EMA

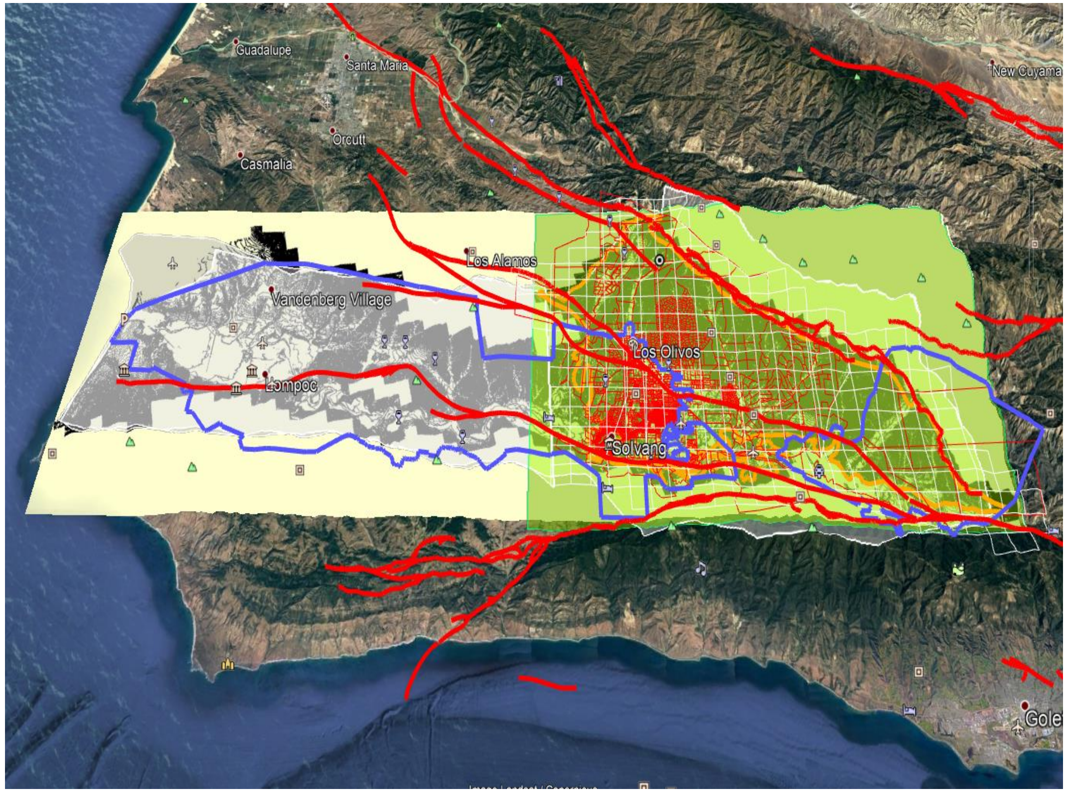
Santa Ynez River Valley Groundwater Basin
Eastern Management Area
Groundwater Sustainability Agency

# Santa Ynez River Basin Eastern Management Area Groundwater Sustainability Plan

…………………………………

## GSP Groundwater Model Development & Application

21 January 2021

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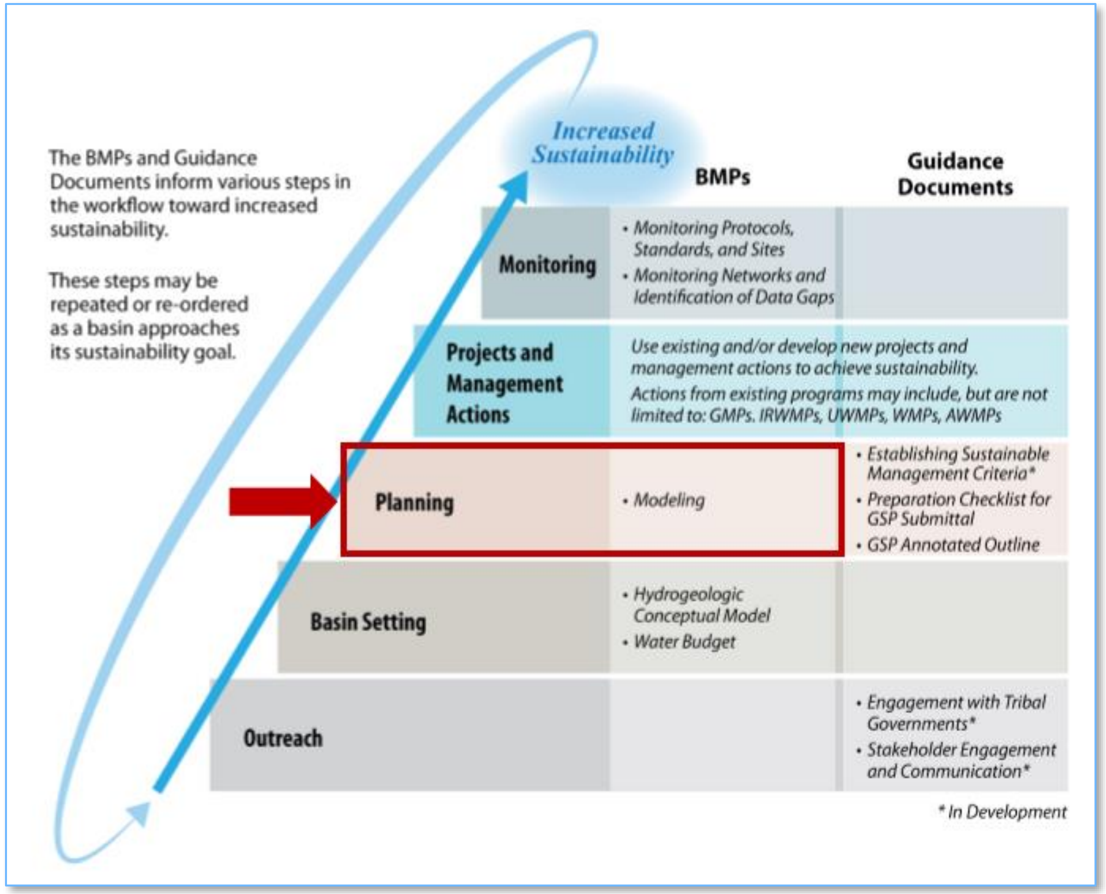
# SYRB EMA GSP MODEL DEVELOPMENT

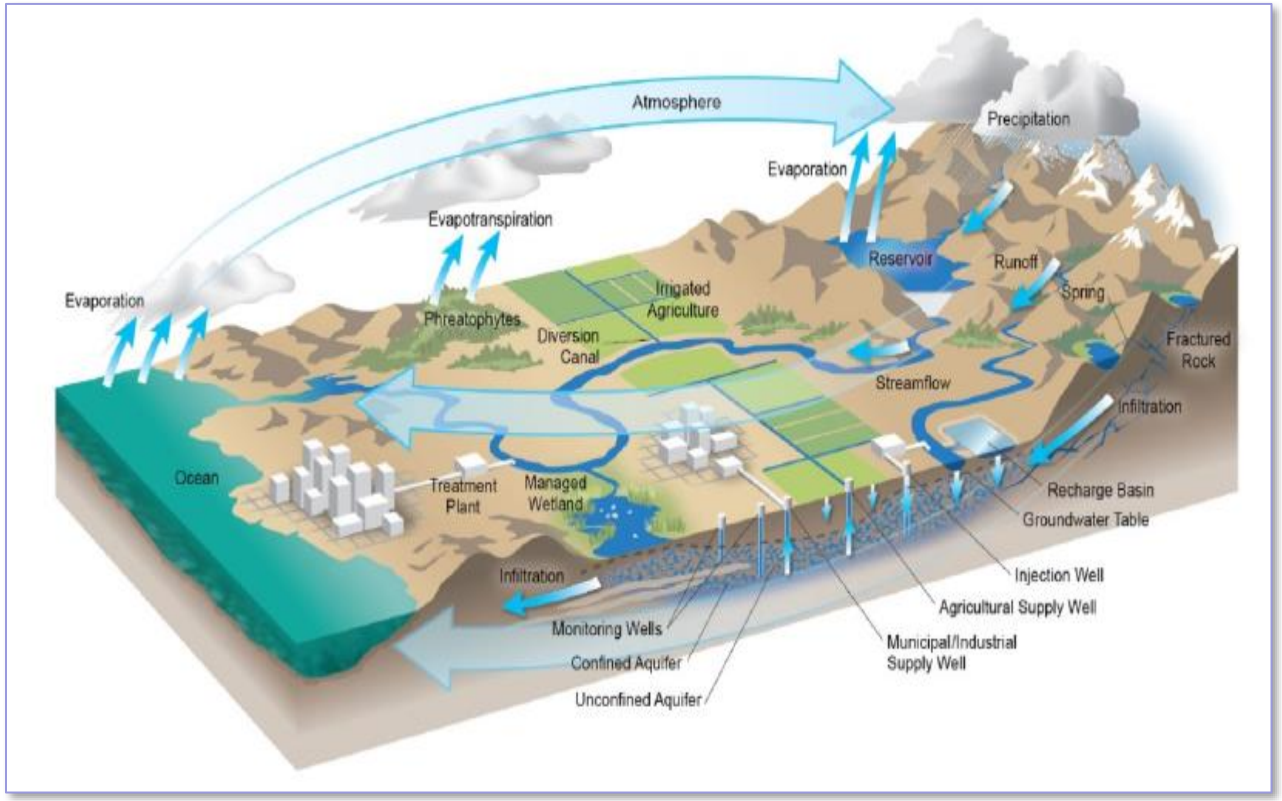
- Numerical model, “computer model”
- Third step in SGMA “Stairway to GSP”
- Based on Hydrogeologic Conceptual Model (HCM) and Water Budget



