Field Data from the Alternative Cover Assessment Program (ACAP): Conventional Covers

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ACAP Objectives:

• Collect field scale data characterizing field performance of alternative and conventional covers.

• Evaluate accuracy of hydrologic models used for final cover design

• Develop guidance for alternative cover designers
Per RCRA Subtitle D, an alternative cover must provide performance that is equivalent to (or better) than that of the intended conventional cover.

Data describing performance of conventional covers scarce (Hamburg study, Georgia and Washington study, Sandia study).

What is performance? … control of erosion and **percolation**, along with acceptable gas control.

§ 258.60 Closure criteria.
(a) Owners or operators of all MSWLF units must install a final cover system that is designed to minimize infiltration and erosion. The final cover system must be designed and constructed to:
(1) Have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present, or a permeability no greater than \(1 \times 10^{-3}\) cm/sec, whichever is less, and
(2) Minimize infiltration through the closed MSWLF by the use of an infiltration layer that contains a minimum 18-inches of earthen material, and
(3) Minimize erosion of the final cover by the use of an erosion layer that contains a minimum 6-inches of earthen material that is capable of sustaining native plant growth.
(b) The Director of an approved State may approve an alternative final cover design that includes:
(1) An infiltration layer that achieves an equivalent reduction in infiltration as the infiltration layer specified in paragraphs (a)(1) and (a)(2) of this section, and
(2) An erosion layer that provides equivalent protection from wind and water erosion as the erosion layer specified in paragraph (a)(3) of this section.
Why Collect Field Data?

• Little verification of models used for predicting the hydrology of conventional covers.

• Large-scale field data provide the acid test for cover performance.
What Defines a Conventional Cover?

**EXISTING LINER**

- No Liner
- Leachate Collection Layer
  - Liner \( K_s < 10^{-6} \) cm/s
- Leachate Collection Layer
  - Liner \( K_s < 10^{-7} \) cm/s
- Leachate Collection Layer
  - Liner \( K_s < 10^{-7} \) cm/s
- Geomembrane

**MINIMUM COVER RECOMMENDED IN SUBTITLE D**

- Erosion Layer
  - Barrier Layer \( K_s < 10^{-5} \) cm/s
  - Geomembrane
- Erosion Layer
  - Barrier Layer \( K_s < 10^{-6} \) cm/s
- Erosion Layer
  - Barrier Layer \( K_s < 10^{-7} \) cm/s
- Erosion Layer
  - Barrier Layer \( K_s < 10^{-5} \) cm/s

- > 155 mm
- > 460 mm
ACAP Sites with Conventional Covers

- Apple Valley, CA
- Albany, GA
- Boardman, OR
- Polson, MT
- Omaha, NE
- Cedar Rapids, IA
- Monterey, CA
- Altamont, CA
- Apple Valley, CA
- Albany, GA
Conventional Cover Profiles Evaluated by ACAP

- Boardman, OR
- Apple Valley, CA
- Altamont, CA
- Albany, GA
- Marina, CA
- Cedar Rapids, IA
- Omaha, NE
- Polson, MT

Legend:
- Compacted Support Layer
- Interim Cover
- Drainage Composite
- Geomembrane
- Geosynthetic Clay Liner (GCL)
- Vegetation (Grass)
- Vegetation (Grasses, forbs, & shrubs)
- Sand
- Vegetative Cover or Storage Layer
- Topsoil
- Compacted Soil Barrier
- Gravel
ACAP Test Section Plan View

Large bathtub filled with cover soil and instruments.

All dimensions in meters

SRO Diversion Berm

SRO Pipe

Perc. Pipe

0.6

10

20

20

30

5

5

4

5

0.6

20

Down Slope
Typical Lysimeter Cross-Section

- LLDPE Cutoff
- Root Barrier
- Cover
- Interim Cover Soil
- LLDPE Cutoff
- Earthen Berm
- Percolation Pipe
- LLDPE Geomembrane
- Existing Slope (>2%)
- Geocomposite Drain
- Earthen Berm
Aerial view of completed test sections at Kiefer Landfill, Sacramento County, California.
Kiefer Site:
Eight months after construction
Construction Methods

Used full-scale construction methods to greatest extent possible

Included single design hole in geomembrane (11 mm diameter) of composite barriers

Leak tested all geomembrane seams with conventional QA methods (air pressure, vacuum box).

