EVALUATION OF COVER SYSTEMS UTILISING GEOSYNTHETIC LAYERS FOR CLOSURE OF COAL WASTE ROCK PILES IN A SEASONALLY HUMID LOCATION

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Presentation Outline

- Background on Reclaimed Waste Rock Piles
- Overview of the Performance Monitoring Systems
- Examples of Cover System Performance
- Final Comments
Enterprise Cape Breton Corporation (ECBC)

- **ECBC was a Federal Crown Corporation responsible for environmental remediation associated with coal mining activities in Cape Breton**
  
  - Mining operations began in 1685 and lasted into the 1980s
  
  - 50 underground mines produced 500 million tonnes of coal

- Consultants through Standing Offer Agreements with PWGSC were engaged to develop closure plans for the coal WRPs

- O’Kane Consultants were engaged to design and install monitoring systems to ensure that the reclaimed WRPs meet closure objectives:
  
  1) Stable landform, 2) Sustainable vegetation and 3) Limiting impacts to receiving environment
Site Location

Site: Near Sydney, NS
Cape Breton Island

- Lingan
- Scotchtown Summit (Summit)
- Victoria Junction (VJ)

Atlantic Canada

Map showing site location near Sydney, NS on Cape Breton Island. Key locations include Lingan, Scotchtown Summit (Summit), and Victoria Junction (VJ). The map also indicates the proximity of the site to Sydney and other major cities in Atlantic Canada.
Background – Cover Profiles

LINGAN

0.5m GROWTH MEDIUM

WASTE ROCK

SCOTCHTOWN SUMMIT

0.5m GROWTH MEDIUM

GEO-FABRIC

HDFE

0.15m BEDDING SAND

WASTE ROCK

VICTORIA JUNCTION

0.9m GROWTH MEDIUM

0.4m GRDL

HDFE

0.15m BEDDING SAND

WASTE ROCK

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Integrated Mine Waste Management and Closure Services
Specialists in Geochemistry and Unsaturated Zone Hydrology
Background – Sydney, N.S.

Climate:

- Mean annual PPT is ~1,500 mm
- 60% occurs in Winter (from October to March)
- ~50% of winter PPT is snowfall
- Mean annual PE ~700 mm
- Energy deficit in most months

Atmospheric Water Demand In Summer
Background - Lingan

Landform:

- Covers an area of 8.5 ha
- 15 m high
- Plateau ~3% slope transitioning to 5:1 side slope
- Runoff ditch constructed around plateau which channels flow to drop structures on side slope
Background - Summit

Landform:
- Covers an area of 44 ha
- Thickness of 1.5m to 10m
- Plateau 3% slope transitioning to 7:1 side slope
- Runoff ditch constructed around perimeter

Background - Summit

● Covers an area of 44 ha
● Thickness of 1.5m to 10m
● Plateau 3% slope transitioning to 7:1 side slope
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Landform:
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Background - Summit

Landform:
**Background – Victoria Junction**

**Landform:**
- Covers an area of 26 ha
- Height of 30m
- Plateau ~7%
- Side Slope 3:1
- Ditch constructed around plateau which channels runoff and interflow to drop structures on side slope
In Situ Direct Monitoring

- **Monitored water balance component:**
  - AET
  - PPT
  - Runoff
  - Interflow
  - Water Storage
  - Net percolation (NP)

- **NP Estimated through:**
  - Water balance
  - Conservative tracer

- **Internal WRP Monitoring System:**
  - Temperature
  - Pressure
  - GW elevations
  - Pore-gas concentrations
  - Pore-water quality
Calculate Potential Evaporation

- Monitored Climatic Parameters at each Site:
  - precipitation
  - air temperature
  - relative humidity
  - wind speed and direction
  - net solar radiation

- Installed multiple net radiometers (north aspect)

- Snowpack (i.e. SWE) measurements
  - Automated and manual
In Situ Cover Monitoring

Eddy Covariance Station
(direct measurement of AET)
**In Situ Cover Monitoring**

**Soil Nest Sensor Configuration**

- **Thermal conductivity (TC) sensors**
  - soil suction and temperature
- **TDR sensors**
  - volumetric water content
- **Gas sampling ports**
  - \(O_2/CO_2\) concentrations
- **OTT water level sensor**
  - Positive pore-water pressure
- **Fully automated monitoring**
- **Numerous monitoring sites to quantify heterogeneity in water dynamics**
In Situ Cover Monitoring

