



# Salinity in the South Platte River Basin

T. K. Gates

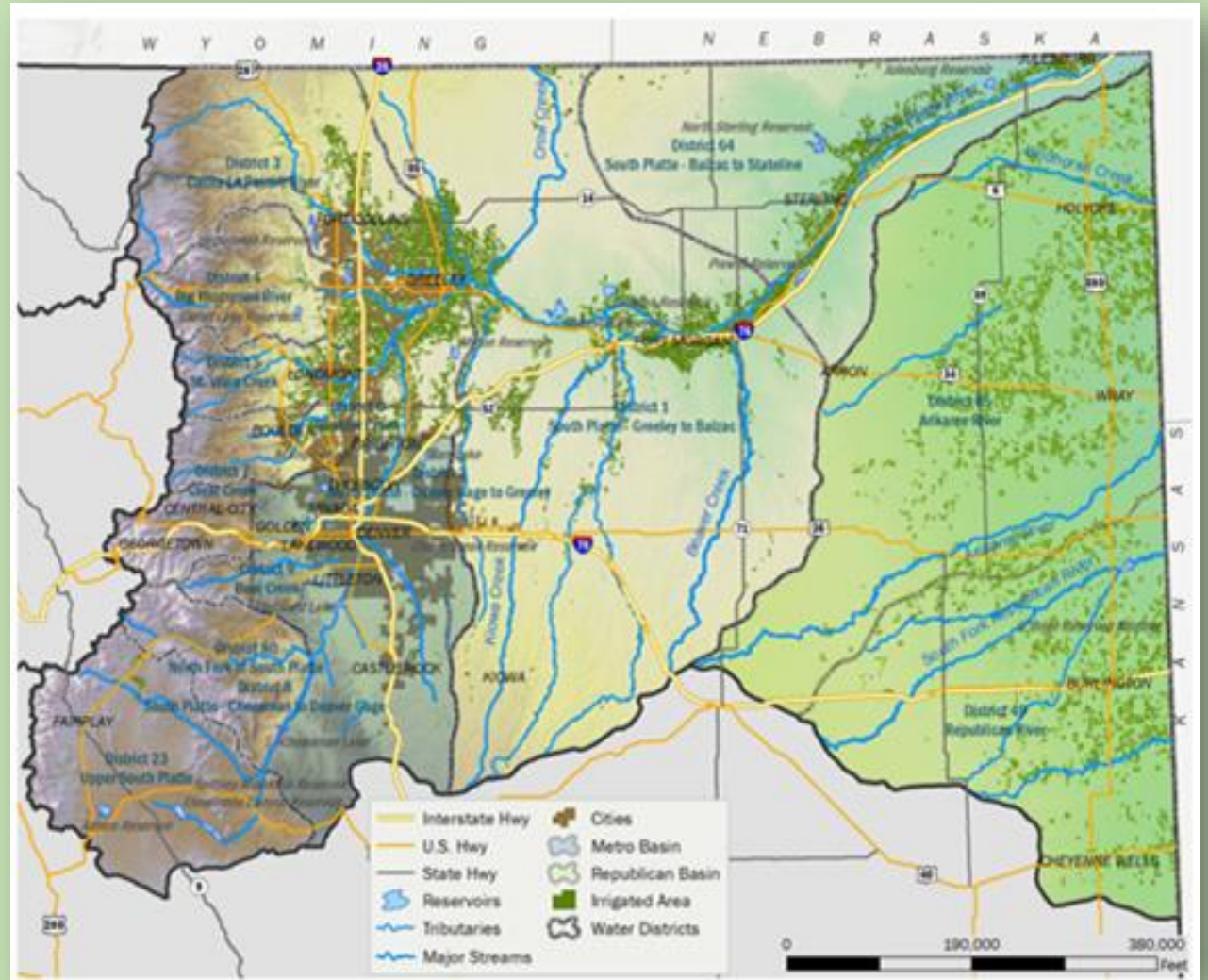


Colorado State University



# South Platte River Basin

- Irrigation began 1860s
- ~700,000 irrigated acres across > 14,000 fields
- Major crops corn, hay, wheat, vegetables

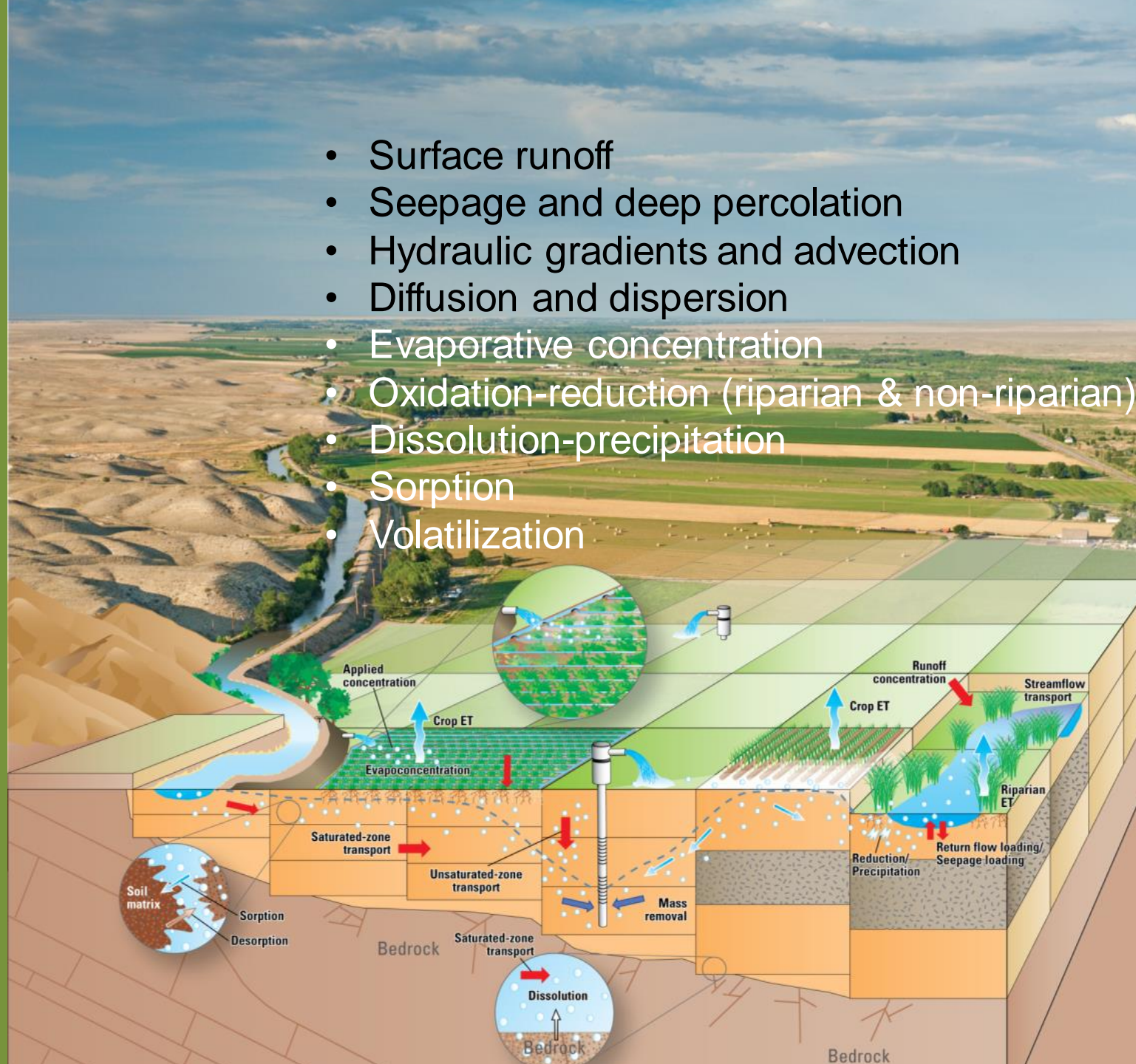




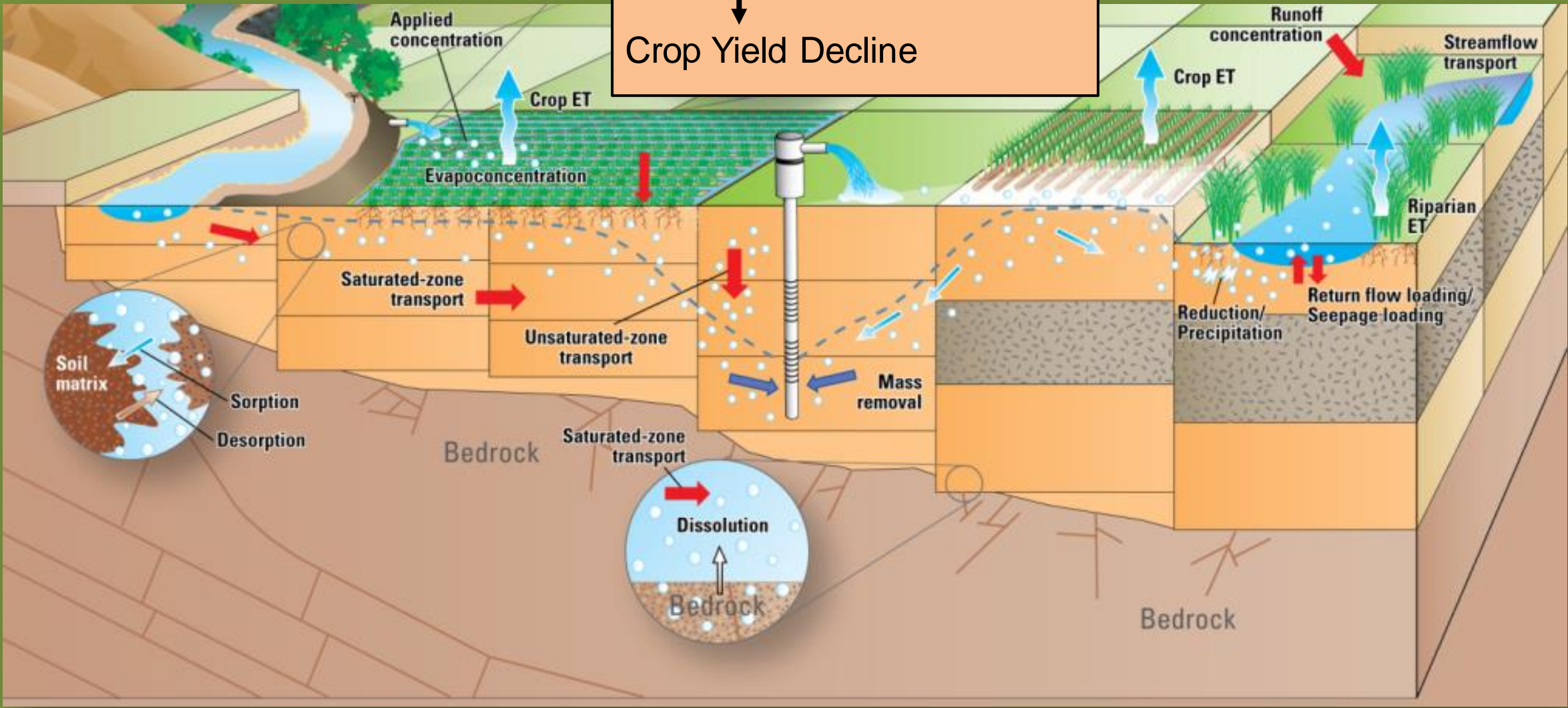


- Surface runoff
- Seepage and deep percolation
- Hydraulic gradients and advection
- Diffusion and dispersion
- Evaporative concentration
- Oxidation-reduction (riparian & non-riparian)
- Dissolution-precipitation
- Sorption
- Volatilization

## Return Flow and Solute Transport Processes in an Irrigated Stream-Aquifer System



Salt Accumulation  
↓  
Water and Land Degradation  
↓  
Crop Yield Decline





**Growing Concern about Salinization of  
Water and Land Resources in  
the South Platte River Basin**

**Anecdotal Evidence  
Intermittent and Limited Data**

# Groundwater Salinity

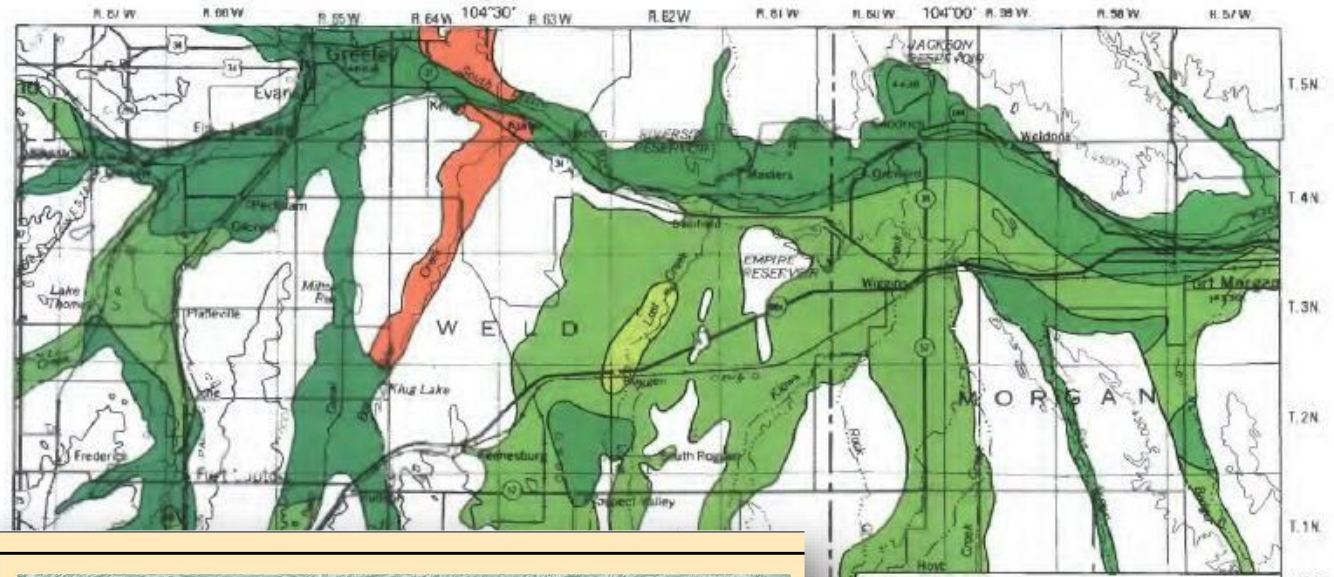
USGS (1957, 1964, 1987, 1998):

Average TDS ~2000 mg/L

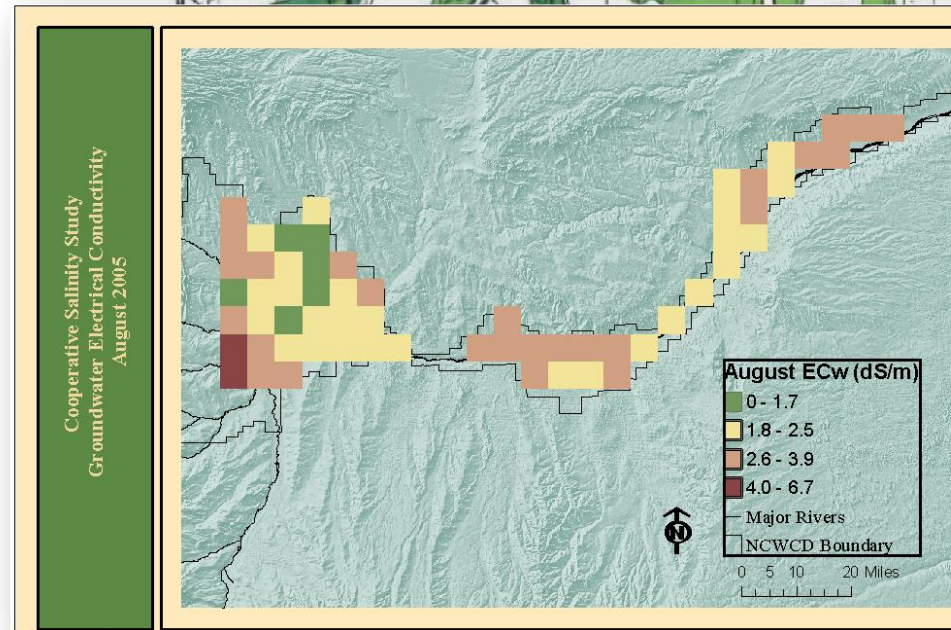
## Northern Water

(2001 - 2006):

Average TDS ~1600 mg/L



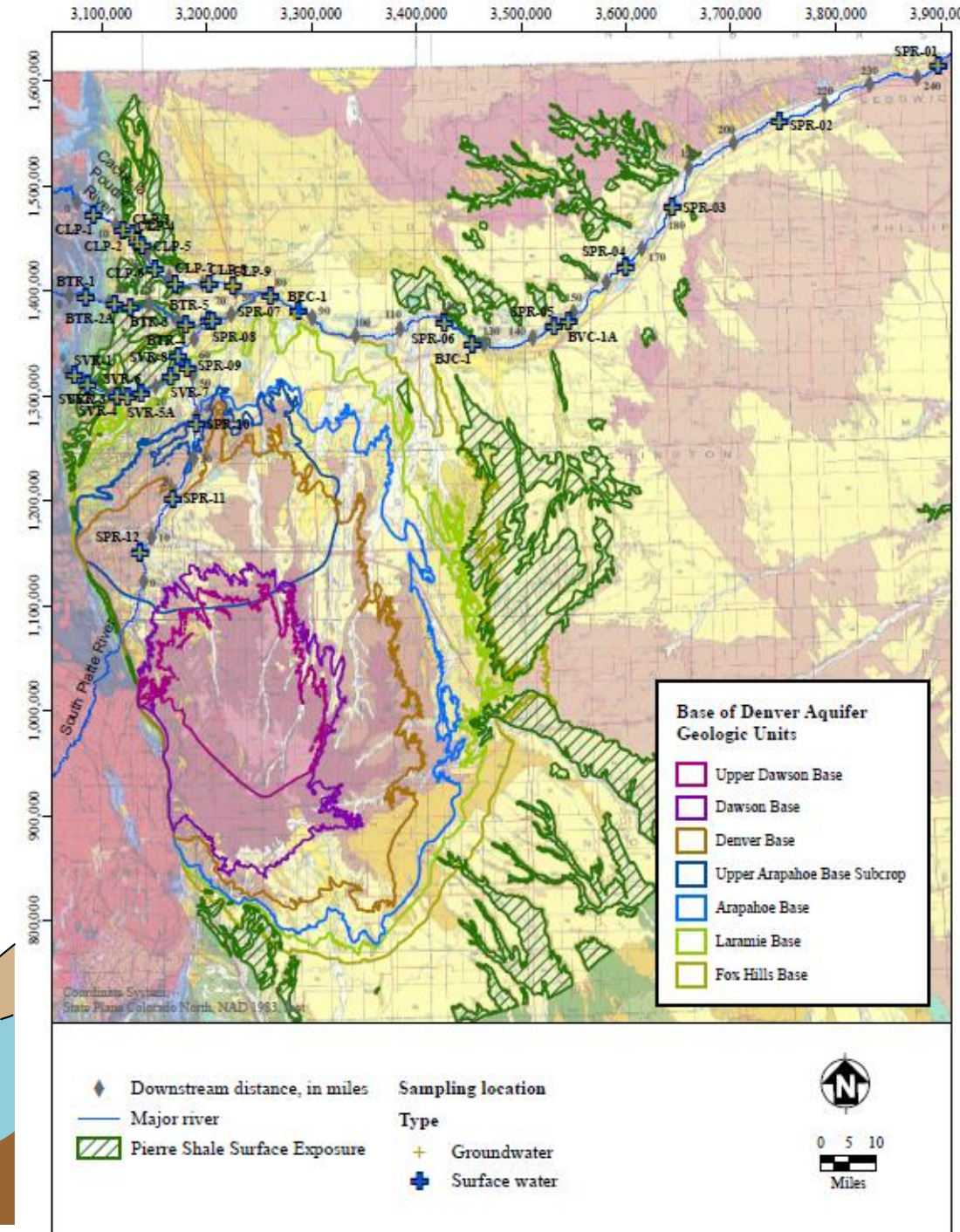
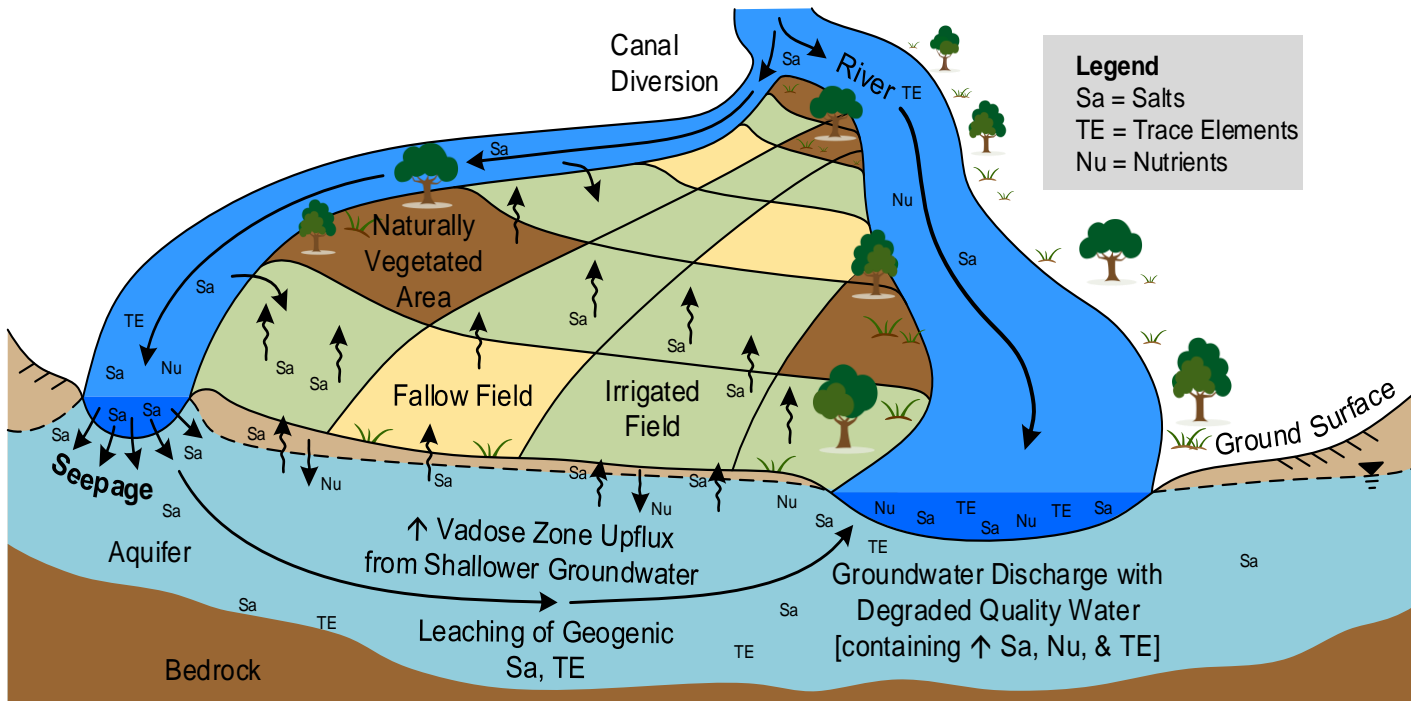
USGS (1987)



Northern Water (2006)

# Affected by biogeochemical reactions

- Oxidation-Reduction
- Sorption
- Ion exchange
- Dissolution and precipitation



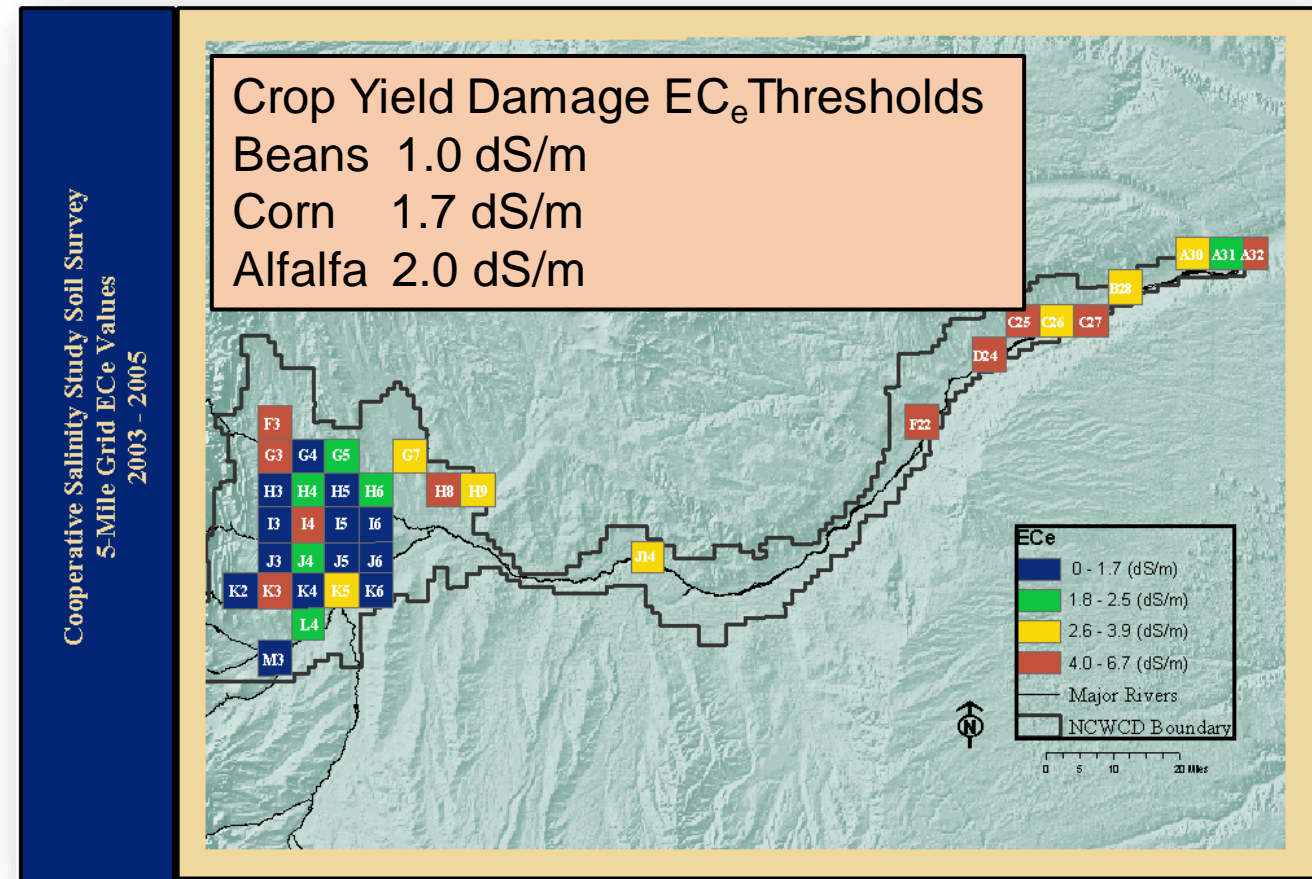
# Soil Salinity

Gates (1998):

Average  $EC_e \sim 2.8$  dS/m  
over 32 sampled fields in  
Larimer and Weld Counties

Northern Water  
(2003 - 2005):

$EC_e > 1.7$  dS/m  
in 64% of 36 sampled fields  
 $EC_e > 2.5$  dS/m  
in 47% of 36 sampled fields



Northern Water (2006)

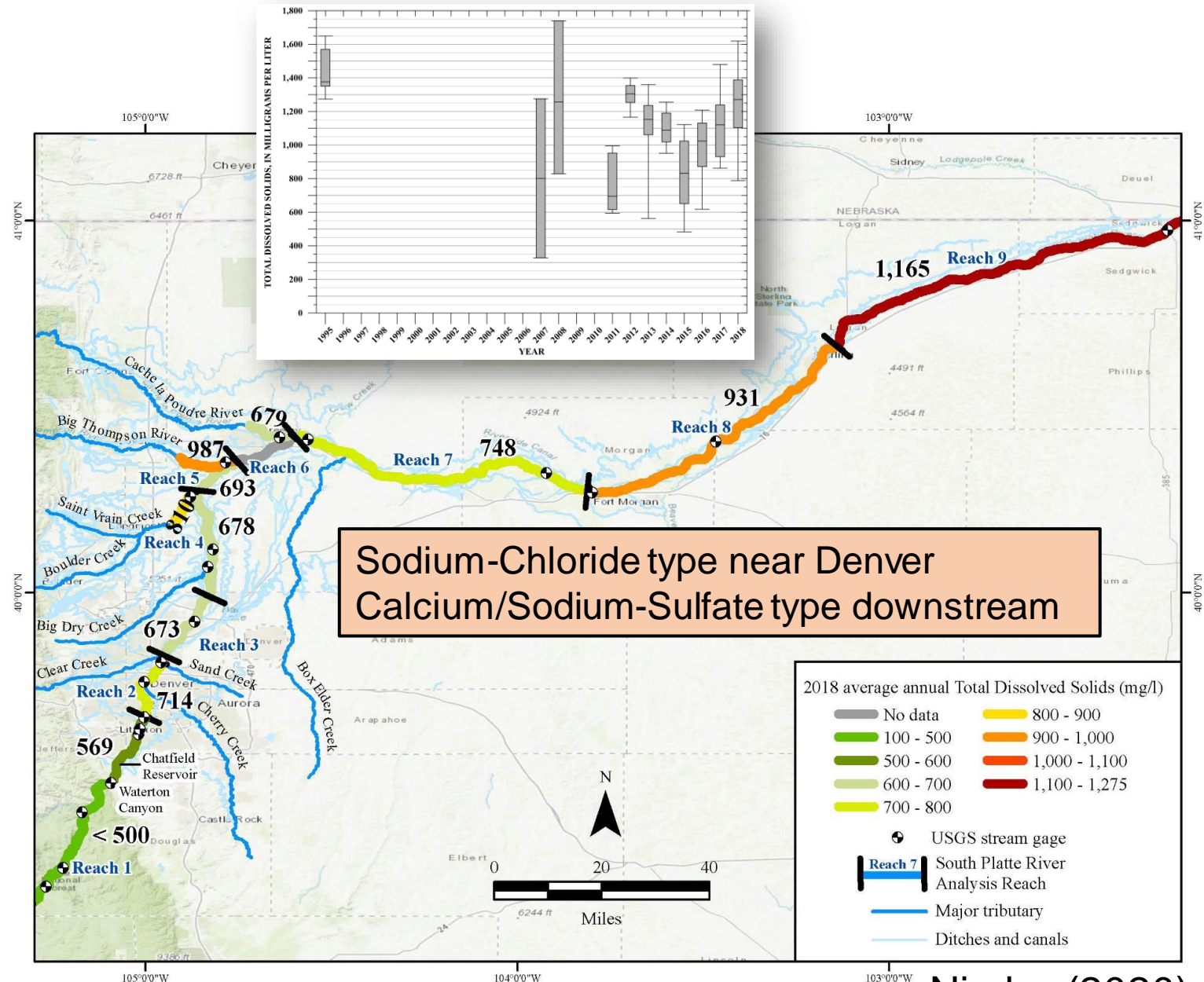
# River Salinity

USGS (1998)

Northern Water  
(2006, 2009)

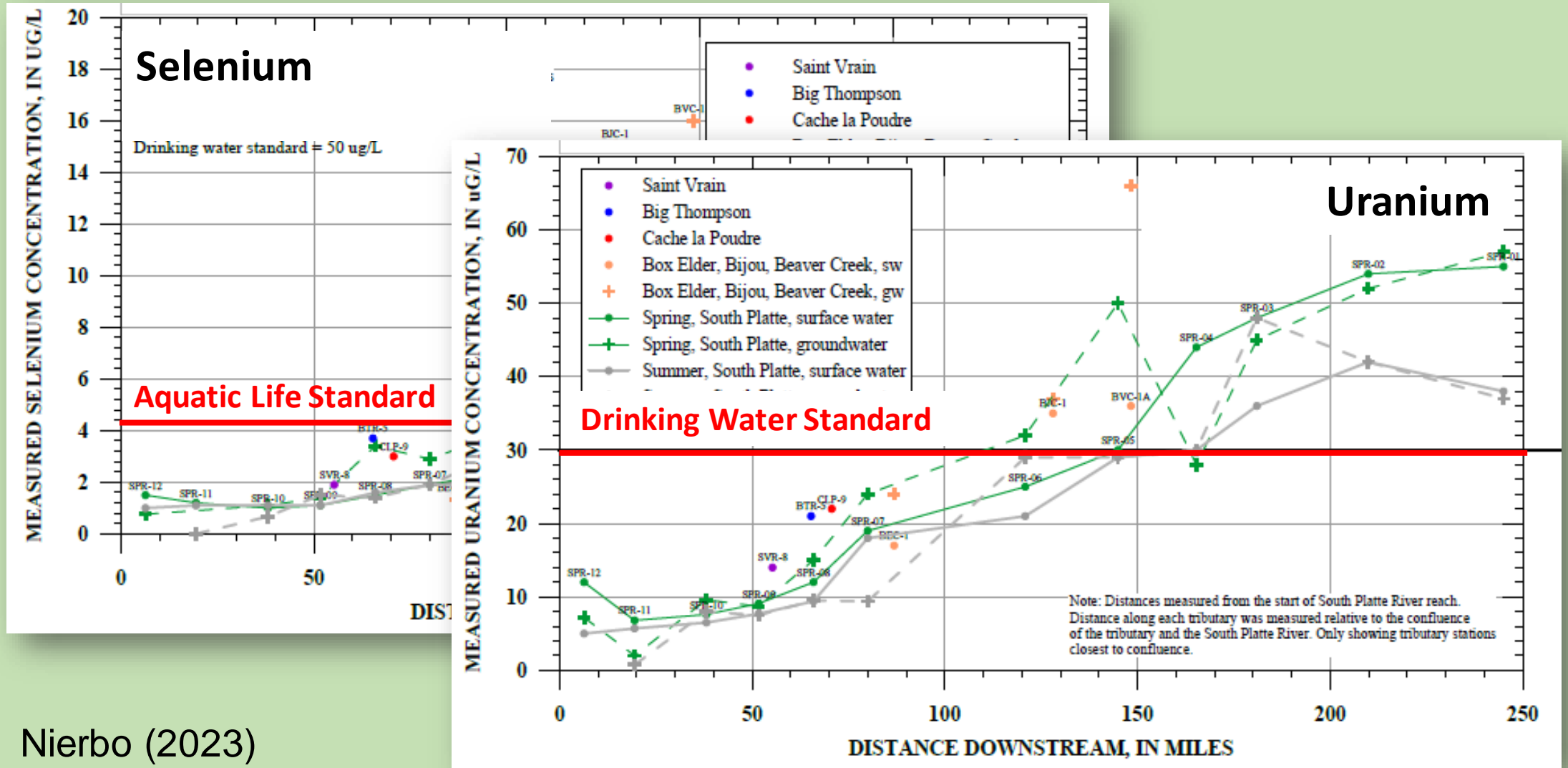
Neirbo (2020, 2023):

Average TDS ranges  
From 600 mg/L near  
Henderson to  
1300 mg/L near  
CO-NE stateline



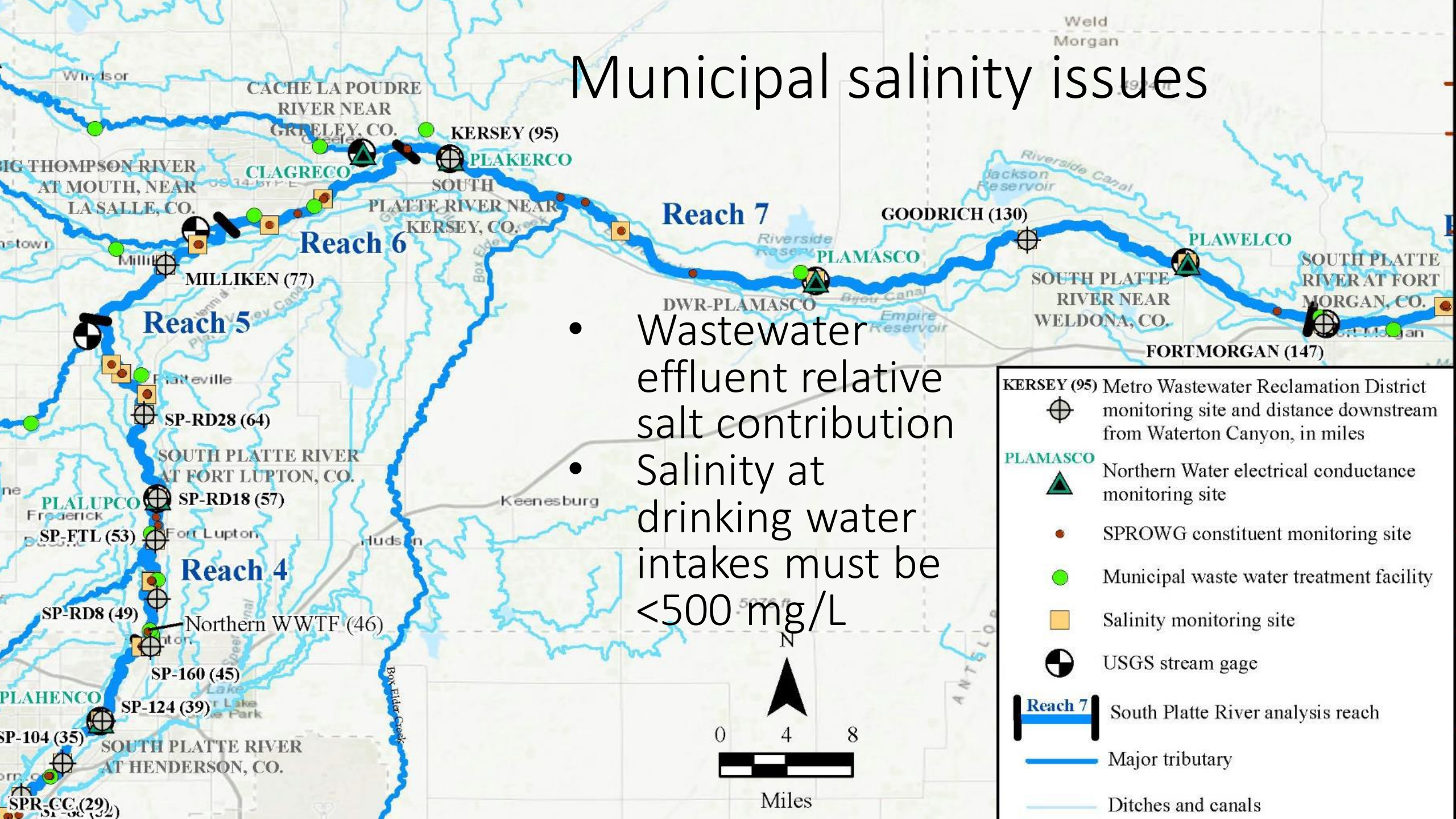
Nierbo (2020)

# Trace Elements



Nierbo (2023)

# Municipal salinity issues



- Wastewater effluent relative salt contribution
- Salinity at drinking water intakes must be  $<500 \text{ mg/L}$

**KERSEY (95)** Metro Wastewater Reclamation District monitoring site and distance downstream from Waterton Canyon, in miles

**PLAMASCO** Northern Water electrical conductance monitoring site

SPROWG constituent monitoring site

Municipal waste water treatment facility

Salinity monitoring site

USGS stream gage

**Reach 7** South Platte River analysis reach

Major tributary

Ditches and canals

## OVERALL ISSUES OF CONCERN

- spatial and temporal patterns in salinity in streams, groundwater, soils;
- relative contribution to river salt from municipal effluent and pavement runoff point sources compared to agricultural return flow nonpoint sources;
- severity of the salinity impact on farmland soils and productivity;
- effects of expanding sprinkler irrigation and curtailment of well pumping on shallow groundwater and soil salinity;
- long-term impact of recharge ponds for well augmentation on subsurface and surface water salinity;
- influence of salinity on municipal water supply and on water/wastewater treatment;
- implications of dissolved salts/trace elements to aquatic life in the stream network;
- potential of alternative land and water management strategies to lower salinity; and
- economic costs and benefits of salinity management.

## Stage 1

# Problem Characterization

Phase 1: Data collection for salinity description & assessment

Phase 2: Extended data collection, identification of impacts, sources, controlling factors

## Stage 2

# Search for Solutions

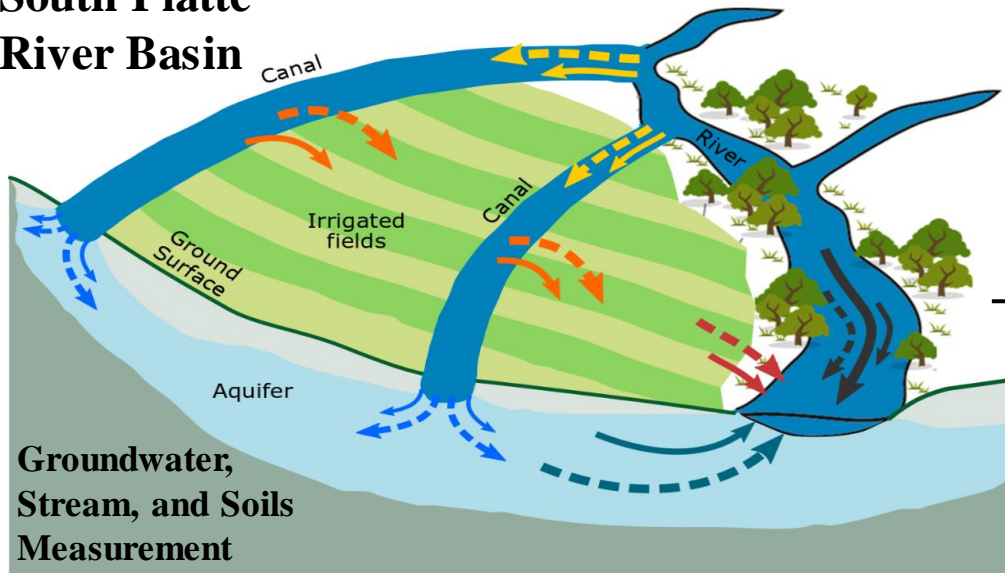
# **Problem Characterization**

## **Phase 1 Research Questions**

- (1) Just how severe and variable is water and land salinity across the SPRB and
- (2) Where and how should further effort be focused to (a) refine understanding and (b) support a search for solutions?

