Economic Recession has created temporary reduction in wallboard demand:

- Increased stockpiles of FGDR at coal-fired power plants (nationally over 60% of FGD produced is recovered into wallboard)
- Wallboard market has grown steadily since the early 1960’s
- Potential for an increase in the amount of waste wallboard on re-start

- Increasing landfill closures and Post-Closure Care around the country
- Post-Closure periods are increasing – typically 10 to 30 years
- On-site operations supports continuing P-C Care beyond regulatory limits

- Two (2) 50-year old waste wallboard landfills
- Stopped accepting off-spec wallboard in 1990
- Closure Plan submitted in April 1995 – Approved by Regulatory Agency in December 1997
GENERAL SITE CONDITIONS:

- Bulk material properties of waste relatively unknown
- Adhered water
- Other plant debris co-disposed
- Unknown subsurface/groundwater conditions

Geotechnical Elements:

1. Workability/compaction
2. Final Cover/Closure cap permeability
3. Shear strength/stability
4. Settlement
5. Erosion/Erodibility
6. Revegetation/drainage
Final closure cover was designed and specified to meet regulatory closure requirements as follows:

- Final cover consisting of not less than 2 feet of compacted soil
- A maximum erosion rate of 5 tons per acre per year
- Final cover must have a slope of not less than two percent (2%) and not greater than thirty-three percent (33%)

**General Grading/Drainage Design:**

- West Slope: 3:1 slopes with 1 bench; perimeter channels; rock toe drain
- East Slope: 3:1 slopes with 3 benches; perimeter channels; sediment basin
- As a result of actual field conditions, a revised sediment basin and principal spillway design was necessary.
Field Change:

- Regulatory Agency required soil cap to be: $k \leq 1 \times 10^{-7}$ cm/s
- Closure Construction began June 1998 and completed in October 1998

- September 1998 - During basin backfilling with stone – Tension Crack (about 250-foot long scarp) develop between the lower and middle benches of the East Pile

- Crack/movement directly upslope of 30-foot depth, 1:1 basin excavation

- Clay layer and seepage noted at base of movement

- Sliding wedge (Janbu) analysis was used to back-calculate waste shear strength

- C = 0 psf; phi = 18 degrees

- Modified Basin design to arrest movement (accelerated basin backfilling; flattened slope (4H:1V); raised stone in basin floor 3 feet)

- Resulting Factor of Safety = 1.6

- Set survey stakes along slope to observe any further movements

- No further movements have been observed since that time
- Construction completed - October 1998

- Inclement weather resulted in re-seeding required - April 1999

- Final inspection - June 1999

- Certification document submitted to Regulatory Agency - June 1999

- Regulatory Approval - July 1999
- Semi-Annual Post Closure Inspections Began November 1999

- 18 inspections to date between 11/99 and 06/09

- Unique opportunity to review Final Cover/Cap performance over time
Major Issues related to long-term maintenance:

1. Settlement/Sinkhole Development
2. Erosion/Erodibility
3. Revegetation Requirements

November 1999 Inspection:

- Site adjacent to farms and pastures
- Cow Manure was observed on final cover – both landfills
- Initial trails were forming - caused by the animals were observed
- Facility was cited by the regulatory agency

Solution:

Installed gates and fences around perimeter access points
Slopes appear rutted with minor slope movement throughout.
Solution:

Revised mowing schedule and equipment
Solution:

Installed gas and leachate control system in new final cover and divided slope with a diversion
Simple perimeter maintenance

Downed tree presented a breach in the compacted clay cap

Possible leachate break-out point

Solution:

Cut and remove fallen timber. Remove woody growth from the landfill and perimeter channels
- November 2003 Inspection – revealed a sinkhole on East Pile bench
- Surface water directly entering fill

Solution:

1. Immediately installed a diversion around the sinkhole
2. Backfilled the sinkhole with a sand/bentonite mixture (1 part granulated Bentonite to 4 parts sand)
3. Mound & Monitor; top-off as needed
Sinkhole started as a rodent burrow?

- Undercutting along bench discharge points
- Repaired with geomembrane underlayment beneath rip rap
- Increased ponding on benches
- Observed settlements
Solution:

Regrade benches to improve drainage
- Used historic topographic maps to estimate primary coefficient of consolidation for the waste wallboard
- Known timeframe
- Known original waste thickness
- Known change in stress
- $C_c \approx 0.5$
Mulch netting introduced an unexpected results on the local snake population.

