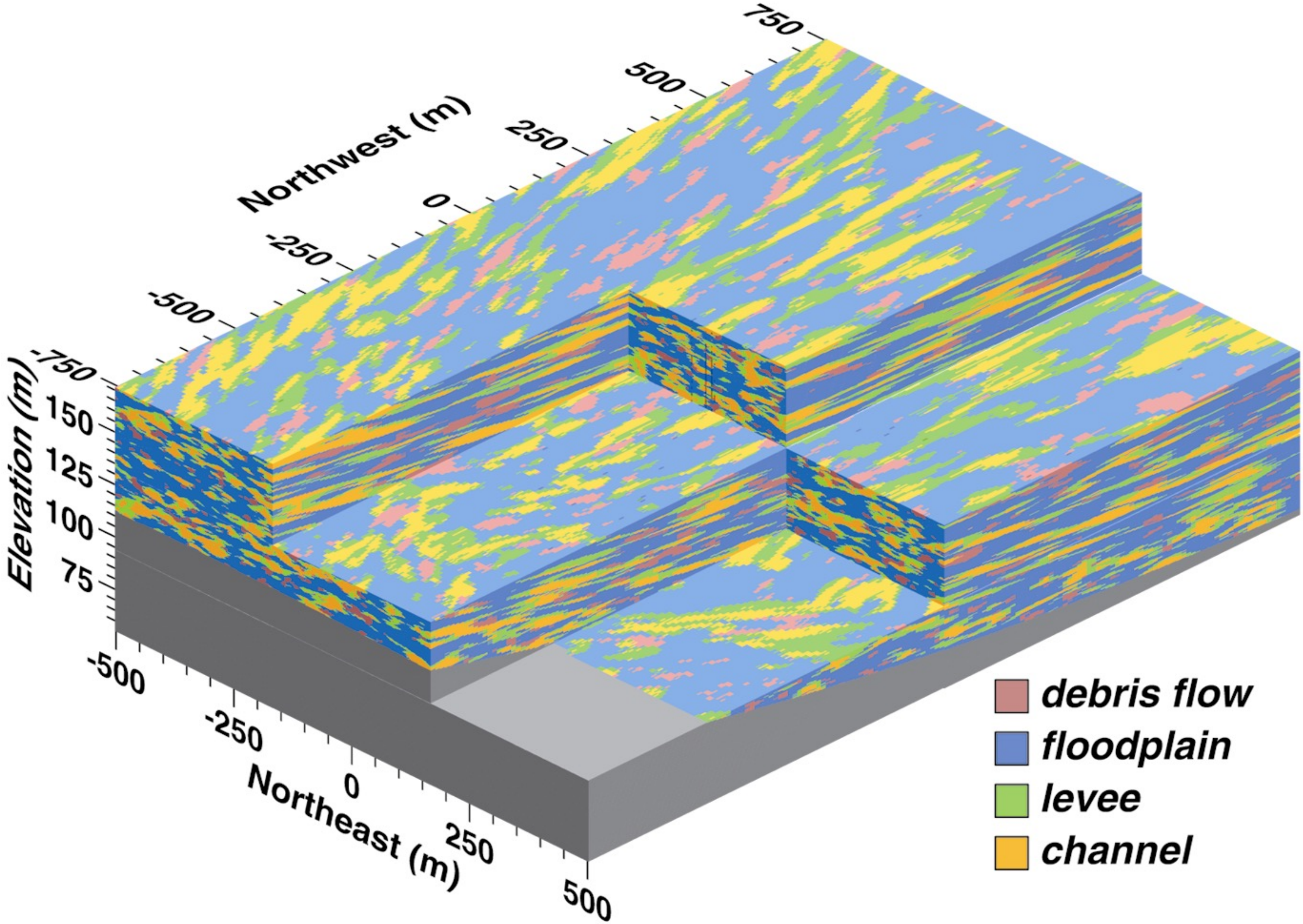
leterogeneity **(Meirovitz,**

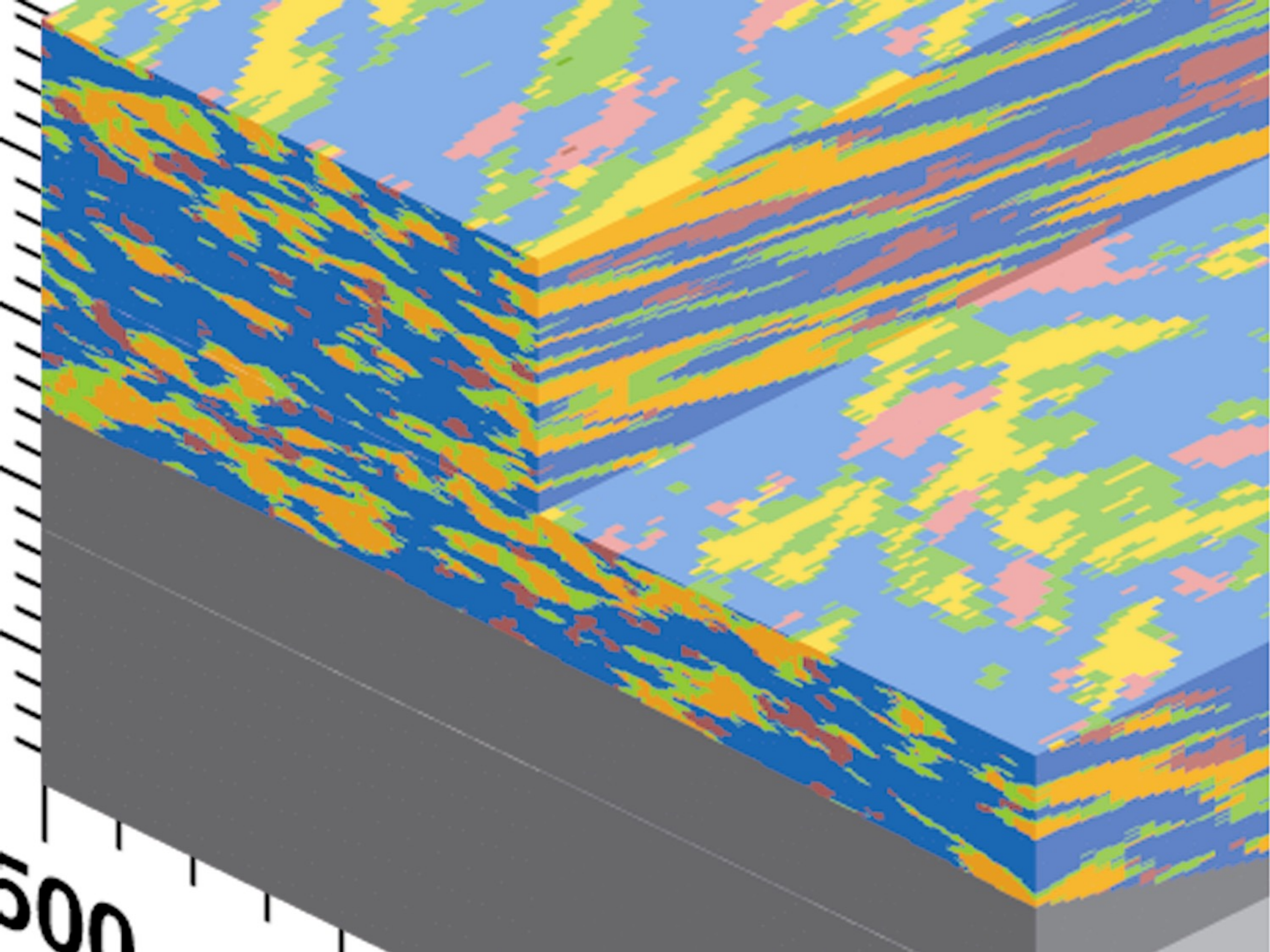
200 well logs

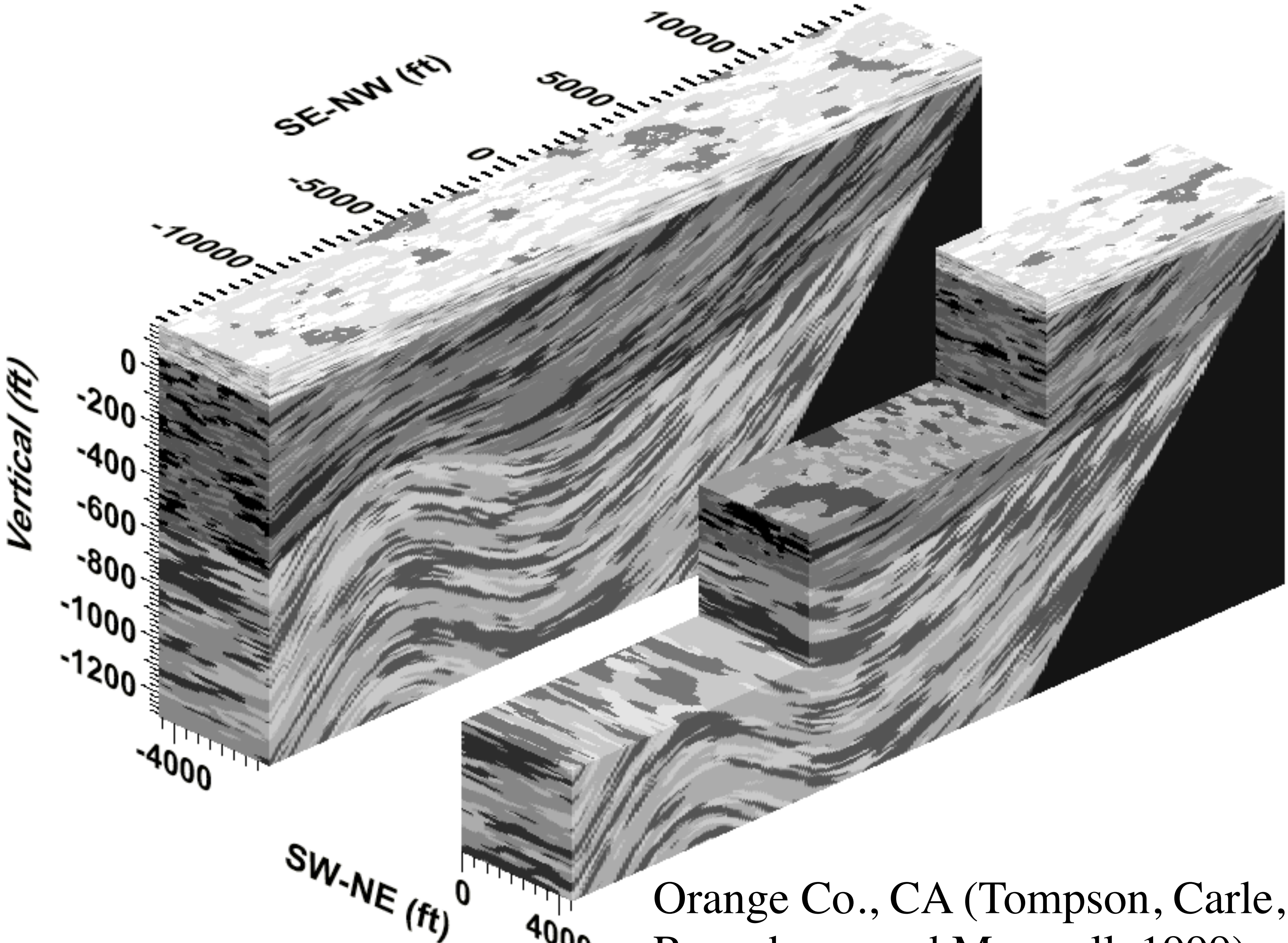
l4)

gy (1) simulates realistic
lerated recharge.

Typical Subsurface Complexty, LLNL Site (Carle & Fogg, 1996)







Orange Co., CA (Tompson, Carle, Rosenberg, and Maxwell, 1999)

So what?

Groundwater-Surface Water Interaction in the Southeastern Sacramento Valley

DEPARTMENT OF WATER RESOURCES
STATE OF CALIFORNIA

Final Project Report

Prepared For:

California Department of Water Resources

University of California Davis, Agreement Number 4600007984

Prepared By:

Danielle Moss, Graham E. Fogg, and Wesley W. Wallender

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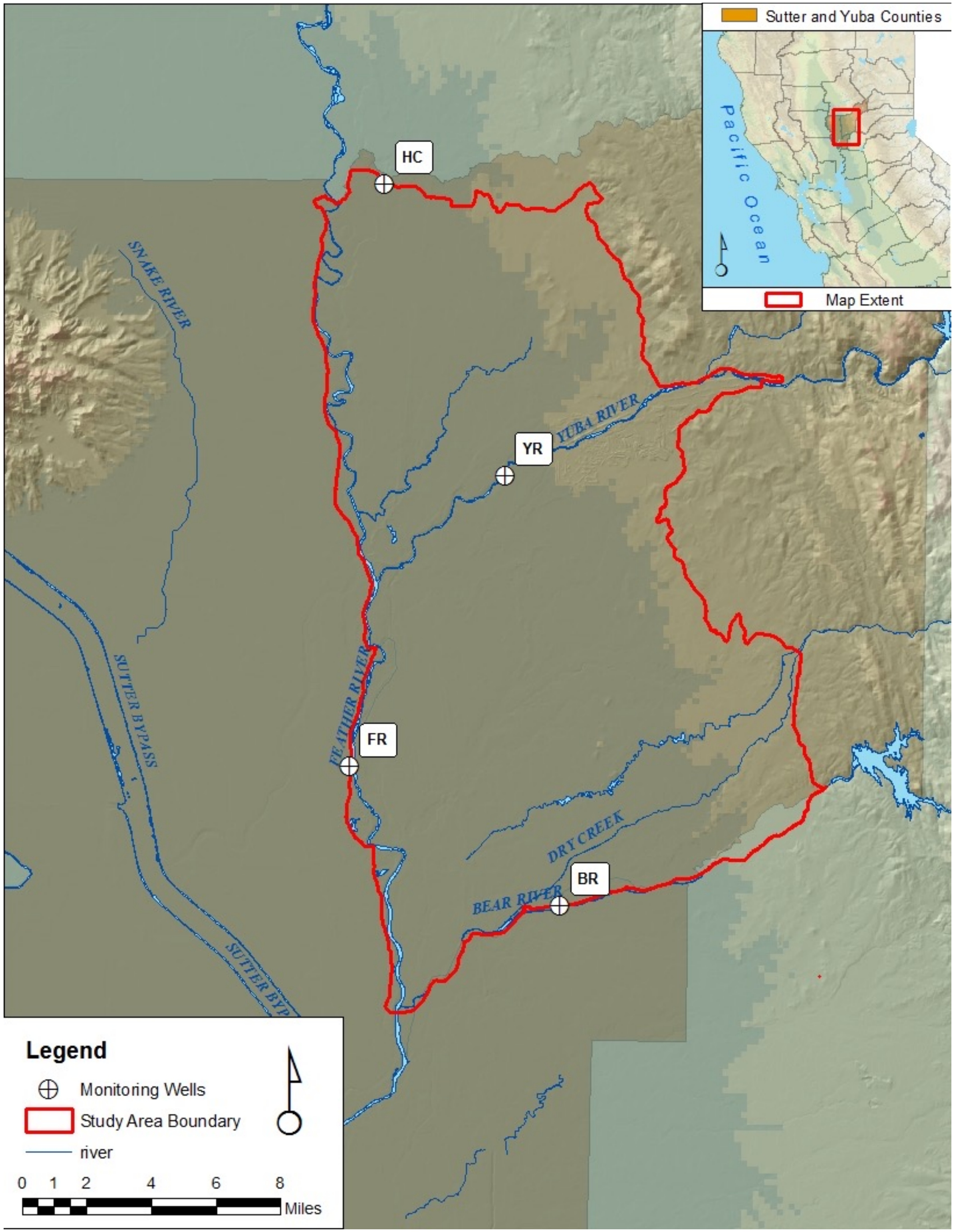
