The Salinity Loop in the South Platte Basin

Colorado Ag Water Alliance

"Commited to the preservation of agriculture through the wise use of Colorado's water resources"

August 27, 2018

Grady O'Brien

NEIRBO HYDROGEOLOGY

Irrigated Agriculture

Sooner or later, the artificially high rate of application of water to land exceeds the natural rate of drainage, the water table rises, and artificial drainage is needed to regain an acceptable water and salt balance.

Salinity and drainage problems usually appear in intensively-irrigated alluvial valleys within a few decades to a few hundred years of the commencement of large-scale irrigation.

Gates and Labadi, 1998

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Irrigated Agriculture

- About 25% of the world's irrigated land is affected by waterlogging and salinity due to saline high water tables (Tanji 1990, Ghassemi et al. 1995)
- 2.5 to 5 million acres of Ag land severely damaged due to irrigation-induced salinization ***each year*** (Umali 1993, Kovda 1983)

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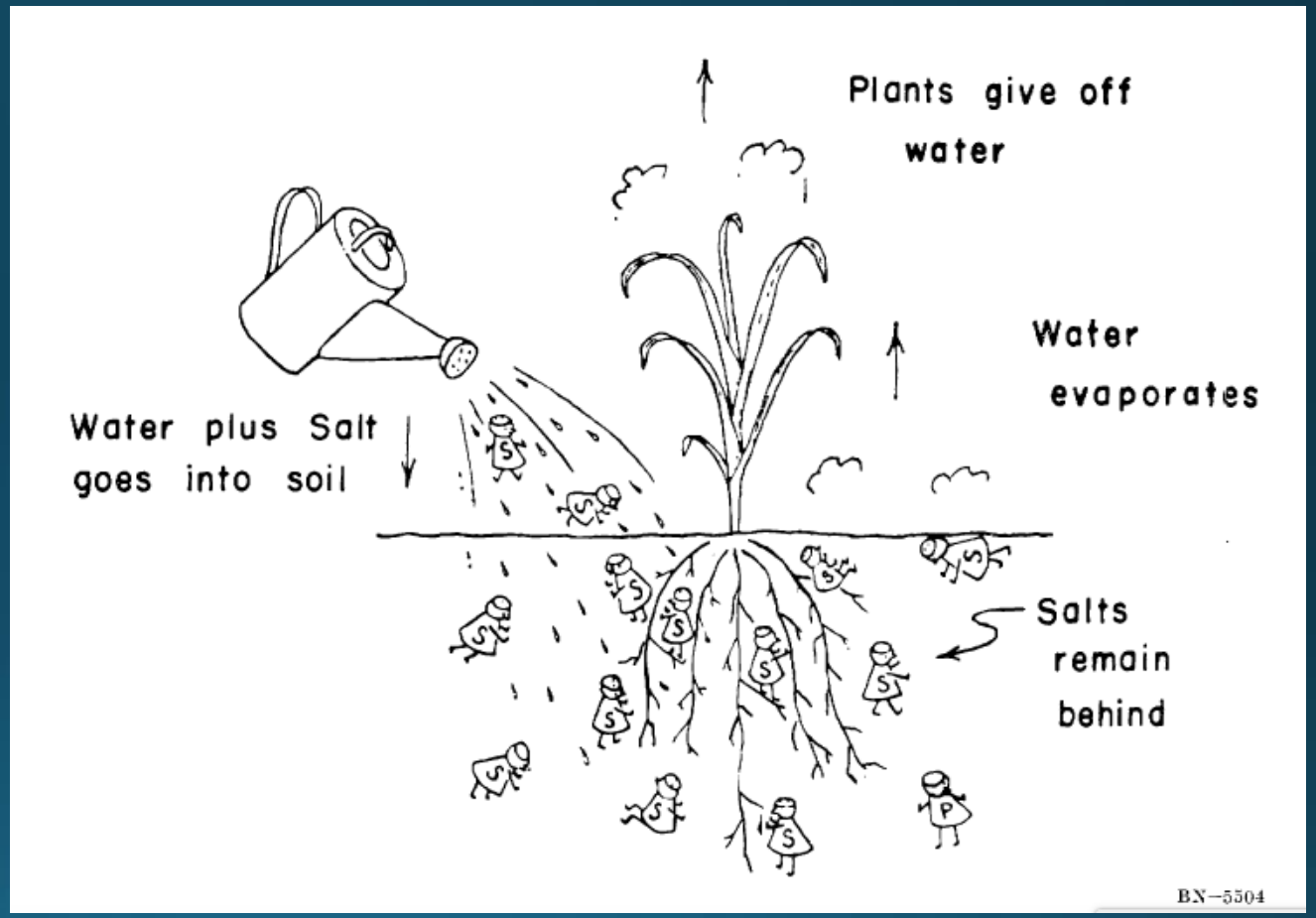
Salinity

- When water evaporates or is removed by plants, collectively termed evapotranspiration, the salts remain in the soil
- Electrical Conductivity
- Specific Conductance
- Total Dissolved Solids (TDS)
- Sodium Adsorption Ratio (SAR)



USDA, 1958. Salt Problems in Irrigated Soils, Agriculture Information Bulletin 190

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Total Dissolved Solids (TDS)

- TDS is an aggregate indicator of the presence of many dissolved chemical contaminants.