**PROBLEM  
CHARACTERIZATION  
Phase 1**

**South Platte  
River Basin**

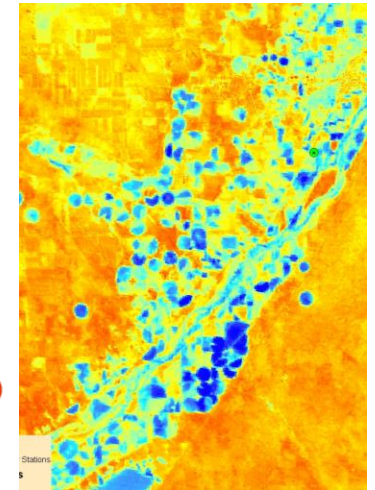


**Groundwater,  
Stream, and Soils  
Measurement**

**Task 1  
Collect  
Field Data**



**Task 2  
Analyze to Describe  
Severity and  
Variability  
of Salinity**



**GIS  
Database  
Development**



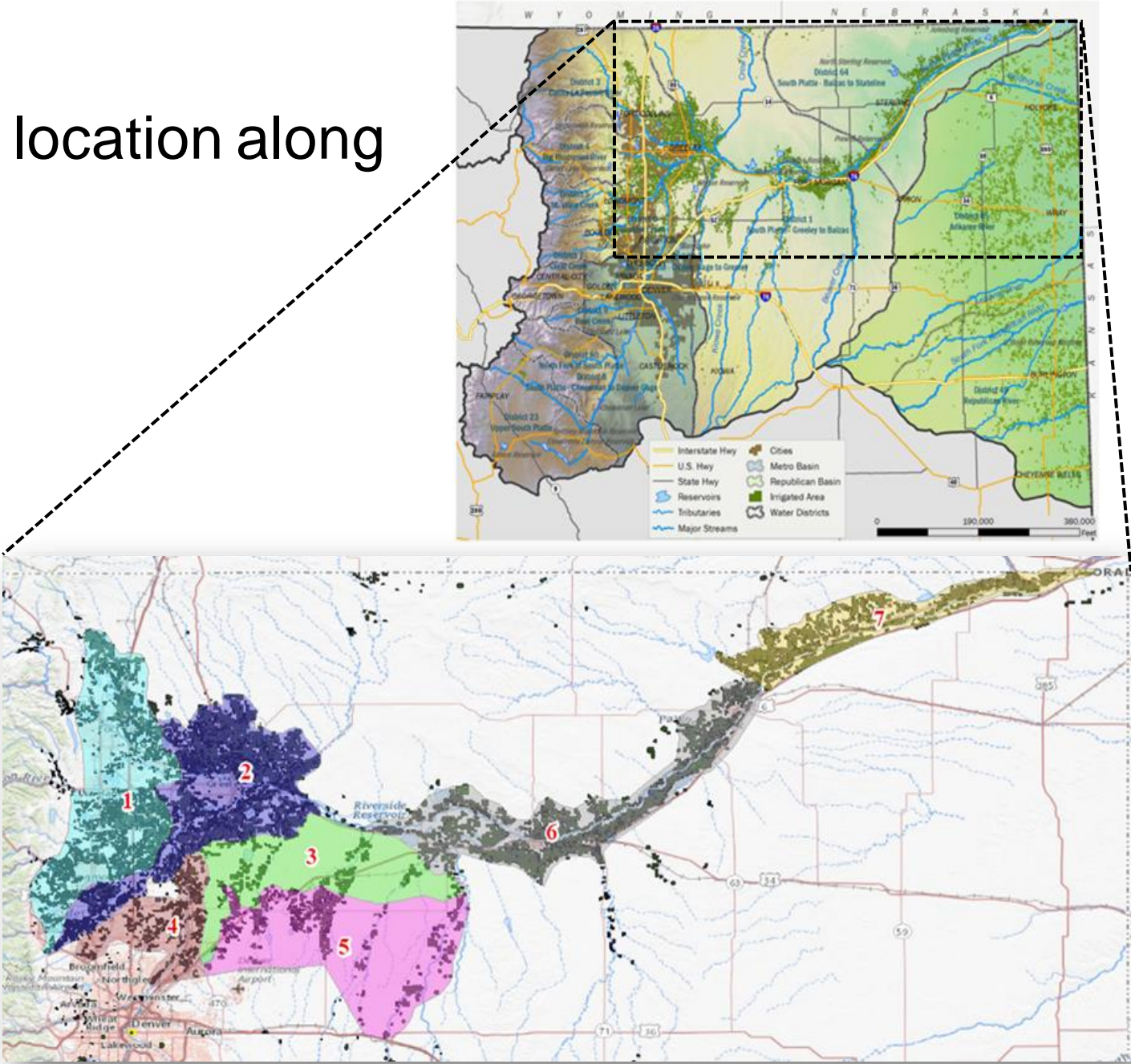
**Stakeholder Engagement**



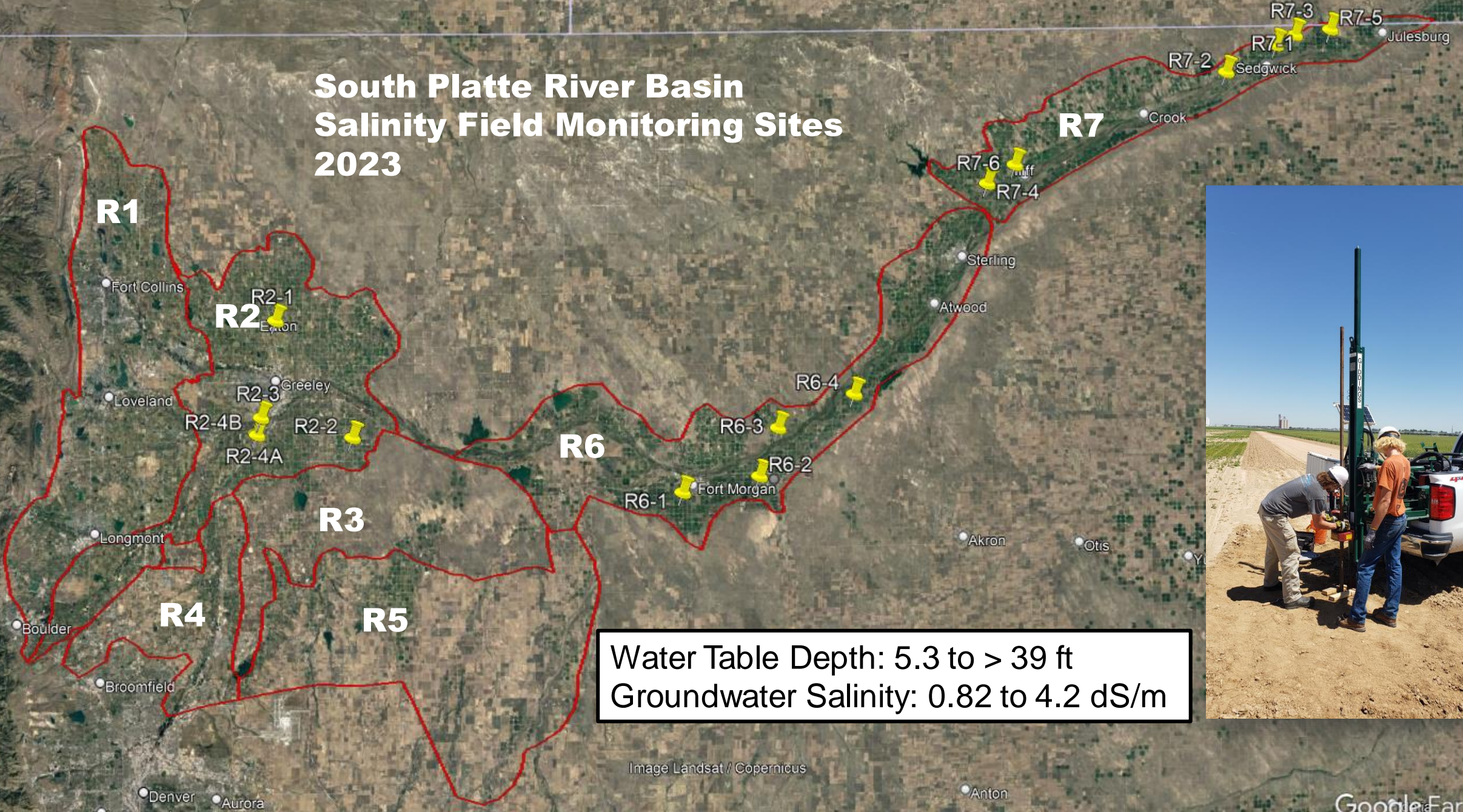
**Task 3  
Plan Phase 2  
of Project**

# Seven study regions

designated based upon location along stream network, soils, subsurface geology.