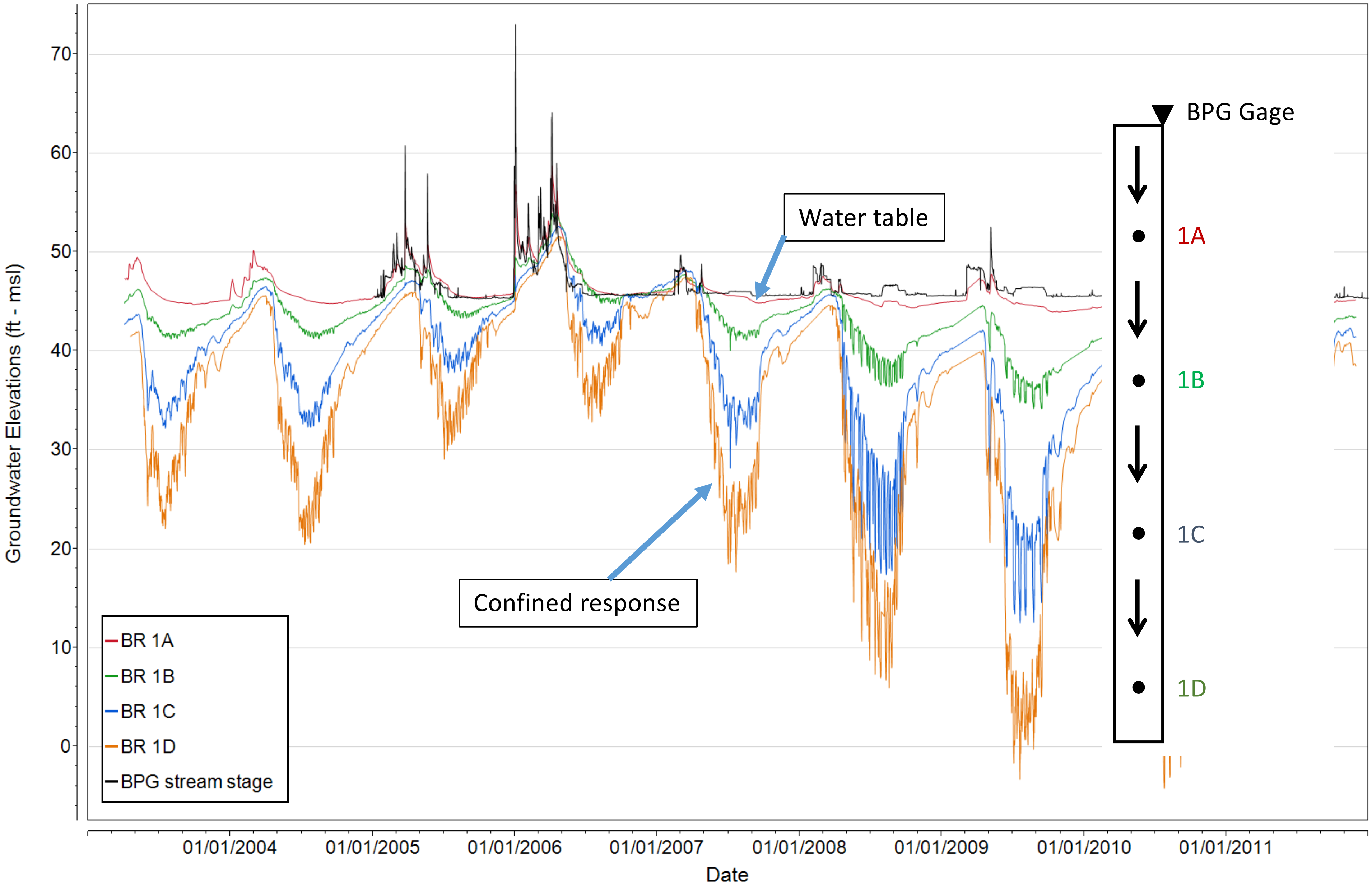
Climate Change • Sustainable Agriculture
Environmental Quality • Landscape Processes