Tow-behind tamping foot compactor for clay barrier layer at Cedar Rapids site.
Data from Composite Covers: Semi-Arid Sites

Polson, MT: semi-arid and seasonal, snow

Altamont, CA: semi-arid and warm, no snow
Polson, MT
Cool and Seasonal Semi-Arid Climate
Conventional Composite Cover
(precipitation ~ 380 mm/yr)

- 150 mm Topsoil
- 460 mm Silty Sand
- 460 mm Silt (< 10^{-5} cm/s)
- Interim Cover

Geomembrane

Drainage Composite
Cumulative Precipitation, Evapotranspiration, and Soil Water Storage (mm)

(a) Composite

- Precipitation
- Evapotranspiration
- Lateral Flow
- Surface Runoff
- Soil Water Storage
- Percolation

Polson, Montana
Altamont, California
Warm Semi-Arid Climate
Conventional Composite Cover
(precipitation ~ 358 mm/yr)

- Geomembrane
- 305 mm Loose Clay with Top Soil
- Drainage Composite
- 300 mm Panoche Claystone (< $10^{-6}$ cm/s)
- 600 mm Claystone Support Layer
- 300 mm Claystone Interim Cover

Support Layer

600 mm Claystone

Interim Cover
Altamont, California

Cumulative Precipitation, Evapotranspiration, and Soil Water Storage (mm)

Cumulative Percolation, Surface Runoff, and Lateral Flow (mm)

(a) Conventional

Precipitation
Evapotranspiration
Soil Water Storage
Surface Runoff
Lateral Flow
Percolation

Altamont, California
Humid Site: Cedar Rapids, IA

Humid Seasonal Climate with Snow
Conventional Composite Cover
(precipitation ~ 915 mm/yr)

305 mm Sandy Clay with Top Soil
Drainage Composite
450 mm Clay (< 10^-7 cm/s)
300 mm Sandy Clay Interim Cover
Cedar Rapids, IA

≈ 10 mm percolation to date
<table>
<thead>
<tr>
<th>Site</th>
<th>Duration (d)</th>
<th>Slope (%)</th>
<th>Total Precip. (mm)</th>
<th>Avg. Annual Precip. (mm/yr)</th>
<th>Surface Runoff (mm/yr)</th>
<th>Lateral Flow (mm/yr)</th>
<th>Perc. (mm/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Altamont, CA</td>
<td>781</td>
<td>5</td>
<td>737.1</td>
<td>358.4</td>
<td>17.2 (5.0%)</td>
<td>2.0 (0.6%)</td>
<td>1.6 (0.4%)</td>
</tr>
<tr>
<td>Polson, MT</td>
<td>1137</td>
<td>5</td>
<td>938.8</td>
<td>380.5</td>
<td>6.2 (2.0%)</td>
<td>9.9 (3.3%)</td>
<td>0.2 (0.1%)</td>
</tr>
<tr>
<td>Boardman, OR</td>
<td>747</td>
<td>25</td>
<td>258.3</td>
<td>225.3</td>
<td>0.0 (0.0%)</td>
<td>0.2 (0.2%)</td>
<td>0.0 (0.0%)</td>
</tr>
<tr>
<td>Apple Valley, CA</td>
<td>251</td>
<td>5</td>
<td>75.8</td>
<td>131.3</td>
<td>0.0 (0.0%)</td>
<td>0.0 (0.0%)</td>
<td>0.0 (0.0%)</td>
</tr>
<tr>
<td>Cedar Rapids, IA</td>
<td>621</td>
<td>5</td>
<td>1585.7</td>
<td>914.7</td>
<td>25.3 (2.7%)</td>
<td>18.1 (1.9%)</td>
<td>5.6 (0.6%)</td>
</tr>
<tr>
<td>Omaha, NE</td>
<td>797</td>
<td>25</td>
<td>995.4c</td>
<td>760.2</td>
<td>36.3 (8.0%)</td>
<td>12.5 (2.7%)</td>
<td>2.5 (0.6%)</td>
</tr>
<tr>
<td>Marina, CA</td>
<td>947</td>
<td>25</td>
<td>818.9</td>
<td>466.1</td>
<td>36.9 (11.7%)</td>
<td>10.3 (3.3%)</td>
<td>20.1 (6.4%)</td>
</tr>
</tbody>
</table>
An Anomaly: Marina, California