# Hydrogeologic Conceptual Model (HCM)

“An idealized description of the real hydrogeological system in the study area, describing in a concise and coherent way the components of the hydrogeological system and the interactions between those components”

- ✓ Hydrogeology ~ Geology + Hydrologic Cycle
- ✓ defensible and simplified, yet as realistic as possible <u>supported by available data</u>



# Hydrogeologic Conceptual Model (HCM)

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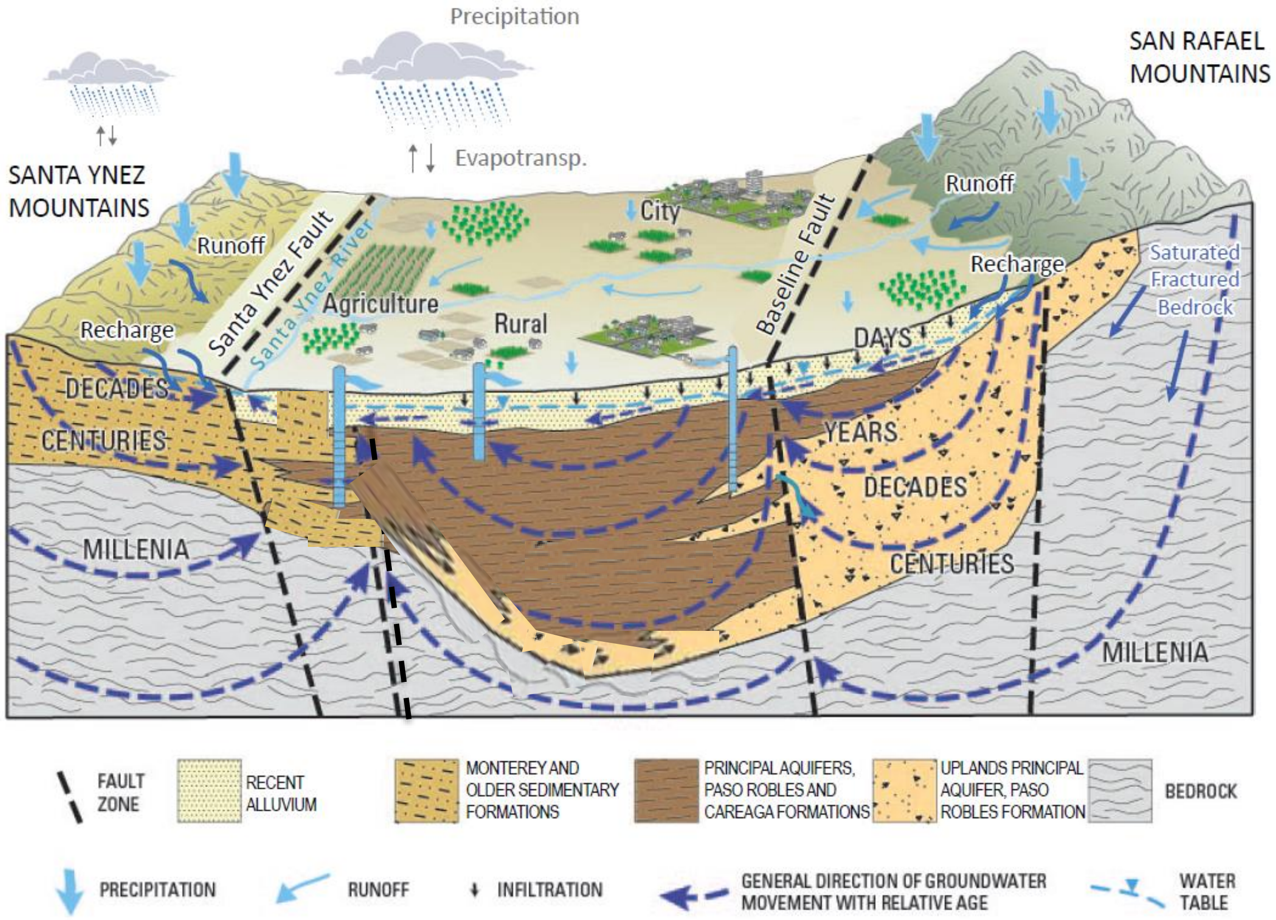
- Key elements of HCM
  - 3D Hydrogeologic model (Leapfrog)
    - Geologic formations and their hydrologic properties
  - Zones of groundwater recharge and discharge
  - Groundwater level maps, flow directions
  - Generalized groundwater response times
  - Define water budget and water budget components, assemble data

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# Santa Ynez River Basin EMA
# GSP Model Development & Application Process

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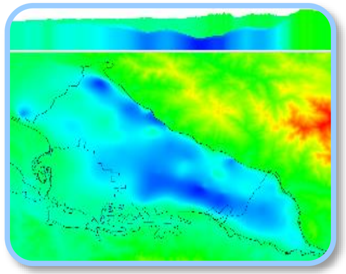

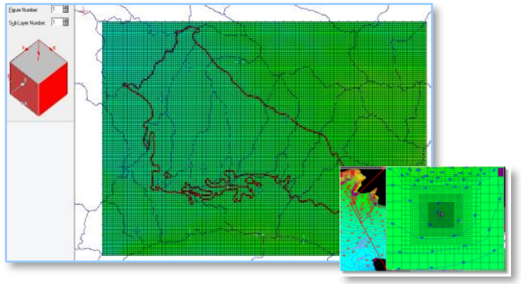

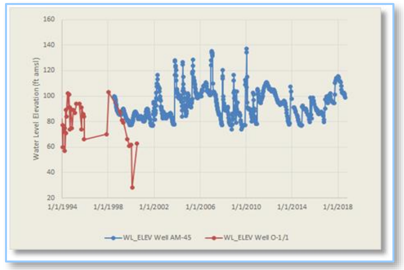

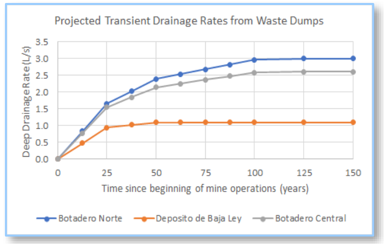


**Hydrogeologic Conceptual Model** → **Develop model structure + prelim. transient model** → **Calibrate transient historical model** → **Run Model for Future Scenarios**

Run Model for Future Scenarios
- Baseline scenario
- Climate change scenario
- Project implementation scenario

<u>Compute changes in SMC indicators</u>

Exclusions:
- Inclusion of geophysics received after August 1, 2020
- …

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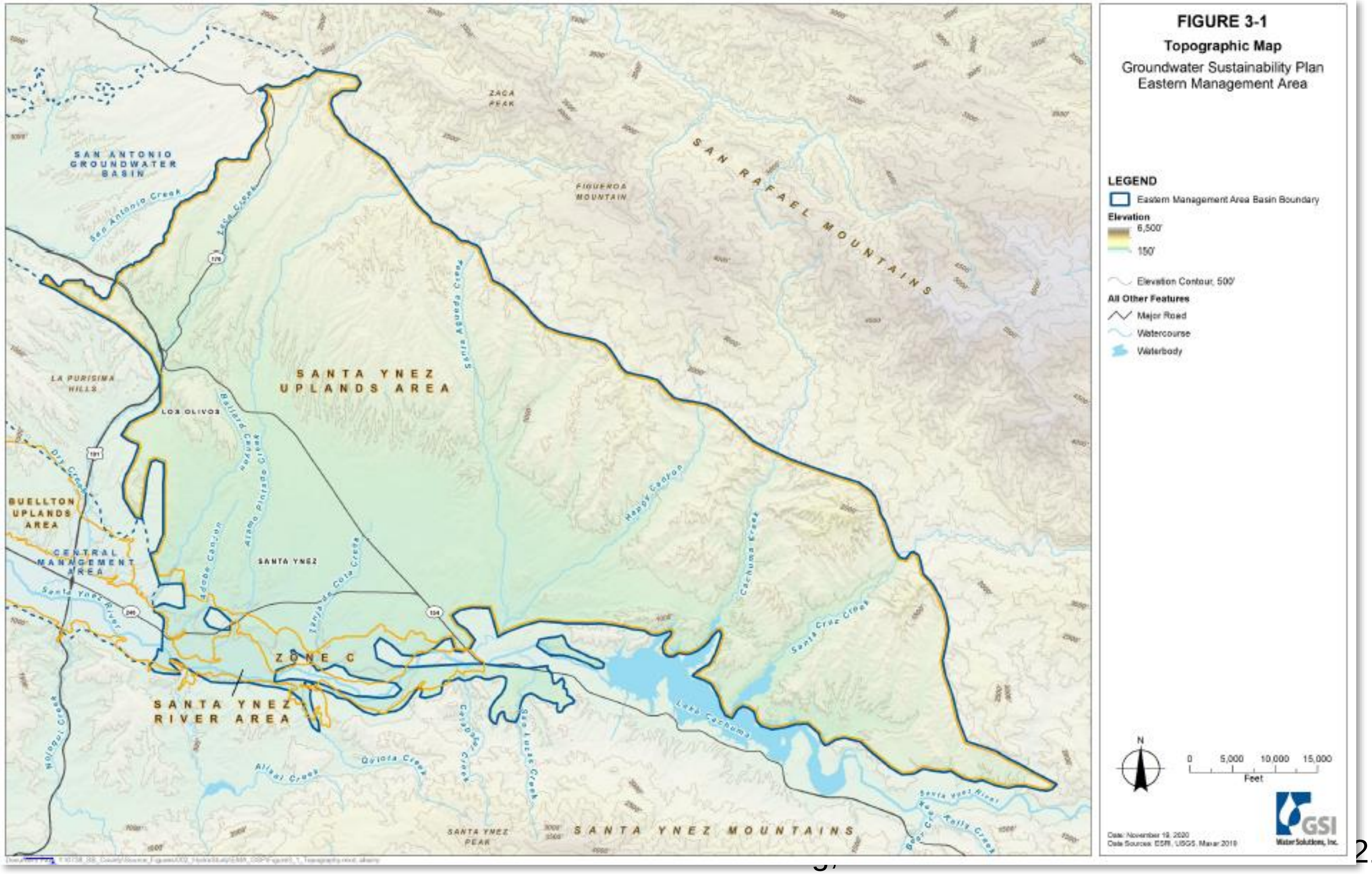
# Model Domain and Boundary Conditions

