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

7th Annual B.C. Metal Leaching / ARD Workshop
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Presented by Dr. Tony Sperling, P.Eng.

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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*

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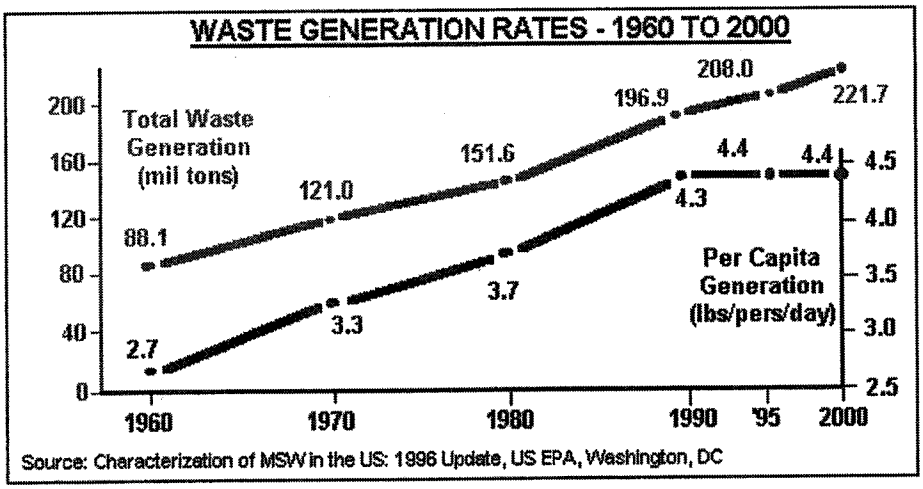
MSW Generation in North America



Source: Characterization of MSW in the US: 1996 Update, US EPA, Washington, DC

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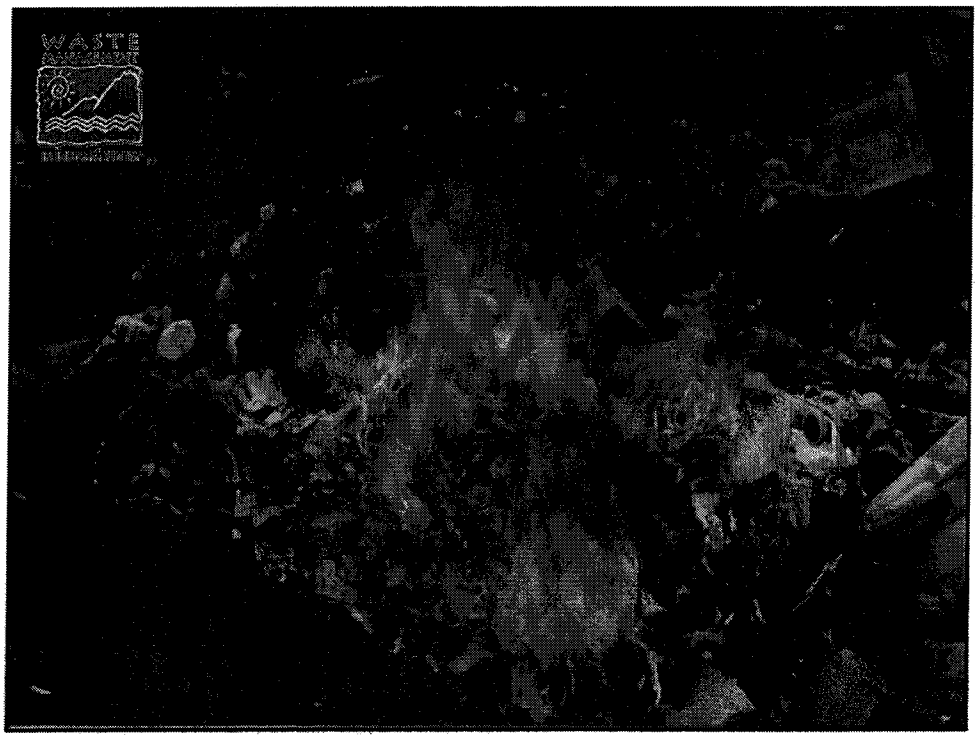

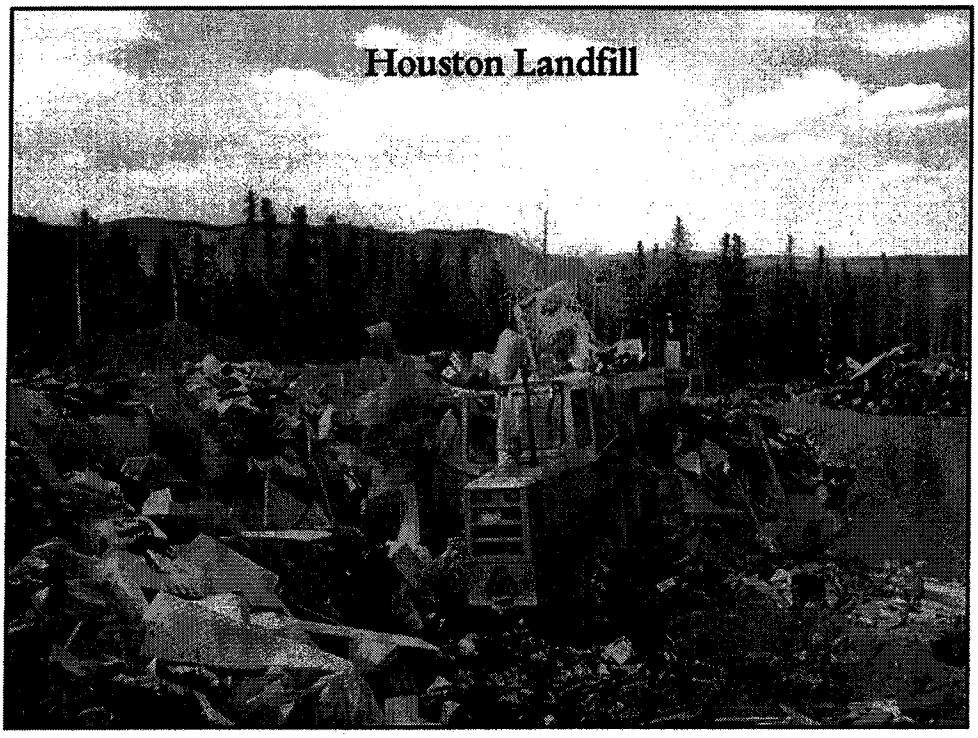

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Leachate at Terrace Landfill

- ***BOD***
- ***Ammonia / Nitrate***
- ***Iron***
- ***Manganese***
- ***Chloride***

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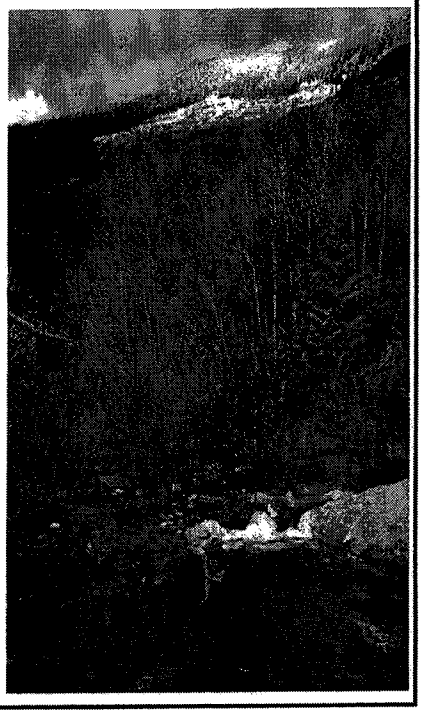
Whistler Landfill in 1998.

