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LIABILITY REDUCTION FROM THE APPLICATION OF AN ALTERNATE CLOSURE PROTOCOL FOR SALT AFFECTED WELLSITES

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Outline

- Liability Management
- Alternate Closure Protocol
- Case Study
- Liability Reductions
- Lessons Learned



Liability Management

- Why is Liability Management a concern?
 - Industry is legislated to manage individual wells, not liability or field wide concerns
 - Current framework is driving the inefficient use of capital
 - In times of decreasing available capital the industry must become more efficient
 - Future - Industry is dealing with a finite resource with increasing liability

Alternate Closure Protocol

Primary objective is to reduce the liability associated with shallow salinity elevated in relation to generic Tier 1 guidelines and obtain site closure.

Cost-effective assessment methodology for Sites that can expedite regulatory closure and certification, often without the need for remediation.

Alternate Closure Protocol

Alternate Closure Protocol was developed independently at MEMS and is a outcome driven approach

Alternate Closure Protocol builds on currently accepted regulatory tools where no current options for alternate closure exist

Why Native Prairie?

Native Prairie is a valued resource that requires protection

In a Native Prairie setting, sites can have a net environmental benefit from not undertaking remediation

The benefits include but are not limited to:

- Avoids unnecessary ecosystem disturbance, which may take many years to recover;
- Avoids the potential introduction of non-native / aggressive weed species
- Removal of greenhouse gas generation by heavy equipment during remediation; and
- Liability is reduced per Site and available to fund other projects.

Alternate Closure Protocol

1. Sites with no current adverse effects on native grassland ecosystems
2. Sites with no likely future adverse effects on native grassland ecosystems

Alternate Closure Protocol

1. Sites with no current adverse effects on native grassland ecosystems
 - demonstrated by meeting specified criteria from the *Reclamation Criteria for Wellsites and Associated Facilities for Native Grasslands*
2. Sites with no likely future adverse effects on native grassland ecosystems
 - demonstrated through multiple line of evidence that future upwards migration of salts is unlikely

Alternate Closure Protocol

- Alternate Closure Method addresses the ecological direct contact exposure pathway;
- Other relevant exposure pathways including the protection of DUA, FWAL, livestock and irrigation watering must also be considered and addressed for Site closure.

Case Study



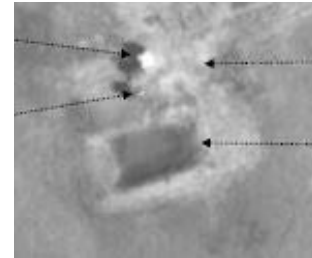
Site Setting

- Sites located in Native Prairie Setting
- Current land use is Agricultural; Livestock Grazing
- Dry Mixed Grass



Site History

- Shallow gas wells drilled in the late 1970's
- Drilled with KCl based drilling fluid
 - Shallow on site DWDA at 0.8 to 1.5 m
- On site fluid retention pits (Evap pits)



Site History

- Production has ended and well bore abandoned
- Background Soil Quality
 - EC; Poor (5 to 10 dS/m) to Unsuitable (>10 dS/m)
 - SAR; Unsuitable (>12)
- Shallow soil (< 1.5 m) with elevated salinity
- EC elevated relative to Tier 1 guidelines (6 to 20 dS/m)

Soil Quality

- Chloride ranges ($\sim 1,000$ to $5,500$ mg/kg)
 - Shallow Zones typically < 0.30 m thickness (DWDA)
 - Deeper zones of elevated chloride (Evap Pits)
- Sites historically at various assessment stages, with multiple historical assessments conducted

Alternate Closure Protocol

1. No current adverse effects

Demonstrated by meeting specified
Reclamation Criteria

- a healthy native grassland community has been re-established on the site, and is on a satisfactory successional trajectory
- Site meets *DSA*; then there is no current adverse effect with respect to the ecological direct contact pathway

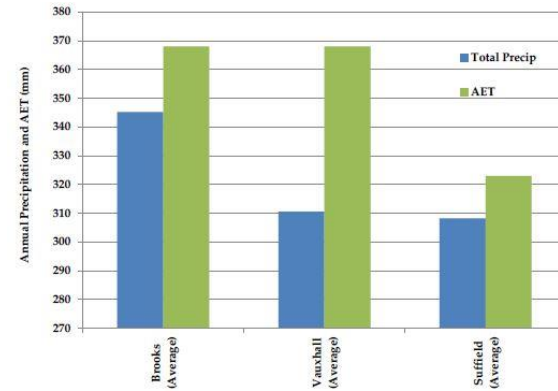
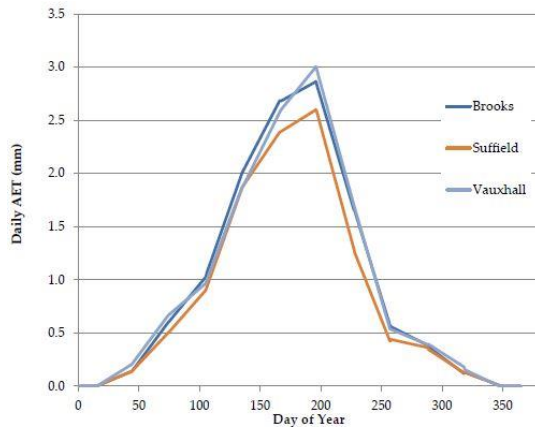
Alternate Closure Protocol