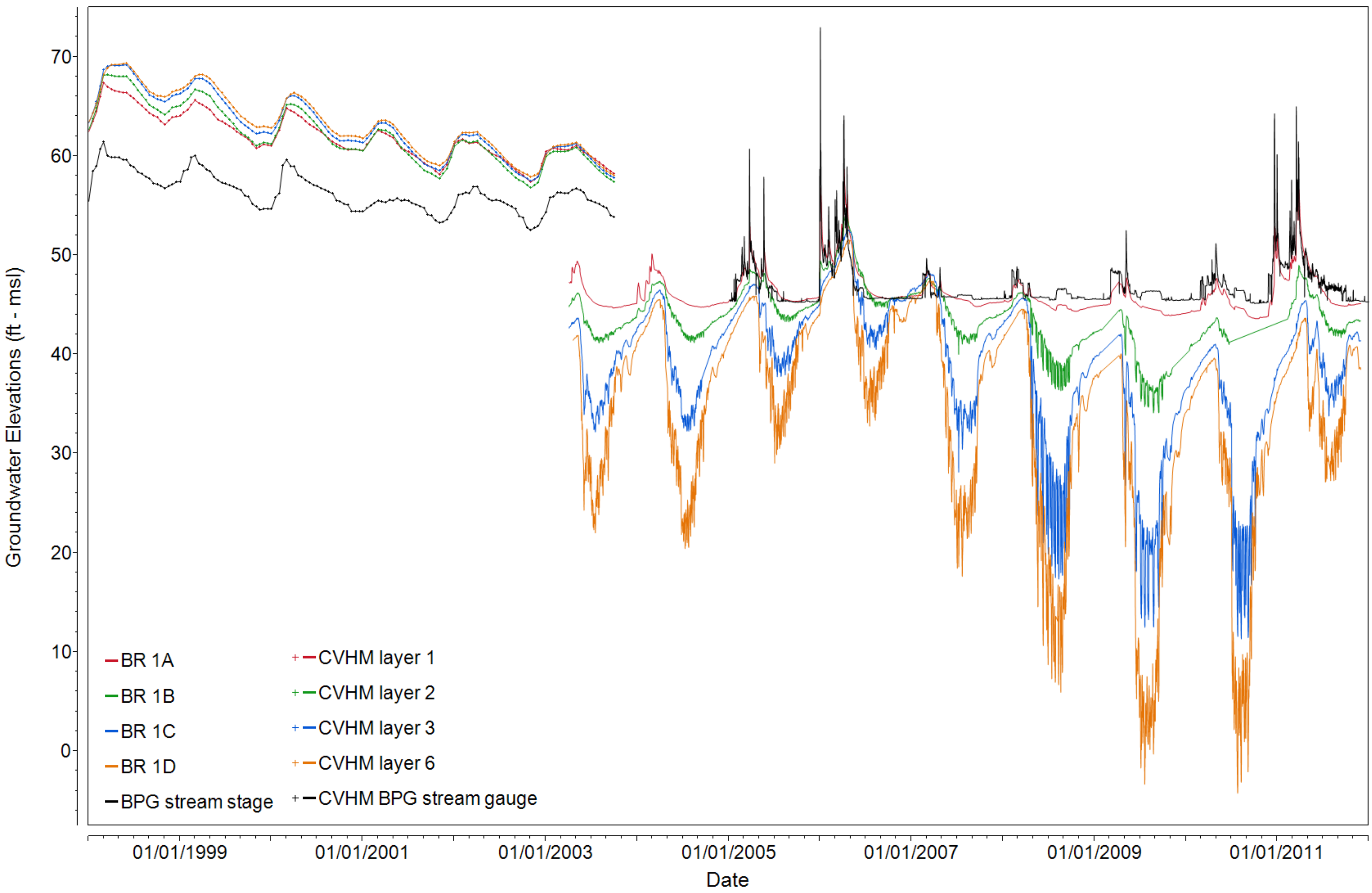


Sutter and Yuba Counties
Pacific Ocean
Map Extent
HC
YR
FR
BR
SNAKE RIVER
YUBA RIVER
FEATHER RIVER
SUTTER BYPASS
DRY CREEK
BEAR RIVER
Legend
Monitoring Wells
Study Area Boundary
river
0 1 2 4 6 8
Miles

