Workshop on
Deep Aquifers Study:
Preliminary Investigation

MONTGOMERY & ASSOCIATES
Water Resource Consultants

October 3, 2022

Prepared by

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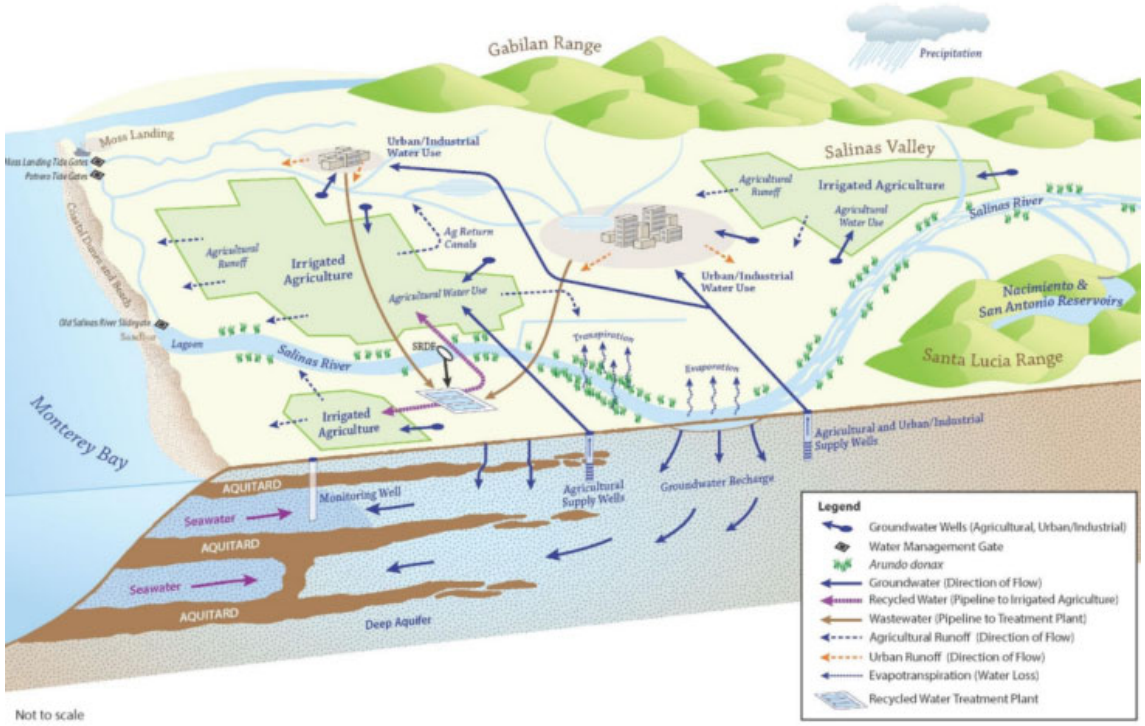
Deep Aquifers within the Salinas Valley



Source: Getty Images/ iStockphoto

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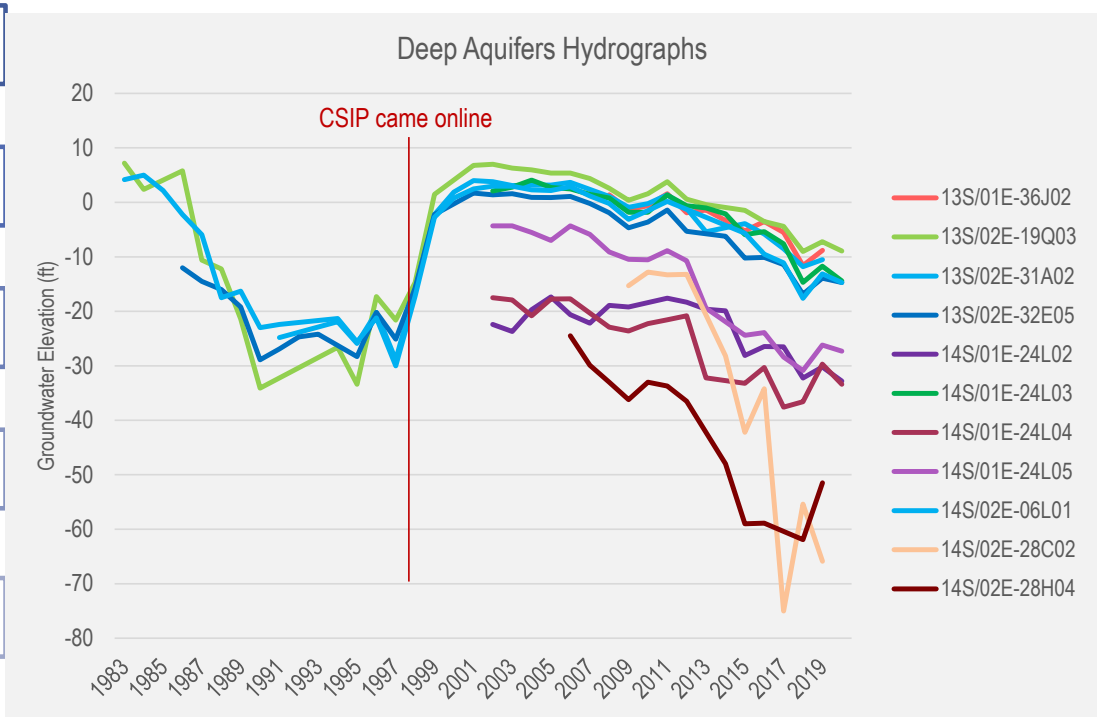
Why this Study is Needed

- Declining groundwater levels
- New well installations & increasing extraction
- Uncertain if/from where there is recharge
- Threat of seawater intrusion and subsidence
- Need to manage per SGMA



Screen in 900-ft Aquifer

Screen in 1100-ft Aquifer (or 800/900 to 1100)

Screen in 1500-ft Aquifer (or from 1100 to 1500)

Screen through 800-ft to 1500-ft Aquifers

Screen deeper than 1500-ft (~1800)

Still 1500-ft Aquifer?

Increasing wells installed & extraction

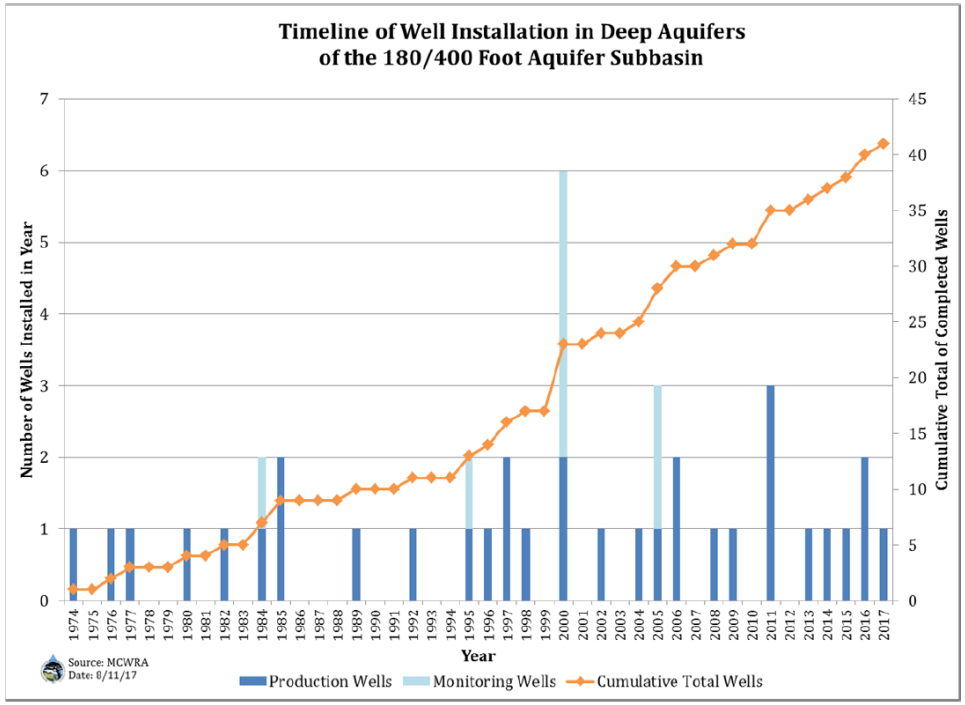


Figure 19 - Timeline of Well Installation in Deep Aquifers of the 180/400 Foot Aquifer Subbasin

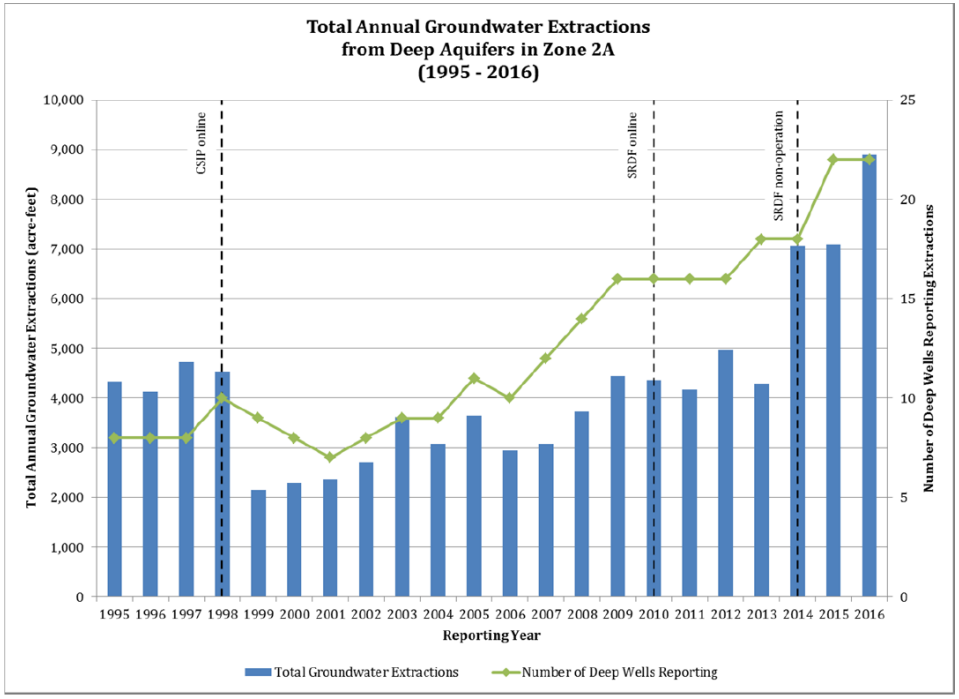
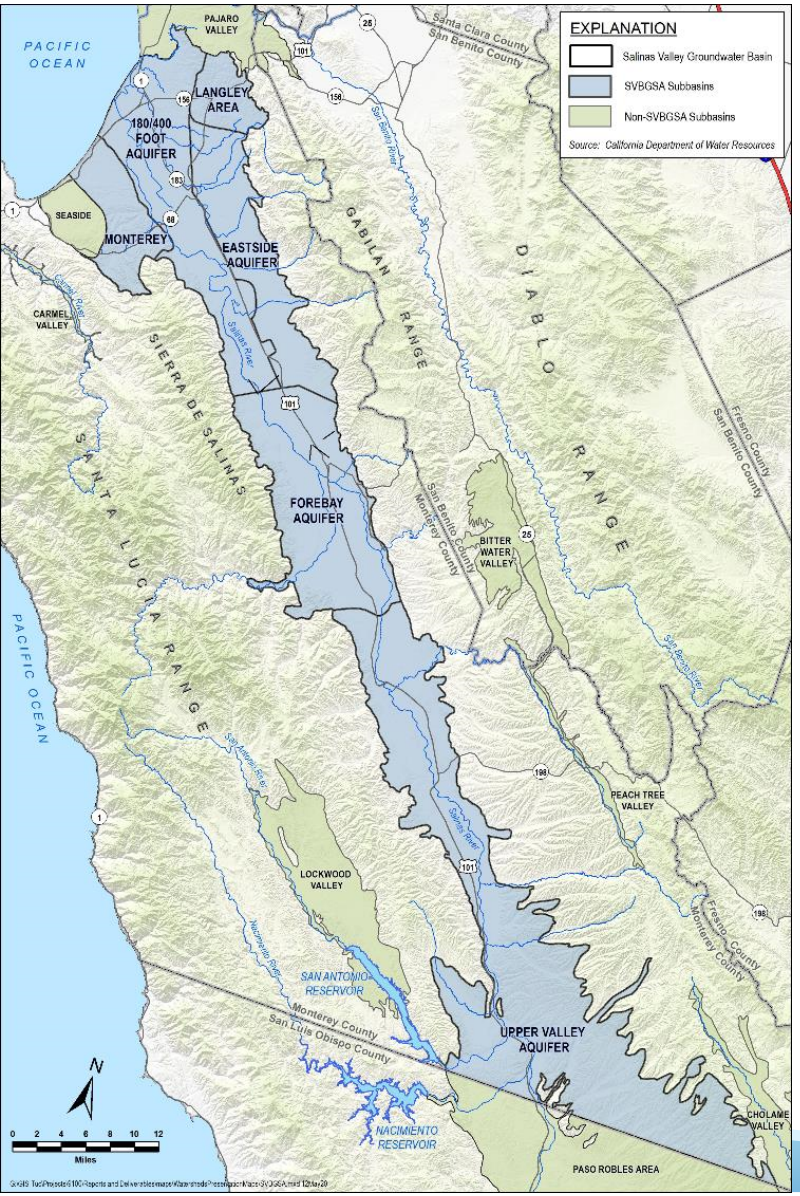


