Sources of Salinity to the Rio Grande

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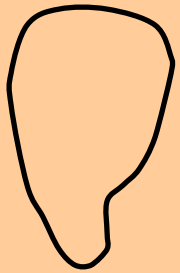
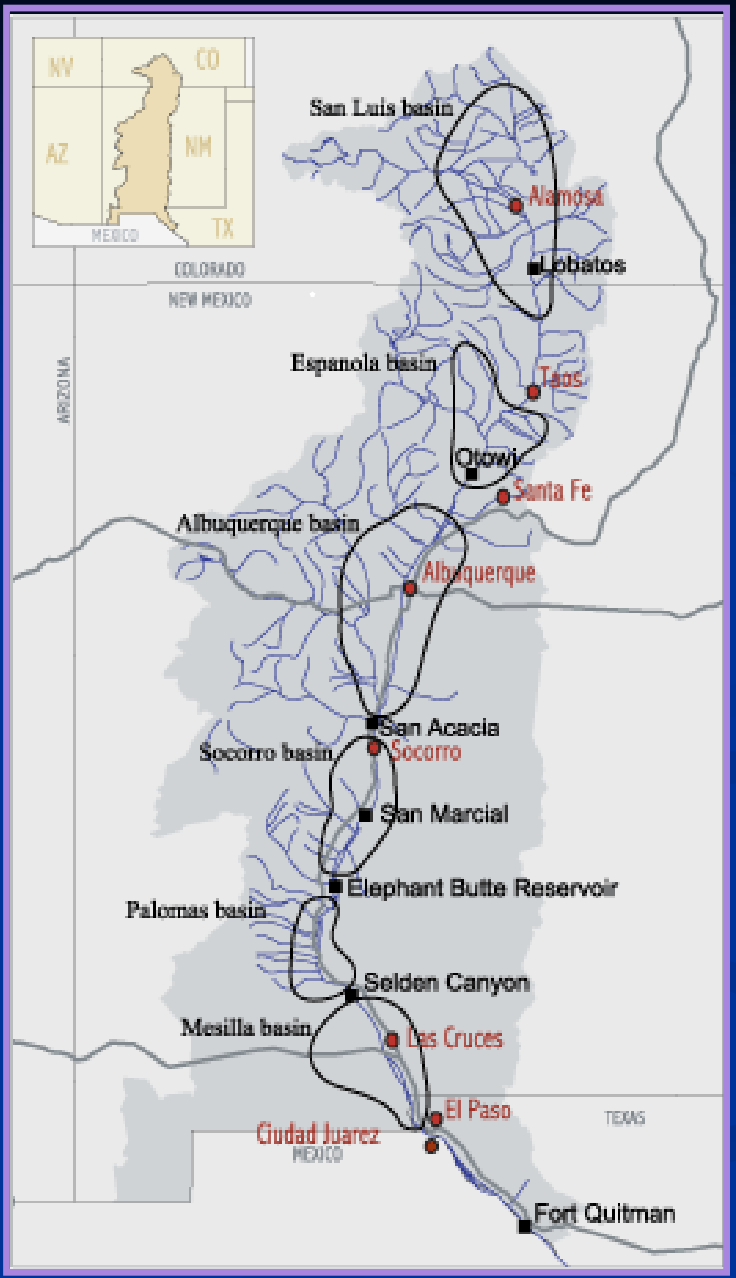
Rio Grande basin

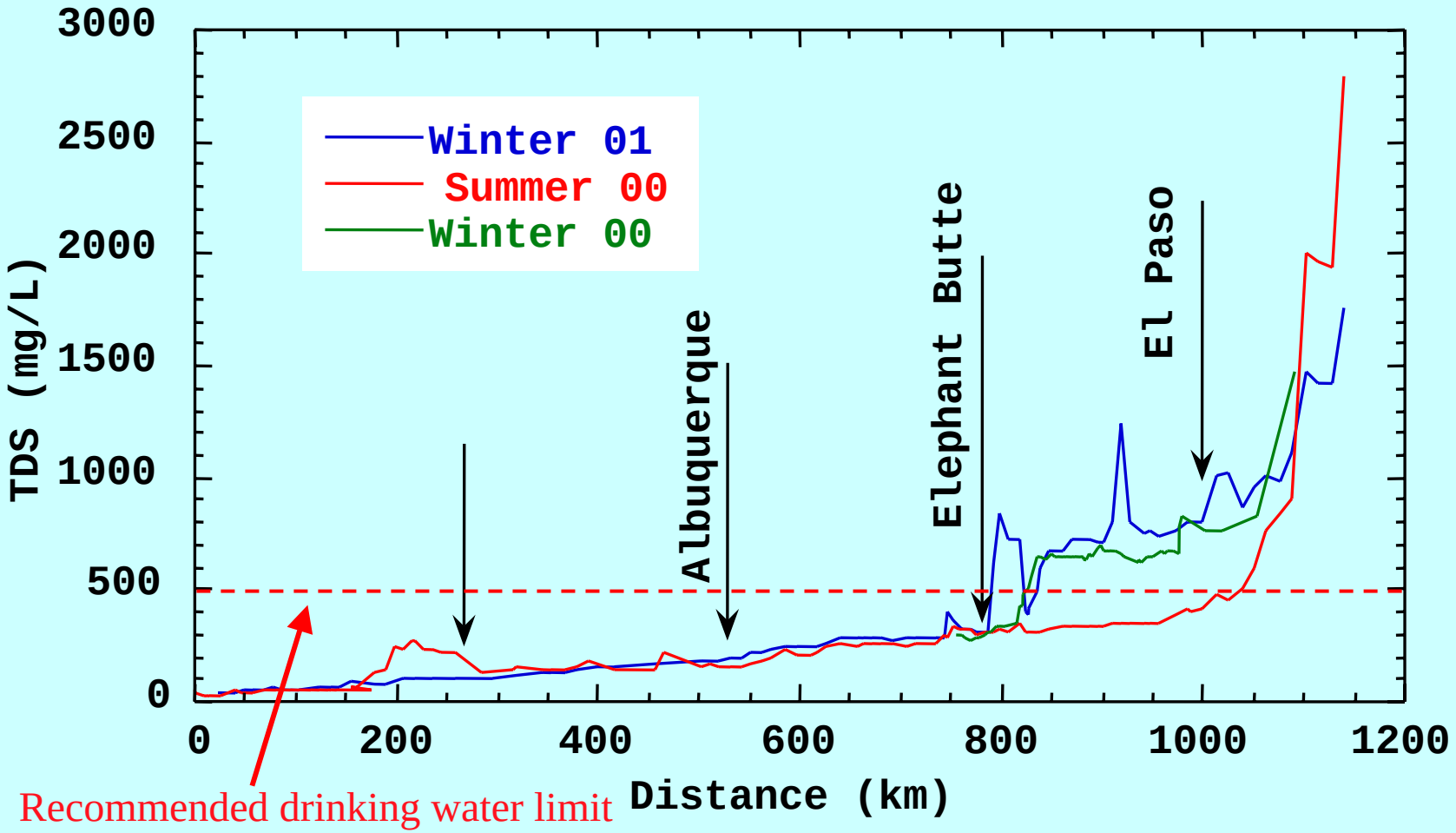


= sedimentary basin

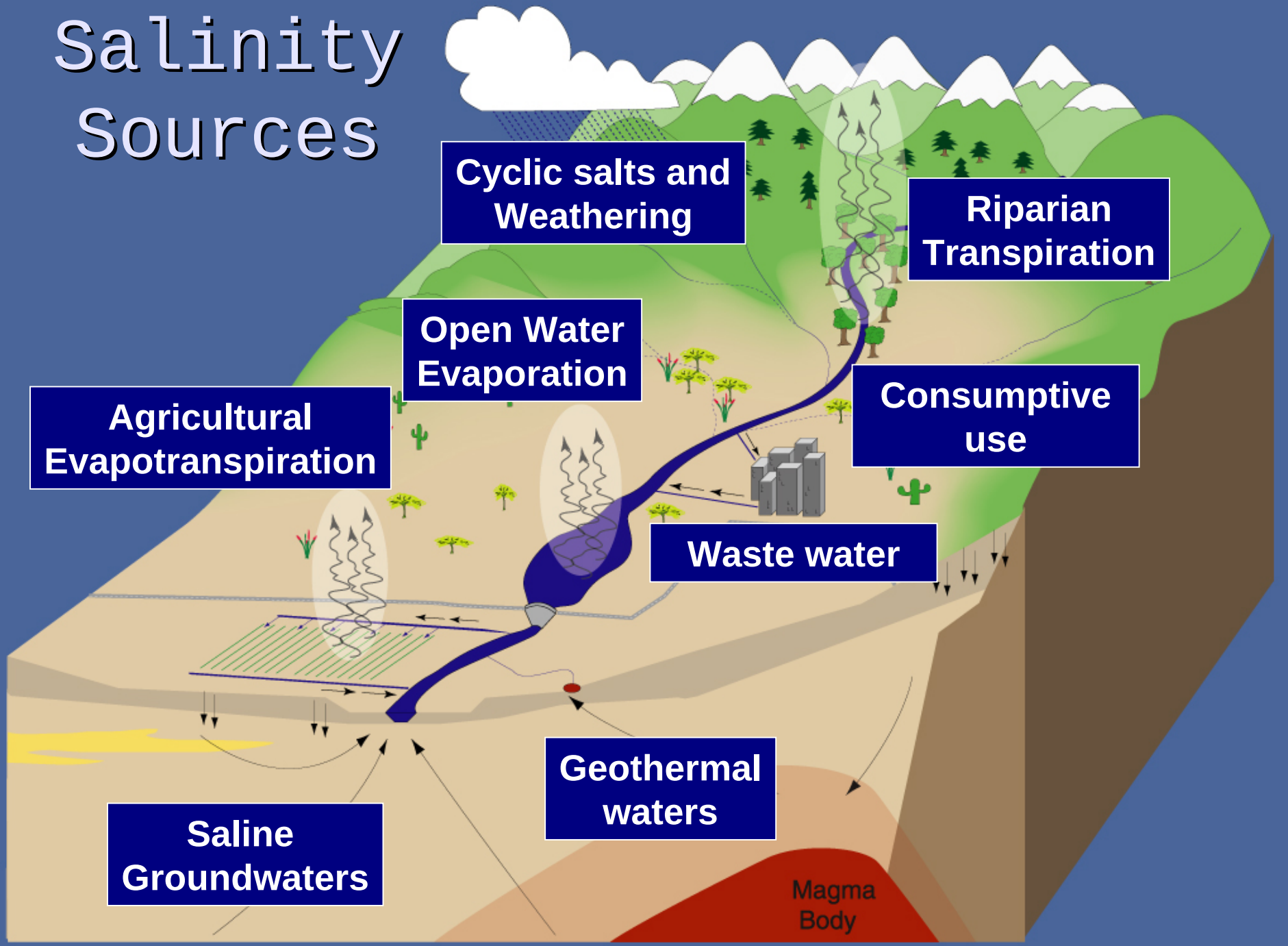
- Basin Area - 32,210 mi^2
- Precipitation - 6 to >50 in.
- Population - 1,072,000 (1990)
- Irrigation - 914,000 acres



TDS of the Rio Grande



Salinity Sources



Causes of River Salinization?

