Landfill Cover Design and Operation

USEPA Workshop on Bioreactor Landfills

Beth A. Gross, P.E.
GeoSyntec Consultants
Engineered Systems at Landfills

- Gas Collection and Removal System
- Cover System
- Surface-Water Management System
- Leachate Collection and Removal System
- Double Liner System
Cover System Components

- Surface/Protection Layer
- Composite Barrier
- Gas Collection Layer
- Foundation Layer
- Drainage Layer
- Waste
Technical Guidance
For RCRA/CERCLA Final Covers

by

Rudolph Bonaparte, Ph.D., P.E.
GeoSyntec Consultants
Atlanta, GA 30342

Beth A. Gross, P.E.
GeoSyntec Consultants
Austin, TX 78748

David E. Daniel, Ph.D., P.E.
University of Illinois
Urbana, IL 61801

Robert M. Koerner, Ph.D., P.E.
Drexel University/Geosynthetic Research Institute
Philadelphia, PA 19104

Steve Dayer, P.E.
Sandia National Laboratories
Albuquerque, NM 87185

United States
Environmental Protection Agency

Office of Solid Waste and
Emergency Response

Washington DC
Component Functions

Surface Layer
- Resist erosion by wind and water
- Be maintainable
- Promote vegetation, if present
- Satisfy aesthetic, ecological, or end use criteria

Protection Layer
- Protect underlying layers from erosion and exposure to damaging environments (freeze-thaw, desiccation, ultraviolet light)
- Serve as a biobarrier
- Store water for vegetation, if present
Component Functions

- **Drainage Layer**
  - Limit hydraulic head on the barrier
  - Drain the overlying soil layers
  - Reduce seepage forces above the barrier

- **Hydraulic Barrier**
  - Minimize percolation
  - Restrict gas emissions
Component Functions

- **Gas Collection Layer**
  - Convey gas to a collection point
  - Limit pressure head beneath the barrier
  - May generally be needed for operating bioreactors with a final cover system

- **Foundation Layer**
  - Provide grade control and smooth surface
  - Provide adequate bearing capacity for overlying layers
  - Reduce differential settlements in overlying layers
Minimum Criteria Cover System for Modern MSW Landfills (40 CFR §258.60)

- Minimize infiltration to prevent the “bathtub” effect
- Minimize erosion
- Not a complete design: missing drainage layer, gas collection layer, etc.
Liquids Management Strategy

EPA regulations for cover systems have evolved within a “liquids management strategy” framework:
- minimizing leachate generation by keeping liquids out of the landfill
- detecting, collecting, and removing leachate as it is generated

Draft EPA cover system guidance: for MSW landfills, maximum cover system percolation rate of 0.1 to 1 mm/yr should prevent bathtub effect.
Leachate Generation Rates Over Time (Bonaparte, 1995)

Leachate Generation Rate (liters/hectare/day)

Date

Active Filling

Cover Installed

Cell Closed (Cover System with GM Barrier)

MSW Landfill in Pennsylvania

Jan-89 Jan-90 Jan-91 Jan-92 Jan-93 Jan-94
Questions

- What are the special considerations for designing a cover system (interim or final) for a bioreactor landfill?

- What characteristics are important for an interim cover system?

- What is the best time frame for constructing a final cover system over a bioreactor landfill?
Special Conditions: Bioreactor Landfills vs. Conventional Landfills

- Increased rate of gas generation (but shorter time frame for exposure of cover system components to gas constituents)

- With more moisture in the waste, greater potential for leachate seeps

- Increased settlements due to increased degradation and higher waste unit weight

- Decreased slope stability due to higher waste unit weight and lower shear strength
## Cover System Design Issues