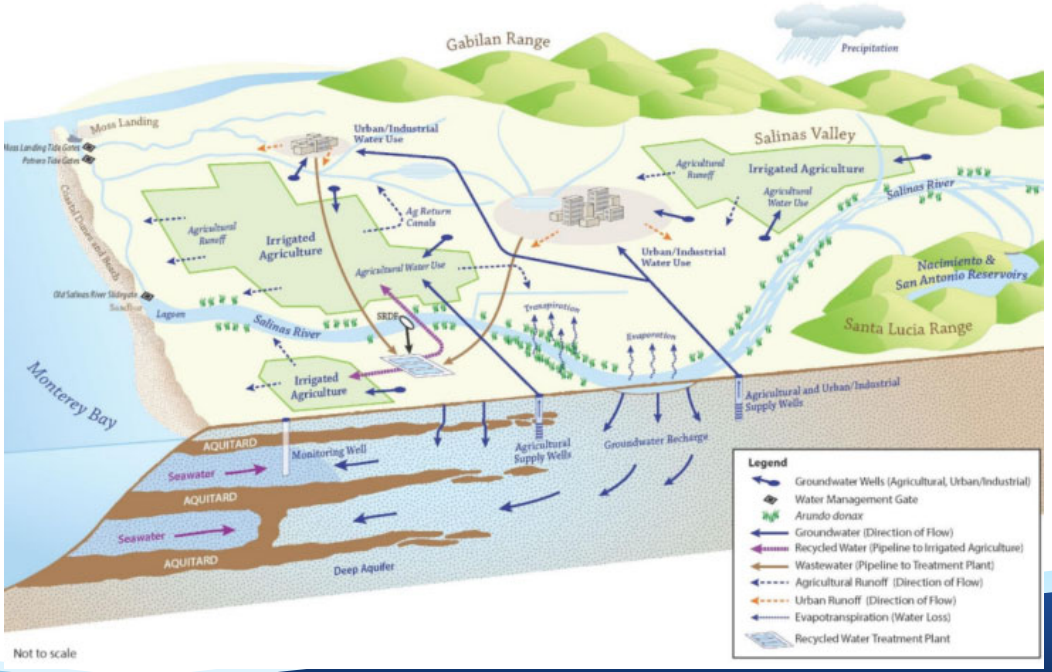
Figure 23 - Total Annual Groundwater Extractions from Deep Aquifers in Zone 2A (1995-2016)

Recommendations to Address the Expansion of Seawater Intrusion in the Salinas Valley Groundwater Basin, Monterey County Water Resources Agency, October 2017

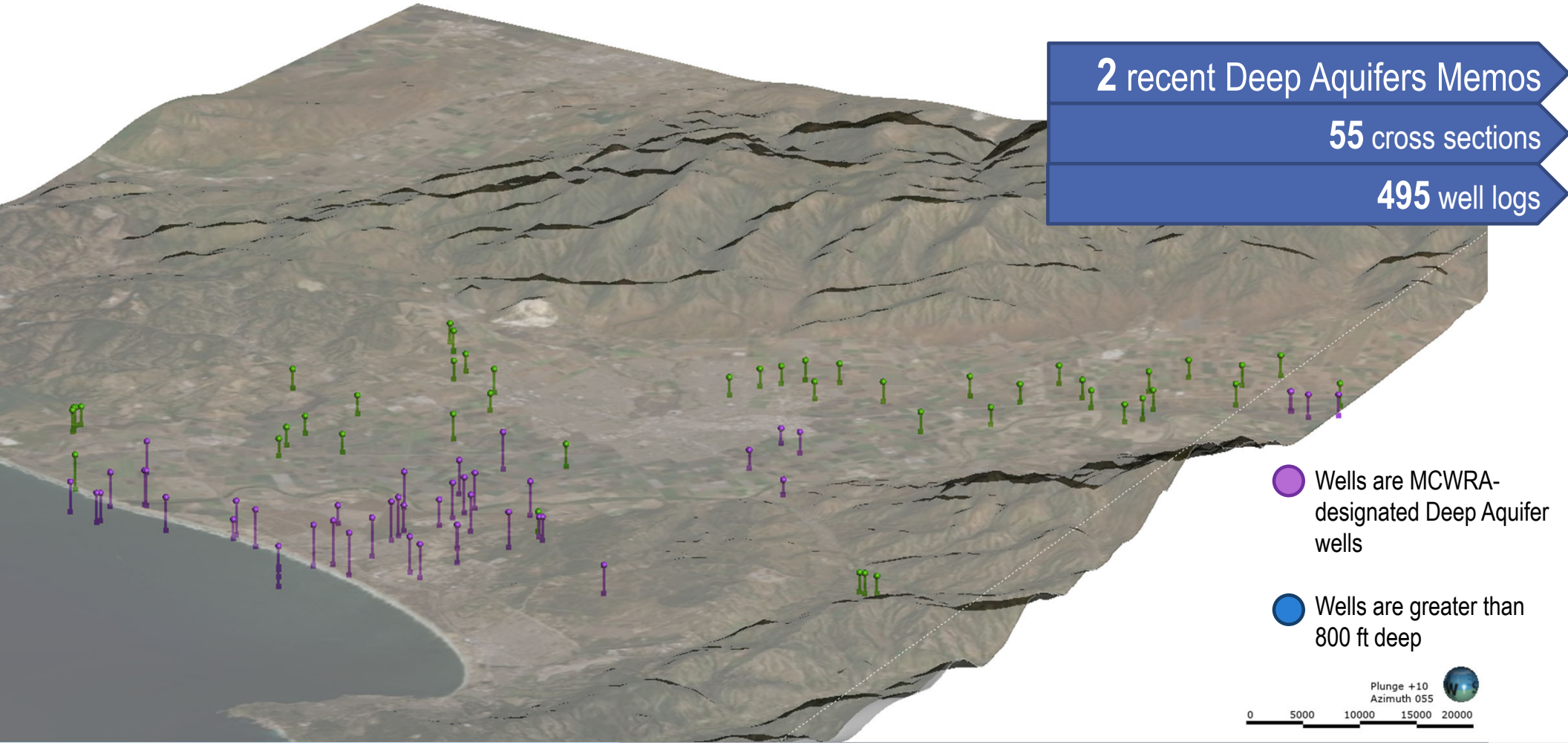


Previous Understandings of the Deep Aquifers

- Close to coast
- Generally, below 900 feet
- Uncertain lateral extent
- Old water
- Uncertain recharge

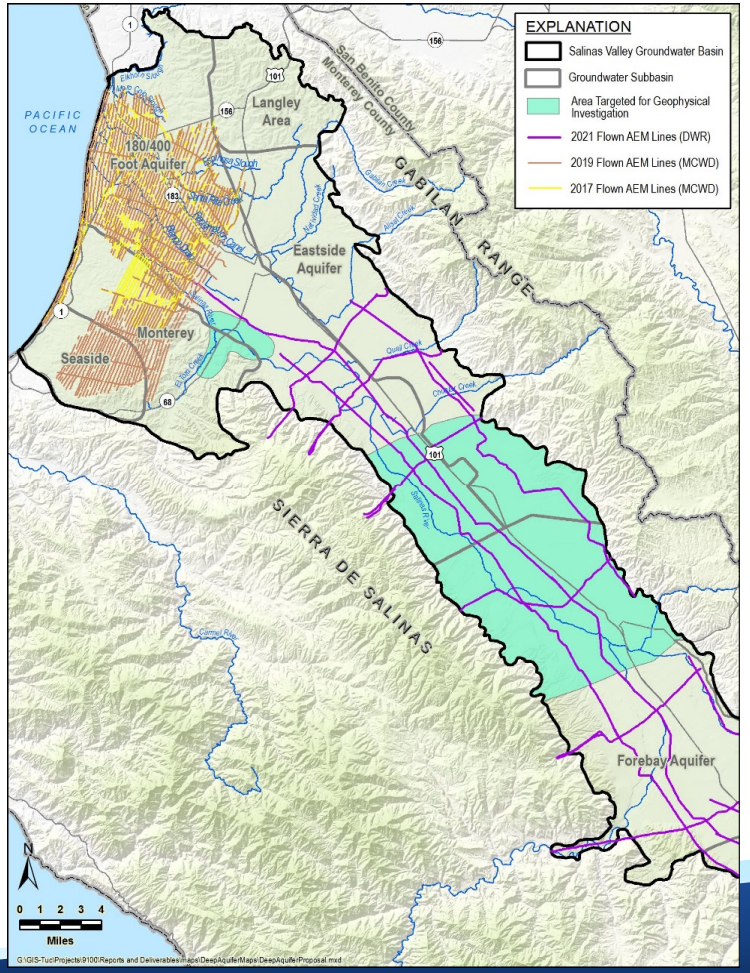


Study Builds Off Existing Deep Aquifers Data



PHASE 1: PRELIMINARY INVESTIGATION

- ✓ Defined the Deep Aquifers
- ✓ Scrutinized existing data with respect to new definition and defined field study locations and techniques
- ✓ Developed interim guidance for monitoring and management



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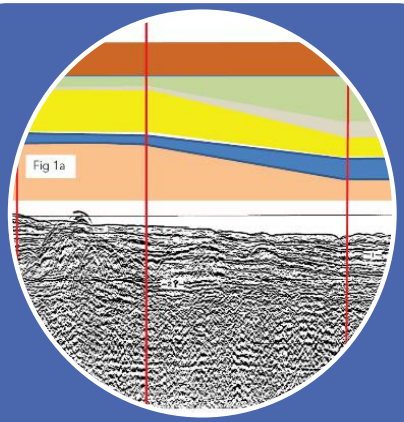
PHASE 2: FIELD STUDIES



