When nothing else will do

Geocell Closure Application for Steep Slopes, Earthquake Zone 4, and Typhoon Conditions



ISWA World Congress & SWANA WASTECON

Chris Lund, PE, PSS, CPESC
GBB Senior Vice President
September 26, 2017

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Chris Lund, PE, PSS, CPESC
GBB Senior Vice President

30 years experience applying his civil and environmental engineering degree to projects across engineering and environmental disciplines and across the country as both a solid waste consultant and regulatory professional.

- Hands on, innovative, multi-disciplined approach
- Wide range of experience in Solid Waste environmental work
- Geotechnical, tropical construction experience, stormwater management expertise

Solid Waste Management – must fit the community it serves

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Gershman, Brickner & Bratton, Inc.

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- Quality – Value – Ethics – Results
- Established in 1980
- Solid Waste Management and Technology Consultants
- Helping Clients Turn Problems into Opportunities

Agenda

- Introduction of Guam, Dump Background
- Existing Site Conditions and Constraints
- Investigation, Design, Cover Evaluation, and Selection
- Details of Cover System
- Construction and Difficulties
- Questions

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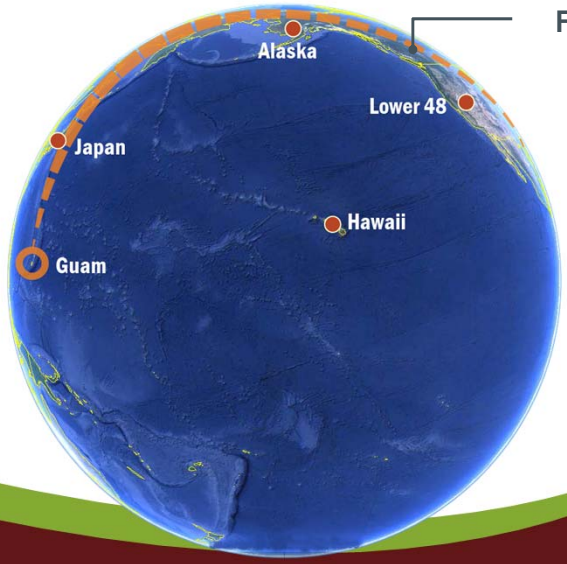
Where is Guam?



Flight Path from Mainland U.S.
(Approximate)

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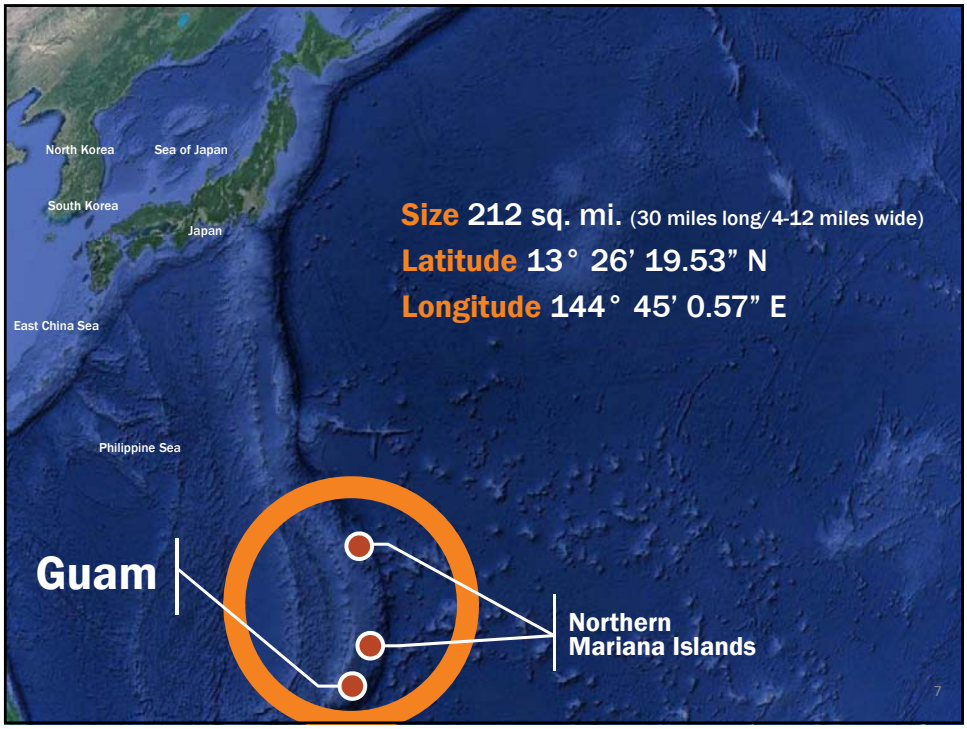
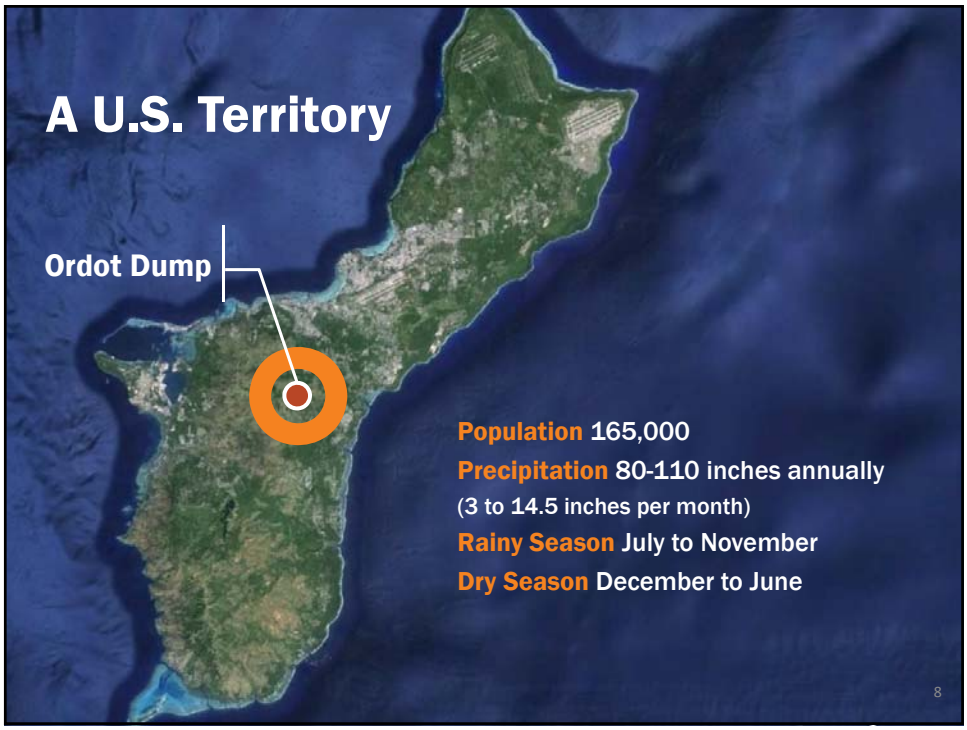

North Korea
Sea of Japan
South Korea
Japan
East China Sea
Philippine Sea
Size 212 sq. mi. (30 miles long/4-12 miles wide)
Latitude 13° 26' 19.53" N
Longitude 144° 45' 0.57" E
Guam
Northern Mariana Islands
7


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
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Ordot Dump Background Information

- 43.5 acres (17.6 hectares) unlined disposal facility
- In operation since World War II
- