Modeling Irrigation Systems in Semi-Arid Regions: Current Status & Emerging Needs for SWAT

Ryan T. Bailey
Timothy K. Gates
Miles Daly

Colorado State University

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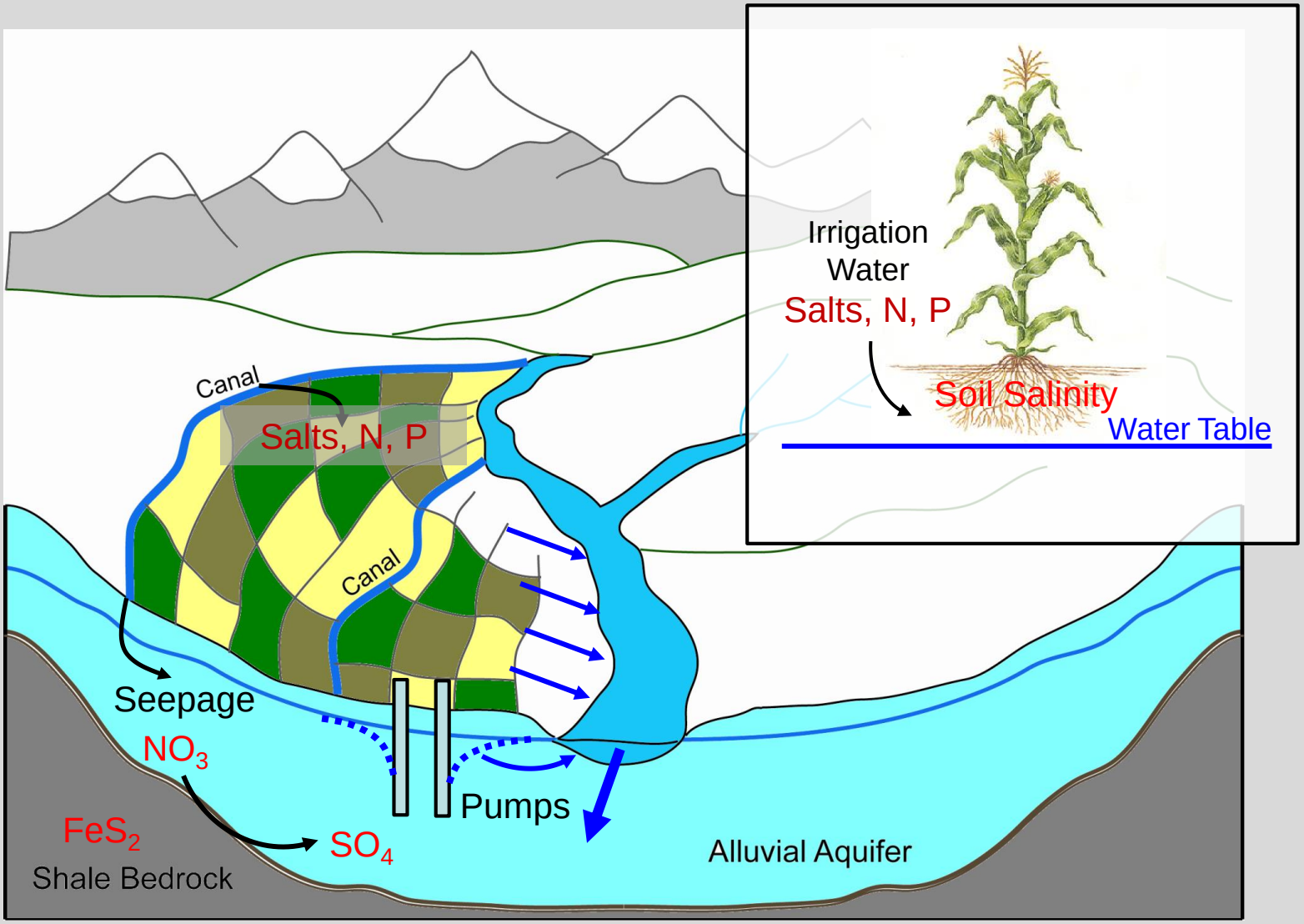
PURDUE UNIVERSITY

Irrigated Stream-Aquifer Systems



Motivation

Simulate water flow and solute transport in irrigated watersheds, under varying management scenarios.

- Effect of high water tables on crop yield (waterlogging; soil salinity)
- Effect of high water tables on municipal infrastructure
- Water rights: Effect of groundwater pumping on nearby streams
- Irrigation groundwater return flows to streams
- Nutrient leaching: effect on groundwater quality, loadings to streams
- Groundwater salinity: effect on groundwater quality, loading to streams

Water Quantity

Water Quality

Outline

1. Irrigation Patterns
2. Salinity (Soil, Groundwater, Loading to Streams)
3. Tile Drains (“Drainsheds”)
4. Water Rights: Groundwater vs. Surface Water