Costal Sub-humid Climate

Conventional Composite Cover

(precipitation ~ 466 mm/yr)

305 mm Sandy Clay from Construction Waste

300 mm Clay (< 10^-6 cm/s)

300 mm Sand Support Layer

300 mm Sand Interim Cover

Geomembrane
Marina, California

≈ 50 mm percolation to date
Why is Percolation Rate High at Marina Site?

- Exact cause unclear.

- Soil placed above geomembrane contained construction debris, and no cushion was placed between the geomembrane and the soil.

- Punctures probably occurred, causing more percolation than anticipated.

- Illustrates the importance of construction quality control.
Data from Clay Covers:
Humid Sites

Albany, GA: humid to subtropical, no snow

Cedar Rapids, IA: seasonal, freezing, snow
Albany, Georgia
Humid Seasonal Climate
Conventional Composite Cover
(precipitation ~ 1265 mm/yr)
Field Percolation Rates

- Prior to dry October 2000: ~ 30 mm/yr
- After dry October 2000: ~ 400 mm/yr, with sudden jumps in percolation record corresponding closely with precipitation events
- Field investigation showed desiccation cracking of clay barrier
Cedar Rapids, IA

Humid Seasonal Climate with Snow
Conventional Composite Cover
(precipitation ~ 915 mm/yr)
≈ 43 mm in 2002, < 10 mm expected
### Summary: Clay Cover Performance

<table>
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<tr>
<th>Site</th>
<th>Duration (d)</th>
<th>Slope (%)</th>
<th>Total Precip. (mm)</th>
<th>Avg. Annual Precip. (mm/yr)</th>
<th>Surface Runoff (mm/yr)</th>
<th>Lateral Flow (mm/yr)</th>
<th>Perc. (mm/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cedar Rapids, IA</td>
<td>621</td>
<td>5</td>
<td>1585.7</td>
<td>914.7</td>
<td>31.5 (3.4%)</td>
<td>14.1 (1.5%)</td>
<td>27.5 (2.9%)</td>
</tr>
<tr>
<td>Albany, GA</td>
<td>985</td>
<td>5</td>
<td>2552.7</td>
<td>1263.4</td>
<td>104.2 (10.9%)</td>
<td>NA</td>
<td>258.6 (27.0%)</td>
</tr>
<tr>
<td>Apple Valley, CA</td>
<td>251</td>
<td>5</td>
<td>75.8</td>
<td>131.3</td>
<td>0.0 (0.0%)</td>
<td>0.0 (0.0%)</td>
<td>0.0 (0.0%)</td>
</tr>
</tbody>
</table>

**2002 only**

Albany: 238 mm/yr (16.2%)

Cedar Rapids: 66 mm/yr (5.4%)
Summary of Composite Cover Performance

- Percolation rates are very low:
  - < 1.5 mm/yr in semi-arid and arid climates
  - < 5 mm/yr in humid climates

- Surface runoff is a small fraction of the water balance:
  - < 5% of precipitation in semi-arid and arid climates
  - < 10% of precipitation in sub-humid and humid climates

- Lateral drainage is a small fraction of the water balance: < 3.5% of precipitation
Summary of Clay Cover Performance

- Percolation rates are much higher than expected:
  - 260 mm/yr at Albany, GA
  - appears dominated by preferential flow

- Damage to clay caps occurs over short service life
  (consistent with decades of experience in agriculture)

- Long-term effectiveness of clay caps questionable.
Sponsors

• USEPA, USDOE, USMC

• Waste Management, Inc., Waste Connections Inc.

• Monterey Solid Waste Management District, Bluestem Solid Waste Agency

• Lake County, MT, Lewis and Clark County, MT

More Information

• www.acap.dri.edu