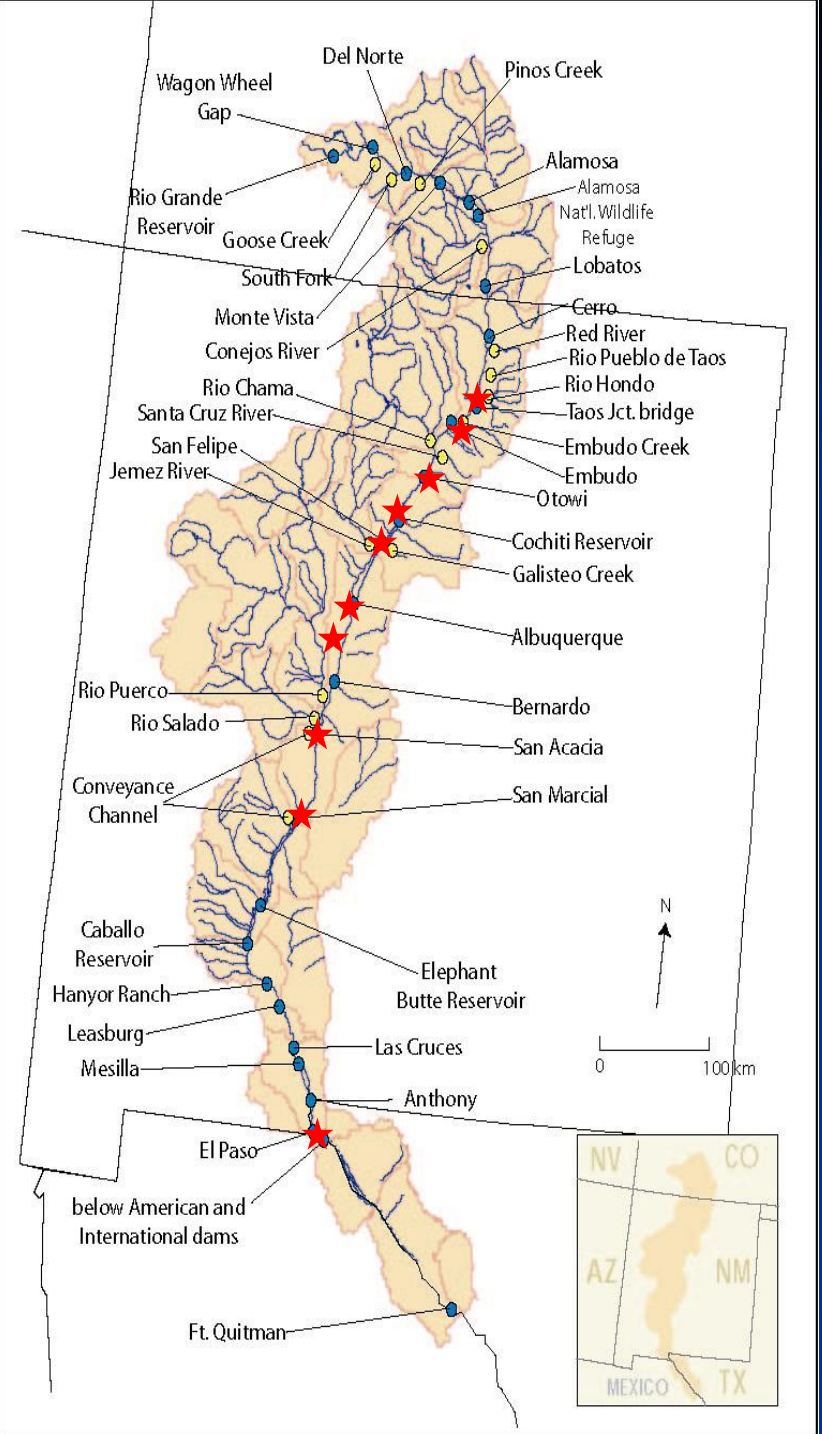
J.B. Lippincott (1939): “The increase in salinity of the waters of the Rio Grande [is] due to their use and re-use [for irrigation] in its long drainage basin...”

Wilcox (1957): “There is a relatively large increase in the tonnage of both sodium and chloride from the upper to the lower stations... [that can be] attributed to the displacement of salty groundwater in the course of irrigation and drainage operations.”

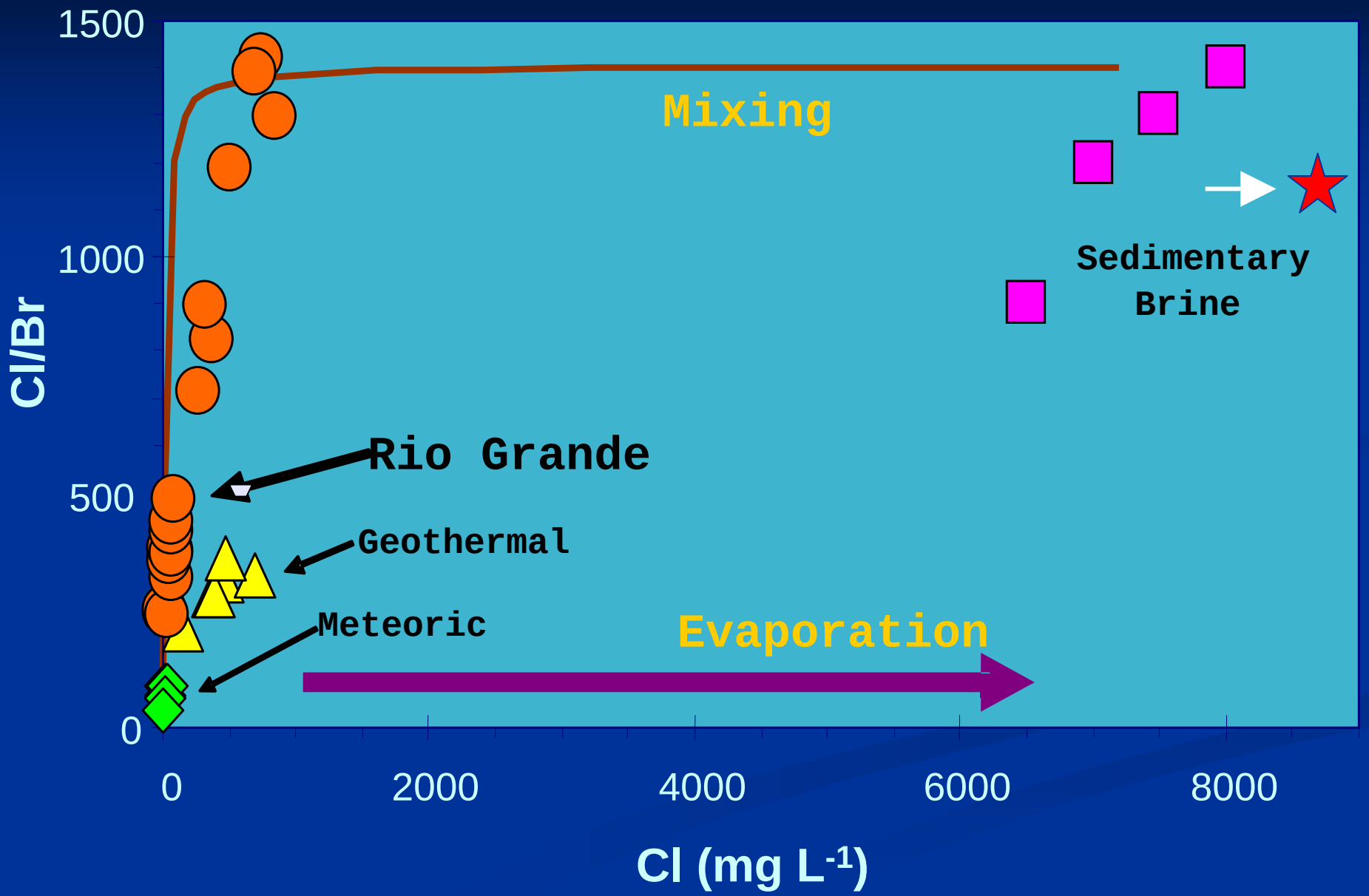
van Denburgh and Feth (1965): Noted that only 4.2% of the chloride burden of the Rio Grande originated from atmospheric deposition over the catchment and attributed the remainder to“continental solute erosion”.

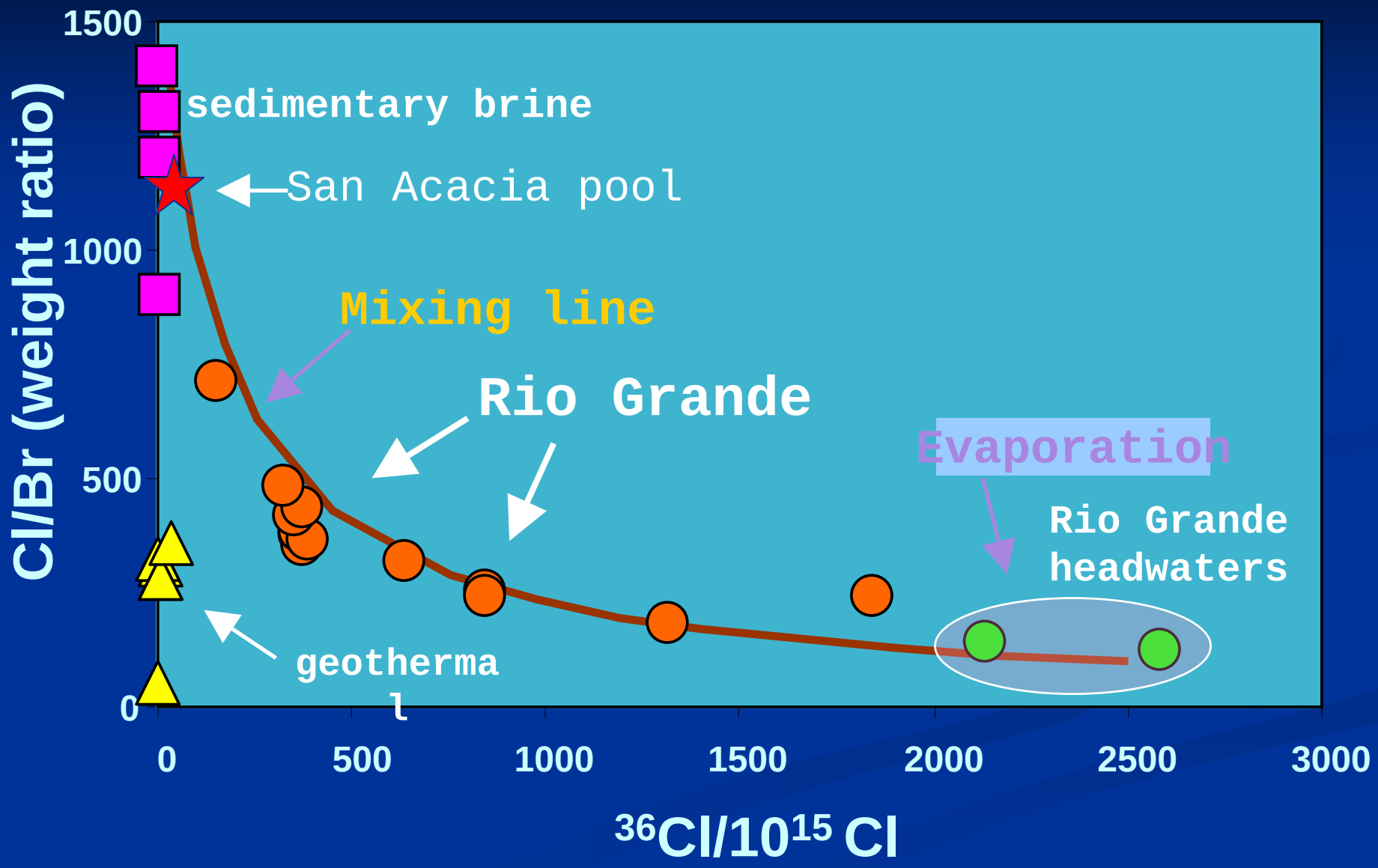
How to Quantify Sources and Causes of Salinization?