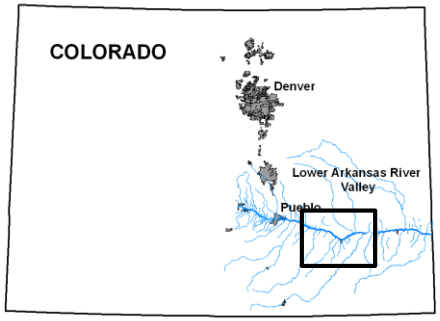
Irrigation Patterns

Irrigation Patterns

Salinity

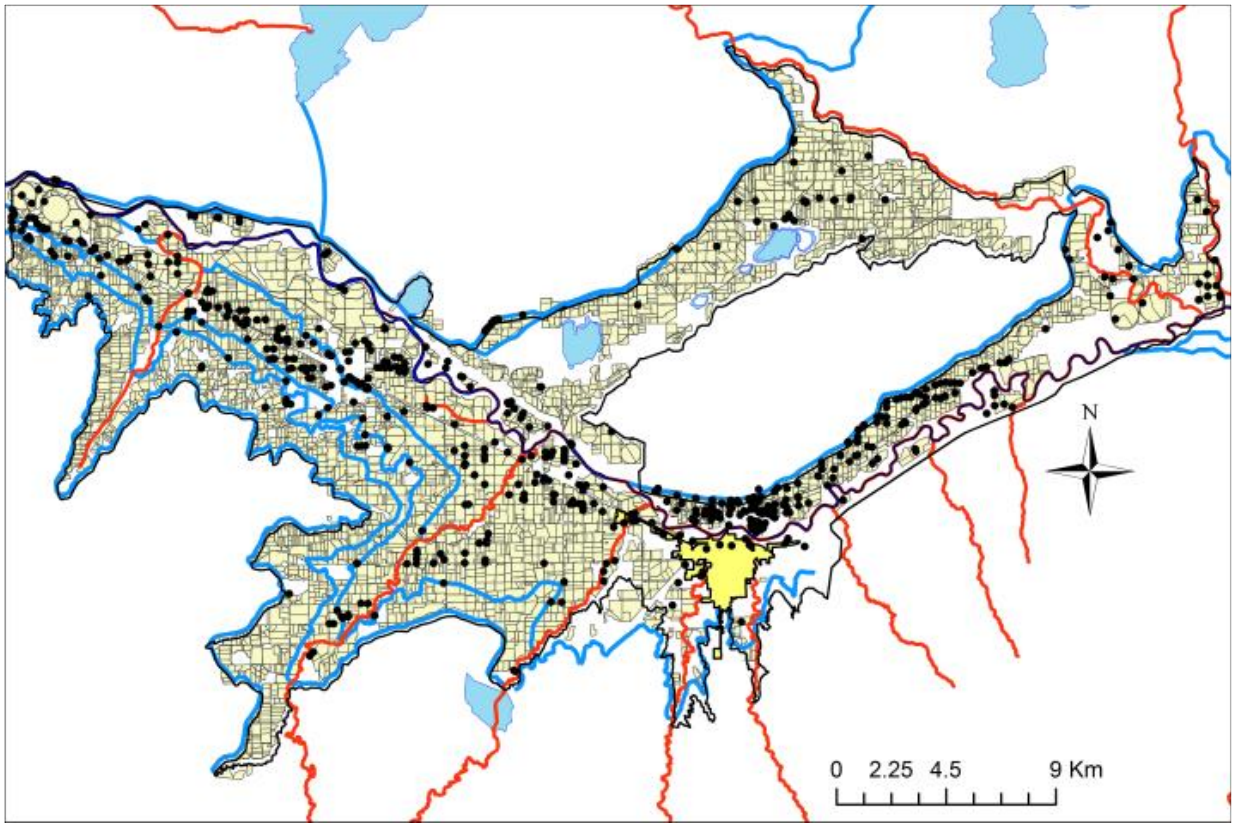
Tile Drains

Water Rights

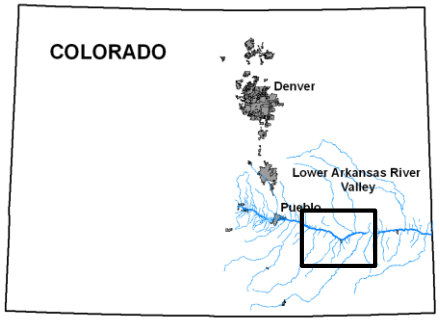


Lower Arkansas River Basin

- Irrigation: Canals (earthen)
- Irrigation: Groundwater Pumping
- Canal seepage



Irrigation Patterns



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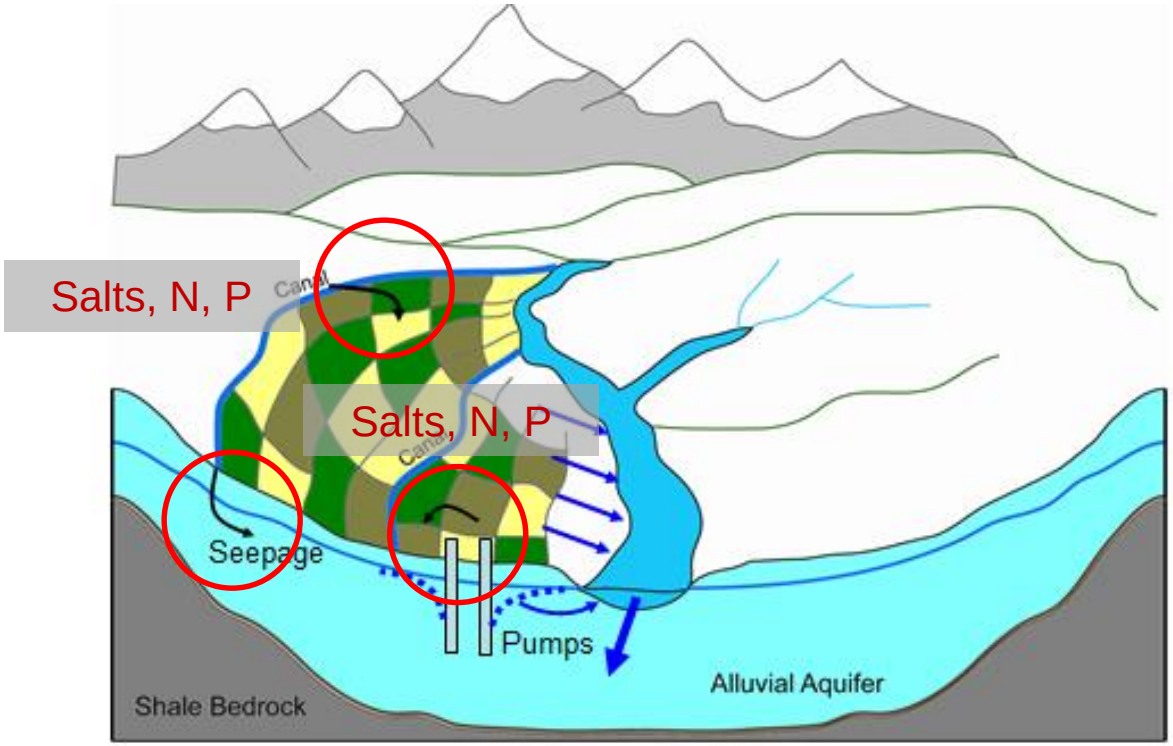


Salinity

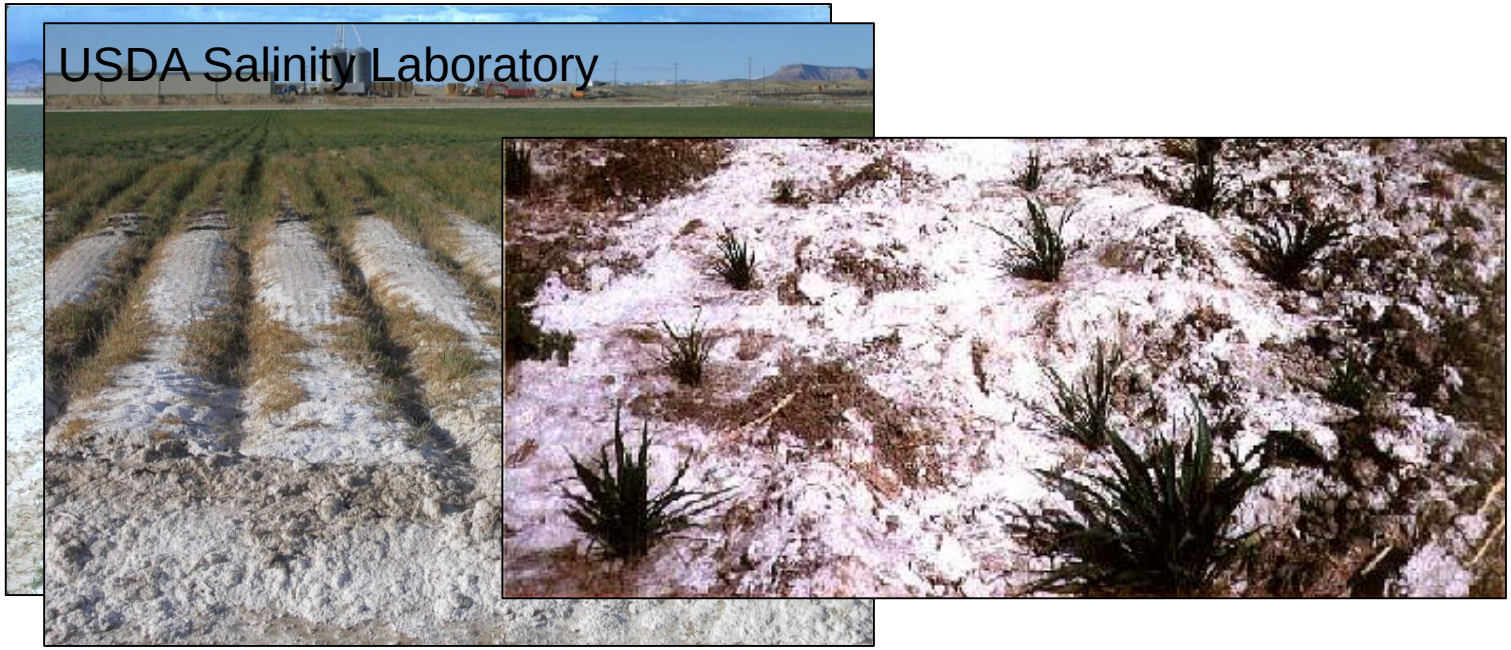
Semi-arid agricultural areas:

- Excessive irrigation
- Seepage from earthen canals
- Inefficient drainage systems
- → Evaporative concentration

