Landfill Cover

Severe Environment

Geocell Closure application for steep slopes, Heavy Precip, Earthquake Zone 4 and Hurricane conditions

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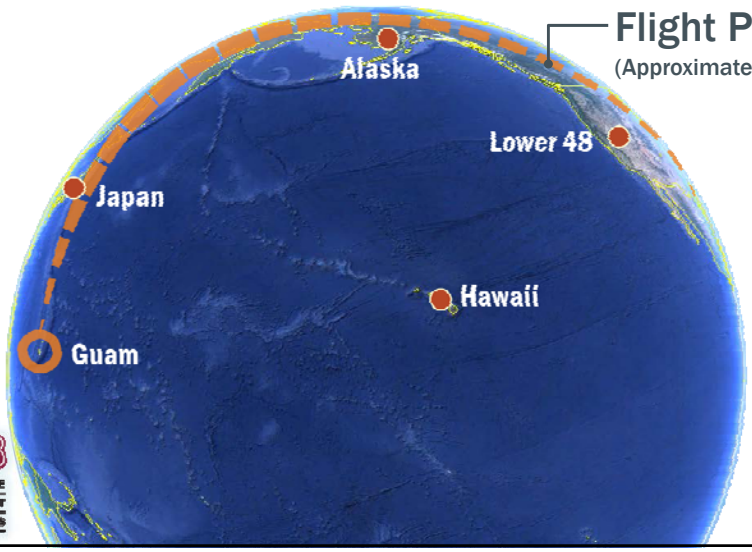
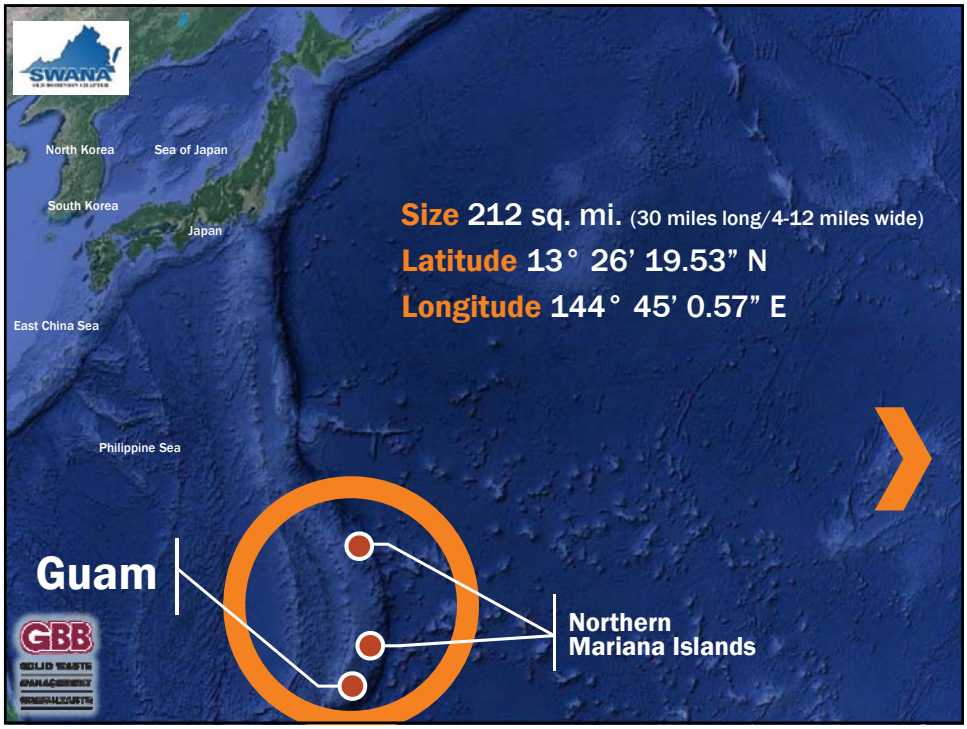
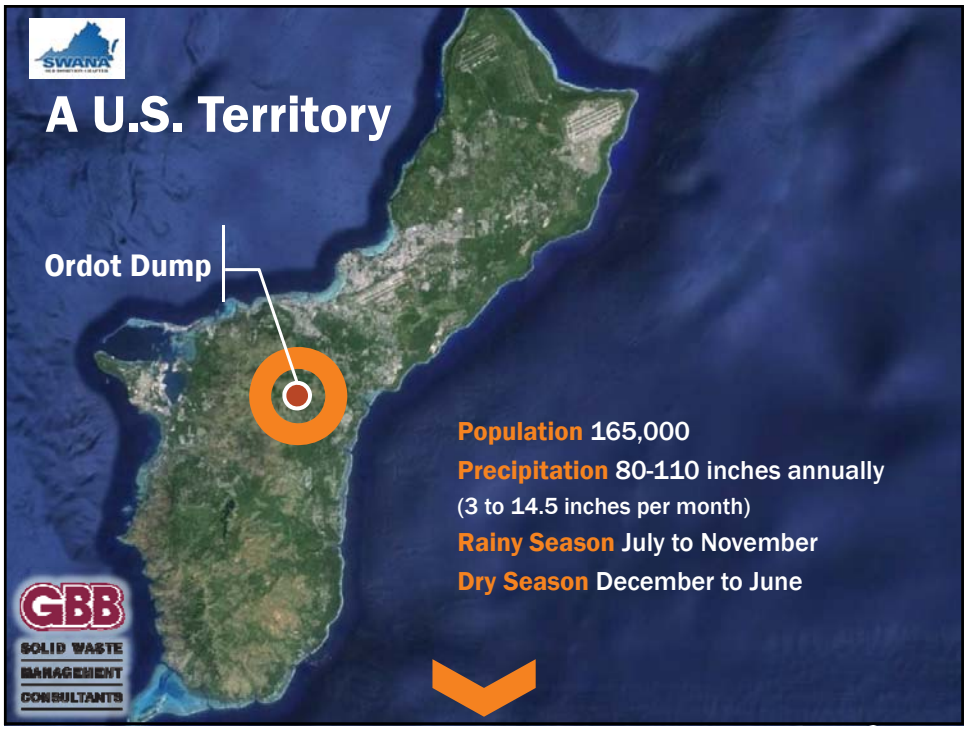
Agenda