# South Platte River Basin Salinity Field Monitoring Sites 2023



Water Table Depth: 5.3 to > 39 ft  
Groundwater Salinity: 0.82 to 4.2 dS/m

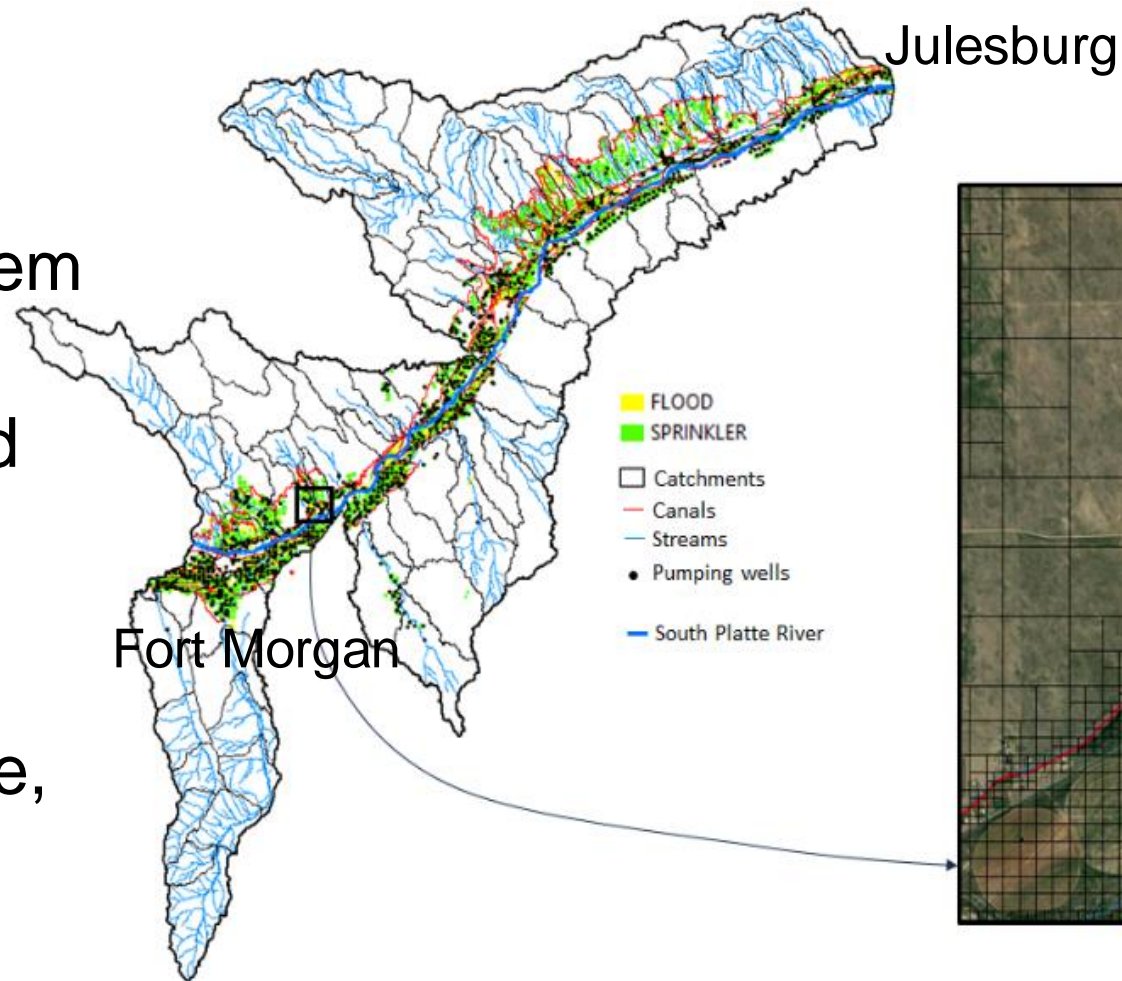


Image Landsat / Copernicus

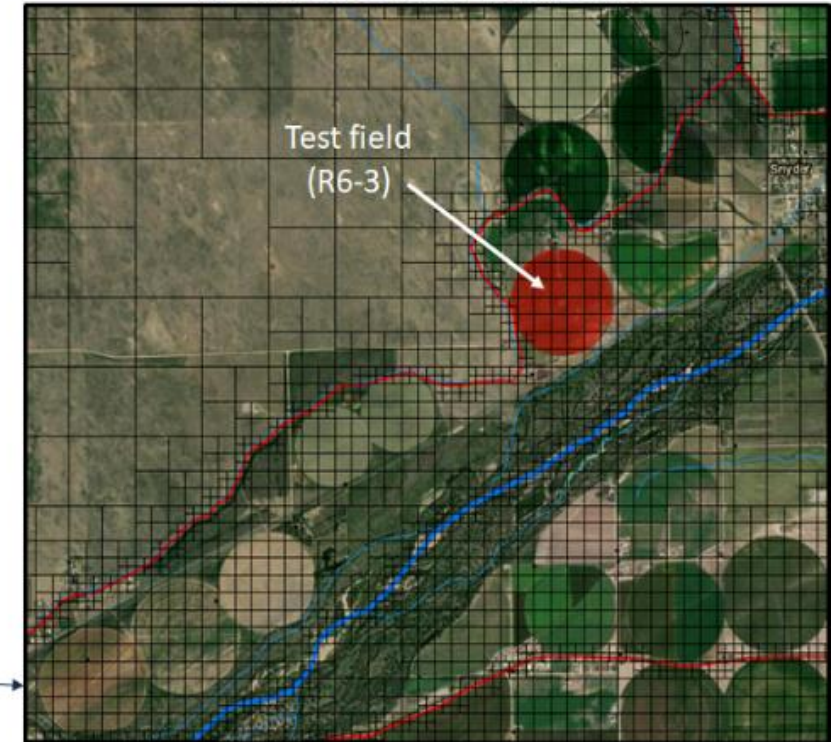
Google Earth

# Search for Solutions

- Data from problem characterization
- SWAT+ flow and salt transport model
- Study impact of climate, land use, water and land management strategies on salinity



Unstructured Grid used for groundwater modeling in SWAT+



Bailey Chavez Gates Andales  
USDA Proposal (2023)