→ High soil salinity
High groundwater salinity

↓

Reduction in crop yield



Salinity

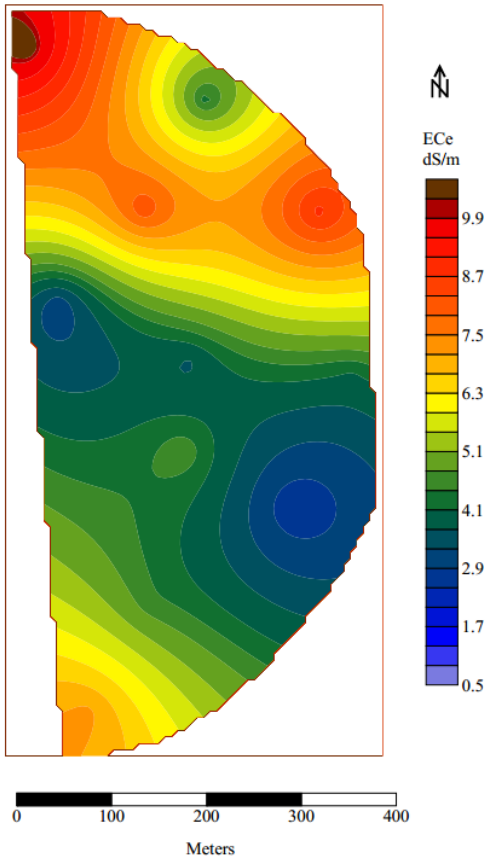
Irrigation Patterns

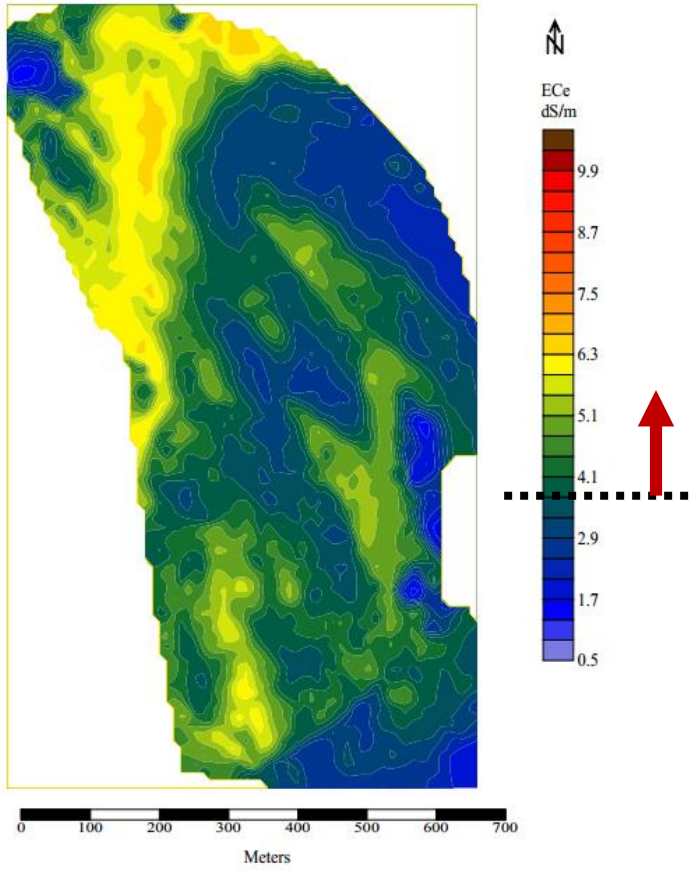
Salinity

Tile Drains

Water Rights

South Platte River Basin





Salinity

Irrigation Patterns

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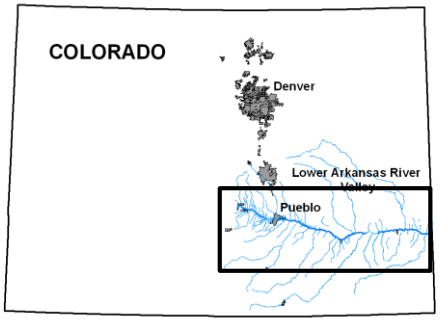
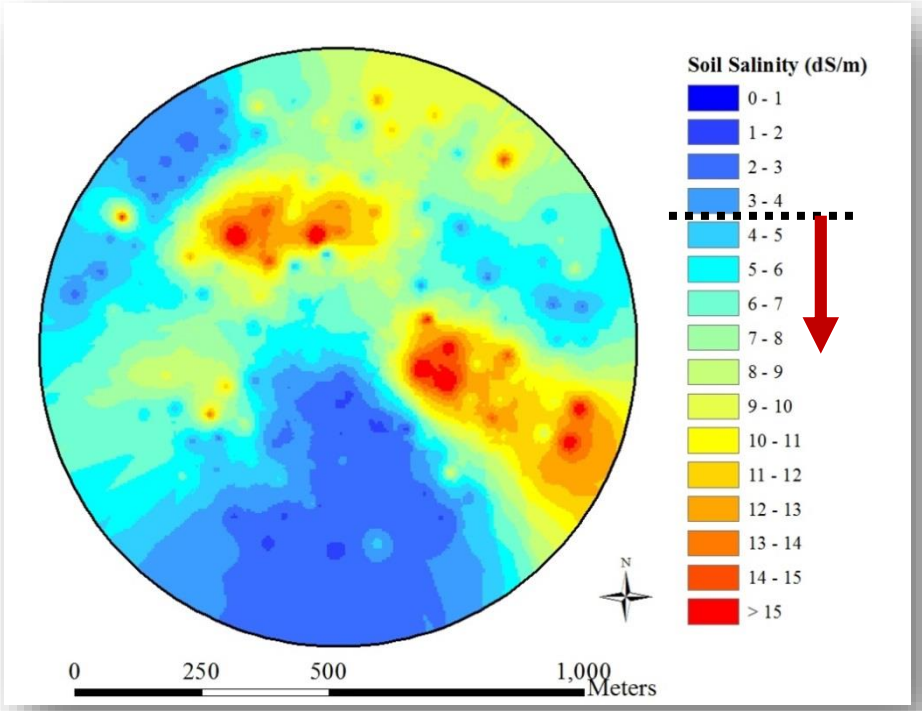
Lower Arkansas River Basin





Salinity

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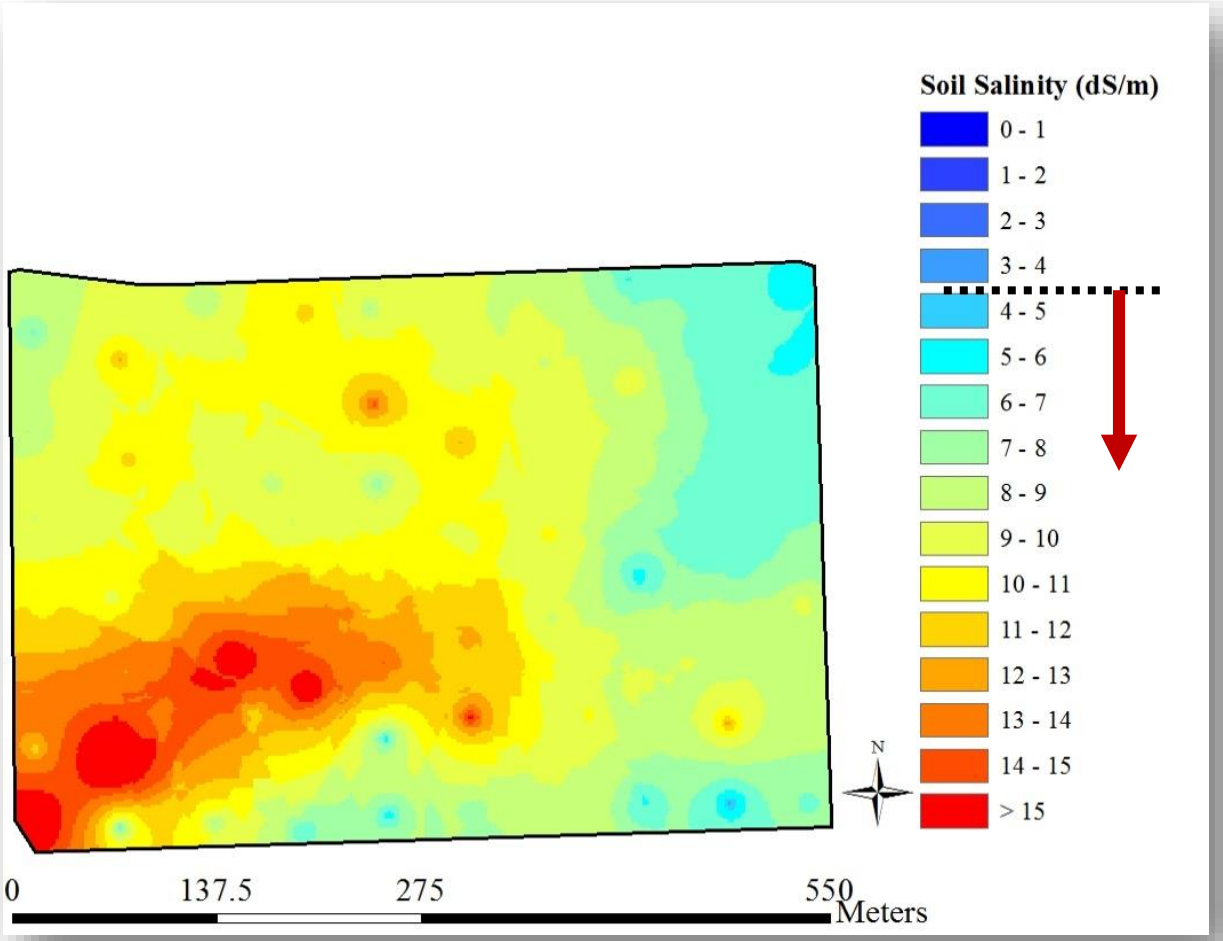

