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Transformational solutions: Bridging the gap between projected water and energy supply and demand in the Western US

Howard Passell[1], Cliff Dahm[2], Jesse Roach[1], Vince Tidwell[1], Katie Zemlick[1]

[1]Sandia National Laboratories

[2]University of New Mexico

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Mind the gap . . .

- US western states (and the world) are facing a gap between projected energy and water supply and projected energy and water demand
- Current plans are not on track to bridge the gap
- Transformational (non linear) solutions must be identified

Three case studies

- Middle Rio Grande, NM
- Western U.S.
- California's Sacramento-San Joaquin Delta

URGSiM Analysis of Climate Risk in the Upper Rio Grande Basin

SAND#2012-####

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Jesse Roach
Sandia National Laboratories
Albuquerque, NM

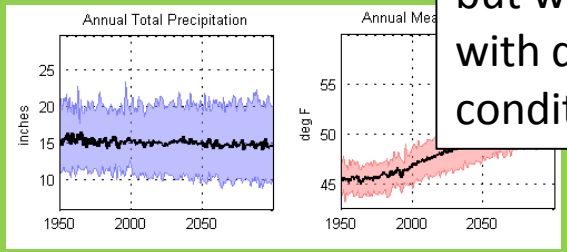
Dagmar Llewellyn[1], Warren Sharpe[1]
U.S. Bureau of Reclamation
[1] Albuquerque, NM

The Rio Grande WWCRA Approach:

112 runs 1950-2099

General Circulation Model (GCM)

112 Statistically Downscaled Regional Projections of ΔP and ΔT



16 models, 3 emissions scenarios for 48 runs, but with multiple runs with different boundary conditions

Post processing bias correction of flows (224 hydrographs)

tions model (URGSiM)

Variable Infiltration Capacity (VIC) Model

112 Runoff Projections Using Rainfall Runoff Model

Impacts to water deliveries, flows, and reservoir levels.

URGSiM Spatial Resolution

Spatial resolution and extent based on URGWOM model:

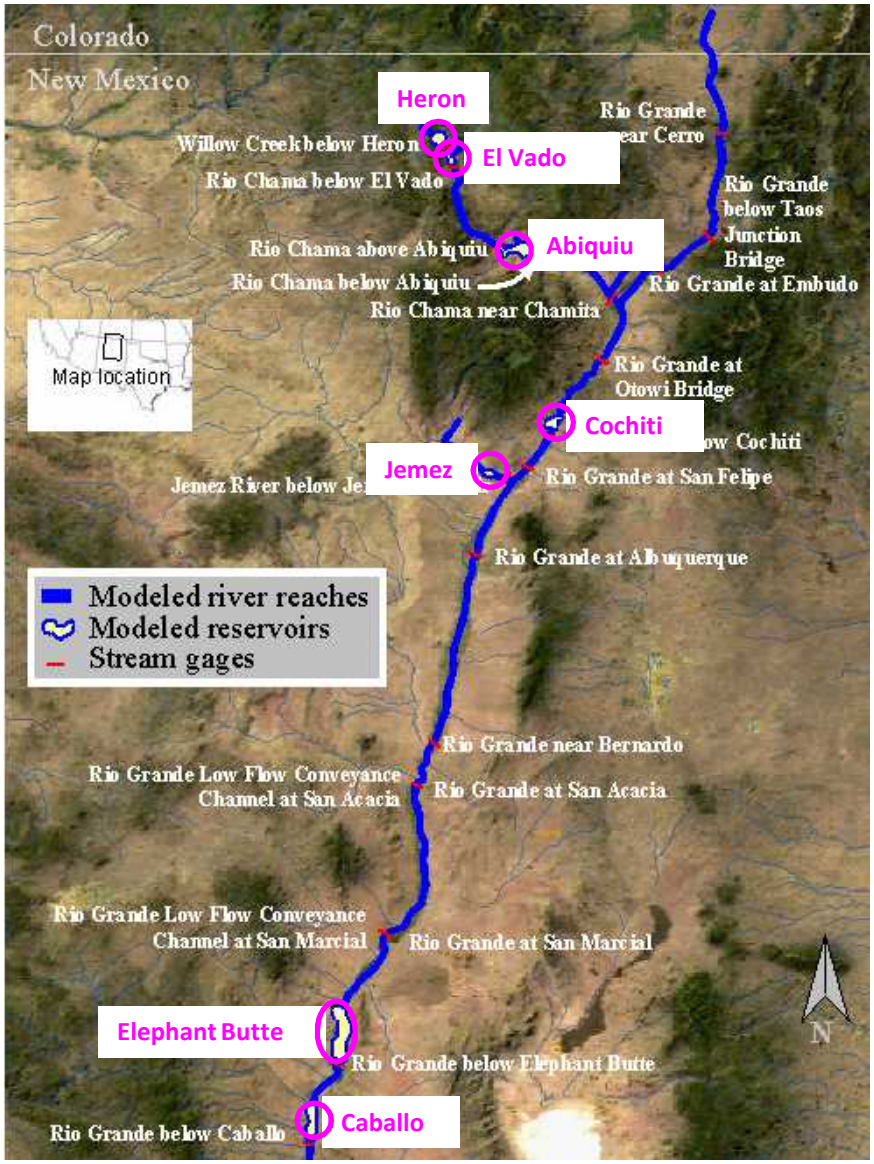
- Dominant historical data set is from USGS stream flow gages:

"River reach": gage location based spatial unit of mass balance.

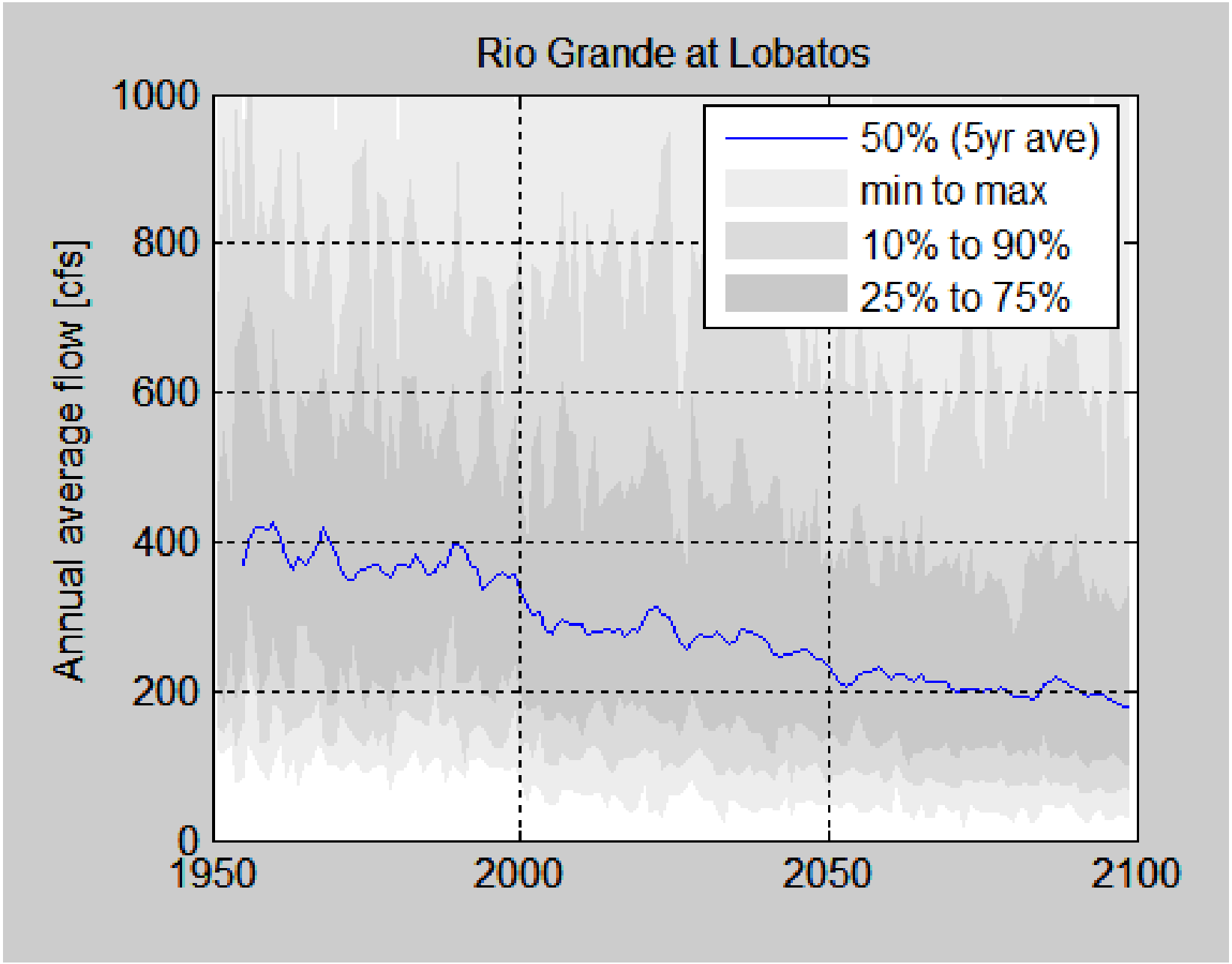
17 river reaches

- 12 Rio Grande
- 4 Rio Chama
- 1 Jemez River

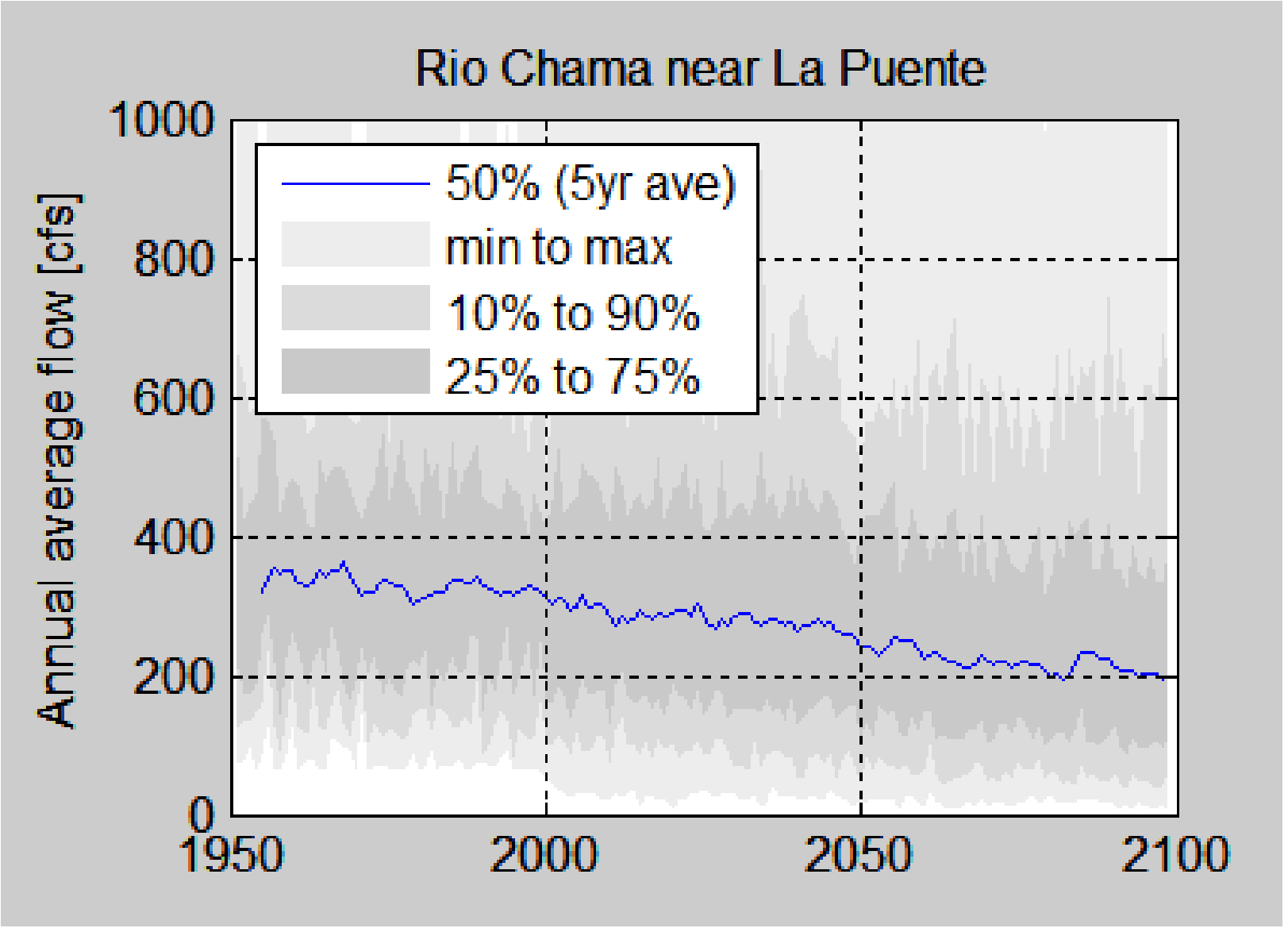
In addition to river reaches, there are 7 spatial mass balance units representing major reservoirs



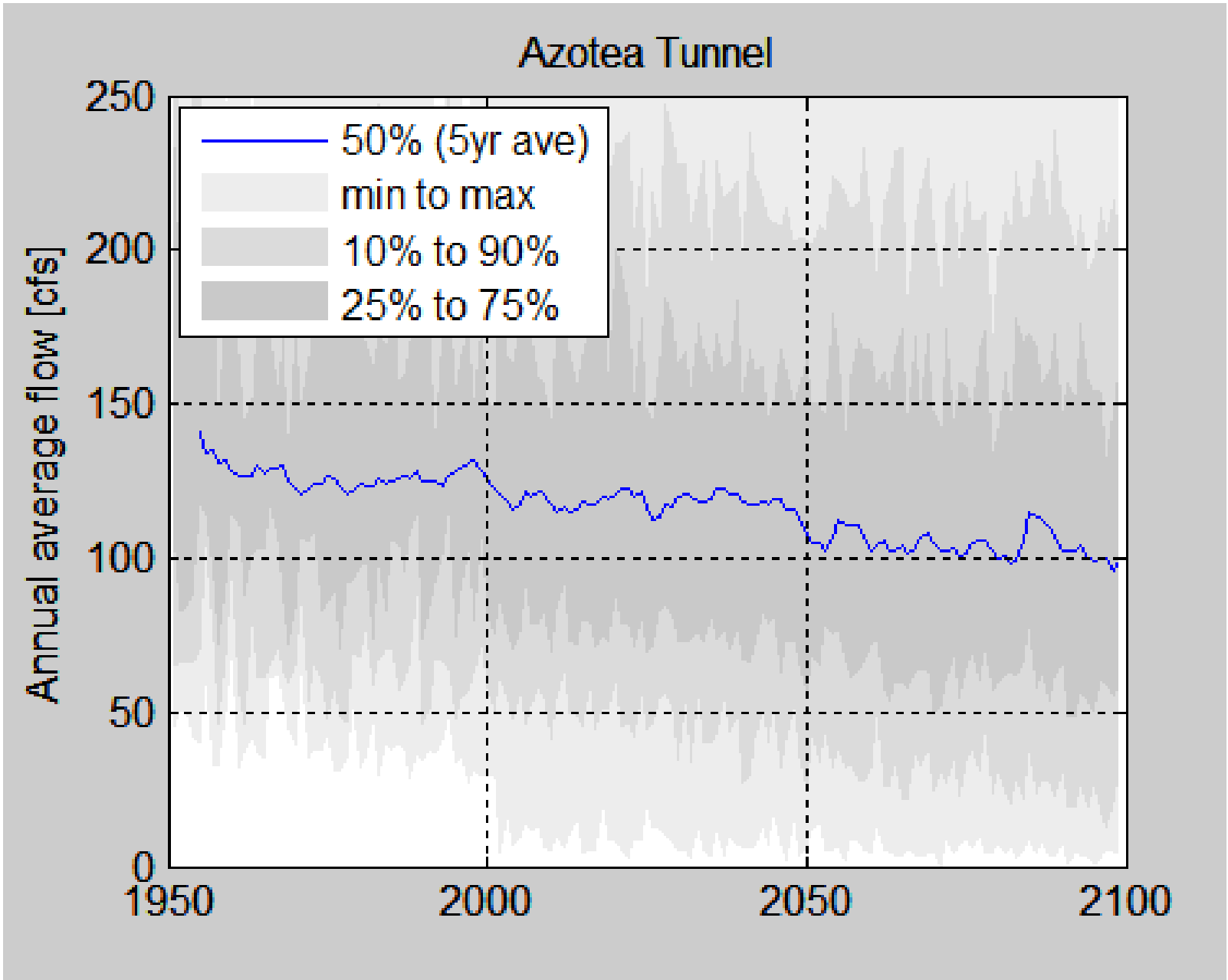
Rio Grande at Lobatos modeled



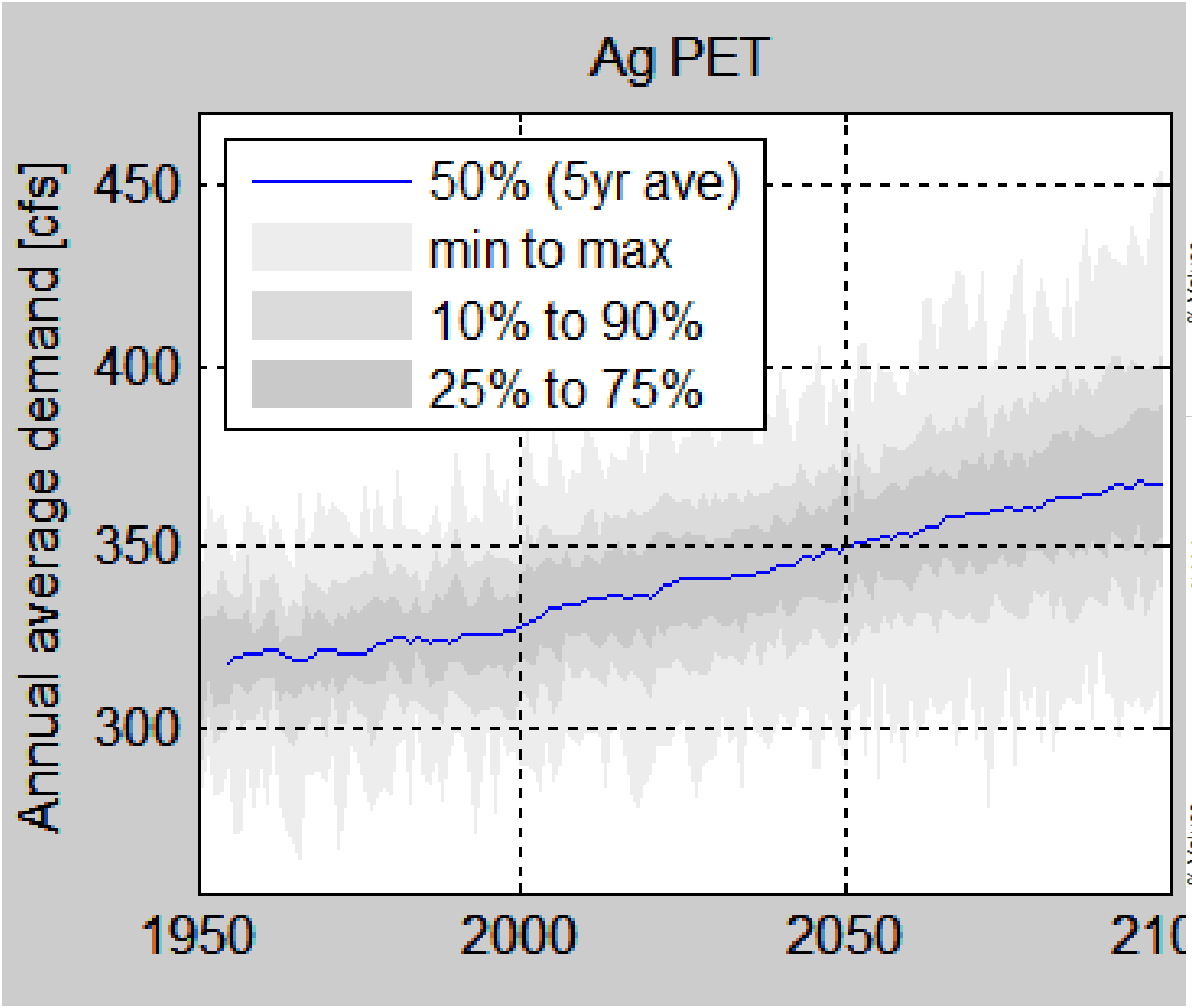
Rio Grande at La Puente VIC input

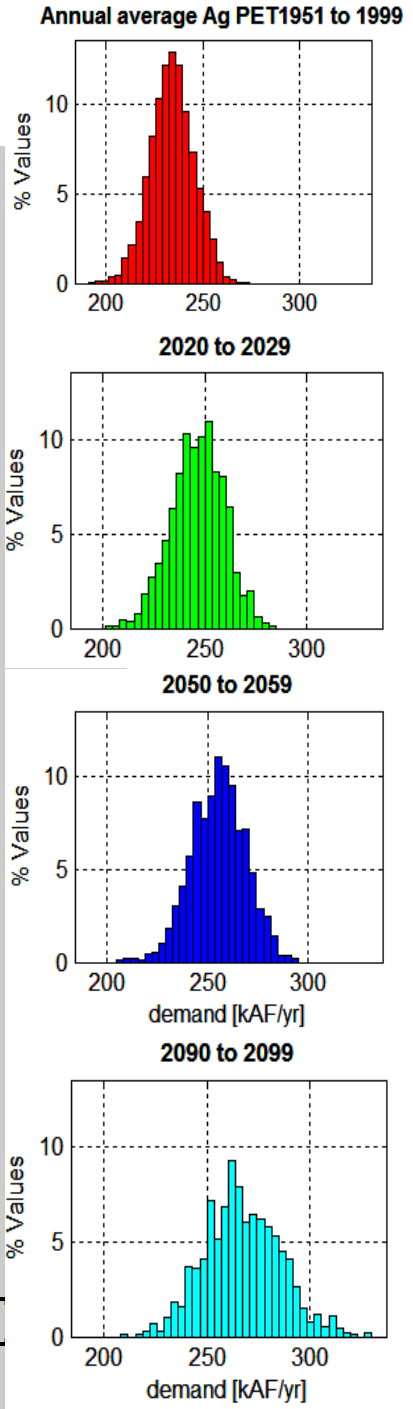


Azotea tunnel modeled

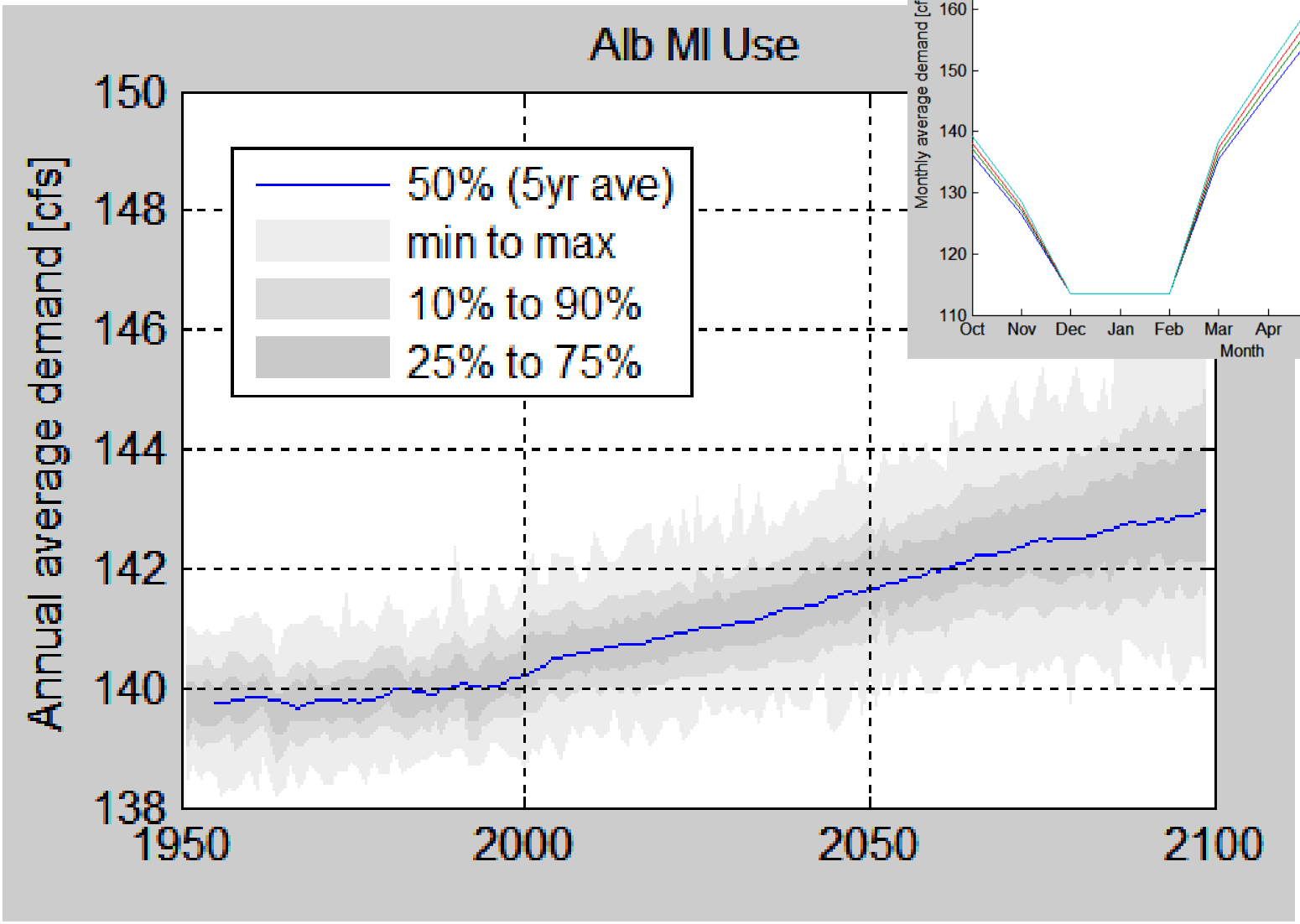


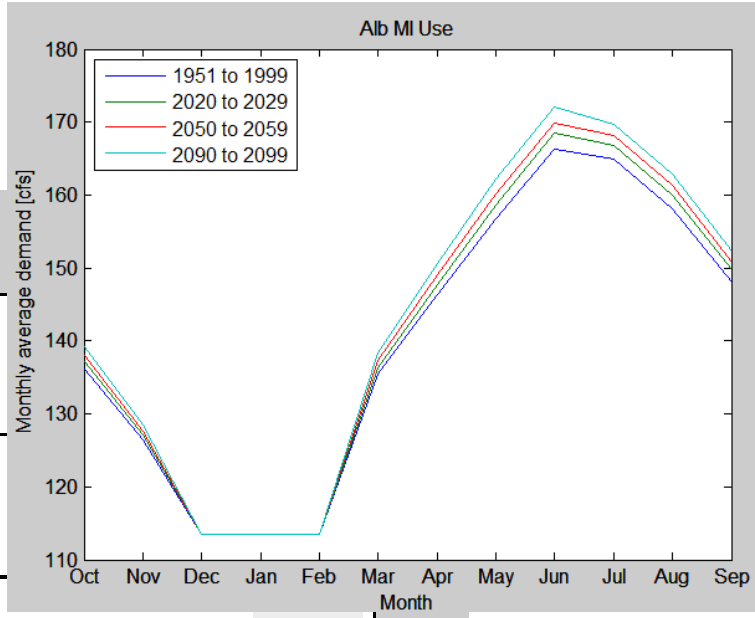
Ag Demands


Ag PET
Annual average demand [cfs]
450
400
350
300
1950
2000
2050
50% (5yr ave)
min to max
10% to 90%
25% to 75%