→domain extent and external and internal boundary conditions



# SYRB EMA Model Domain: Extend to Contributing Watershed Boundaries

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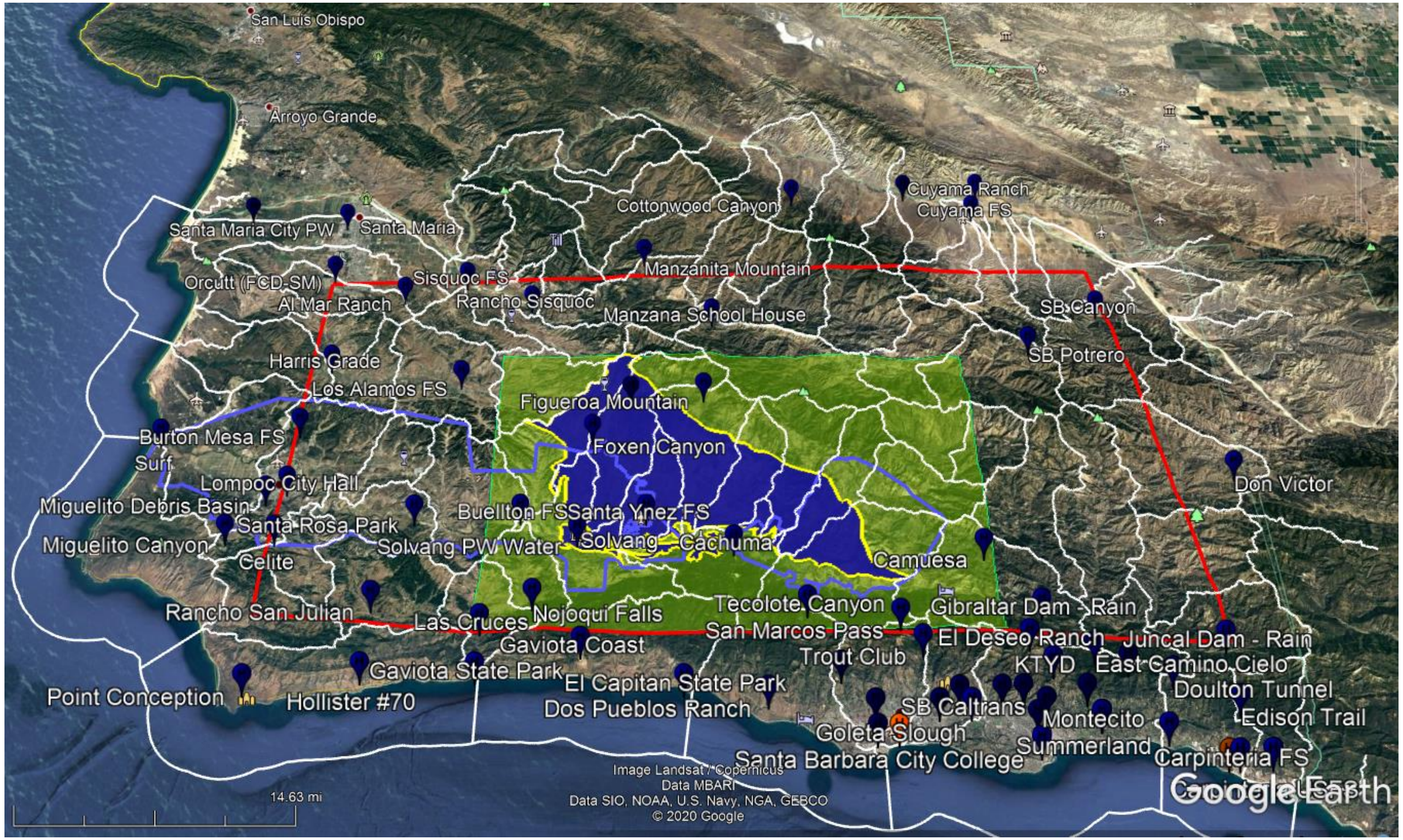
- SYRB EMA principal aquifers (PURPLE shading DWR Bull. 118) do not extend to surface water subbasin boundaries
  - Available data on runoff and recharge extends to watershed limits
  - Hydraulic properties representative of Monterey Fm and deeper bedrock from EMA limit to watershed limits

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# 3D Geologic Model – Basin View from South

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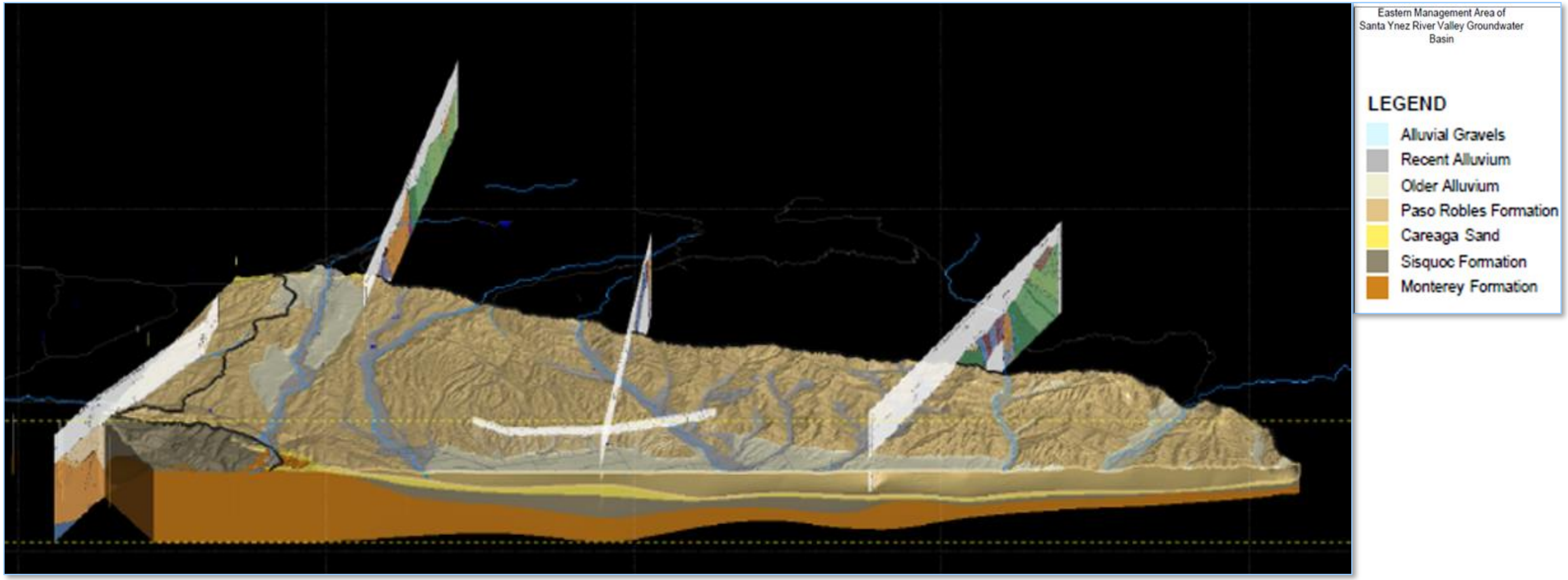


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# EMA Model With MODFLOW-USG

