

## HISTORIC PRODUCED WATER SPILL SITE CHARACTERIZATION Pre-Reclamation Guide

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**Sublette, Bert Fisher, and Ken Carlson were the key consultants who served North Dakota Oil and**

**Gas Research Fund/Energy Environment Research Council**

**The EERC at UND characterized brine impacted soils and water of**

**North Dakota's Ground Zero Bottineau County**

### Visual inspection

- Vegetation damage
- Salt tolerant vegetation
- Salt crusts
- Sodic soils
- Erosion
- Corrosion of surface steel products

### Geophysical survey

- EM31 or equivalent (penetrates to 15-20 ft.)
  - \*Soil coring for ground truthing of geophysics and depth characterization
    - Composite samples by depth: 0-6", 6-12", then every foot thereafter
    - Saturated paste analysis: EC, SAR, TDS, pH, B, cation/anion balance
- Resistivity surveys for large complex sites
  - \*Penetrates to larger depths
  - \*Reduces soil coring requirements

### Drainage analysis

- Slope
- Stratigraphy (permeability)
- Drainage gradients
- Environmental receptors

### Threat to groundwater (relative weights shown in parentheses)

- Chloride mass (10)
- Aquifer thickness (7)
- Depth to groundwater (3)
- Annual precipitation (2)
- Evaporation index (2)
- Surface soil type (4)
- Slope (1)
- Vadose zone material (> 3ft) (5)
- Aquifer hydraulic conductivity (4)
- Width of contamination perpendicular to direction of groundwater flow (3)

North Dakota Soils all have sodium sulfide salts. With intense farming sodium sulfides become concentrated. This is especially true in areas troubled by intense grazing and sheet erosion. Often, grass and cash crops are stunted or unable to grow at all. Therefore:

1. Each site should have a groundwater survey to determine the regions baseline levels of cations and anions. We cannot assume all the salted lands in the Williston Basin are from oil field brine. Many areas have mixed loads of sodium sulfide and sodium chloride.
2. Landowners should be involved in the development in their own reclamation plan. Not only the NDIC and North Dakota Health Department have relevant data but also that the ND State Water Commission has a treasure trove of groundwater information.
3. Individual landowners should obtain a soil survey prepared by a professional soil classifier. That survey will aid in comparing soil series that are located nearby on the oil industry impacted landscape. The goal is to find nearby lands which we are reasonable convinced have never been affected by the oil industry. The survey will provide information on the landowner's soil, its development and characteristics.
4. The last step in confirming successful reclamation is to compare the Productivity Index pre- and post-reclamation. This last step will always demonstrate the difference in reclamation outcomes directed by engineers who do not even plan for restoration of productivity to soil scientists who do concern themselves with restoration productivity. This means the Salt Contaminated Land and Water Council endorses reclamation leadership be provided by soil scientists who see soils as **agronomic engines**.
5. Every reclamation plan should be designed and directed by soil scientists.