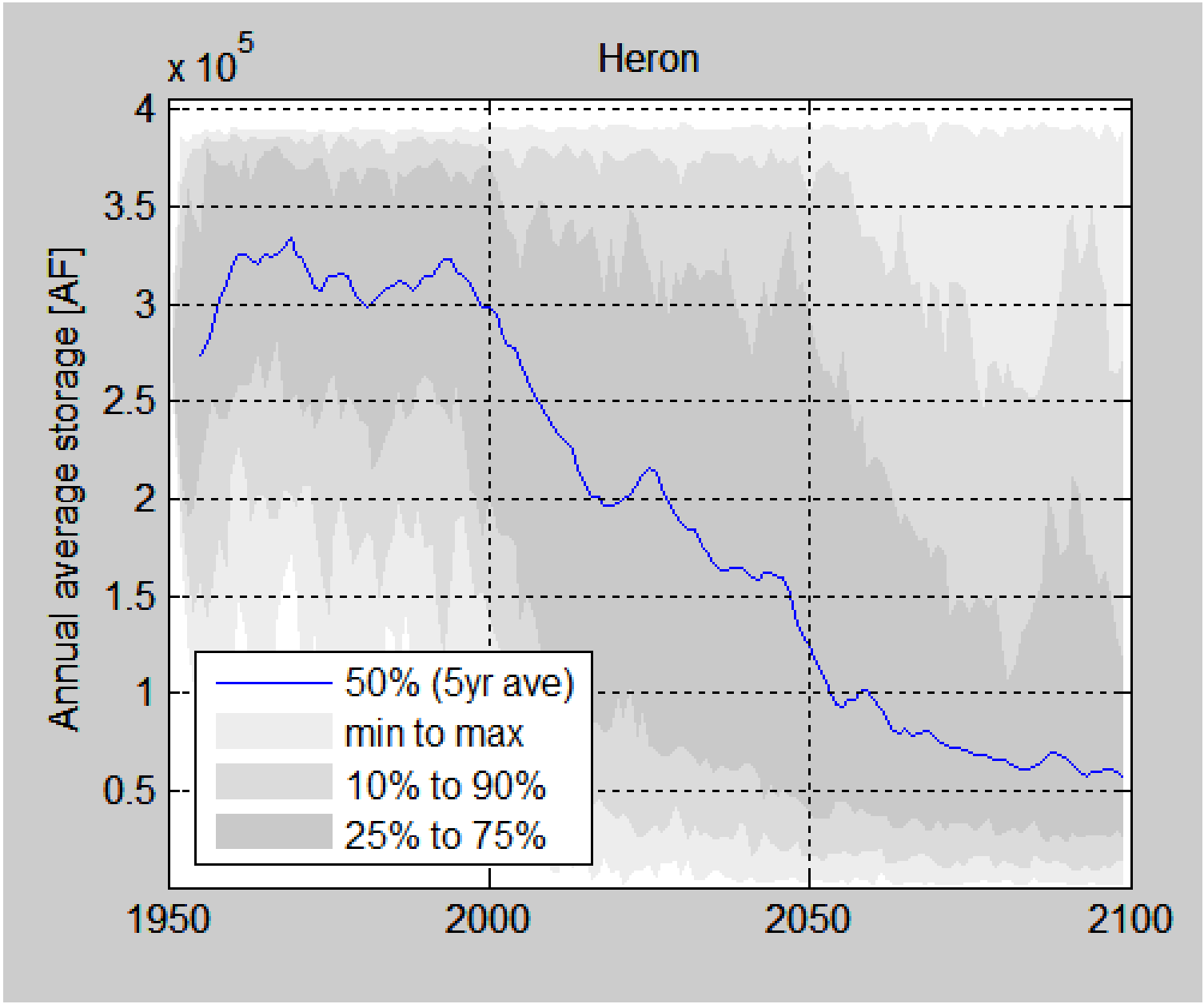

Annual average Ag PET1951 to 1999
2020 to 2029
2050 to 2059
2090 to 2099
% Values
demand [kAF/yr]
0
5
10
200
250
300

MI Demand

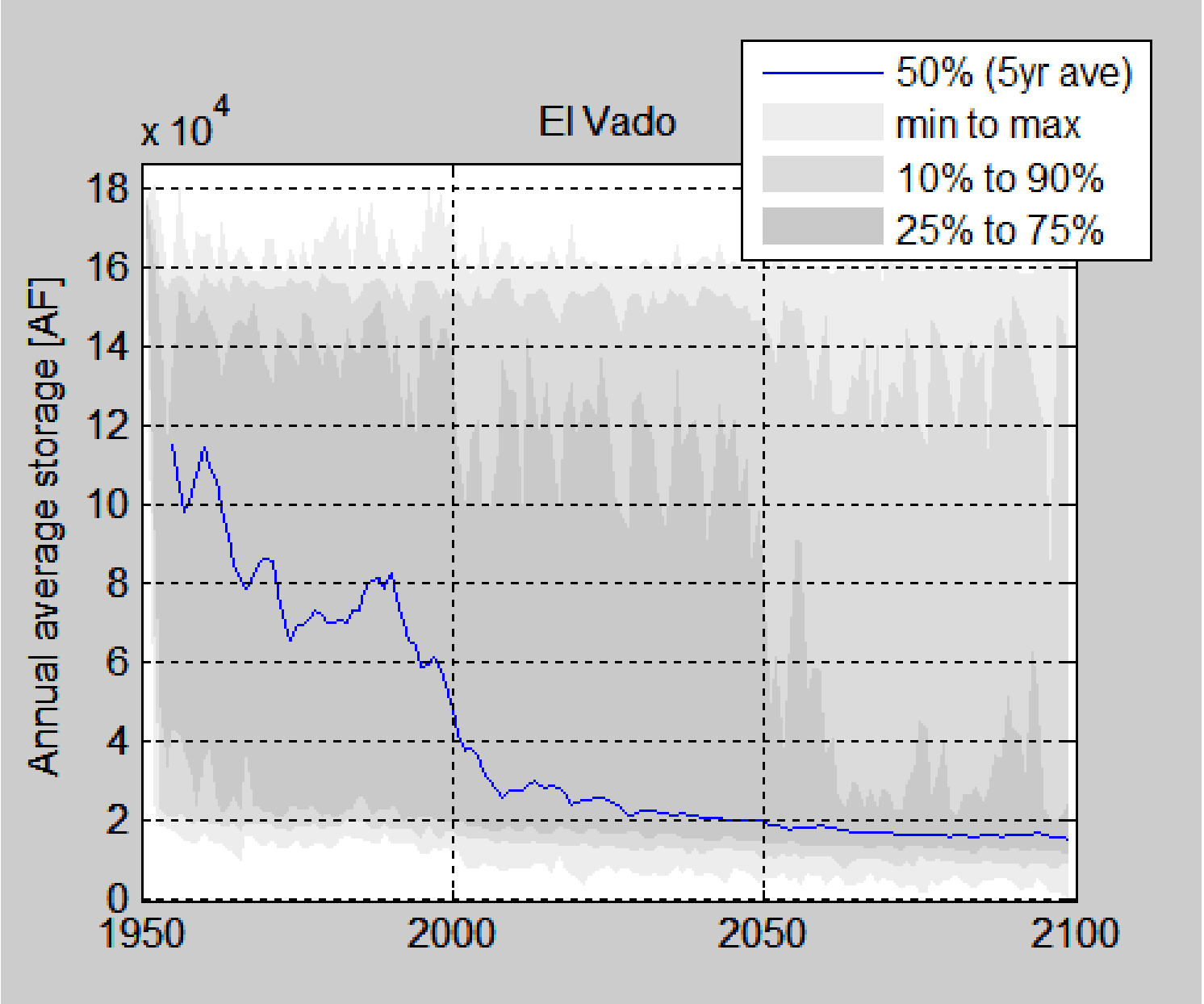

Alb MI Use
Annual average demand [cfs]
150
148
146
144
142
140
138
1950
2000
2050
2100
50% (5yr ave)
min to max
10% to 90%
25% to 75%


Alb MI Use
Monthly average demand [cfs]
180
170
160
150
140
130
120
110
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Month
1951 to 1999
2020 to 2029
2050 to 2059
2090 to 2099

