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# A Salinity Simulation Tool for Highly Managed Agro-Urban Watersheds

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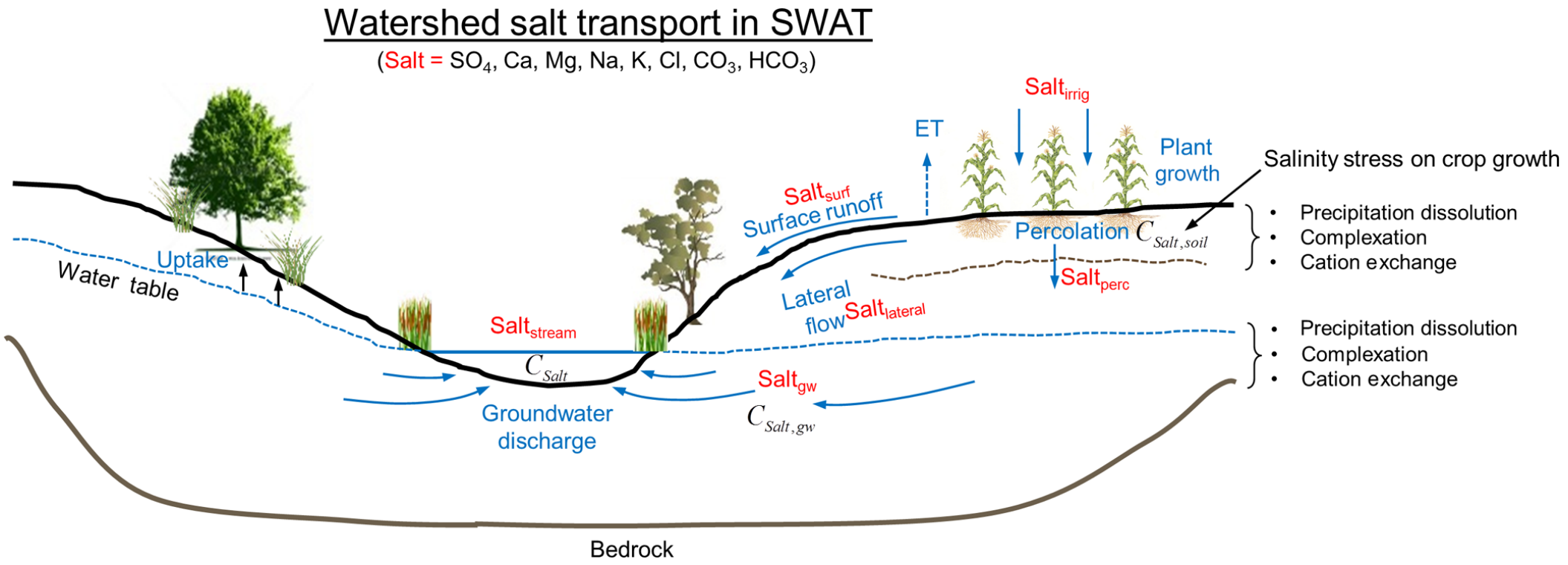
# Outline

- Why We Need a New Salinity Tool?
- Study Region: Managed Agro-Urban System
- Modeling Framework: Extending SWAT+*gwflow*
- Findings
- Next Steps and Ongoing Work

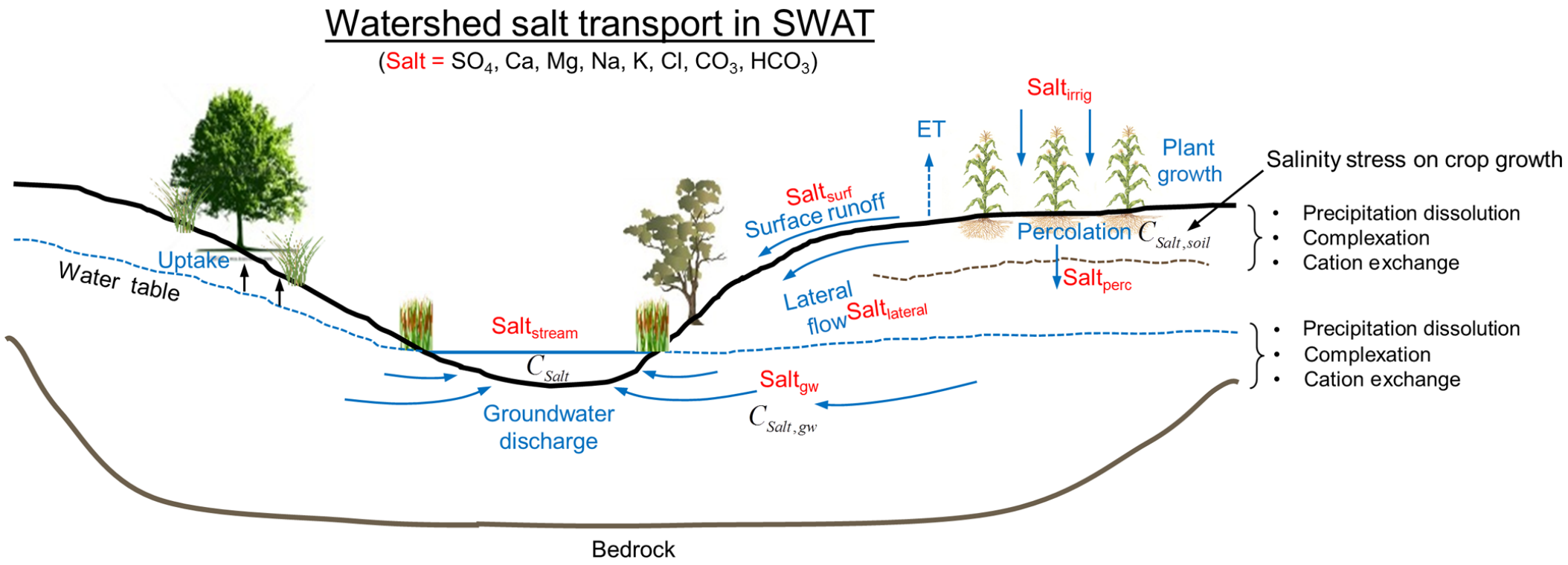
# Why We Need a New Salinity Tool?

- There is currently no watershed-scale salinity model that simulates ion fate and transport in a physically based, spatially distributed manner across all major hydrologic pathways.



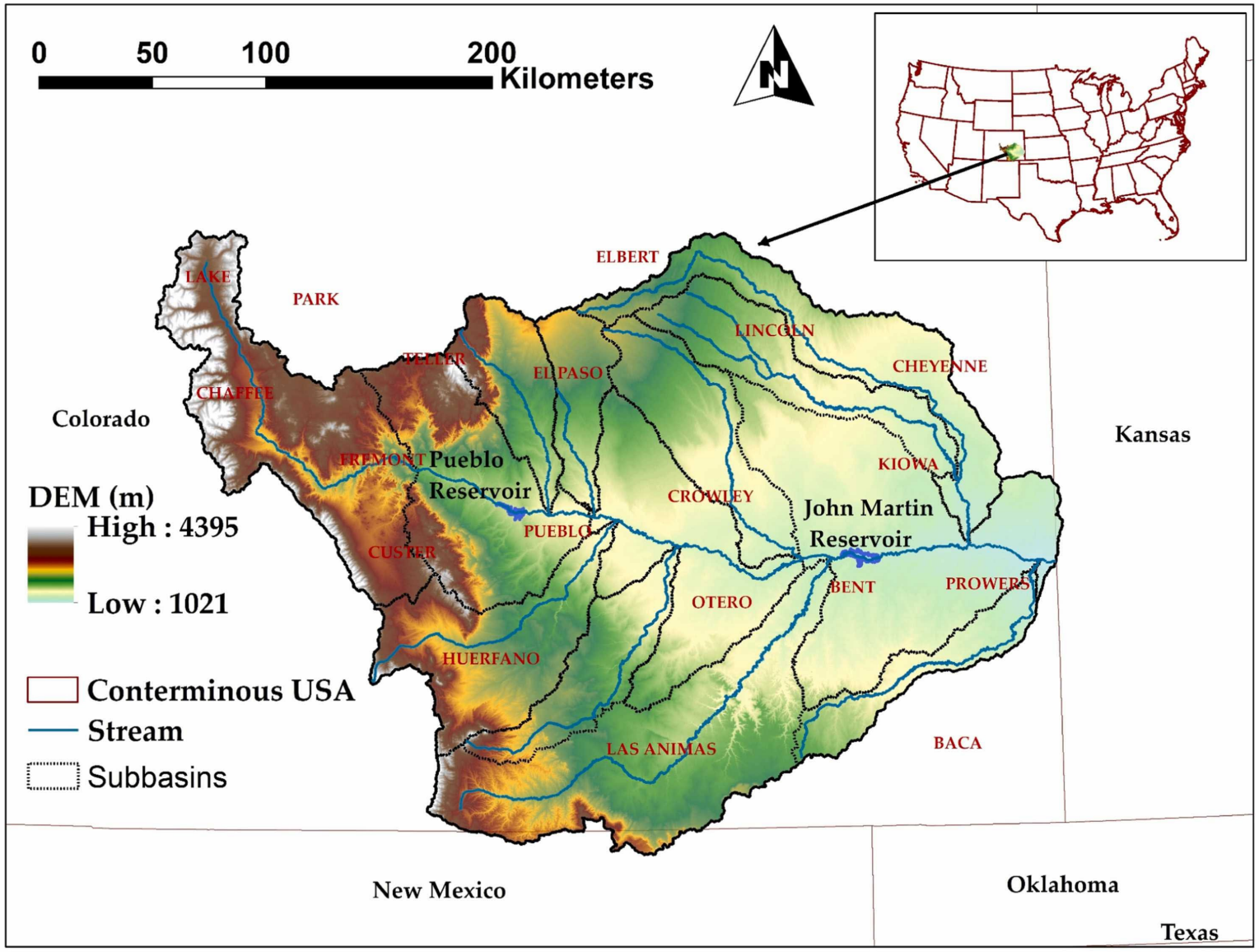
# Why We Need a New Salinity Tool?

