C.4 Use of Low Permeability Covers and Liners in Solid Waste Management - An Opportunity for Technology Transfer

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Use of Low Permeability Covers and Liners in Solid Waste Management
An Opportunity for Technology Transfer

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AGENDA

- Solid Waste Management in B.C.
- Environmental Impacts
- Current Regulations
- Elements of Landfill Covers
- HELP Model
- Closure Solutions
- Slope Stability
- Top Soil and Revegetation
- Surface Water Control
- Typical Costs
Leachate at Terrace Landfill

- BOD
- Ammonia / Nitrate
- Iron
- Manganese
- Chloride
Whistler Landfill in 1998.

- Leachate can be toxic to fish (96 hour LC₅₀)
- Treatment options are:
  - Waste Water Treatment Plant.
  - On-site aeration pond.
  - Wetland treatment.
  - Phyto-remediation.
Delta Shake and Shingle

Regulations

- Landfills regulated by MoELP.
- Operational certificates set performance standards.
  - 2 m clay liner $K<1\times10^{-6}$ cm/s or membrane.
  - Water table depth $>1.2$ m.
  - Clay or geomembrane cap.
  - 300 m setback from houses & wells.
  - 100 m setback from creeks.
  - No pollution beyond property boundary.
  - Quarterly monitoring program.

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Regulations for Landfill Closure

- Close inactive areas within one year.
- Final closure cap to include:
  - 1 m thick barrier with $K < 1.0 \times 10^{-5} \text{ cm/s}$
  - 300 mm thick top soil layer.
- Monitoring to continue 25 years post closure.
- Contributions to closure fund required during operations.

Objectives of Landfill Closure

- Isolate refuse from receptors.
- Minimize leachate production.
- Facilitate collection of landfill gas.
- Provide growing medium for vegetation.
- Return land to compatible end use.
Strategies for Effective Closure

- Prevent run-on with diversion ditches.
- Provide adequate grade on landfill (5-33%).
- Effective impervious cover.
- Run-off control.
- Sedimentation.
- Design for settlement.

Rule of Thumb #1: Keep clean water clean.

Elements of Landfill Closure Systems

- Top Soil
- Filter (geotextile, soil)
- Drainage Layer (geonet, sand)
- Barrier (geomembrane, clay)
- Filter (geotextile, soil)
- Gas Collection Layer (gravel)
HELP Model

- Developed by Corp. of Engineers for U.S. EPA.
- One dimensional model of water flow through soil and waste.
  - Precipitation
  - Run-off
  - Evapotranspiration
  - Soil Storage
  - Lateral Drainage
  - Percolation

HELP Sensitivity Analysis
(1m Soil Barrier With Drainage Layer, 25% Slope)

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Closure Solutions

- Clay Barrier
- Geomembrane Barrier
  - PVC
  - LLDPE
  - HDPE
  - GCL
- Composite Barrier
- Dryland Cover System
Clay Desiccation

Rule of Thumb #2: Finish Construction by End of September.
Slope Stability

- Deep seated failure.
- Cover System Veneer failure.
- Interface friction is critical.
  - HDPE / Geotextile
  - PVC / Clay
  - PVC / Sand
- Pore water pressures reduce stability.

Rule of Thumb #3:
- Clay caps on slopes < 2.5H to 1.
- Membrane caps on slopes < 3H:1V.
Cover Veneer Failure at Port Mann

Closure Issues

- Lack of interface friction resulted in failure of cover.
- Interface friction testing and test pad is critical to avoid such problems.

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Rule of Thumb #4: Build a Test Pad first.