- Traditional approach: Measure discharge and salt concentrations at gaging stations and compute salt burden
- Alternative Approach: Measure environmental tracers at high spatial resolution and employ dynamic simulation to interpret results



Sampling locations along the Rio Grande


1500
1000
500
0
Cl/Br
Mixing
Sedimentary
Brine
Rio Grande
Geothermal
Meteoric
Evaporation
0
2000
4000
6000
8000
Cl (mg L-1)

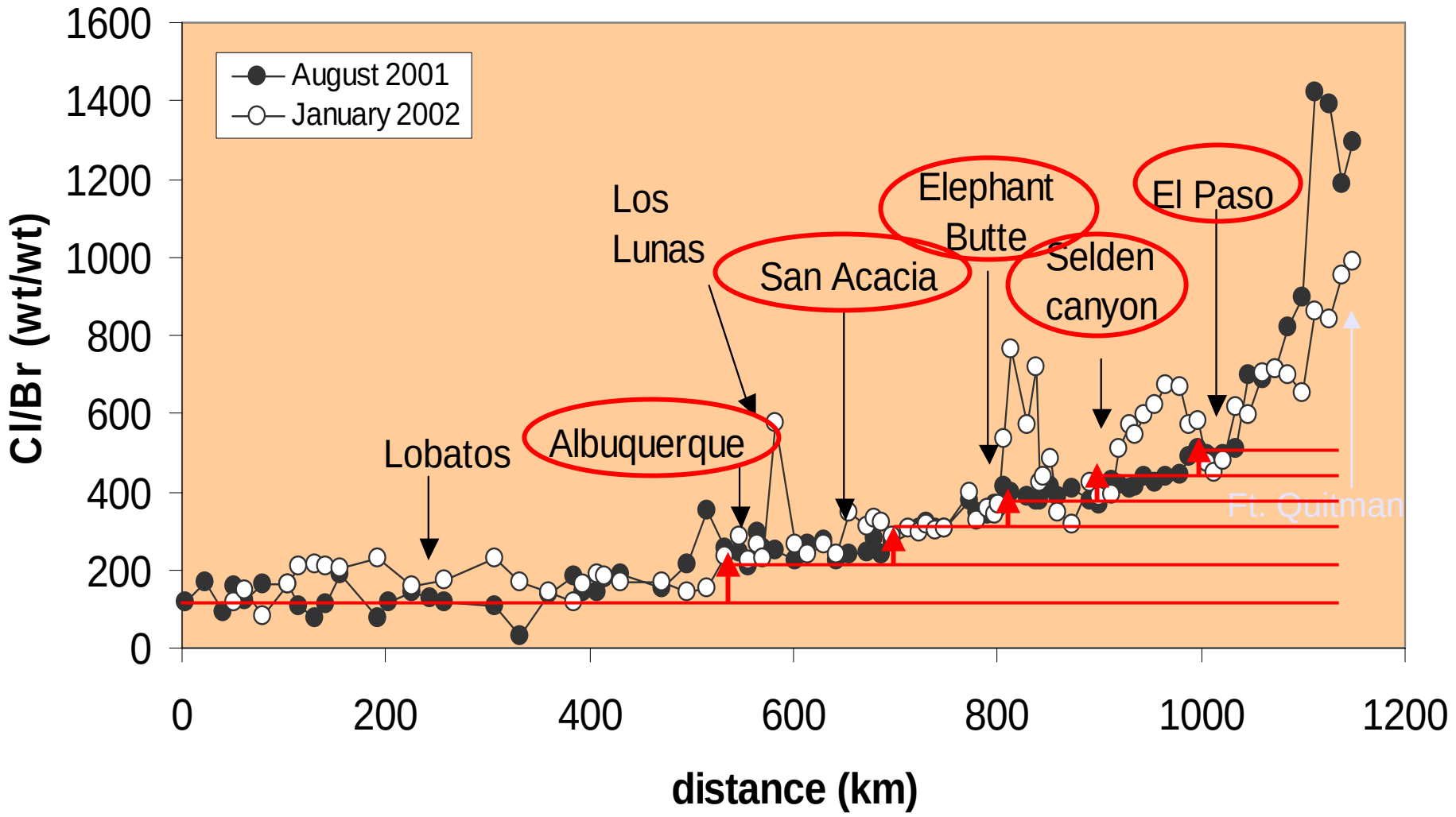

1500
1000
500
0
Cl/Br (weight ratio)
sedimentary brine
San Acacia pool
Mixing line
Rio Grande
Evaporation
Rio Grande
headwaters
geotherma
l
0
500
1000
1500
2000
2500
3000
36Cl/1015 Cl

Result from tracer work

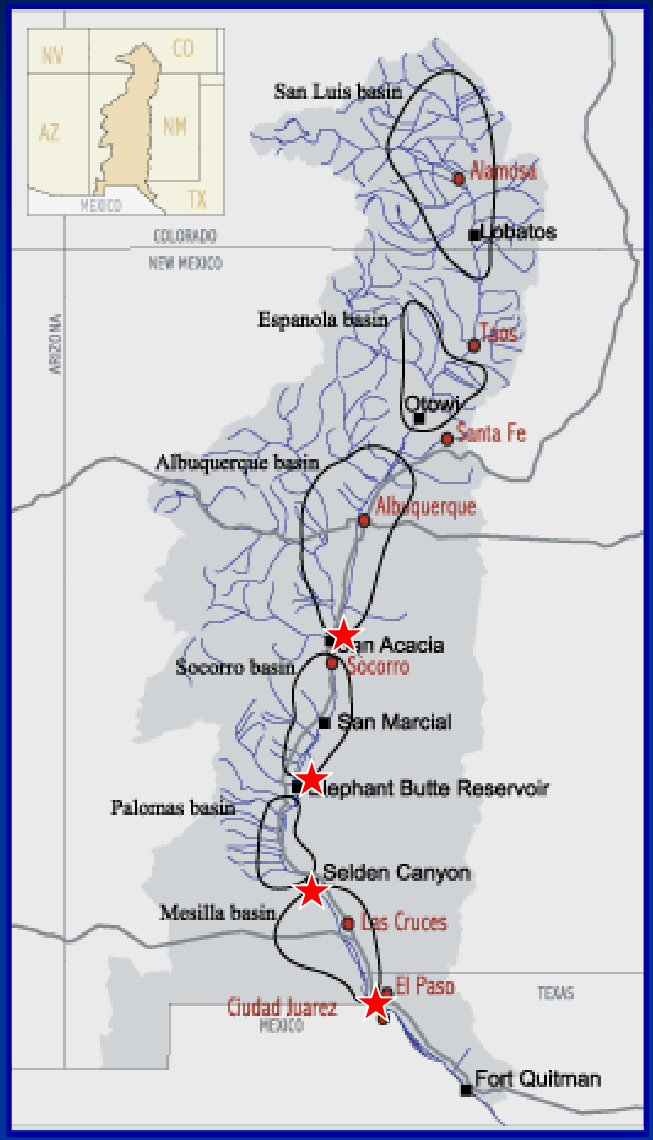
A large part of the salinization of the Rio Grande is due to seepage of deep, sedimentary-origin brines

Where are these brines entering the Rio Grande?

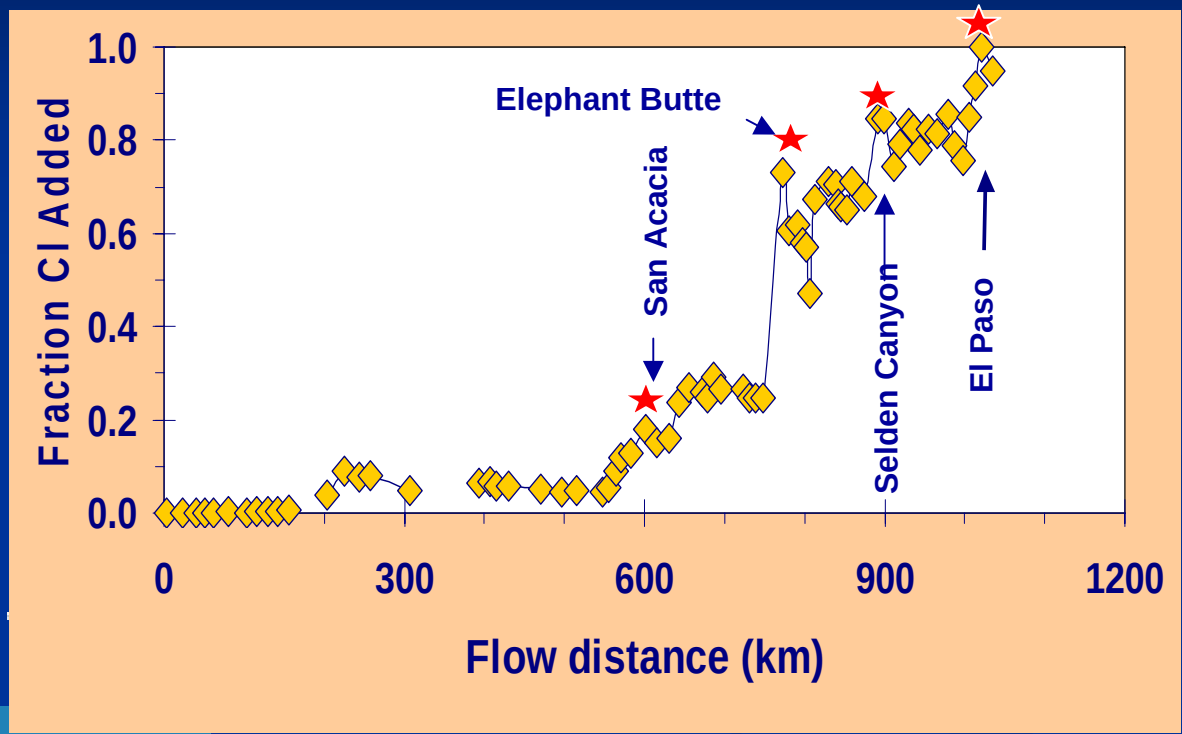
Patterns of Salt Addition cont'd: Cl/Br in the Rio Grande