- ***Leachate can be toxic to fish (96 hour LC_{50})***
- ***Treatment options are:***
  - ***Waste Water Treatment Plant.***
  - ***On-site aeration pond.***
  - ***Wetland treatment.***
  - ***Phyto-remediation.***



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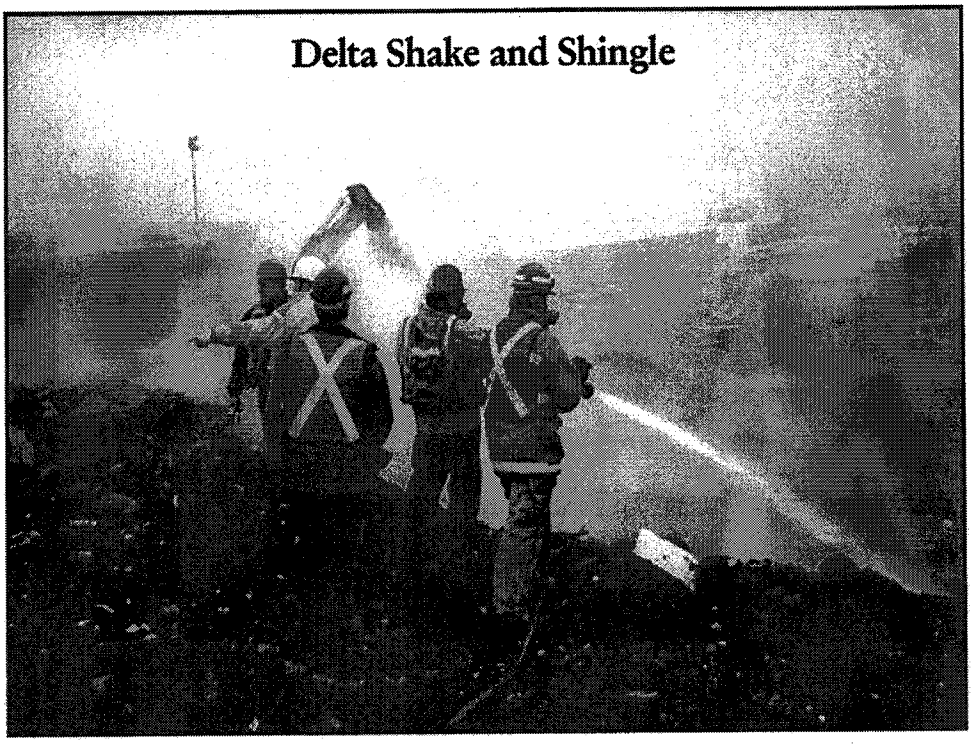
Delta Shake and Shingle



Regulations

- ***Landfills regulated by MoELP.***
- ***Landfill Criteria (1995) provide guidelines.***
- ***Operational certificates set performance standards.***
  - ***2 m clay liner K<1x10^{-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 $K<1.0x10^{-5}$ cm/s***
  - ***300 mm thick top soil layer.***
- ***Monitoring to continue 25 years post closure.***
- ***Contributions to closure fund required during operations.***

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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.***

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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.

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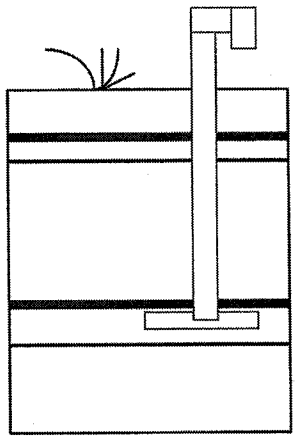
Elements of Landfill Closure Systems

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



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HELP Model

- *Hydrologic Evaluation of Landfill Performance.*
- *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*

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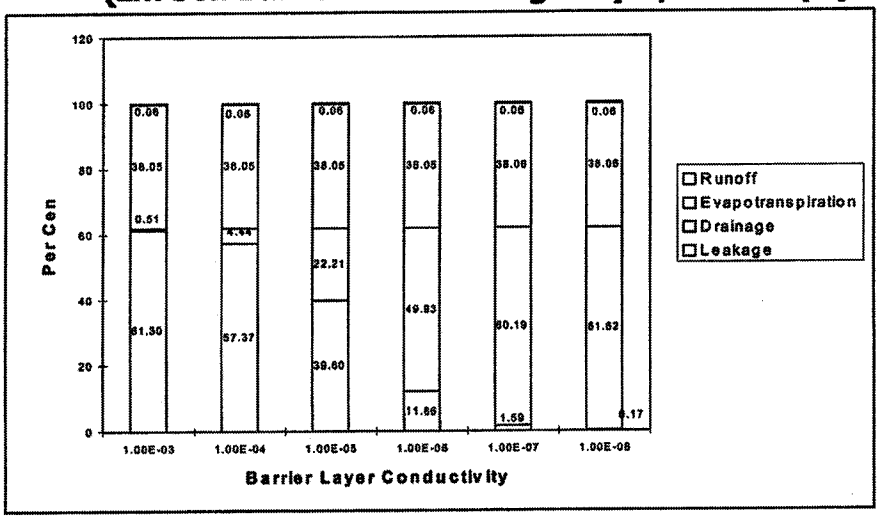
HELP Sensitivity Analysis (1m Soil Barrier With Drainage Layer, 25% Slope)



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Closure Solutions

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

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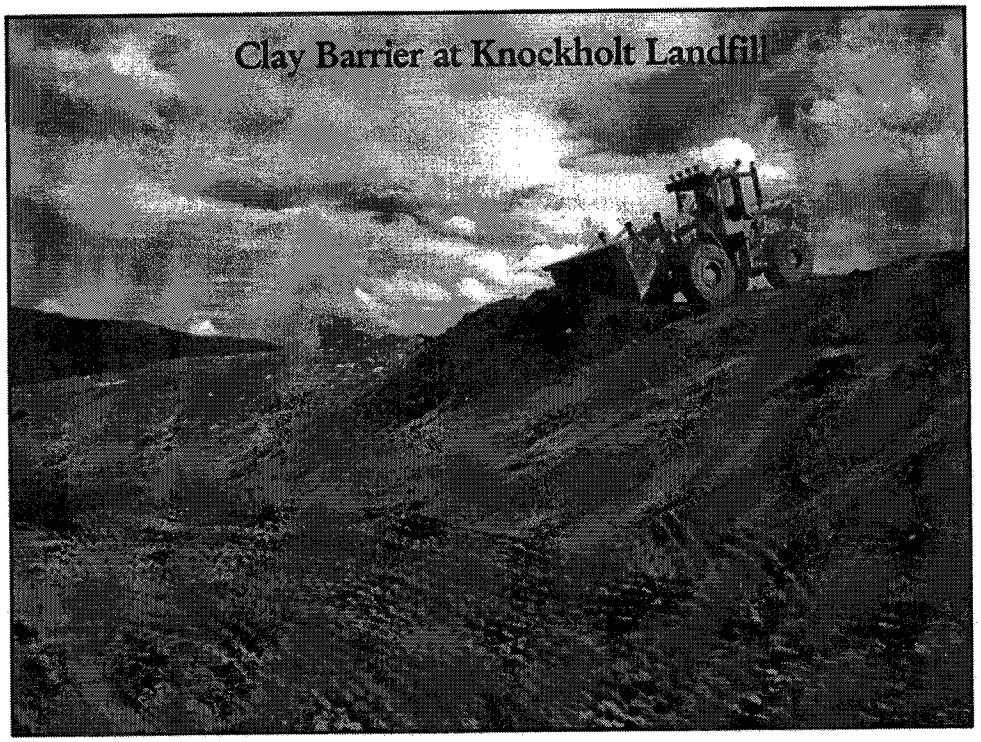

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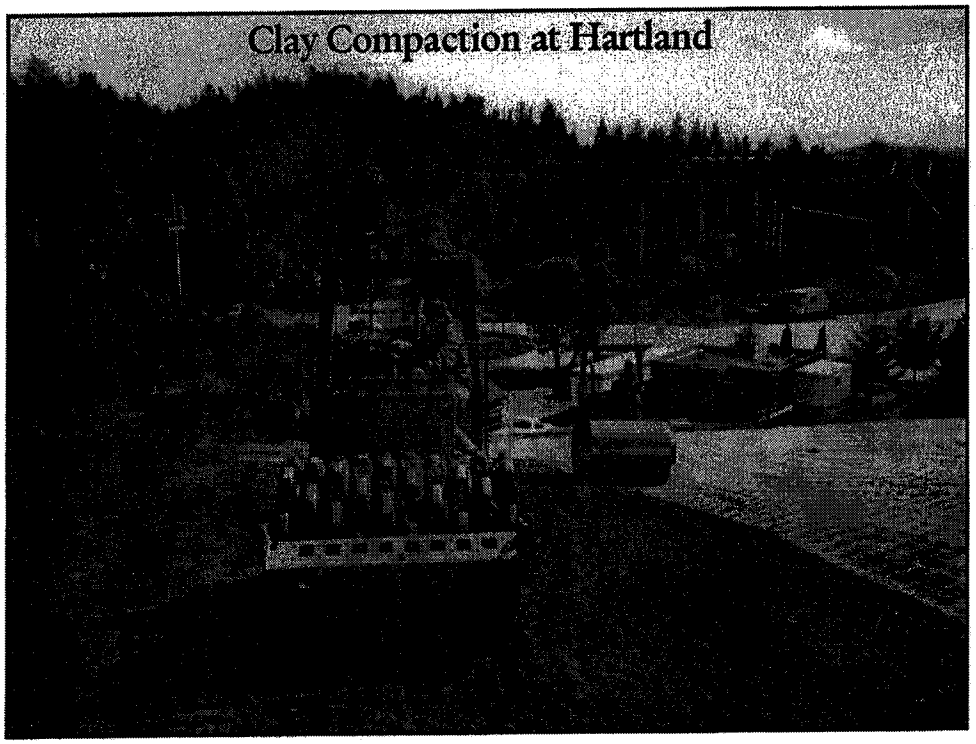

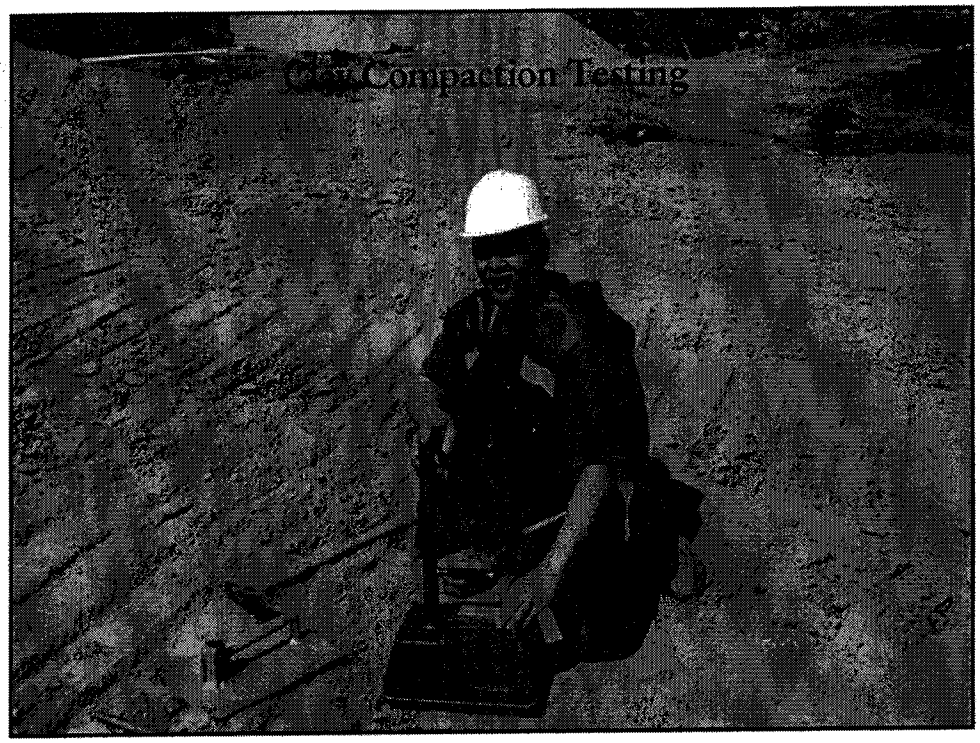

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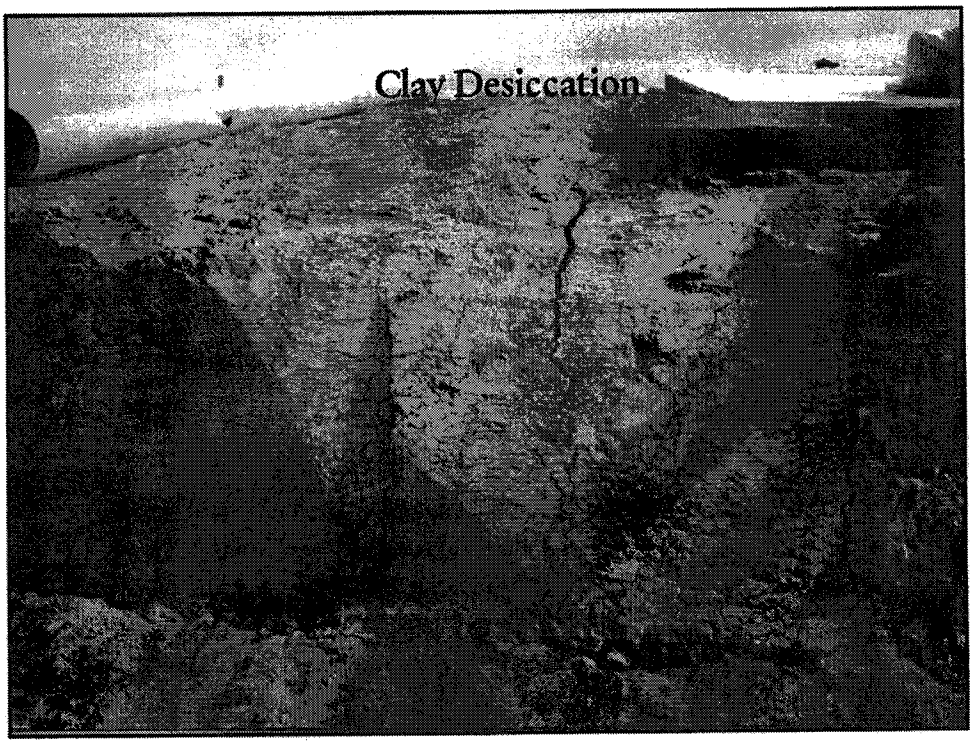

