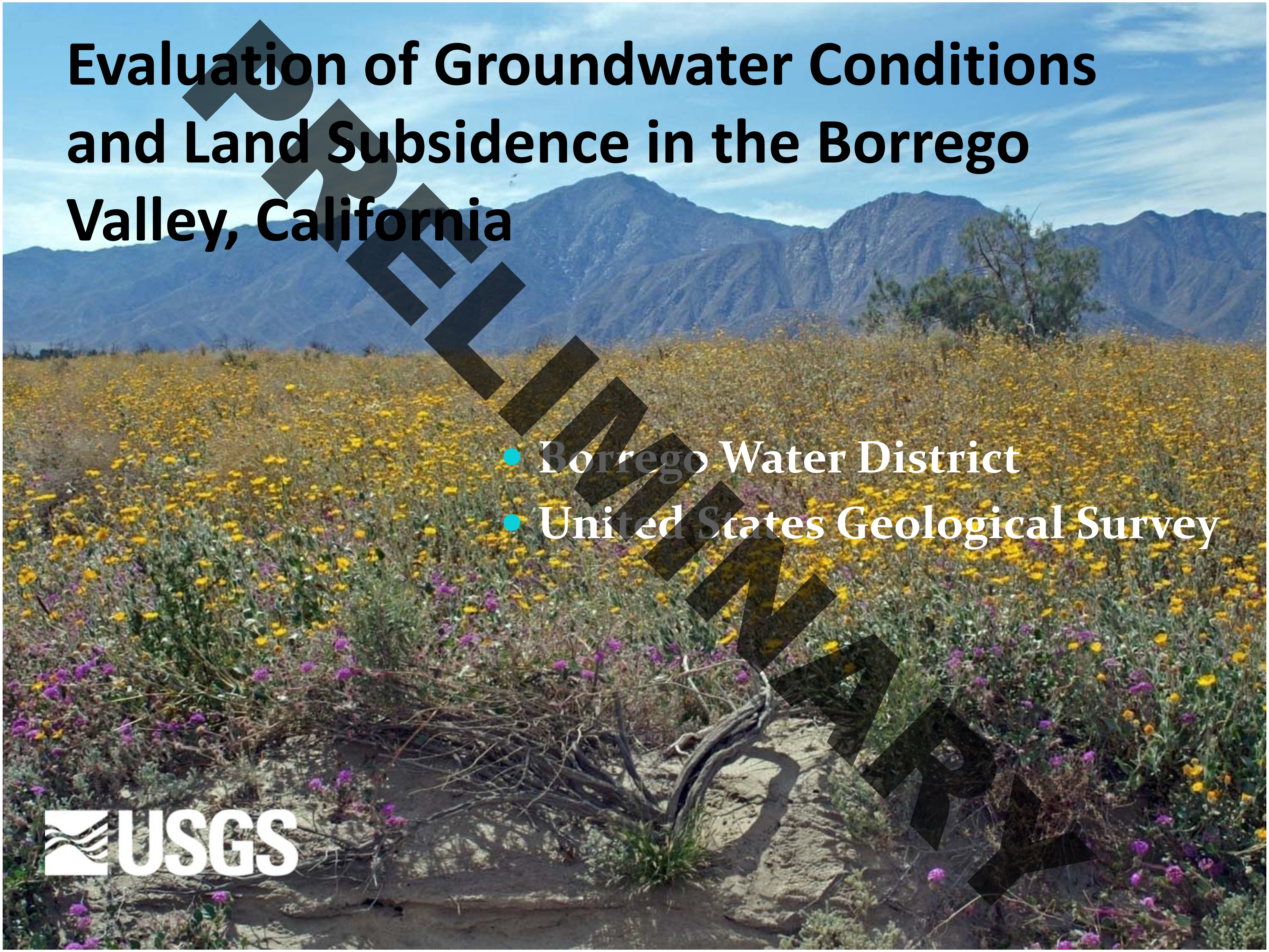
Evaluation of Groundwater Conditions and Land Subsidence in the Borrego Valley, California

- Borrego Water District
- United States Geological Survey



Problem:

- Groundwater is virtually the sole source of water in Borrego
- Annual groundwater pumping exceeds natural recharge by about four times
- Pumping has resulted in water levels dropping over two feet per year for the past twenty years
- Water-level declines in areas with significant clay deposits could result in land subsidence
- As the more permeable upper aquifer is dewatered, water-level declines may accelerate and water quality may deteriorate

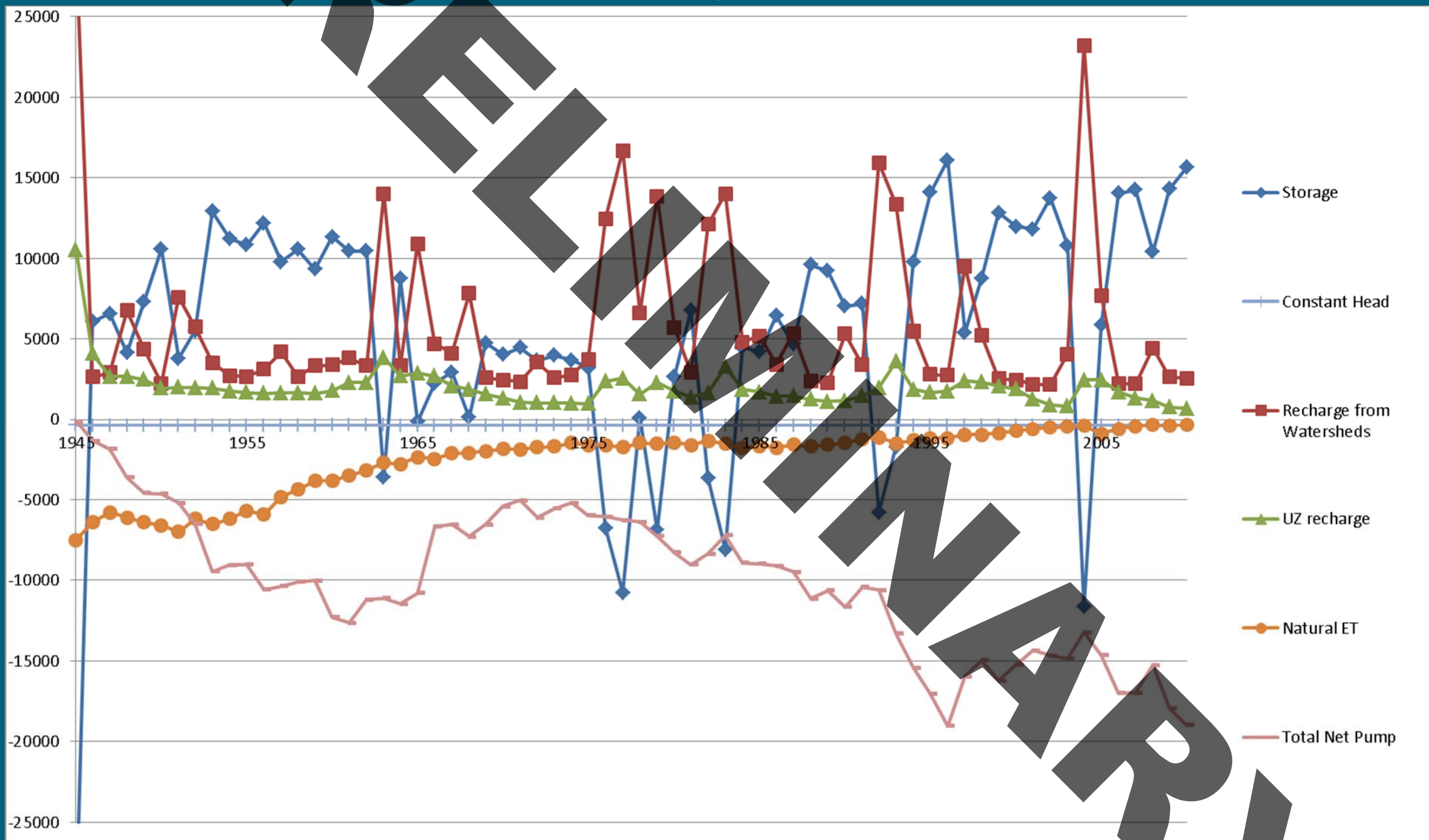
USGS

Basic groundwater budget

Preliminary Groundwater Budget (acre-feet per year)		
IN	Pre-development	Current
Natural Recharge	6,000	6,000
OUT		
Flow out southern end	350	350
Natural ET	5,650	250
Wells		19,000
Storage Change	0	-13,600