1. Introduction of Guam/Dump Background
2. Existing Site Conditions and Constraints
3. Investigation/Design/Cover Evaluation/Selection
4. Cover System
5. Construction/Difficulties/Lessons Learned
6. Questions

Where is Guam?




North Korea
Sea of Japan
South Korea
Japan
East China Sea
Philippine Sea
Size 212 sq. mi. (30 miles long/4-12 miles wide)
Latitude 13° 26' 19.53" N
Longitude 144° 45' 0.57" E
Guam
Northern Mariana Islands


A U.S. Territory
Ordot Dump
Population 165,000
Precipitation 80-110 inches annually
(3 to 14.5 inches per month)
Rainy Season July to November
Dry Season December to June

Dump Background

- 43.5 acre unlined disposal facility
- Operated since World War II
- Ceased operations in 2011
- On the National Priorities list under CERCLA
- Guam is in US EPA Region 9
- Came under Federal Receivership

Existing Site Conditions

- Unlined dump with minimal cover soil
- Over steepened waste slopes (as steep as ½ (horz) to 1 (vert))
- Numerous leachate seeps
- Uncontrolled landfill gas migration
- Encroachment into wetlands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Detailed Site Investigation/Closure Design

- Site geologic/hydrogeologic evaluation
- Groundwater/landfill gas investigation and monitoring
- Waste limits evaluation
- Stormwater analyses
- Cover System Evaluation

Cover System Evaluation

Regulatory Overview:

- Under Guam Environmental Protection Agency oversight
- Adopted CFR Title 40, Part 258 Regulations
- Prescriptive final cover to provide a $\leq 1 \times 10^{-5}$ cm/sec barrier layer
- May approve alternative cover with equivalency