- Existing salinity models lack full integration between surface and subsurface processes, making them suitable only for field or small-watershed scales.



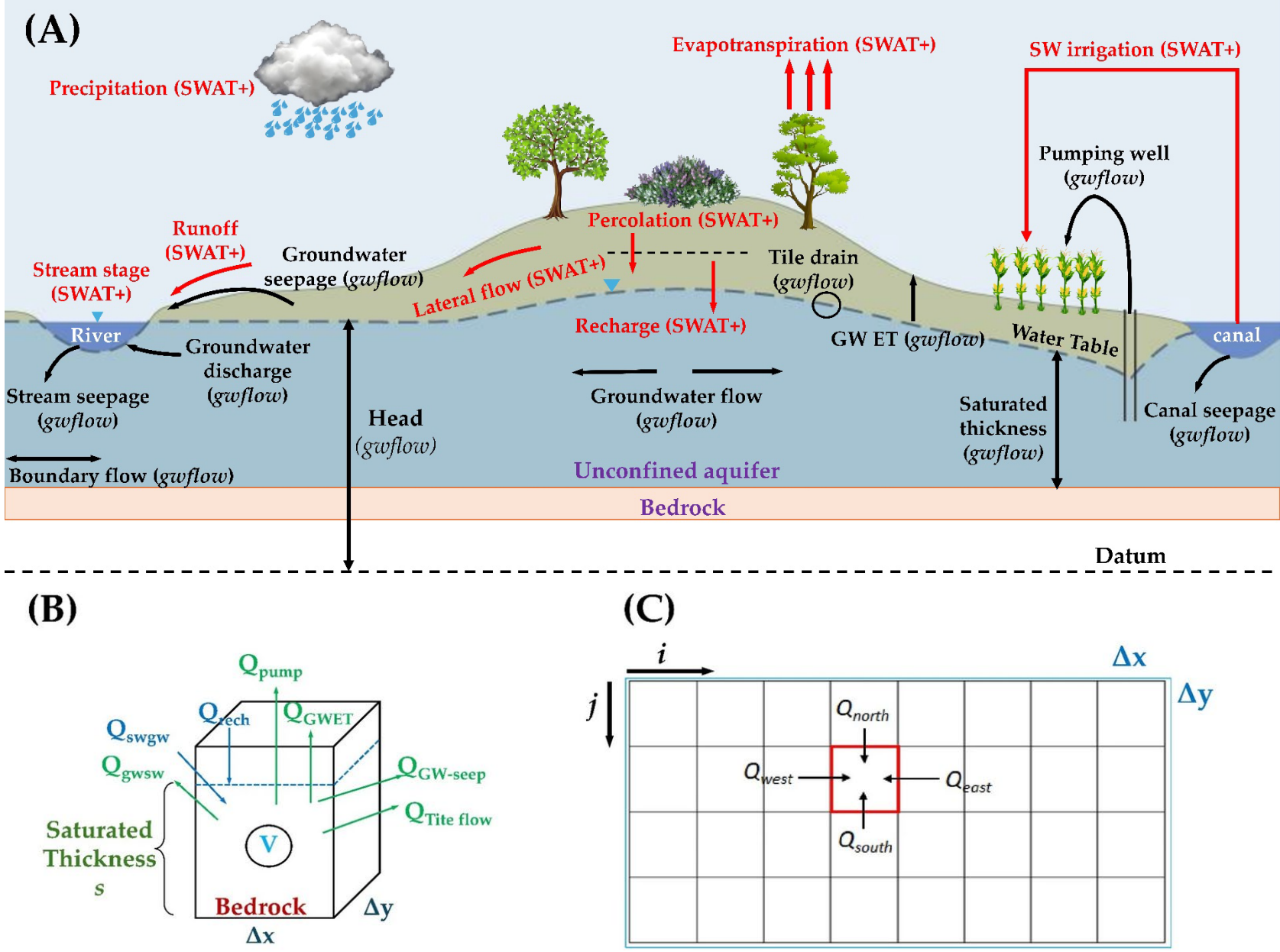
# Study region: Lower Arkansas River Basin (LARB)

- Semi-arid region (~300 mm annual rainfall)
- Intensively irrigated agricultural watershed
  - Canal diversions and groundwater pumping
- Area ≈ 64,000 km² (13 HUC-8 subbasins)
- Salinization increasing since 1970s due to irrigation return flows and salt buildup
- High shallow water tables (10–20 m) from over-irrigation
- Narrow valley (~10–15 km wide) over sandy alluvial aquifer