Adding Sand Friction Layer
Drainage Layers

- Reduce Head Build Up
- Improve Top Soil Stability
- Improve Efficiency of Cover System (10=20%)
- Mandatory in Wet Climate

Help Sensitivity Analysis.
Peak Daily Average Heads on Top of Barrier Layer

Without Drainage Layer

With Drainage Layer

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Top Soil and Seeding

- Strip and stockpile top soil materials
- Top soil layer thickness > 300 mm
- Consider biosolids enhancement
- Select right seed mix
  - Native species
  - Plant height and root penetration
  - Wildlife attraction
- Broadcast vs. hydroseeding
Top Soil Application at Knockholt

Saving Peat from Heal Lake
Drying Peat at Hartland

Applying Dried Peat as Top Soil

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The End Product

Excavating from Footprint in Chilliwack
Rule of Thumb #5: Conserve on-site resources for future closure.

480,000 m³ of extra air space plus clay and gravel for final closure at cost of $2.76/m³.

Run-Off Control

- Design for 100 year storm events.
- Provide ditching every 15 to 20 m elevation.
- Armour ditching with rip-rap (75-150 mm).
- Protect ditch from erosion with geotextile.
- Design for settlement:
  - downchutes in middle of landfill
  - grades toward thickest fill
- Use flexible lining systems
Rigid culvert don’t work well.
Sedimentation Pond at Hartland
Run-On Diversion Ditch at Savona

Rule of Thumb #6: Always Oversize Diversion Ditches and Culverts.

Trans-Canada Highway after Washout
## Actual Landfill Closure Costs in B.C.

<table>
<thead>
<tr>
<th>Landfill</th>
<th>Year</th>
<th>Area (ha)</th>
<th>Cap Type</th>
<th>Gas Berm</th>
<th>Toe Berm</th>
<th>Cost (in $)</th>
<th>Unit Cost (in $/m²)</th>
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<tbody>
<tr>
<td>Hartland South Face</td>
<td>1995</td>
<td>2.5</td>
<td>PVC/Clay</td>
<td>Yes</td>
<td>Yes</td>
<td>$1,044,909</td>
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<td>$1,845,071</td>
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<td>Savona</td>
<td>1996</td>
<td>0.6</td>
<td>Sand</td>
<td>No</td>
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<td>$46,317</td>
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<td>Knockholt</td>
<td>1997</td>
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<td>Clay</td>
<td>No</td>
<td>Yes</td>
<td>$196,874</td>
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<td>Campbell Mountain</td>
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<td>Hope</td>
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<td>Clay</td>
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<td>Yes</td>
<td>$234,877</td>
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<td>Nanaimo</td>
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<td>Iona</td>
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<td>0.9</td>
<td>LLDPE/Clay</td>
<td>No</td>
<td>No</td>
<td>$180,108</td>
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<td>Logan Lake</td>
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<td>No</td>
<td>No</td>
<td>$238,750</td>
<td>$9.55</td>
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## Landfill Closure Costs

- **For closure we budget $250,000 to $350,000 per Ha, including purchase and transport of materials.**
- **Toe berms and gas collection add 25 to 50% to costs.**
- **Costs can be reduced if soils available on-site.**
- **Costs can be reduced if exemptions justified:**
  - Dryland closure with native materials.
  - Reduced clay thickness if low permeability clay.
  - Bioreactor closure approach.

**Rule of Thumb #7: Keep footprint as small as possible to minimize costs and leachate volumes.**

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Conclusions

- Covers and liners are effective in preventing pollution of environment. “Keep clean water clean”.
- Cost of lining systems is $250,000 to $500,000 per ha.
- For reliable covers side slopes < 3H:1V.
- To ensure stability, build a test pad first.
- Always provide effective drainage, oversize.
- During stripping conserve overburden resources for eventual closure.
- Maintain disturbed footprint as small as possible to minimize costs.

Food for Thought

- Highland Valley mines 90 million m³ per year.
- 365 million lbs of copper per year worth $292 million.
- Revenue per m³ disturbed is $3.24.

- Hartland Landfill consumes 150,000 m³ of air space per year.
- Tipping fee revenue about $75 per m³.
- Landfill costs are about $35/m³.
- Landfills produce 10 to 20 times more revenue per m³ than open pit mines.
Opportunities at Afton or Lornex?