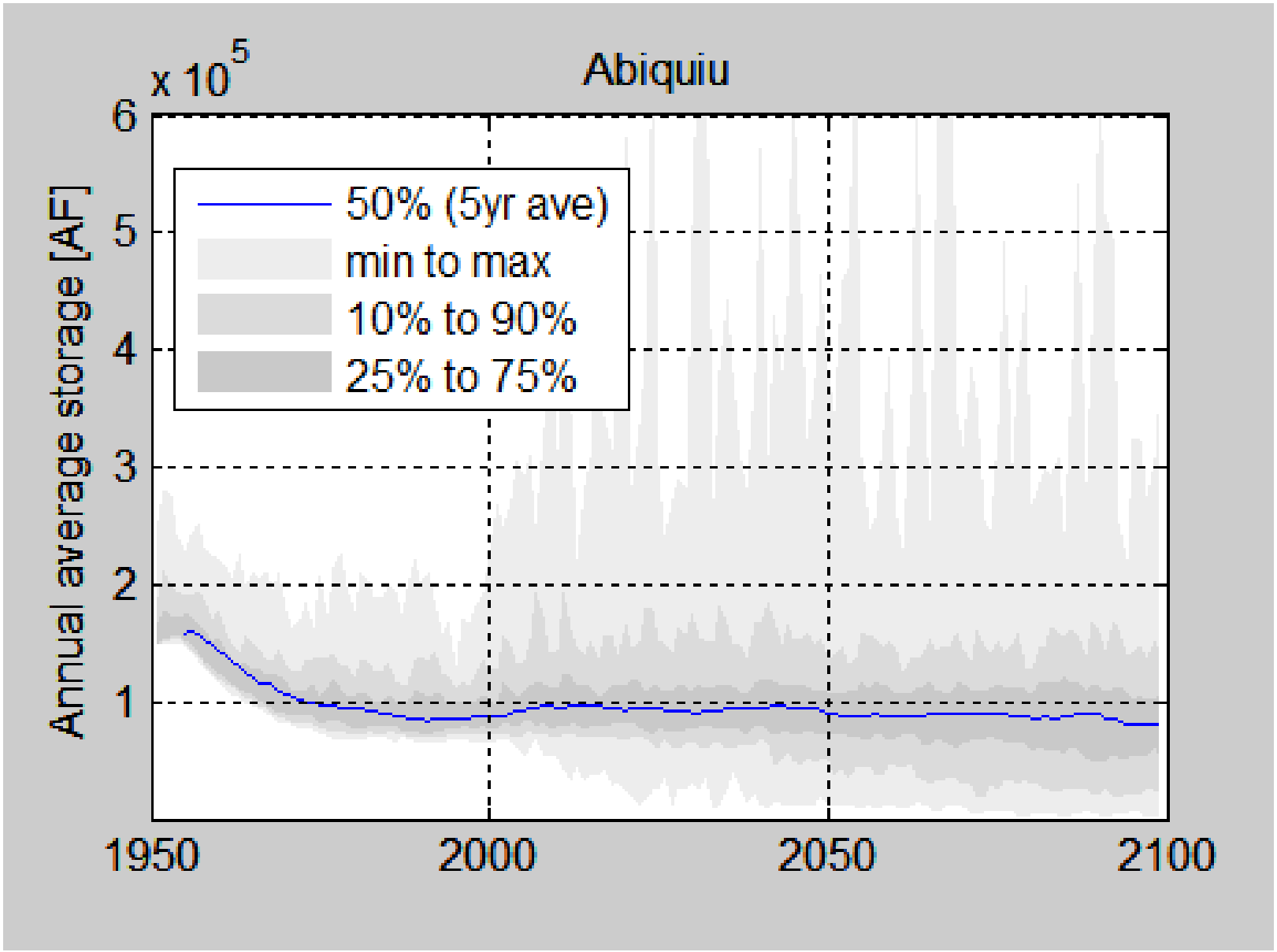
System response: Heron



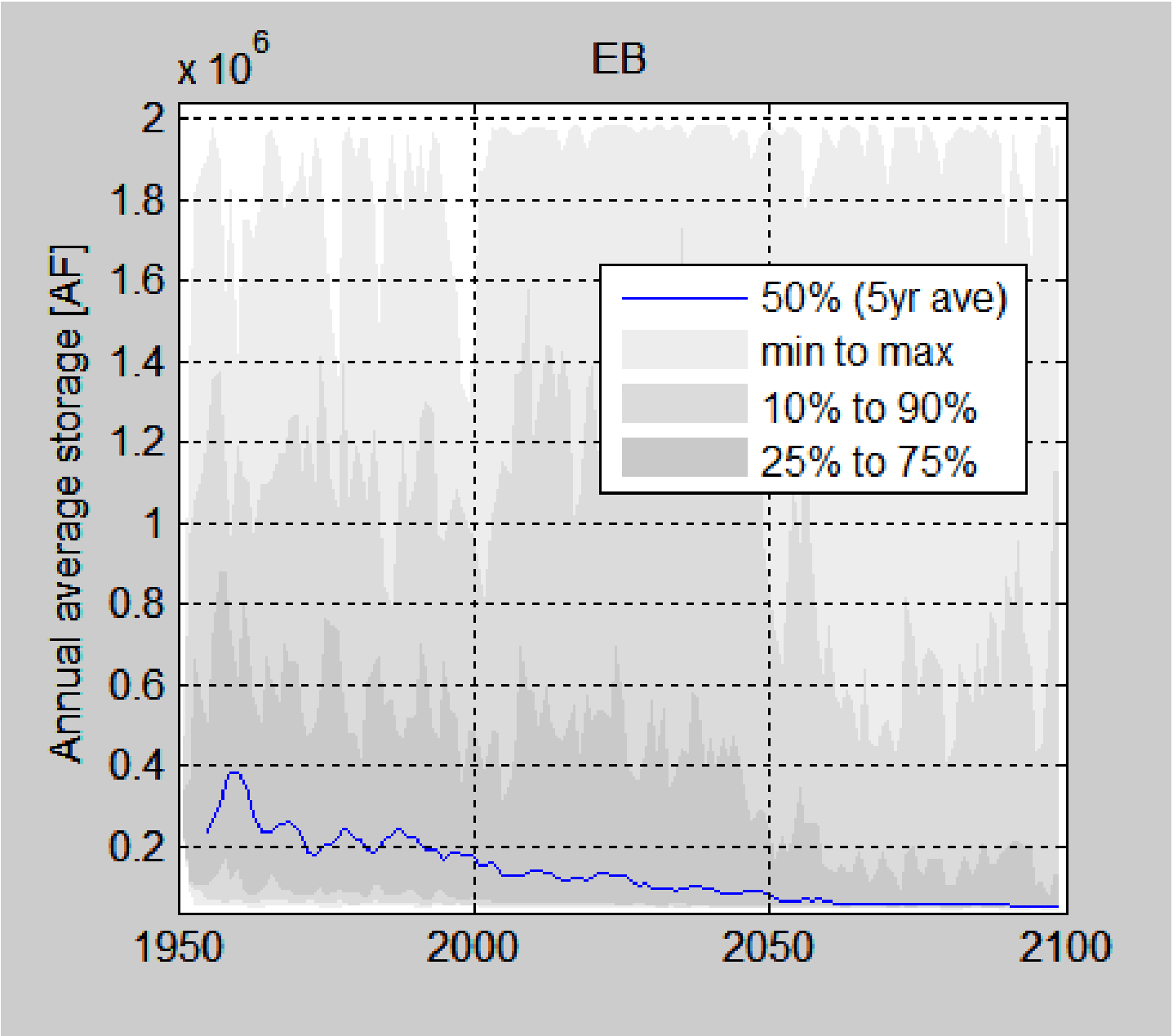
System response: El Vado



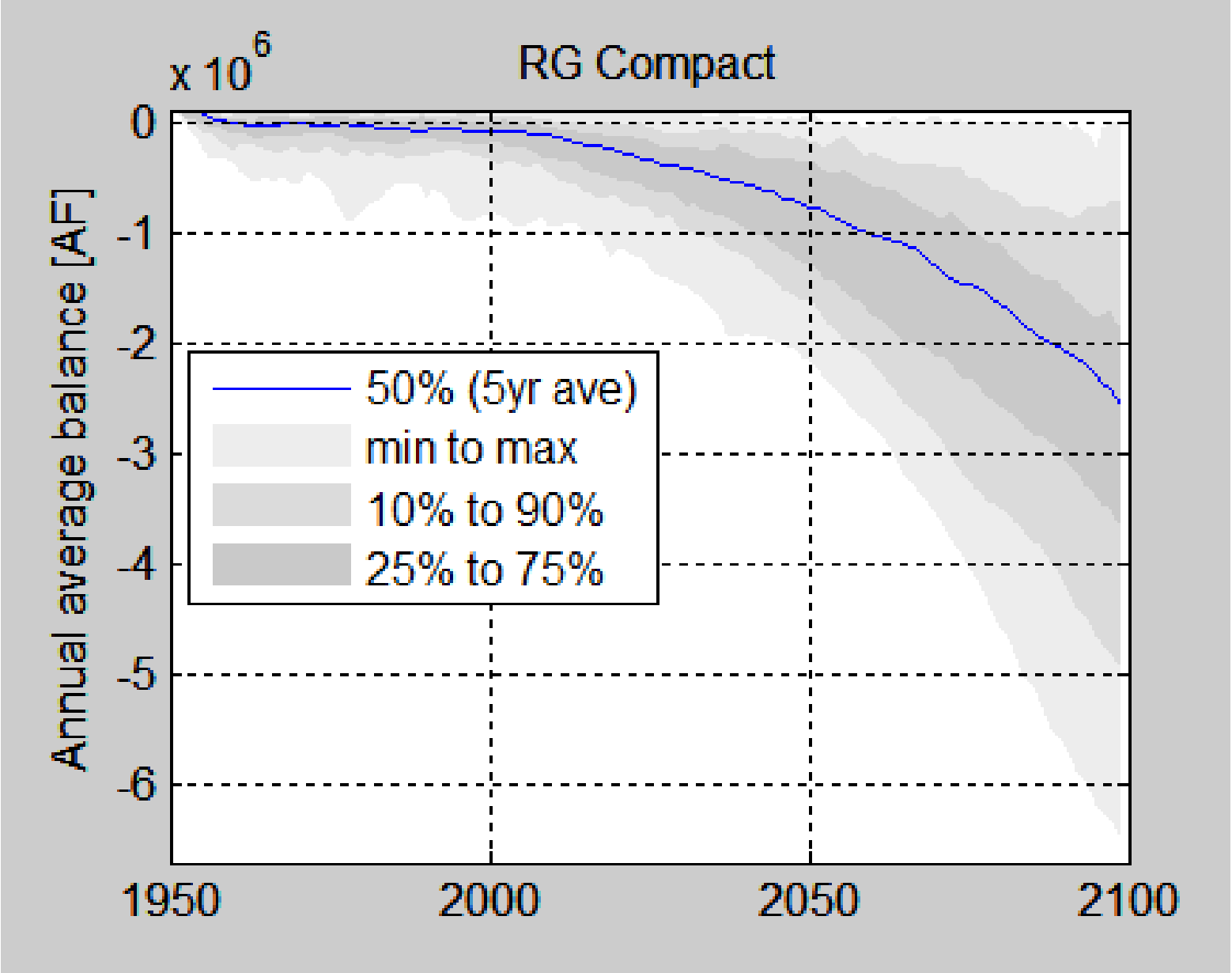
System response: Abiquiu



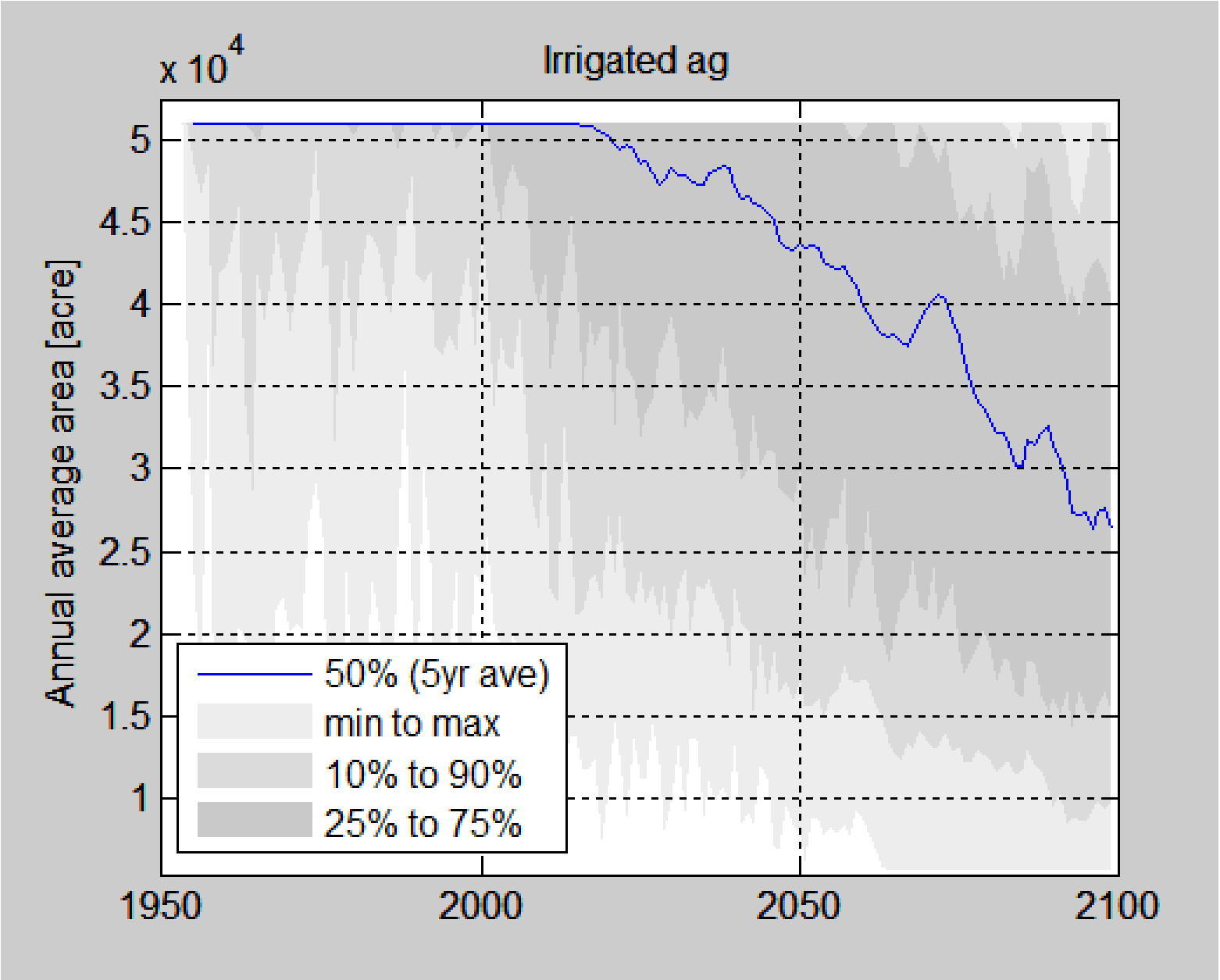
System response: Elephant Butte



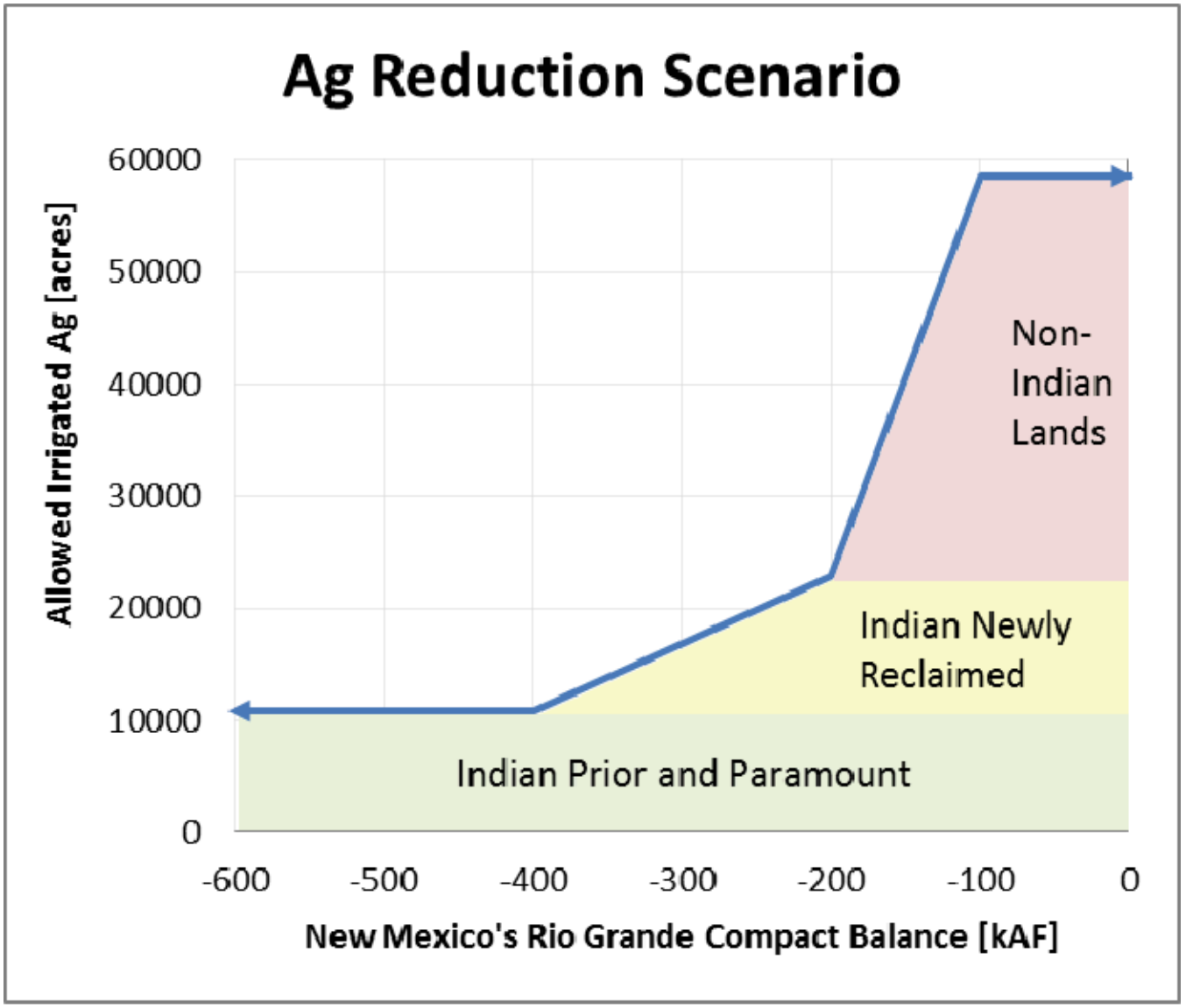
System response: RG Compact

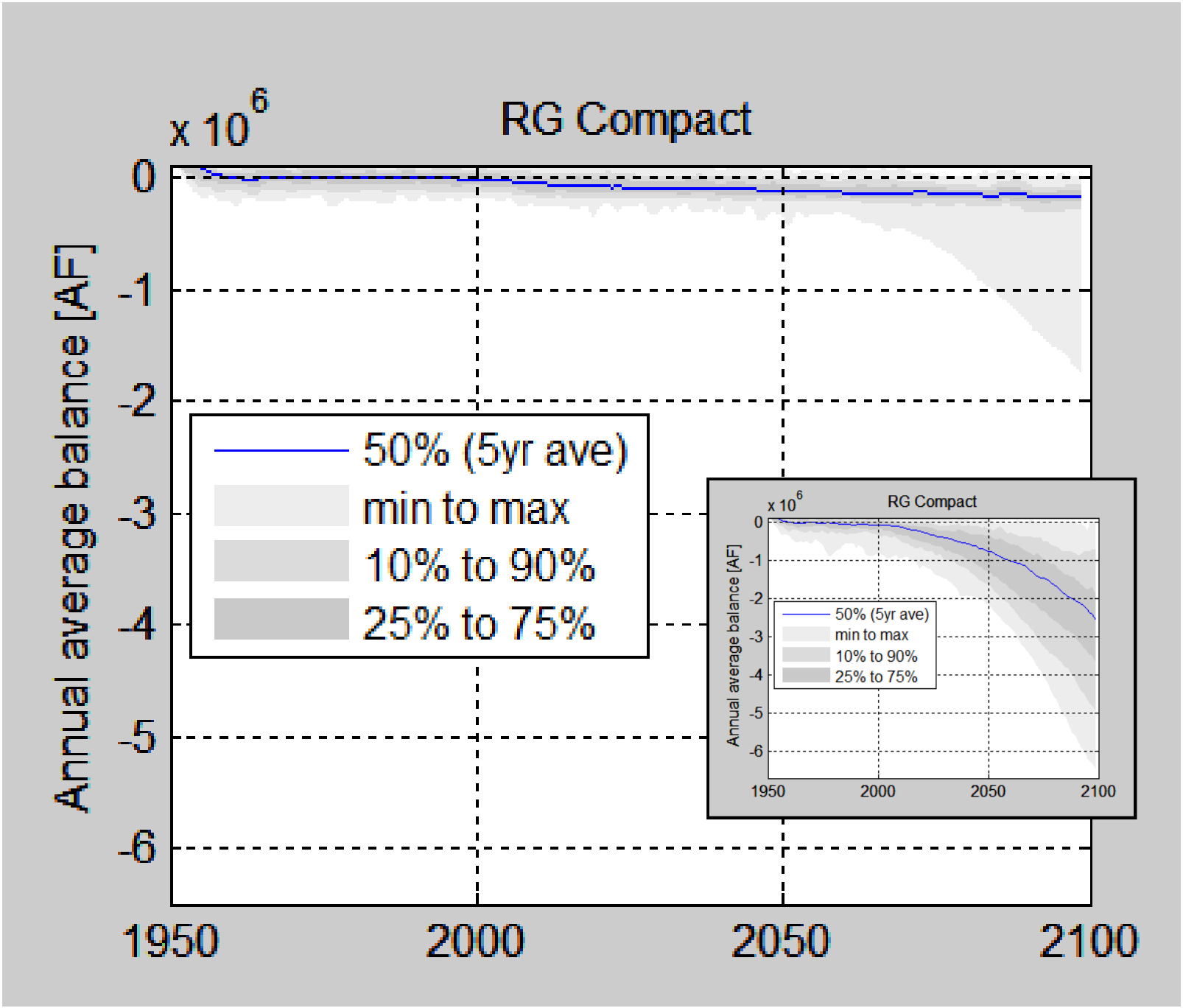


Ag reductions as a possible strategy:

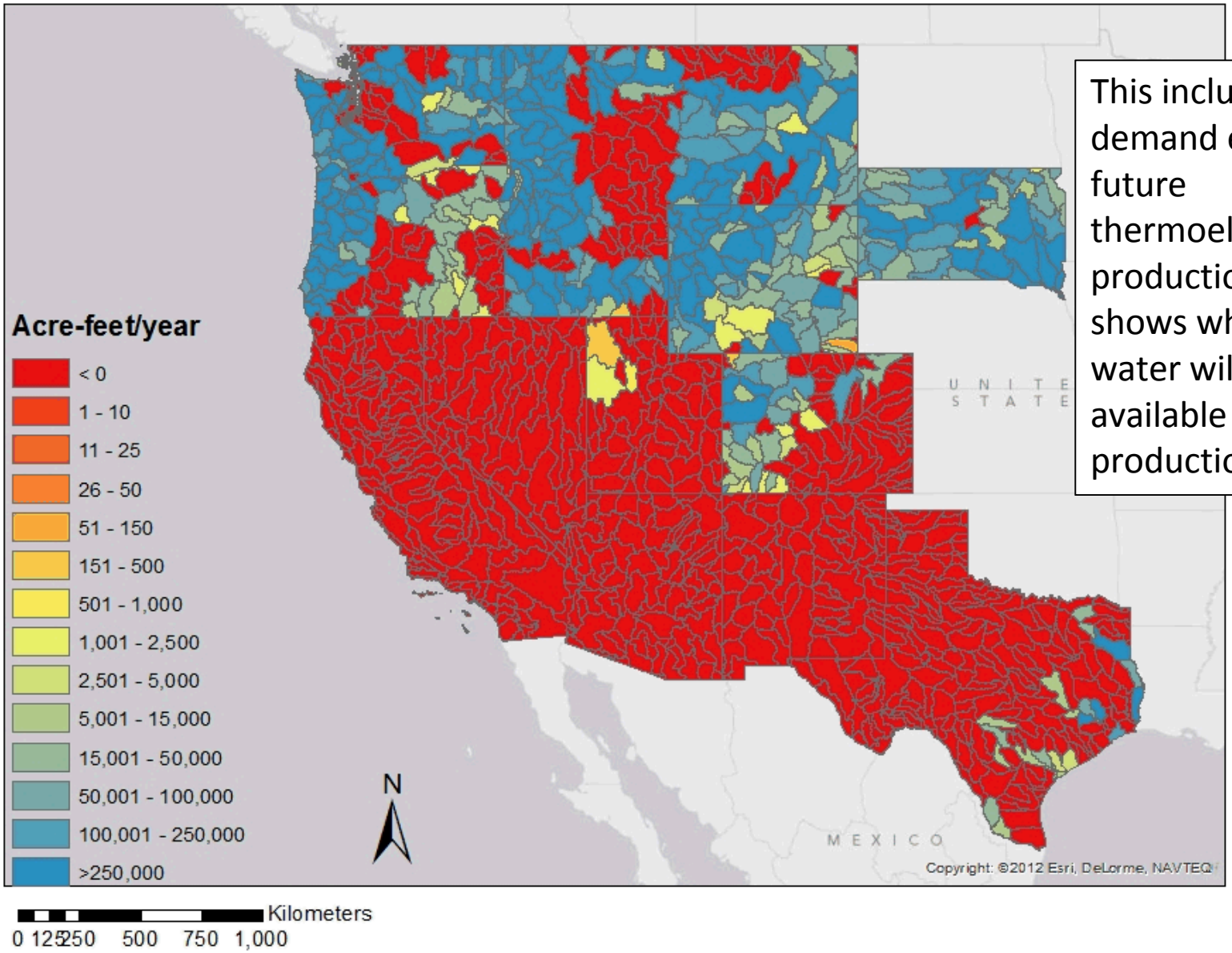


Ag reduction scenario:



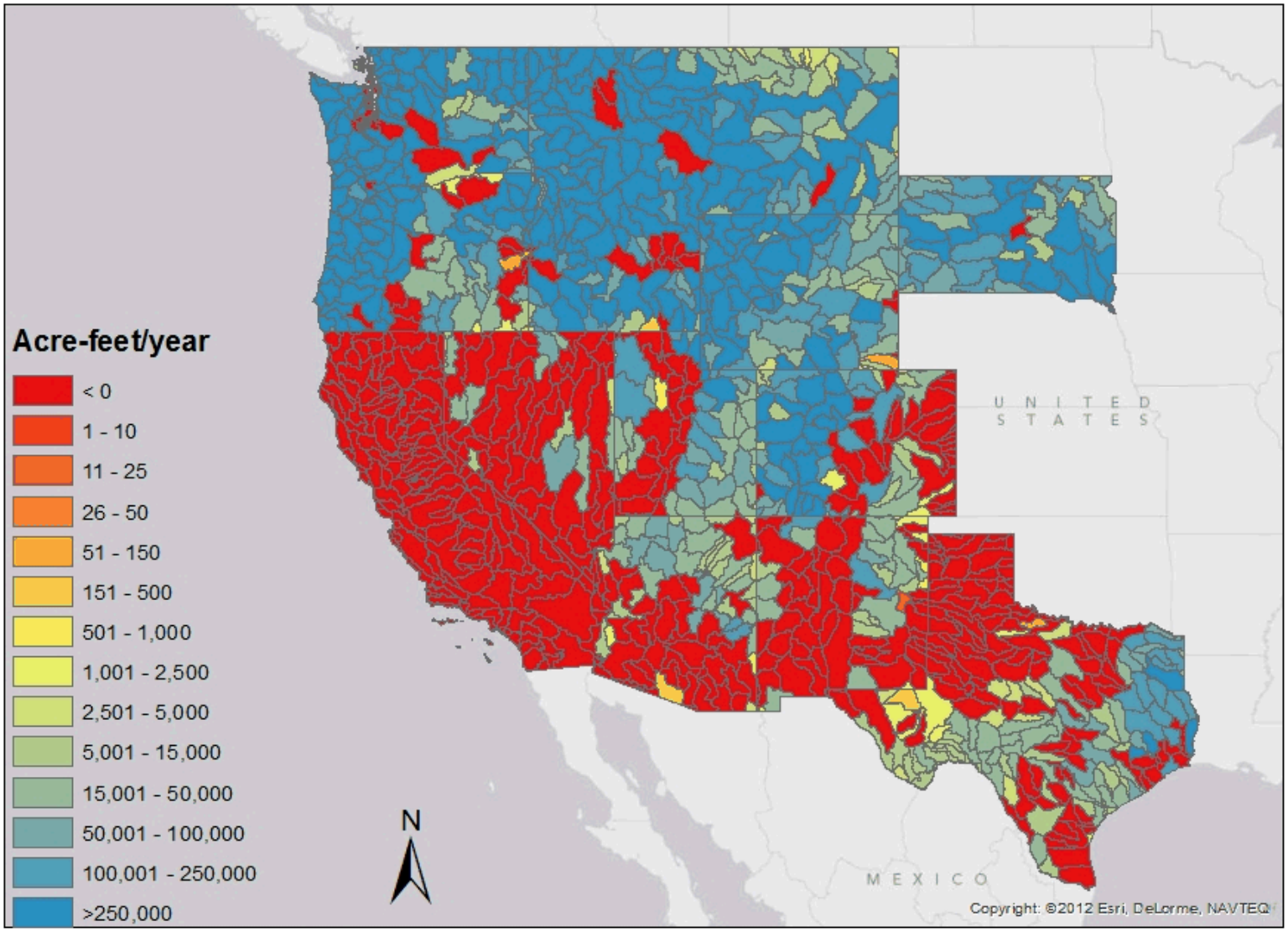

RG Compact
x 10^6
Annual average balance [AF]
0
-1
-2
-3
-4
-5
-6
1950
2000
2050
2100
50% (5yr ave)
min to max
10% to 90%
25% to 75%
RG Compact
x 10^6
Annual average balance [AF]
0
-1
-2
-3
-4
-5
-6
1950
2000
2050
2100
50% (5yr ave)
min to max
10% to 90%
25% to 75%

Unappropriated Surface Water - Demand, 2030

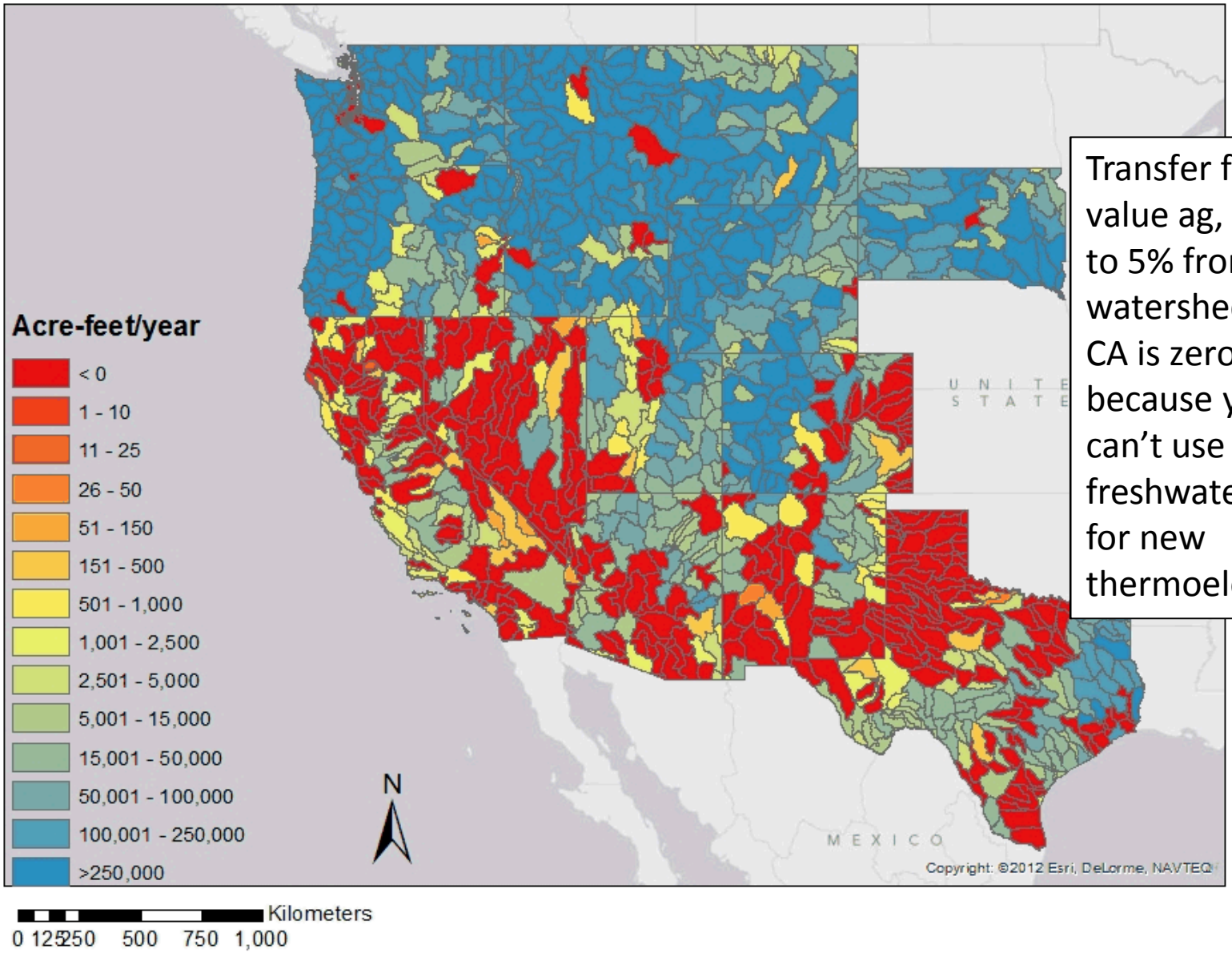


This includes all demand except future thermoelectric production. This shows where water will be available for that production.

Unappropriated Surface Water + Potable Groundwater - Demand, 2030

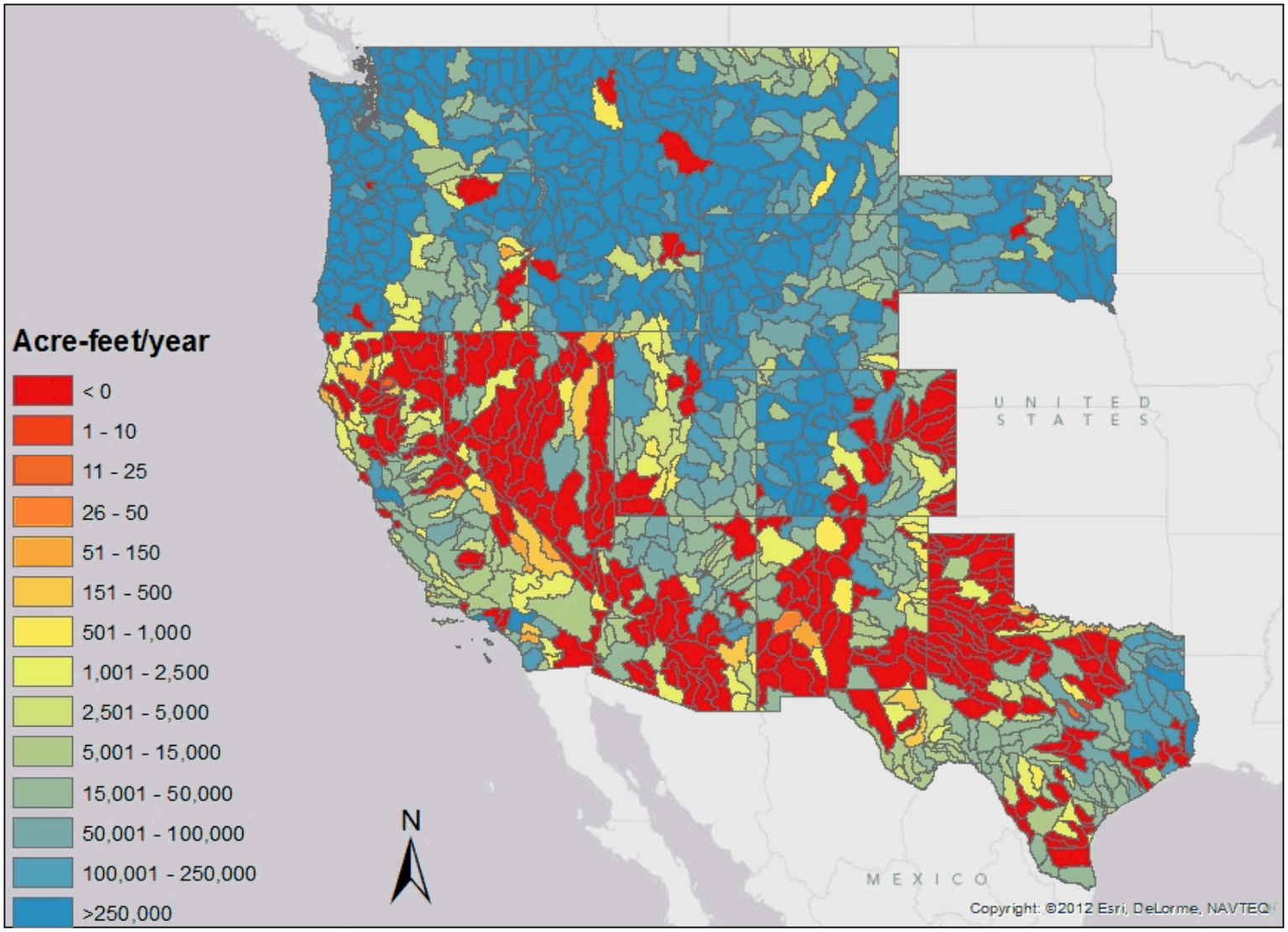


Unappropriated Surface Water + Potable Groundwater + Appropriated Water - Demand, 2030