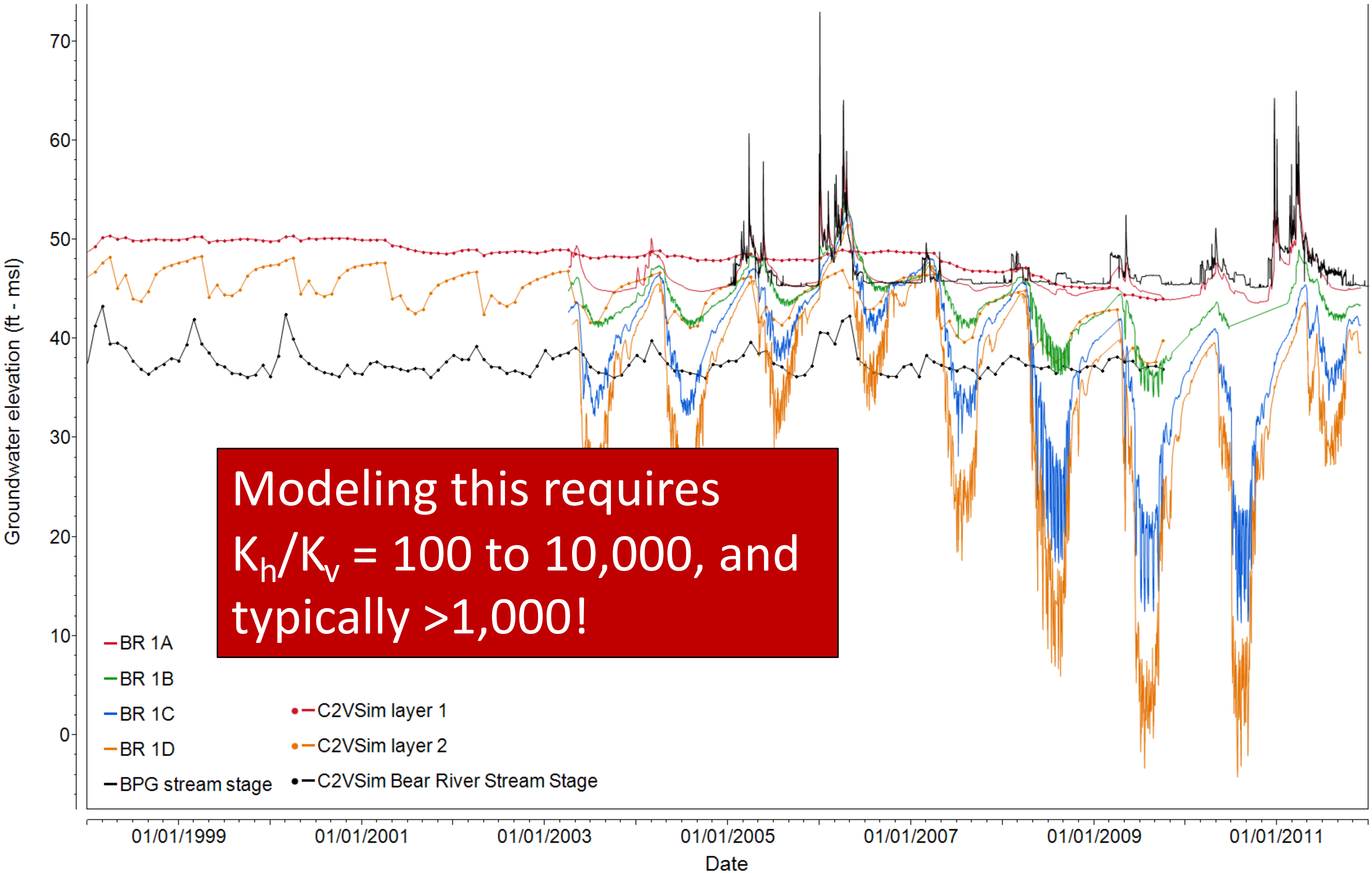
Bear River Monitoring Wells (well nest)



Bear River measured & modeled (CVHM, 2013) h



Bear River measured & modeled (C2VSIM, 2013) h



Modeling this requires K_h/K_v = 100 to 10,000, and typically >1,000!

Key Point (Myth 4)

- Without properly calibrating for model representation of vertical head gradients and vertical anisotropy, the model will not properly represent critically important dynamics of the aquifer system:
  - Interplay between pumping and recharge
  - Groundwater and surface water interaction
  - Shallow and deep response to recharge
  - Effects and dynamics of ‘sweet spots’ of greater vertical connectivity for recharge
  - Groundwater budgets

Summary

- Ironically, the best groundwater budget typically comes from a carefully constructed and calibrated model, not the other way around (Myths 1 & 2).
- All groundwater budgets are dynamic and not static; hence a model is essential for anticipating how the budget terms will change under different water management strategies (Myth 3).
- Recognize that most of our aquifer systems are definitely NOT unconfined, but rather, leaky confined (i.e., semi-confined) (Myth 4).
- Modeling approaches are still too strongly 2D rather than 3D – need to fully extend to 3D by representing semi-confined or leaky confined conditions by calibrating vertical anisotropy to data on vertical h gradients (Myth 4).
- Good data and models are key to making "the invisible visible!