Salinity

Irrigation Patterns

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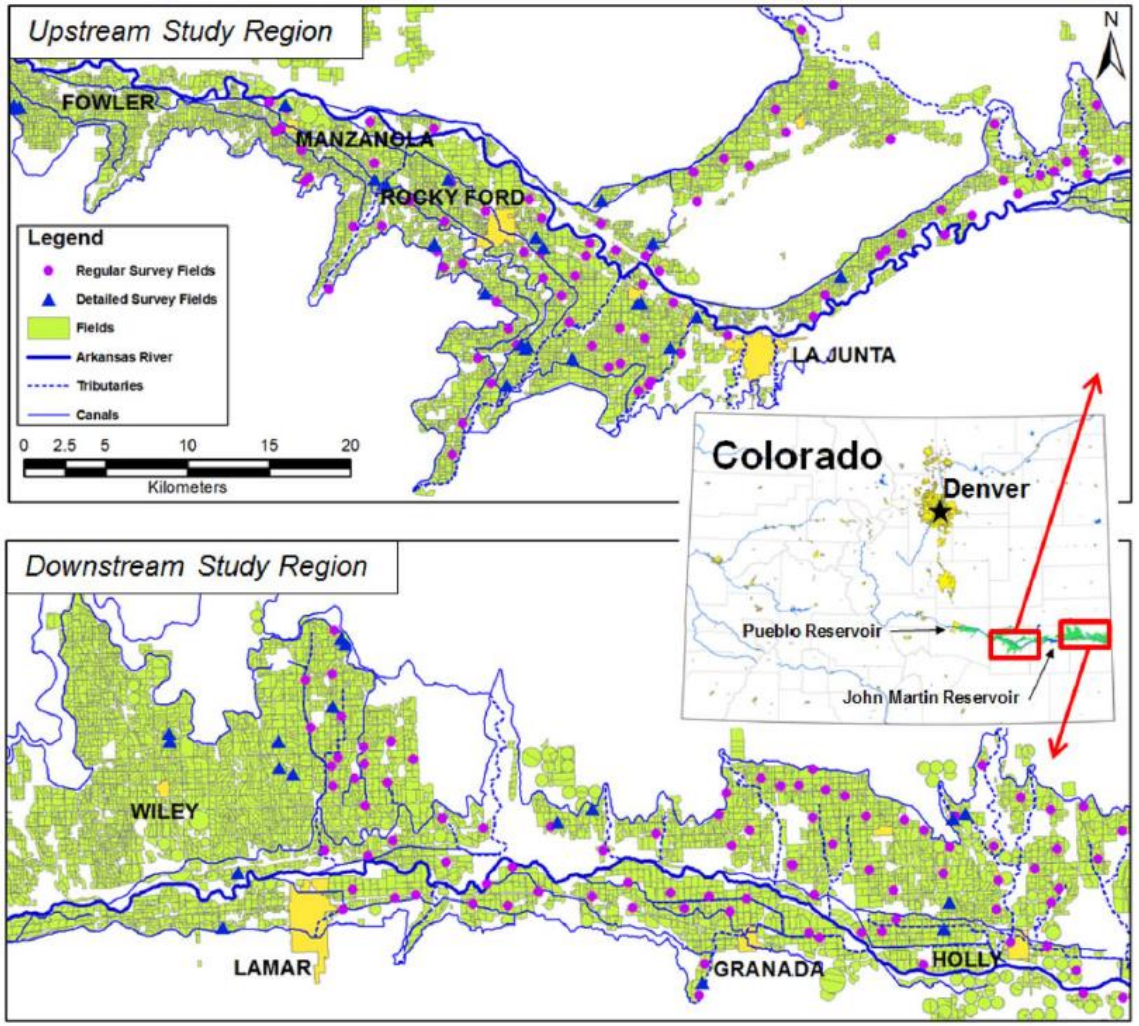

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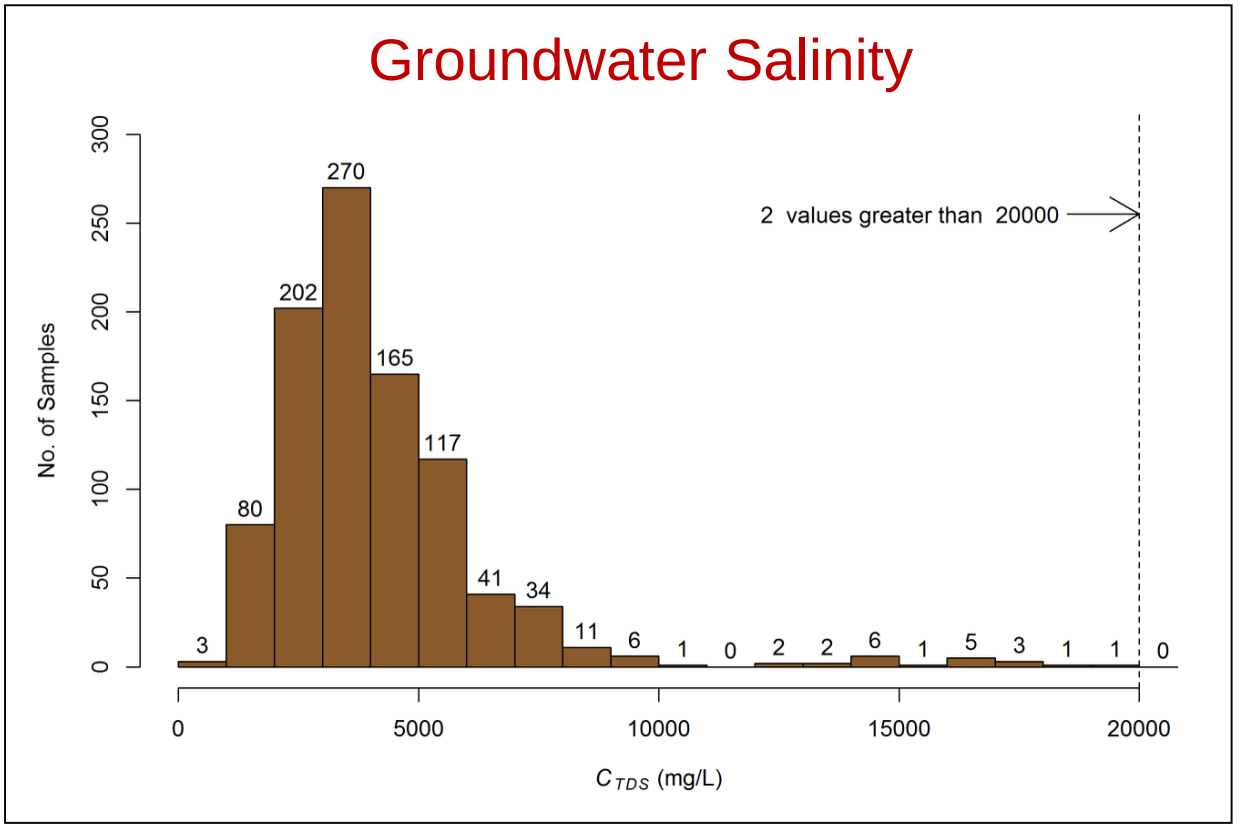