<table>
<thead>
<tr>
<th>Layer</th>
<th>Factor</th>
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<tbody>
<tr>
<td>Surface Layer</td>
<td>Erosion by water and/or air</td>
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<td></td>
<td>Evapotranspiration</td>
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<td></td>
<td>Native versus exotic vegetation</td>
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<td></td>
<td>Post-closure land use</td>
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<tr>
<td>Protection Layer</td>
<td>Erosion by water</td>
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<tr>
<td></td>
<td>Evapotranspiration</td>
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<tr>
<td></td>
<td>Slope instability due to pore pressure buildup</td>
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<td></td>
<td>Animal burrows</td>
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<td></td>
<td>Deep root penetration</td>
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<tr>
<td>Drainage Layer</td>
<td>Excessive clogging</td>
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<tr>
<td></td>
<td>Insufficient flow rate capacity</td>
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<td></td>
<td>Insufficient number or flow rate capacity of outlets</td>
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## Cover System Design Issues

<table>
<thead>
<tr>
<th>Layer</th>
<th>Factor</th>
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</thead>
<tbody>
<tr>
<td>Barrier</td>
<td>Cracking due to desiccation (wet/dry or freeze/thaw cycling)</td>
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<td></td>
<td><strong>Deformations from waste settlement</strong>, or seismic motions</td>
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<td></td>
<td>Root penetration</td>
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<td></td>
<td>Insufficient resistance to gas flow</td>
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<tr>
<td></td>
<td>Slope instability</td>
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<tr>
<td></td>
<td>Creep of all materials (CCL, GCL, GM, asphalt)</td>
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<tr>
<td>Gas Collection Layer</td>
<td>Insufficient coverage over waste</td>
</tr>
<tr>
<td></td>
<td>Insufficient flow capacity</td>
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<tr>
<td>Foundation Layer</td>
<td>Insufficient strength</td>
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<tr>
<td></td>
<td><strong>Insufficient slope</strong> (inadequate grading or post-construction settlement)**</td>
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</tbody>
</table>
Interim Cover During Bioreactor Operation
# Relative Performance of Different Interim Cover Materials

<table>
<thead>
<tr>
<th></th>
<th>Relatively Permeable Soil</th>
<th>Less Permeable Soil</th>
<th>Includes GM Barrier</th>
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</thead>
<tbody>
<tr>
<td>Infiltration Over Waste Surface</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Concern with Deformation</td>
<td>Low</td>
<td>Medium to High</td>
<td>Medium to High</td>
</tr>
<tr>
<td>Potential for Leachate Seeps</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Potential for Gas Emissions/Air Intrusion</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
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<tr>
<td>Potential for Erosion</td>
<td>Low</td>
<td>Medium</td>
<td>Low to High</td>
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<tr>
<td>Operations and Maintenance</td>
<td>Low</td>
<td>Medium to High</td>
<td>Medium to High</td>
</tr>
<tr>
<td>End Use Flexibility</td>
<td>High</td>
<td>Medium to High</td>
<td>Low to Medium</td>
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Final Cover System Installation

- If a final cover system is constructed during bioreactor operations, it may require more maintenance than an interim cover and, potentially, some reconstruction after the waste has stabilized.

- For increased design flexibility, the final cover should be constructed after waste has been sufficiently stabilized.

- When a soil interim cover is proposed, its performance should be monitored and, if necessary, an interim cover that incorporates a geomembrane or a final cover system should be installed.

- The final cover system should be designed to prevent the bathtub effect.
Final Thoughts

The design considerations for a bioreactor landfill cover system (interim or final) depend on when the cover is to be constructed. For example, when a final cover system is constructed at the end of bioreactor operations, gas and infiltration control and the ability to tolerate deformations would less important than if the cover system was constructed during bioreactor operations. When a final cover system is constructed over a stabilized landfill there is more flexibility in design (e.g., alternative materials).

An interim cover consisting of a relatively permeable soil layer may enhance bioreactor operations by distributing infiltrating water across the waste surface. The soil layer can subsequently be used as part of the final cover system.
An interim cover such as a vegetated soil layer may be sufficient to control erosion and gas emissions. The soil layer can subsequently be used as part of the final cover system.

If gas emissions through a soil interim cover are excessive and can not be adequately controlled by the gas collection system, the cover system may require a gas collection layer beneath the soil layer or a geomembrane barrier.

After bioreactor operation ceases and assuming the toxic constituents in the waste have been degraded or fixated, the primary function of the final cover system would be to prevent the bathtub effect. If the liner system could be made more permeable at his time, the final cover system would only need to serve as an isolation layer.