- The ten major dissolved ions that make up TDS in natural rivers:
  - calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium, (Na^{+}), potassium (K^{+}), boron (B3+), silica (Si), chloride (Cl^{-}), sulfate (SO_4^{2-}), bicarbonate (HCO_3^{-}), and carbonate (CO_3^{2-}).

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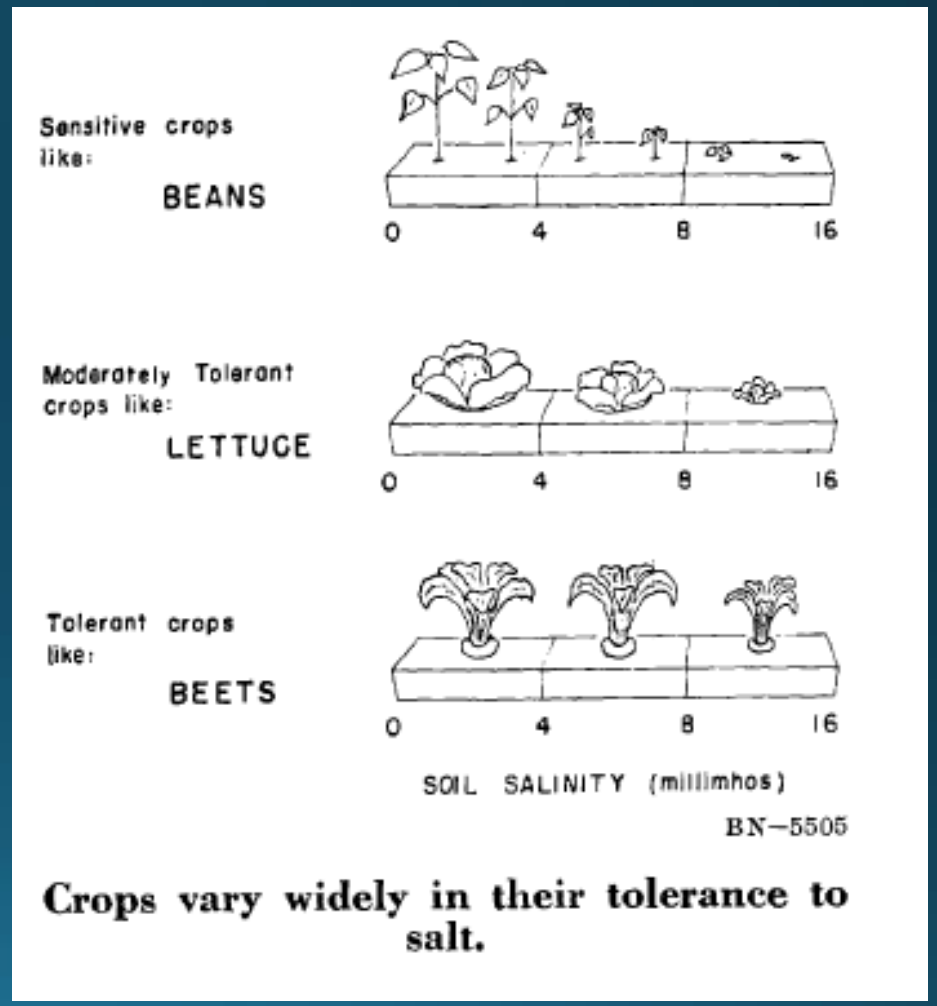
Salts in water – why do we care?

- Reduced crop yields
  - Crop stress to death
  - Different crops have different tolerance
- Decreasing land values
- Lower Arkansas River Basin the cost of decreased crop yields has been estimated at $50 to $83 per acre (Houk et al. 2006)



USDA, 1958. Salt Problems in Irrigated Soils, Agriculture Information Bulletin 190