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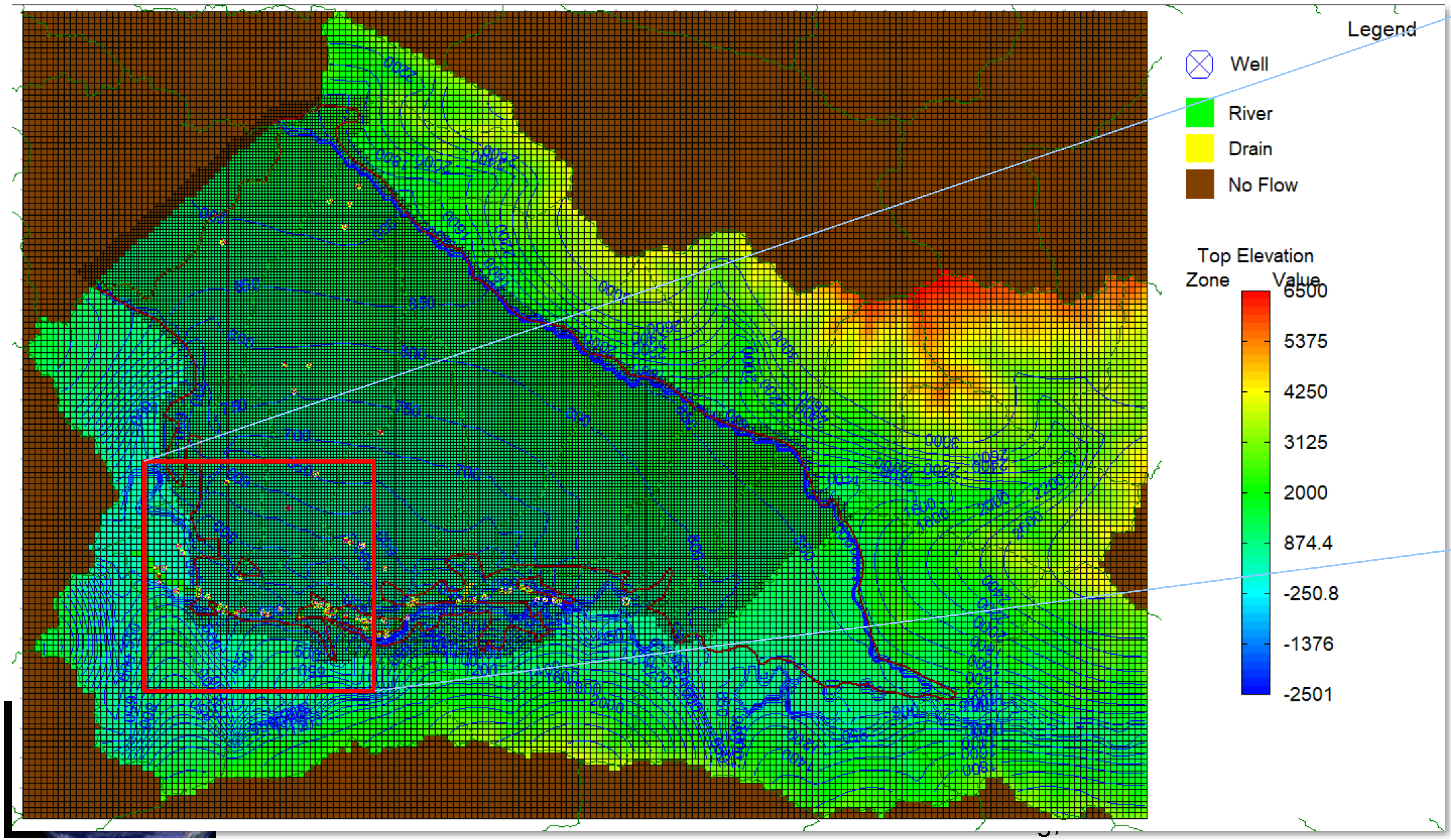
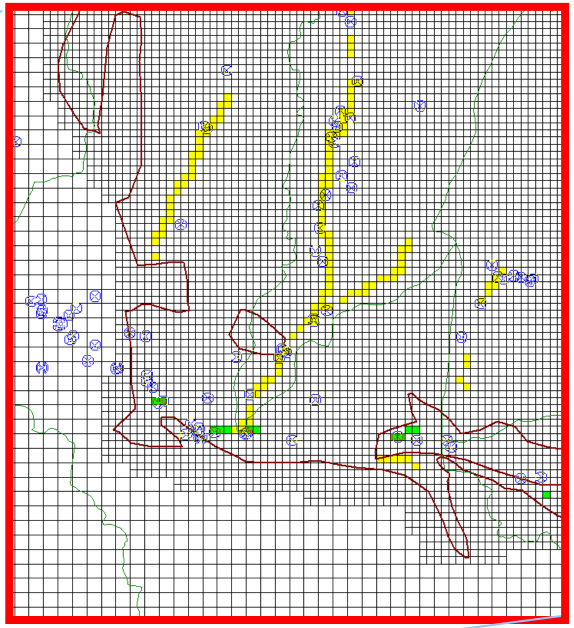
## 4-acre grid cells within EMA, 16-acre grid cells outside to watershed limit





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# EMA Model Hydrogeologic Units
# Import Leapfrog 3D Geology to MODFLOW

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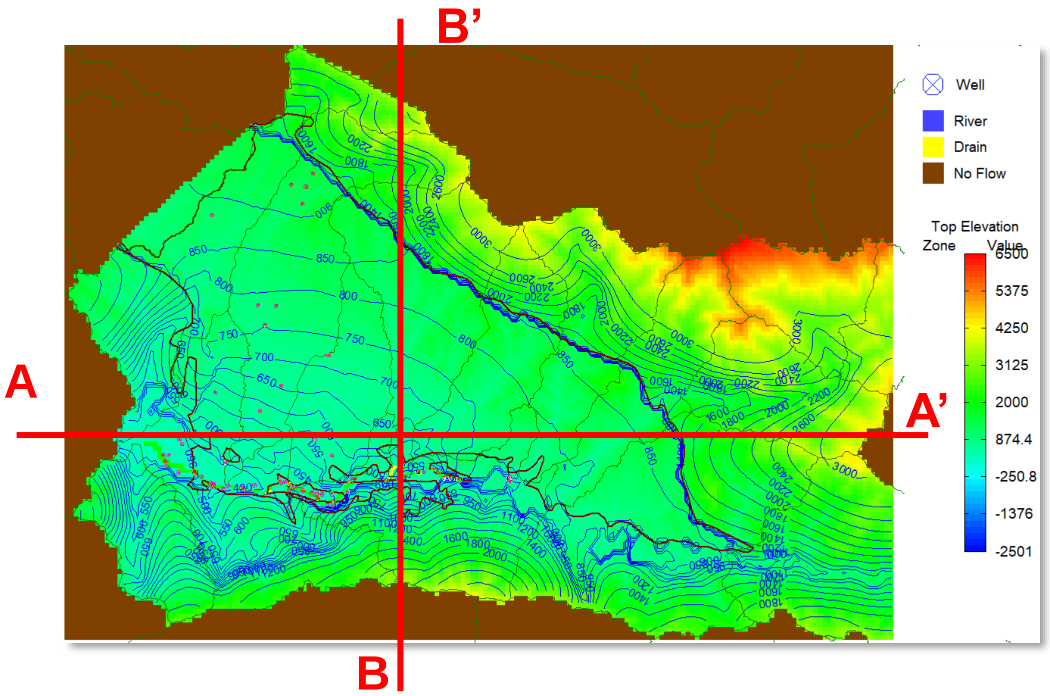
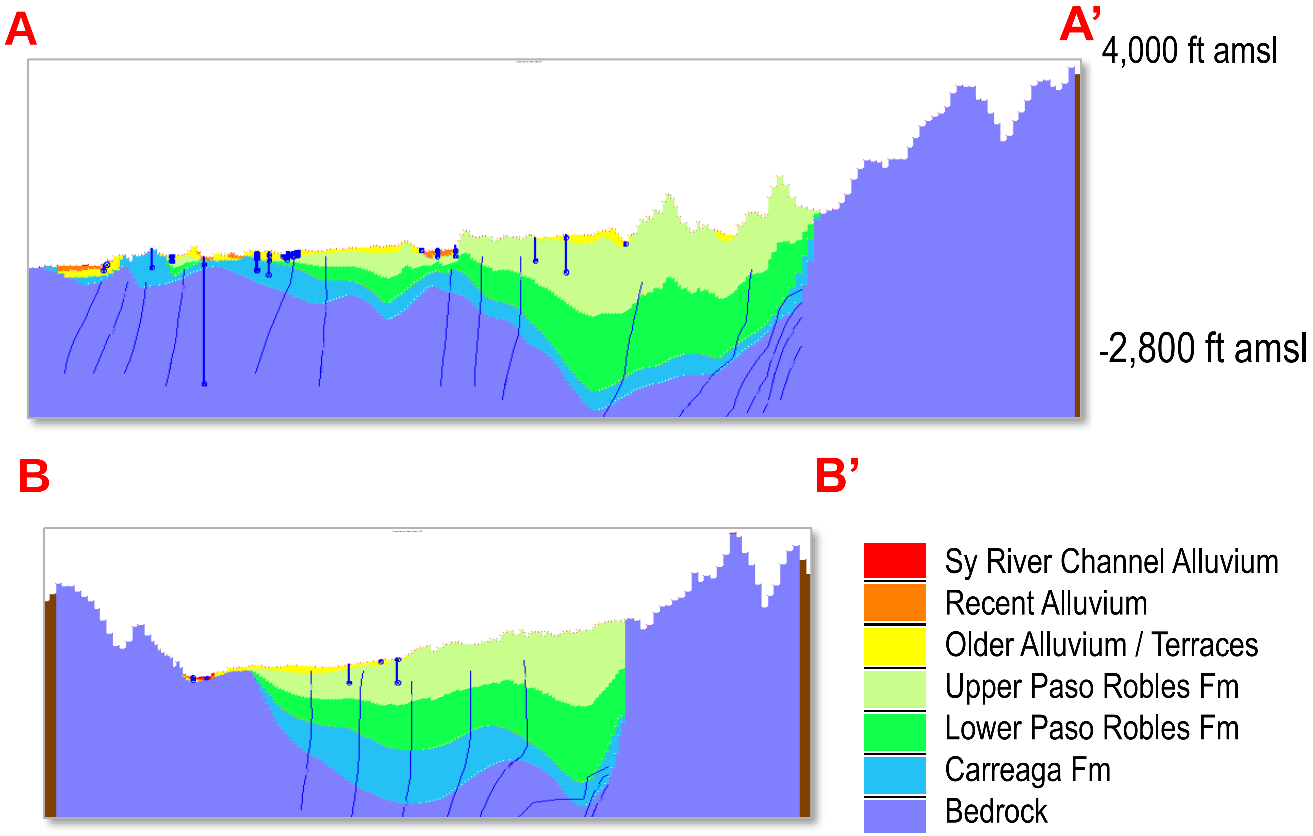
## Hydrogeologic Cross-Sections through Numerical Model Domain

