Engineered Soil Covers For Management of Salt Impacted Sites

by

Outline/Purpose

- Present design concepts of soil covers used in the mining industry and its potential applicability for salt impacted sites.
- Present a hypothetical analysis.
- Present a process for further research and development.
Introduction

- Salt impact at operating oil and gas facilities is a significant environmental concern.
- Drainage improvement and chemical amendments have limited success at fine grained sites.
- Excavation and disposal is costly.
Introduction

- Good majority of sites – fine grained and low sensitivity sites wrt. to groundwater
- Major environmental challenge – vegetation sustainability and mitigation of long term impact.
- Research into new approaches is ongoing.
- Another option, Engineered soil covers.
Soil Cover Systems
Mining Application

- The use of Engineered Soil Cover Systems in mining – since late 1980’s.
- Primarily used in ARD.
- Significant body of theoretical research, instrumented test covers and constructed covers.
ARD Design Objectives

- Minimize flux of oxygen.
- Minimize flux of precipitation.
- Long term stability – physical and ecological.
Types of Engineered Soil Covers

- Conventional low k covers.
- Store and release covers
- Covers incorporating a Capillary barrier.
Low k Covers

- Compacted clay, $10^{-9}$ m/s.
- Effective where precip. = evap.
- Semi arid climate (precip < evap) likely desiccation.
Store and Release Covers

- Effective when precip < evap.
- Acts as a sponge – infiltration of moisture then evapotranspiration before wetting front moves below base of rooting zone.
- Effective when precipitation events are not excessive and of long duration.
Capillary Break

Fine grained material over a coarse grained material.
Low infiltration – coarse layer has lower k than fine layer. Prevents flow.
Unsaturated conditions must be maintained.

Figure 2.15  Hydraulic conductivity function for the coarse and fine textured materials used in the capillary barrier diversion length example.
Unsaturated Groundwater Flow Case Study

- theoretical & laboratory scale study to characterize moisture movement through layered sand and clay
- high flux & low flux scenario

Schematic of a column with segregated coarse and fine textured materials (O’Kane et al., 1999).
Flow Through Sand or Clay?

[Graph showing hydraulic conductivity vs. suction for coarse and fine materials with different flux values]
Application to Salt Impacted Sites

- Fine grained sites - Low sensitivity wrt Groundwater

**Design Objectives**
- Properly reclaimed soil for vegetation growth.
- Minimize (zero) infiltration.
- Minimize exfiltration flux.
- Long term sustainability
Proposed Soil Cover System

- **Fine Textured Soil Layer**
- **Coarse Textured Soil Layer**
- **Waste Material**

Regulatory Framework

- Risk Management an option.

**Criteria to meet**

- Equivalent land capability restored – reclamation and store and release cover.
- No long term impact to environment and human health demonstrated – moisture movement limited.
Hypothetical Analysis

- Hypothetical Site Characteristics
  - agricultural land base
  - located near Edmonton (climate data)
  - clay till profile
  - 3 m depth to groundwater table
  - low sensitivity wrt groundwater utilization
  - shallow profile impacted by salinity
Hypothetical Analysis

- **Analysis Objectives**
  - numerical modelling to predict vadose zone groundwater movement through various soil profiles
  - attempt to design cover system to control vertical gw movement
  - **SoilCover Model used**
    - climatic data – Edmonton climatic Normal season
    - soil properties – typical sand and clay properties, no site specific data available
SoilCover Analysis

- **BASE CASE:**
  - no cover.

- **COVER SYSTEM 1:**
  - 1 m of uncompacted till (store and release cover).

- **COVER SYSTEM 2:**
  - 0.5 m capillary break layer and 1 m of uncompacted till (store and release).
SoilCover Results

- **Base Case – no cover**
  - Exfiltration causing upward migration of salts.
  - No short term improvement
  - No long term improvement due to long term salts migration.
SoilCover Results

- Cover System 1: 1 m store and release cover.
  - Upward exfiltration flux.
  - Less than Base Case, but upward migration of salts.
  - Short term improvement due to importing clean fill.
  - Long term decrease in productivity due to long term salts migration.
SoilCover Results

- **Cover System 2**: 1 m store and release cover and capillary break.
  - Net infiltration flux ~ 1% of precip or 4 mm/yr – could be engineered to zero.
  - Short term improvement due to importing clean fill.
  - Long term vegetation sustainability by controlling salt migration.
SoilCover Results

Static Pressure Distribution

uncompacted Till

Loose Sand

Native Till

Elevation Above Water Table (m)

Matric Suction (kPa)

Percent Saturation
Where to From Here?

- Stakeholder Input
- Research Study Program
  - Pre-Feasibility Study
  - Site Selection
  - Feasibility Study
  - Field Trial
  - Long Term Performance Trends
- Full Scale Investigation
Summary

- Application of Soil Cover Systems to salt impacted sites possible.
- Research and development approach required similar to mining approach.
- Multi stakeholder involvement required.