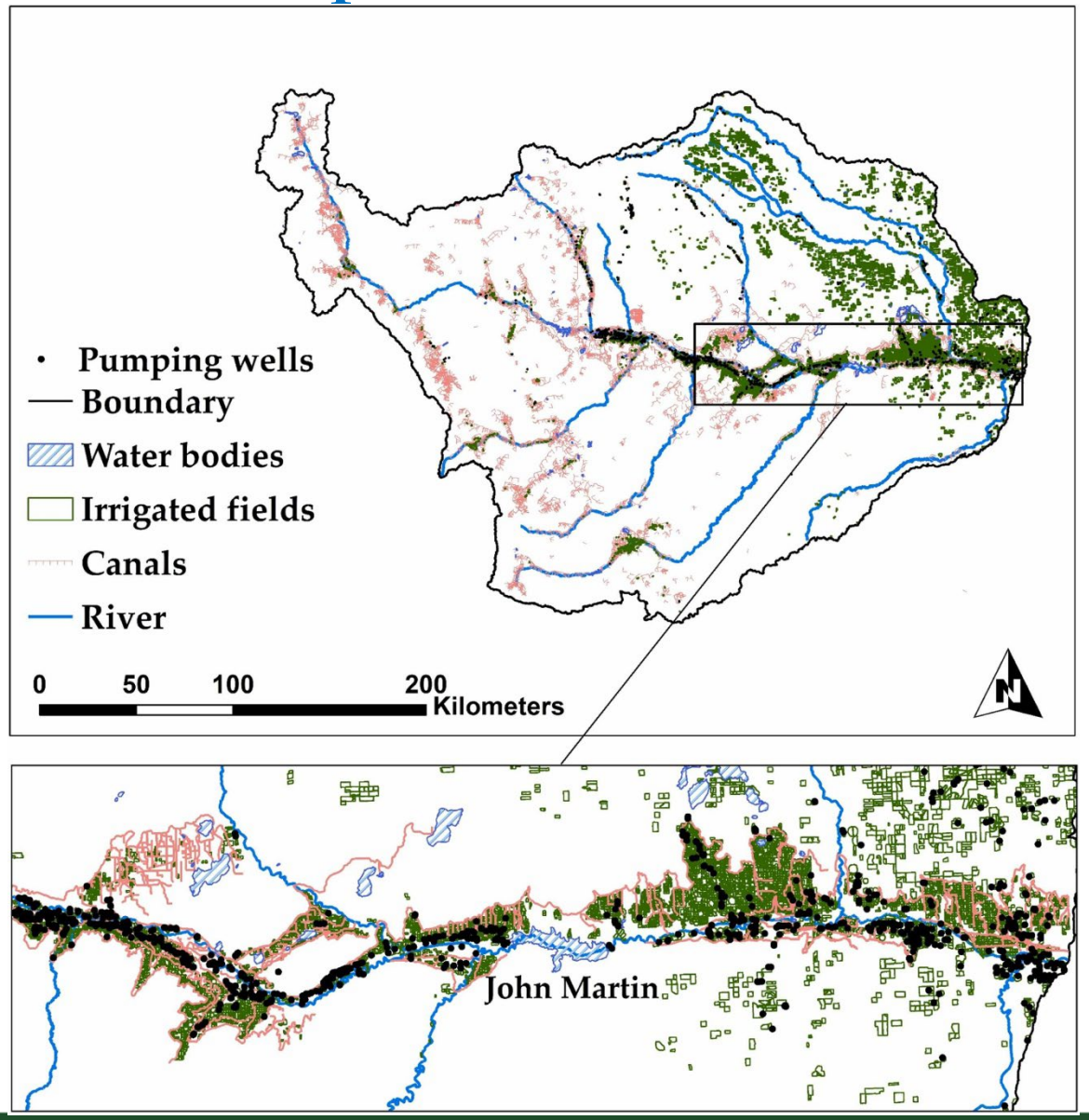
# Modeling framework

- SWAT traditionally represents groundwater in a simplified, lumped manner, assuming steady-state flow with no spatial connection between aquifer cells.
- *gwflow* module



# Hydrologic Model Setup

- Based on **National SWAT+ model (National Agroecosystem)** covering 13 HUC8 watersheds
- Enhanced with **gwflow module**
- Includes **~8,000 irrigation fields** and canal seepage processes
- Simulation period: 2000–2020

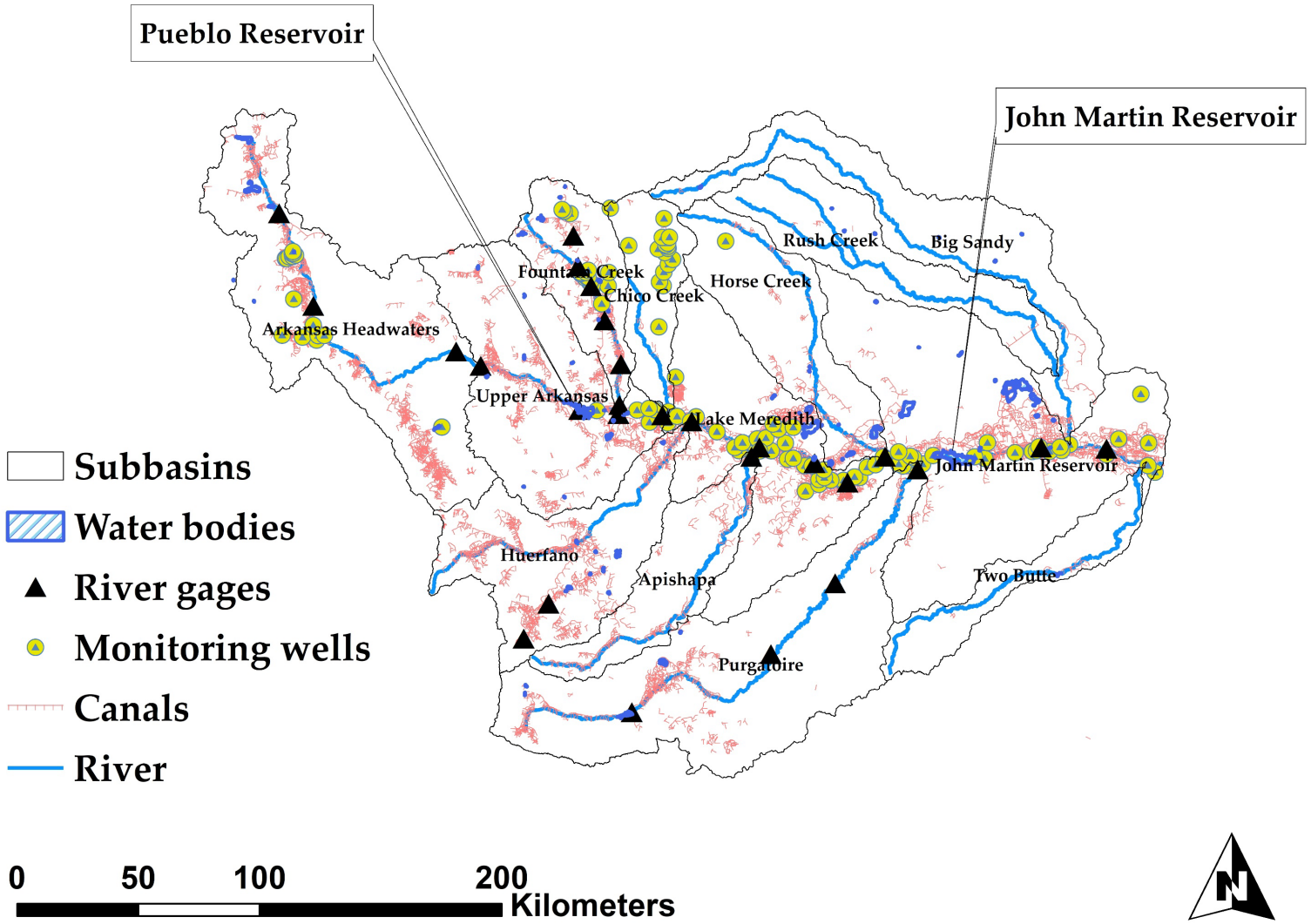


# Hydrologic Model: Calibration & Evaluation

- **Morris Screening** for key flux sensitivities

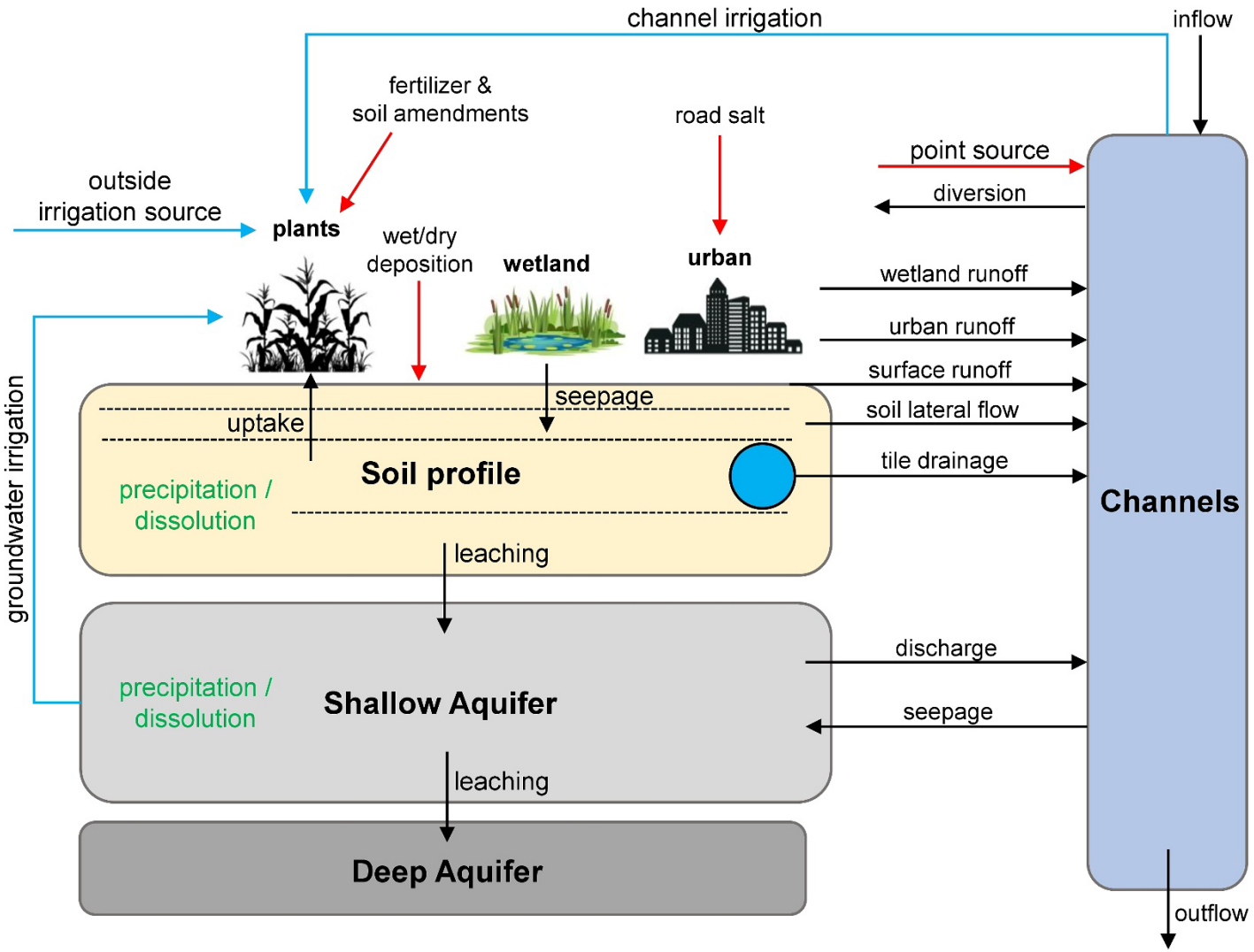
- **Iterative Ensemble Smoother (IES)** calibration using:
  - Monthly streamflow (24 stations)
  - Groundwater head (130 wells)

