Landfill Closure

SWANA NLC Conference

May 2017
CLOSURE DISCUSSIONS

• What is Final Closure?
• Regulations
• Steps to Implement Final Closure
• Design Considerations
• Cover Systems
• Contaminating Lifespan
• Financial Considerations
WHAT DOES CLOSURE MEAN?

- Final cover and environmental systems placed on and over the landfill once it stops accepting waste.
- Final cover provides long-term protection against vectors, while reducing infiltration and soil erosion.
- Long-term protection of ground and surface water resources.

Source: Scientific American
CLOSURE OBJECTIVES

- Minimize post-closure leachate generation (protect environment).
- Minimize post-closure maintenance.
- Allow site to return to some beneficial use as quickly as possible.
- Make site aesthetically acceptable.
- Accommodate for differential settlement.
- Prevent wind blown litter.
- Mitigate against risk of fire.
- Monitor performance of engineered controls.
Environmental Management and Protection Act (2010)
Stormwater Guidelines (2014)
- Site Assessment Chapter
- Corrective Action Plan Chapter
GUIDANCE DOCUMENTS

- Impacted Sites Guidance (2015)
Municipal Refuse Management Regulation

Submission of proposal and approvals required to closure landfill.

- Outline Steps to be taken to protect the environment.

Ministry of Environment sets terms and conditions to carry out landfill closure, dependant upon site sensitivity.


Saskatchewan Environmental Code
B.1 Environmentally Impacted Sites

• Site Assessment
  ▪ Evaluation of the environmental condition of the site.
    - Establishing if contaminants are present
    - Understand the affects on the environment
    - Evaluation of risk to environment and human receptors.

• Corrective Action Plan
  ▪ Document that proposes remedial strategies to address identified environmental impacts at the site.
  ▪ The CAP will form the basis of the Closure Plan.
  ▪ Adaptive to site specific conditions!!
Stormwater Guidelines (2014)

- Guidance with respect to stormwater management and water quality.
- Closure systems to address long-term post-closure stormwater.
- Off site discharge of stormwater. Use of sediment forebays and pond structures.
### STEPS TO FINAL CLOSURE

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Notification</td>
<td>• Provide Notification to Ministry of Environment of Intent to Close the Landfill Site</td>
</tr>
<tr>
<td>Stop Accepting Waste</td>
<td>• Site Closure - buys time to implement the below steps.</td>
</tr>
</tbody>
</table>
| Closure Plan                              | • Landfill owner submits a Proposal to Environment, outlining the steps which will be taken in closing the landfill to protect the environment.  
  • Environmental Monitoring Plan.        |
| Approvals                                 | • Obtain approval for closure prior to undertaking closure activities.       |
| Detailed Design                           | • Design and construction.  
  • Closure Report.                        |
| Post-Closure Plan                         | • Typically developed after closure design.                                 |
| Post-Closure Monitoring                   | • Environmental control system performance monitoring and closure system maintenance. |
CLOSURE PLAN

- Report years site in operation and quantity of waste in place.
- Schedule for completion of closure works.
- Identify site sensitivity / receptors.
- Site cleanup.
- Address storm water, leachate, landfill gas, and erosion control measures.
- Final contours and cover system design concept.
- Buffer zones and compliance boundaries.
- Water balance / long term-leachate generation.
- Decommissioning of facilities.
- Estimation of contaminating lifespan.
CLOSURE DESIGN CONSIDERATIONS

- Estimation of Percolation Leachate Generation
- Surface Water Runoff onto Adjacent Lands
- Long-Term Performance & Durability
- Material Availability
- Cost
- Erosion and Slope Stability
- Site Assessment & Corrective Action Plan
- Spatial Constraints
COMPONENTS OF CLOSURE SYSTEM

- Final Grading
- Cover System
- Storm water management
- Leachate management
- Landfill Gas Management
- Environmental Monitoring
FINAL GRADING

- Final grading a key component in landfill closure often not given its due.
- Slopes typically between 5 and 33 percent.
- Settlement of 10 percent (or more) of total waste height should be expected for MSW. Differential settlement common.
- Crest slope critical.
- Drainage from slopes.
Numerous types of landfill cover systems have been developed.

Suitable cover system options are site specific based upon factors such as:

- Regulations
- Native Soils
- Climate
- Impacts
- Expertise
ROLES OF COVER SYSTEM COMPONENTS

Vegetative Cover – reduces infiltration, wind erosion, and improves slope stability.

Filter Layer – Prevents sifting of cover soil into drainage layer.

Drainage Layer – provides conduit for water to exist cover system.

Barrier Layer – minimizes infiltration through cover, barrier for vectors, and odour control.
CLAY COVER SYSTEMS

- Readily constructible.
- Low capital cost (if suitable material available)
- Approvals well defined.

- Susceptible to shrinkage cracking and/or freeze/thaw cycles.
- Typically higher permeability than base liner.
- May be susceptible to damage from differential settlement.
EVOPOTRANSPIRATION COVERS

- Climatic specific. Suitable for semi-arid environments.
- Not significantly impacted by drying or freeze/thaw cycles.
- May be more effective than compacted clay covers.
- Design and regulatory approvals more intensive.
- Suitable soils required.
- Biocover hybrid to reduce GHG emissions.
• Excellent performance with very low infiltration rates possible.
• Suitable for high sensitivity.
• Not affected by freeze/thaw or drying.
• Decreased profile depth.

• May have higher capital costs relative to clay.
• Design and regulatory approvals may be more intensive.
• Require specialized installation and QA/QC.
STORMWATER MANAGEMENT

• Manage, at a minimum the 1:25 year event. May be required to manage the 1:100 year event depending on site conditions and receptors.

• Balancing Act: Preserve hydrologic cycle and getting storm water off limit of waste area ASAP.

