Exposed Geomembrane Covers (EGCs) for Landfills

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Presentation Outline

- History of EGCs
- Evolution of EGCs
- Feasibility of EGCs
  - Technical
  - Regulatory
  - Financial
History of EGCs for Landfills

Note that:
• Exposed geomembranes have been used in dams since the 1970s.
• Several geomembrane wind uplift papers were publications in the 1970s.

Delaware Solid Waste Authority, DE

- 35-mil scrim-reinforced fPP, Green Stevens Geomembranes
- Construction 1997
- Area 42 acres
- Long-term Interim Cover
Sabine Parish, LA

- 60-mil HDPE Textured, Green
- Construction 1999
- Area 15 acres
- Approved as Final Cover

Other Examples of EGCs

- Yolo County landfill near Davis, CA
  - Reinforced Polypropylene Geomembrane

- Coffin Butte Landfill, Corvalis, OR
  - EPDM Geomembrane

- Polk County, FL
  - HDPE Geomembrane
Evolution of EGCs

Solar Caps

- Hickory Ridge Landfill, Atlanta, GA
- Area 45 acres, ~10 with solar
- Construction 2011
- 60-mil scrim-reinforced TPO, Green
Crazy Horse Landfill, CA
- 50-mil structured LLDPE
- Construction 2011-12
- Area 63 acres
- Anchored with Closure Turf
- Approved as Final

Technical Feasibility of EGCs
Advantages and Disadvantage
Advantages of EGCs (1)

- **Reduced Construction Materials, Cost, and Effort**
  - Elimination of the topsoil, cover soil, drainage, and vegetation components of a final cover system may reduce total construction costs by as much as $25,000 to $60,000 per acre.

  ![Figure 1. Typical Final Cover System](image1)
  ![Figure 2. Exposed Geomembrane Cover System](image2)

Advantages of EGCs (2)

- **Reduced Greenhouse Gas Emissions**
  - 80% less CO2 emissions than Subtitle D cover construction

- **No Cover Soil Erosion and Reduced O&M Costs and Effort**
  - **Subtitle D covers:**
    - require mowing, tree removal, weeding/herbicide, frequent erosion damage repair, reseeding, sediment removal from SWM system
  - **EGCs:**
    - require only minor patching and seaming, sedimentation reaching the stormwater system from an EGC is minor

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Advantages of EGCs (3)

- No stability issues
  - Veneer stability of soil on geomembrane is not an issue
  - Can place EGCs on steeper slopes
- Settlement effects on EGC are not significant and settlement is easier to repair
- Can capture airspace created by waste settlement in the future much easier than with a Subtitle D cover

Disadvantages/Design Considerations of EGCs

- Aesthetic Concerns
- Limited Cover Access
- Limited Design Life
- Wind Uplift of EGC (need anchoring)
- Increased Volume and Velocity of Stormwater Runoff
- Potential for Damage by Birds, Hail, etc.
Aesthetic Concerns

- Geomembranes are available in many colors (Black, White, Gray, Tan, and Green)

Limited Cover Access

- Roads can be built on EGCs; they double up as anchors
**Limited Design Life**

- All geomembranes are formulated materials consisting of:
  - resin, carbon black and/or other colorants, and short-term processing stabilizers
  - long-term "weathering package" containing UV light absorbers, light stabilizers, and antioxidants
- Expected exposed service life >30 years (GRI, 2010)

<table>
<thead>
<tr>
<th>Material</th>
<th>First EGC Experience</th>
<th>Typ. Gauge (mil)</th>
<th>Warranty (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reinforced fPP</td>
<td>1997</td>
<td>45</td>
<td>20</td>
</tr>
<tr>
<td>HDPE</td>
<td>1999</td>
<td>60</td>
<td>5-20</td>
</tr>
<tr>
<td>Reinforced TPO</td>
<td>2009</td>
<td>60</td>
<td>20-30</td>
</tr>
<tr>
<td>EPDM</td>
<td>2011</td>
<td>45</td>
<td>20</td>
</tr>
</tbody>
</table>

**Wind Uplift – Typical Anchor Trench Design**

- Vertical anchor trenches are the most common method
  - 3x3-ft trenches every 60-100 feet
  - Average cost $20,000 per acre
Earth anchors are new, less costly method
- No trenching/backfilling, geomembrane use reduced by 15%
- Anchor every 15-25 feet
- Average cost $10,500 per acre

Wind Uplift Predictions using CFD Modeling

Botelho, Heynes, and Giroud, “Evaluating Wind Uplift for Exposed Geomembranes using Computer Modeling”, Geosynthetics 2013, April 1-4, Long Beach, California
Increased Stormwater Runoff

- Need bigger capacity for perimeter ditches and ponds

Potential for puncture by hail, animals, etc.