Geophysics
maps important geologic features

Aquifer testing
provides data on groundwater movement and storage

Groundwater quality samples
identify aquifer connectivity and recharge areas

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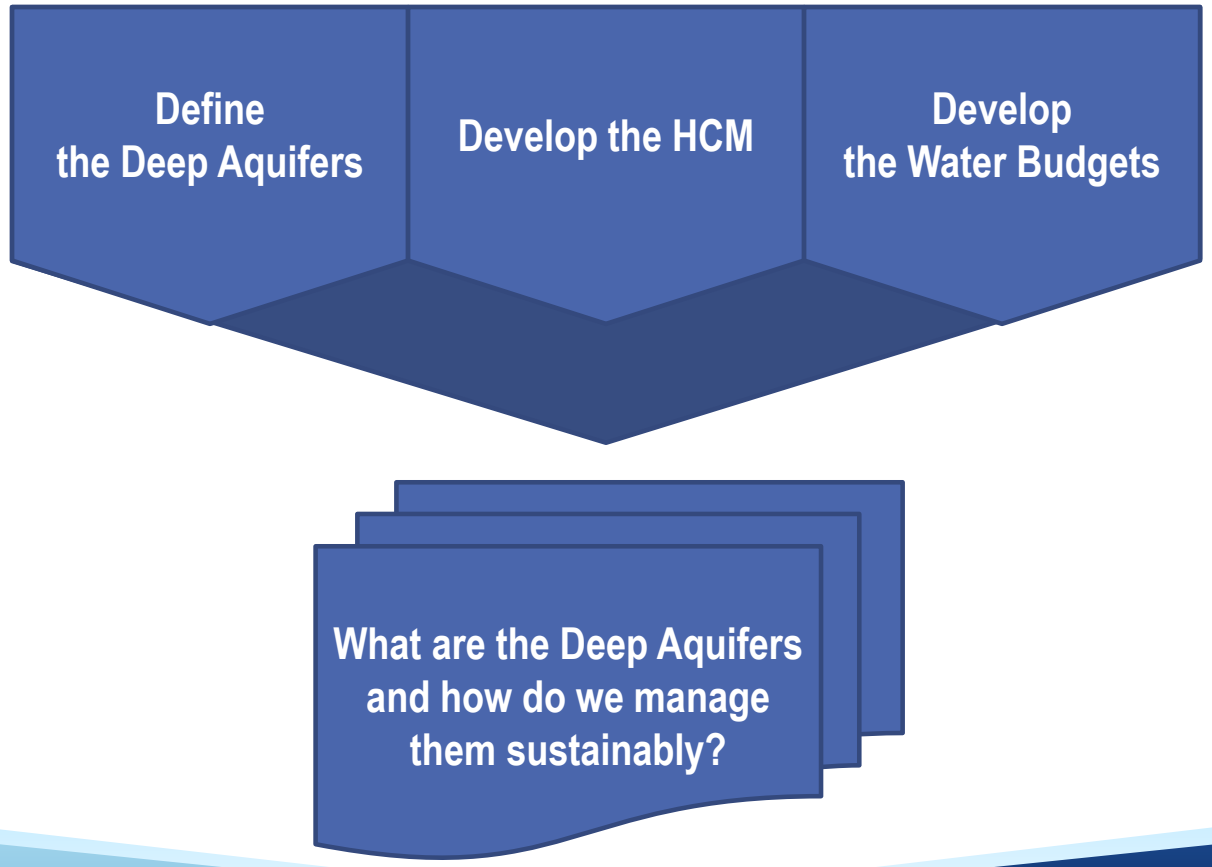
PHASE 3: BRINGING IT ALL TOGETHER



This study will provide

- Defined extent of the Deep Aquifers
- Hydrogeologic Conceptual Model of the Deep Aquifers
- Water budget for the Deep Aquifers
- Guidance for management based on science
- Proposal for Deep Aquifers monitoring

Phase I: Preliminary Investigation

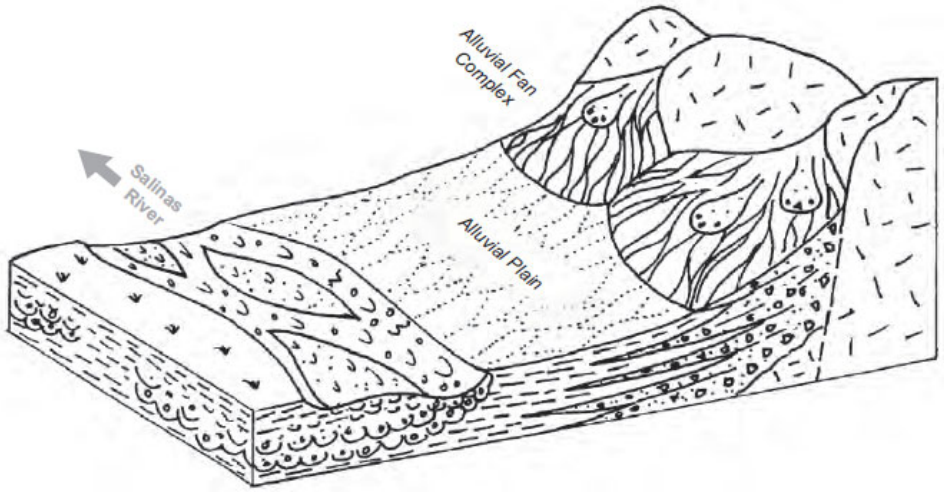
- Definition of the Deep Aquifers
- Extent
- Current conditions
- Sustainable yield
- Guidance for interim monitoring and management

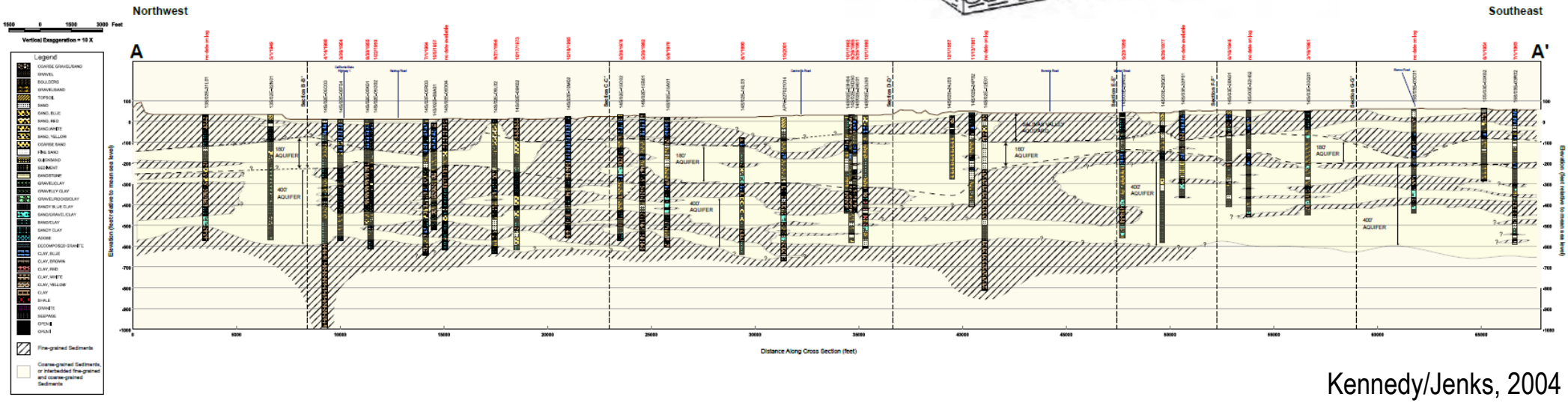
***Results are preliminary and will be refined through additional data acquisition and continued analysis*

Definition & Extent

The Salinas Valley Basin – Geology

- Complex
- Layered/Mixed





Kennedy/Jenks, 2004

The Salinas Valley Basin – Hydrogeology

- 180-Foot Aquifer
- 400-Foot Aquifer
- Deep Aquifers

Merge into

- Basin Fill Aquifer

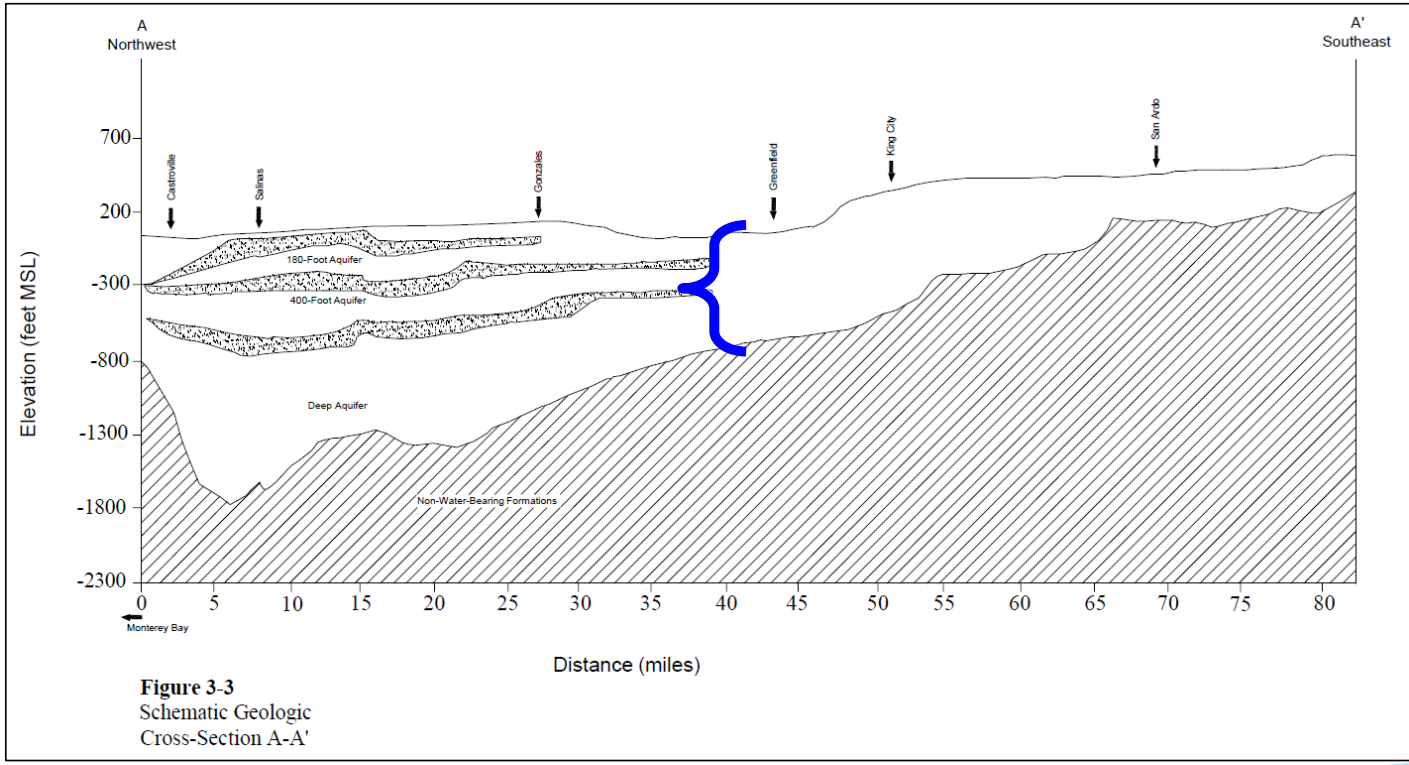


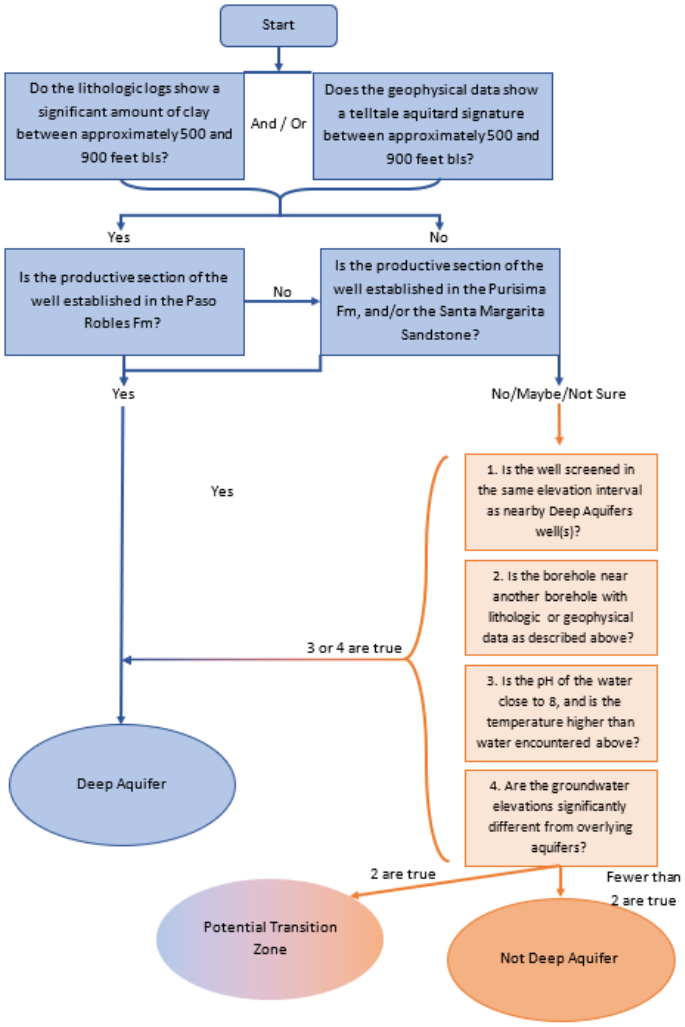
Figure 3-3
Schematic Geologic
Cross-Section A-A'