- Performance: **NSE = 0.53–0.94**, **MAE = 0.1 to 2.0 m**



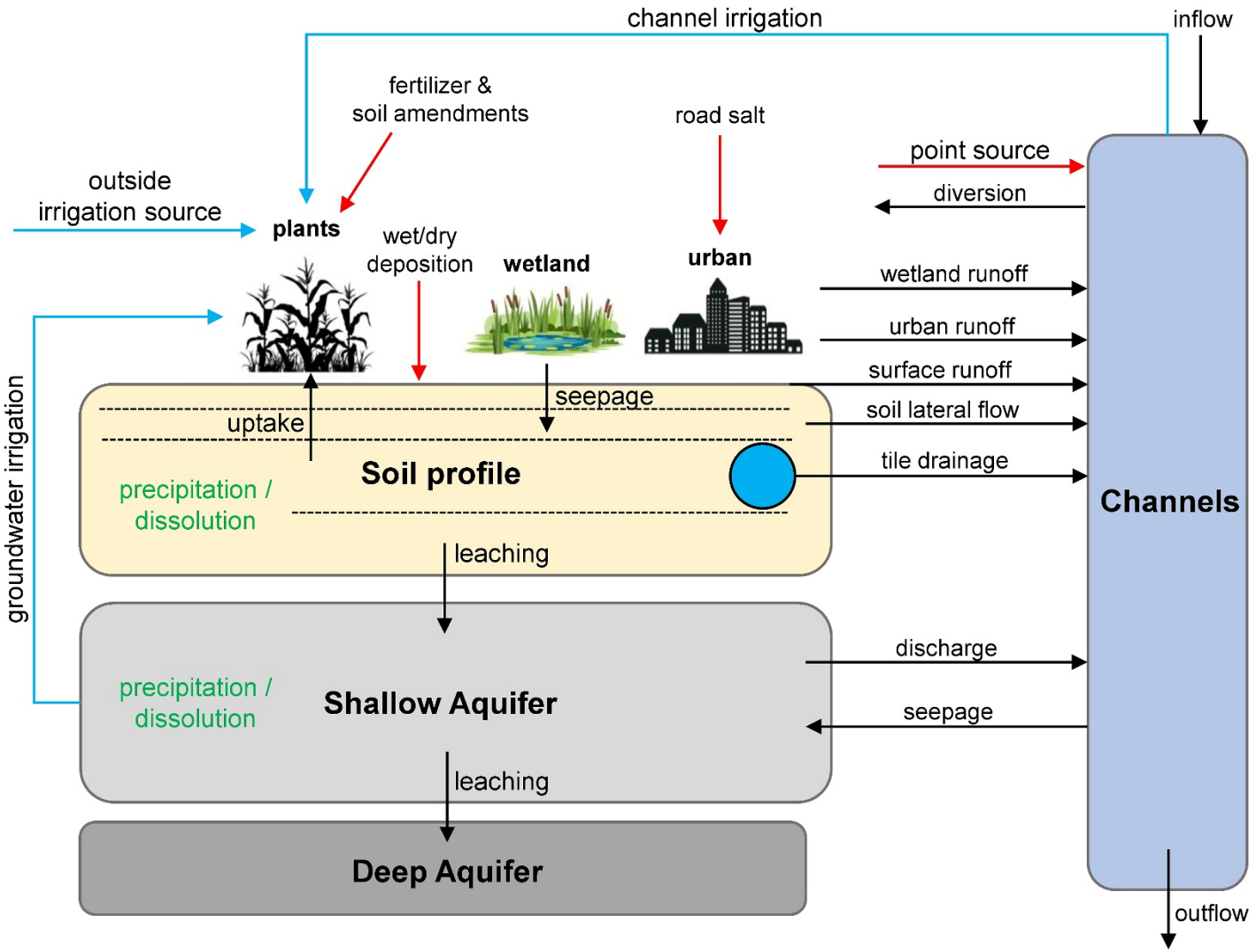
# Salt Transport Model

- Simulates surface–subsurface **salt dynamics** within the SWAT+*gwflow* framework
- Incorporates multiple salt sources: fertilizer, irrigation, road salt, and atmospheric deposition
- Simulates transport through **soil and shallow aquifer** layers
- Represents key processes: **precipitation/dissolution, leaching, seepage, uptake, and discharge**
- Ensures mass-balance consistency across surface, soil, and groundwater domains