Points of Salt Addition

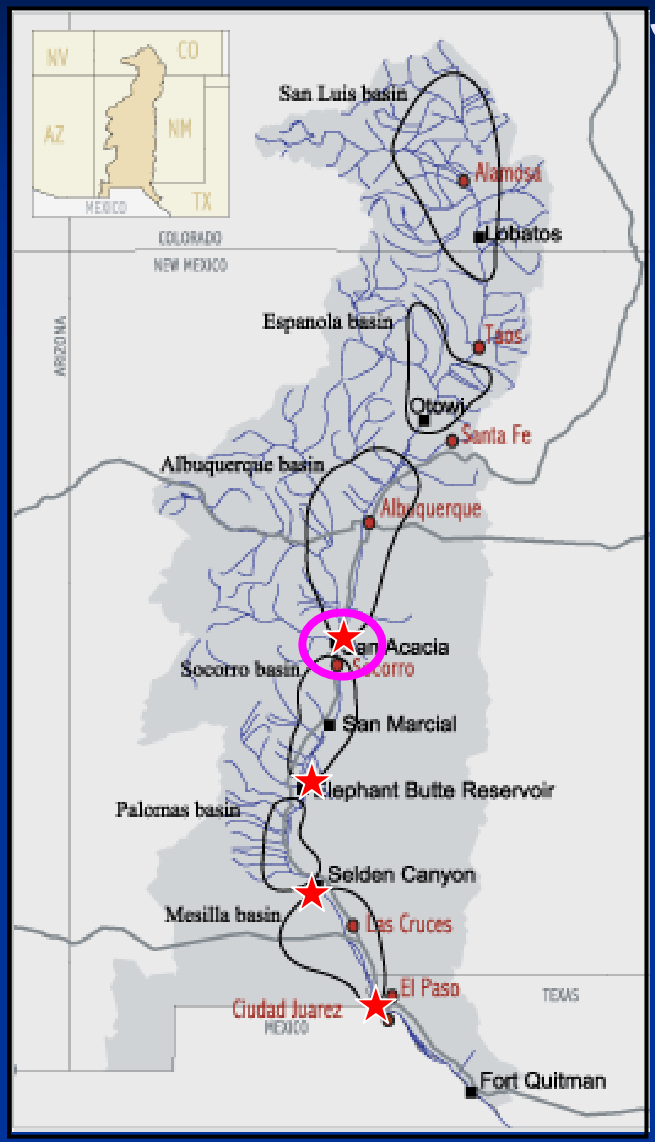


Fraction Cl Added vs. flow distance

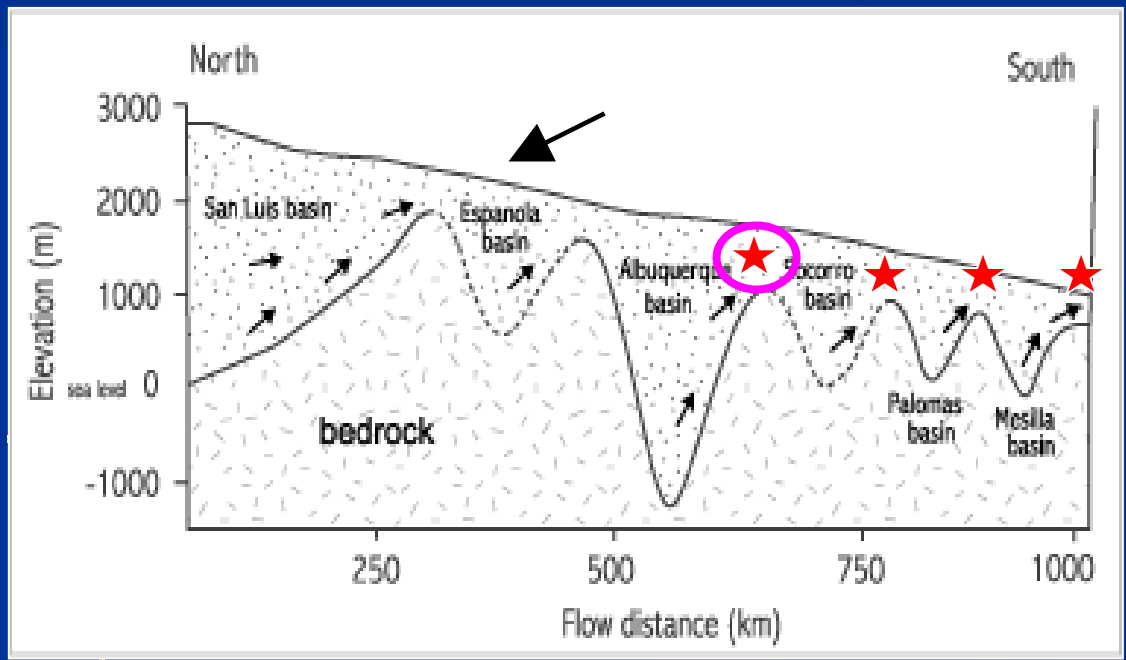


★ = basin terminus

Basin Groundwater Systems



Schematic Hydrogeologic Cross-Section, Parallel to River Path

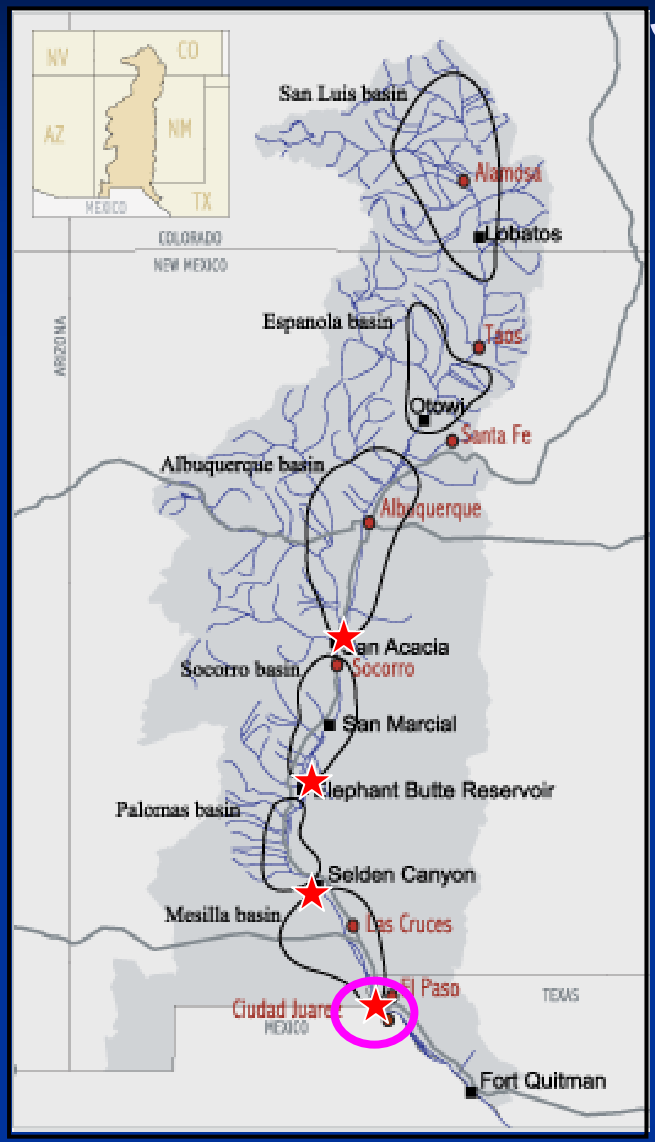


★ = basin terminus

Saline input: San Acacia pool

[Cl^-] = 32,300 mg L^{-1}

Basin Groundwater Systems



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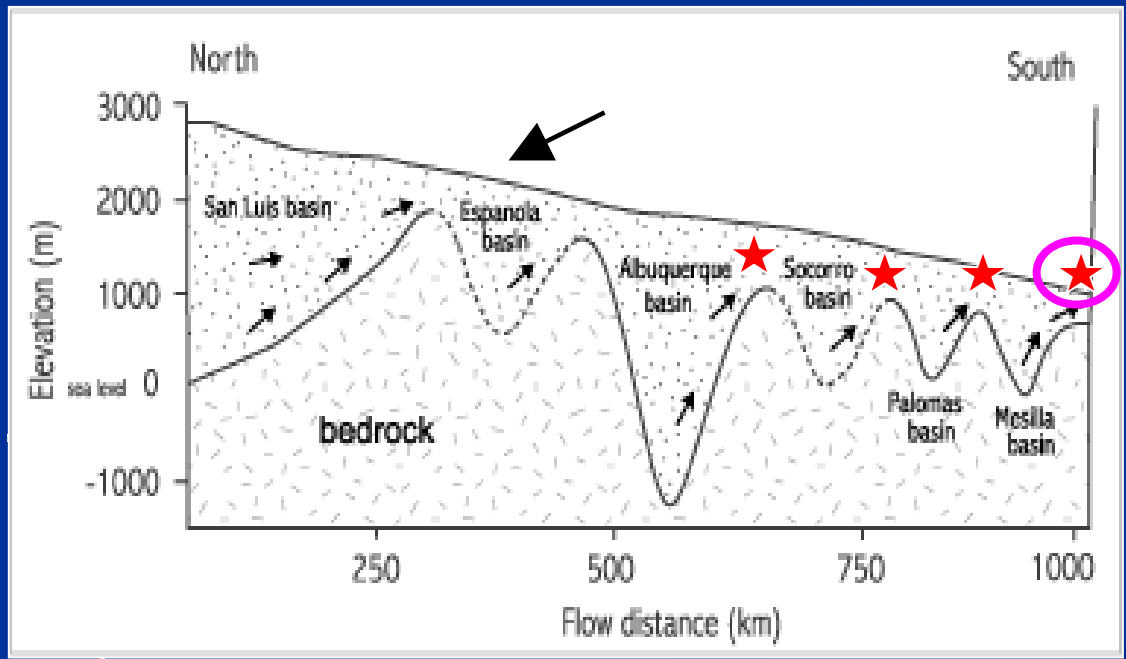