USGS

Groundwater budget changes with climate variability



PRELIMINARY

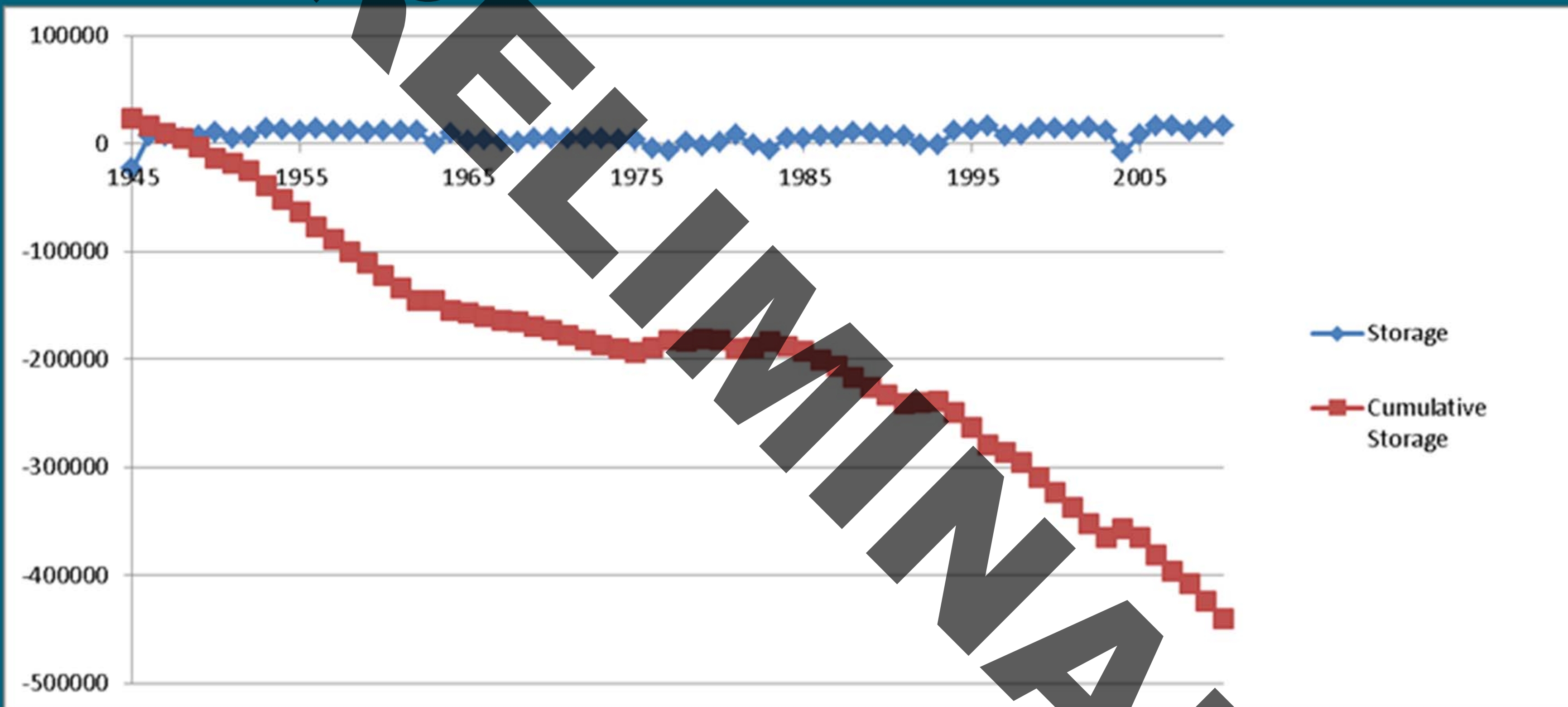
USGS

Recharge

- Natural recharge:
  - Adjacent watersheds – vast majority
  - Local precipitation - negligible
    - Relatively small amount during storms
    - Most lost to evaporation
- Anthropogenic recharge:
  - Irrigation return flow
    - range 65-85% (improves with time)
    - much lost to evaporation
  - Septic tank effluent
  - Thick unsaturated zone
    - vertical conductivity is approximately 0.005 feet/day
    - Example: 200 feet to water about 100 years

