Modelling Groundwater Flow and Transport in Peat with Focus on Northern Alberta

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Outline

• Background

• Problem Statement

• Case Study
Northern Alberta

wetlands, peat bogs, fens, sloughs and rivers

Photo Source: Google Earth
Key Infrastructure

Photo Source: www.albertawilderness.ca
Problem Statement

• Maintain infrastructure and protect environment
• Spills and contaminant concentrations
• Remediate and manage contaminated wetlands
• Conceptual models must integrate peat properties
Key Definitions

- Hydraulic conductivity (K) is ability of a porous medium to transmit water under a given hydraulic gradient.

- Anisotropy (of K) means that K is directionally dependent.

- Heterogeneity (in K) refers to distinctly non-uniform distribution of K in space.
Northern Alberta

Slough

Peat Bog

Mineral Soil Plateau
Case Study

- Slough
- Peat Bog
- Mineral Soil Plateau
- Affected Bog Region

Spill Area
Objectives

• Investigate the impacts of spill

• Propose conceptual model and predict movement

• Propose management options
Case Study

- Slough
- Peat Bog
- Mineral Soil Plateau
- Affected Bog Region
Objectives

- Investigate the impacts of spill
- Propose conceptual model and predict movement
- Propose management options
Contamination Hotspots

- Chlorides: ~24,000 mg/L
- Chlorides: ~60,000 mg/L
- ~Chlorides: 20,000 mg/L

Affected Bog Region
Slough
Vertical Culverts
Culvert Trench
Hotspots
Management Plan

- Affected Bog Region
- Slough
- Vertical Culverts
- Culvert Trench
- Hotspots

Protect Slough

Excavate

Pump, monitor, predict and manage
Prediction

- FEFLOW Groundwater flow and transport model
- Predict Slough concentrations
- Improve conceptual model
- Propose management options

Flow Calibration
Transport Calibration

Model Domain
Observation Points
Culverts and Trenches
Slough

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Transport Calibration

**Graphs**

- **P10-32A**
  - Concentration [mg/L]
  - Time [days]
  - Observed and Simulated data points

- **P08-14A**
  - Concentration [mg/L]
  - Time [days]
  - Observed and Simulated data points
Scenario Modelling

Model Domain
Observation Points
Culverts and Trenches
Slough

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Scenario Modelling

Additional trench installed at end of 2018
Scenario Modelling

Chloride concentrations at Slough with time

Guideline for Surface Water: 120 mg/L
Formation Sequence

Stage 1: Receding glaciers

Stage 2: Shallow Glacial Lake

Stage 3: Colonization by vegetation

Stage 4: Cold and oxygen poor conditions Prevent normal degradation of sinking dead plants resulting into formation of peat

Stage 5: Accumulation continues; nutrient poor conditions result into slow growth and accumulation; older, deeper peat continues to degrade further, while fresh vegetation on top creates more porous surface layer
Peat Properties

• Exponential decrease in saturated hydraulic conductivity (K) with depth
  
• High degree of anisotropy and heterogeneity
  
• Pools of peat deposits – deposition history
  
• Closed pores, backward diffusion, fibre absorption, deep pools unique processes to peat
K-Depth Relationship

Flow Calibration

- Model Domain
- Observation Points
- Culverts and Trenches
- Slough

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Flow Calibration

Simulated without layered peat

Simulated with layered peat
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TYPICAL CROSS SECTION

Source: WorleyParsons Canada Services Ltd.
Peat Pools

Affected Bog Region

C chlorides: ~24,000 mg/L

C chlorides: ~60,000 mg/L

~C chlorides: 20,000 mg/L

Hotspots

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Peat Properties

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Conceptual Model

• Initial mode of water transport dominantly overland

• Vertical movement into low K zone

• Accumulation into thicker peat zones

• Freshwater movement in upper high K zone
• Flow and transport in peat is different than mineral soils

• Solutions need to consider anisotropy and peat layering

• Long term implications of peat properties