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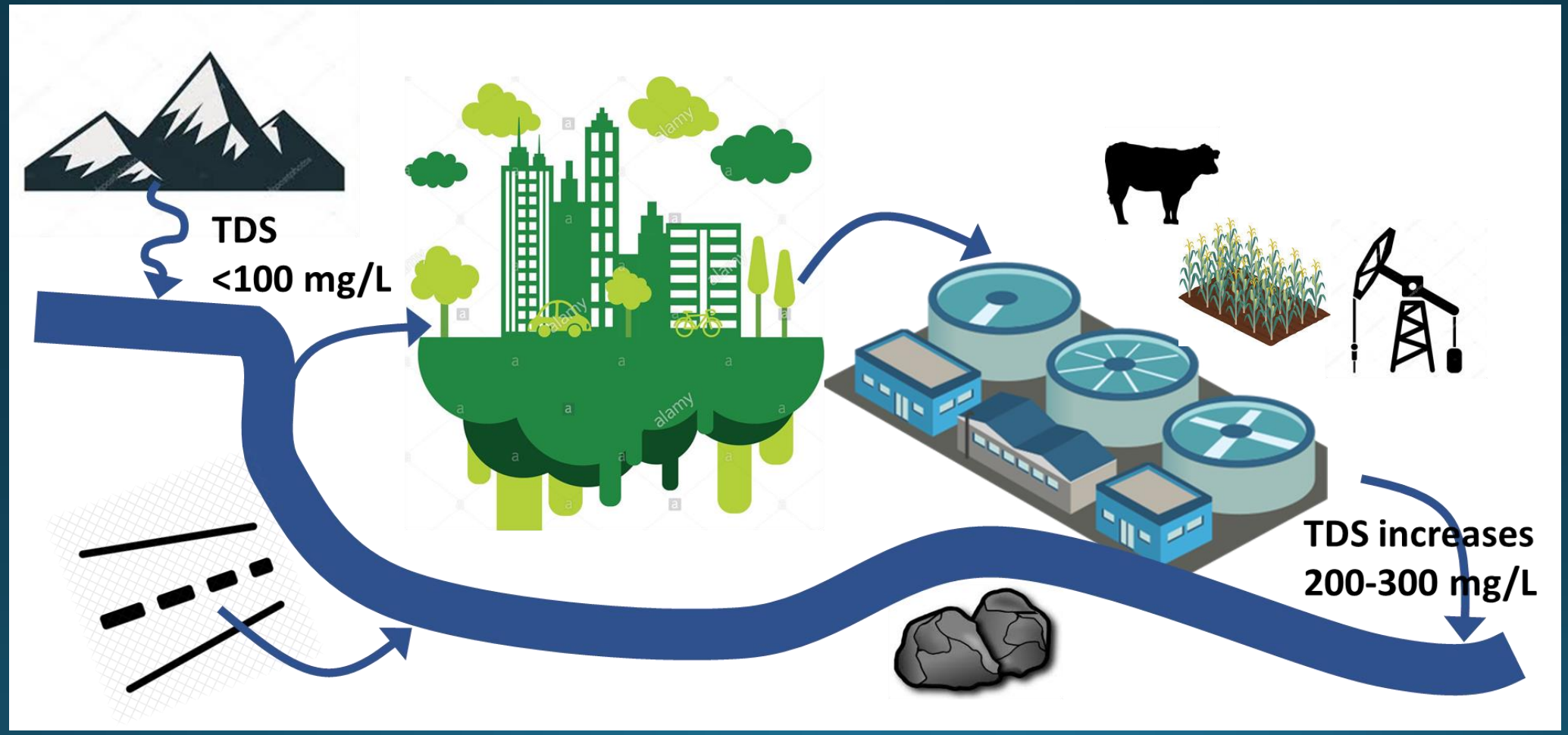
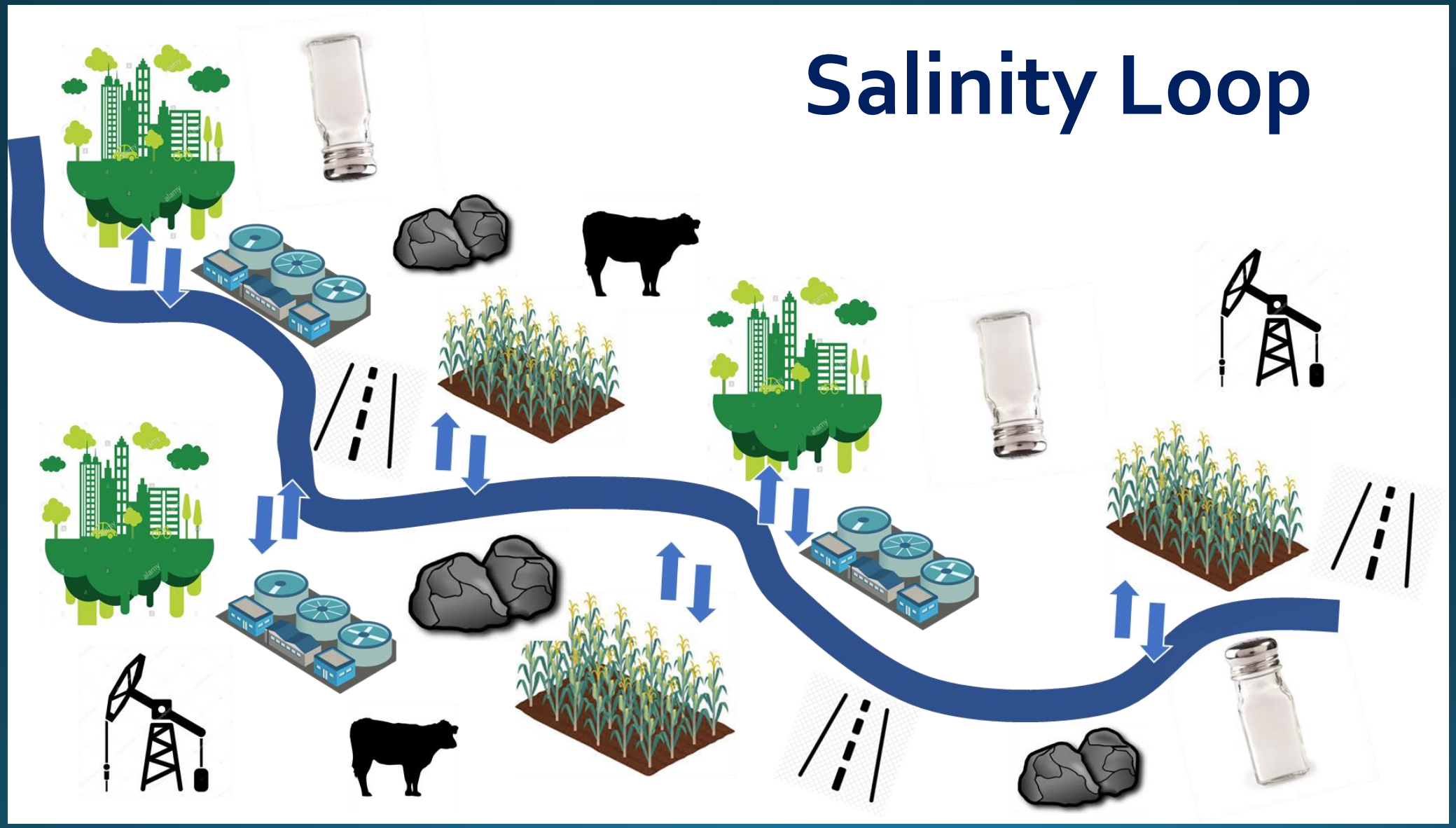
Salinity Sources