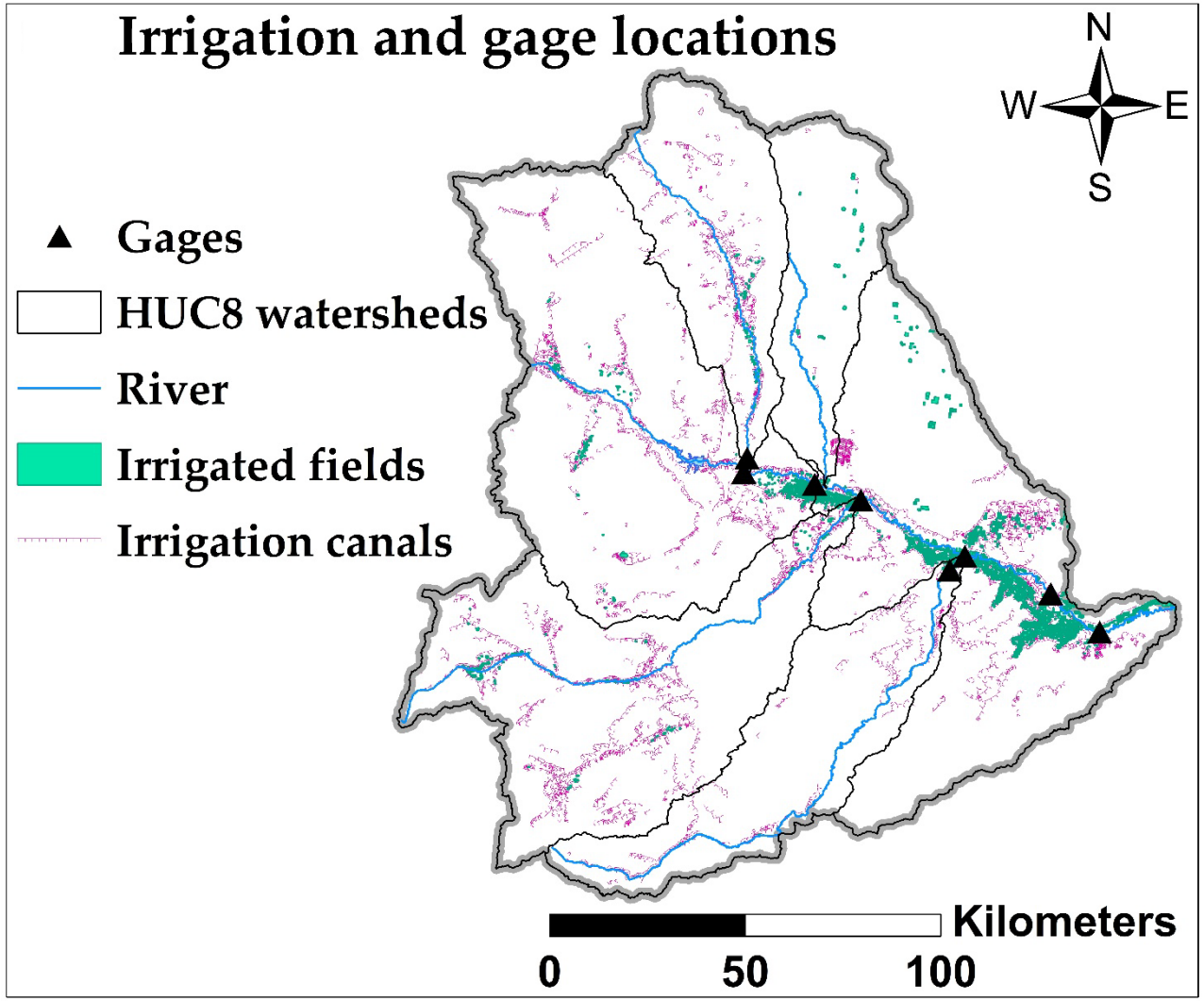
# Salt Transport Model

- salt_hru.ini
- salt_aqu.ini
- salt_channel.ini
- gwflow.solutes
- salt_road
- salt_urban
- salt_irrigation
- salt_plants
- salt_uptake
- salt_res

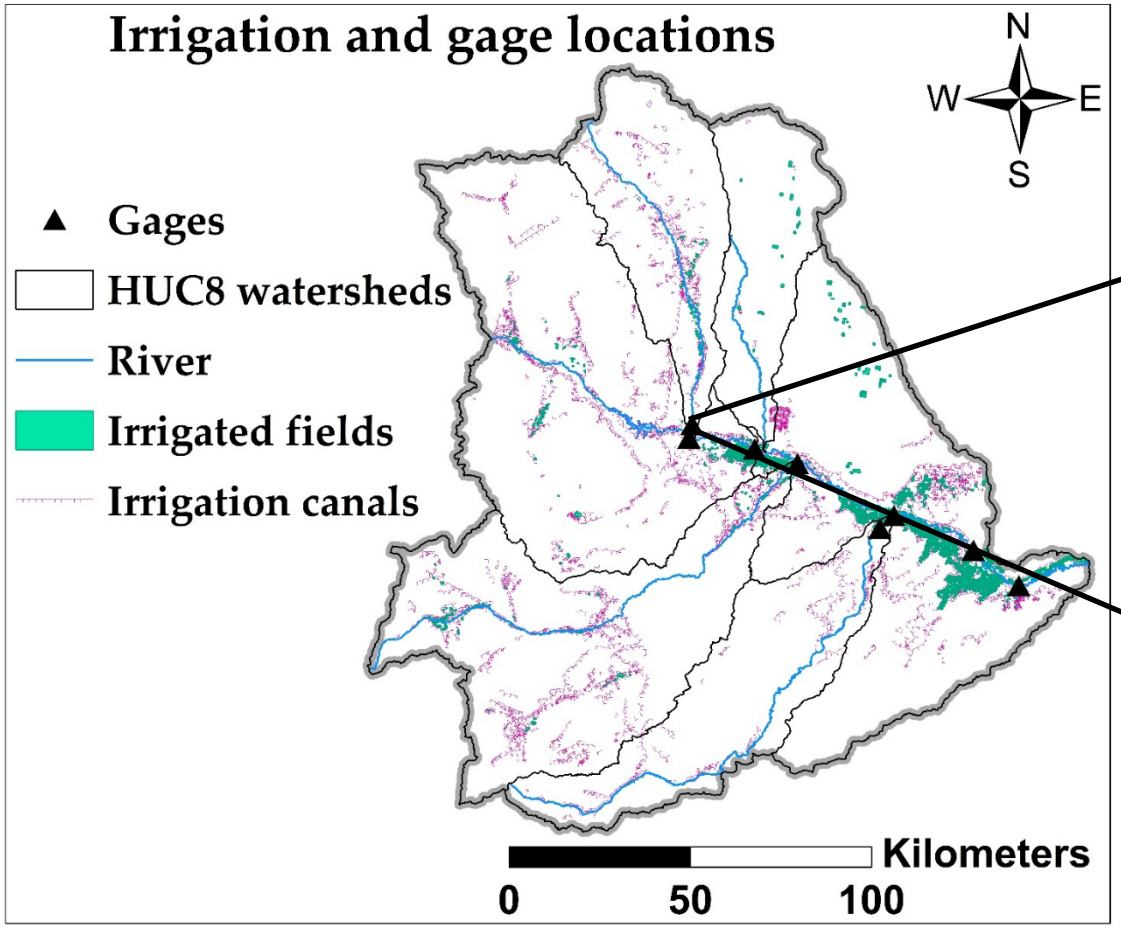


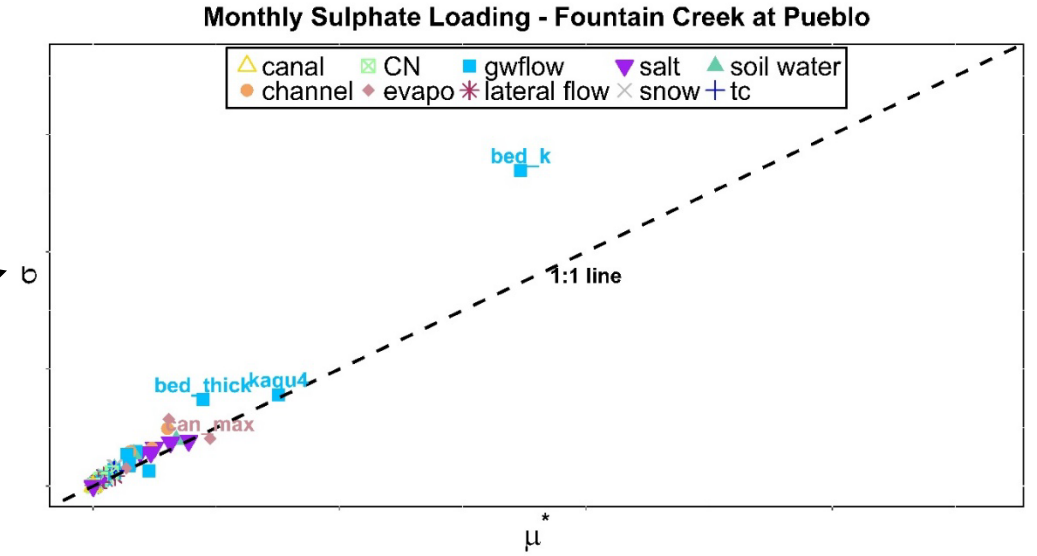
# Salt Transport Model

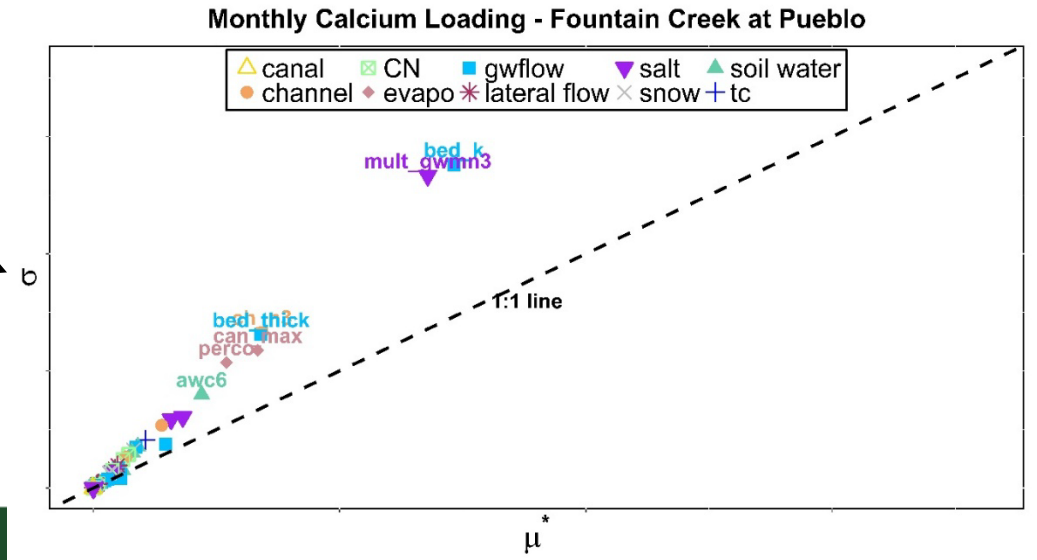
- 6 HUC8
- Fountain Creek, Chico Creek, Huerfano, Apishapa, Upper Arkansas, and Lake Meredith
- 6 Salt ions (SO4, Ca, Mg, K, Na, Cl).
- Model calibrated at 6 locations (salt loadings at monthly timestep).