# Remediation of Brine Impacted Soils



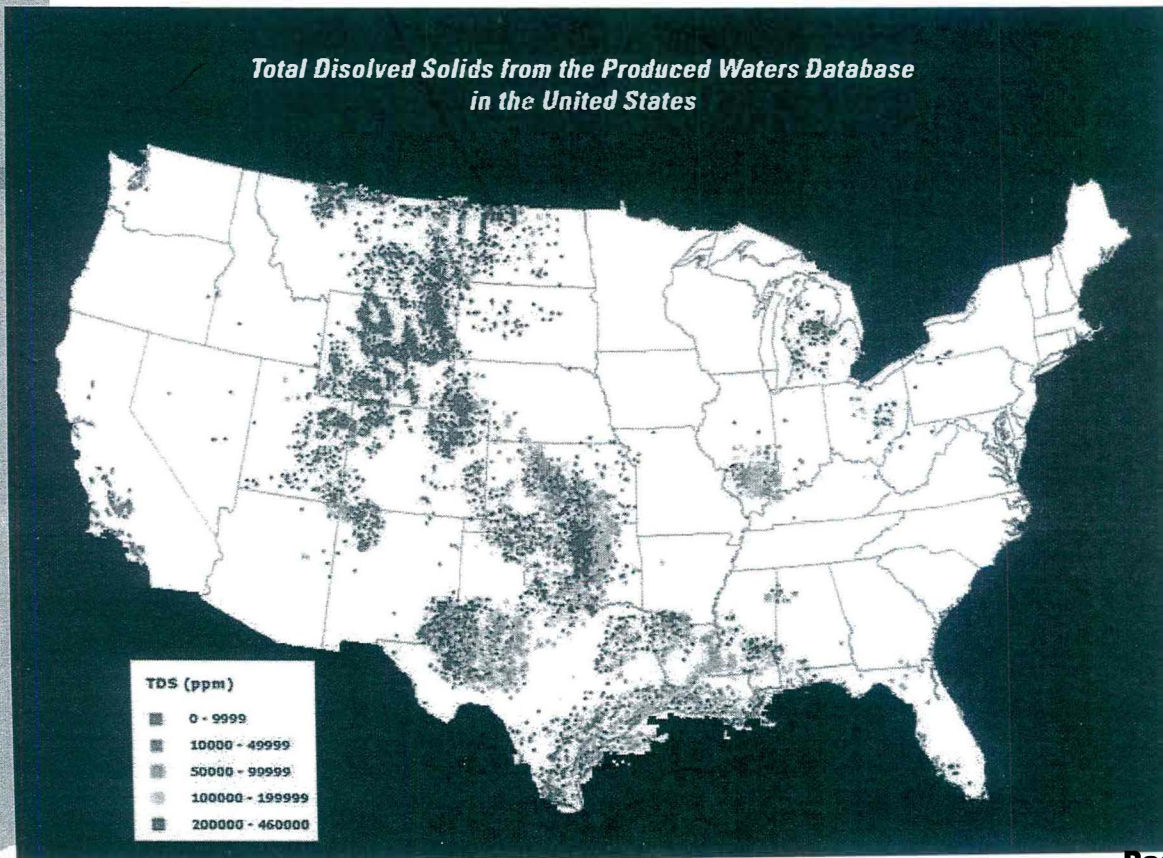
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Most of the TDS (total dissolved solids) are salts

*Total Dissolved Solids from the Produced Waters Database  
in the United States*



# ND Bakken Produced Water

Chemical Composition of Brine Solution

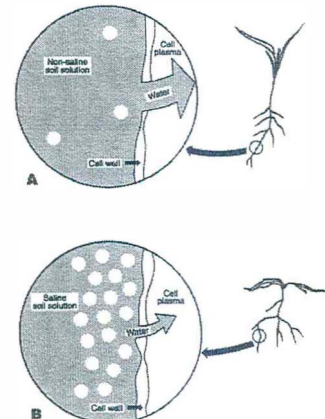
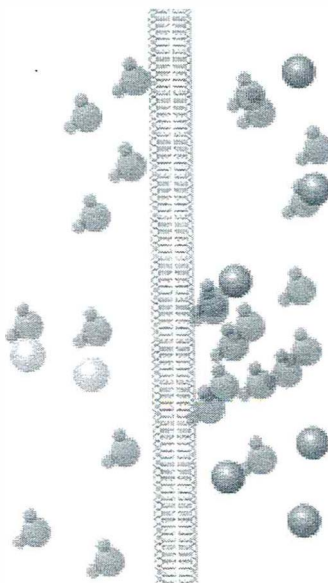


Spills of produced water or brine on soil result in two types of damage:

*Wet*

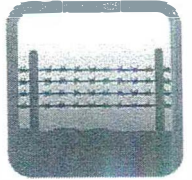
## \* Excess salinity

- Creates an osmotic imbalance that reduces water uptake by plant roots. Plants can go into drought stress even though there is plenty of water in the soil.





## Management of revegetation sites



- # Light mulch
  - Protects seeds from wind and water erosion, conserves moisture, moderates soil temperature
  - Use local hay, weed free
  - Tackifiers help in windy climates (guar gum, polyacrylamides)
- # Protect from grazing until roots have firmly established (usually 2-3 years)
- # Watch for signs of foraging by wildlife
- # Hand pull weeds or spot herbicide
  - Most grass seedlings can tolerate herbicide application after reaching the 4 leaf stage

## Management of revegetation sites

- # Watch for
  - Foraging by wildlife
  - Erosion
  - Areas of revegetation failure
- # Nutrient management is especially important when gypsum has been used in remediation of brine spills!