Salinity Loop



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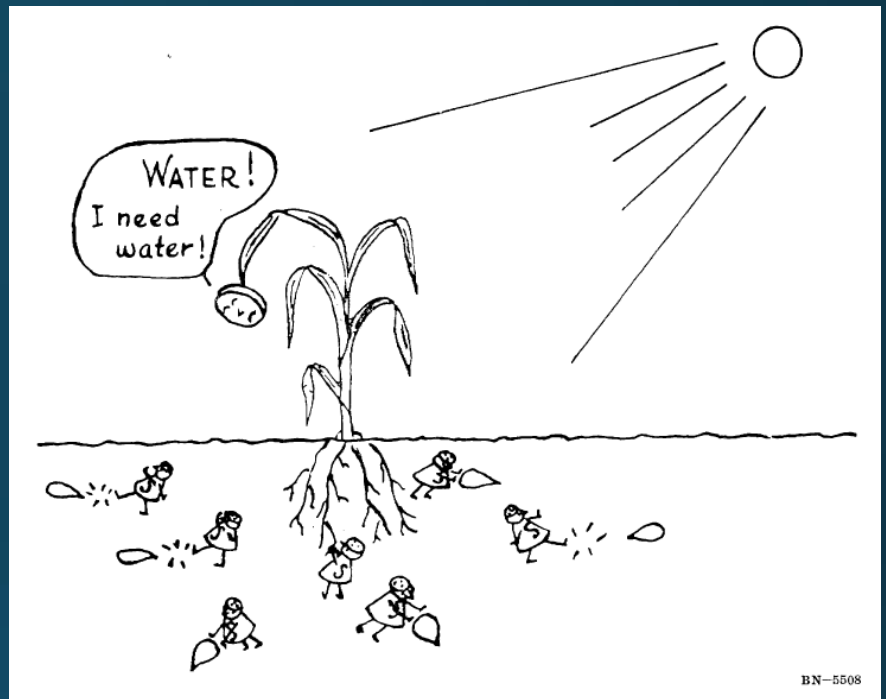
Soil Structure Damage

- Salt can build up in soils
  - Sodium exchanged for calcium and magnesium
  - Salts not being flushed out
  - Evaporation
  - Plant transpiration
- Poor drainage
- Crop yields can decrease



The presence of salts in the soil makes it difficult for crops to take up water.