# Global Sensitivity Analysis (GSA) for Salt Loadings



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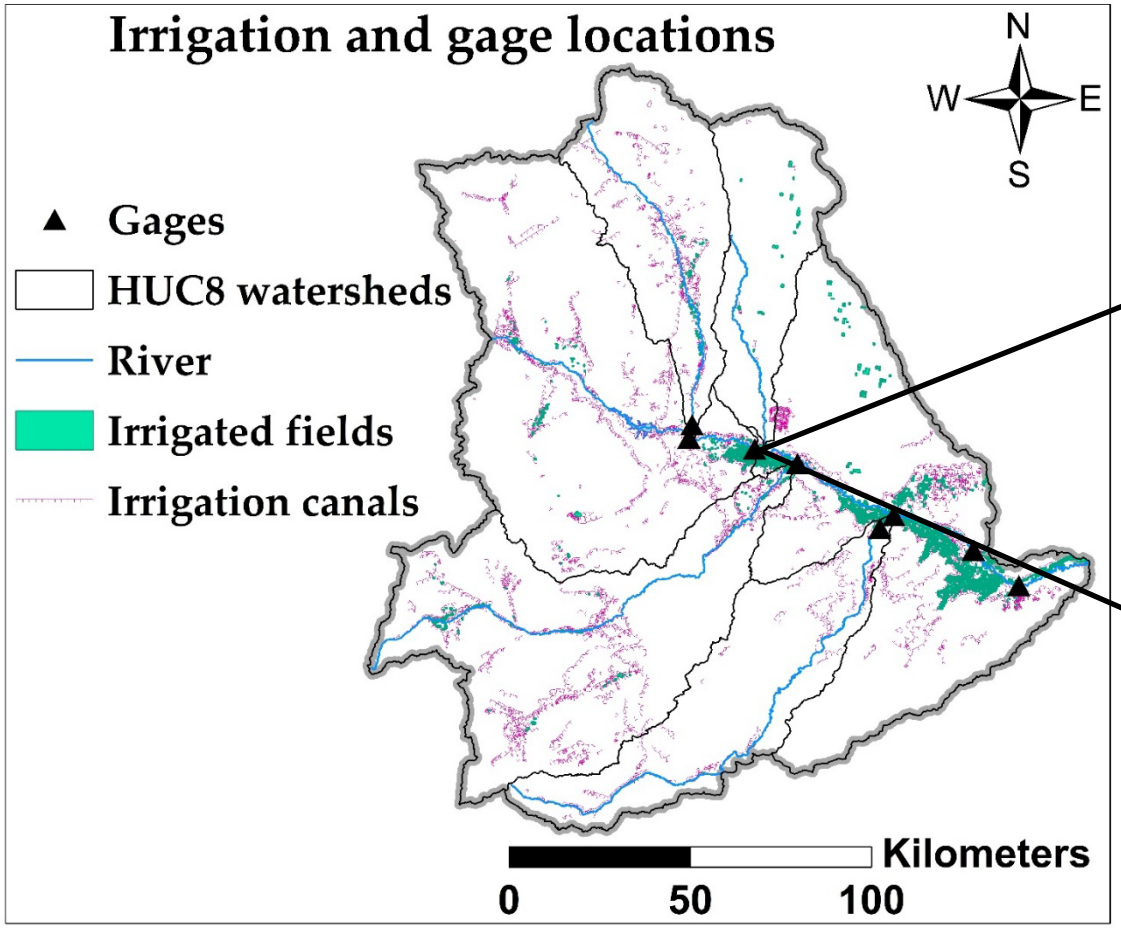