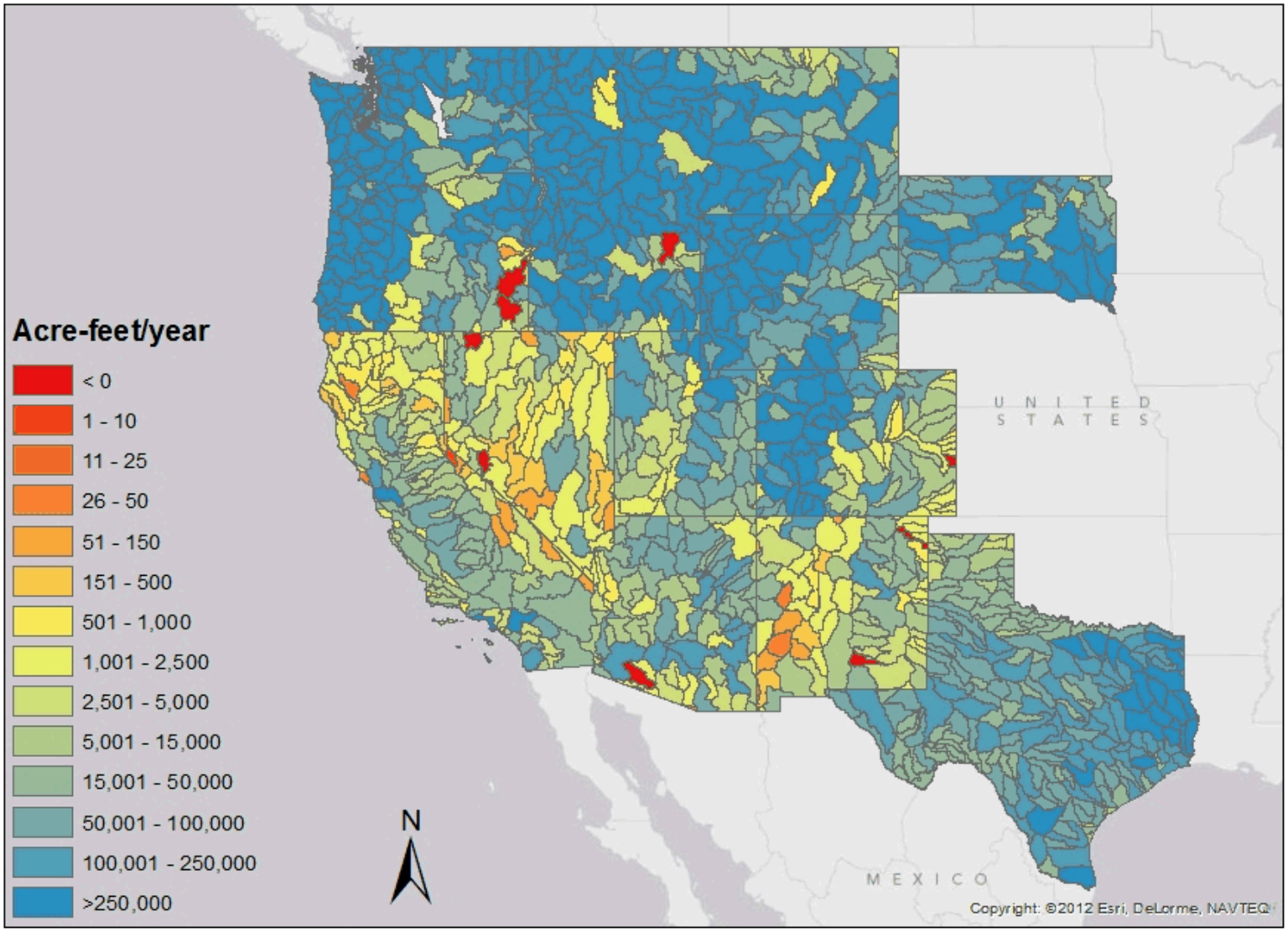


Transfer from low value ag, limited to 5% from each watershed, and CA is zeroed out because you can't use freshwater there for new thermoelectric

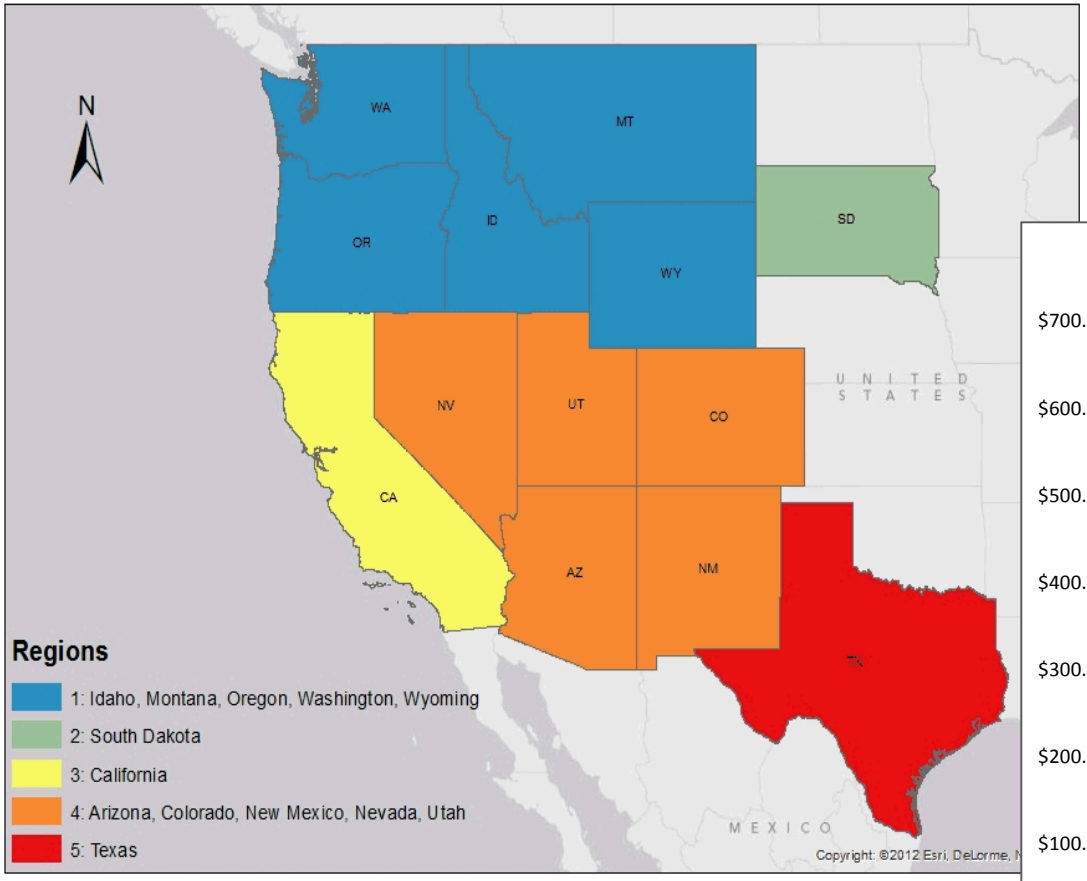
Unappropriated Surface Water + Potable Groundwater + Appropriated Water + Wastewater - Demand, 2030

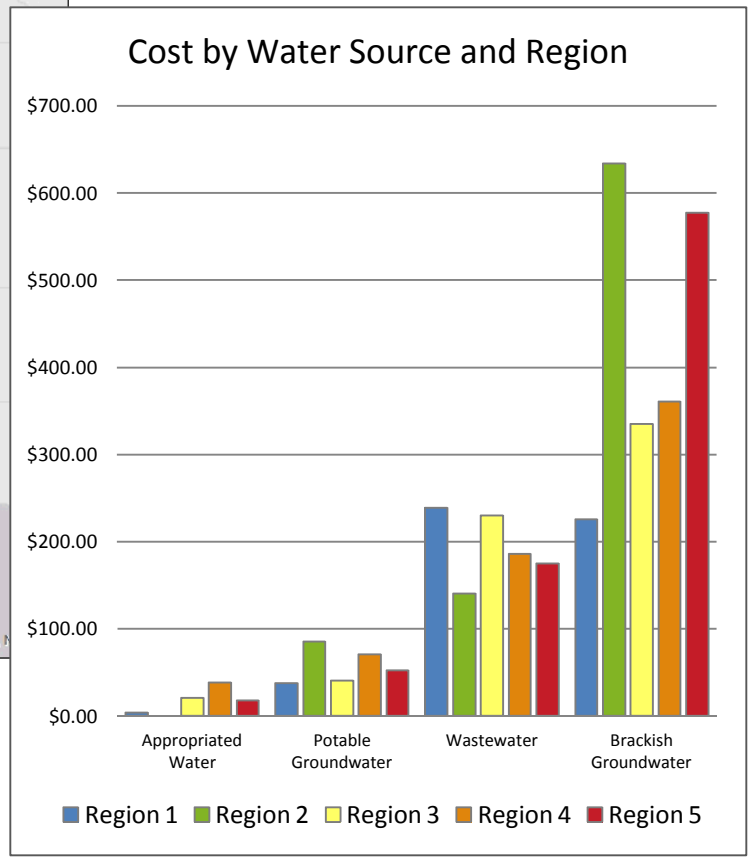


Unappropriated + Appropriated Water + Potable Groundwater + Wastewater + Brackish Groundwater - Demand, 2030



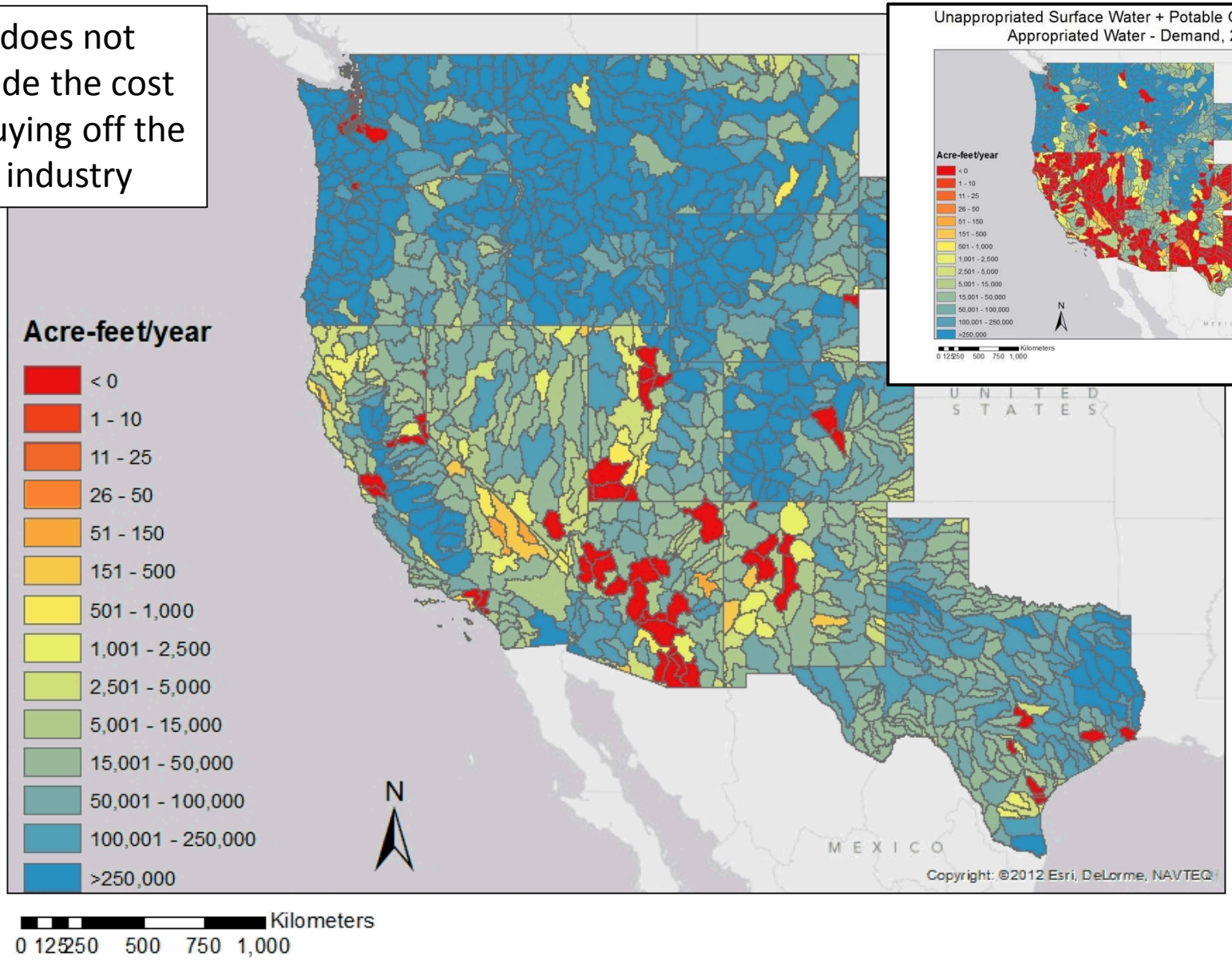
Regional Water Costs



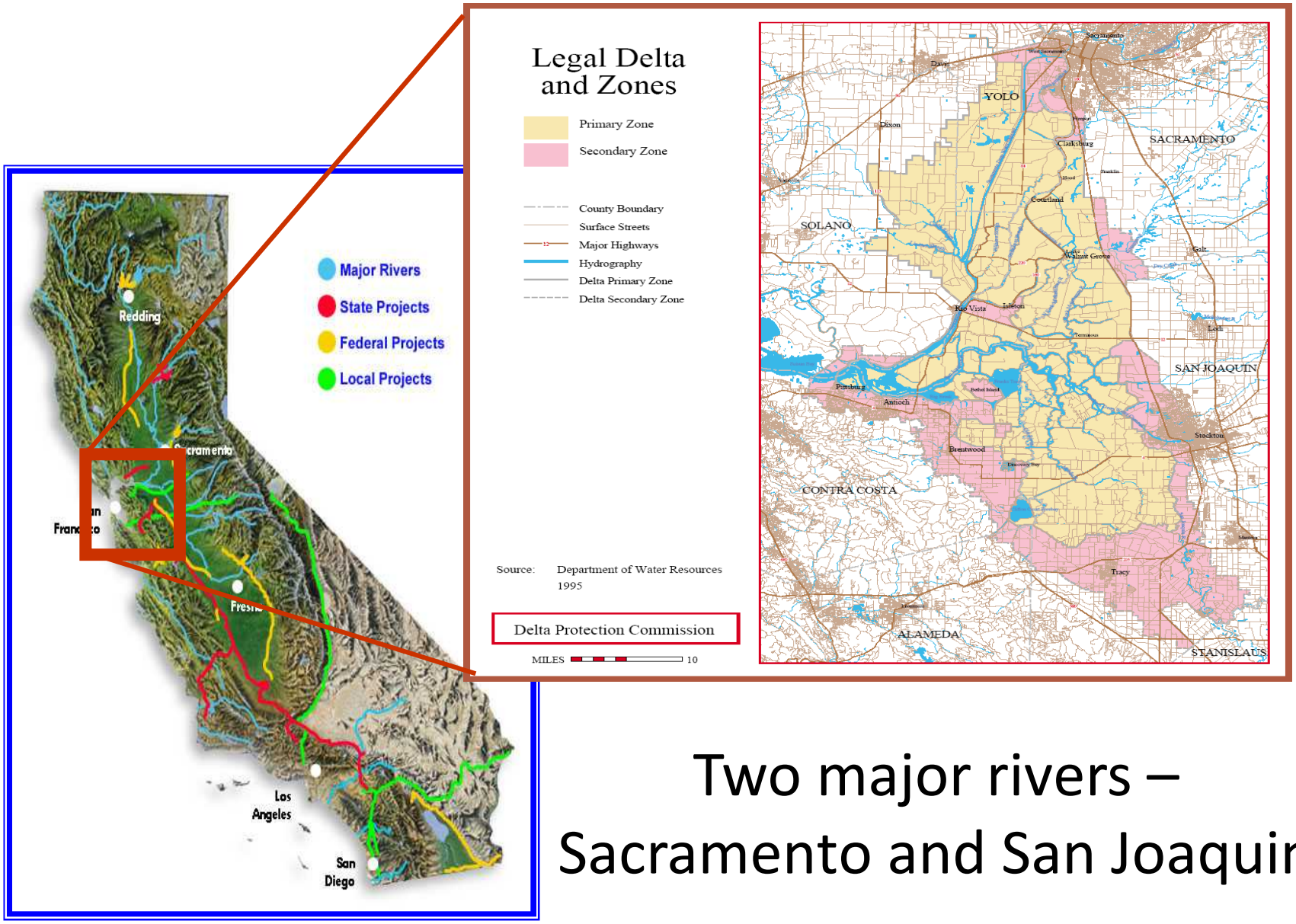


Unappropriated + Appropriated Water + Potable Groundwater + 50% Irrigated Agriculture - Demand, 2030