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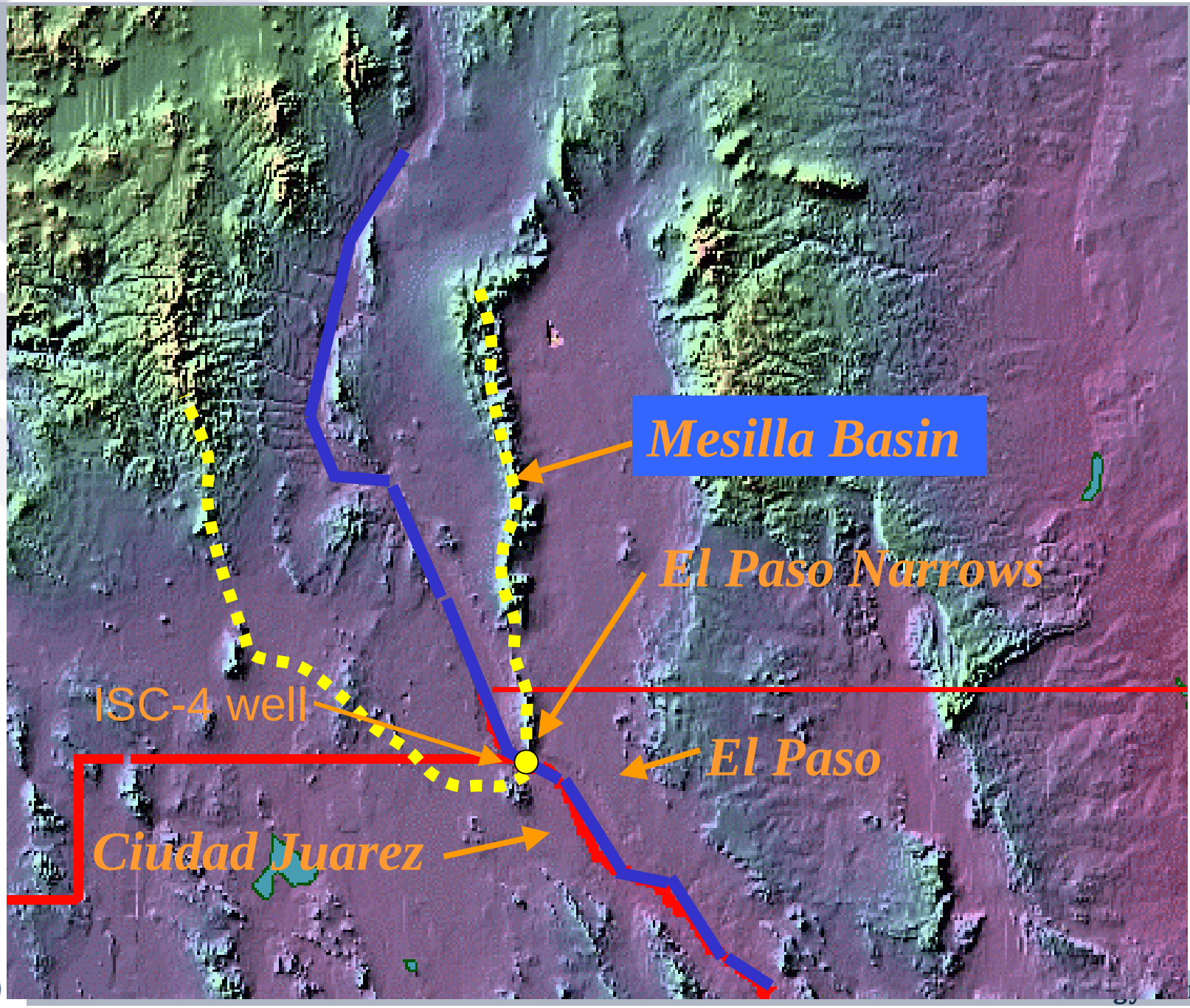
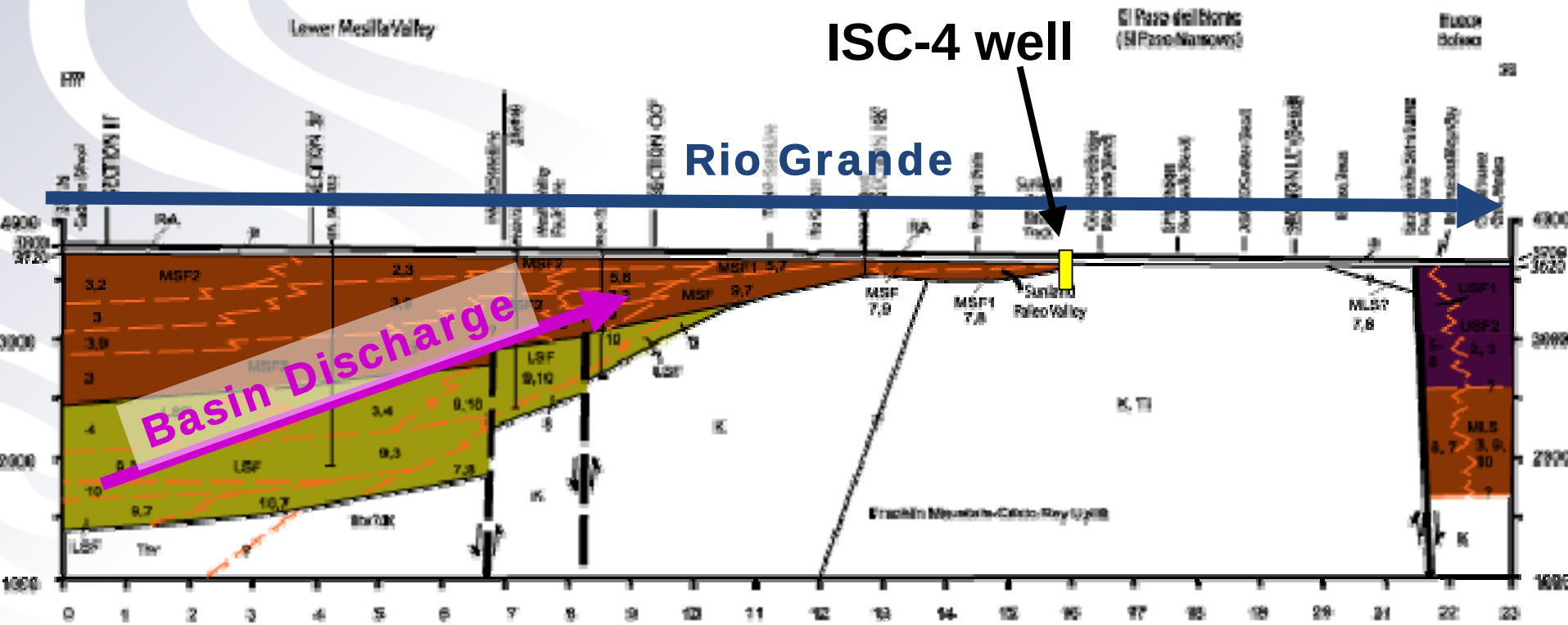
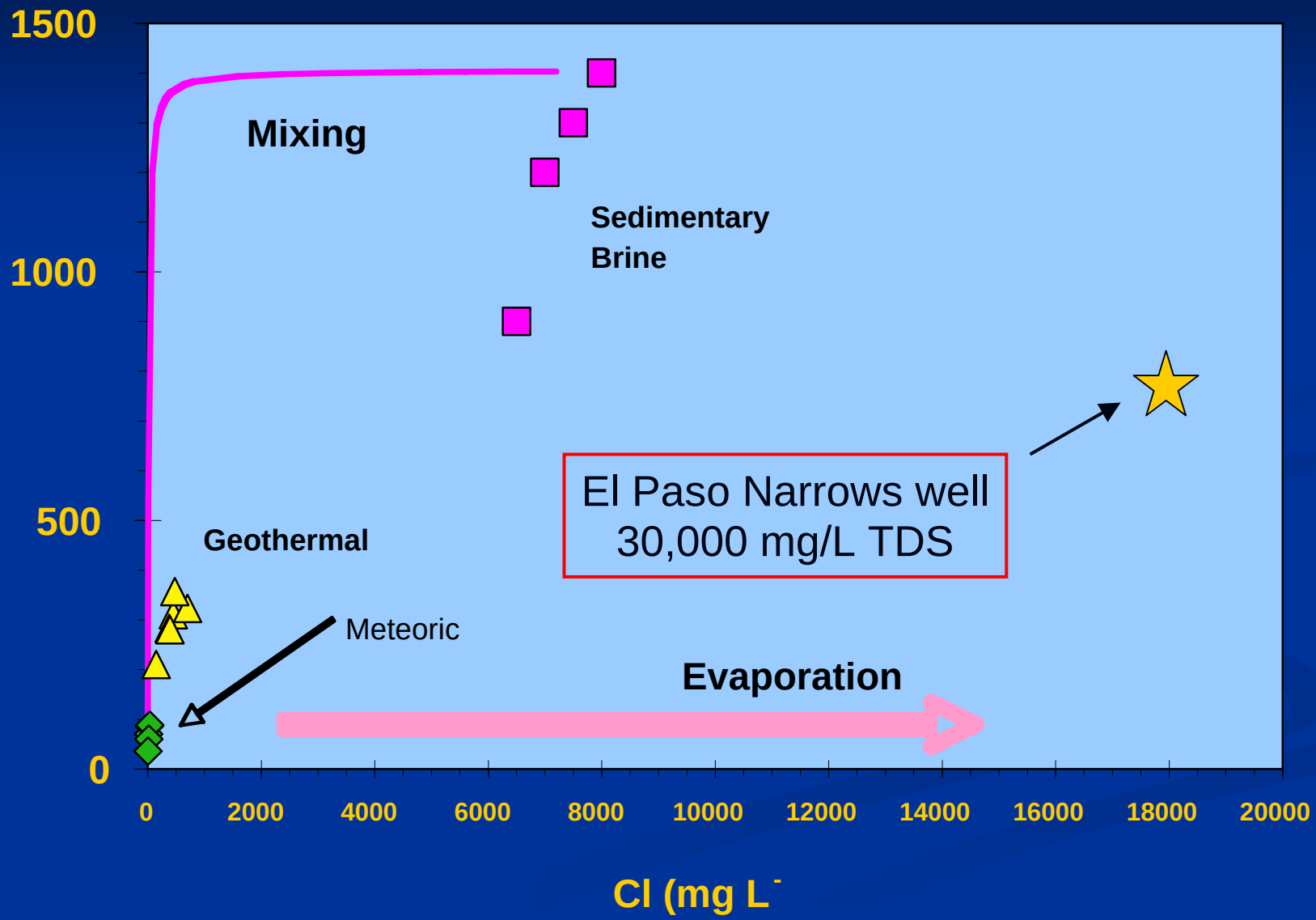

Mesilla Basin
El Paso Narrows
ISC-4 well
El Paso
Ciudad Juarez

El Paso del Norte



- Cross section through Paso del Norte along Rio Grande
- Basin flow from Mesilla basin forced up
- Recharge when entering the Hueco Bolson