Previous Understandings of the Deep Aquifers

Previous Understandings	Contributions from this Study to date
Multiple definitions of what constitutes the Deep Aquifers *(Depth-specific; Geologic; Thorup 1976; Feeney & Rosenberg 2003; Monterey County Ordinances 5302 and 5303; MCWRA; Brown & Caldwell 2015)*	Standardized definition
Varied, or incomplete lateral extents *(Thorup 1976; Feeney & Rosenberg 2003; Monterey County Ordinances 5302 and 5303; MCWRA; Brown & Caldwell 2015)*	Lateral extent for the Salinas Valley Basin *Based on synthesis of all available data and reports and additional analyses*

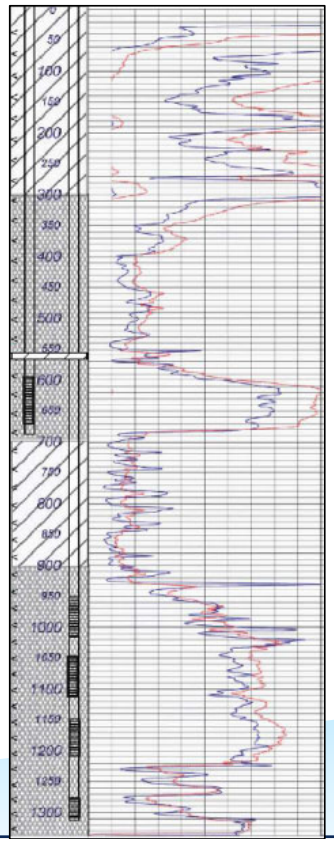
Conceptual Definition of the Deep Aquifers

- **The Deep Aquifers are generally considered to be water-bearing sediments present below the 400-Foot Aquifer**
- More specifically, the working definition of the Deep Aquifers is the water-bearing sediments that:
  1. Are below a relatively continuous aquitard or area of higher clay content encountered between approximately 500 feet and 900 feet below land surface within the Salinas Valley Basin. The relatively continuous high-clay aquitard must furthermore be below the identified 400-Foot Aquifer, or its stratigraphic equivalent.
  2. And are established in the Paso Robles Formation, Purisima Formation, and/or Santa Margarita Sandstone.



Analysis of Deep Aquifers Extent

- Based on the following analysis and synthesis of multiple data sources:
  - **Previously published reports**
    - **Basin structure, and depth to basin bottom**
    - **Paso Robles Formation extent in the subsurface**
  - **MCWRA Deep Wells designations**
  - **Lithology analysis**
  - **AEM surveys (2019 and 2022)**
  - **E-logs analyses**



Lateral Extent

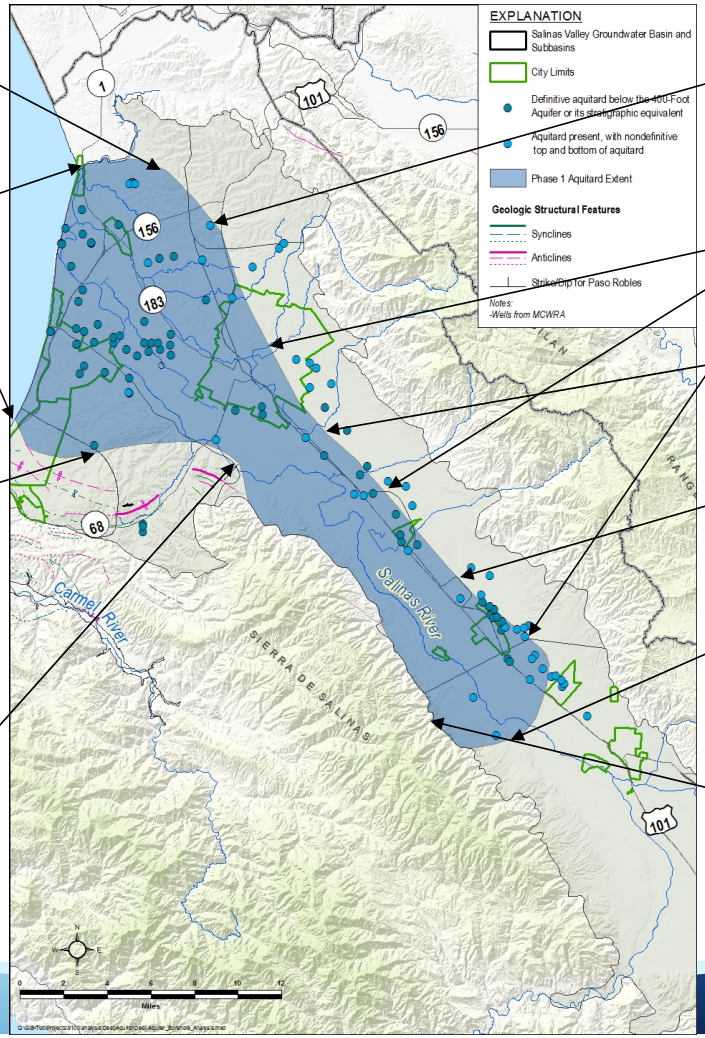
Following structural & depositional features

Respecting basin boundary features

Following structural features

Respecting MCWRA designation, WCR and e-log analysis. Questions about continuity to coastal wells remain.

Based on Thorup oil well analysis and cross-section showing extent of Paso Robles Fm. Relying on structural boundary more.



Based on WCR and Thorup Paso Robles Formation

Following convergence of Thorup and structural boundaries

Respecting Thorup

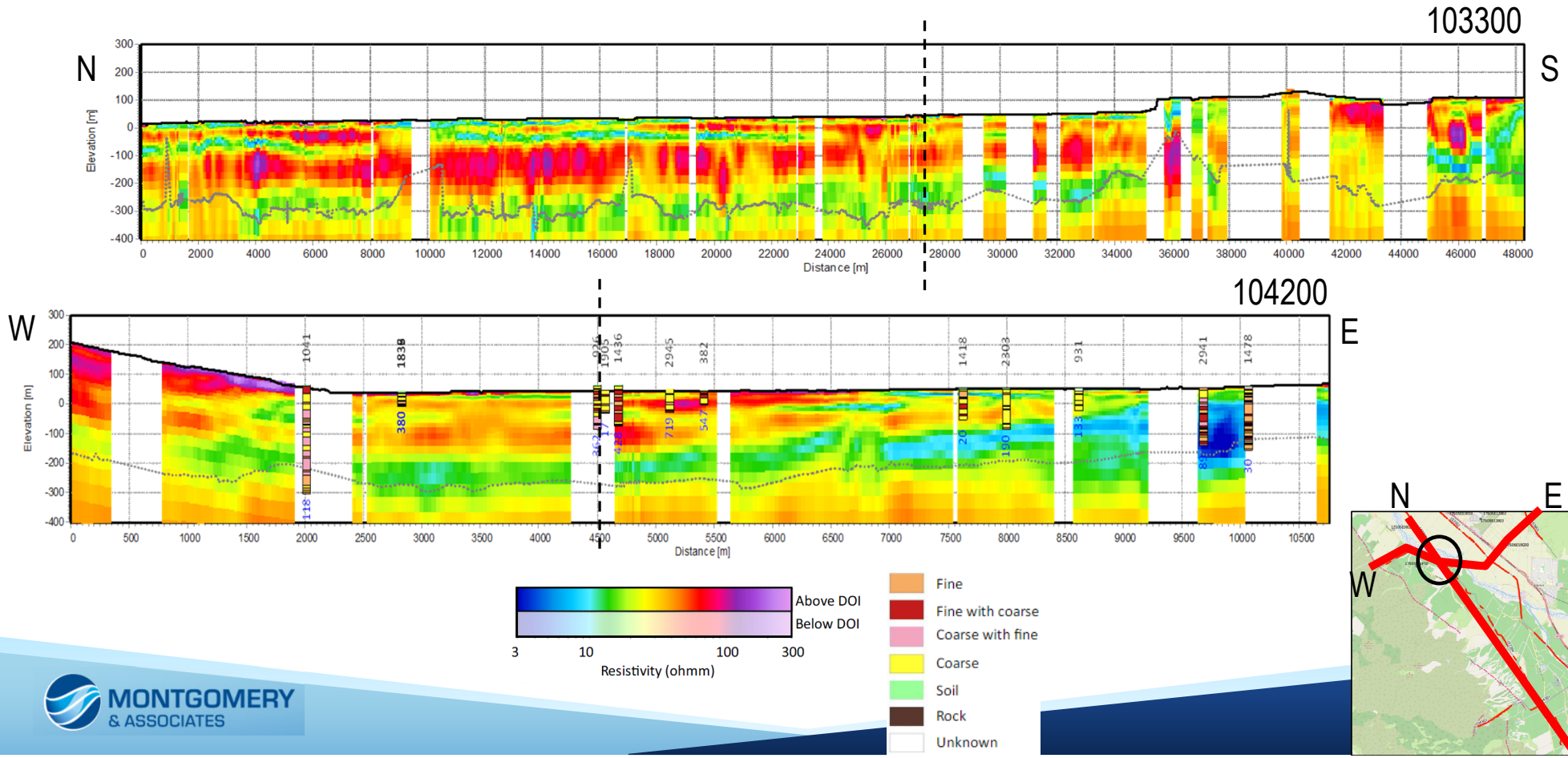
Based on Thorup and State DWR AEM

Based on State DWR AEM

Respecting structural & basin boundary features

Data Analysis – State AEM

AEM Lines and intersection used



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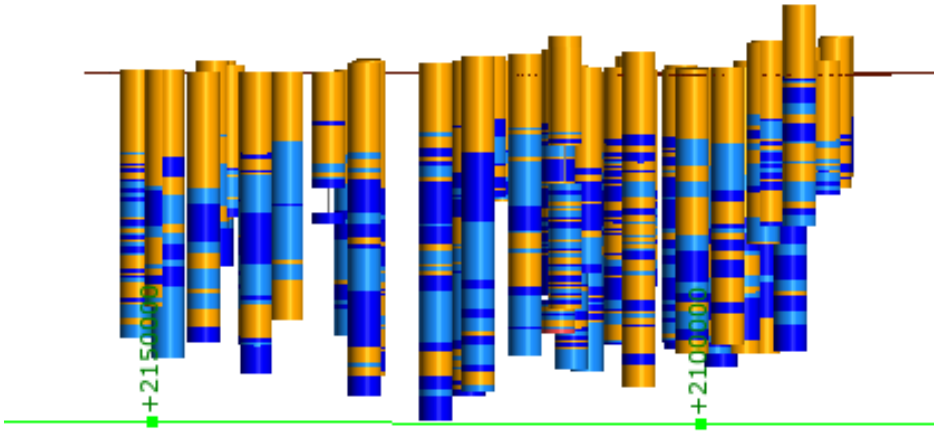
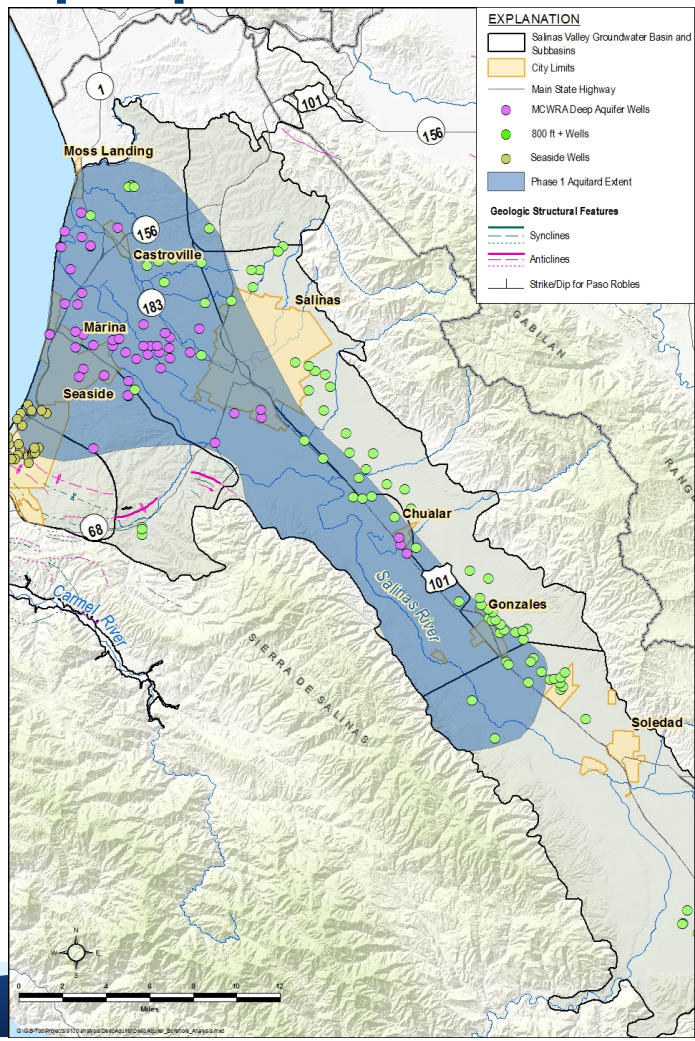
Aquitard