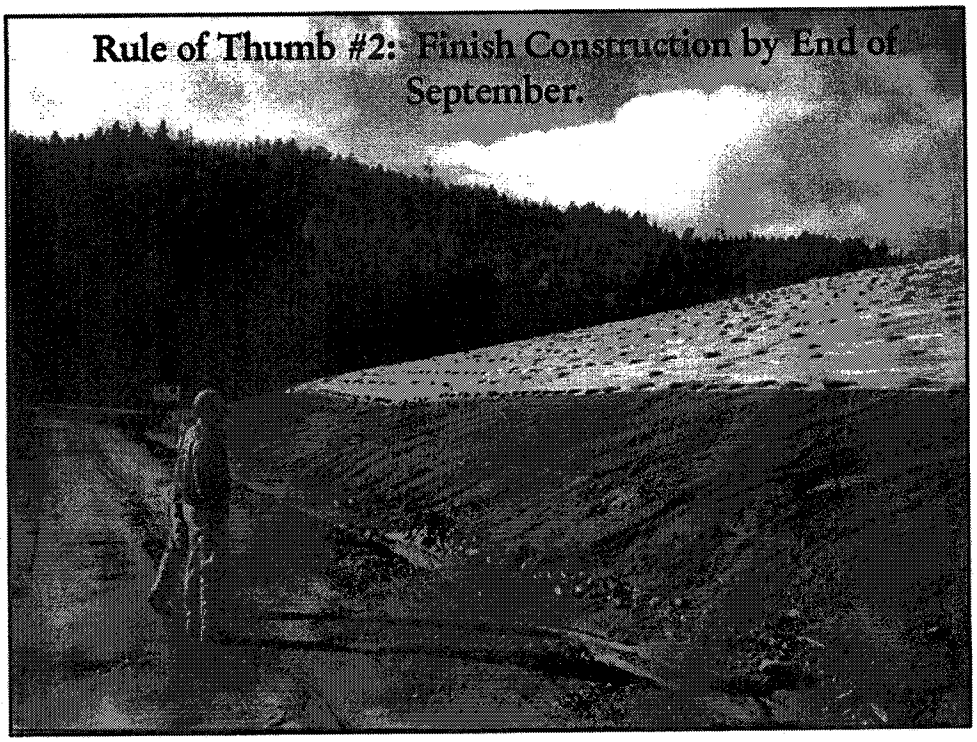

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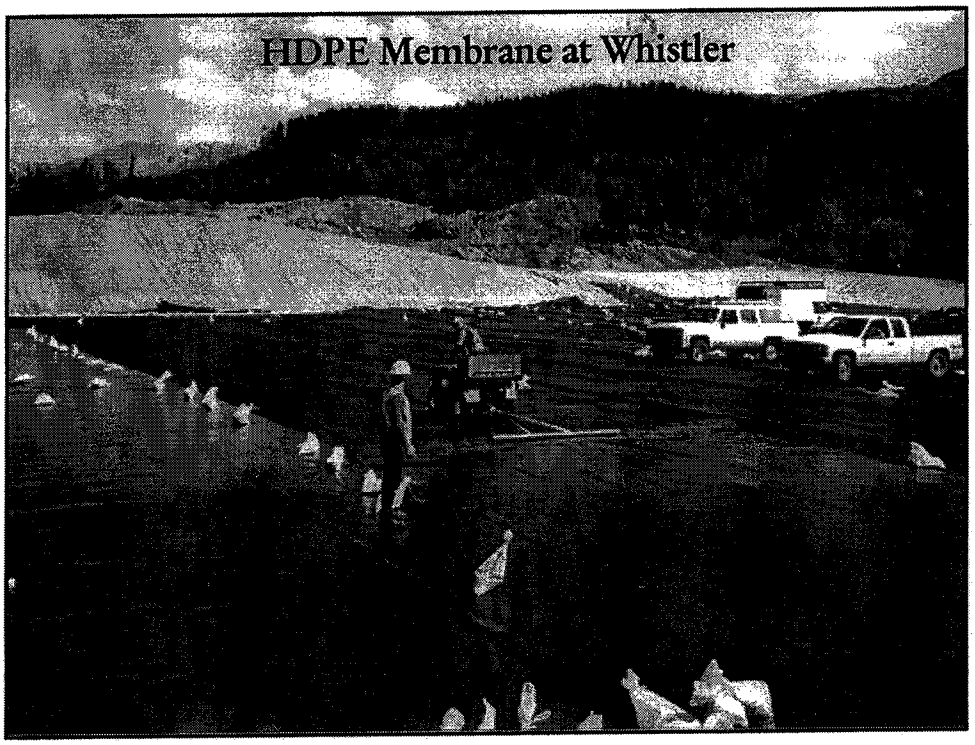

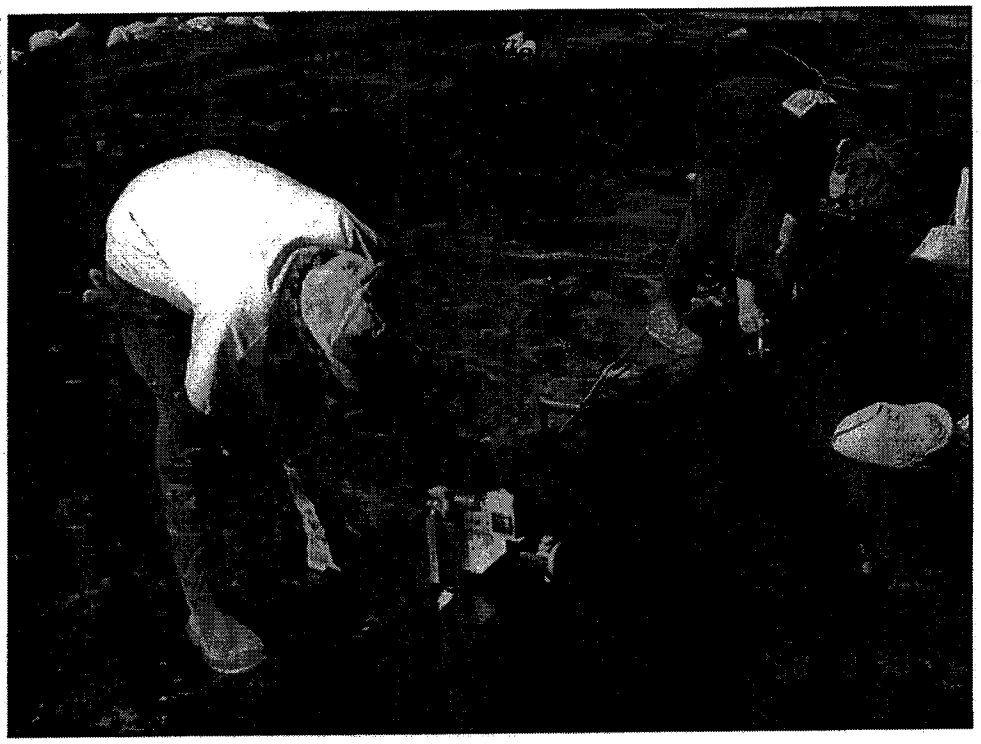

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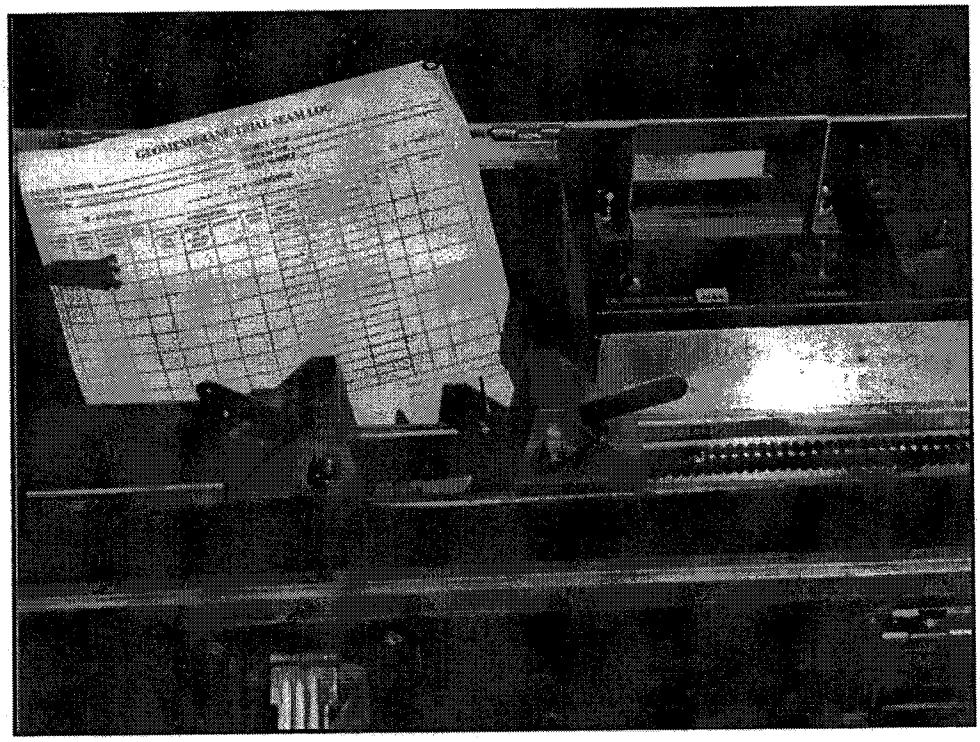

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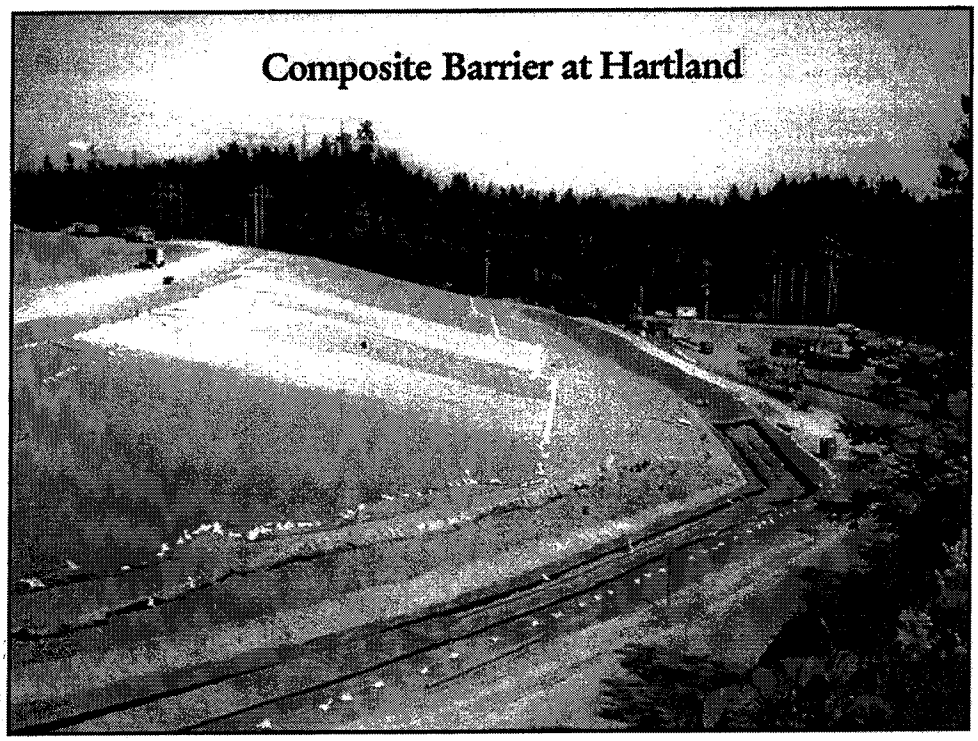