El Paso Narrows well results



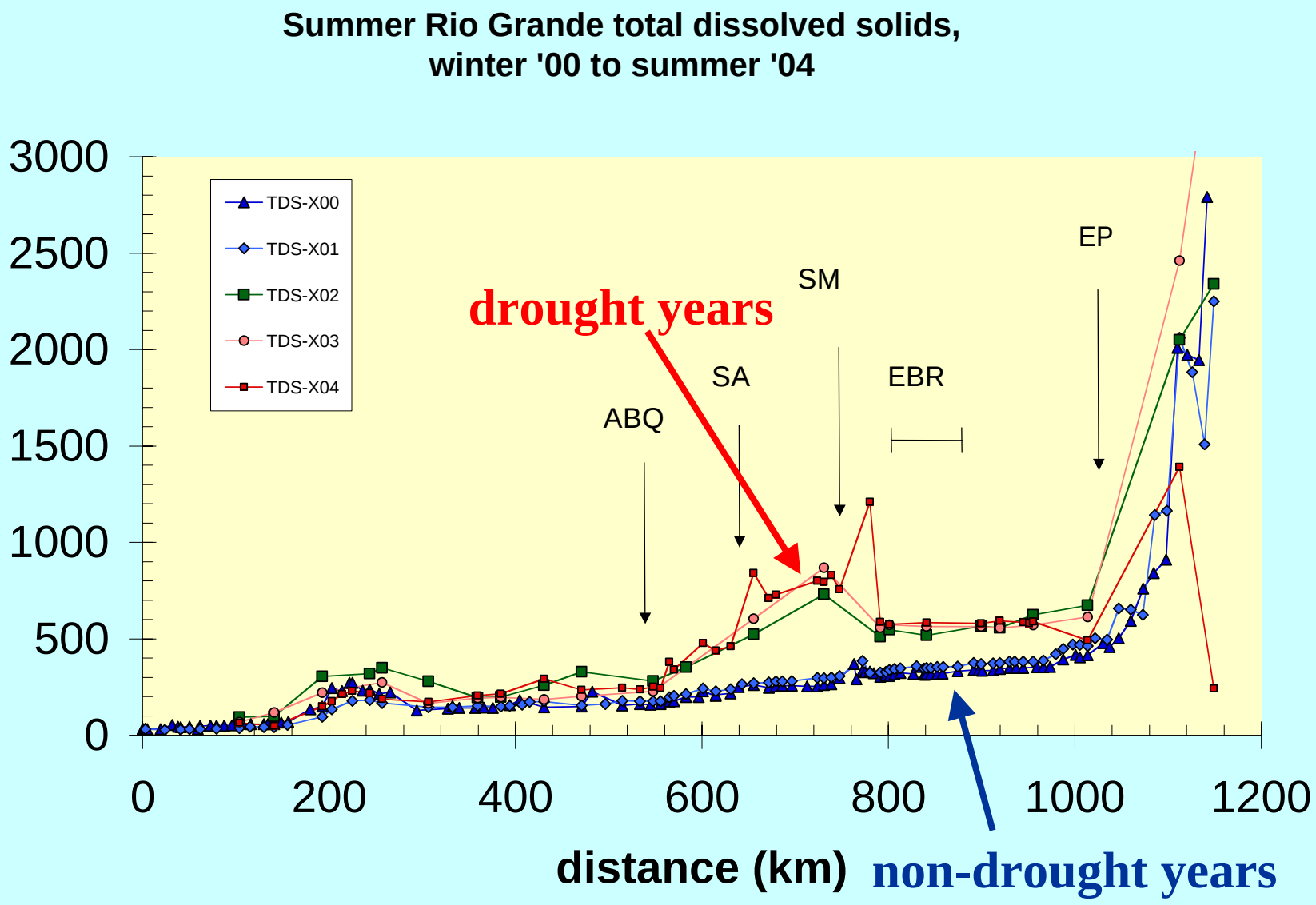
Findings from subsurface investigations

Sites of brine leakage along structurally-controlled pathways can be clearly identified in the field

Summary of Findings

- Salt addition to the Rio Grande occurs in a stepwise pattern
- Salt is added at San Acacia, Elephant Butte, Selden Canyon, and the El Paso narrows (and T or C)
- Salt is either connate or from long-term rock/water interaction

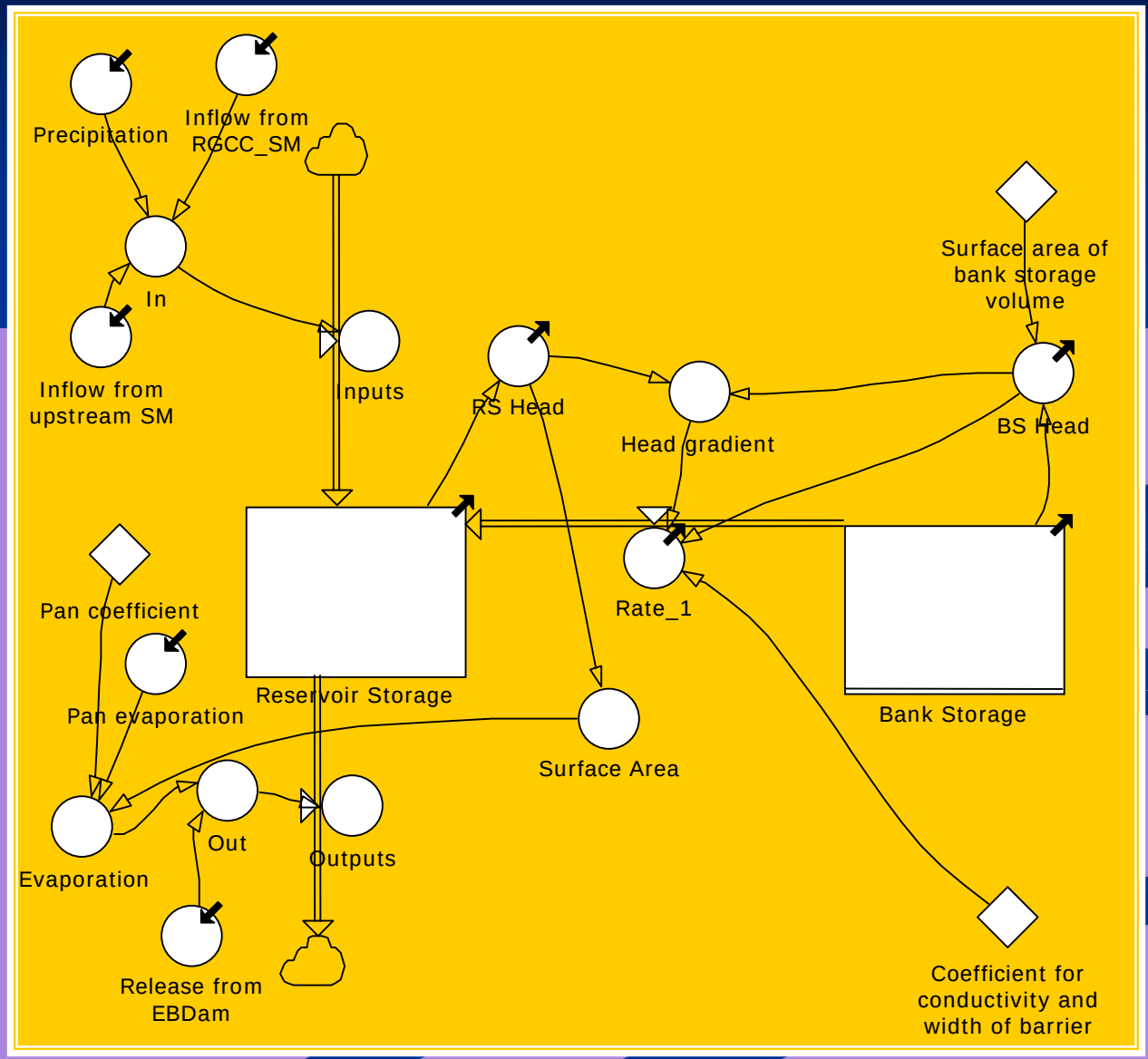
Response to drought



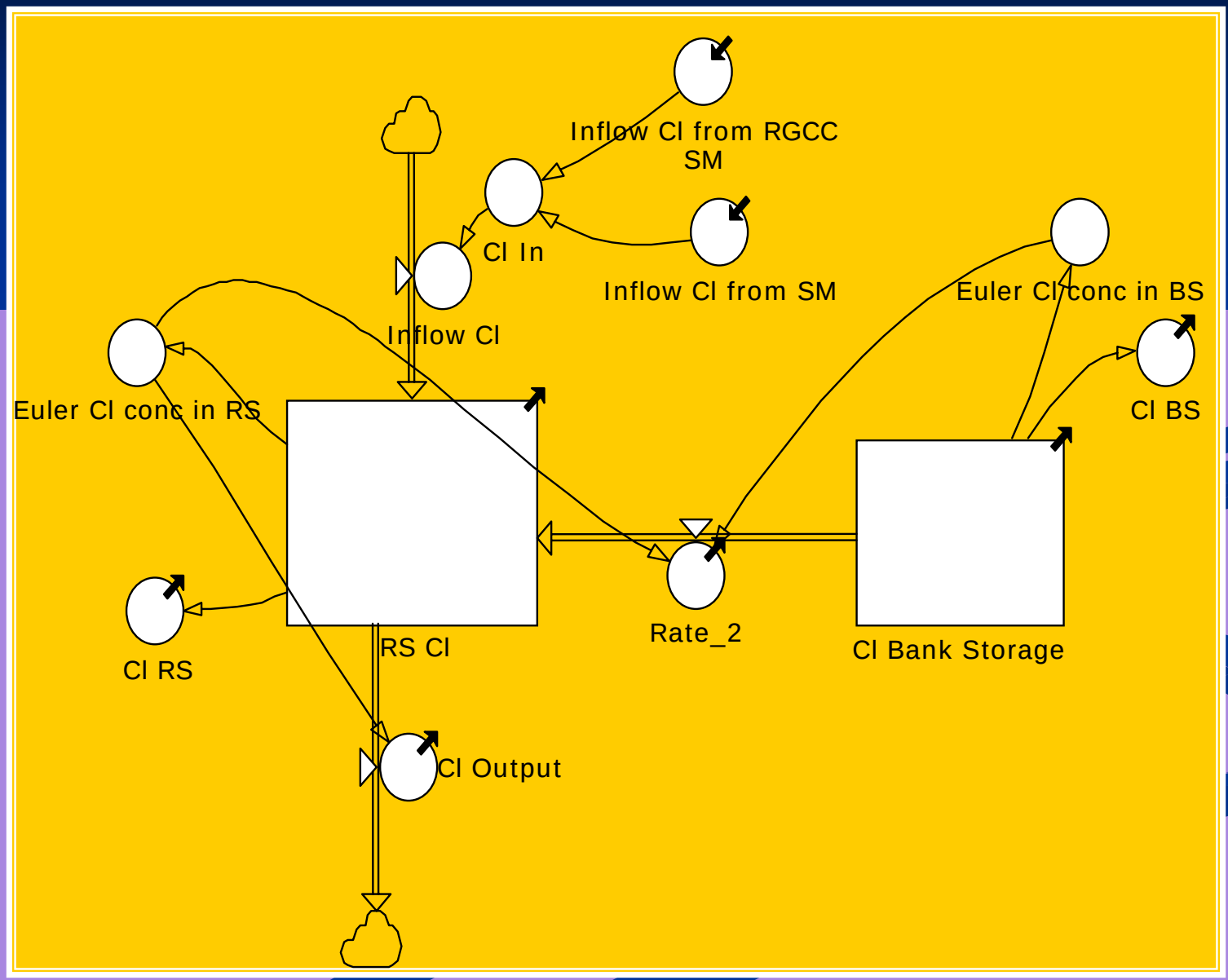
Chloride concentrations and loads are highly variable in time and location