Factors Considered in the Evaluation

- Final waste limits
- Dump geometry/grading
- Stormwater control and management facilities
- Highest seismicity, (Zone 4) and high winds/precipitation (175 mph/95 inches/yr)
- Erosion
- Landfill gas and leachate generation
- Costs – Long term maintenance
- End-use goals

Cover Alternatives Evaluated

- Prescriptive soil cover system
- Exposed geomembrane system
- Covered Geomembrane system

Prescriptive Soil Cover System

From top to bottom:

- 6-inch-thick erosion layer,
- 18-inch-thick low permeability layer ($k \leq 1.0 \times 10^{-5}$ cm/sec),
- 12-inch-thick foundation layer

Exposed Geomembrane System

Layers from top to bottom:

- Side slopes: Geogrid to support vegetation (ie – No Soil Cover)
- Geocomposite drainage/protection layer
- Geomembrane – primary barrier layer
- Geocomposite landfill gas/leachate interception layer, and
- 12-inch-thick soil foundation layer

Additionally another exposed geomembrane system was evaluated but proved not sufficient to handle the design parameters for this severe environment.

Covered Geomembrane System

From top to bottom:

- Top-deck:24-inch-thick erosion/protection layer (coralline sand/gravel)
- Side slopes: 6- to 8-inch thick erosion/protection layer (a geocell with coral sand/gravel infill)
- Geocomposite drainage/protection layer
- Geomembrane layer
- Geocomposite landfill gas/leachate interception layer
- 12-inch-thick soil foundation layer

EQUIVALENCY DEMONSTRATION

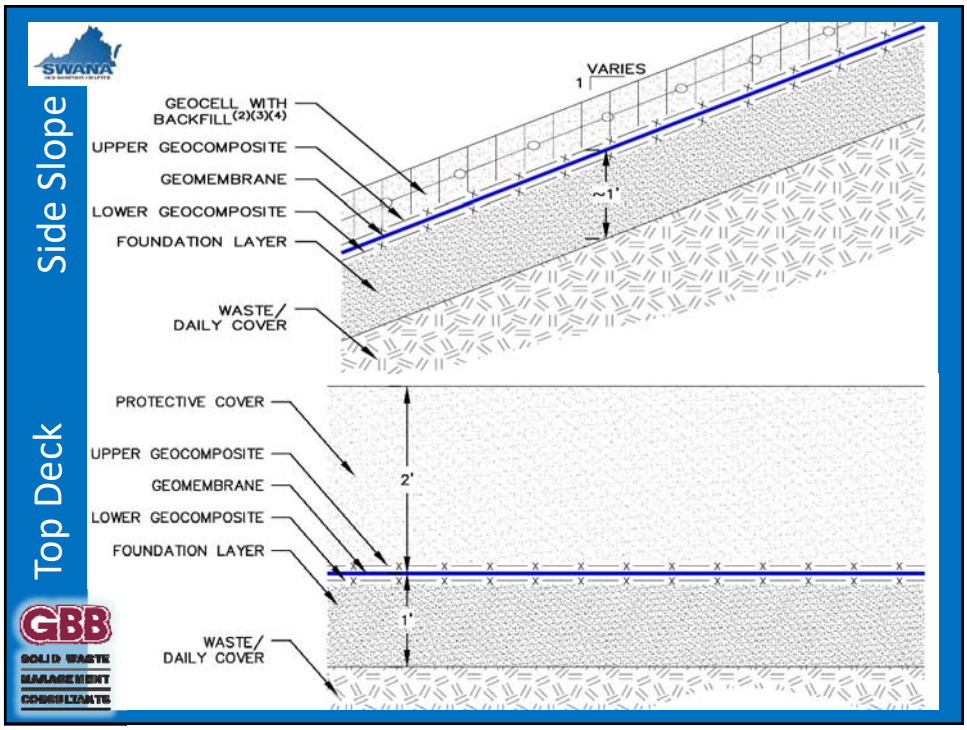
HELP MODEL RESULTS

Simulated Cover System	Cover Percolation/Leakage Predictions (Inches/Yr.)					
	Year 1	Year 2	Year 3	Year 4	Year 5	Average Annual
Prescriptive Soil Cover	57.6	63.1	44.9	44.0	59.2	53.8
Alternative Geomembrane Cover (with Soil Cover)	2.3	2.4	1.8	1.9	2.2	2.1