Salinity

Irrigation Patterns

Salinity

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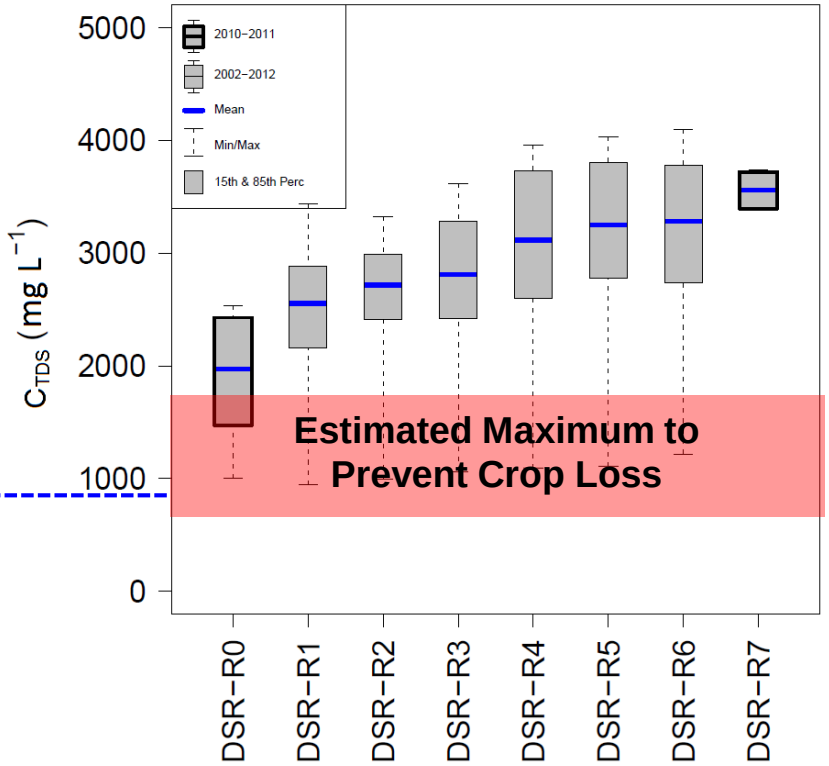
Water Rights

River Water Salinity

~ 900 mg/L

Freshwater Limit (WHO)



Salinity

Irrigation Patterns

Salinity

Tile Drains

Water Rights

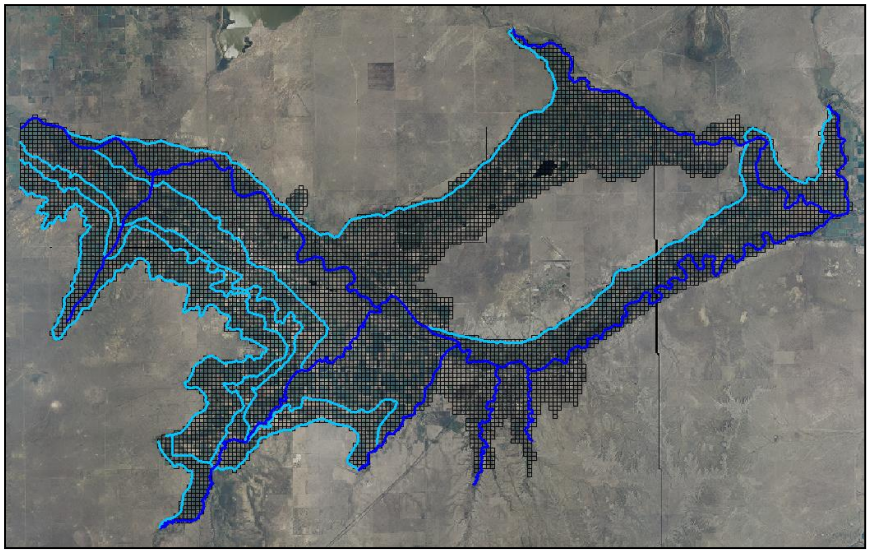
Assess Impact of BMPs on Salinity

- Soil Salinity
- Groundwater Salinity
- Salt loads to River

Modeling: Groundwater Flow and Transport Model

MODFLOW
+
RT3D

1. Sulfur Cycling
2. Major Ion Chemistry
3. Precipitation-Dissolution



Salinity

Irrigation Patterns

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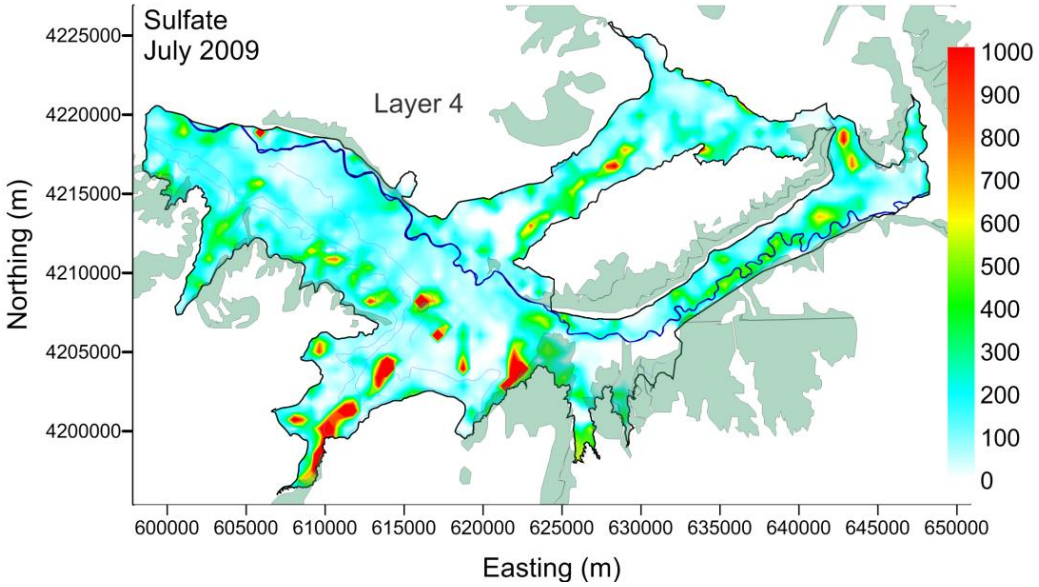
Modeling: Groundwater Flow and Transport Model