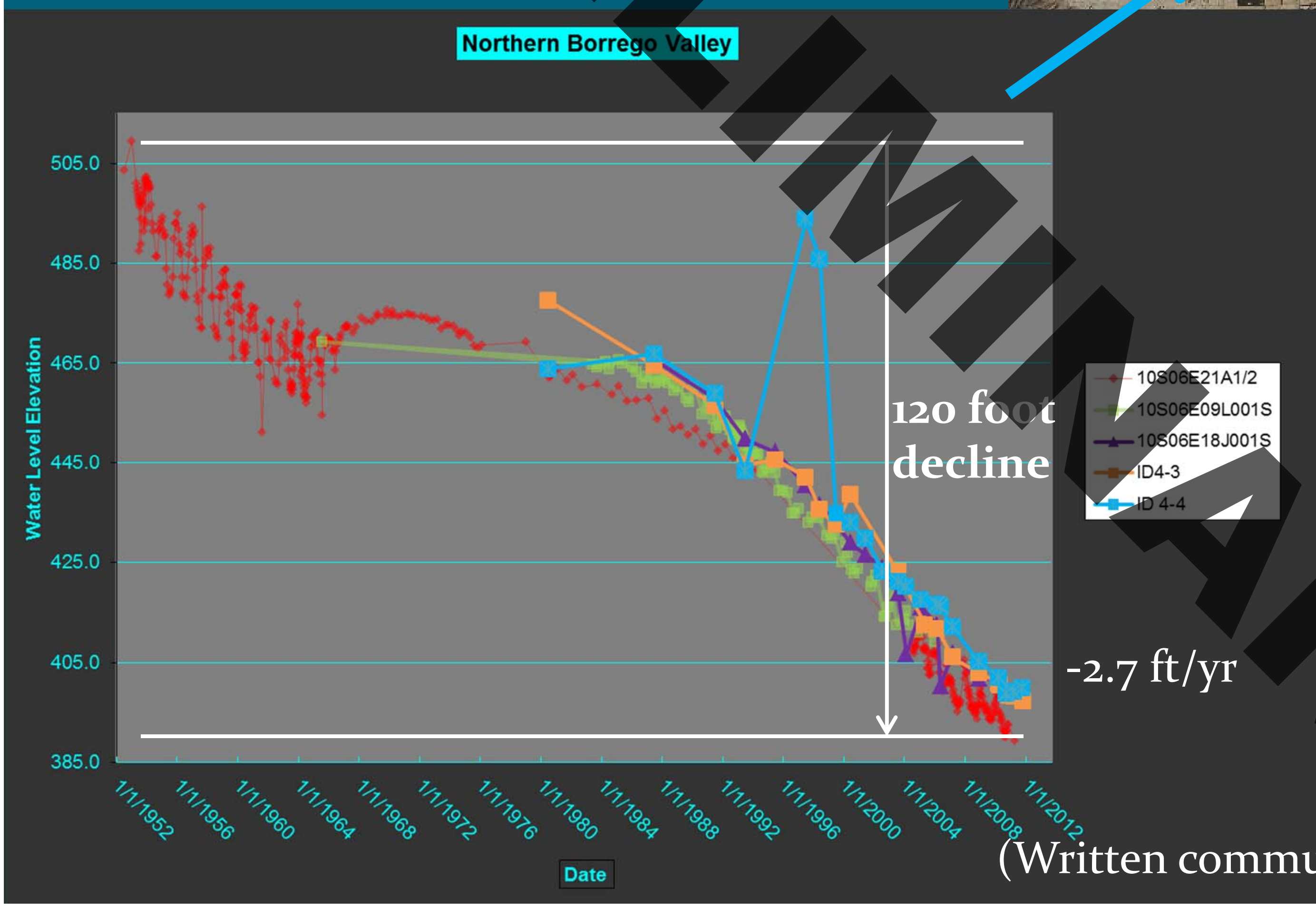
USGS

Overall climate variability small compared to the cumulative storage change



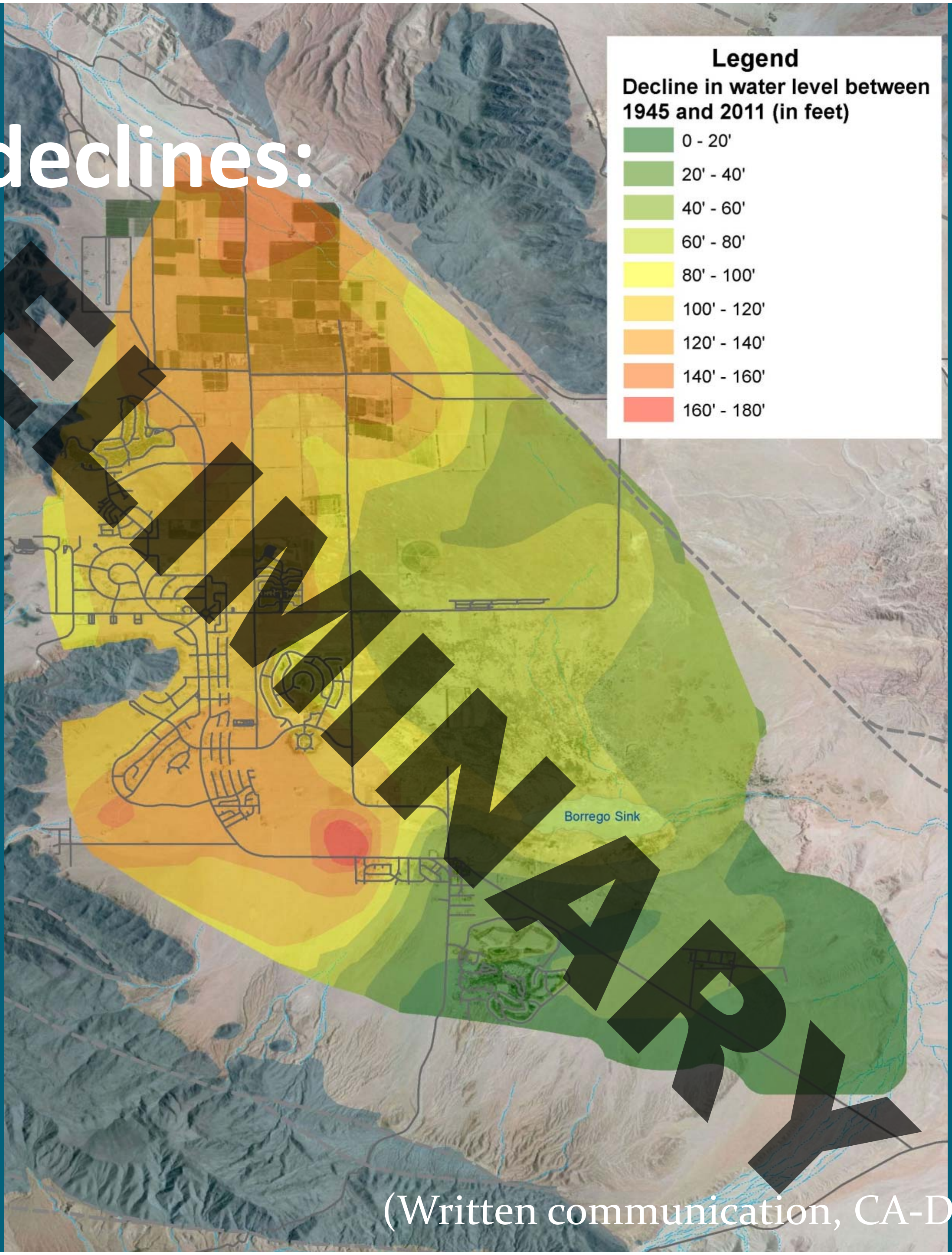
USGS

Water level declines:



(Written communication, CA-DWR, 2012)

Water level declines:



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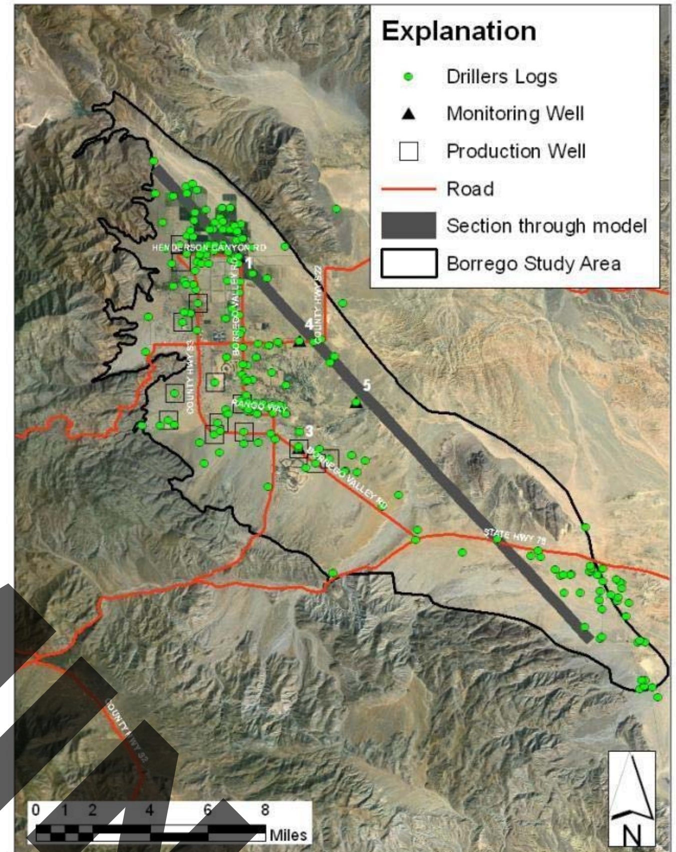
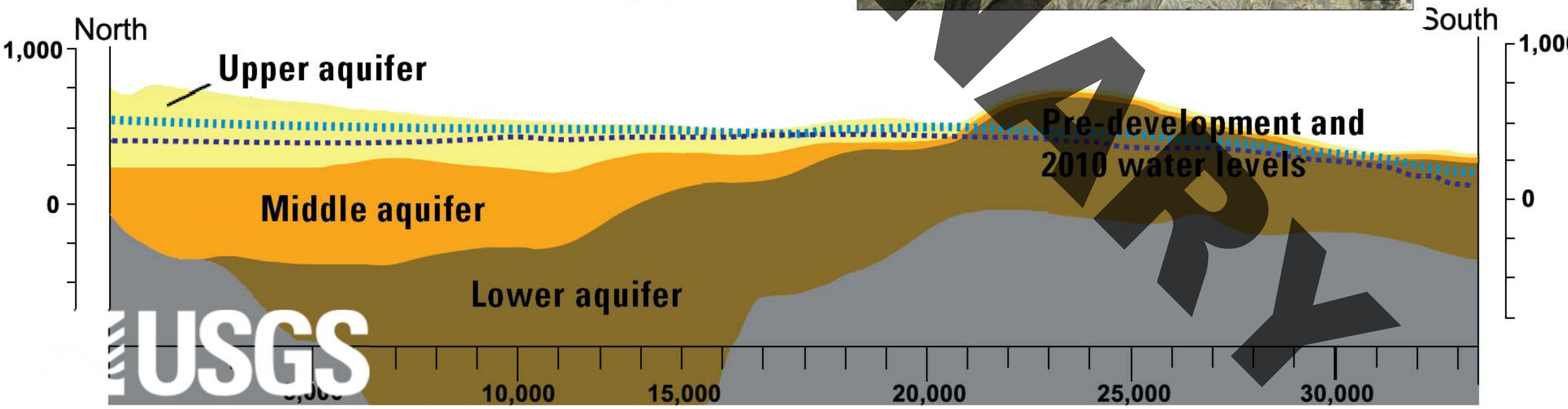
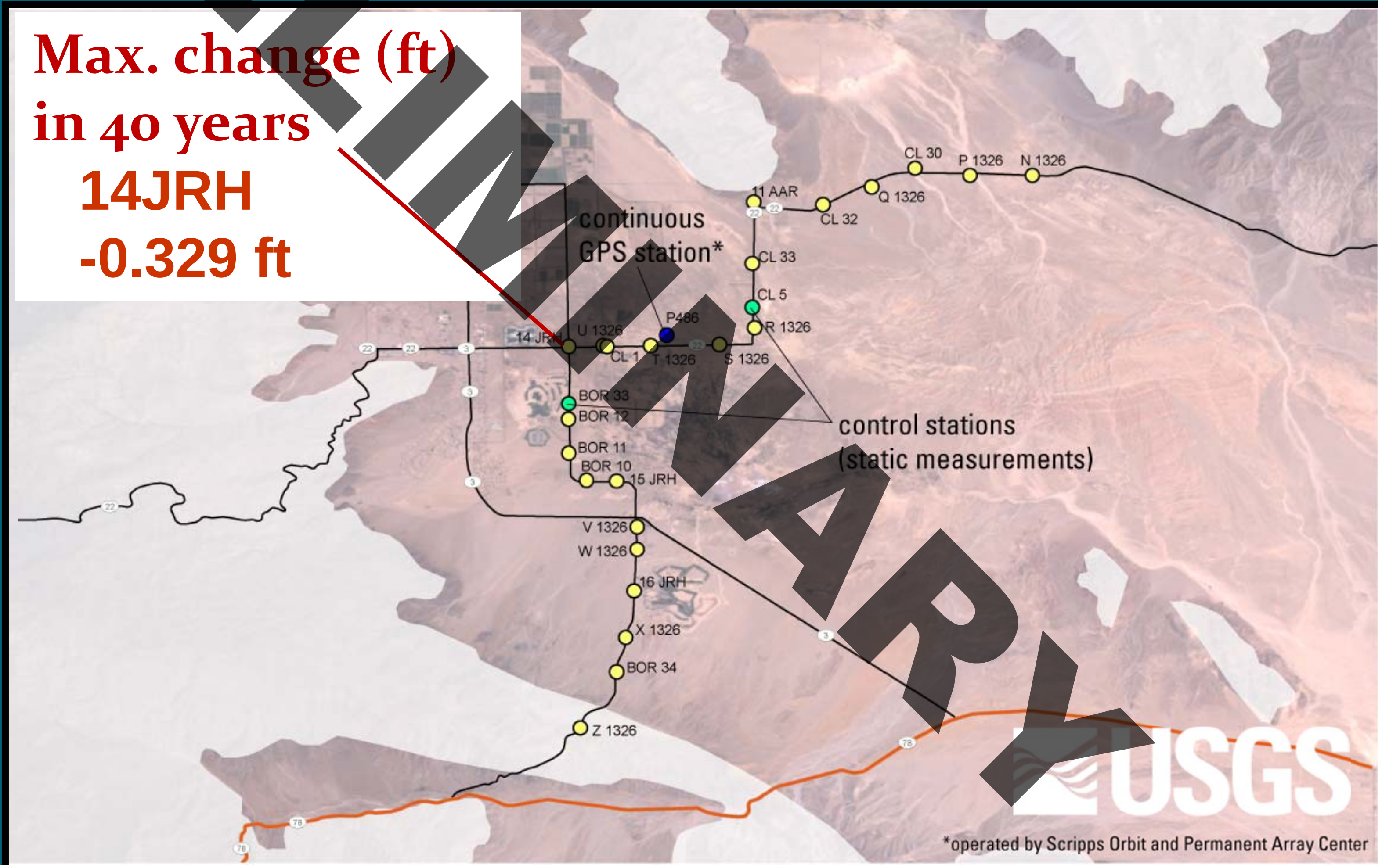
Water level declines:





Land Subsidence

- Elevations for all 25 benchmarks are stable (< 6”) compared to elevations derived from leveling measurements in 1978 (23 benchmarks) or 1969 (2 benchmarks)

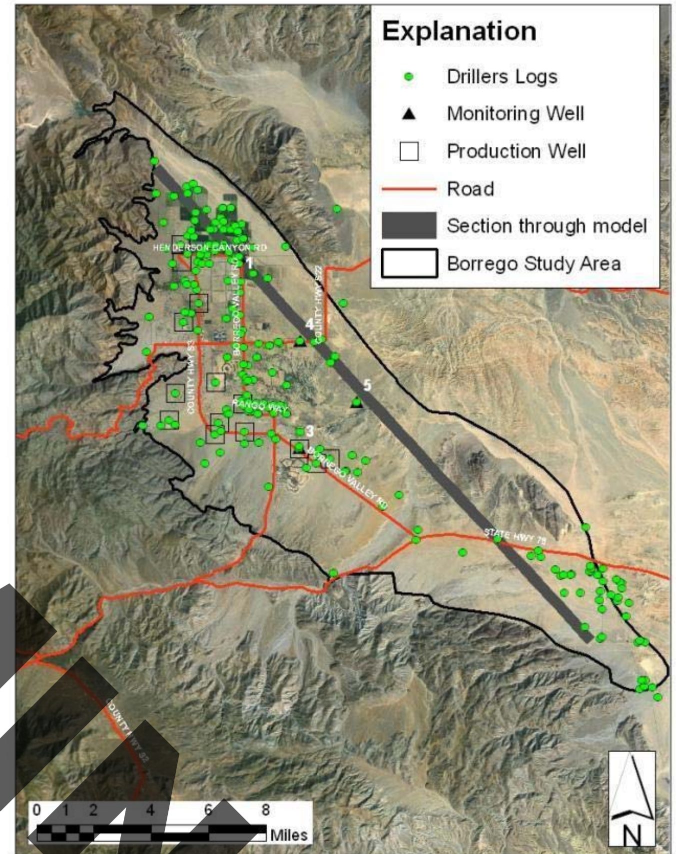


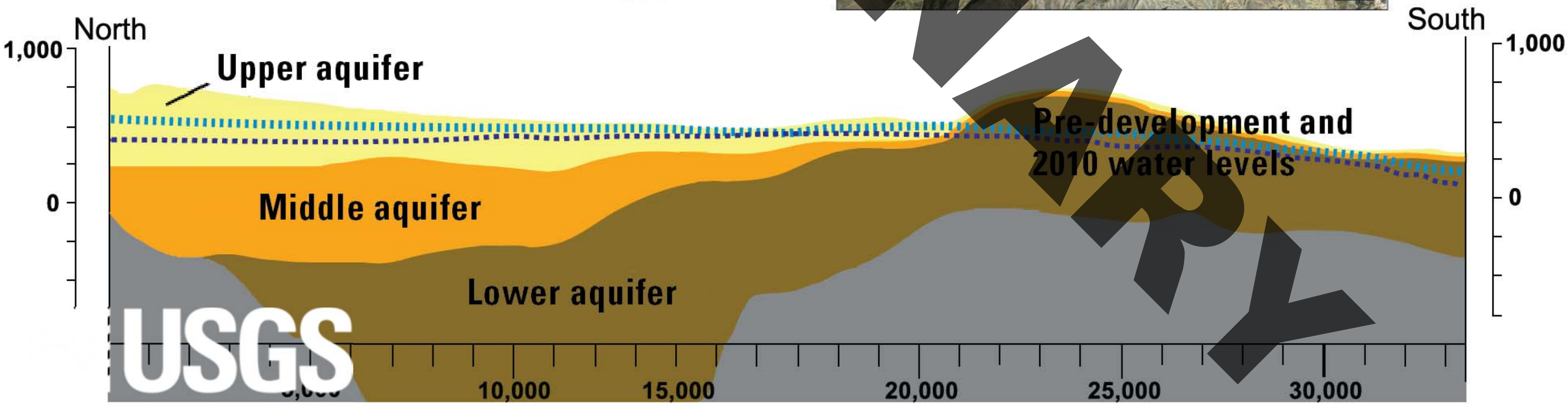
Hydrogeologic characterization:

Horizontal hydraulic conductivity (Permeability)