Victoria Junction Sensor Nest
Surface Runoff Monitoring
Surface Runoff Monitoring
Monitoring Data – Summit

Water Dynamics: Erosion

Comparative Analysis for Slope Section

<table>
<thead>
<tr>
<th>Ks (cm/s)</th>
<th>Infiltration Rate (mm/day)</th>
<th>Maximum Height of Water in Cover (m)</th>
</tr>
</thead>
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<tr>
<td></td>
<td>2.7</td>
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<td>1.5</td>
<td>1.2</td>
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<tr>
<td>1E-01</td>
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</tbody>
</table>
Monitoring Data - Summit

Long-Term Erosion

Severe erosion hazards zone - revegetation improbable.

Critical erosion hazards zone - revegetation success poor.

Moderate erosion hazards zone - revegetation success fair.

Moderate erosion hazards zone - revegetation success good.

Moderate erosion hazards zone - revegetation success very good.

Slight erosion hazards zone - slope influence minimal.

- Chemically Stable
- Low Slope Angles
- Significant Vegetation
- Pore-Water Effects!!!
Monitoring Data – Summit
Water Dynamics: Leakage
**Monitoring Data – Summit**

**Water Dynamics: Leakage**

**Comparative Analysis for Plateau**

<table>
<thead>
<tr>
<th>Ks (cm/s)</th>
<th>Infiltration Rate (mm/day)</th>
<th>Maximum Height of Water in Cover (m)</th>
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<tbody>
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<td>17.5 14.7 11.5 7.5 4.2</td>
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<tr>
<td>1E-03</td>
<td>4.2 3.6 2.8 1.9 1.1</td>
<td>4.2 3.6 2.8 1.9 1.1</td>
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<tr>
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<td>1.1 1.0 0.8 0.6 0.4</td>
</tr>
<tr>
<td>1E-01</td>
<td>0.4 0.3 0.2 0.2 0.1</td>
<td>0.4 0.3 0.2 0.2 0.1</td>
</tr>
</tbody>
</table>
Monitoring Data – Victoria Junction

Water Dynamics:

- VJ granular drainage layer is drained, minimizes potential for leakage, maximize slope stability
Monitoring Data – Victoria Junction

Water Dynamics:

- The outlet from the plateau drainage layer is a bottle neck to flow and could result in erosion or failure.
- Perimeter ditch constructed perpendicular to slope along the crest will be ‘fighting’ natural geomorphic processes.
Monitoring Data – Victoria Junction

Water Dynamics:

3:1 Side Slope

Perimeter Ditch

Plateau

Drainage Layer

Till / DYKE

HDPE

Drainage Layer
Monitoring Data – Lingan / VJ / Summit

Water Balance:

- **Runoff at Summit ~60%**
- **Interflow at Victoria Junction ~15%**
  - Interflow offsets proportional runoff volume
  - Minimum 20% interflow volumes to minimize buildup of positive pore-water pressures
- **Net Percolation at Lingan ~30%**
  - Net percolation offsets a proportional runoff volume
Net Percolation Rates

Cover System Type

- Geomembrane
- Growth Medium

Range of Net Percolation Rates

- <5% Very Low
- 10% Low
- 20% Moderate
- 30% High

Growth Medium

- 20%
- 10%
- <5%

Net Percolation Rates

- Very Low
- Low
- Moderate
- High

Images:

1. Geomembrane covered area
2. Soil layer detail
Runoff Rates

Cover System Type

Growth Medium

- Very Low
- Low
- Moderate
- High

Geomembrane

- 20 to 30%
- 50%
- 60%
- No Drainage

Range of Runoff Rates

*Growth Medium* vs *Geomembrane*
Final Comments

- **Reclaimed WRPs** have resulted in improvements to the receiving environment.
- Given the relatively **small WRPs**, the issues identified here would be **more significant** when scaled up to a larger landform.
- As **environmental regulations** become more **stringent**, geosynthetics may become more common as a closure option.
- An understanding of the **engineering properties** for geosynthetics have been developed but **limited information** is available in regards to the **in-service performance**.
Final Comments

- Focus your engineering design on **protecting** and **maximizing the performance** of the barrier layer.
Thank You!

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Habitat for Humanity Initiative – El Salvador

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