- 400-Foot/Deep Aquitard
- Complex, layered subsurface
- Except the few early wells, most wells screened across multiple formations and/or aquifers



Extent compared to MCWRA-designated Deep Aquifers Wells

- Preliminary extent includes more wells than MCWRA has designated as Deep Aquifers wells
- Deep wells data gap inland and close to Sierra de Salinas



Current Conditions & Sustainable Yield

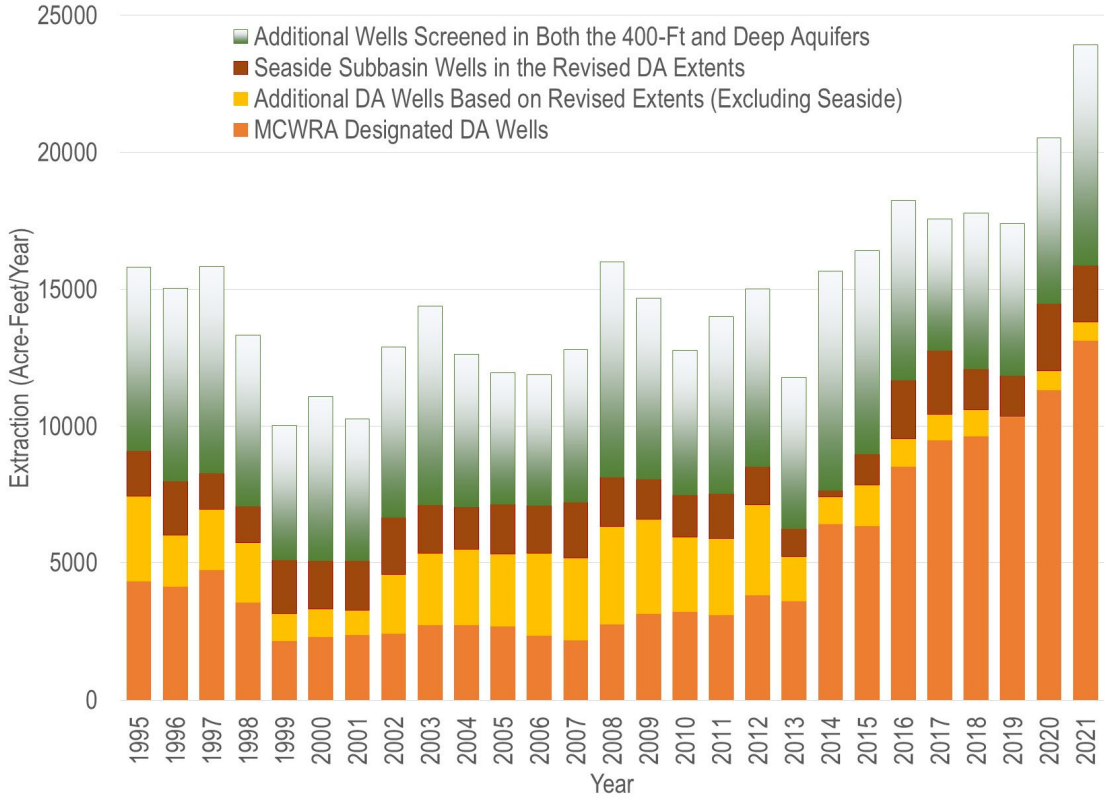
Previous Understandings of the Deep Aquifers

Previous Understandings	Contributions from this Study to date
Analysis of Deep Aquifers closer to coast, but not inland *(Hanson, 2002; Feeney & Rosenberg 2003; MCWRA)*	Deep Aquifers-wide groundwater conditions analysis *Cataloguing of data, joining groundwater levels, extraction, and multiple-aquifer influences into a more cohesive view.*

Deep Aquifer Conditions Reviewed/Addressed in Current Study:

- Groundwater Pumping
- Groundwater Levels
- Hydrologic Connection to Other Aquifers
- Seawater Intrusion
- Subsidence Potential

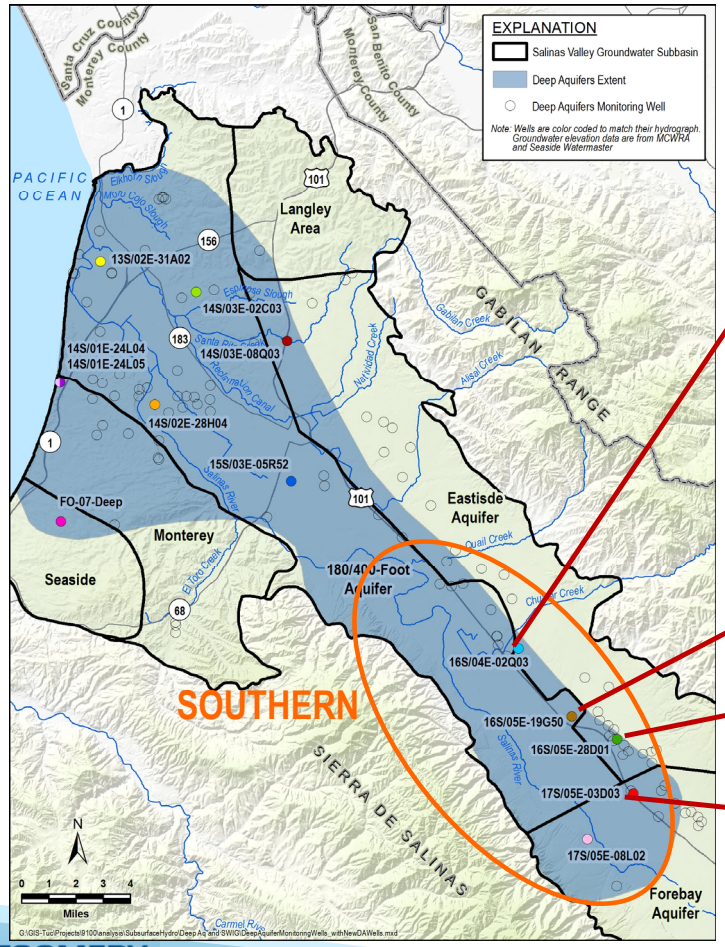
Revised Extents Results in More Groundwater Extraction than Previously Reported

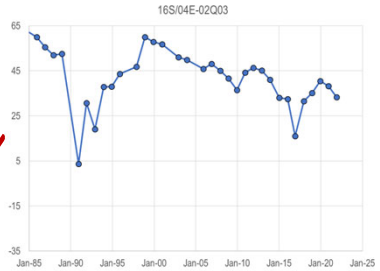


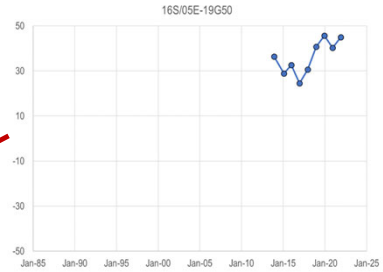
MCWRA-designated Deep Aquifer wells account for **58%** of pumping from Deep Aquifer ONLY wells (79% since 2014)

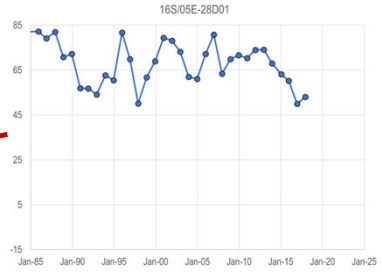
Unquantified additional pumping comes from wells screened in both the Deep Aquifer and 400-Foot Aquifer

Groundwater Elevations have Declined Across the Deep Aquifers









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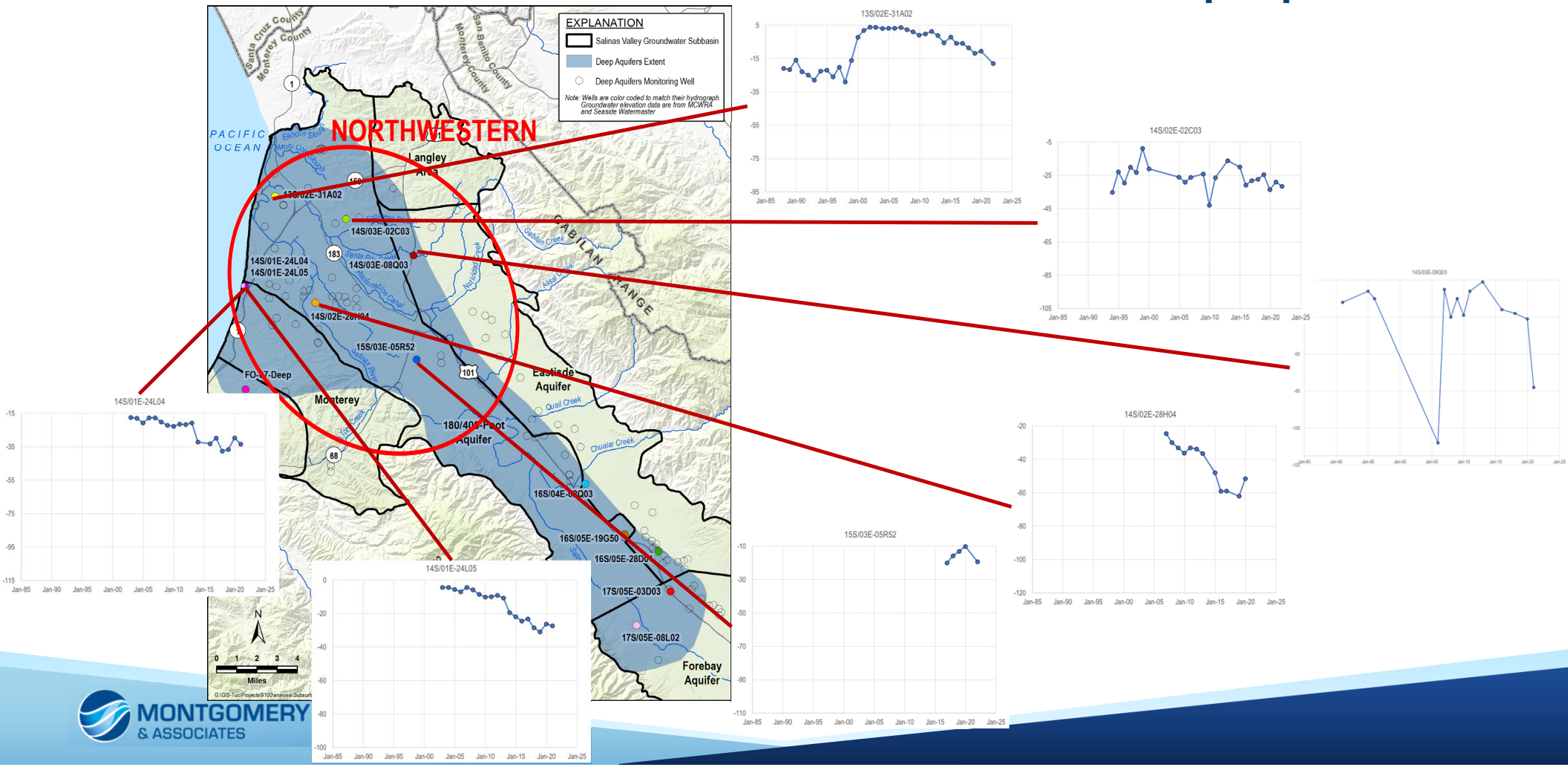