We need a dynamic modeling tool to adequately understand budgets and variability of solutes in the Rio Grande

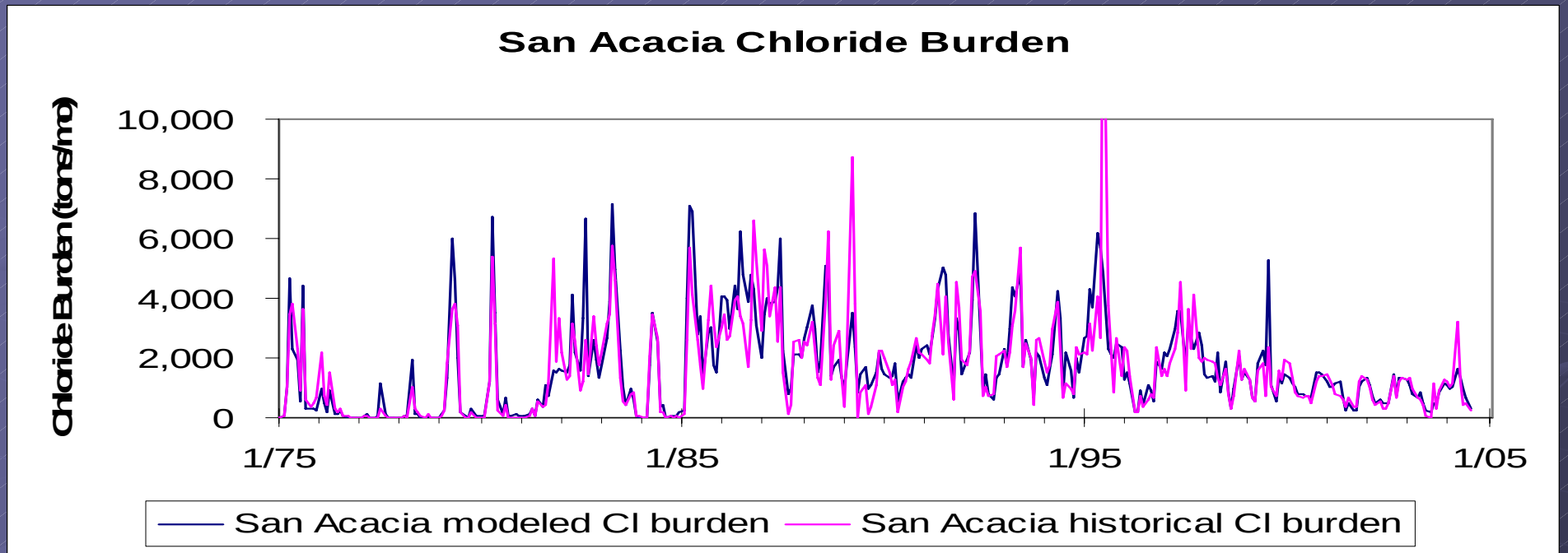
Powersim modeling - water model

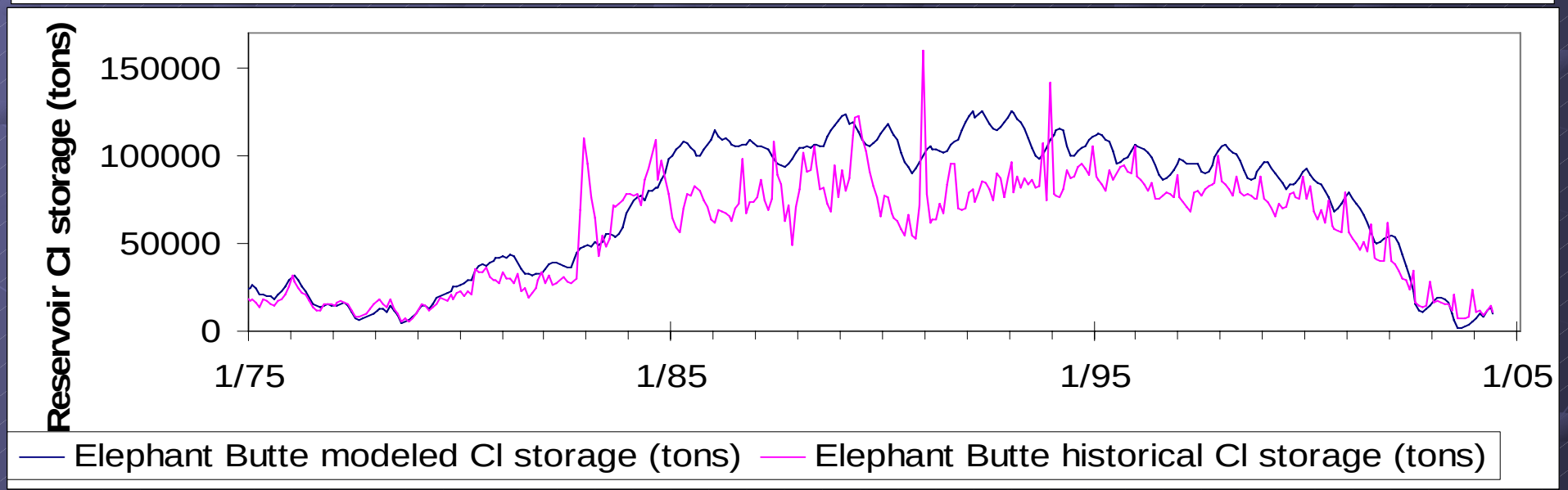


Powersim modeling - chloride model

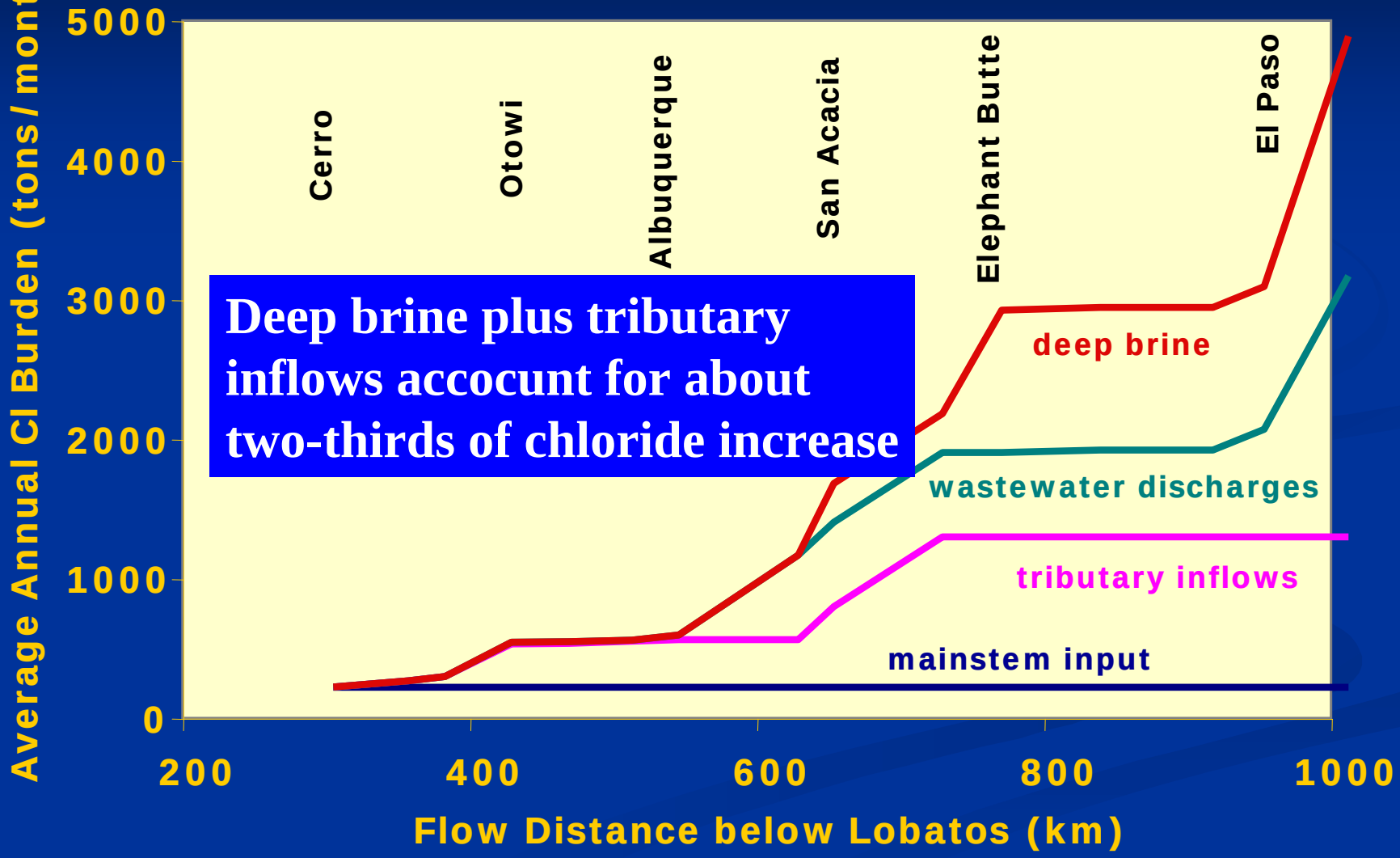


Model Results w/brine inflows: Cl burden





Cumulative Chloride Sources



Historical Perspective

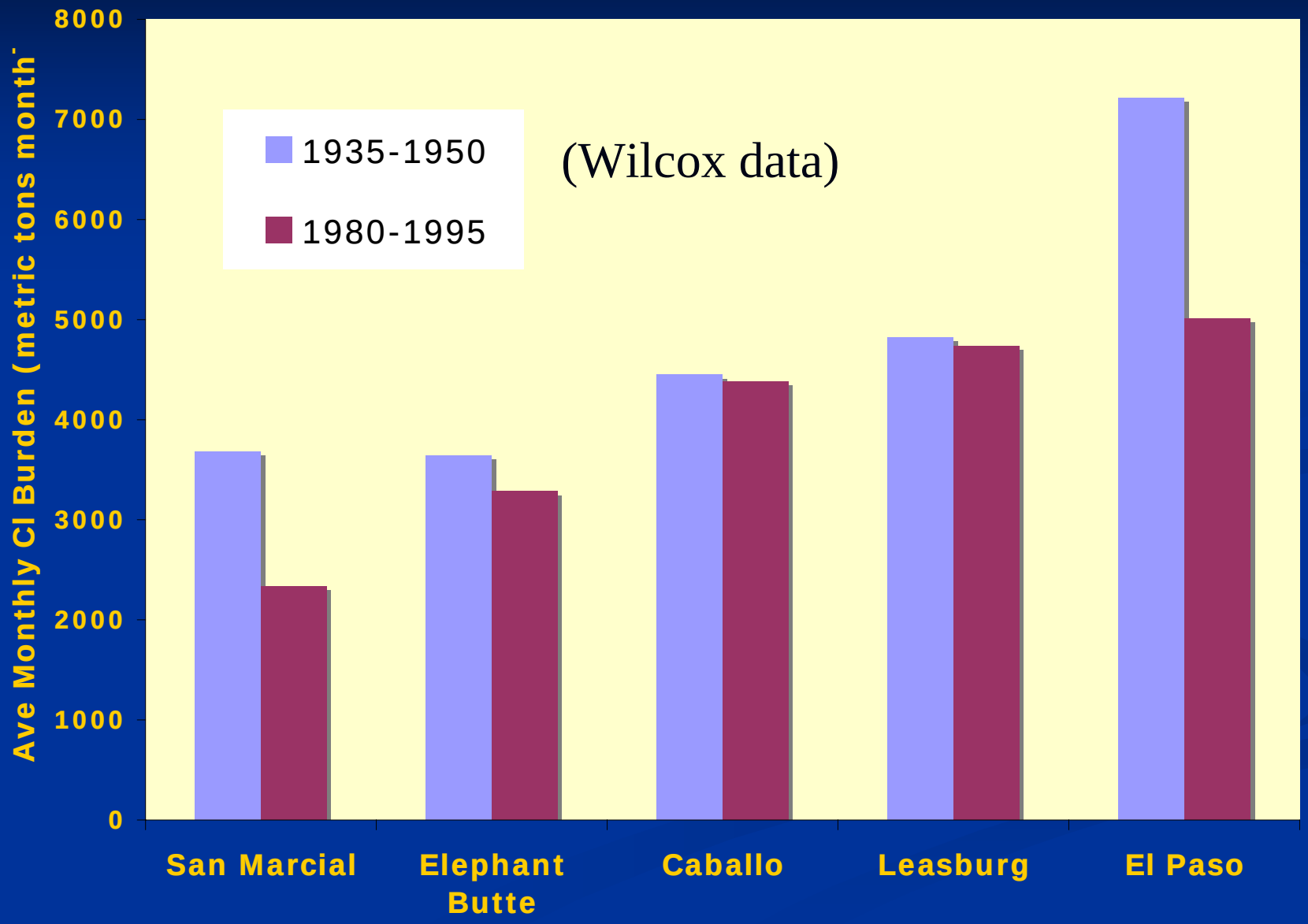
Are modern practices responsible for worsening water quality? (perhaps by increasing brine inflows?)

Two important past studies:

- **Wilcox 1934-1950 at many gauging stations**
- **Stabler 1905-1907 at San Marcial and El Paso**

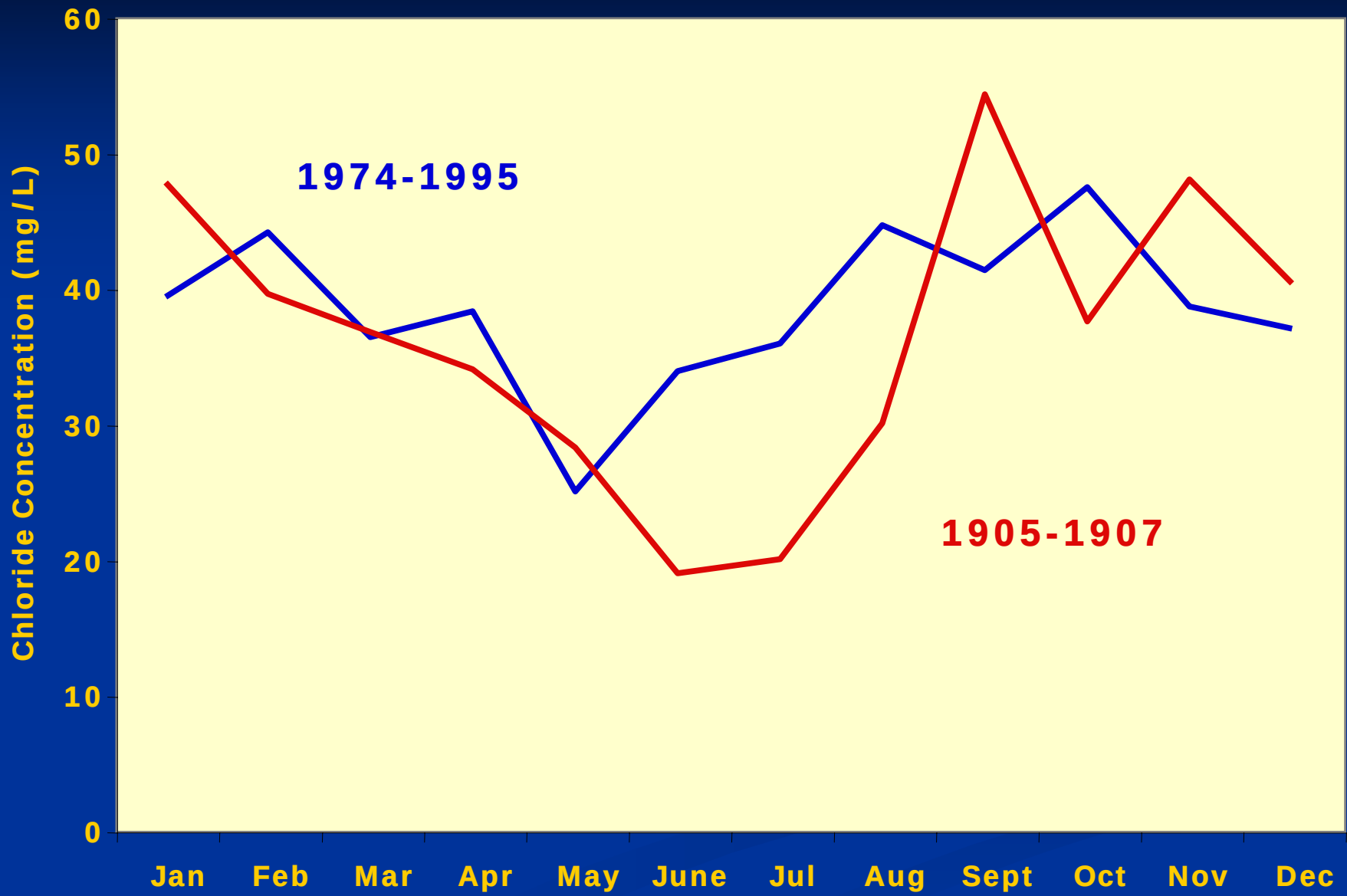