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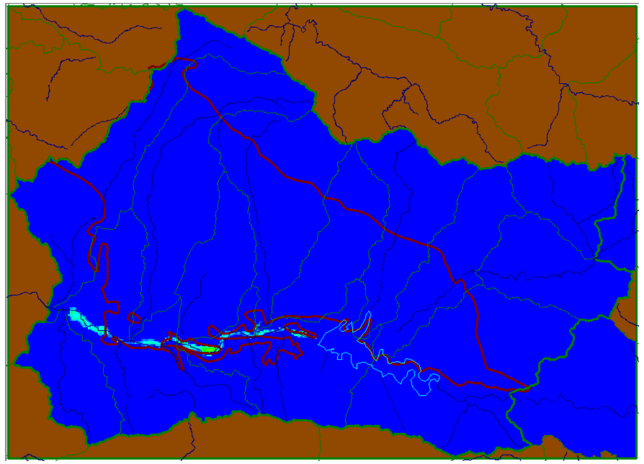
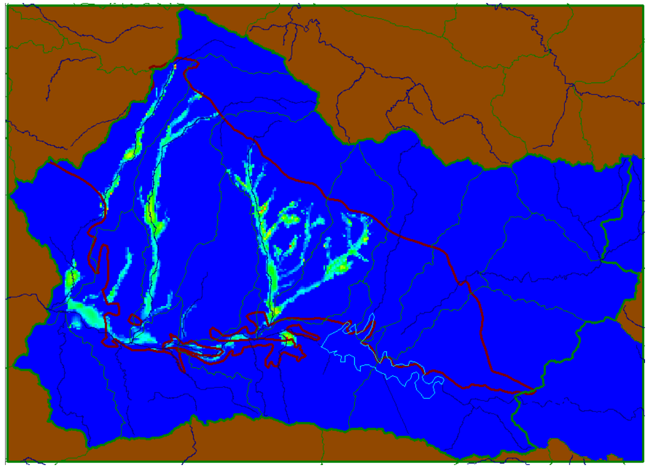
# Import Leapfrog 3D Geology to MODFLOW:

## Isopach Maps of Layer Thickness in MODFLOW-USG

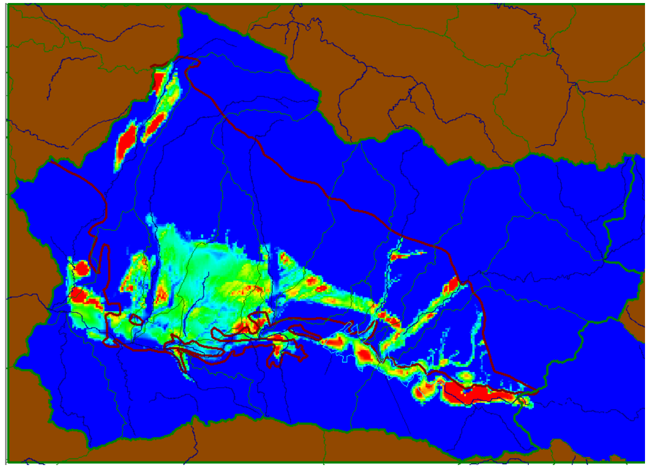
Layer 1: River Gravels and Cobbles

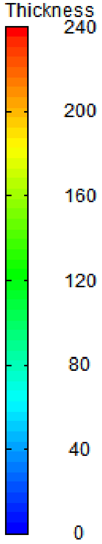


Layer 2: Recent Alluvium

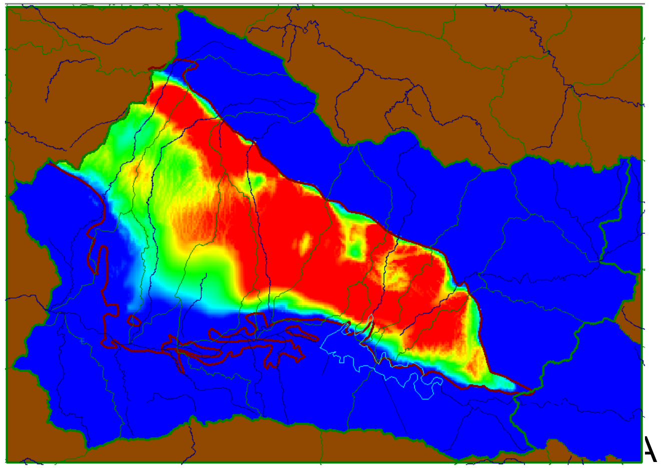


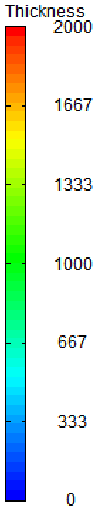
Layer 3: Older Alluvium



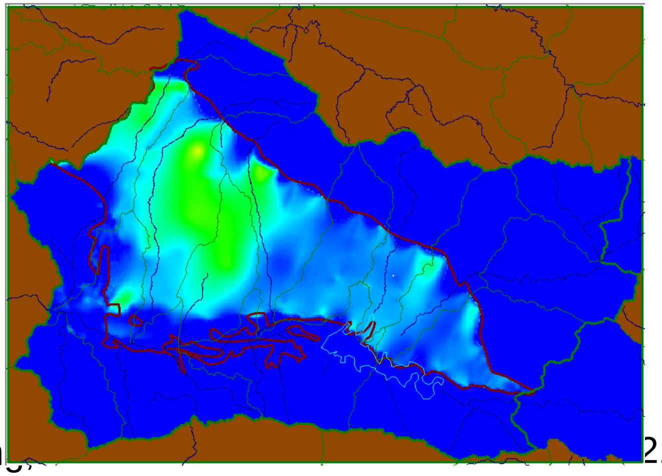



Layer 4: Paso Robles Formation






Layer 5: Carreaga Sandstone Fm.



# Hydrogeology:

# Hydraulic Properties of Geologic Units

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| Hydrostratigraphic Unit | Principal Location (Lateral Extent) | Vertical Extent | Thickness (feet) | Hydraulic Conductivity (feet/day) | Storativity (dimensionless) $S_c$ | $S_y$ | Porosity (Vol/Vol) |
|---|---|---|---|---|---|---|---|
| Santa Ynez River Alluvium | Santa Ynez River Floodplain Riparian Zone | Surface to 80 feet | 0 - 60 feet<br>Average: 42 | 100 - 600<br>Arith. Avg: 260<br>Geomean: 222 | $4.2 \times 10^{-4}$ | 0.23 | 0.3 |
| Tributary Alluvium | Along principal tributaries in Santa Ynez Uplands | Surface to 70 feet | 0 - 70 ft<br>Average: 35 | 100 - 500<br>(estimated)<br>Geomean: 200 | $3.5 \times 10^{-4}$ | 0.2 | 0.3 |
| Older Alluvium | Draped atop Paso Robles Fm from terraces near river up to 1 to 2 miles upslope from river | Surface to depth of 150 feet | 0 - 150<br>Average: 60 | 70 - 280<br>Arith.Avg: 136<br>Geomean: 117 | $6.0 \times 10^{-4}$ | 0.1 | 0.2 |
| Paso Robles Formation | Across entire extent of EMA, outcropping across approximately 70% of EMA, except for along the river, tributary channels, and older alluvial terraces within 1- to 2- miles of river | To depths up to 3,150 feet, Upper part generally more permeable than Lower, but very heterogeneous | 200 - 4150<br>Average: 1570 | 0.2 - 96<br>Average: 17.6<br>Geomean: 4.1 | $1.0 \times 10^{-2}$ | 0.04 | 0.15 |
| Careaga Sand | Deeply buried beneath Santa Ynez Uplands, rising to near-surface near and beneath Solvang | Below Paso Robles Fm and shallow alluvium, to maximum depth greater than 3,500 ft | 200 - 900<br>Average: 800 | 0.8 - 20<br>Average: 7.5<br>Geomean: 4.6 | $8.0 \times 10^{-4}$ | 0.05 | 0.12 |
| Sisquoc Formation | Deeply buried beneath entire EMA, and outcropping in adjacent uplifted mountains | To depth of up to 4,000 feet | up to 1000 | Very low, < 0.1 | $1 \times 10^{-6}$ / ft | 0.002 est | 0.005 |
| Monterey Formation | Deeply buried beneath entire EMA, and outcropping in adjacent uplifted mountains | To deeper than 5,000 feet | up to 1500 | Very low, < 0.1 | $1 \times 10^{-6}$ / ft | 0.002 est | 0.005 |

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# Model: Tool for Integrating Inflow and Outflow Data, Historical Conditions and Future Scenarios

- Natural conditions model
  - Precipitation, Runoff, Evapotranspiration, and Recharge
  - Recharge to groundwater both areal and localized tributary stream percolation
  - SY river and connected alluvial groundwater considered one unit

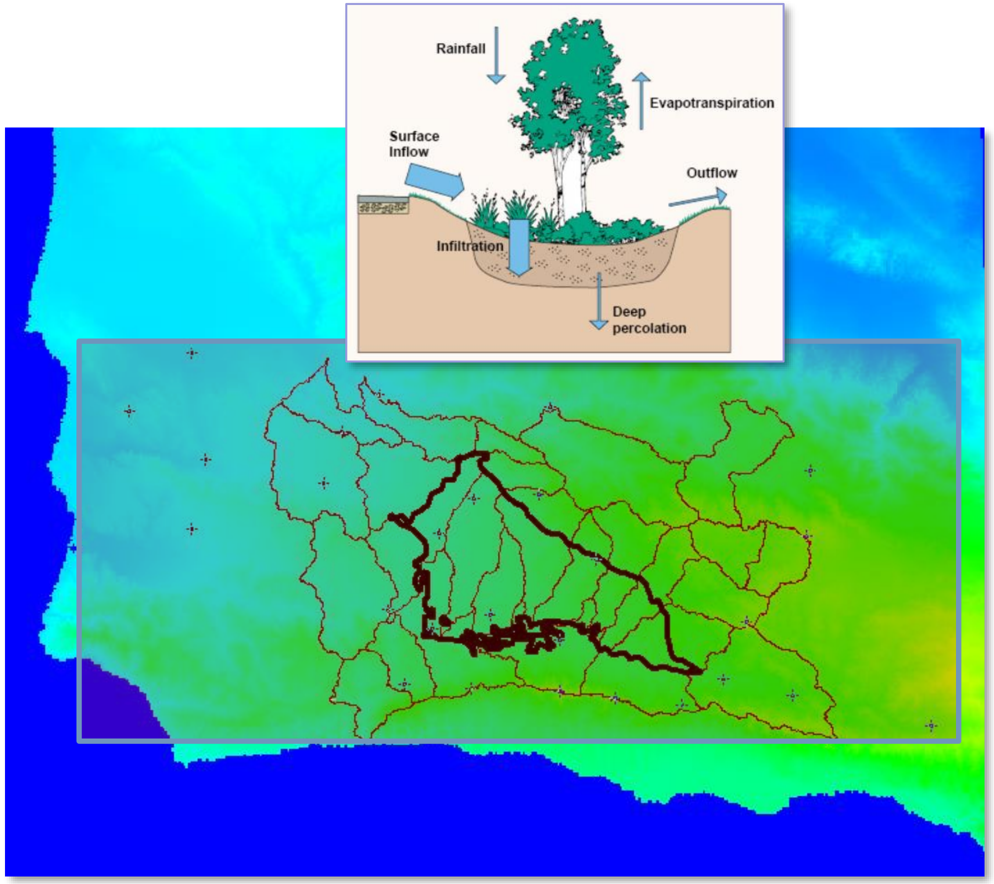
  → NO Pumping!