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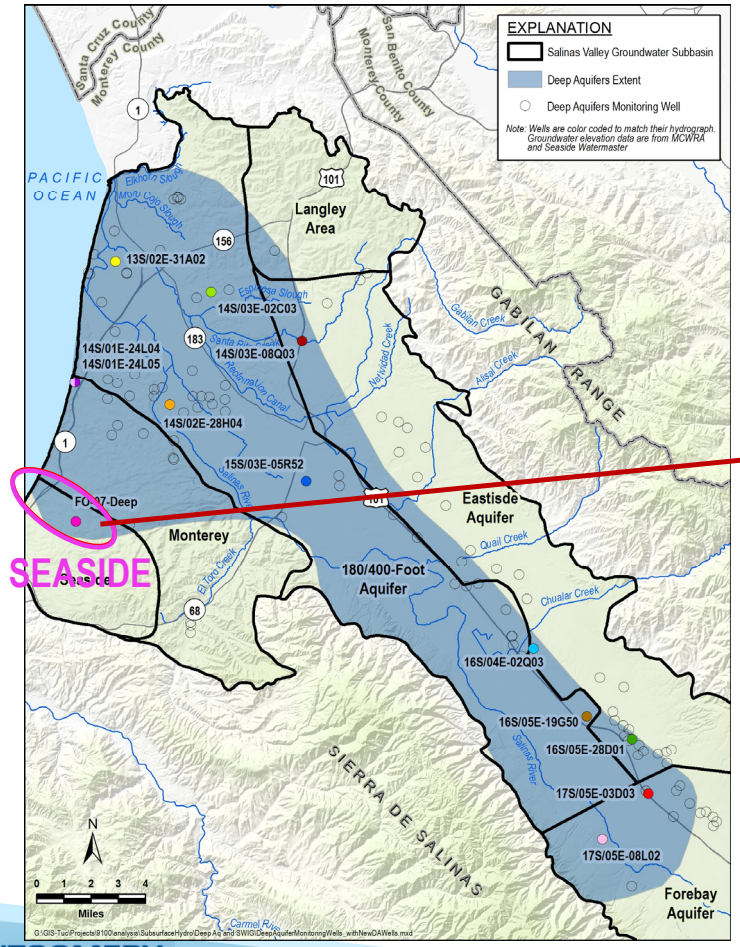

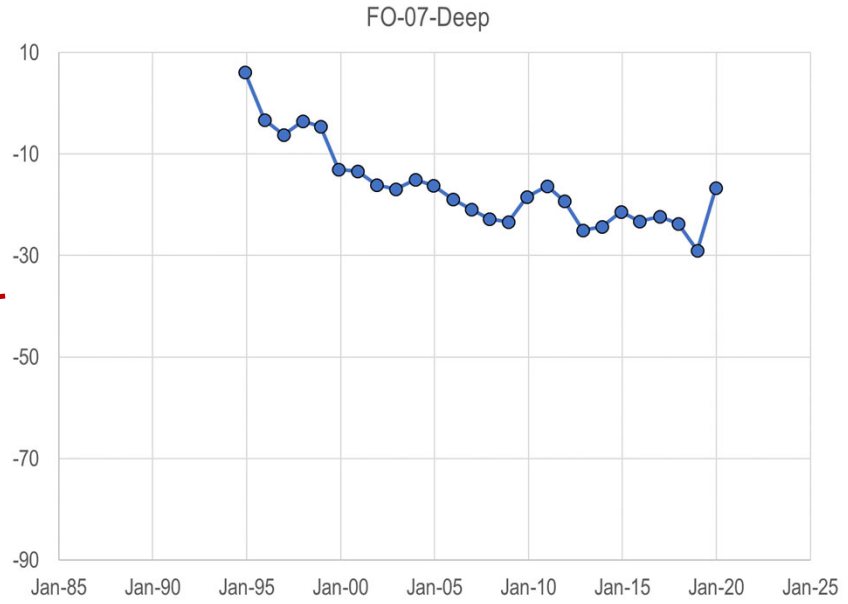

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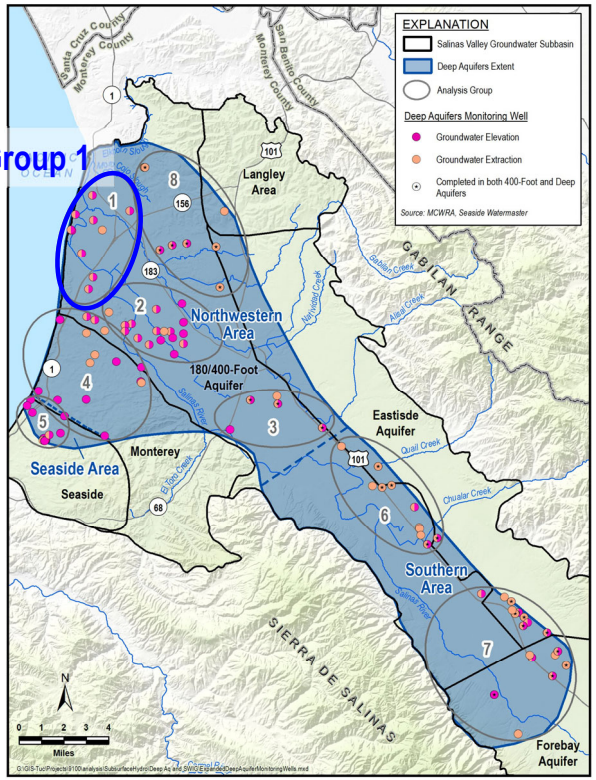
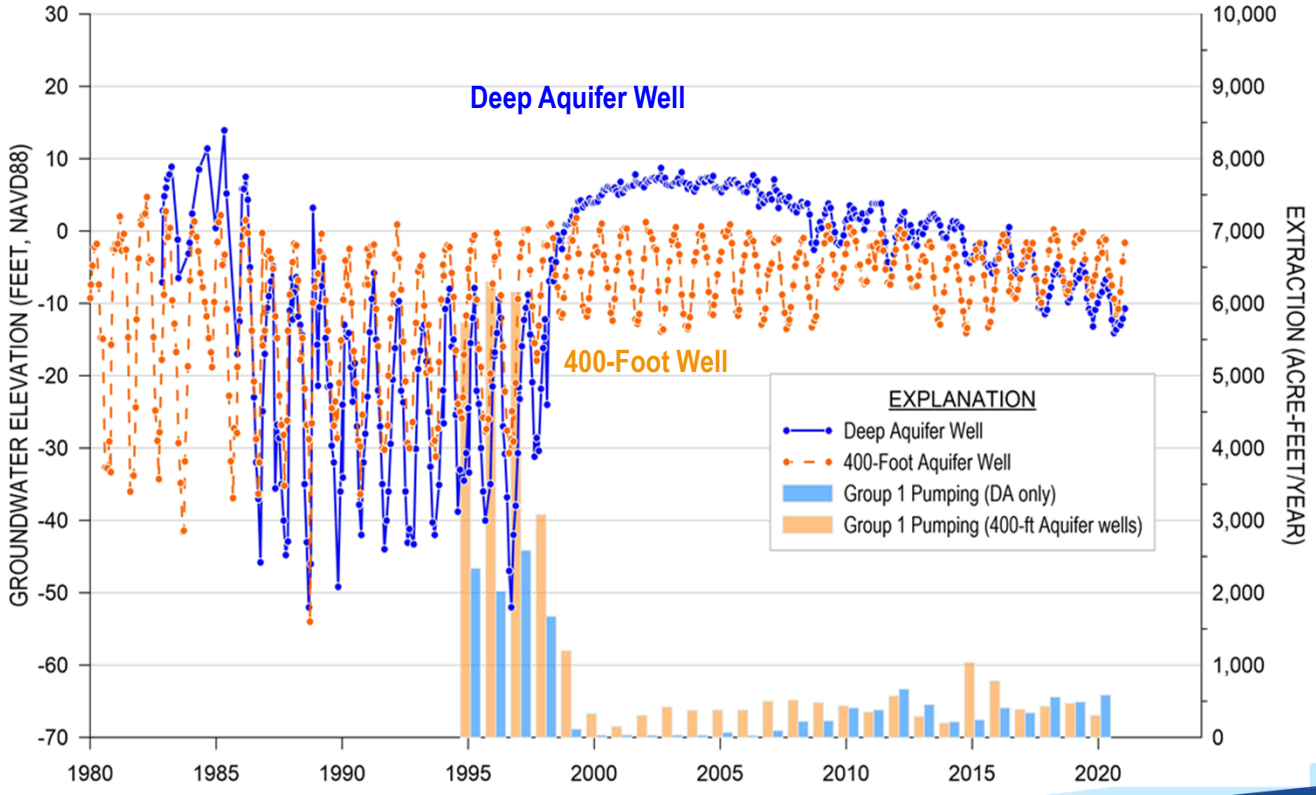
Deep Aquifers are Hydrologically Connected to Other Aquifers

- Horizontal
  - Deeper sediments outside of the mapped Deep Aquifers likely interact with Deep Aquifers
- Vertical
  - Connection varies across extent of Deep Aquifers
  - Vertical flow may be slow where more clay is present, but could be significant when summed over large areas
  - Slow leakage less likely to be visible on hydrographs

Potential Hydraulic Connection with the 400-Foot Aquifer





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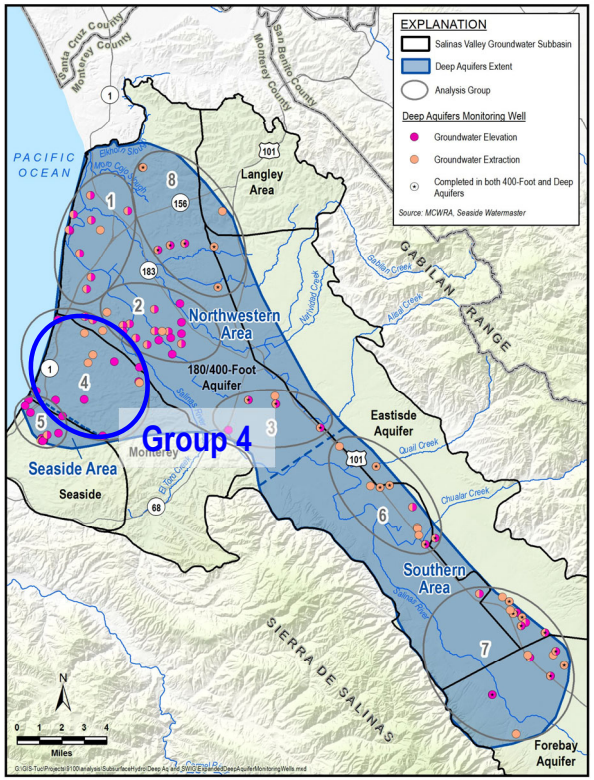