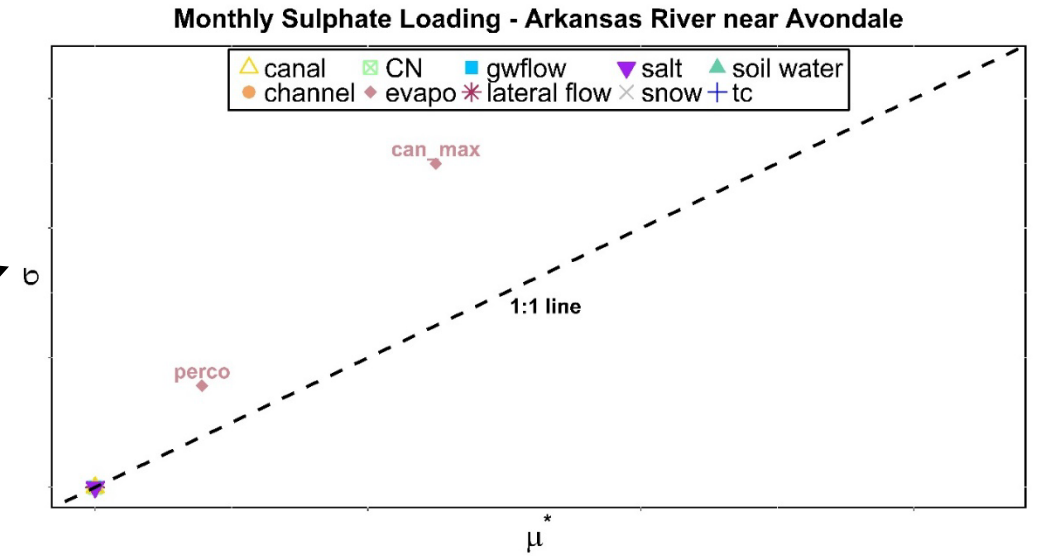
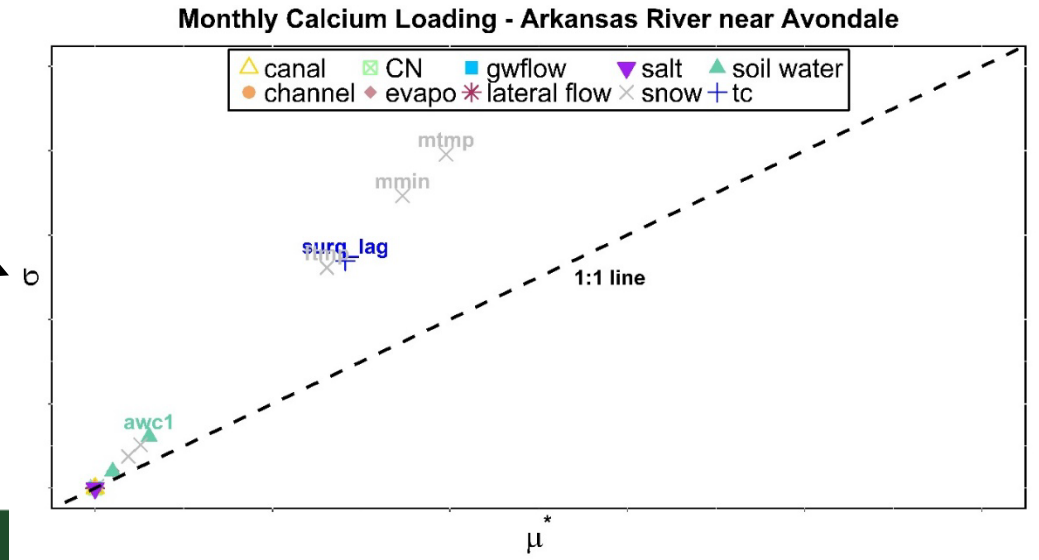
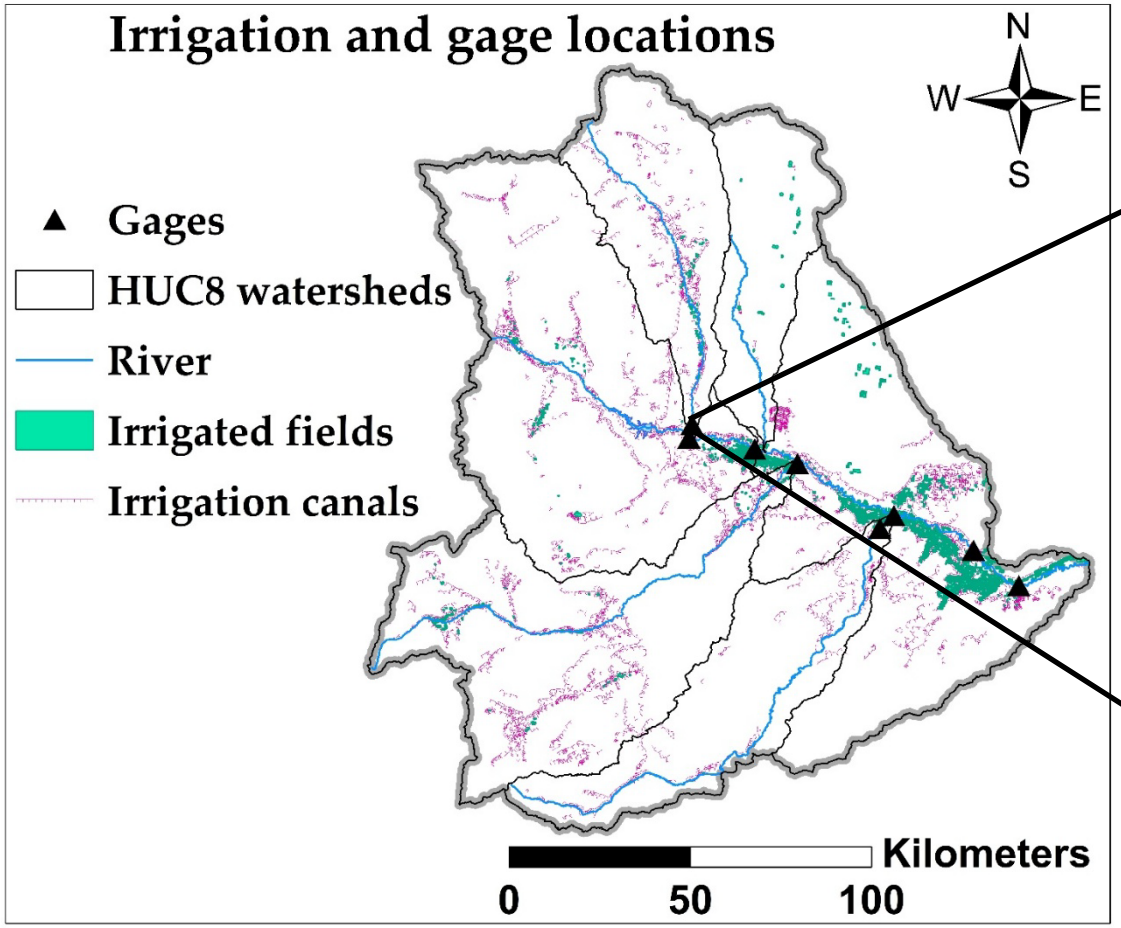
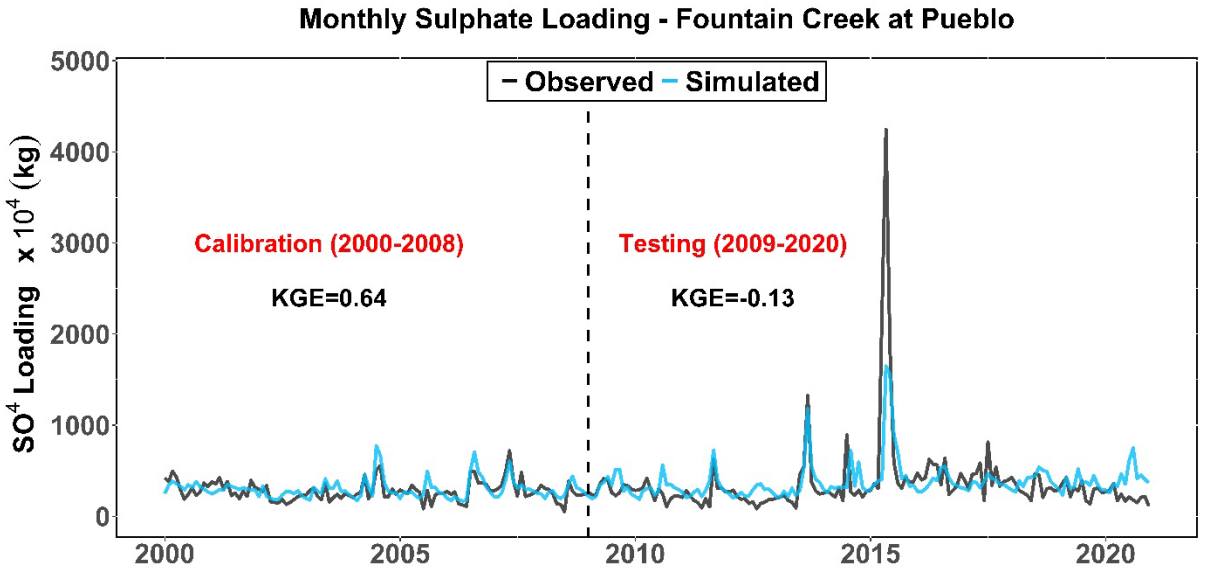