This does not include the cost of buying off the beef industry



Part 1: The California Delta - USA

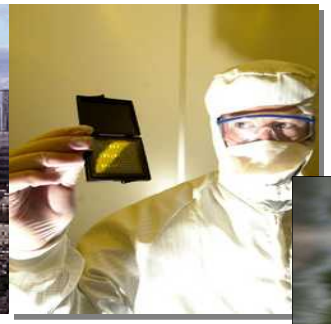


Two major rivers – Sacramento and San Joaquin

Importance of the California Delta

- 2/3 of California (~25 million residents) rely on some Delta water
- Irrigates ~45% of the fruits & vegetables produced in US
- About 80% of California's commercial fishery species live in or migrate through the Bay-Delta
- Habitat for ~60 threatened and endangered species listed by the Endangered Species Act

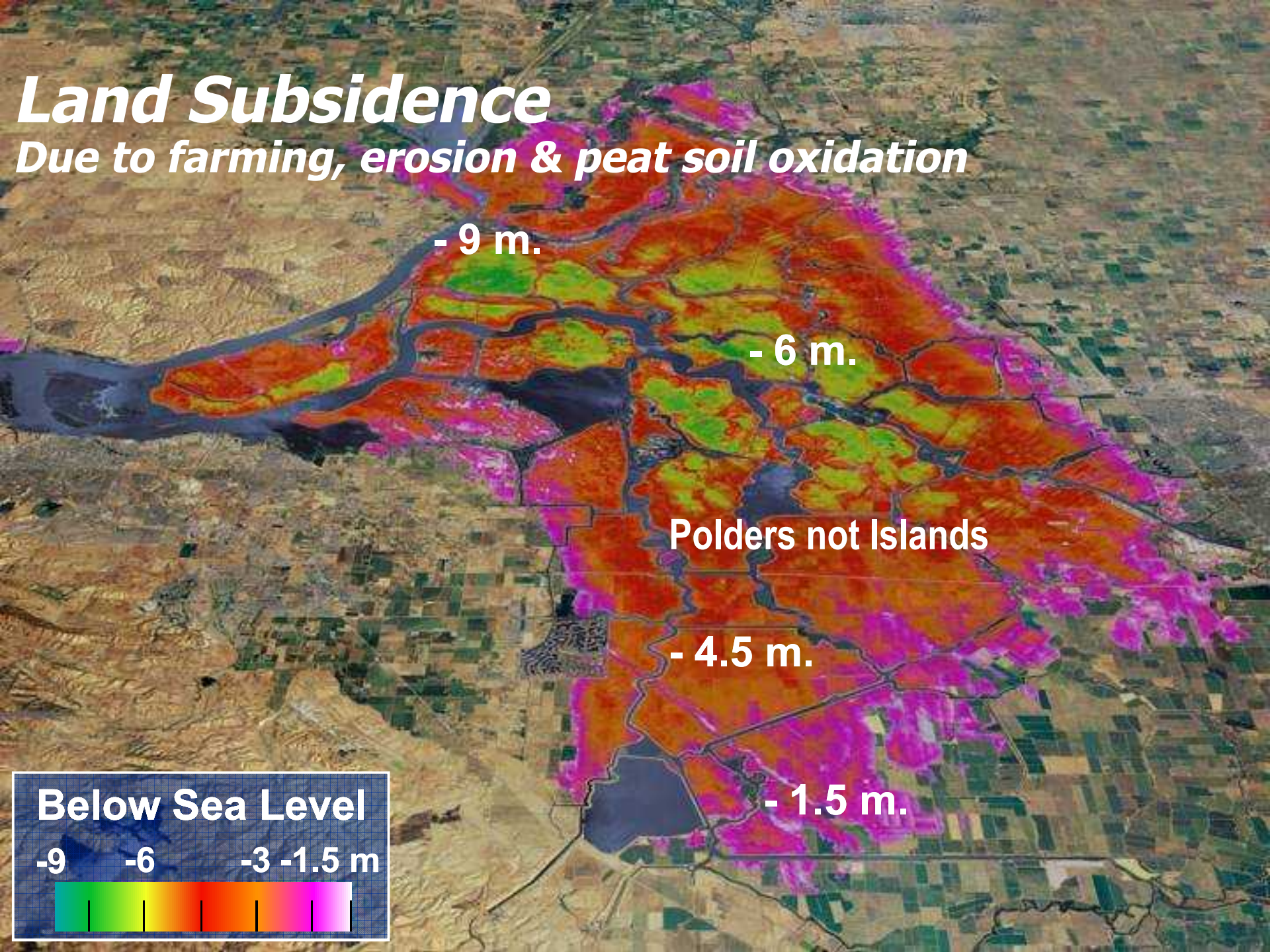




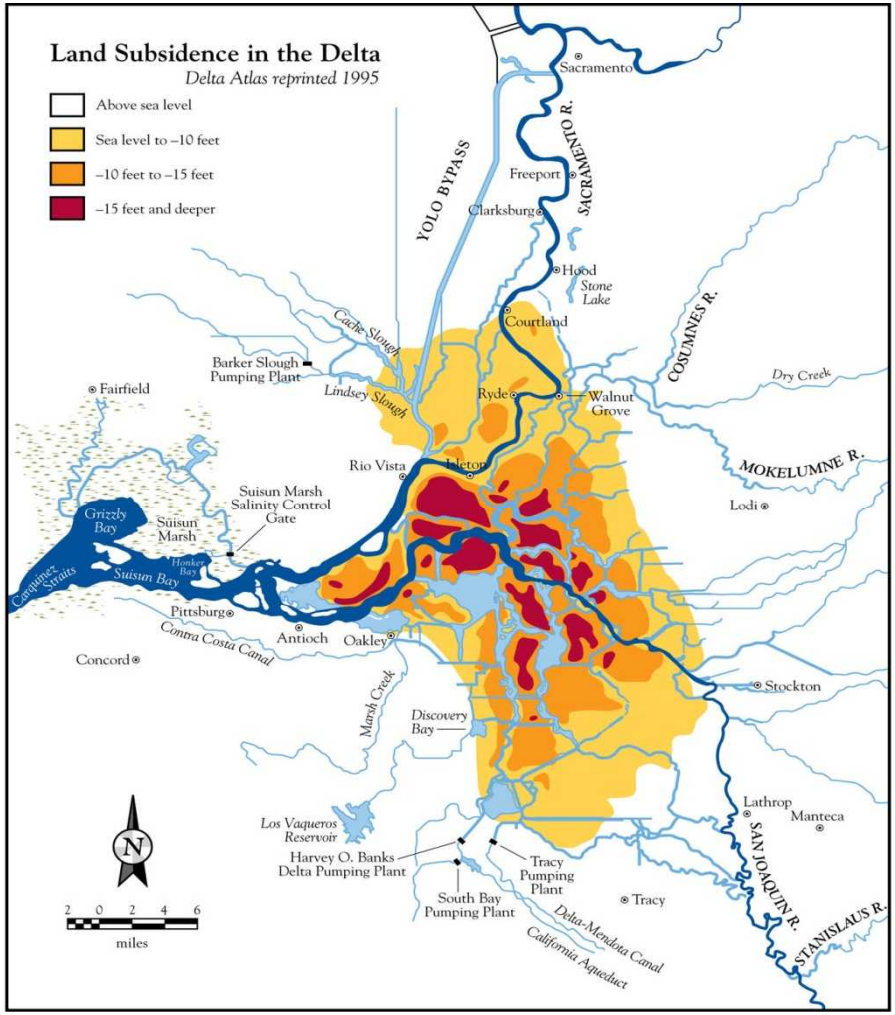
Importance of the Bay-Delta (too)

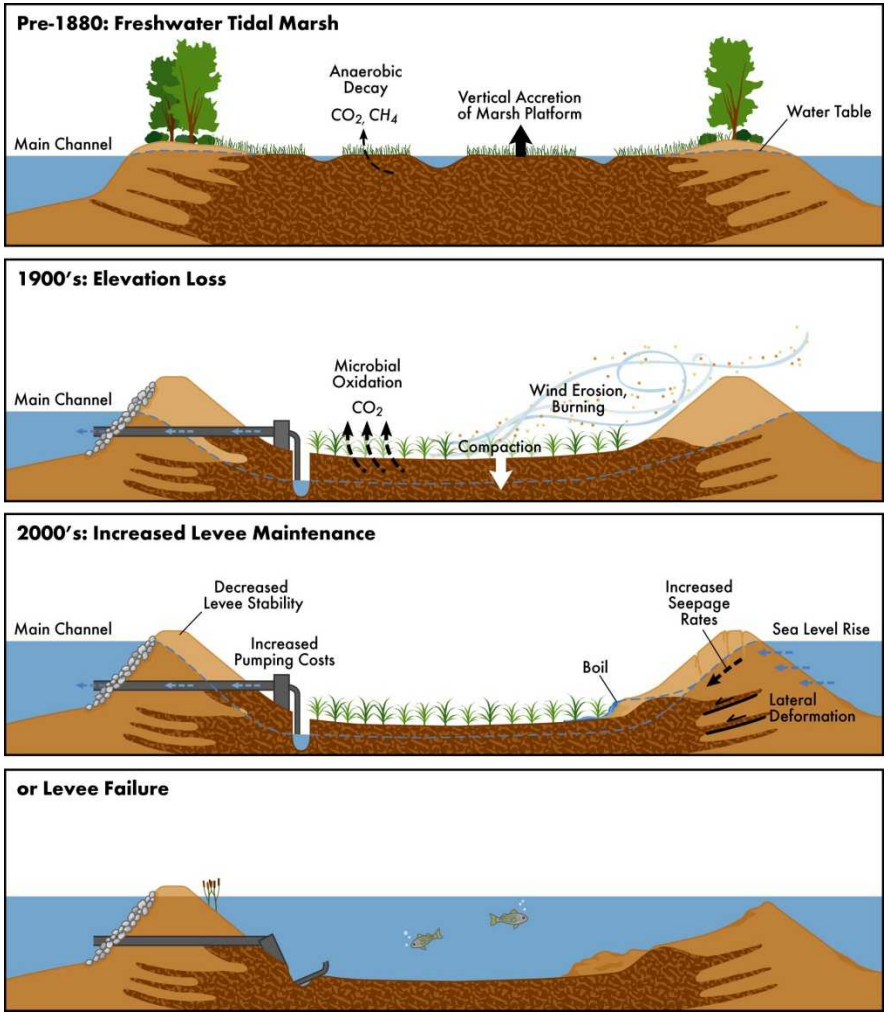
- More than 500,000 people live in the legal Delta
- Portions of five counties and 12 cities
- Agriculture - Average Annual Gross Value totals more than $2 billion in the Delta
- More than 12 million visitors annually



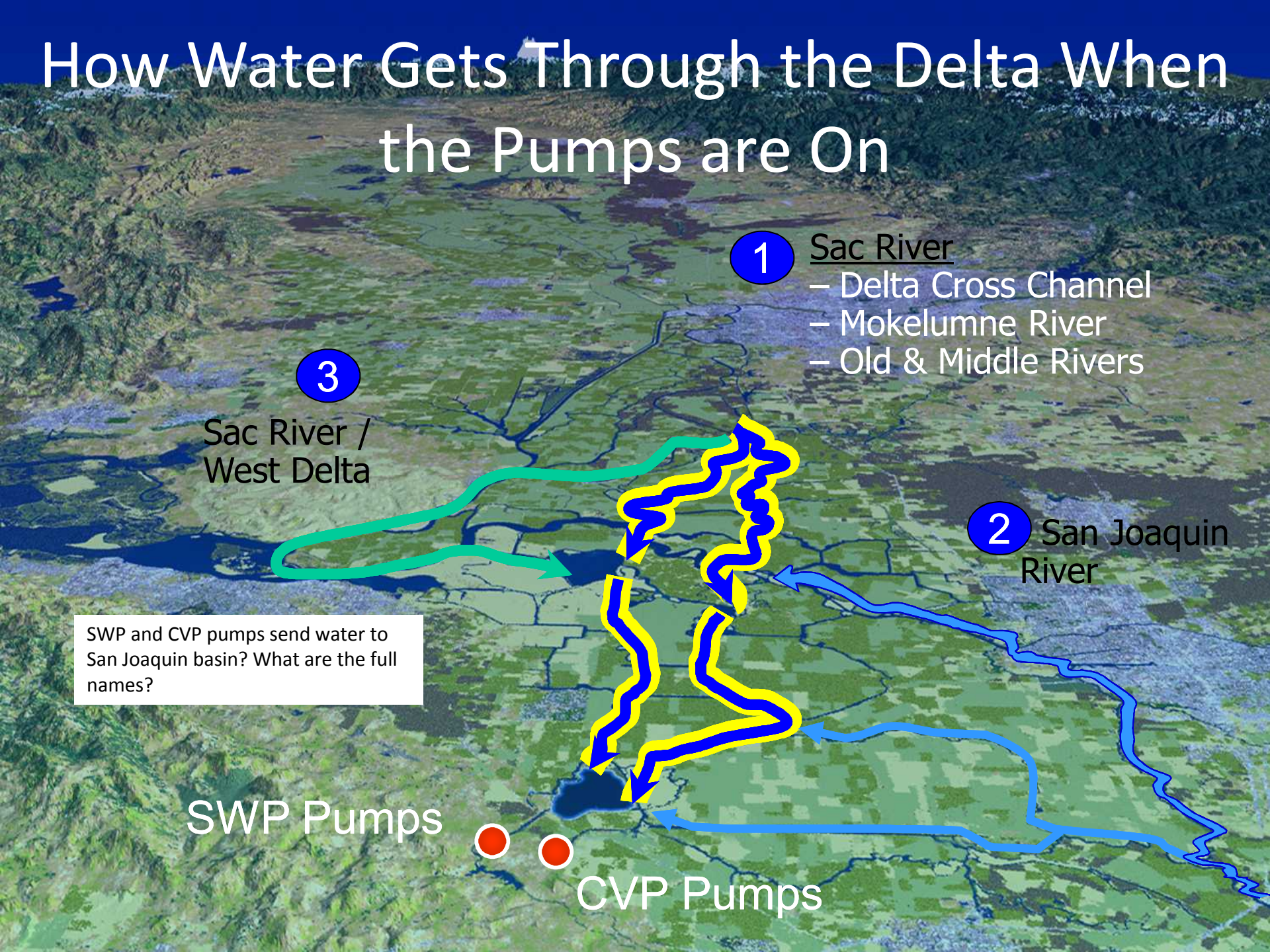

Land Subsidence
Due to farming, erosion & peat soil oxidation
- 9 m.
- 6 m.
Polders not Islands
- 4.5 m.
- 1.5 m.
Below Sea Level
-9 -6 -3 -1.5 m