• Ongoing maintenance and inspection.
• Leachate Management ranges from natural attenuation to active treatment.

• Active treatment range from on-site treatment, wetlands, to pumping via force main to off-site treatment facility.
LANDFILL GAS MANAGEMENT
ENVIRONMENTAL MONITORING

- Monitoring performance of environmental controls, and closure systems.
- Groundwater
- Surface water
- Soil gas
POST-CLOSURE PLAN

- Address long-term site inspection, monitoring and maintenance.
- Address post-closure reporting and record keeping requirements.
- Ongoing post-closure care through “Contaminating Lifespan” of site.
Financial Considerations

INVESTMENTS AND
FINANCIAL PLANNING

“I retire on Friday and I haven’t saved a dime. Here’s your chance to become a legend!”
FINANCIAL CONSIDERATIONS

- Contributions to Reserves
- Closure Costs
- Contaminating Lifespan
- Post-Closure Liabilities
# Elements of Post Closure Care

<table>
<thead>
<tr>
<th>Final Cover System</th>
<th>Storm water management</th>
<th>Leachate Management</th>
<th>Landfill Gas Management</th>
<th>Environmental Monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Erosion control</td>
<td>• Ditch maintenance</td>
<td>• Leachate treatment and disposal</td>
<td>• LFG collection system operations, maintenance.</td>
<td>• Groundwater</td>
</tr>
<tr>
<td>• Mowing and Overseeding</td>
<td>• Pond dredging</td>
<td>• Maintenance, flushing and inspection</td>
<td>• Equipment replacement.</td>
<td>• Surface water</td>
</tr>
<tr>
<td>• Invasive Species</td>
<td>• Damage due to large storm events</td>
<td></td>
<td></td>
<td>• Soil gas</td>
</tr>
</tbody>
</table>
CONTAMINATING LIFESPAN

• How long before I can walk away from a landfill site?

• Termination of post-closure care when:
  ▪ Contaminants of concern do not exceed background concentrations.
  ▪ Waste stabilization.

• Landfill contaminating lifespan site-specific and can be significantly longer than 25 years.

The Big Question – “will closure / post-closure reserve funds cover long-term liabilities?”
So.....How Much??

- $15-35 per square meter for compacted clay cover systems when materials readily available, low sensitivity.
- $35-50 per square meter for compacted clay covers systems when material scarce or medium to high sensitivity.
- $50-75 per square meter for geosynthetic composite covers for high sensitivity areas where “entombment” is required.
CLOSURE / POST-CLOSURE RESERVES

Planning for landfill closure is a lot like planning for your retirement!!

• Start early.
• Be conservative with length of contaminating lifespan.
• Account for closure, post-closure activities, and a contingency fund to replace the hot water tank and roof.

How much to stash away per year into a reserve fund?

• Life cycle cost analysis.
• Talk to your financial Advisor (or friendly neighborhood Engineer)
“RULE OF THUMB” STUFF

If all else fails....

- $4 to $6 per tonne is a good place to start, depending upon size of site and time until closure.
- Post-closure monitoring & reporting: $20,000 to $50,000.
- Post-closure maintenance: $10,000+
- Leachate management and disposal – current unit costs.
CLOSURE EXAMPLE

- Rural attenuation landfill.
- Low sensitivity.
- Existing GW monitoring wells (3).
- No storm water infrastructure.
- Attenuation (unlined) site.
- Closure area of 1.2 hectares.
- Topsoil stockpiled on site.
- Readily available clay barrier soil.
- Some regrading required to achieve 3H:1V (33 percent) slopes.
## CLOSURE COSTS

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Unit</th>
<th>Approx. Quantity</th>
<th>Unit Price</th>
<th>Total Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Administration and Execution Requirements</td>
<td>Bonds, Insurance, Mobilization, Demobilization, Temporary Controls and Closeout (15%)</td>
<td></td>
<td></td>
<td></td>
<td>$53,025</td>
</tr>
<tr>
<td>Closure / Reclamation</td>
<td>Grading</td>
<td>Cubic Metre</td>
<td>1,500</td>
<td>$15</td>
<td>$22,500</td>
</tr>
<tr>
<td></td>
<td>Final Cover / Reclamation - supply, place, compact, grade, and seed</td>
<td>Square Metre</td>
<td>12,000</td>
<td>$25</td>
<td>$300,000</td>
</tr>
<tr>
<td>Stormwater</td>
<td>Ditching</td>
<td>Liner Metre</td>
<td>400</td>
<td>$40</td>
<td>$16,000</td>
</tr>
<tr>
<td></td>
<td>Stormwater Pond</td>
<td>Lump Sum</td>
<td></td>
<td></td>
<td>$15,000</td>
</tr>
<tr>
<td></td>
<td><strong>Subtotal</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>$375,525</strong></td>
</tr>
<tr>
<td></td>
<td>Engineering and Approvals (10%)</td>
<td></td>
<td></td>
<td></td>
<td><strong>$37,553</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Total (Excluding GST)</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>$413,078</strong></td>
</tr>
</tbody>
</table>
# POST CLOSURE LIABILITIES

<table>
<thead>
<tr>
<th>Description</th>
<th>Annual Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental Monitoring (3 wells, bi-annual)</td>
<td>$14,000</td>
</tr>
<tr>
<td>Final Cover Maintenance</td>
<td>$5,000</td>
</tr>
<tr>
<td>Stormwater Management Maintenance</td>
<td>$5,000</td>
</tr>
<tr>
<td>General Maintenance Reserve</td>
<td>$5,000</td>
</tr>
<tr>
<td><strong>Total (Per Year)</strong></td>
<td><strong>$29,000</strong></td>
</tr>
</tbody>
</table>
Thank You!!