USDA, 1958. Salt Problems in Irrigated Soils, Agriculture Information Bulletin 190

Crop	Percent Yield Reduction			
	0	10	25	50
	Total Dissoved Solids, ppm (mg/l)			
Alfalfa	832	1,408	2,304	3,776
Potato	704	1,088	1,600	2,496
Corn (grain)	704	1,088	1,600	2,496
Corn (silage)	768	1,344	2,240	3,648
Onion	512	768	1,152	1,856
Dry Beans	448	640	960	1,536

Adapted from "Quality of Water for Irrigation." R.S. Ayers. Jour. of the Irrig. and Drain. Div., ASCE. Vol 103, No. IR2, June 1977, p. 140.

Irrigation Water Quality Criteria, Fact Sheet No. 0.506, by T.A. Bauder, R.M. Waskom, P.L. Sutherland and J. G. Davis

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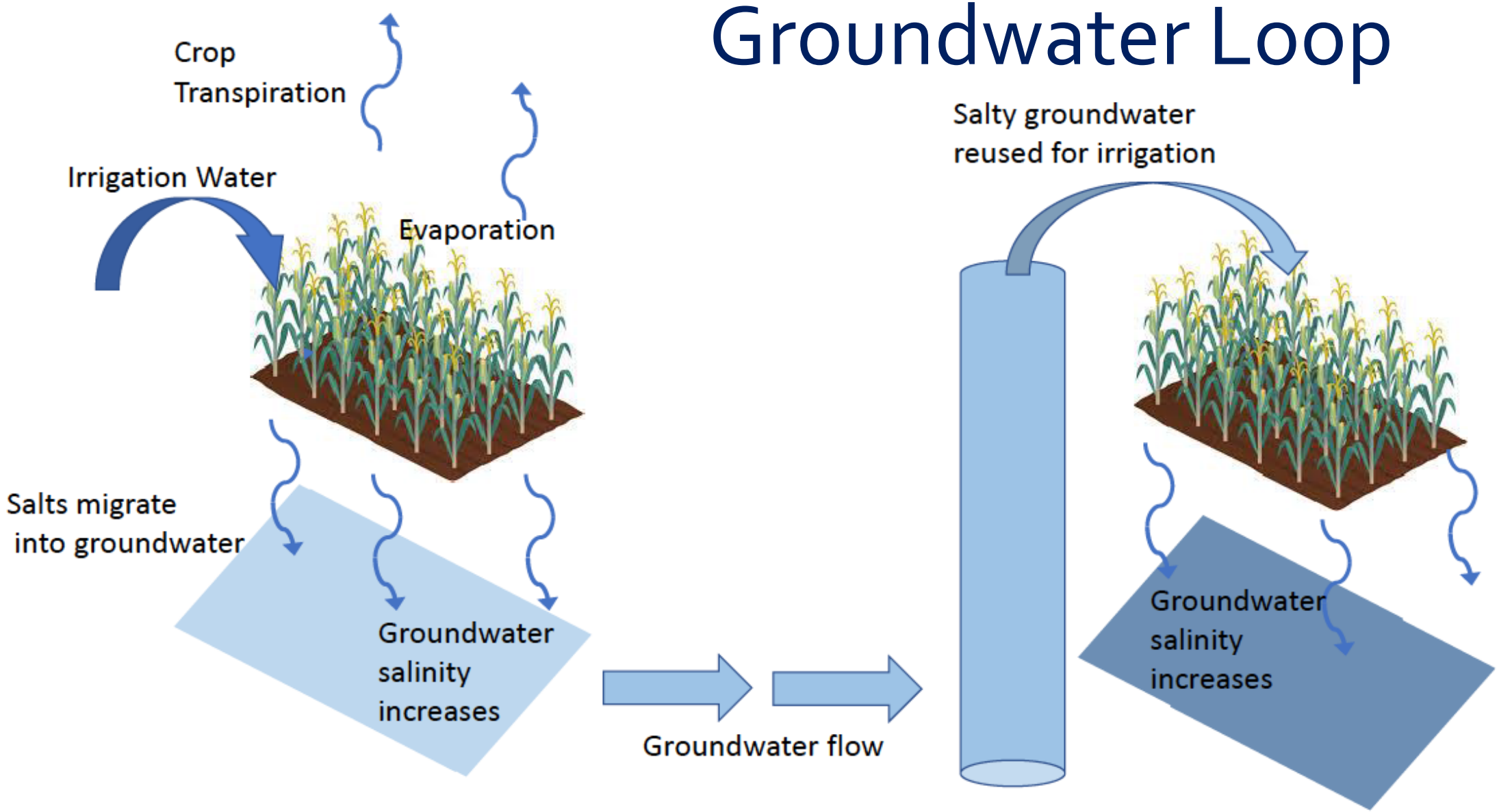
Groundwater Loop