Hydrostatic puncture resistance per ASTM D 5514
Simulates a 1” Rock (Sharp) at a 1” Spacing on a 20” Pressure Surface
Minimizing Potential Damage by Birds

Wires across cap discourage birds from landing on EGC

Regulatory Feasibility of EGCS
Precedents from Other States

- GSI survey, 2009 queried all 50 states on the issue of permitting EGCs as alternative covers
  - 32 responses
  - Is EGC allowed as an alternative cover design?
    - Yes = 7 (22%)
    - Yes, conditionally = 9 (28%)
    - No = 16 (50%)
  - Performance bonding and financial assurance requirements varied, about 50/50 split between bonding and FA

- Variances for EGCs at landfills have been granted since the 1990s in 16 states
  - 12 states (2009 – 2011)

U.S. EPA Position

- U.S. EPA encourages landfill owners to work with state regulators to reduce the environmental footprint of activities needed to install and maintain a cover system
- Integrating landfill cover designs with reuse of a site for generating energy from solar resources can meet this objective
- Solar geomembrane covers specifically identified as examples of covers that “can meet Subtitle D alternative cap requirements while converting solar energy to useable power”

Source: “Green Remediation Best Management Practices” for landfill cover systems and energy production (2011)
### Financial Feasibility of EGCs

#### Example Cost Comparisons

**Unit Capital Costs (per acre)**
- Excl. Mobil/demobil., site grading and preparation, SWM, engineering and CQA, and contingency

<table>
<thead>
<tr>
<th>Cover Type</th>
<th>Trenches</th>
<th>Anchors</th>
<th>No Anchors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposed (HDPE)</td>
<td>$52,700</td>
<td>$43,200</td>
<td>-</td>
</tr>
<tr>
<td>Exposed (TPO)</td>
<td>$67,900</td>
<td>$58,400</td>
<td>-</td>
</tr>
<tr>
<td>Subtitle D</td>
<td>-</td>
<td>-</td>
<td>$83,700</td>
</tr>
</tbody>
</table>

**Unit O&M Costs (per acre)**
- Routine activities on the cover only, not grounds maintenance, SWM systems, etc.

<table>
<thead>
<tr>
<th>Cover Type</th>
<th>O&amp;M</th>
<th>15-year Replac.</th>
<th>30-year Replac.</th>
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</thead>
<tbody>
<tr>
<td>Exposed (HDPE)</td>
<td>$200</td>
<td>30%</td>
<td>70%</td>
</tr>
<tr>
<td>Exposed (fPP, EPDM, TPO)</td>
<td>$100</td>
<td>30%</td>
<td>70%</td>
</tr>
<tr>
<td>Subtitle D</td>
<td>$750</td>
<td>-</td>
<td>-</td>
</tr>
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</table>
Example Life Cycle Cost Scenarios

Closure Costs (-$MM, NPV basis after 30 years); 110 acres

<table>
<thead>
<tr>
<th>Cover Type</th>
<th>Total Cost</th>
</tr>
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<tbody>
<tr>
<td>Subtitle D (Baseline)</td>
<td>18.83</td>
</tr>
<tr>
<td>EGC (HDPE) – anchors</td>
<td>14.21</td>
</tr>
<tr>
<td>EGC (TPO) – anchors</td>
<td>17.13</td>
</tr>
<tr>
<td>EGC (HDPE) – trenches</td>
<td>16.14</td>
</tr>
<tr>
<td>EGC (TPO) – trenches</td>
<td>19.07</td>
</tr>
</tbody>
</table>

Summary

- EGCs have been used for landfill closures since 1997
- EGCs provide environmental, technical, and financial benefits over Subtitle D covers at many landfill sites
- Design methods have been developed and implemented at many sites
- Improvements in geomembrane materials, design methods, and installation procedures are continuing.
THANK YOU.

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