Landfill Closure
ARWMAS
August 2020
CLOSURE DISCUSSIONS

• What is Final Closure?
• Regulations
• Steps to Implement Final Closure
• Design Considerations
• Cover Systems
• Mystery Detour
• 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.
- Closure can be final closure of a site or progressive closure of cells at an operating site.

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.
• Aesthetics.
• Accommodate for differential settlement.
• Mitigate against risk of fire.
• Monitor performance of engineered controls.
SASKATCHEWAN REGULATIONS

• Environmental Management and Protection Act (2010)
• Municipal Refuse Management Regulation (1986)
• Environmental Code – B.1 Impacted Sites (2015)
  – Site Assessment Chapter
  – Corrective Action Plan Chapter
GUIDELINES

• Saskatchewan Environmental Quality Guidelines (SEQG)
• Landfill Closure Guidance (2015)
• Impacted Sites Guidance (2015)
Permit to Operate

- Permit to Operate may have requirements for:
  - Decommissioning and Reclamation Plan; or
  - Closure Plan.

- This requirement provides for proactive planning for future closure of cells and sites.
Municipal Refuse Management Regulation

Submission of proposal and approvals required to close 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 (CAP)
  ▪ 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!!
STEPS TO FINAL CLOSURE

**Notification**
- Provide Notification to Ministry of Environment of Intent to Close the Landfill Site

**Stop Accepting Waste**
- Site Closure - buys time to implement the below steps.

**Site Assessment & Corrective Action Plan**

**Closure Plan**
- Landfill owner submits a Proposal to Ministry of 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.
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.
TYPES OF COVER SYSTEMS

• 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
  - Env. Sensitivity
  - 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

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

Disadvantages
• Susceptible to shrinkage cracking and/or freeze/thaw cycles.
• Typically higher permeability than base liner.
• May be susceptible to damage from differential settlement.
• May not be available locally trucking can be costly.
Advantages

• Suitable for semi-arid environments.
• Not significantly impacted by drying or freeze/thaw cycles.
• May be more effective than compacted clay covers.
• Material may be available locally

Disadvantages

• Design and regulatory approvals more intensive.
• Climatic specific.
• Suitable soils required.
Advantages

- Excellent performance with very low infiltration rates possible.
- Suitable for high sensitivity.
- Not affected by freeze/thaw or drying.
- Decreased profile depth.

Disadvantages

- May have higher capital costs relative to clay.
- Design and regulatory approvals may be more intensive.
- Require specialized installation and QA/QC.
New Kid in Town!!

ETLBC!!
Methane is a Potent GHG with Global Warming Potential 25x CO₂
What is an Evapotranspiration Landfill Biocover?

- Evapotranspiration
- Methane Oxidation
- Evapotranspiration Landfill Biocover
Evapotranspiration Cover Systems

• Store moisture in soil - evaporation and transpiration
• Effective at limiting infiltration and leachate generation
Methane Oxidation

- Naturally occurring, aerobic organisms
- Methanotrophs convert $\text{CH}_4$ to $\text{CO}_2$
ET Biocover Closure

• Suitable to semi-arid regions.
• Acts like a sponge to store moisture.
• Can outperform clay caps in suitable environments.
• Provides a suitable habitat for bacteria to convert methane to carbon dioxide.
Hat-Trick!

1. Organics diversion
2. Use for previously landfilled by-product
3. Reduced emissions

"I tell you this thing is a touchdown! It's a slam dunk! A home run! And, consequently, a hat trick."
1. Organics Diversion

- Composting programs
- Reduce LFG emissions
- Reduce settlement, increase airspace opportunity
2. Previously Landfilled Byproduct

- Screenings from compost are typically landfilled
- Opportunity to use as soil amendment
- Nutrient supplement for methanotrophs
3. Reduced GHG Emissions

- Methanotrophic oxidation of methane
- Reduced GHG fugitive emissions
How does the ET Biocover compare to a conventional cover?

• **Materials used**
  - Fine grained soil and compost
  - Soil requirements not as stringent as with clay

• **Material sourcing**
  - Much wider selection of soils available

• **Ease of installation**
  - No compaction required as with clay barrier layer
  - Less material testing

• **Grading**
  - Use the same grades as clay or geomembrane cover
AND NOW BACK TO
OUR REGULARLY
SCHEDULED
PROGRAMMING
• 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

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

ENVIRONMENTAL MONITORING
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

Final Cover System
- Erosion control
- Mowing and Overseeding
- Invasive Species

Storm water management
- Ditch maintenance
- Pond dredging
- Damage due to large storm events

Leachate Management
- Leachate treatment and disposal
- Maintenance, flushing and inspection

Landfill Gas Management
- LFG collection system operations, maintenance.
- Equipment replacement.

Environmental Monitoring
- Groundwater
- Surface water
- Soil gas
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??

$10-25 per square metre for ET or ETLBC cover when materials readily available.

$15-35 per square meter for compacted clay cover systems when materials readily available.

$30-50 per square metre for ET or ETLBC cover when materials not readily available.

$35-50 per square meter for compacted clay covers systems when material scarce.

$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 (unlined) landfill.
- Low sensitivity.
- Existing GW monitoring wells (3).
- No storm water infrastructure.
- Closure area of 1.2 hectares (3 acres).
- 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><strong>Closure / Reclamation</strong></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><strong>Stormwater</strong></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><strong>Subtotal</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$375,525</td>
</tr>
<tr>
<td><strong>Engineering and Approvals (10%)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$37,553</td>
</tr>
<tr>
<td><strong>Total (Excluding GST)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$413,078</td>
</tr>
</tbody>
</table>

*Approx. 75% of closure costs are cover material and placement*
### 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>
Financial Analysis Summary

• Based upon 25 year post closure liabilities
  ▪ Total Cost: $1.1M
  ▪ Net Present Value:
    – Discount Interest Rate: 3.5%
    – Inflation Rate: 2.0%
    – NPV: $995,000

• Based upon 50 year post closure liabilities
  ▪ Total Cost: $1.8M
  ▪ Net Present Value:
    – Discount Interest Rate: 3.5%
    – Inflation Rate: 2.0%
    – NPV: $1.4M