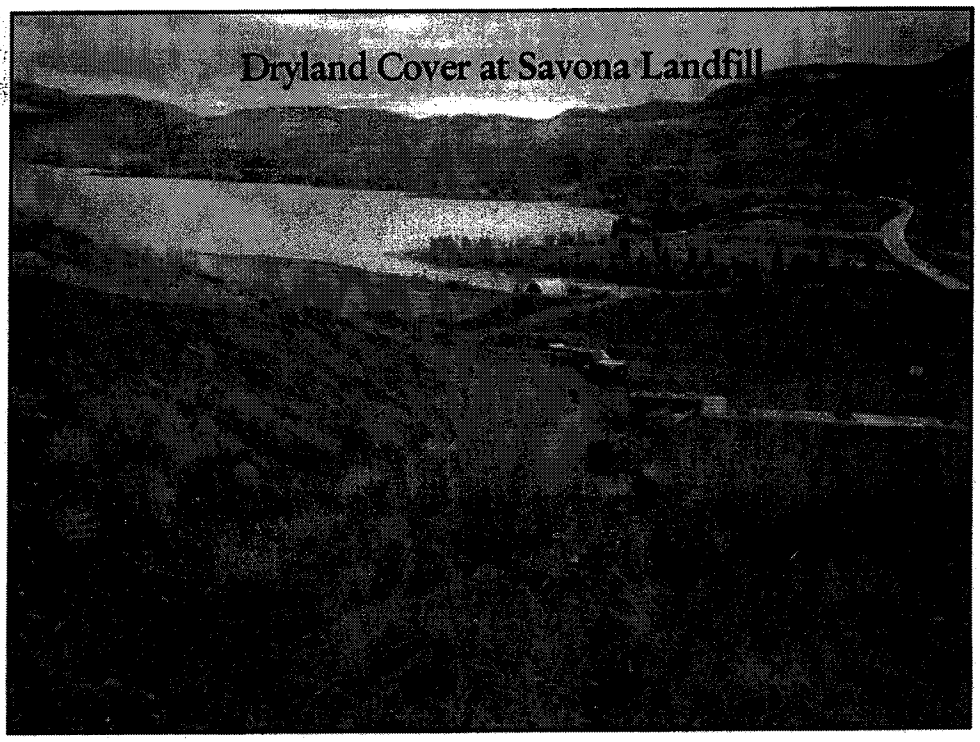

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Slope Stability

- ***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.

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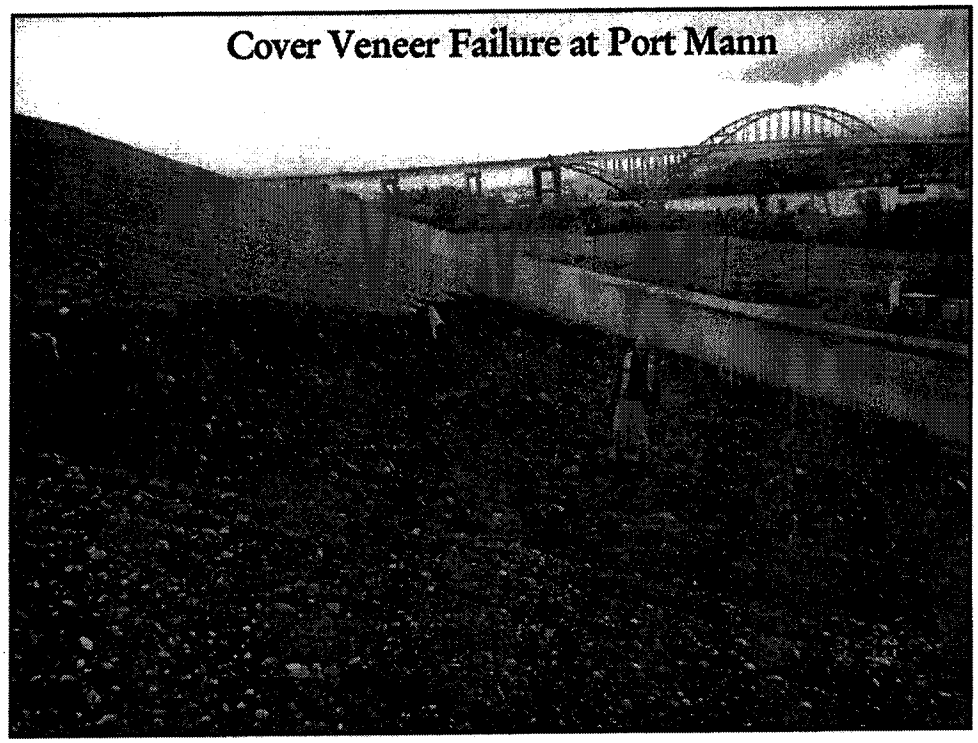
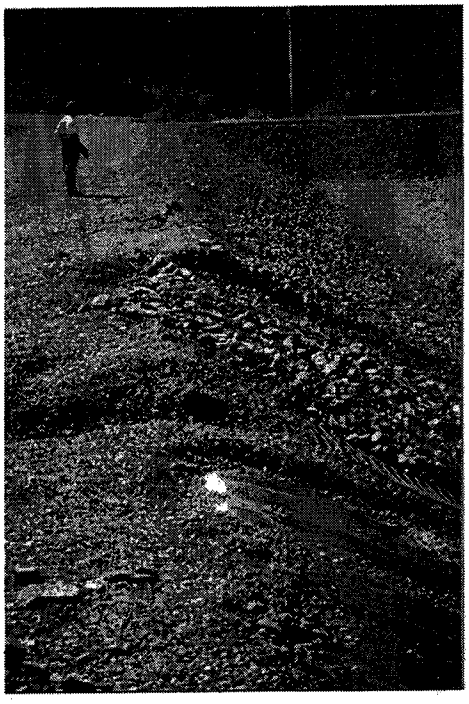
Cover Veneer Failure at Port Mann



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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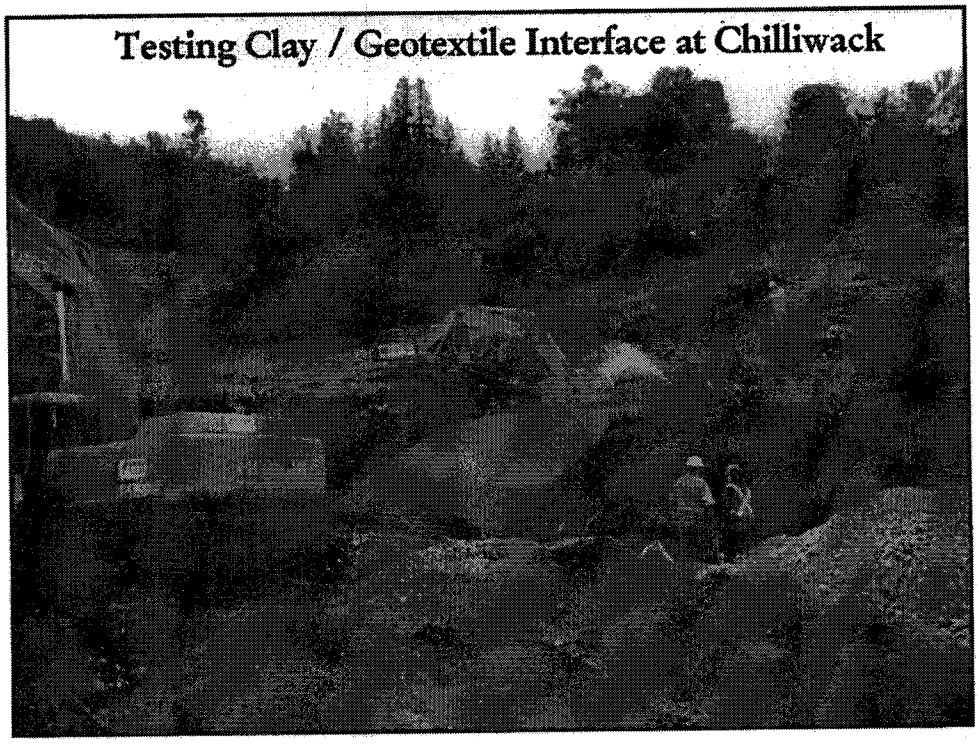