2. No likely future adverse effects

- Demonstrate that there is no long term net upwards moisture flux in the unsaturated zone
- MEMS Protocol requires multiple independent methods to demonstrate this.
 - Site-Specific Soil Moisture Modelling
 - Natural Salinity Profile

Site Specific Soil Moisture Modelling

- Long-term net moisture flux in the vadose zone
- HYDRUS-1D model based on site-specific physical and climatological information



Site Specific Soil Moisture Modelling

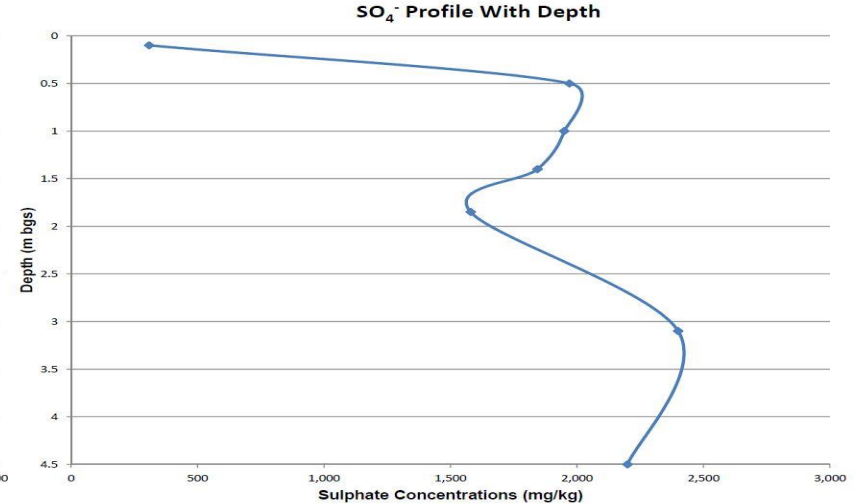
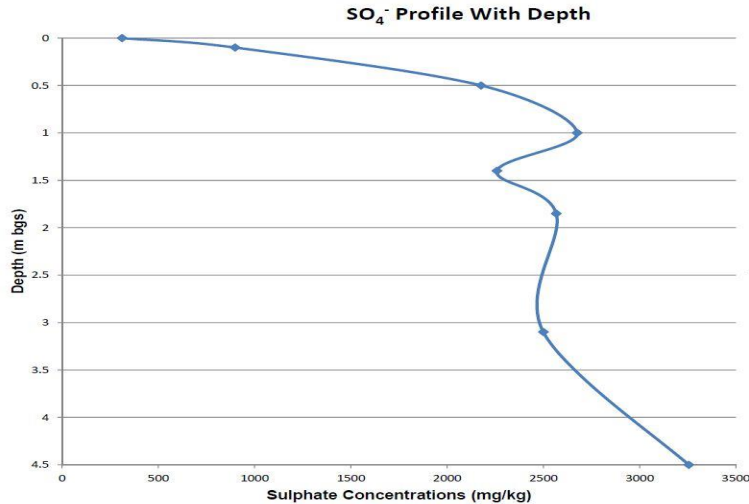
- The model output predicts that net moisture (salt flux) will be downward at a water table deeper than 0.81 m.
- Water table was confirmed to be greater than 6.0 m confirming net downward movement of water

Natural Salinity Profile Method

- naturally-occurring salts (Sulphate);
 - A pedogenic tracer of salinity
 - As an indicator of net long-term moisture flux
- Absence of sulphate at the surface is an indicator of long-term net downwards migration of moisture / salts

Natural Salinity Profile Method

- Natural soil sulphate profile with depth



Other Exposure Pathways (DUA, FWAL, LW, IW)

3D Hydrus Model

- Site specific model that inputs site specific chloride data
- Realistically represents the spatial distribution of chloride at the Site and distances to known receptors
- Beneficial for sites that require an alternate solution

Other Exposure Pathways (DUA, FWAL, LW, IW)

Subsoil Salinity Tool

- Tier 2A and 2B Models have been used in conjunction with the alternate closure protocol
- Beneficial for sites where site conditions meet the input parameters of the tool

Subsoil Salinity Tool

- Chloride Guideline Results
 - Livestock and Irrigation Watering; NGR (Water Table > 4 m)
 - DUA and FWAL; Typically at Management Limits ($\sim 7,000$ mg/kg)
- Protection was demonstrated for all other exposure pathways for all sites

Liability Reduction

MEMS Applied this method for 49 Sites in the study area with a soil volume $>$ Tier 1 of $25,550 \text{ m}^3$

- MEMS Alternate Closure Protocol reduced remediation volume $\sim 20,050 \text{ m}^3$
- Standard Tier 2 methods reduced remediation $\sim 4,500 \text{ m}^3$
- Represents $> 12\text{X}$ savings multiplier per dollar spent

Liability Reduction

MEMS Applied this method for 2 larger Sites in the study area with soil volume $>$ Tier 1 of 6,000 and 4,500 m³

- Application of the methods outlined in this presentation reduced the remediation volume to 0 m³
- Represents $>$ 10X savings multiplier per dollar spent

Lessons Learned

- Key Assessment Data
 - Background soil quality
 - Field verification of receptors
 - Data validation
- Collaboration with all parties is essential
- Risk Based Closure



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QUESTIONS
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