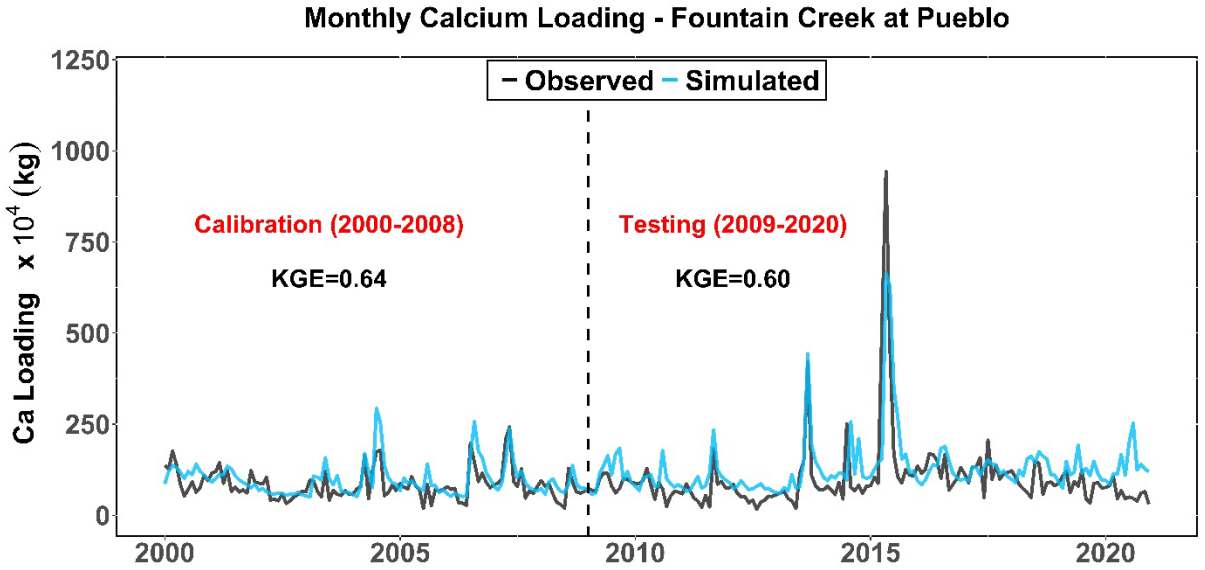



# Calibrated Salt Model



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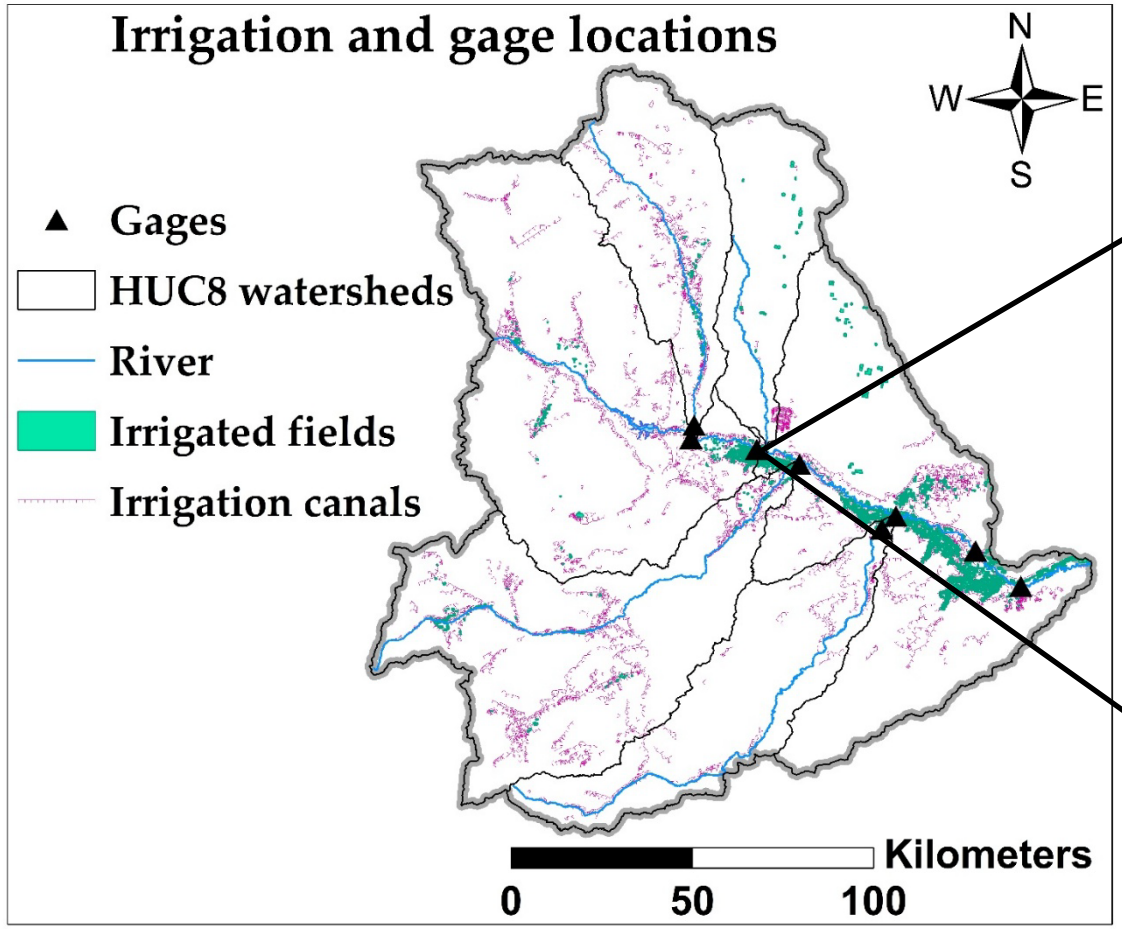


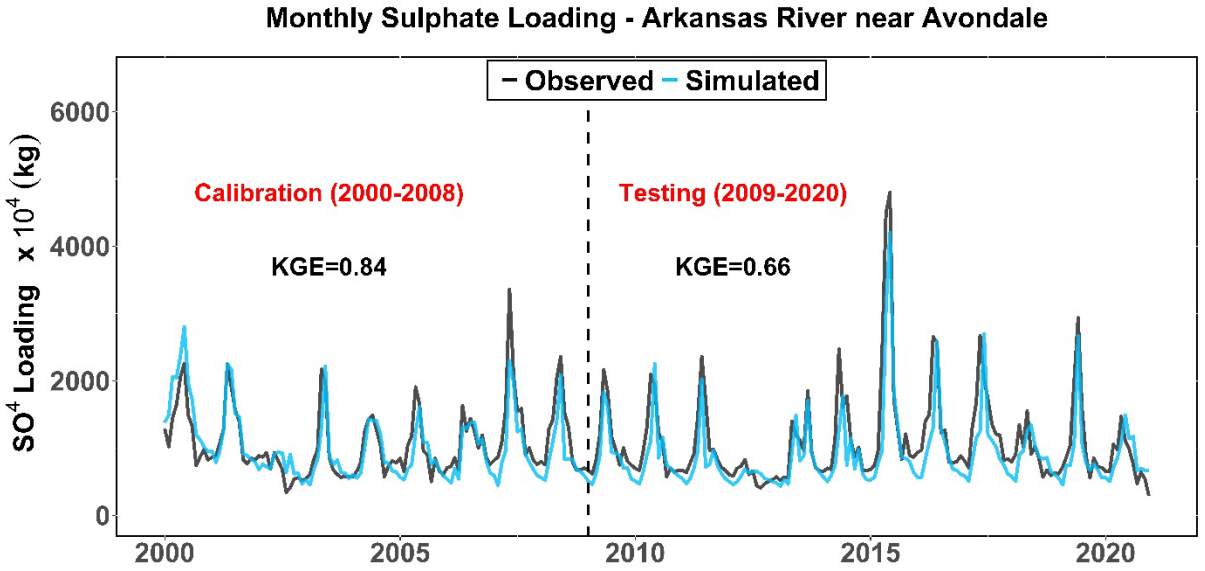


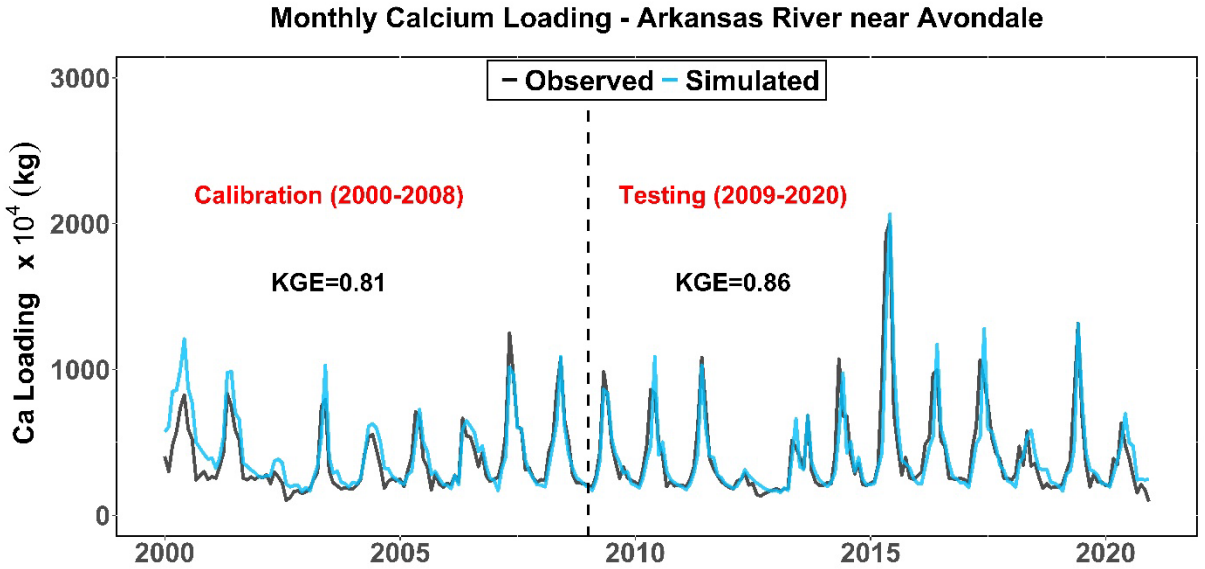

# Future Research Directions

- The **long-term goal** of this project is to reduce reliance on freshwater sources for irrigation and competing demands through **integrated modeling within the CFSM framework**.

- Future work will **evaluate agroecosystem responses**—including soil and stream salinity—under **scenarios of changing irrigation sources and climate variability** (wet and dry cycles).

# Thank you

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