Selected Cover

Covered geomembrane with geocell and soil infill

- Superior leakage protection versus prescriptive cover
- Superior erosion protection versus prescriptive cover
- Superior wind/puncture resistance versus exposed cover
- Lower long term maintenance versus other cover options
- However, it required re-grading of existing waste slopes



Geocell design parameters

- 8-inch thick geocell used on upper slopes for wind uplift
- 6-inch thick geocell used on lower slopes
- Kevalar® tendons used for stability on slopes steeper than 2.5 (horz) to 1 (vert)
- Polyester tendons used on slopes flatter than 2.5 to 1
- Concrete filled geocell used in stormwater collection channels for differential settlement

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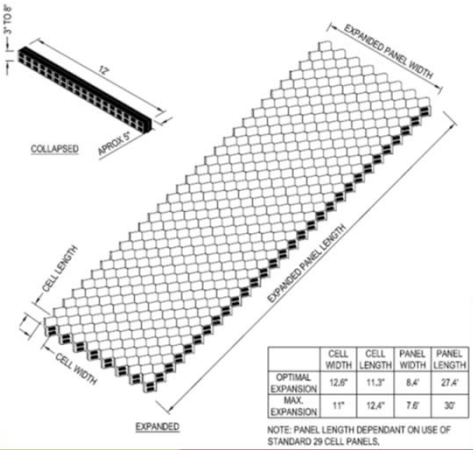
Geocell material and physical properties

- Sheets of 50-60 mil thick HDPE are welded into panels
- Panels expand in size to 8ft wide by 27ft long
- Each expanded cell is 12in x 11in nominal expanded cell size



	CELL WIDTH	CELL LENGTH	PANEL WIDTH	PANEL LENGTH
OPTIMAL EXPANSION	12.6"	11.3"	8.4'	27.4'
MAX. EXPANSION	11"	12.4"	7.6'	30'

NOTE: PANEL LENGTH DEPENDANT ON USE OF STANDARD 29 CELL PANELS.

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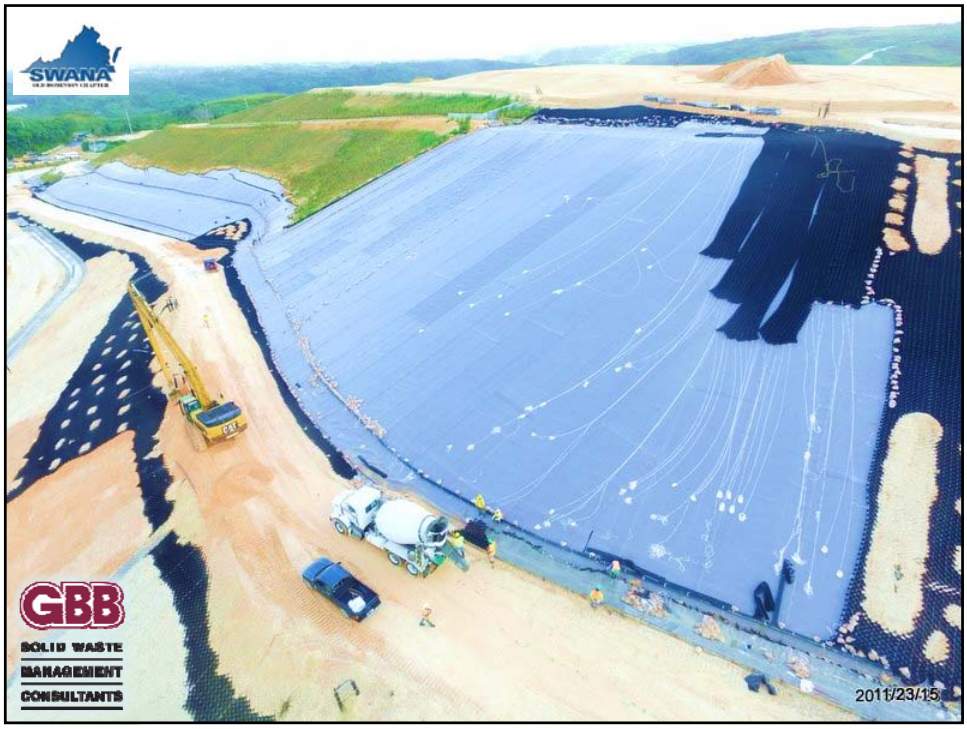
Geocell layer construction aspects