Water Management

- The Colorado Water Plan (2015) and the South Platte Basin Implementation Plan (SP-BIP) encourage water conservation and successive water use / water reuse
- Fresh, low salts water is diverted out of South Platte River for municipal use and replaced with salty sewage effluent
- Successive use of water - currently estimated that water is reused about seven times as it flows through the Basin.
- Each time water is reused, it accumulates more salts, and salinity increases

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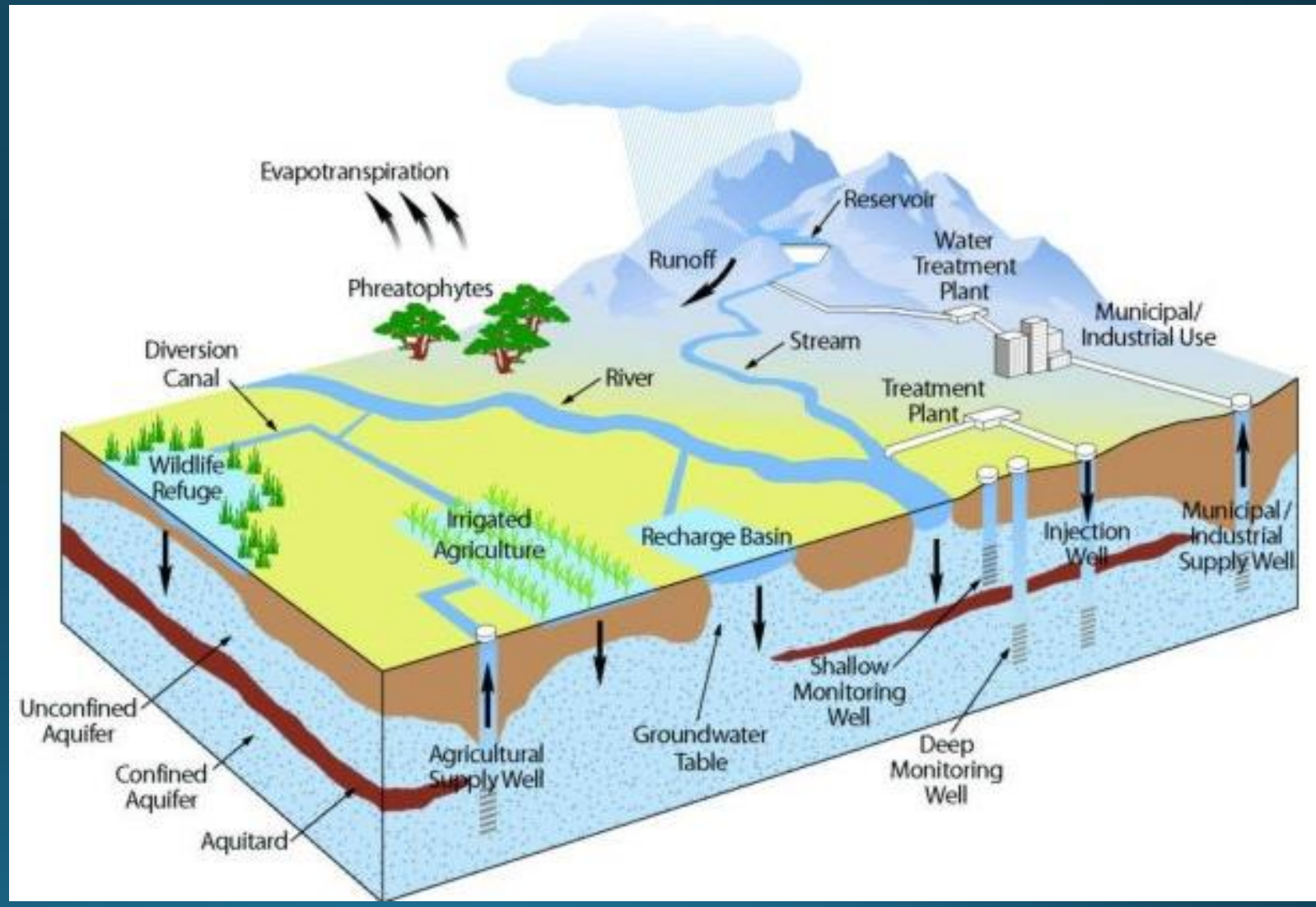
Water Management

- Water reuse
- Water conservation
- Decreased groundwater pumping
- Recharge basins
- Augmentation



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Water Management

Unintended consequences

- Less salt flushing
- Increasing salinity
- Rising groundwater levels / waterlogging
- Soil damage
- Crop damage
- Property damage

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Salinity / Water-quality Data