SO_4 Groundwater concentration



Salinity

Irrigation Patterns

Salinity

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Water Rights

Assess Impact of BMPs on Salinity

- Soil Salinity
- Groundwater Salinity
- Salt loads to River

Modeling: Groundwater Flow and Transport Model

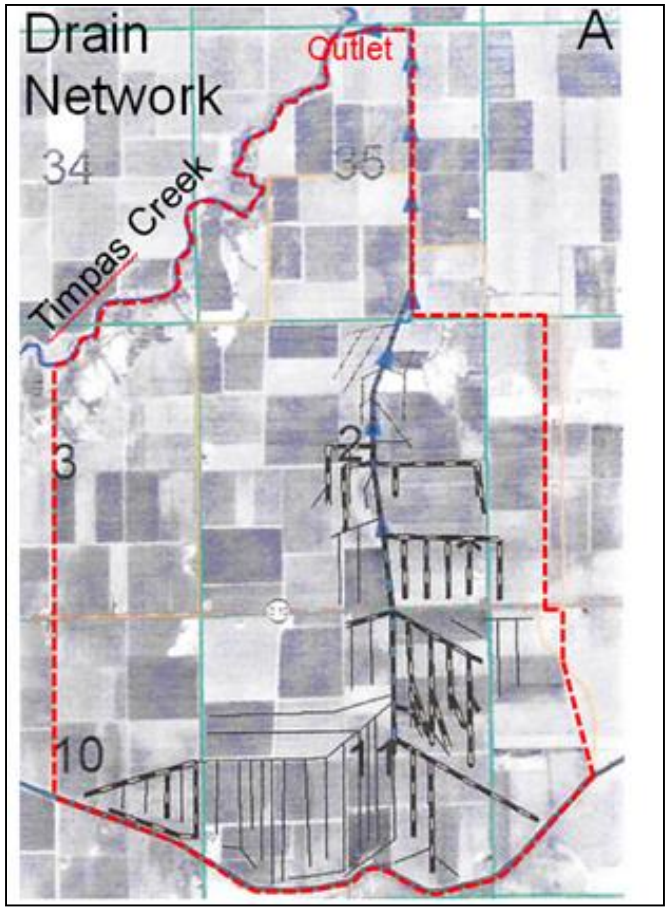
SWAT

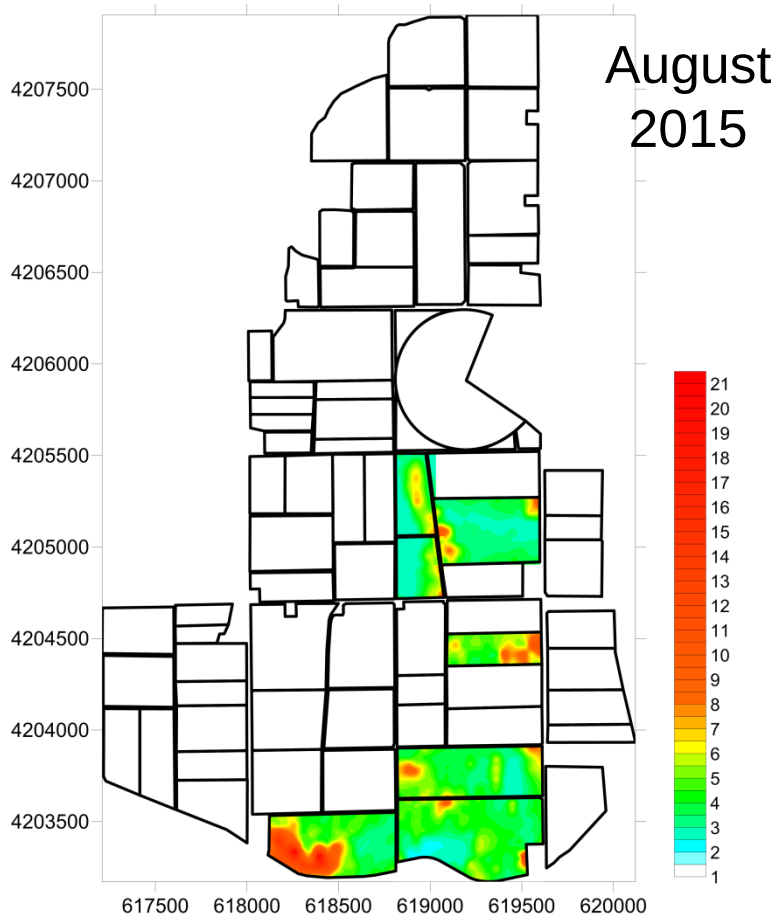
(SWAT-MODFLOW)

Salinity Module

Tile Drains

- Irrigation Patterns
- Salinity
- **Tile Drains**
- Water Rights





Loading of: Salt

Nutrients (N,P)

Trace Metals (Se, U)

Tile Drains

Irrigation Patterns

Salinity

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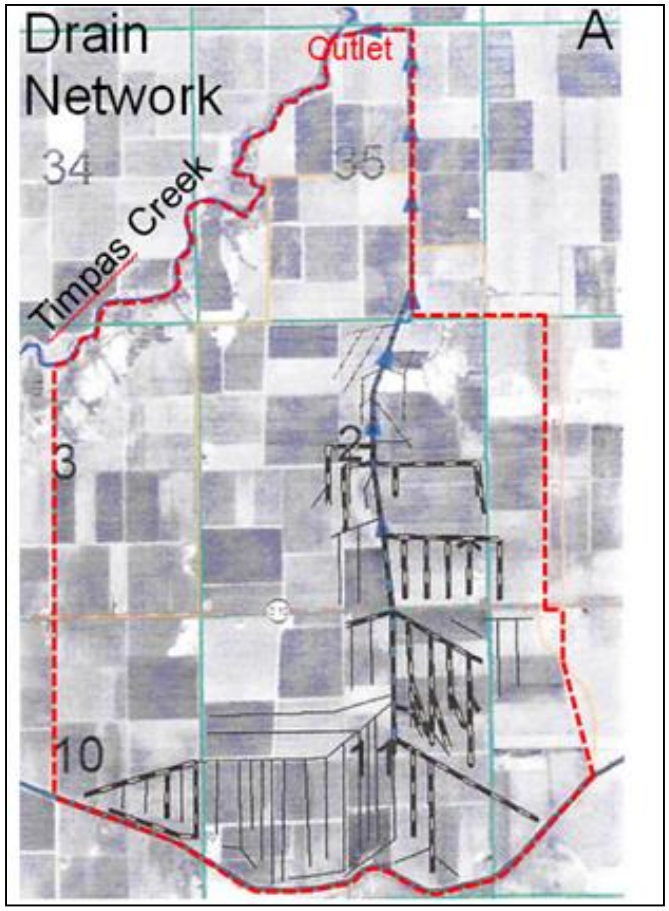
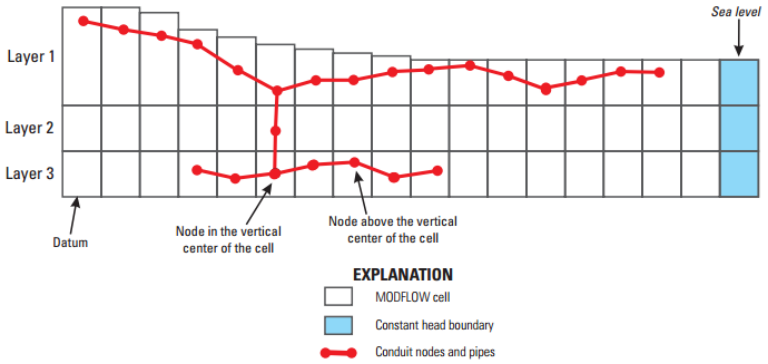
Water Rights



Modeling

MODFLOW
Conduit Flow Package



+

MT3D CFP (Solute Transport)