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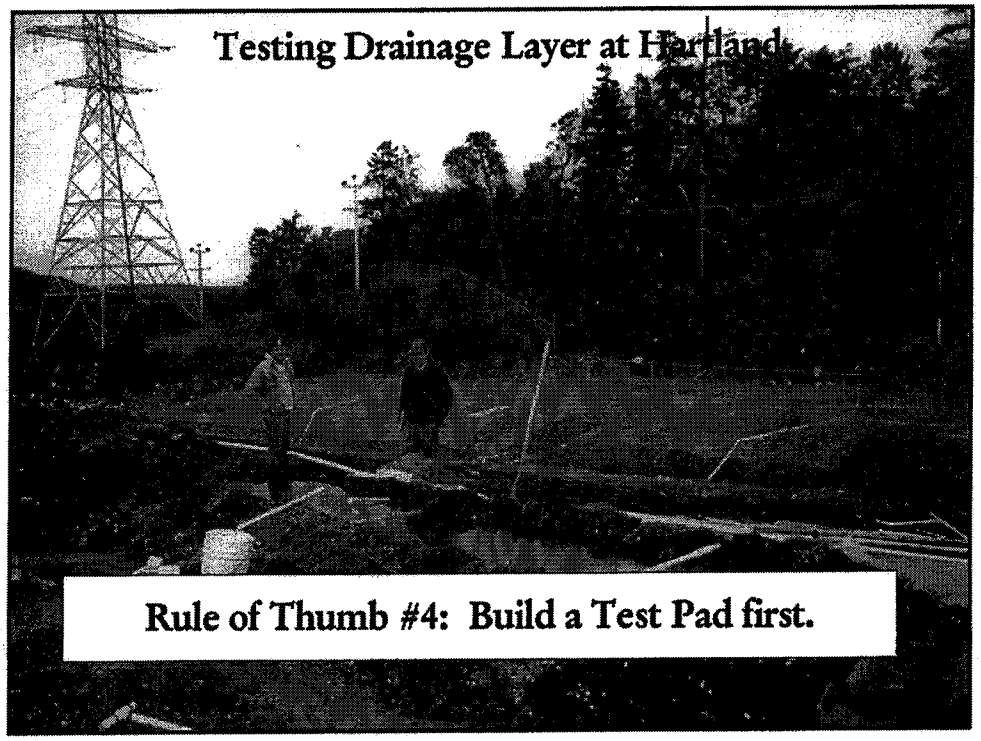

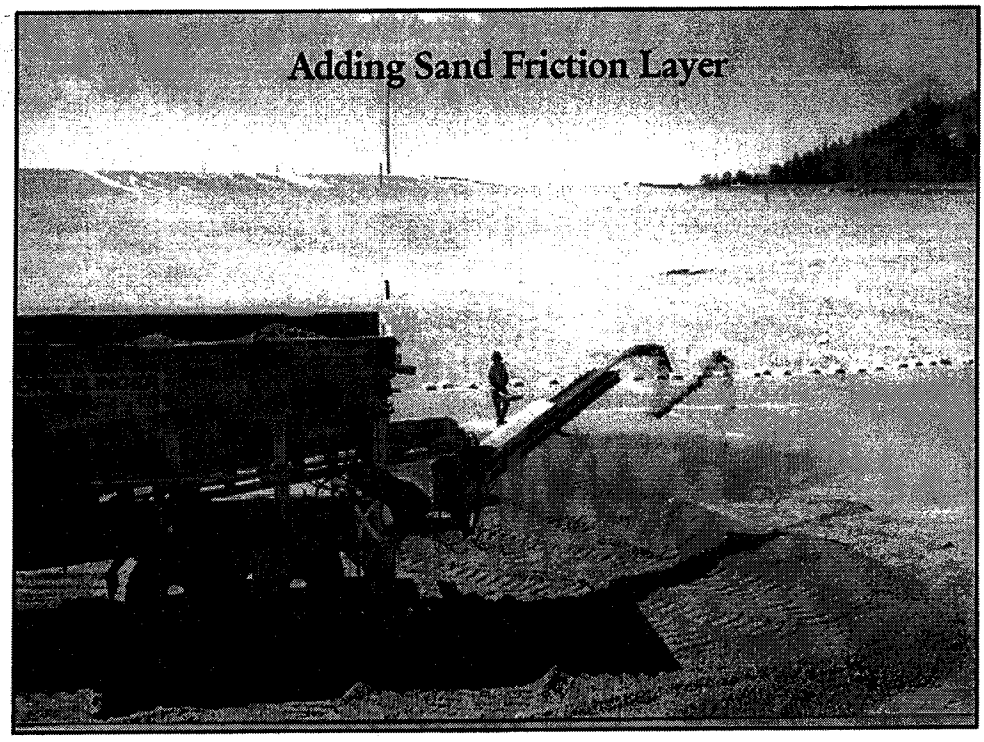

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Drainage Layers

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

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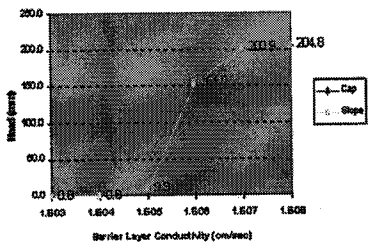
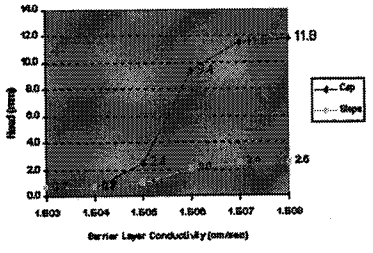
Help Sensitivity Analysis.

Peak Daily Average Heads on Top of Barrier Layer

Without Drainage Layer



With Drainage Layer



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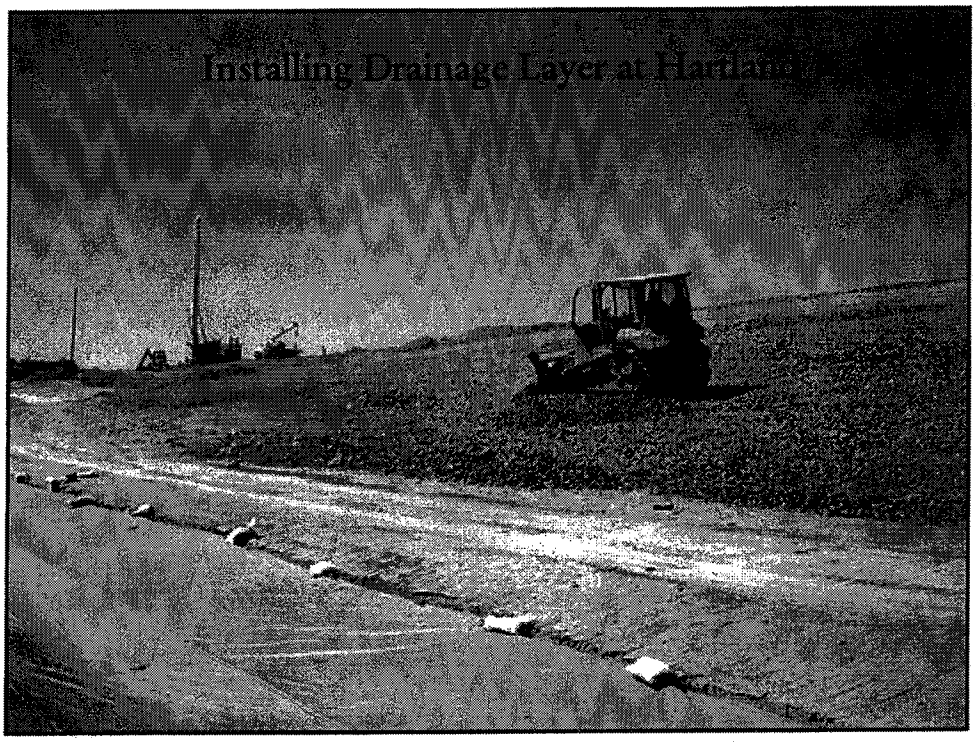