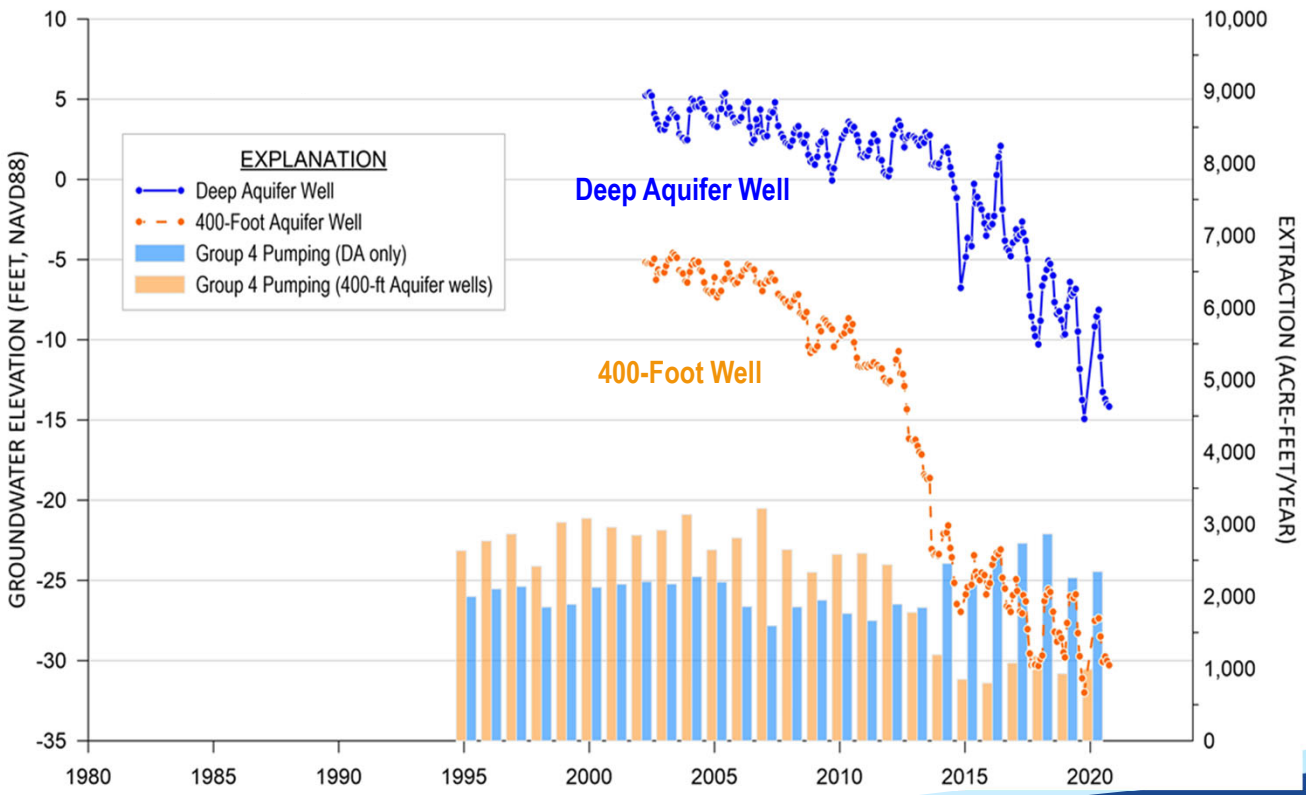

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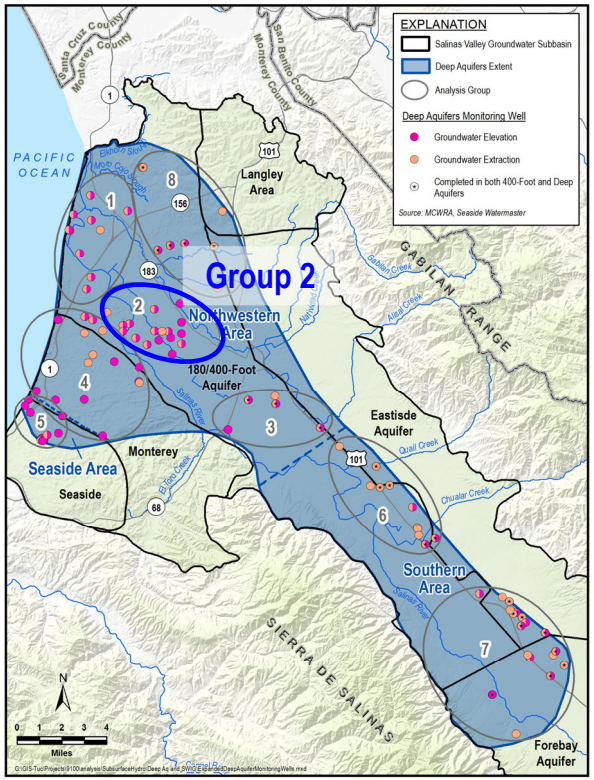
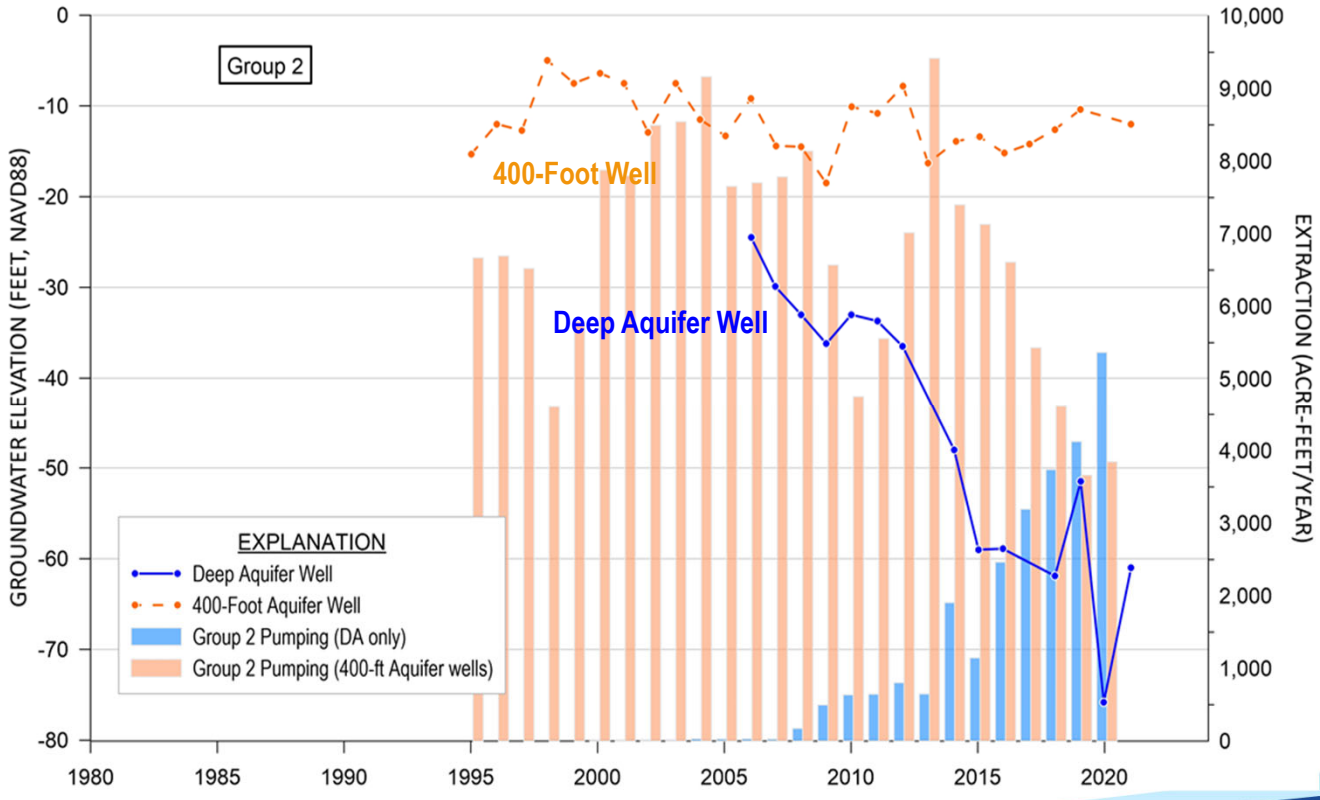
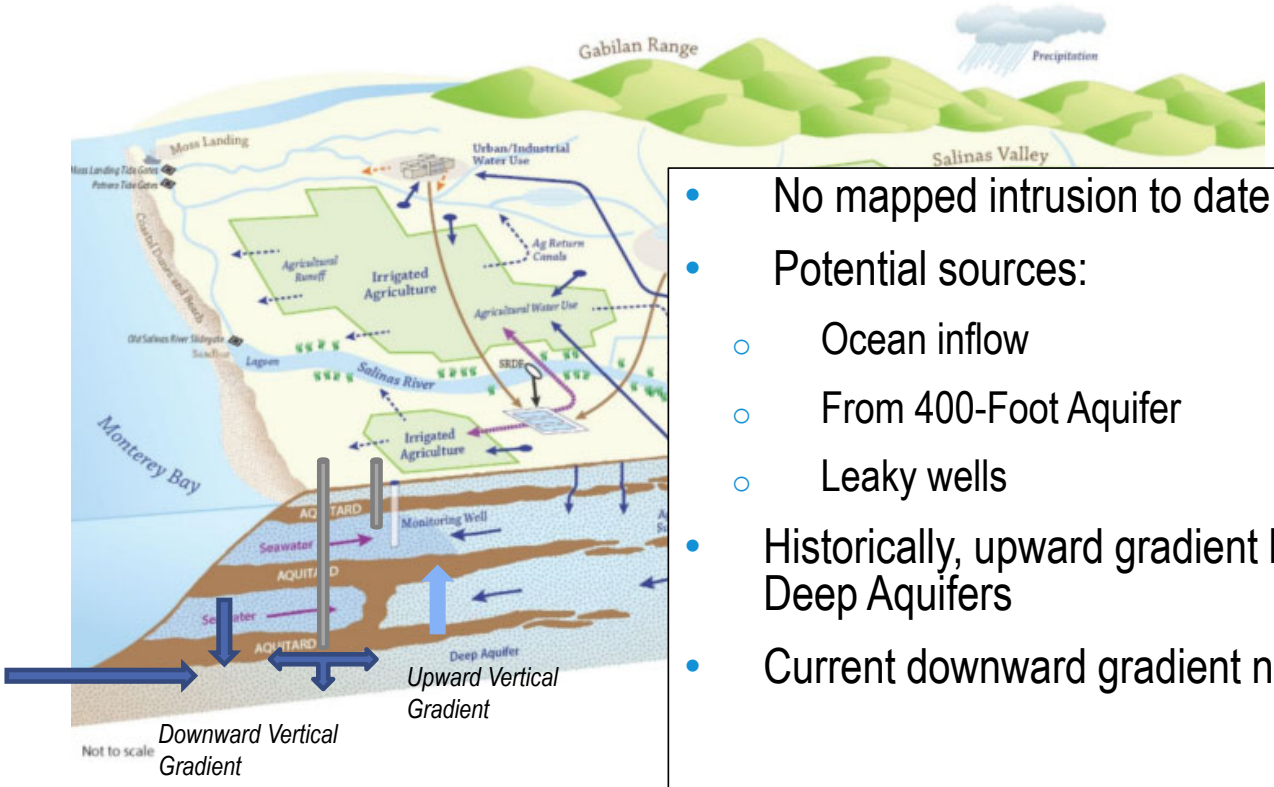




Deep Aquifers Risk of Seawater Intrusion



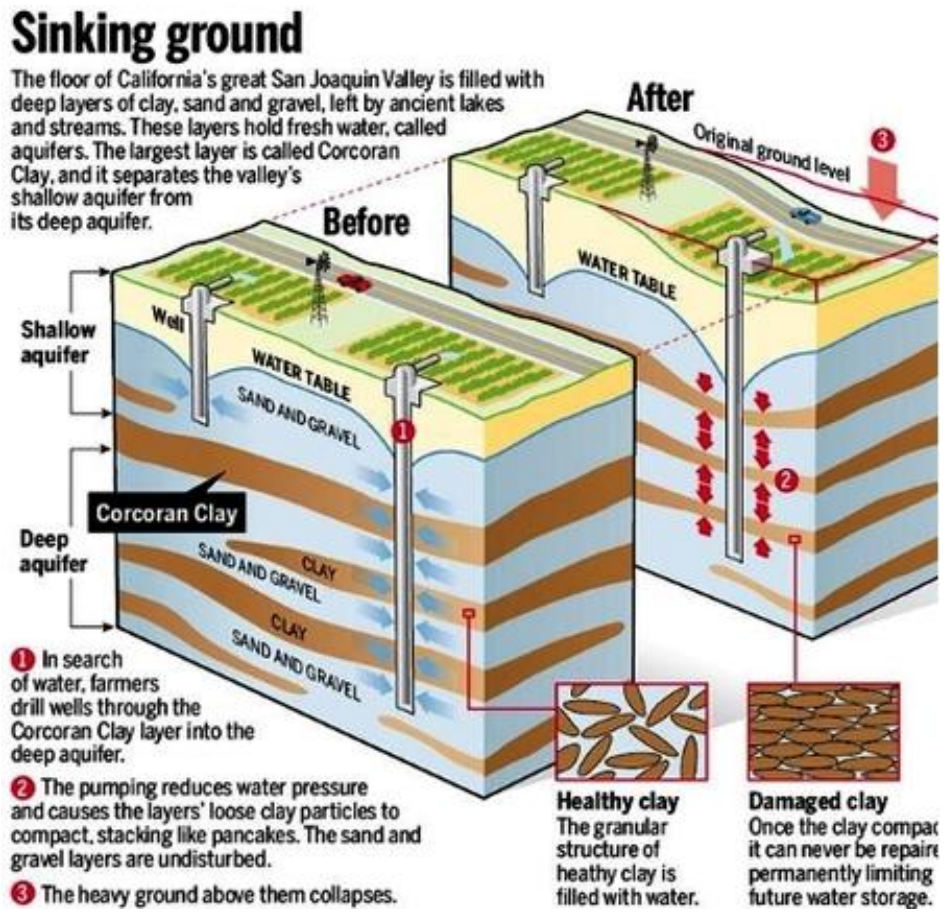
- No mapped intrusion to date
- Potential sources:
  - Ocean inflow
  - From 400-Foot Aquifer
  - Leaky wells
- Historically, upward gradient helped prevent seawater intrusion into Deep Aquifers
- Current downward gradient near coast increases seawater intrusion risk