→ SWAT capabilities for Tile Drain Flow

Water Rights

Irrigation Patterns

Salinity

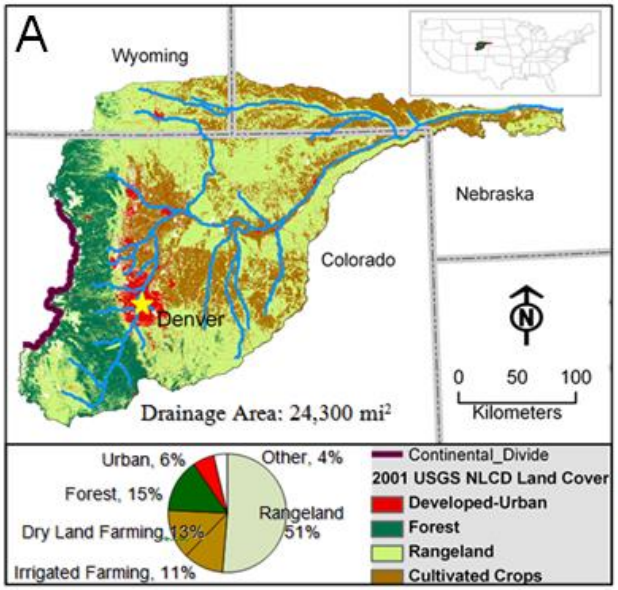
Tile Drains

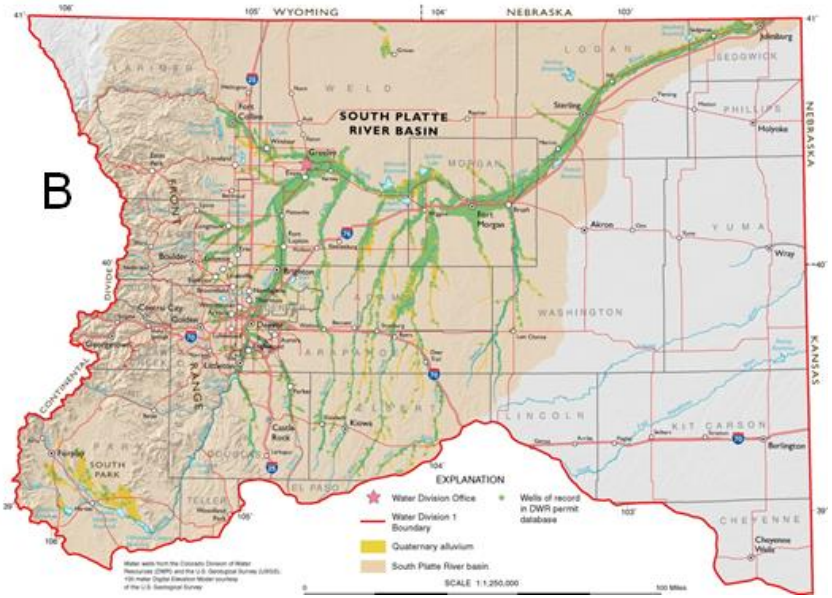
Water Rights

The use of water in many of the states in the western U.S. is governed by the doctrine of Prior Appropriation.
(also known as the "Colorado Doctrine" of water law)

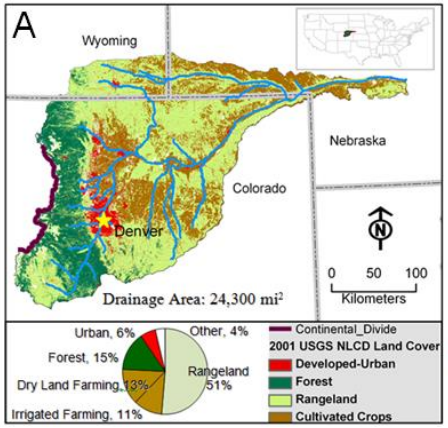
Allocation of Water = “First in Time, First in Right”

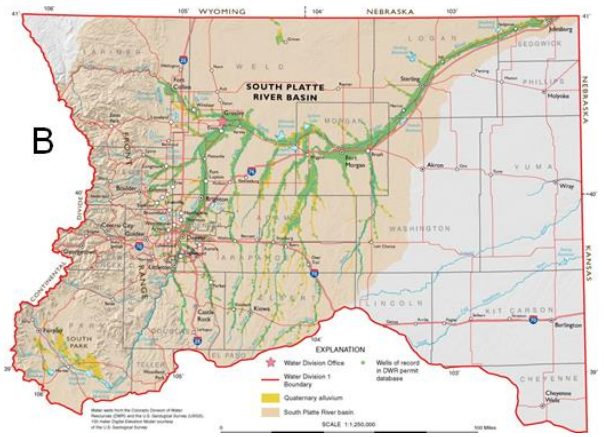
South Platte River Basin



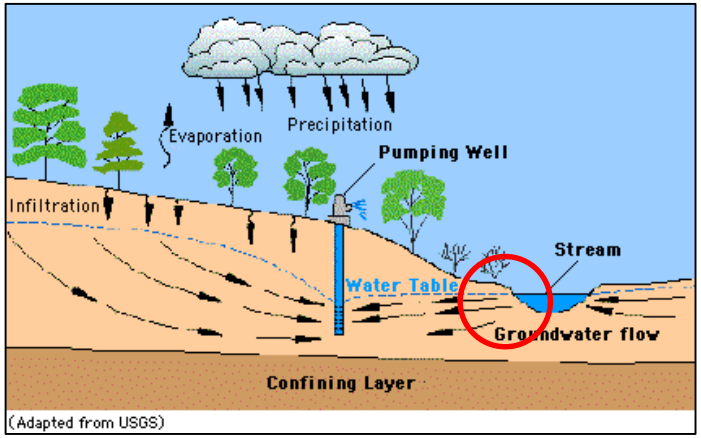


Water Rights





- By 1965: 10,000 wells drilled in South Platte Basin
- 2003 (drought): 3,000 not allowed to pump
- May 7, 2006: 440 wells shutdown



Water Rights

Irrigation Patterns

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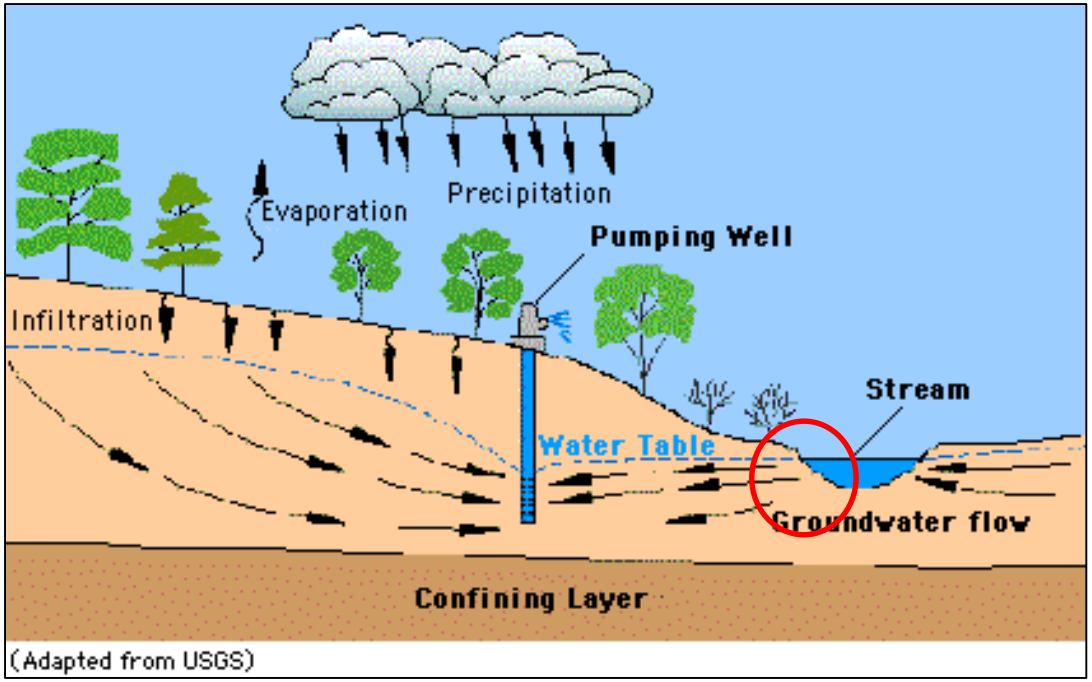
Water Rights

Augmentation Plans

Pump Groundwater → Estimate Stream Depletion → Add recharge water to mimic return flows to stream