Top Soil and Seeding

- ***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***

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Top Soil Application at Knockholt

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Saving Peat from Heal Lake

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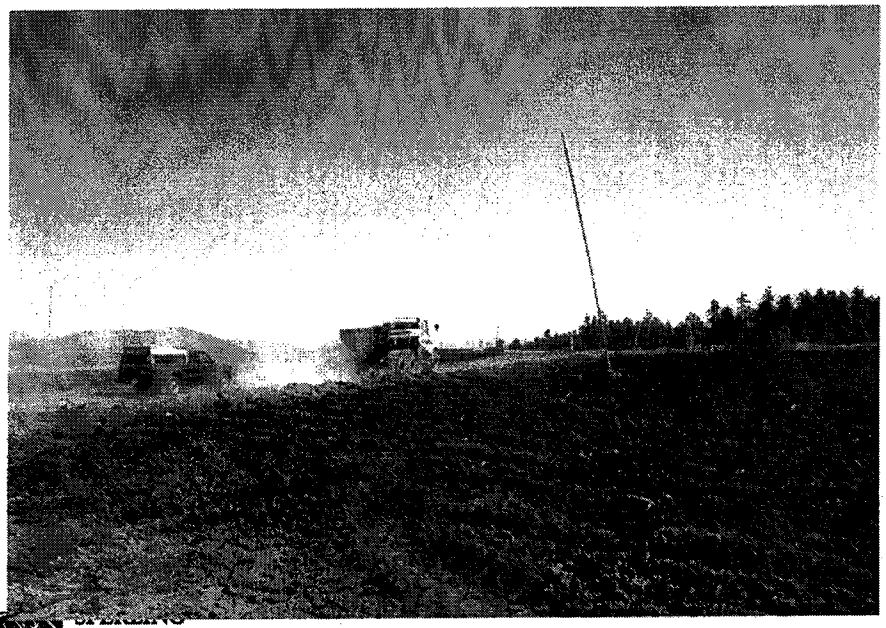

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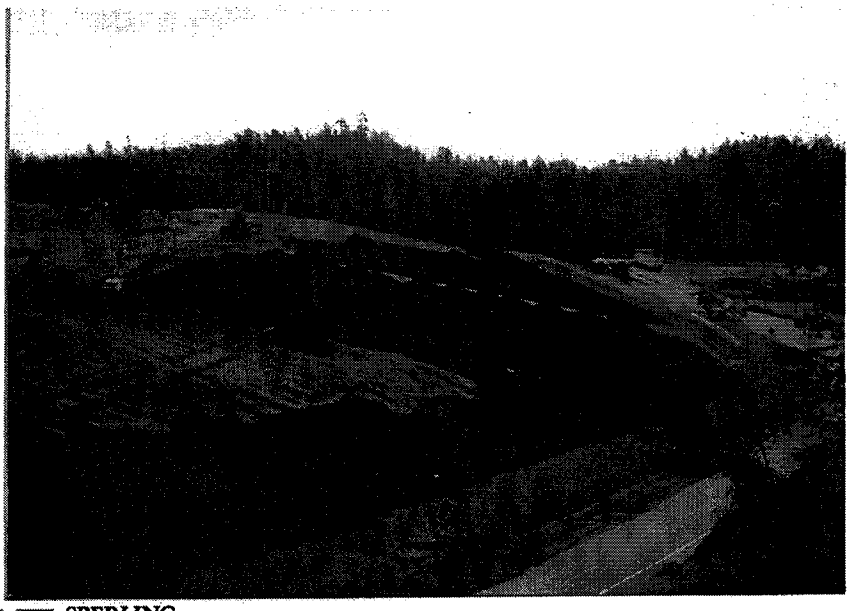
Drying Peat at Hartland



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Applying Dried Peat as Top Soil

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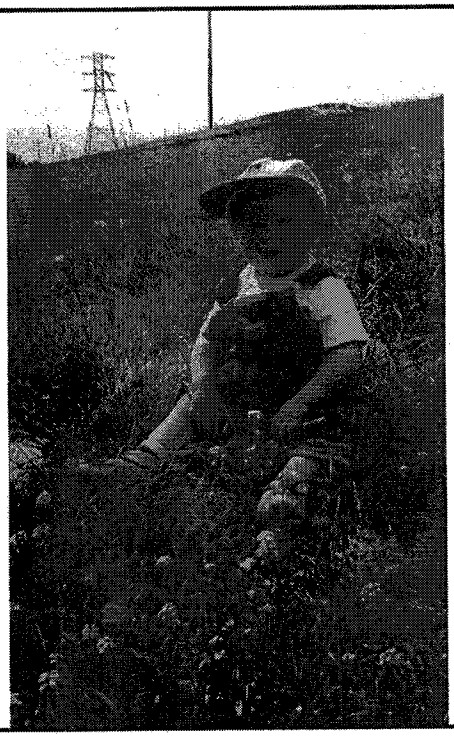
The End Product



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Excavating from Footprint in Chilliwack

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Rule of Thumb #5: Conserve on-site resources for future closure.

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480,000 m^3 of extra air space plus clay and gravel for final closure at cost of \$2.76/m^3.

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***

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Rigid culvert don't
work well.

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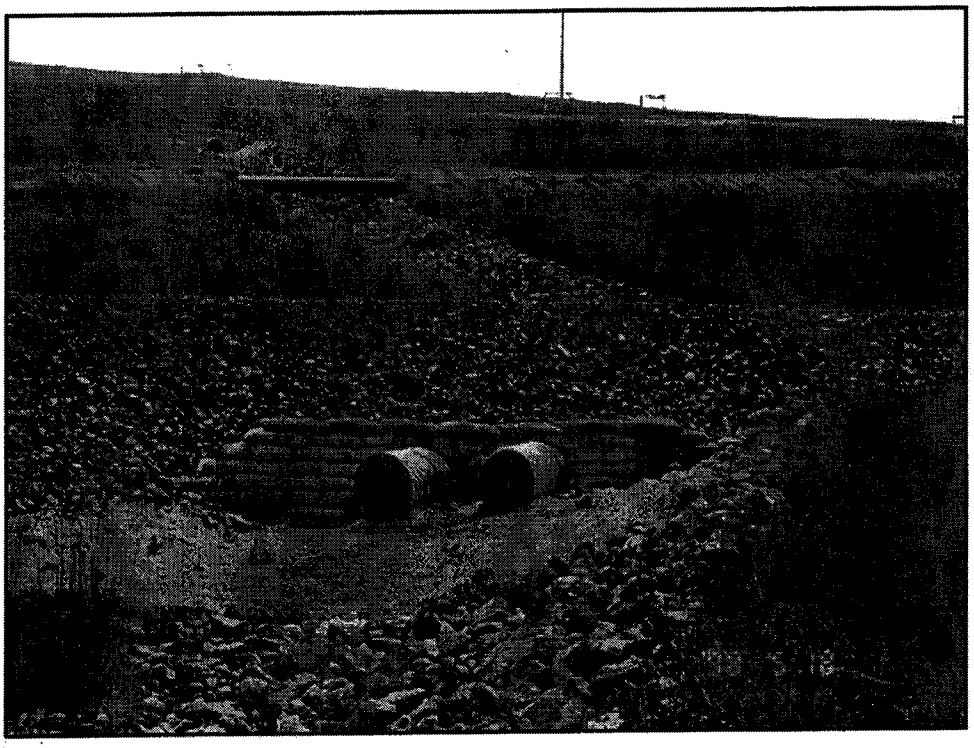