- Previous / On-going water-quality monitoring
  - Northern Water
  - Central Colorado Water Conservancy District (CCWCD)
  - Colorado Water Quality Control Division
  - USGS
  - EPA
- Electrical Conductivity / Specific Conductance
- Water-quality sampling / analysis

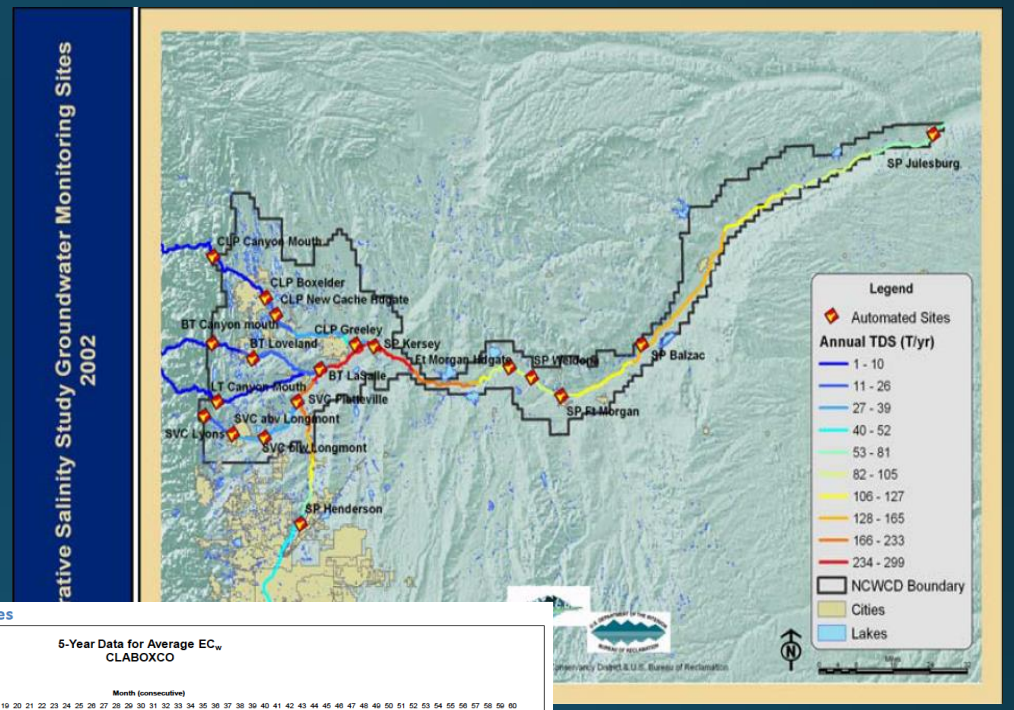
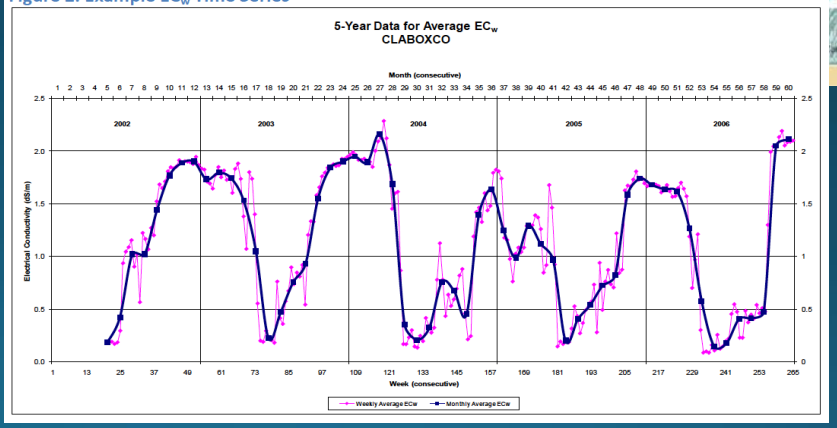


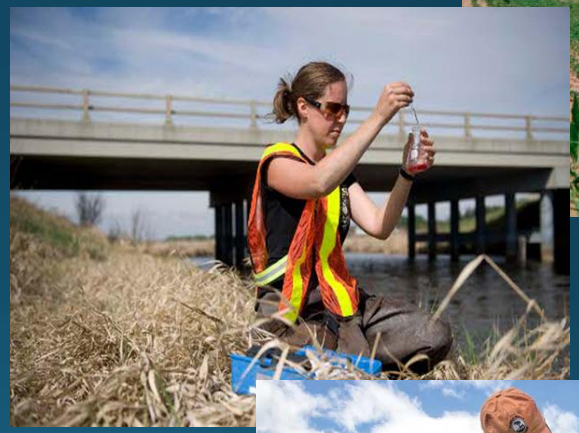
Figure 2. Example EC_w Time Series



A Study of Salinity in the Lower South Platte Basin; Compiled 5-Year Study; Northern Water In Cooperation with: United States Bureau of Reclamation, 2009