# WATER & LAND MANAGEMENT BMPS

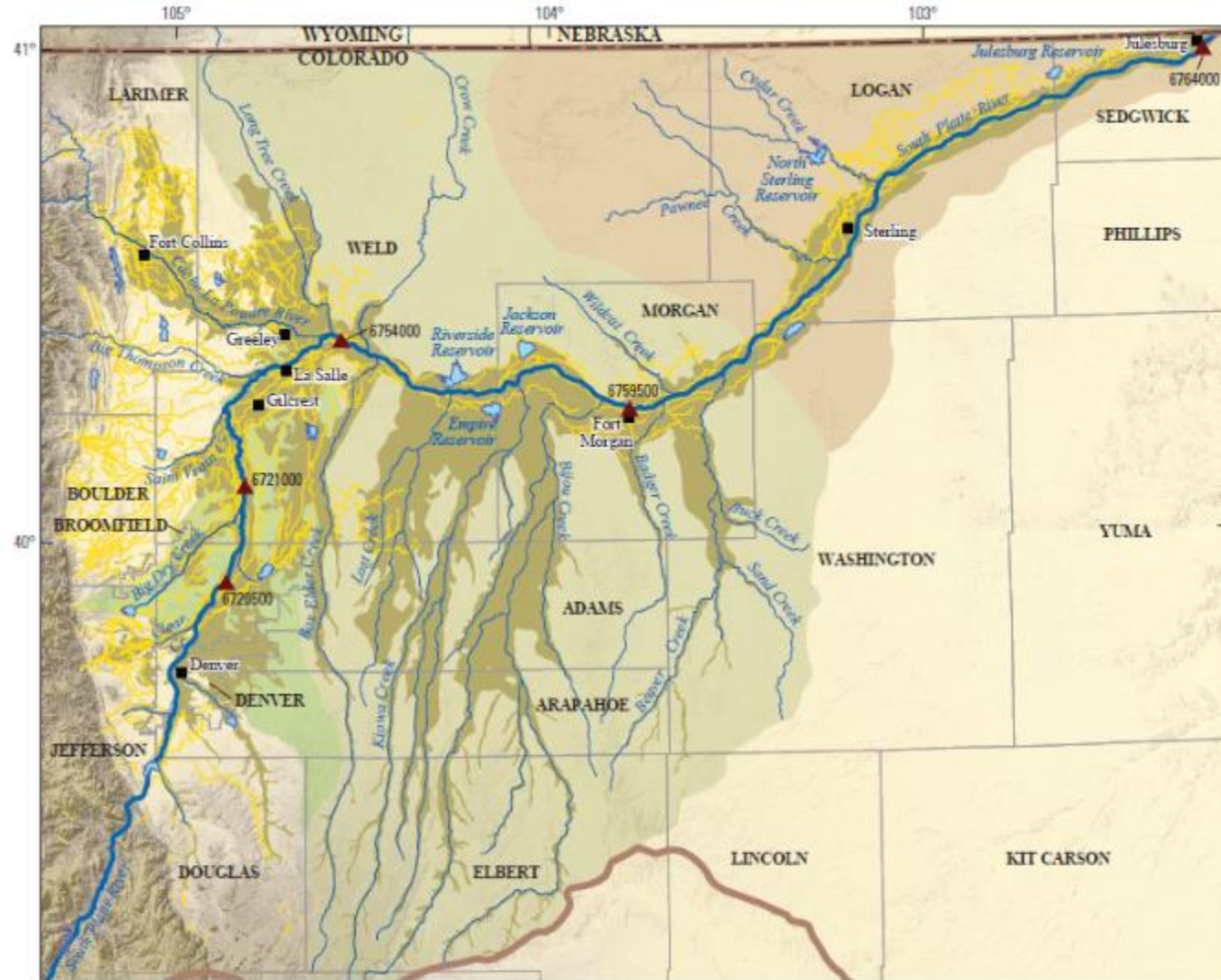
- Reduce excess irrigation applications;
- Control canal seepage;
- Insure adequate leaching under sprinkler irrigation;
- Strategically locate recharge ponds and augmentation wells;
- Lower excess fertilizer and manure applications;
- Enhance treatment of urban effluent discharge; and
- Refine control of urban road salt runoff.

- *CAES, CO Corn, CWCB Current Projects*
  - *USDA Proposal Submitted Sep 23*
    - *CWCB WPG Proposal Dec 23*

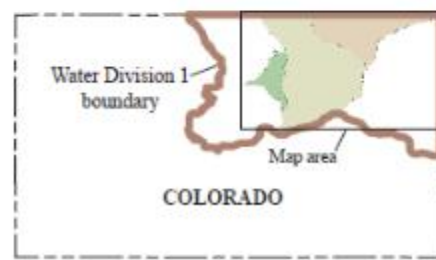


*Questions &  
Comments*

# SPRB Alluvial Aquifer (USGS 2015)

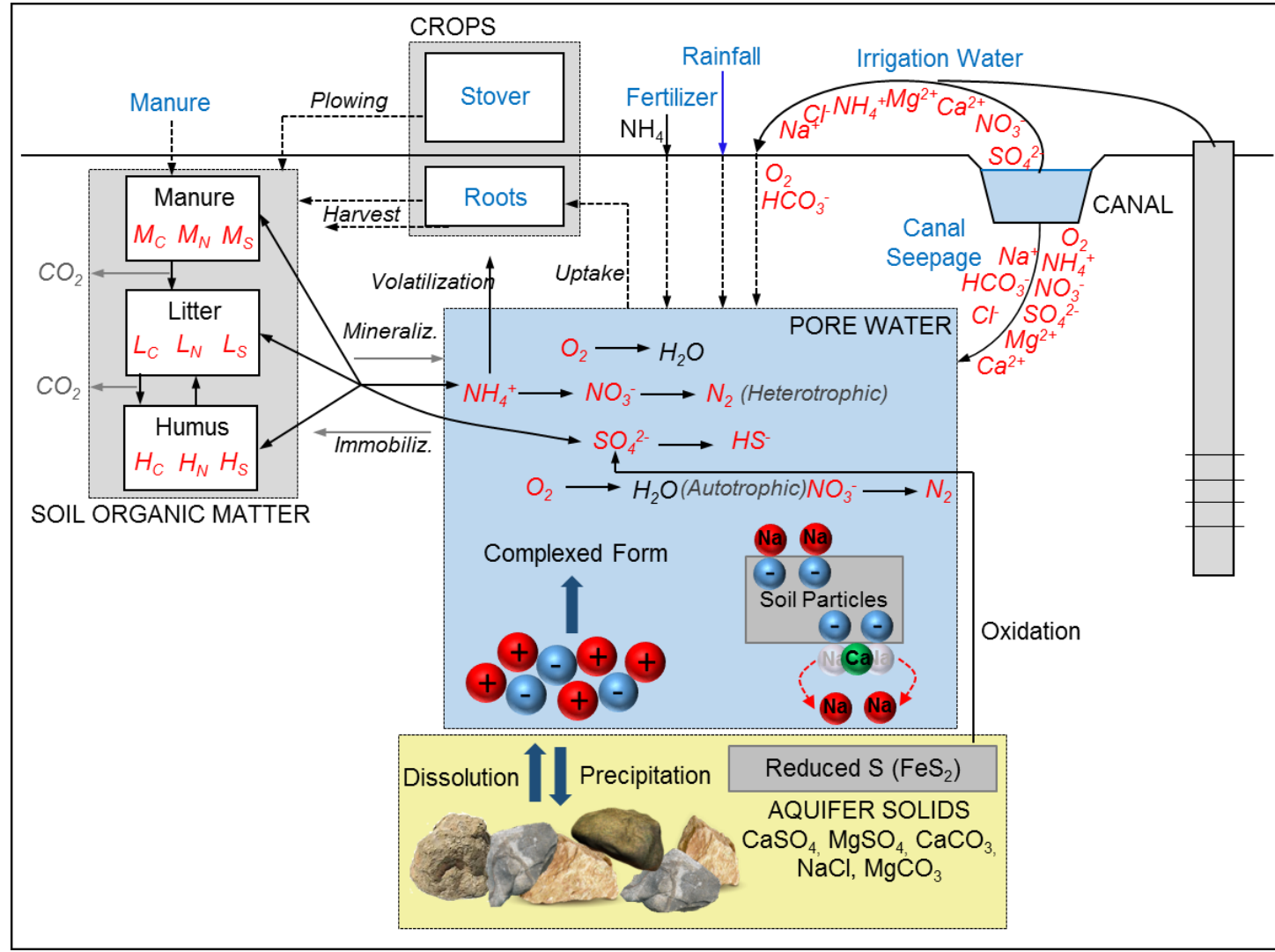


Base from U.S. Geological Survey digital data, 2009, 1:100,000  
Lambert Conformal Conic projection (Colorado State Plane Central)  
Standard parallels 38°27'N and 37°45'N, central meridian 105°00'W



**EXPLANATION**

- Water Division 1
- Water District 1
- Water District 2
- Water District 64
- South Platte River alluvial aquifer
- South Platte River
- South Platte tributary
- Ditch
- Gaging station and number



# Why is Soil Salinity Important?

20-40-20  
**20%** of irrigated land produces  
**40%** of the food for the world, and  
**20%** of that land is hindered by salts.

## Legend

### Type and severity levels of salt-affected soils

 saline slight	 sodic slight	 saline-sodic slight
 saline moderate	 sodic moderate	 saline-sodic moderate
 saline high	 sodic high	 saline-sodic high
 saline extreme	 sodic extreme	 saline-sodic extreme

Data from Harmonized World Soil Database v 1.2