Slowest

Fastest

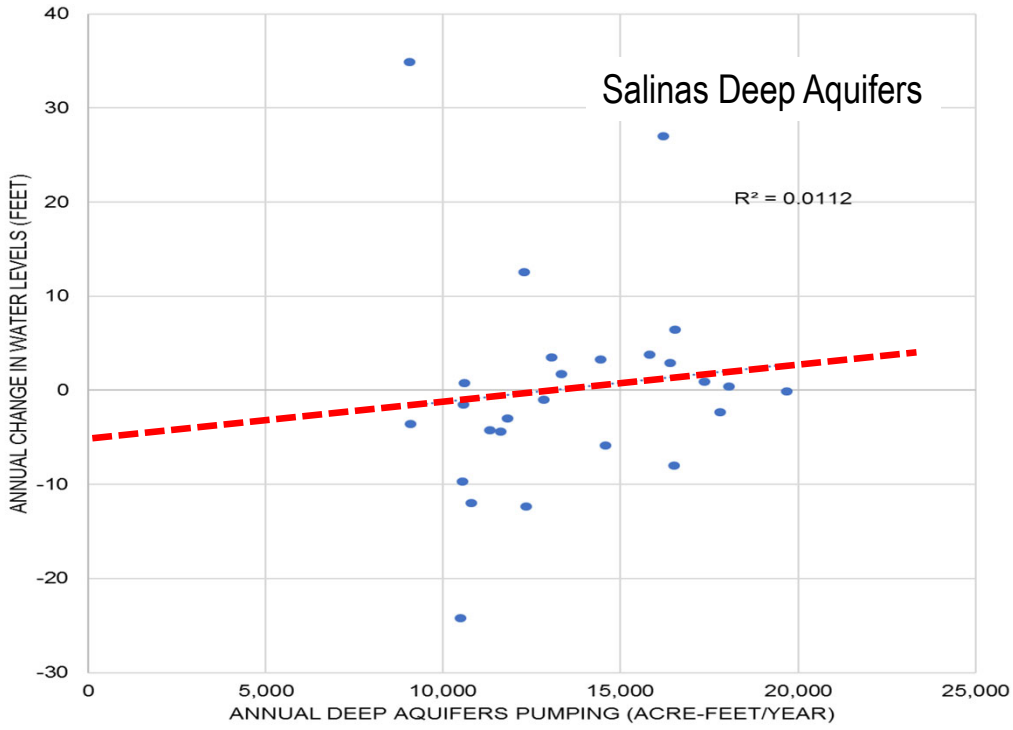
Potential Subsidence Risks

- **No subsidence observed to date**
  - Seawater intrusion in the 180- and 400-Ft Aquifers avoid land subsidence from pumping these upper aquifers risk
- Extensive clays above the Deep Aquifers provide the conditions for land subsidence
  Example: San Joaquin Valley & Corcoran Clay
- Continued pumping may initiate clay dewatering and land subsidence



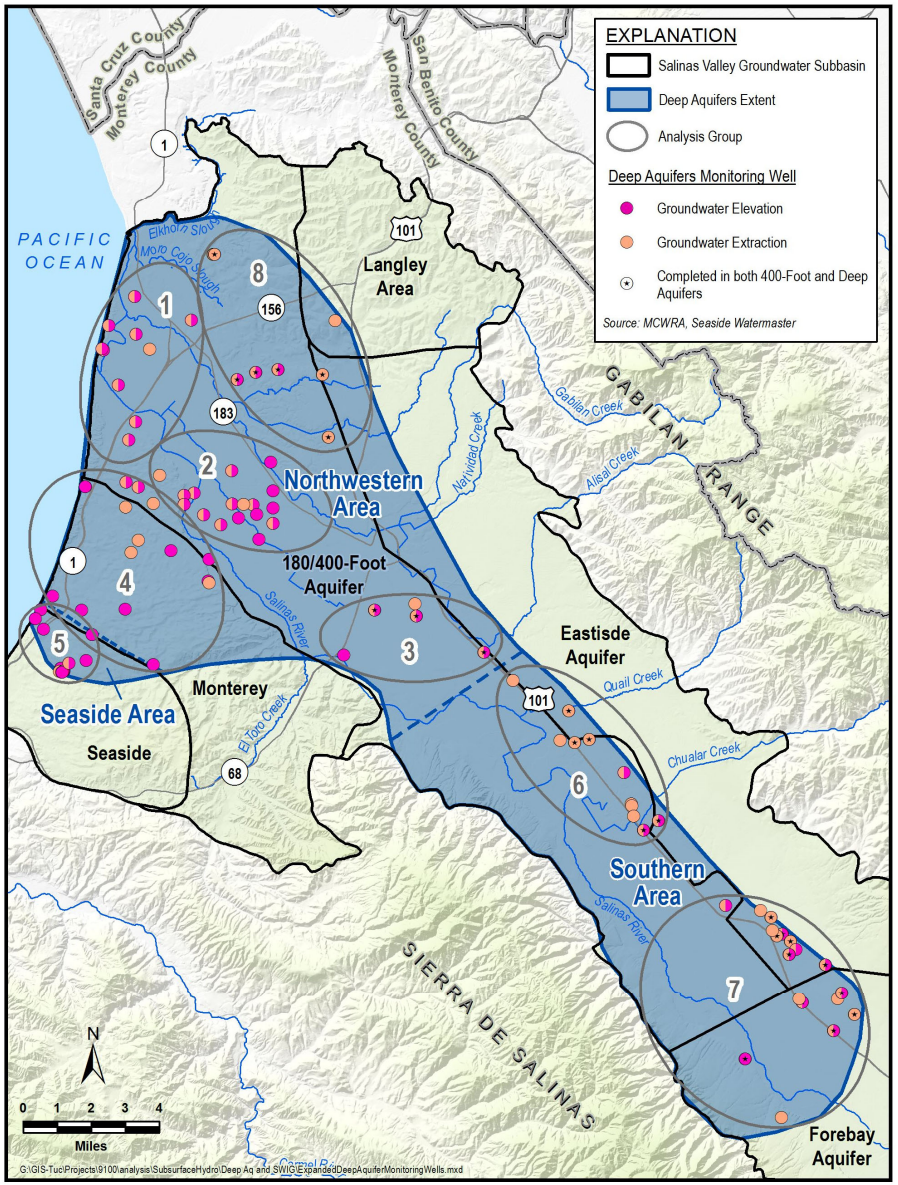
Existing Data do not Provide Estimates of Sustainable Yield

- **Dropping groundwater levels suggest that the sustainable yield is likely much less than current pumping**
- Attempts to estimate the sustainable yield using the practical rate of withdrawal method were unsuccessful
  - Incomplete data
  - Inflows from and outflows to overlying and adjacent aquifers



Groundwater Conditions Summary

- **Groundwater elevation are declining throughout most of the Deep Aquifers.**
- **Conditions vary across the Deep Aquifers**
  - Location of pumping
  - Hydraulic connection with the 400-Foot Aquifer
  - Hydraulic connection with surrounding aquifers
- **Pumping results in a risk of both seawater intrusion and subsidence**
- **Complicated system with limited data prevent reliable estimates of sustainable yield**
- **By the end of the Study, we'll have a better estimate of the sustainable yield**



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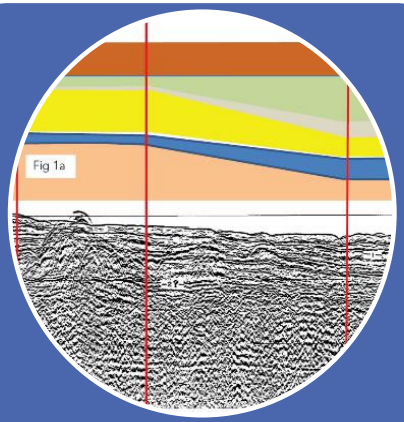

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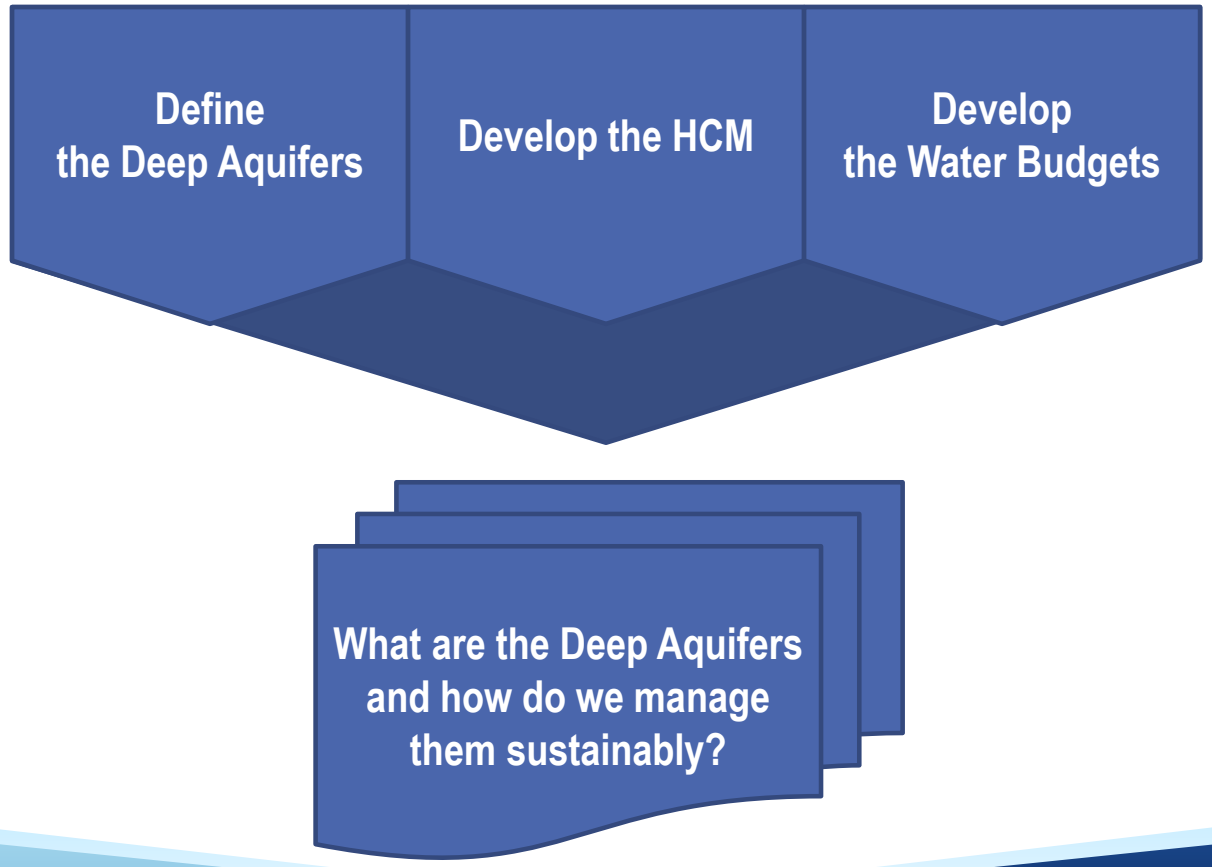

Questions?