Subsidence: Past and Future





How Water Gets Through the Delta When the Pumps are On

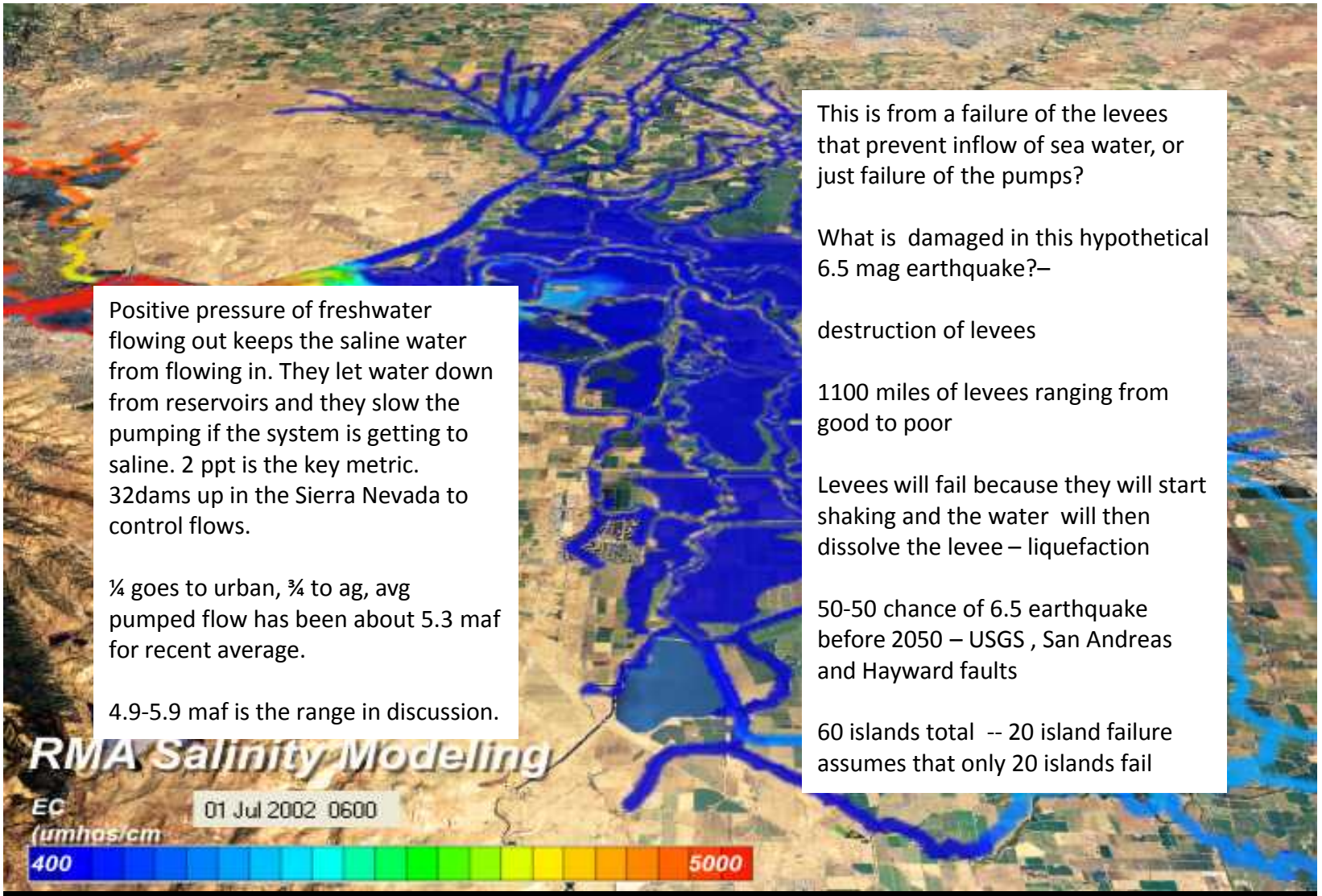


Pump operations

- How do pumps operate now?
  - They keep sea water out? – only in that they reduce
  - They move water from Delta into irrigation systems for the San Joaquin valley ag
  - Other uses?
- How much energy do they use? Is that energy use increasing over time? Is it expected to increase with further subsidence and with sea level rise?
- What does it cost?
- 19 % of energy use in CA is related to water. 7% is used to move it. 12% is for domestic, M&I treatment.

- 12000 cfs is total capacity of both pump locations

6.5 Magnitude Earthquake
causing 20-Island Failure



Positive pressure of freshwater flowing out keeps the saline water from flowing in. They let water down from reservoirs and they slow the pumping if the system is getting to saline. 2 ppt is the key metric. 32dams up in the Sierra Nevada to control flows.

¼ goes to urban, ¾ to ag, avg pumped flow has been about 5.3 maf for recent average.

4.9-5.9 maf is the range in discussion.

This is from a failure of the levees that prevent inflow of sea water, or just failure of the pumps?

What is damaged in this hypothetical 6.5 mag earthquake?–

destruction of levees

1100 miles of levees ranging from good to poor

Levees will fail because they will start shaking and the water will then dissolve the levee – liquefaction

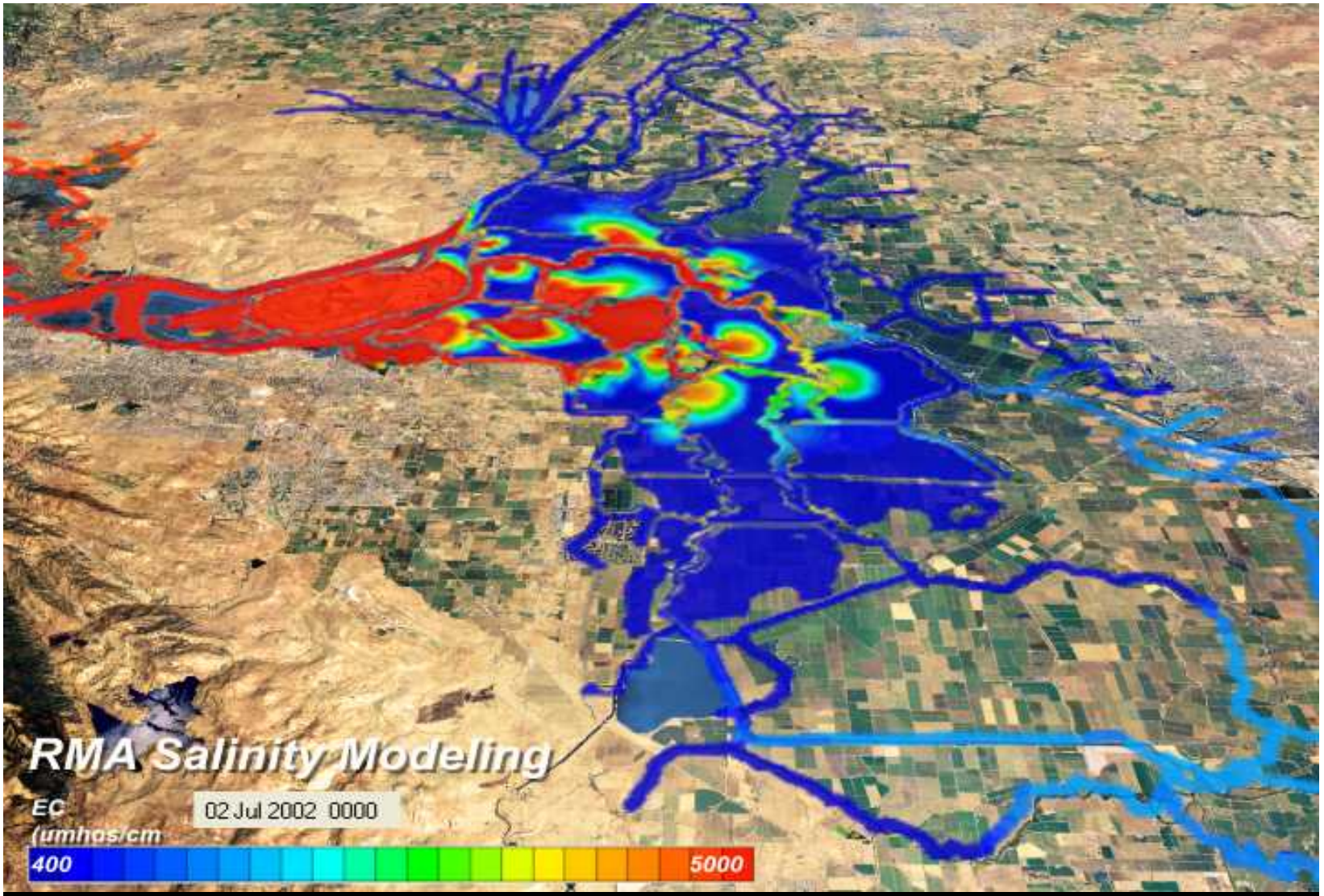
50-50 chance of 6.5 earthquake before 2050 – USGS , San Andreas and Hayward faults

60 islands total -- 20 island failure assumes that only 20 islands fail

0 – 6 hours: Islands flood with fresh water

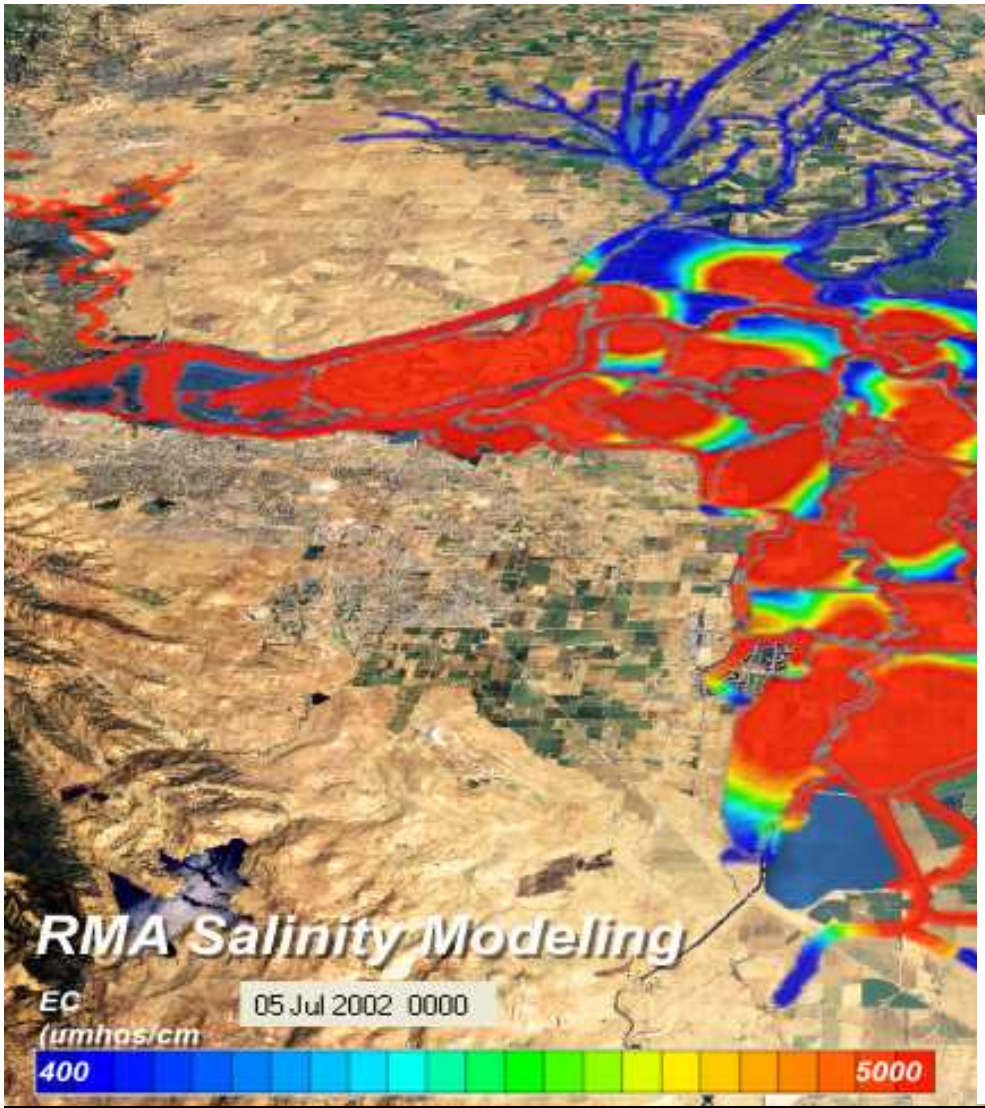
6.5 Magnitude Earthquake

causing 20-Island Failure



12 – 24 hours: Salt water intruding into Delta

6.5 Magnitude Earthquake
causing 20-Island Failure



What are the estimated financial losses associated with this?

20-40B including lost ag, remediation, costs to cities for other water

Katrina was 20-30B

Remediation would take months to years

Remediation would mean rebuilding levees and pumps and then pumping out all the saline water, right?

Meanwhile, ag in San Joaquin basin would crash? YES

Other risks -- atmospheric rivers triggering massive rainfaill, earthquakes, sea level rise, storm surges on high tide.

1 – 7 days: Salt water throughout Delta

Solutions

- Water supply variability in CA is most of all states. For Delta, as low as 7maf, as high as 50 maf – current allocation to downstream users is about 5.3 af for both pumping locations, which means they would be taking 5.3/7 of the total freshwater flow.
- Solution: scale take of water to the amount of water the delta recieves, and then downstream users
- Solution: better storage – GW +SW storage south of the Delta which would smooth out the peaks and troughs
- Solution: Conservation, use of other sources (desal, WW)
- Distributed desal could be important
- Modify demand to meet supply
  - Median inflow is about 12-14 maf
- Again, the consequence is more $$