**COST OF POST-CLOSURE MAINTENANCE/REPAIRS:**

- Major site repairs monitored and conducted in Year 2, Year 7 and Year 8
- Year 2: $12,000 Contracted re-seeding, erosion repairs
- Year 7: $149,000 Contracted leachate/gas, Venting/final cover replacement
- Year 8: $20,000 Contracted reseeding, erosion repairs
- Mowing, tree/shrub removal not included – by plant staff
- Closure construction cost totaled $1.3 Million
- Suggests about 15% P-C over 10 years on a staggered schedule
**Lessons Learned:**

1. Conduct an early site visit to capture the actual conditions for bidding/construction
2. Stuff happens – landslide remediation
3. Livestock and rodents – don’t underestimate the impact of these seemingly minor nuisances
4. Treat the soil loss equation with respect.
5. Test your site-specific soils for nutrient deficiencies

**Lessons Learned (cont.):**

6. It is possible to provide too much maintenance.
7. Remove dead/dying trees from the perimeter of the site – can cause cap damage
8. Conduct site visits with sufficient frequency to protect the large investments in closure costs
9. Consider joint visits with the regulatory agencies to earn trust and confidence.
10. With frequent visits, the cost of repairs can be controlled to coincide with budgets and prevent more significant damage and failures from occurring. It is not necessarily a uniform annual fee.

**Unanswered Questions:**

- How/why does the waste material seem to move up through the final cover soil?
- What is the long-term impact of the H2S on the vegetation?
- Although somewhat limiting due to H2S, did borrows contribute to sinkhole development?
- Does consolidation theory hold true for gypsum?
- At what point in time does the internal reactions in the waste reduce H2S production below levels that affect vegetation?
Case Study: Rehabilitation of a Soil Dike for a Wastewater Treatment Facility

Presented At:
A.S.C.E., N.C. Section Meeting
Greensboro, N.C.
August 28, 2003
by
Gregory G. Mills, P.E.

The Wastewater Pond

Outboard Slope of Dike

Area of Distressed Cypress Trees
Possible source of distress.

Typical water level at the toe of the outboard slope

Dry season

Seep Area

Hand Augered Piezometer
Exploring Seep

Repair Goals
- Prevent seepage from impacting the wetlands
- Improve dike stability
- Least cost

Information About the Dike
- Dike constructed 40+ years ago
- Constructed entirely of soil
- No geosynthetic or soil liner in Pond
- No cutoff or toe drain in the dike
- Outboard slopes approx. 3H:1V

Dike Cross Section

CROSS SECTION THROUGH THE EXISTING SOUTH BAY DIKE
Summary of Physical Characteristics

- Top of dike at approx. EL 32 ft (MSL)
- Toe approx. EL 15, but as low as EL 8
- Flood stage of nearby creek ~EL 15 ft.
- Pond water approx. EL ~28 ft.

Questions:

- What type of soil was used for the dike?

Questions:

- What were the materials used for the dike?
- Was there any quality control?

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- What is the stability of the dike?
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- What is the stability of the dike?
- What is the water level/phreatic surface through the dike?

Questions:

- What were the materials used for the dike?
- Was there any quality control?
- What is the stability of the dike?
- What is the water level in the dike?
- What records are available regarding the dike?

Dike Raised in 1993

1993 Geotechnical Evaluation by S&ME, Inc.

- Dike was raised by as much as 3 or feet along the segment with the seep.
- Report covers an investigation prior to increasing the dike height.
- Does not provide as-built documentation.
Map of 1993 S&ME Borings

Index Properties 1993 Samples

Boring Log from 1993

Triaxial Shear Results 1993
Exploration Geoprobe Samples

Approximate Dike Cross Section

CROSS SECTION THROUGH THE EXISTING SOUTH BAY DIKE

Geoprobe Sample Results
Questions

- 2005 Geoprobe sample results different from 1993 results.
- 1993 results said sandy clay or clayey sand
- 2005 results showed less than 15% fines.

Conclusion:

- Sand is prevalent in the area
- Most other dikes are constructed of sand
- Seepage coming through sand dike

Conclusion:

- Sand is prevalent in the area
- Most other dikes are constructed of sand
- Seepage coming through sand dike
- Let's try a pump test!
- If successful, then install a series of wells
- Overlap the radii of influence
- Contain the seepage
Hydrometer - Geoprobe Sample

Atterberg Limits - 2005 Boring Sample

Piezometer in Geoprobe Boring

Remedies
- A series of pumps
Remedies

- A series of pumps
- Sheet Pile
- Slurry Cut-off Trench
- French Drain Collection Trench at the Toe

Wetlands
Proposed Collection Trench

Proposed Collection Sump

Start of Trench Excavation
Excavating the Sump at the North End of the Collection Trench

Reaching Confining Clay Layer

Collection Sump

Installing the Sump Riser and the Collection Pipe
Permitted Wetlands Impacts

The Perforated Collection Pipe Installed in the Trench

Standing Water Above the PVC Geomembrane

PVC Geomembrane

Six Fence