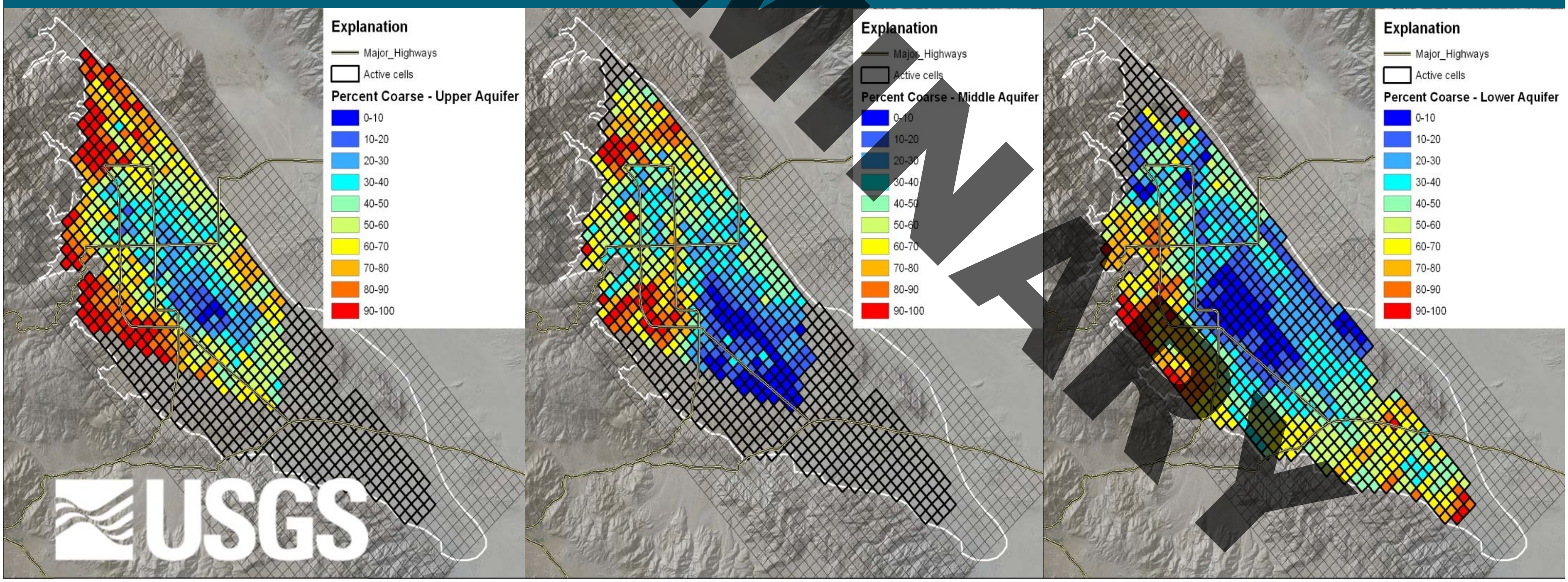
- Upper aquifer 43-81 feet/day
- Middle aquifer 1-10 feet/day
- Lower aquifer 0.1-2 feet/day

Preliminary Estimates





Hydrogeologic characterization - permeability

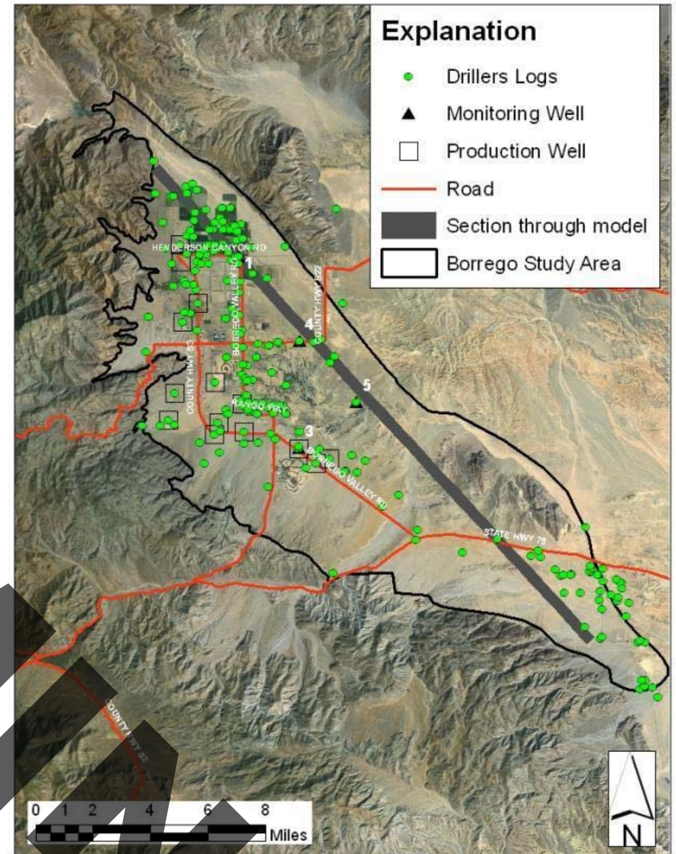


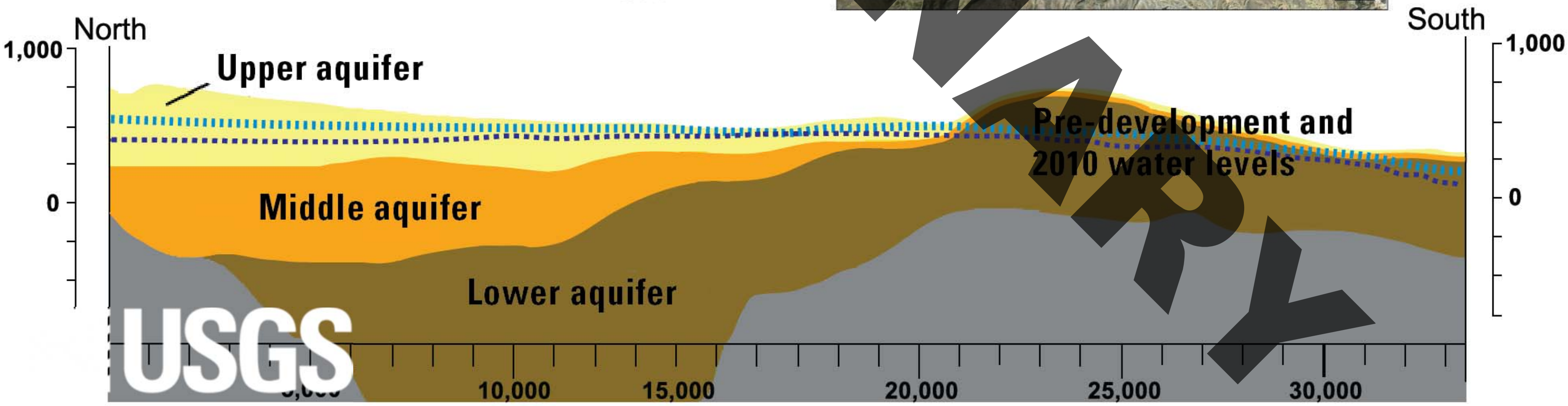
Hydrogeologic characterization:

Specific Yield (Storage)

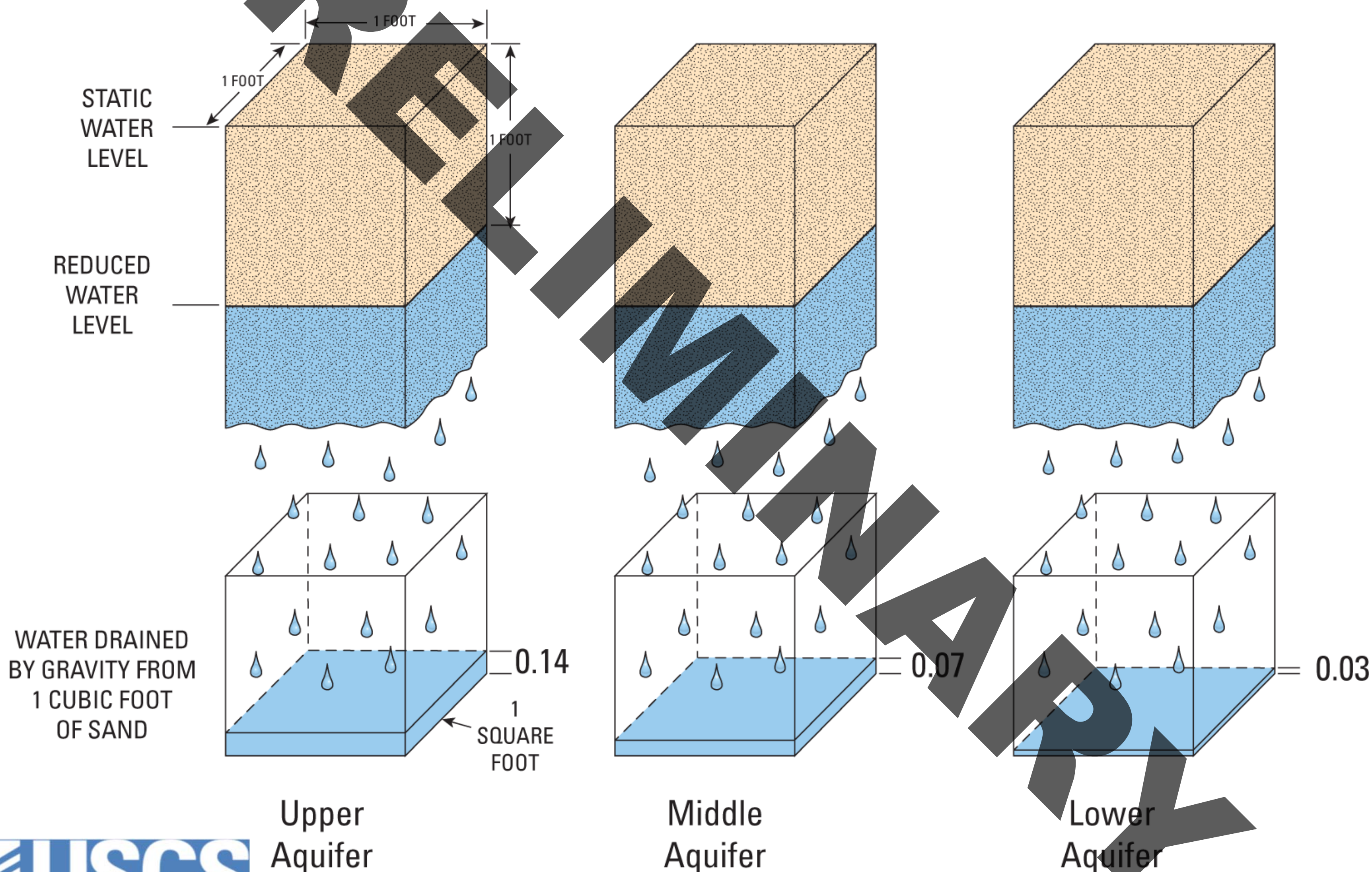
- Upper aquifer 14%
- Middle aquifer 7%
- Lower aquifer 3%