- Installation starts at each bench
- A 2-inch schedule 80 PVC pipe is used to anchor tendons
- Geocell is deployed and soil infilled along with first few rows of cells filled with concrete as anchor for geocell deployment downslope
- Geocell panels with tendons weaved through each panel and panels side by side stapled together with stainless steel staples.
- Installed downslope to next bench
- At each toe of slope, the terminal edge of geocell panels is concrete filled just above the stormwater channel completing the system.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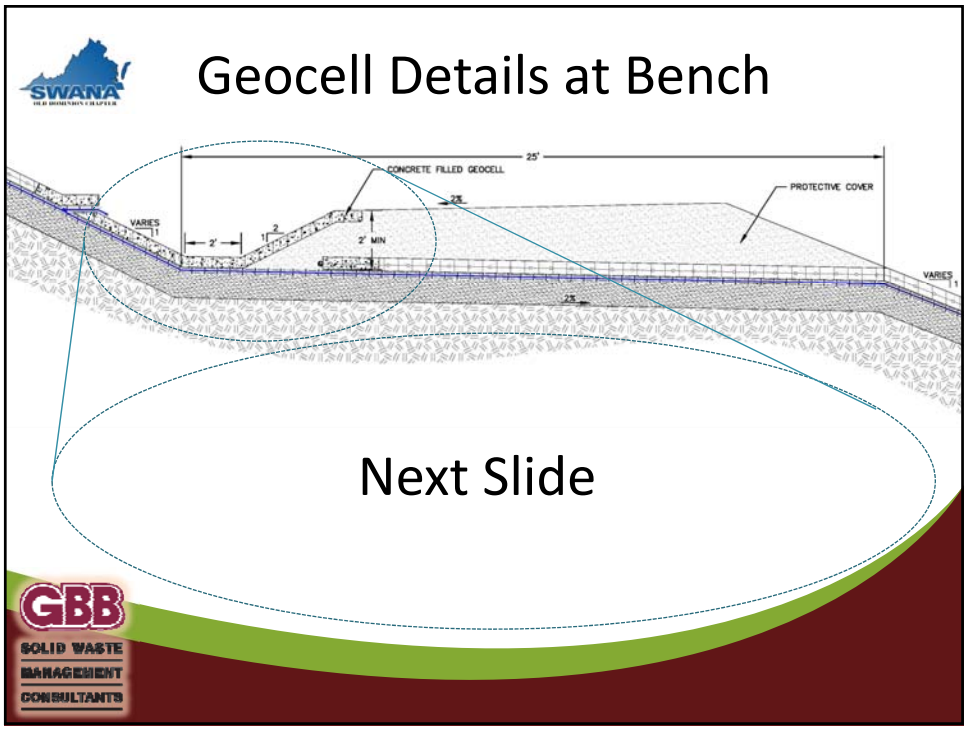
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Geocell Details at Bench
25'
CONCRETE FILLED GEOCELL
PROTECTIVE COVER
VARIES
2'
2' MIN
VARIES
Next Slide
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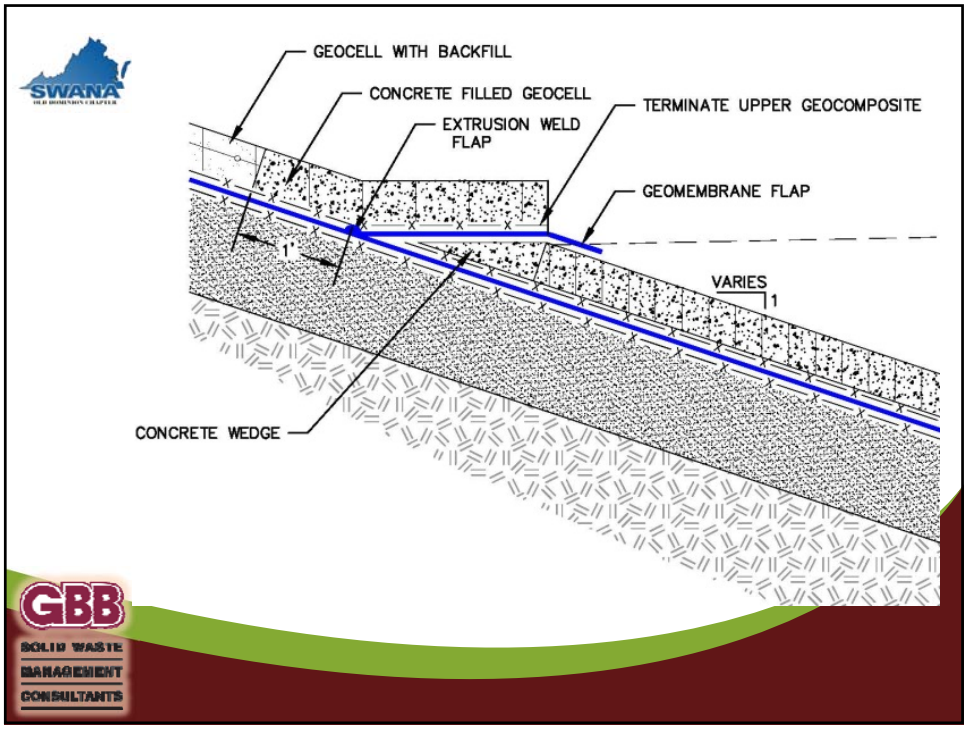
GEOCELL WITH BACKFILL
CONCRETE FILLED GEOCELL
EXTRUSION WELD FLAP
TERMINATE UPPER GEOCOMPOSITE
GEOMEMBRANE FLAP
1'
VARIES
1
CONCRETE WEDGE
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Benefits of using Geocell in Final Cover

- Enhanced erosion control
- Steeper waste slopes acceptable to EPA
- Use of tendons enhance veneer stability
- Protection of geomembrane from wind uplift/damage
- High tolerance to differential settlement
- Ability to mitigate high precipitation/pore pressure build-up in cover soil


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Geocell Cost (2013)

- Geocell Panels (per acre supplied installed (41 acres))
  - 8 inch (26 acres) $ 75,000
  - 6 inch (15 acres) $ 64,000
- Tendons (per acre supplied installed)
  - Kevlar (40%) $ 16,300
  - Polyester (60%) $ 4,400
- Infill (per acre supplied Installed)
  - Soil/Gravel $ 24,000
  - Concrete $ 44,000
- Geocell Installed per acre: $175,000 (approx.)
- Upper Geocomposite/ Geomembrane (48 acres) (per acre supplied Installed): $100,000

Total $275,000/ac

Geocell construction difficulties/lessons learned

- Placing cell infill on long slopes
- Anchoring geocell on downslope ridge points
- Width of access benches made installation more difficult
- Forming geocell at toe of benches to construct concrete filled stormwater channels
- Overfill of cells with concrete


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QUESTIONS
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