East TX Test Site (1/2 Treated)
CATION EXCHANGE CAPACITY (CEC)

- It is a measure of the quantity of cations reversibly adsorbed per unit weight of soil.
- CEC is expressed in meq/100 g of mass (meq is milliequivalents)
  CEC is a measure of the quantity of cations reversibly adsorbed per unit weight of soil.
- The predominant cations in soils are Ca$^{2+}$, Mg$^{2+}$, Na$^{+}$ and K$^{+}$
- Percentage of CEC occupied by the basic cations is called Base Saturation. Fertile soil has Base Saturation greater than 80%, predominantly Ca and Mg.
CATION ADSORPTION ON SOIL

- Cations are held at the exchange sites with different adsorption strengths.
- For most minerals the strength of adsorption depends on cationic species: $\text{Ca}^{2+} > \text{Mg}^{2+} > \text{NH}_4^+ > \text{K}^+ > \text{Na}^+$
- Strength of cationic adsorption depends on the following:
  - Adsorption strength is directly proportional to the **charge** on cations.
  - Strength of similar charge is influenced by **ionic radius** of the hydrated cations.
  - The **quantity** of the cations added.
SODIUM CONTAMINATION OF SOILS

- Effects of Sodium & Chlorides ($\text{Na}^+ \text{ Cl}^-$)
  - Osmotic pressure - plant dehydration (EC)
  - Loss of vital plant nutrients
  - Sodium toxicity

- $\text{Na}^+$ is particularly detrimental due to its toxic effect on plants and its effect on soil structure.

- When a high percentage of Cationic Exchange Capacity (CEC) is occupied by $\text{Na}^+$, the soil disperses.
  - clays - soil deterioration - no percolation - erosion
Electrical Conductivity (EC) & Total Dissolved Solids TDS

- Soluble constituents (ions) present in the soil conduct electric current.
- Ability to conduct electric current is known as *Electrical Conductivity*.
  
  *Controls Osmotic Pressure which effects the ability of the plant to uptake water.*

- EC is measured as *m mhos/cm or m S/cm*.
- **EC is an indirect measure of TDS.** TDS = 613 x EC
- Example: If EC = 2.0 m mhos/cm; TDS = 613 * 2.0 = 1226 mg/L.

  0-2 mmhos/cm – no affect on plant life
  2-4 mmhos/cm – slight affect on plant life
  (consistent with Rule 8 guidelines)
  4-8 mmhos/cm – moderate affect on plant life
  8-16 mmhos/cm – only tolerant plants yield well
  >16 mmhos/cm – only very tolerant plants yield well
SODIUM ADSORPTION RATIO (SAR) & EXCHANGEABLE SODIUM (ESP)

- As the presence of sodium in soil has detrimental influence on fertility, SAR is used as the comparative measure against other cationic species such as Ca and Mg. But MAY NOT reflect permanent damage.
  \[ \text{SAR} = \frac{(\text{Na})}{[(\text{Ca} + \text{Mg})/2]^{0.5}} \]

- ESP reflects the Na actually attached to the soil structure and therefore indicates permanent damage.
  \[ \text{ESP (\%)} = \frac{(\text{Na}_X / \text{CEC}) \times 100}{1 + (-0.0126 + 0.01475 \text{SAR})} \]
  Threshold level for ESP for Na is 15%.

- If SAR is known, under equilibrium condition, ESP can be imcomputed by an empirical expression
  \[ \text{ESP (\%)} = 100(-0.0126 + 0.01475 \text{SAR}) / [1 + (-0.0126 + 0.01475 \text{SAR})] \]
So What do the Numbers Mean SALINE to SODIC SOIL

- **Saline Soil:**
  - EC > 4 m mho/cm
  - SAR > 12
  - ESP < 15 %
  Clay particles remain aggregated even after rain

- **Saline/Sodic Soil:**
  - EC > 4 m mho/cm
  - SAR > 12
  - ESP > 15 %
  Clay particles can disperse if rain lowers the salinity

- **Sodic Soil:**
  - EC < 4 m mho/cm
  - SAR > 12
  - ESP > 15 %
  Clay particles disperses after rain
To use the chart below:
(1) Select the appropriate soil type
(2) Determine the salt concentrations in the produced water (Cl⁻ ppm, TDS, or water density)
(3) Determine the size in acres of the contaminated area (1 acre = 43,560 square feet)
(4) Using the graph, determine the DeSalt Plus™ requirements per acre
(5) It is recommended that DeSalt Plus™ be diluted with fresh water at a minimum of 10:1
(6) After application, irrigation with fresh water is required to accelerate the removal of the contamination.

Gallons of DeSalt Plus™ per acre
Based on Soil types and contaminating fluid
SODIUM SOIL REMEDIATION

- Remediating in a **timely** manner necessitates lowering excess exchangeable sodium with a stronger cationic source.
- The active cations will **displace the sodium ions** present in the soil, allowing the displaced sodium to be flushed out of the root zone by water.
- Accumulated salts in soils contain: \( \text{Na}^+, \text{K}^+, \text{P}^+ \text{NH}_4^+, \text{Ca}^{2+} \) and \( \text{Mg}^{2+} \)………. as cations. \( \text{Na}^+ \) is particularly detrimental due to its **toxic effect on plants** and **its effect on soil structure**. Sodic soils disperse and erode or compact becoming impermeable to water and develop a hard surface crust.