Preliminary Estimates

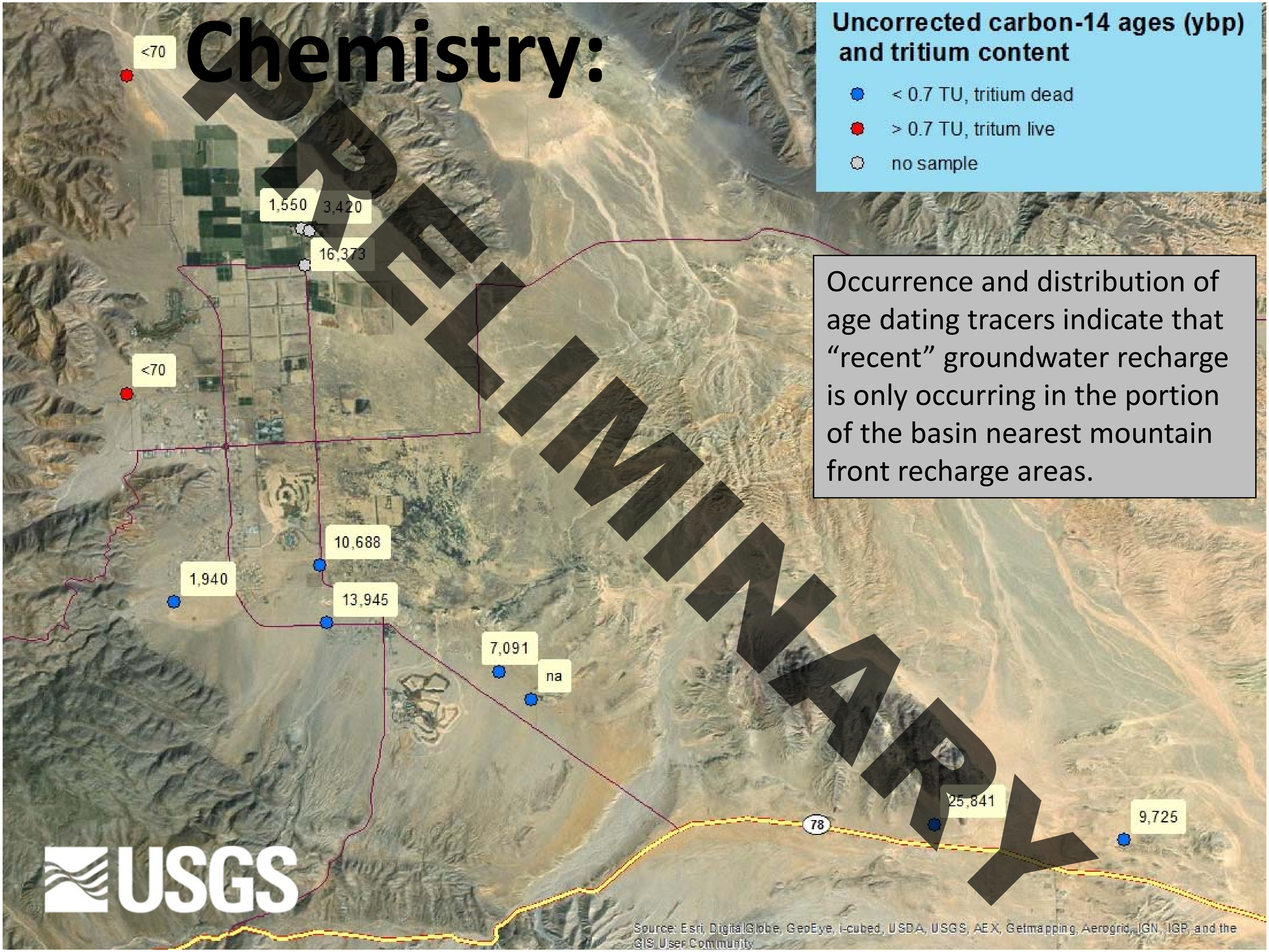




Specific yield of sediments



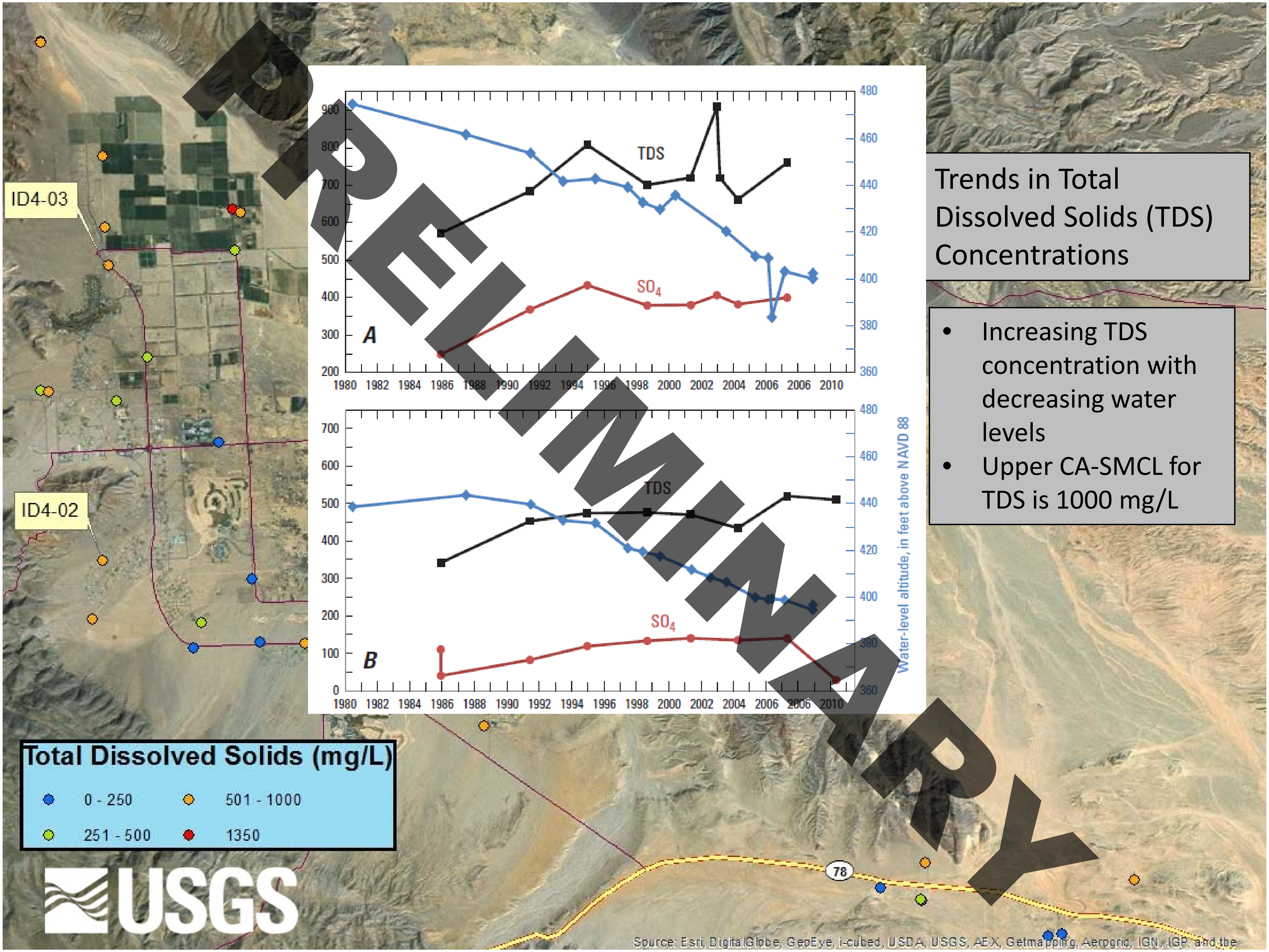
Chemistry:

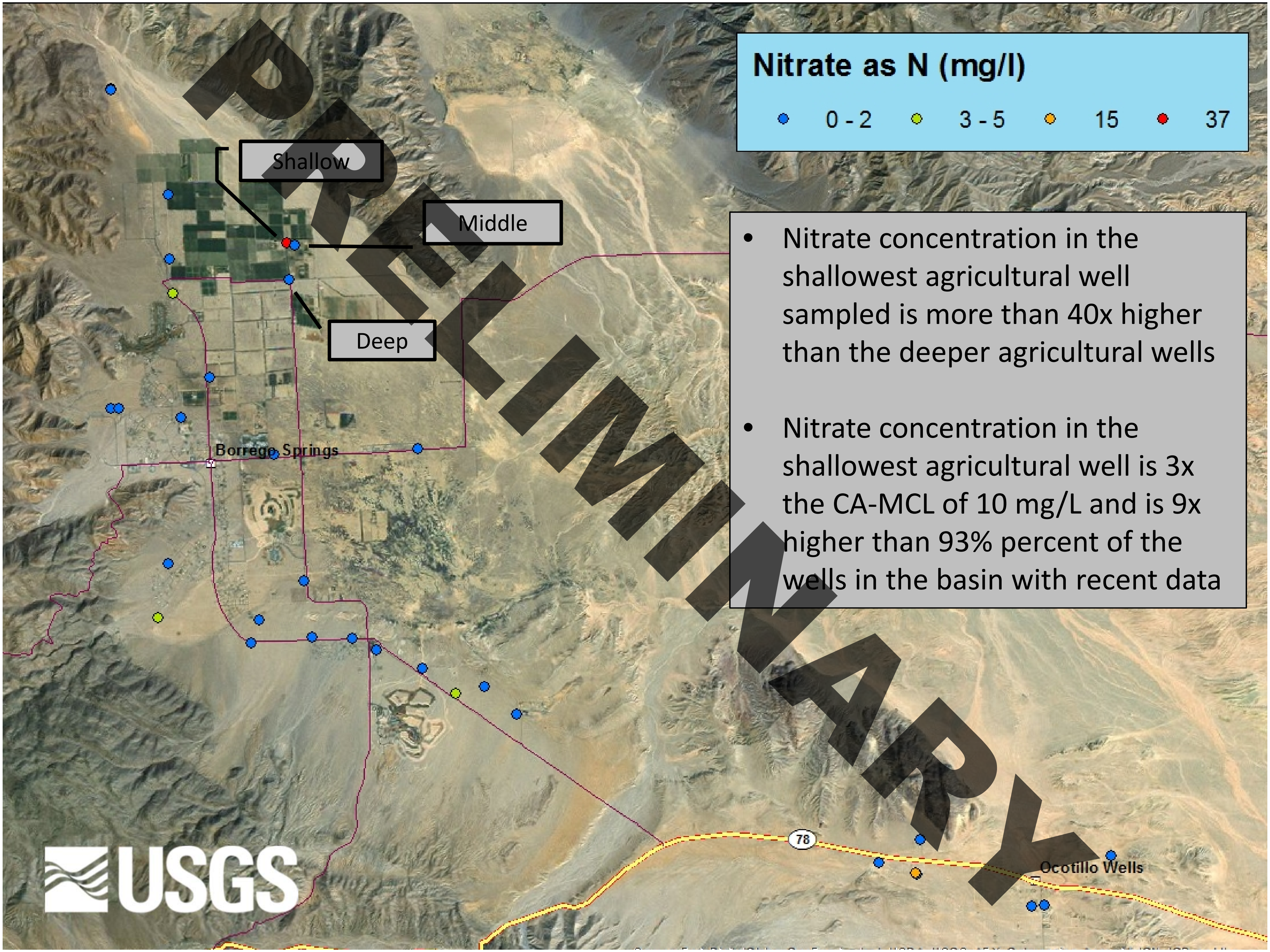


Occurrence and distribution of age dating tracers indicate that “recent” groundwater recharge is only occurring in the portion of the basin nearest mountain front recharge areas.

Trends in Total Dissolved Solids (TDS) Concentrations

- Increasing TDS concentration with decreasing water levels
- Upper CA-SMCL for TDS is 1000 mg/L

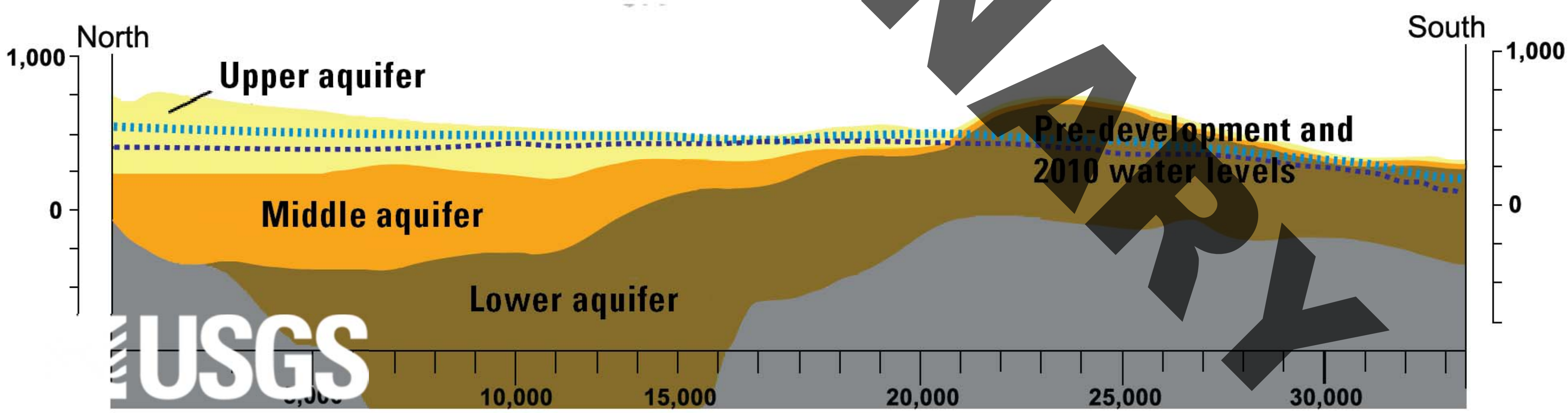



Nitrate as N (mg/l)
0 - 2
3 - 5
15
37
Shallow
Middle
Deep
Borrego Springs
78
Ocotillo Wells
USGS
PRELIMINARY
• Nitrate concentration in the shallowest agricultural well sampled is more than 40x higher than the deeper agricultural wells
• Nitrate concentration in the shallowest agricultural well is 3x the CA-MCL of 10 mg/L and is 9x higher than 93% percent of the wells in the basin with recent data

Predictive simulations:

5 Scenarios

(1) No action 50 years
(2-4) Several Growth Scenarios
(example: Ag red. 50%; Golf red. 50%; Muni inc. 75%)
(5)WATER USAGE REDUCTION TO REACH SUSTAINABILITY
(Ag red. 75%; Golf red. 75%; Muni red. 50%)