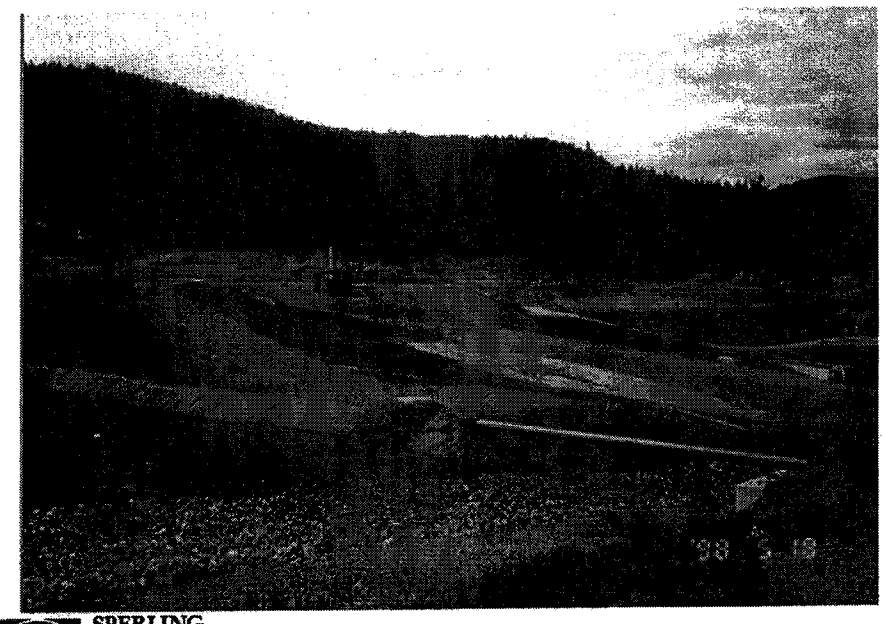

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Sedimentation Pond at Hartland

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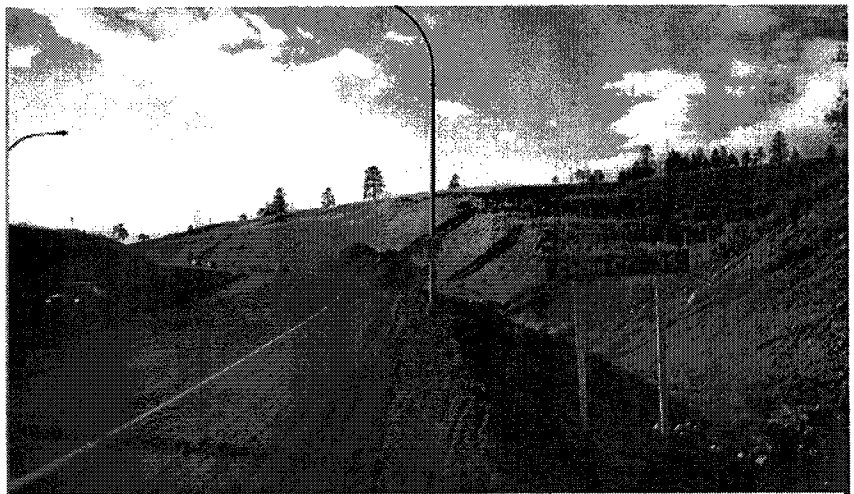
Run-On Diversion Ditch at Savona



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

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Trans-Canada Highway after Washout

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Actual Landfill Closure Costs in B.C.

Landfill	Year	Area	Cap Type	Gas	Toe	Cost	Unit Cost
		(ha)			Berm		(/m2)
Hartland South Face	1995	2.5	PVC/Clay	Yes	Yes	$1,044,909	$41.80
Hartland North Face	1996	5.2	PVC/Clay	Yes	Yes	$1,845,071	$35.48
Savona	1996	0.6	Sand	No	No	$46,317	$7.72
Knockholt	1997	0.2	Clay	No	Yes	$196,874	$82.03
Campbell Mountain	1998	0.6	Clay	No	Yes	$172,831	$27.88
Hope	1998	0.5	Clay	No	Yes	$234,877	$51.06
Nanaimo	1999	0.7	PVC/Clay	Yes	Yes	$304,072	$46.42
Nanaimo	2000	0.5	PVC/Clay	Yes	Yes	$360,463	$80.10
Iona	2000	0.9	LLDPE/Clay	No	No	$180,108	$19.37
Logan Lake	2000	2.5	Clay	No	No	$238,750	$9.55

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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.*

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Food for Thought

- *Highland Valley mines 90 million m^3 per year.*
- *365 million lbs of copper per year worth $292 million.*
- *Revenue per m^3 disturbed is $3.24.*

- *Hartland Landfill consumes 150,000 m^3 of air space per year.*
- *Tipping fee revenue about $75 per m^3.*
- *Landfill costs are about $35/$m^3$.*
- *Landfills produce 10 to 20 times more revenue per m^3 than open pit mines.*

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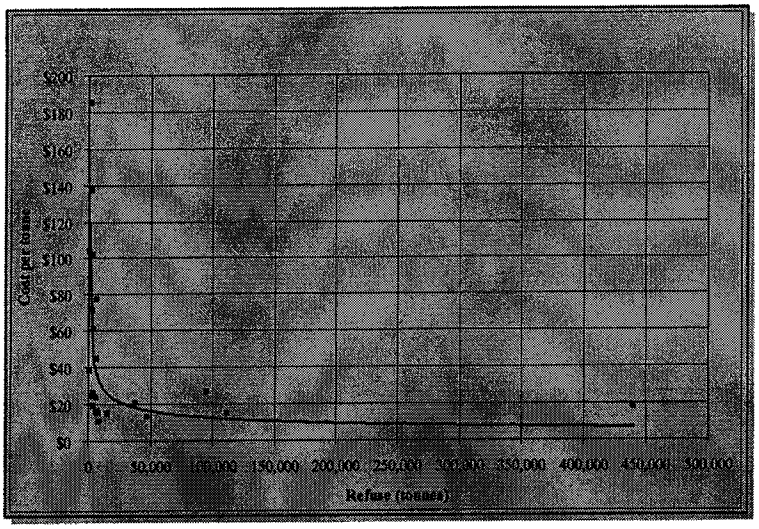
Operating Cost per Tonne - B.C. Experience



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Train Haulage Optic

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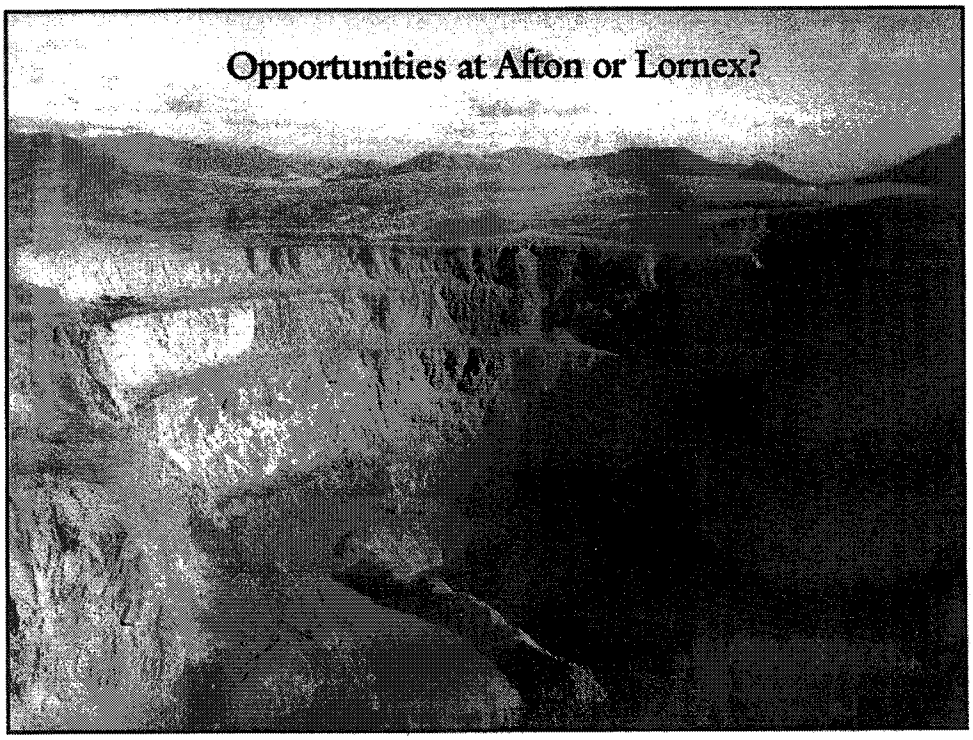

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