**Closure & Recommended values for farming and growing conditions:**

- \( \text{EC} \) 0-4
- \( \text{SAR} \) < 12
- \( \text{Sodium} \) < 500 ppm
- \( \text{ESP} \) < 15%
DeSalt Plus™

a Complete Amendment System

✓ A water soluble, active solution specially designed for prevention, reclamation & revitalization of severely salt damaged soils.

✓ The DeSalt Plus™ soil amendment links and optimizes Ca++, Mg++, K+ & NH4+ ions (stabilized to prevent conversion), selected activating organic acids, and flocculating agents, polymers and penetrants to improve percolation and surface contact. The DeSalt Plus™ is more than a chemical, it is a system. A soil amendment system proven over nearly 20 years and 3 continents.

✓ Note: DeSalt Plus™ - no nitrates!
Develop the Remediation Program

- Delineate & determine contamination levels
  - EC; SAR, ESP, CEC
  - Area and depth of remediation (Cu Yds.; Cu Meters; Acre Ft)
  - Potential for re-contamination (evaporation/wicking)

- Determine amendment types and requirements
  - Soil types and contamination level will dictate amendment requirements
  - Is gypsum an option? Dig & Haul? Capillary barrier needed?
  - Water availability etc.

- Develop the Work Plan
  - Site Preparation
  - Leaching process
    - Irrigation requirements/options
    - Contamination capture and disposal options
      - Vertical vs lateral drainage
      - French drains, Capture sump, disposal etc.
  - Amendment Application
    1. Rip & Turn Soil (breaks soil barriers)
    2. Bulk with Hay or Mulch (keeps soil open)
    3. Apply *Desalt Plus™* - Irrigate - Monitor
    4. Apply *GeoRinse™* (with irrigation water)
    5. Apply *JumpStart™* (nutrients package)

- Re-vegetate & Monitor
New Spill on Sandy Soil (First Response Treatment)
Break In Salt Water Line
East Texas
Pipe Line Break
(First Response Treatment)
Haynesville Louisiana

- Historical Site
- Salt Water Disposal

Site Condition
- Saline / Sodic
- Sandy Clay
- Top Soil Erosion
  - EC 17 - 49
  - SAR 12 - 64
  - ESP 17 - 52
  - CEC 6 - 15

Treatment
- Install drain system
- Deep plow and bulk
- Apply amendments
- Flush with water

Amendments Applied
- DeSalt Plus™
- GeoRinse™
- JumpStart™

Test Seeding
Replanting of Native Grass

Time Lapse = 24 months
Harris County, Texas

- Historical Site
- Salt Water Disposal System

Site Condition
- Saline / Sodic Soil
- Heavy Clay
  - EC 77
  - SAR 125
  - ESP 93
  - CEC 40

Treatment
- Deep plow and bulk soil
- Install drain pattern with bulking materials
- Applied amendments
- Irrigate

Amendments Applied
- DeSalt Plus™
- GeoRinse™
- JumpStart™

Re-seed with grass (& Turnips)
Time Lapse = 18 months
Montgomery County, TX

- Saline / Sodic
- Salt Water Leak

Site Condition

- Sandy Clay
  - EC 84
  - SAR 38
  - ESP 35
  - CEC 17

Treatment
- Test soil
- Apply amendments
- Flush with water

Amendments Applied
- *DeSalt Plus™*
- *GeoRinse™*

Test Seeding
Re-seeding with Native Grass

Time Lapse = 9 months
Gregg County, TX

- Historical Site
- Salt Water Disposal Pit

Site Condition
- Sodic Soil
- Top Soil Erosion
- Sandy Clay
  EC   12
  SAR  27
  ESP  50
  CEC  5

Treatment
- Deep plow and bulk soil
- Apply amendments
- Flush with water

Amendments Applied
- DeSalt Plus™
- GeoRinse™

Re-seed with native grass

Time Lapse = 12 months
Terrebonne Parish, Louisiana

- Historical Site
- Salt Water Disposal Pit

Site Condition

- Sodic Soil
- Heavy Clay

<table>
<thead>
<tr>
<th>EC</th>
<th>SAR</th>
<th>ESP</th>
<th>CEC</th>
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<tbody>
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<td>20</td>
<td>30</td>
<td>43</td>
<td>46</td>
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</tbody>
</table>

Treatment

- Disc soil
- Apply amendments
- Flush with water

Amendments Applied

- DeSalt Plus™
- GeoRinse™

Test Seeding

Time Lapse = 18 months
**S E Oklahoma**
- Produced Salt Water
- Underground pipe leak
- 4+ Acres – 12 feet deep

**Site Condition**
- Saline / Sodic
- Red Clay
- Top Soil Erosion

**EC** 30+
**SAR** 70
**ESP** 50
**CEC** 24

**Treatment**
- Excavate to 12’ depth contamination & install drain tiles and sump
- Bulk soil with hay and replace in 2 ft. lifts
- Apply Amendments
- Irrigate/Flush with water
- Capture flush water and send to disposal well

**Amendments Applied**
- *DeSalt Plus™*
- *GeoRinse™*
- *JumpStart™*

Re-seed pasture

**Time Lapse = 16 mos.**