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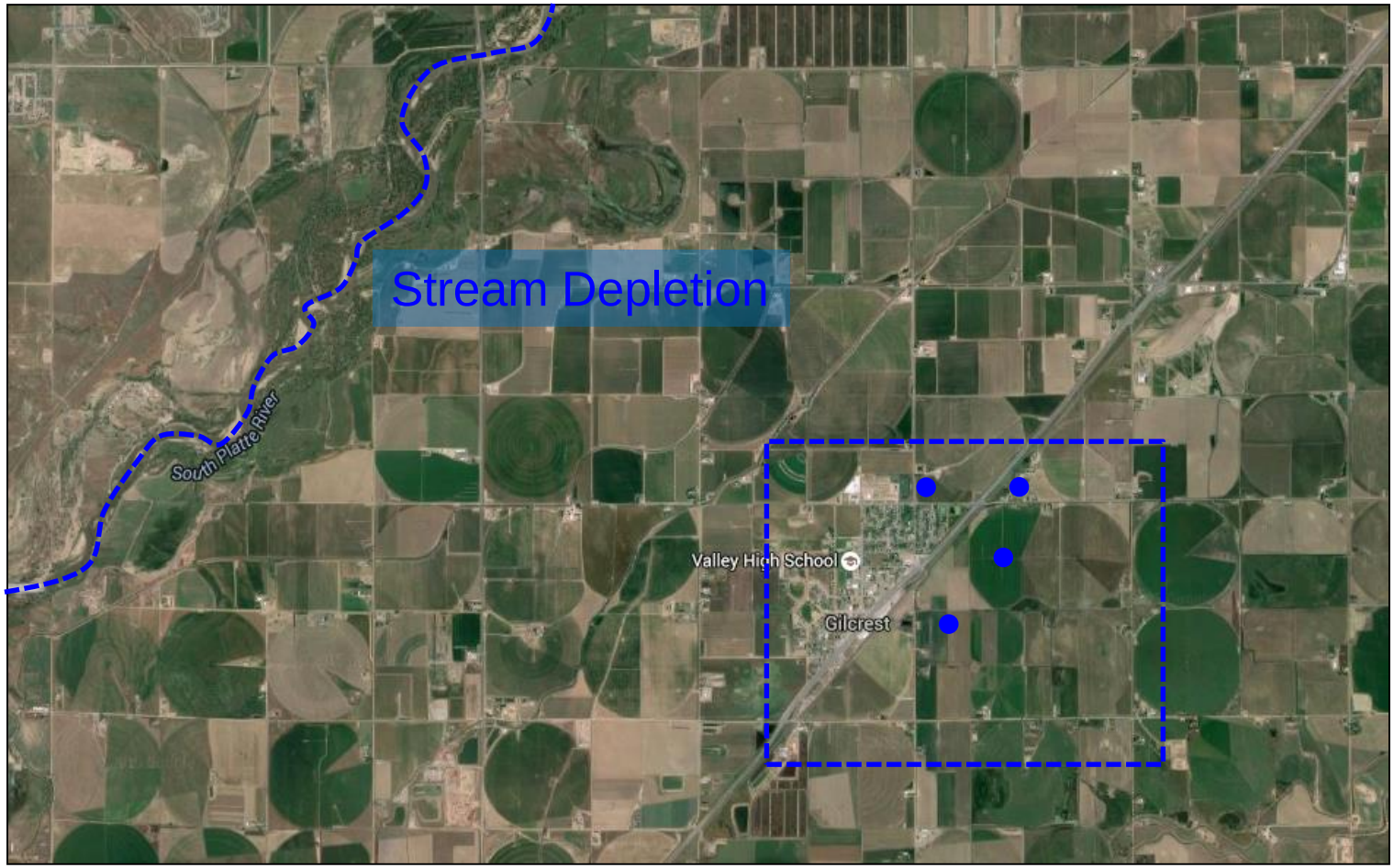
South Platte River



Water Rights

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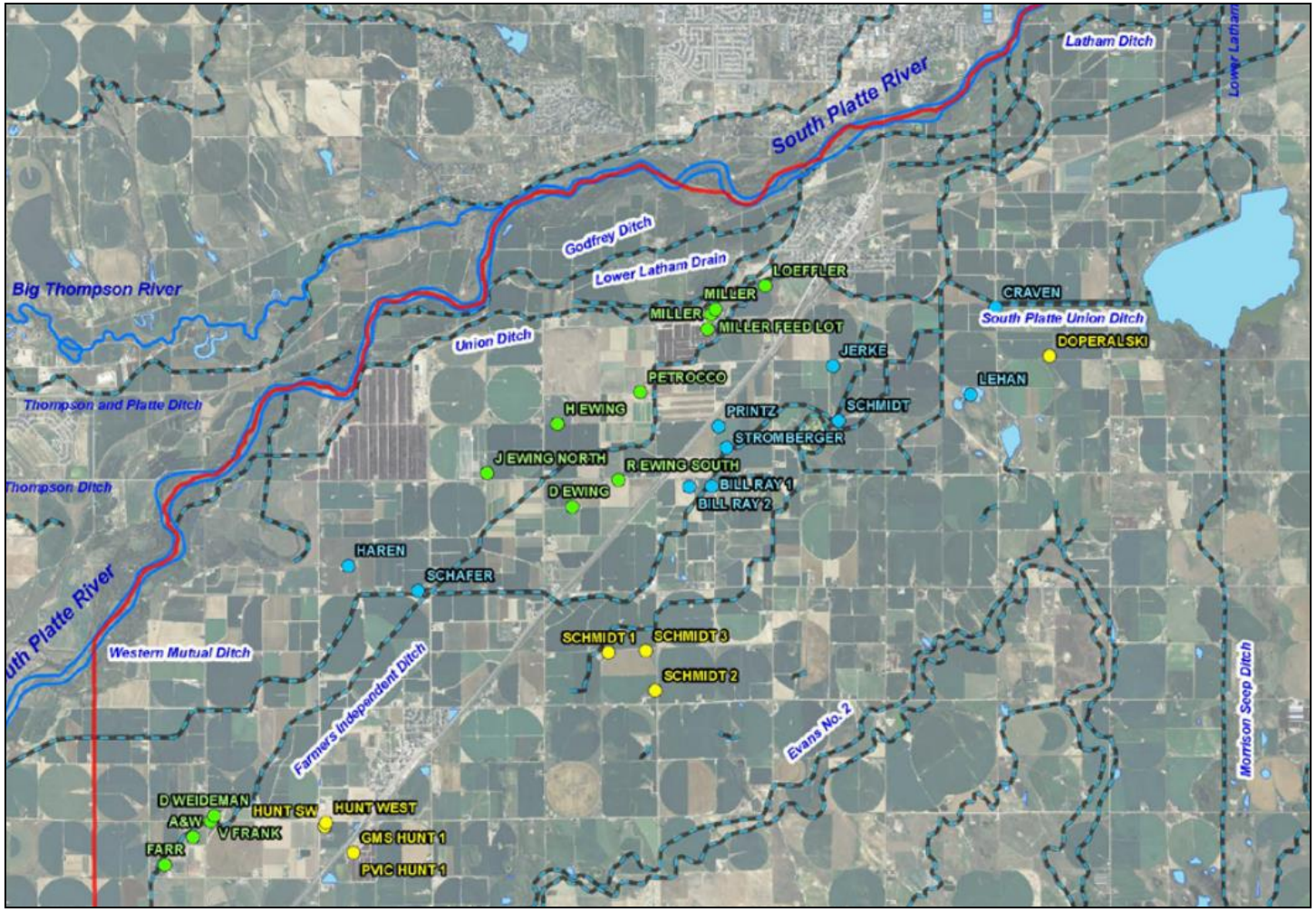
Water Rights

COLORADO
Division of Water Resources
Department of Natural Resources

Recharge Ponds



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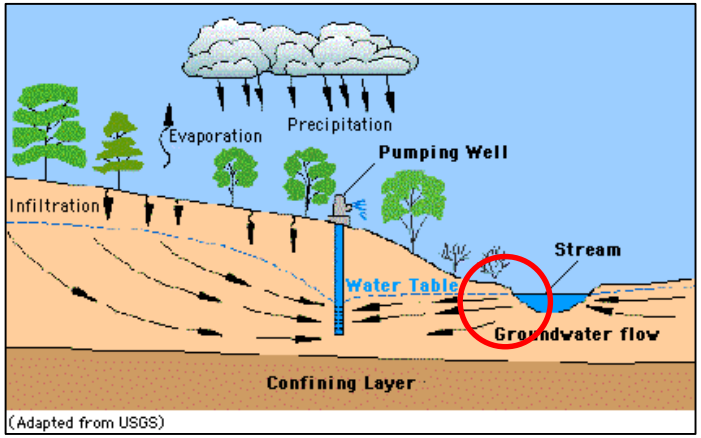
MODELING

Glover Model (1D Analytical)

MODFLOW

SWAT

(SWAT-MODFLOW)



Summary

To use SWAT in Irrigated Stream-Aquifer Systems:

1. Irrigation Patterns
2. Salinity (Soil, Groundwater, Loading to Streams)
3. Tile Drains (“Drainsheds”)
4. Water Rights: Groundwater vs. Surface Water

- SWAT+ (object connections)
- SWAT-MODFLOW-RT3D


Questions