Comparison with Wilcox (1934-1950) data set

Monthly Chloride Burden

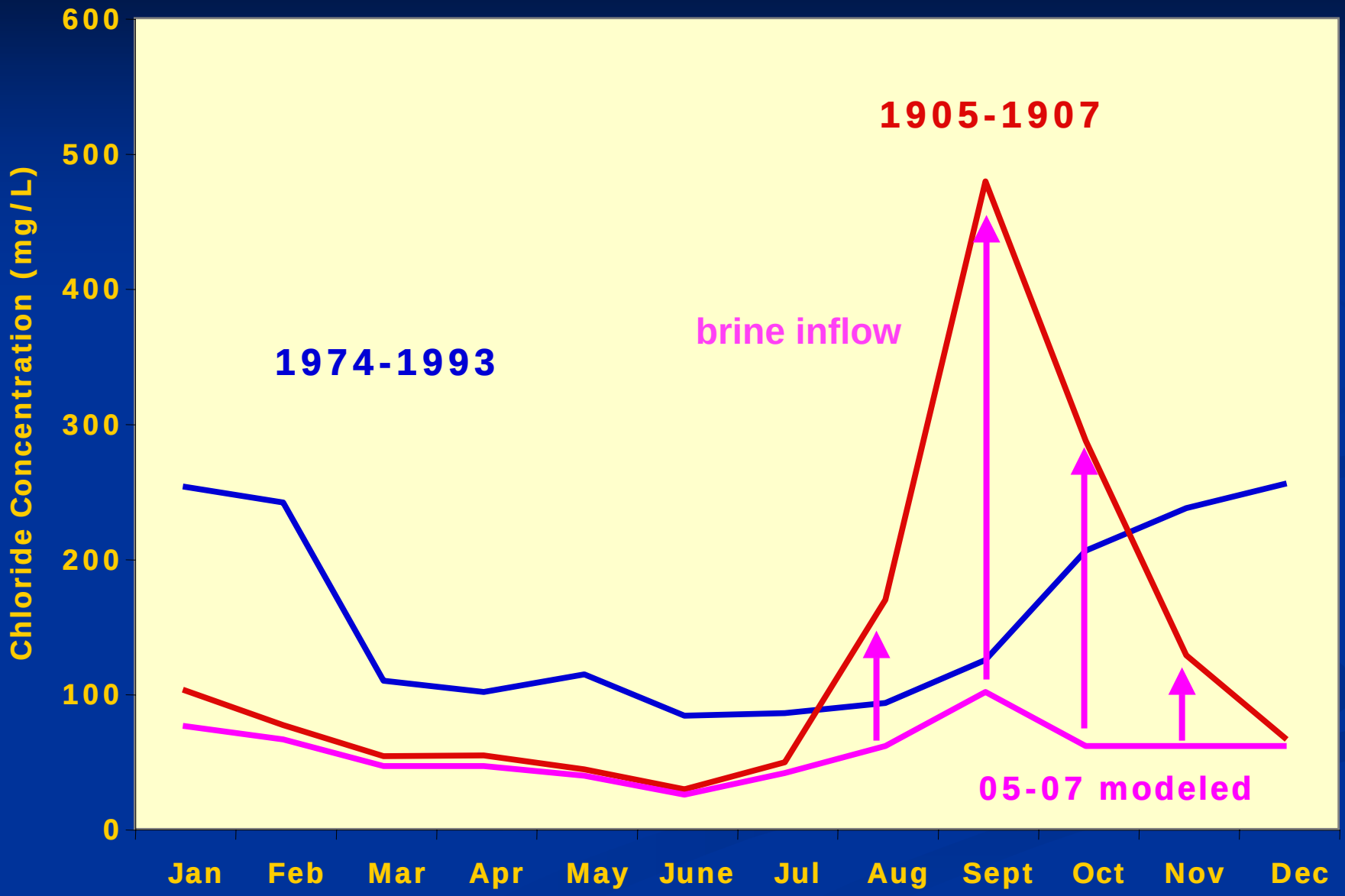


Comparison with Stabler (1905-1907) data set (before Elephant Butte Dam!)

San Marcial Chloride Concentrations



El Paso chloride



Conclusions

- About 2/3 of the chloride increase of the Rio Grande is from “geological salt”, either from brine leakage or tributaries
- The brine leakage is along structural features (mostly faults) and might be intercepted and pumped

Conclusions

- The brine leakage predates development of the river and may have actually decreased over the 20th Century
- Agriculture contributes to the salinization of the Rio Grande but probably plays only a secondary role