- Baseline Historical Model
  - include human influences (e.g., pumping, irrigation, …_)

- Future Conditions
  - Baseline climate, changing human uses / stresses
  - Climate change, changing human uses / stresses

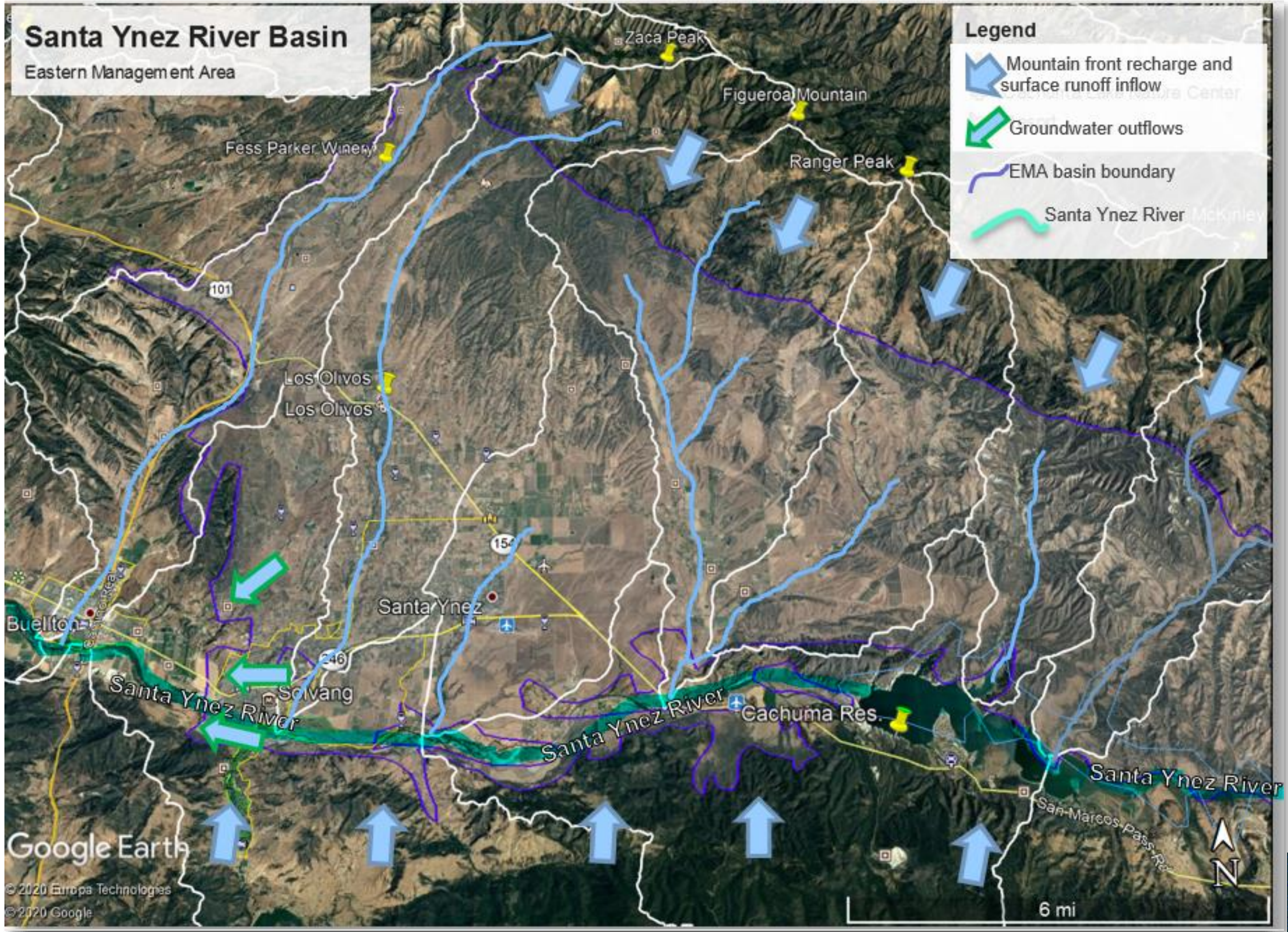
# Basin Characterization Model (BCM): Important Data Source for Natural Inflows

- BCM Data for model
  - Areally distributed water balance on 886 x 886 ft (~20 acre) grid cells, monthly timestep
    - Precipitation
    - Plus Recharge, Runoff, Evapotranspiration (ET)
  - Quality Assurance (QA) analysis of BCM precipitation
    - compared to weather stations in area
    - BCM precipitation, Santa Barbara Co., Dec 1980
    - On average ~ 1.5% overestimation error over 1980 – 2018 period over all met stations in area
      - **Develop correction based on weather station data**



# Inflows and Outflows with and w/out *Human Influences*

- Components:
  - INFLOWS
    - Mountain front recharge
    - Precipitation recharge
    - Tributary percolation
    - ✓*Irrigation return flow*
    - ✓*Septic tank percolation*
    - ✓*Imported water (State Water Project)*
  - OUTFLOWS
    - ✓*Groundwater pumping*
    - GW discharge to surface streams ("baseflow")
    - GW Outflow to CMA
    - Evapotranspiration



# Diversions and Return Flows

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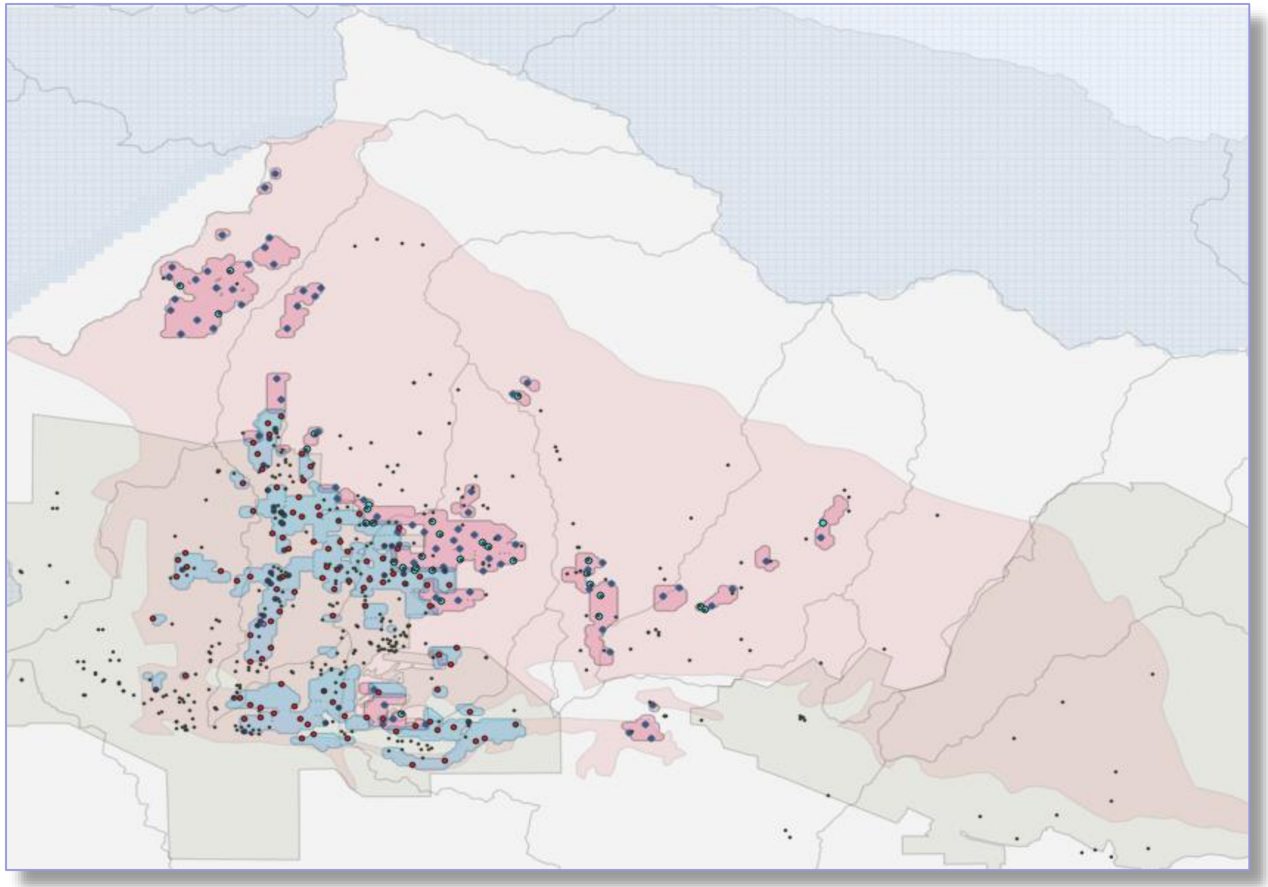
- Outflows: Surface water and groundwater diversions
- Inflows: Irrigation return flows, septic system return flows (incl. imported SWP water)