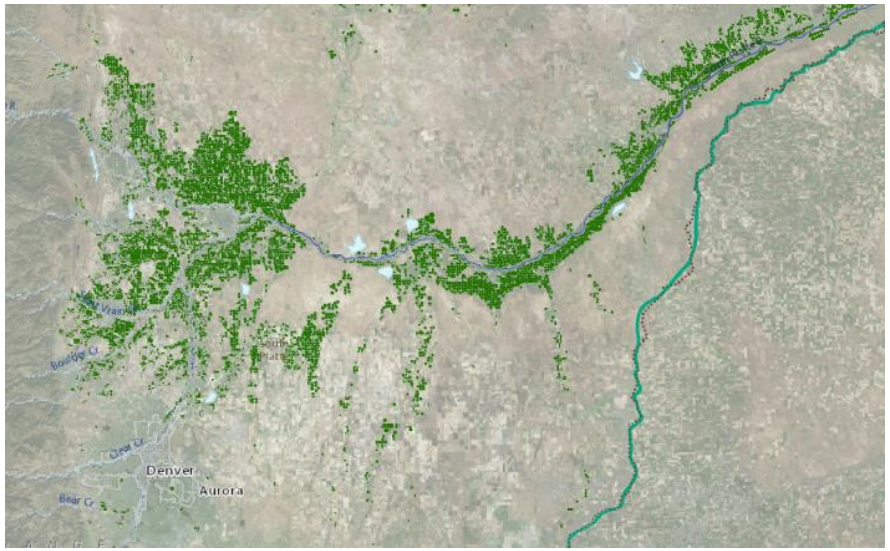
Salinity Study

- Have conditions changed due to changing management practices?
- Scoping-level study
- Field-data collection
  - Electrical Conductivity / Specific Conductance
  - Water-quality sampling
  - Laboratory analyses – major ions, TDS
- Upstream of Denver to State line
- South Platte River, major tributaries, major diversions



Project Advisors

South Platte River Basin
Irrigated Agriculture



- **Mark Sponsler**
  - Executive Officer, Colorado Corn Growers Association
- **Dr. Tim Gates**
  - Professor, Civil and Environmental Engineering Department, Colorado State University
  - Arkansas River basin salinity studies

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QUESTIONS?

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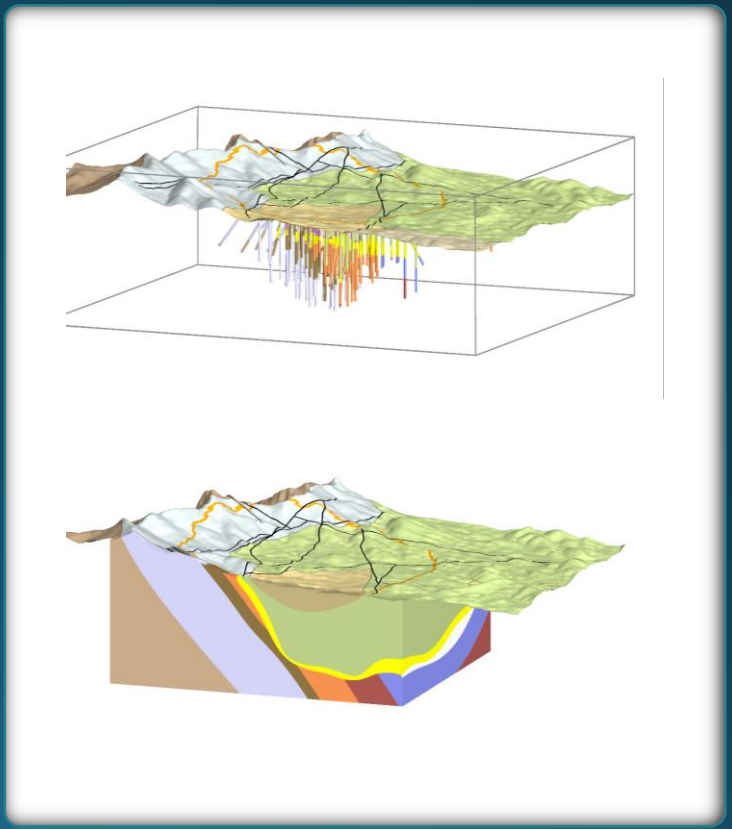
BACKGROUND INFORMATION SLIDES

NEIRBO HYDROGEOLOGY

- Fort Collins based consulting firm
- Principal / Owner Grady O'Brien
- Founded in 2012
  - Characterization
  - Conceptualization
  - 3-D Geologic and Groundwater Modeling
  - Engineering effects
  - Engineering design



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