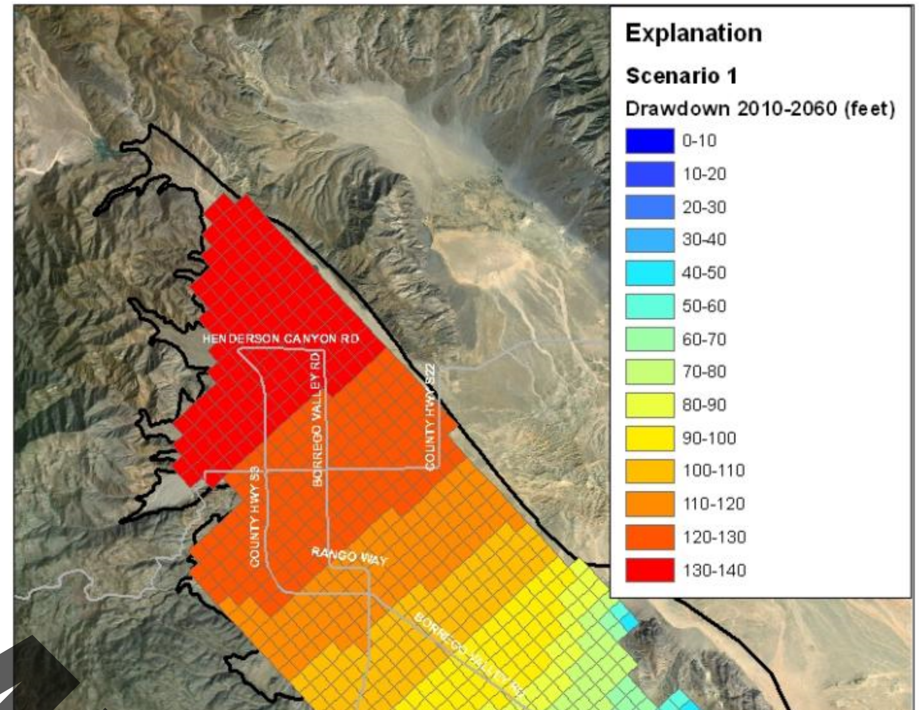


Basic groundwater budget

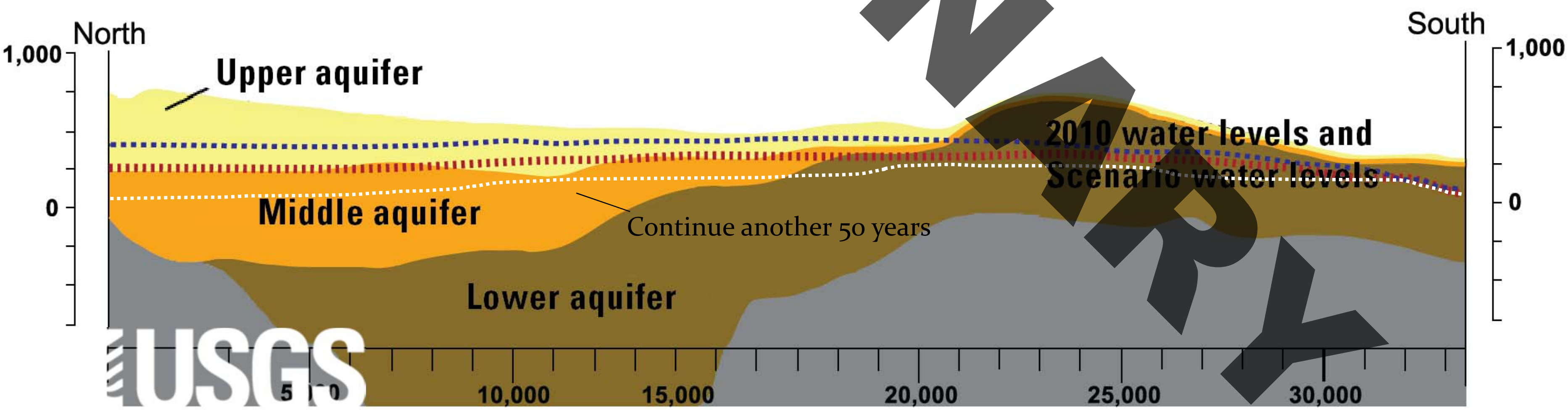
Preliminary Groundwater Budget (acre-feet per year)				
IN	**Pre-development**	**Current**	**Scenario**	**Sustainable**
Natural Recharge	6,000	6,000	6,000	6,000
OUT				
Flow out southern end	350	350	350	350
Natural ET	5,650	250	200	200
Wells		19,000	12,000	5,450
Storage Change	0	-13,600	-6,550	0

Scenario 1:

No action 50 years
Continue current pumping rates



Scenario 1



Change in storage through time

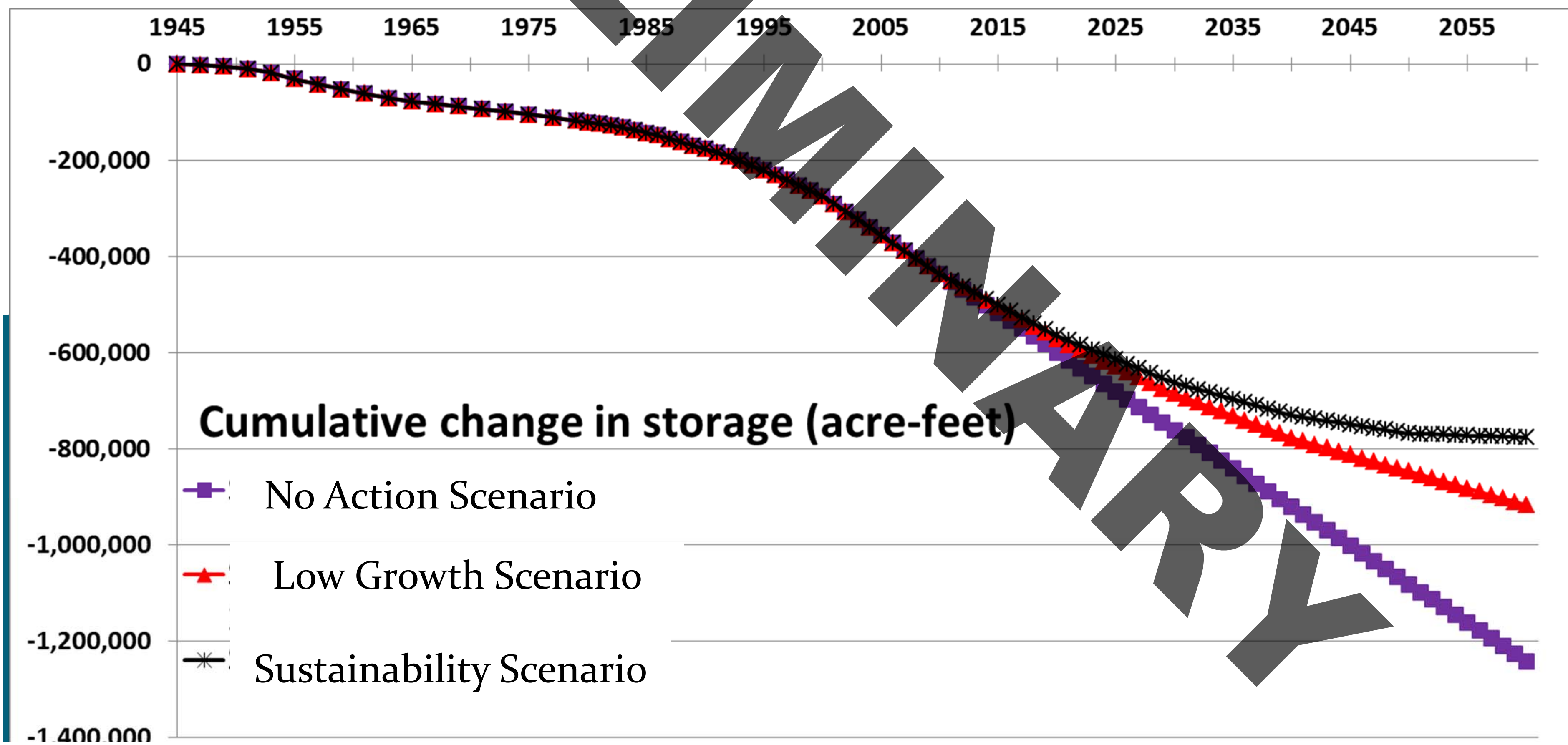
(1) No action 50 years

(2) Low Growth Scenario

(Ag red. 50%; Golf red. 50%; Muni inc. 75%)

(3) WATER USAGE REDUCTION TO REACH SUSTAINABILITY

(Ag red. 75%; Golf red. 75%; Muni red. 50%)



Conclusions:

(1) Water Budget

- Currently, more water being pumped than recharging basin
- As a result, water levels are declining and will continue to decline until this changes
- The rate of decline may increase and the water quality may deteriorate with continual lowering of water levels

(2) Subsidence

- Currently, small amount of subsidence is happening
- Not likely to be a big issue in this basin now or in the future

(3) Water Quality

- "Recent" natural groundwater recharge is only reaching the basin near mountain front recharge areas
- TDS concentrations are increasing as water levels decrease indicating that TDS may be a water quality issue in the future
- The distribution of nitrate in groundwater indicates that agricultural operations are impacting "shallow" water quality in the northern portion of the basin

(4) Final thought

- The issue isn't that the basin will run out of water, but that water is likely to become more expensive
  - Costs from deepening wells, increasing number of wells to get the same yield, treating for water quality issues, etc.