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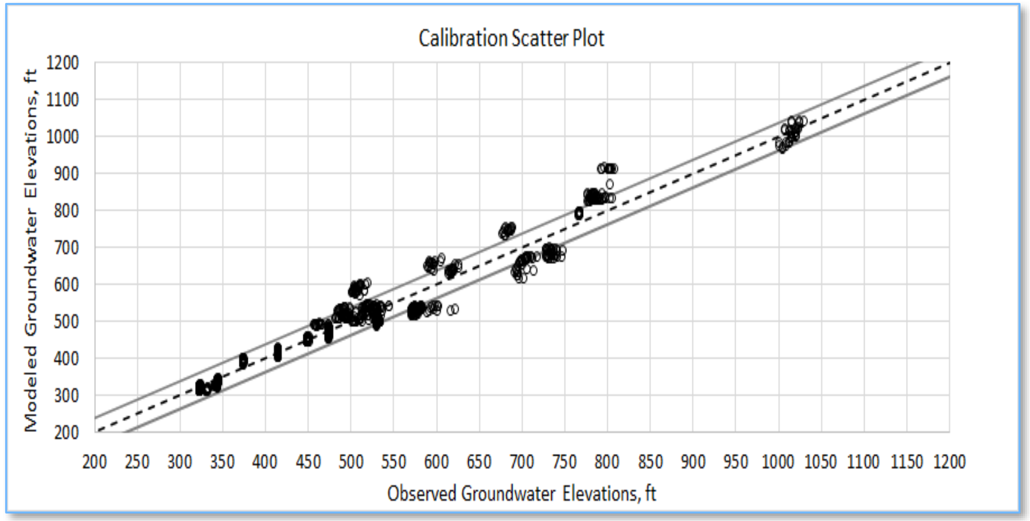
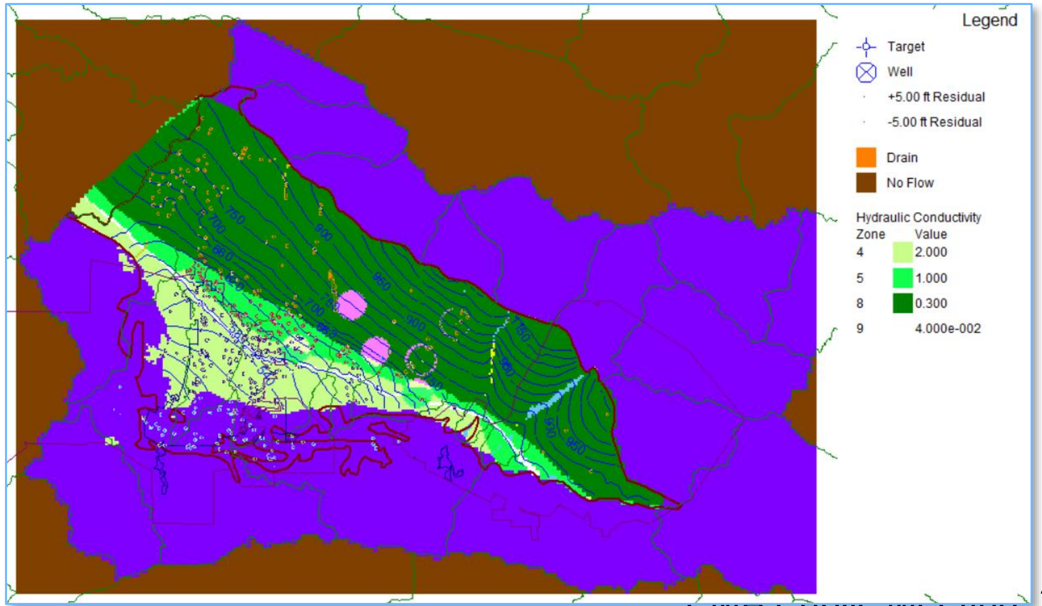
# Baseline Historical Model, Preliminary Calibration

- Iterative calibration process, calibrate model to observations
- Initial “Out-of-the-Box” model used constant properties for each hydrogeologic unit: Relative error, scaled RMS = 20.7%
  - → Relative error should be < 10%
- Needed to reduce permeability of Paso Robles formation beneath EMA Uplands (within range of observed values)
- Greatly reduced the Relative Error: Scaled RMS = 3.7%
  - **→ Considered good calibration**

| All Wells | |
|---|---|
| MEAN RES | -2.48 |
| Stdev Res | 26.8 |
| Range | 734 |
| Scaled RMS | 3.7% |
| Min | 310.0 |
| Max | 1043.9 |
| Count | 9048 |



# Baseline Historical Model Preliminary Calibration

# Well Hydrograph Results

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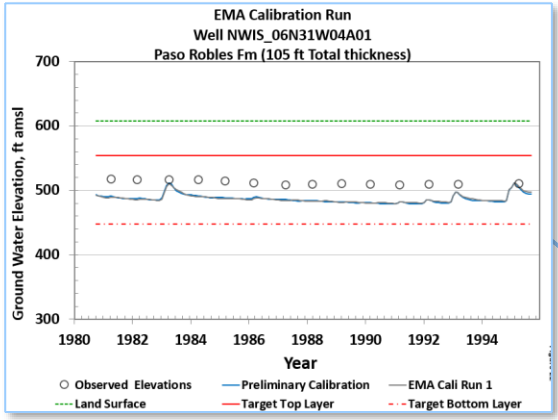


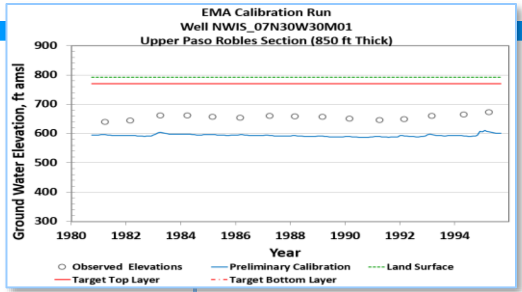


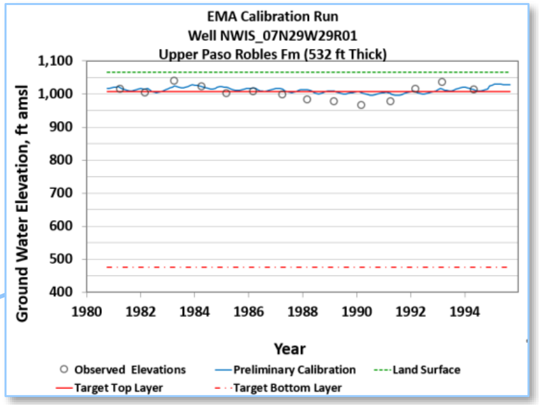


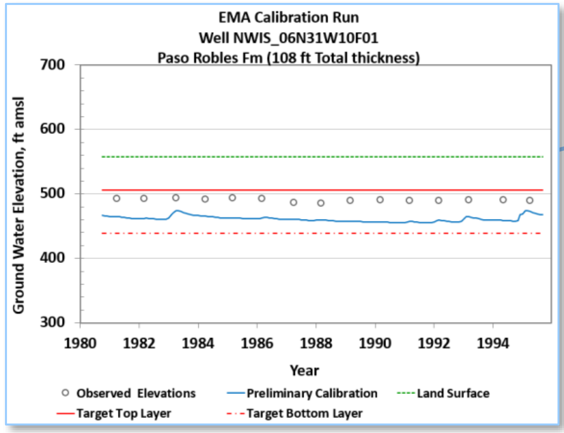


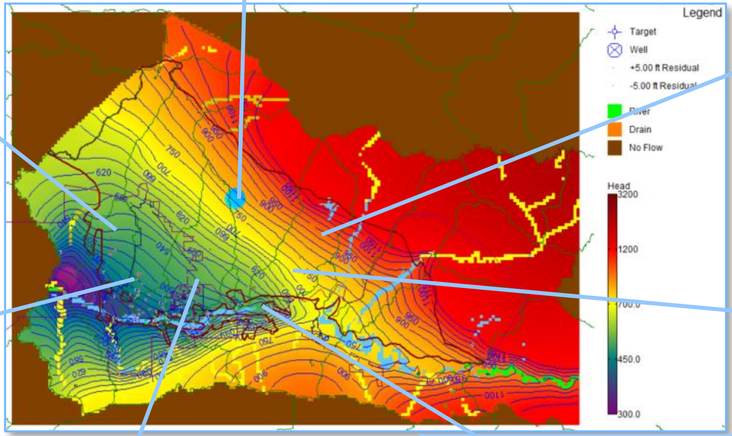


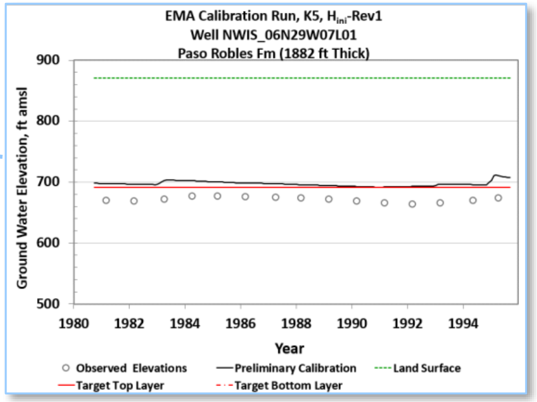


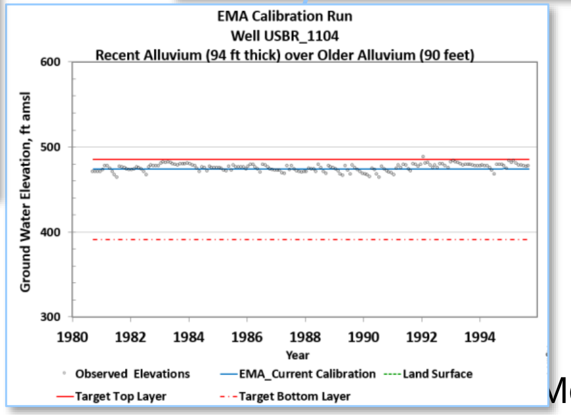


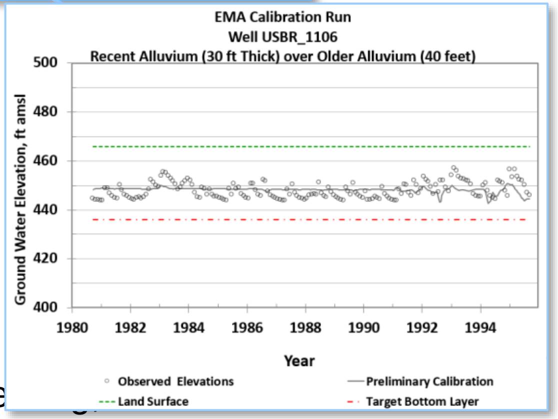


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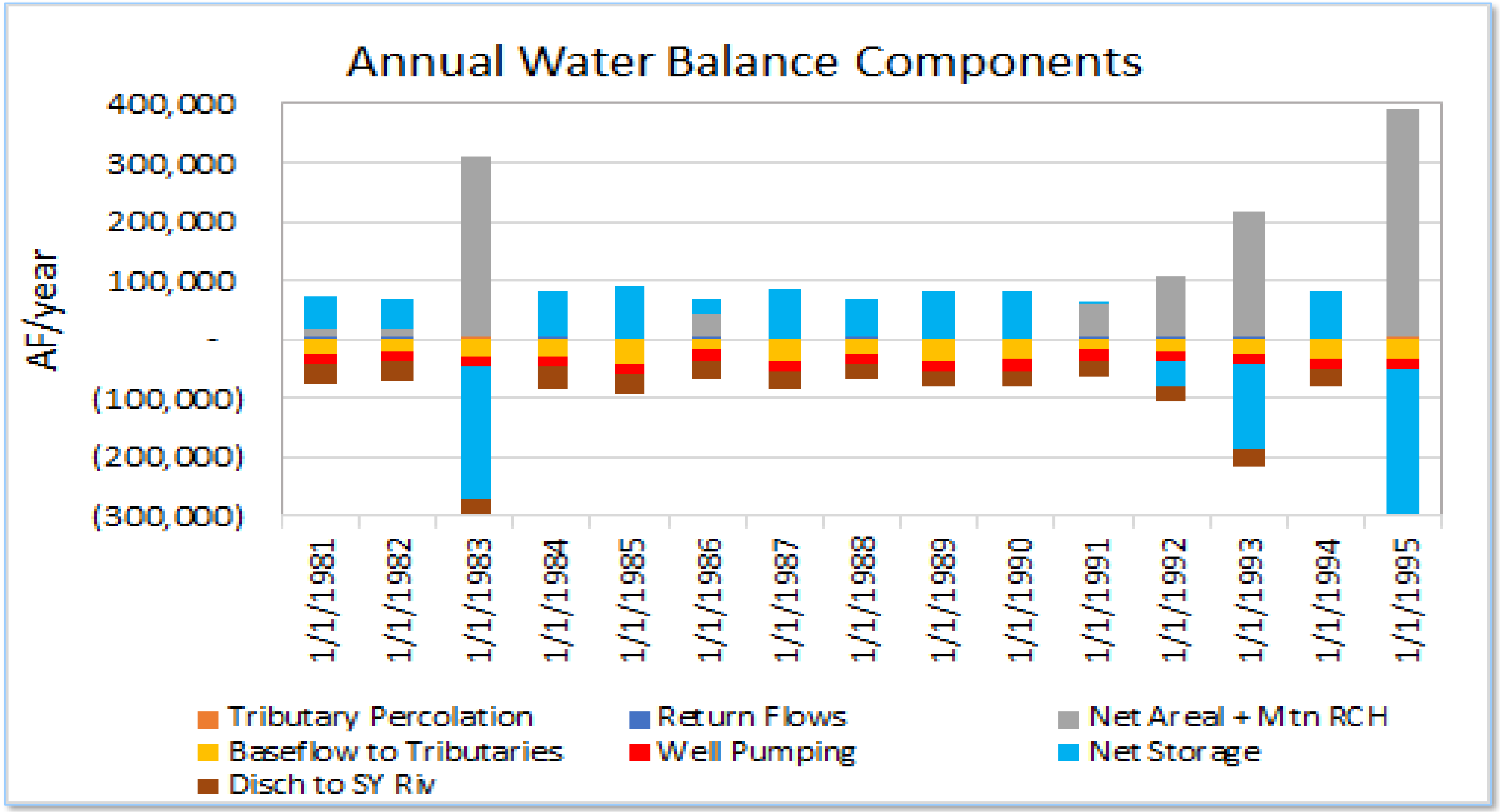
# Baseline Historical Model Preliminary Calibration
# Global Mass Balance Results



# Next Step: Zone Budgets for Study Area

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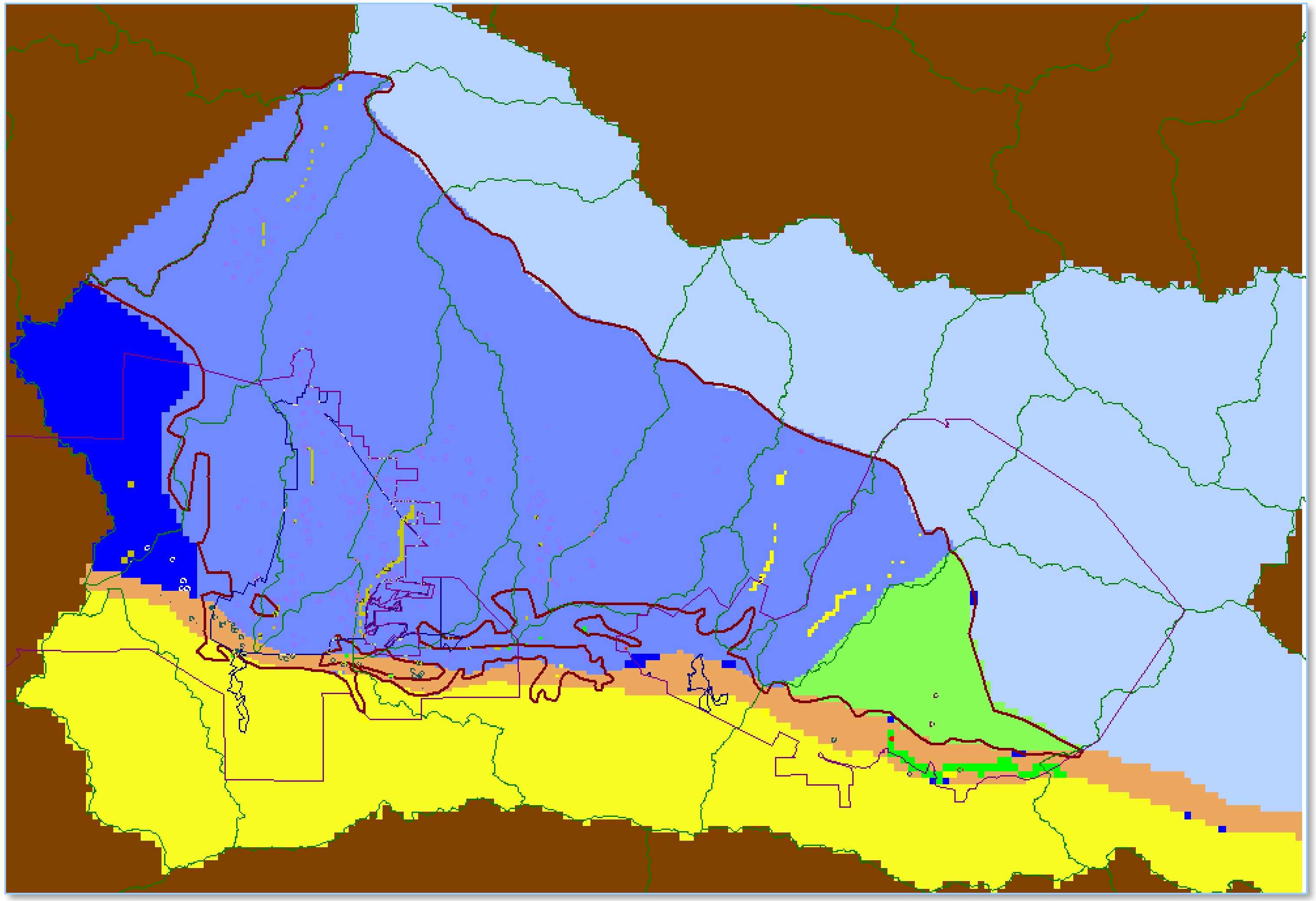

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# Numerical Model: Steps to Complete

- Finalize calibration of Baseline Historical Model
  - Use PEST (Parameter ESTimation) computer program to improve and finalize calibration
  - Verify calibration with 1996 – 2018 data

- Future Conditions
  - Baseline climate, changing human uses / stresses
  - Climate change piled on top of changing human uses / stresses

# Questions?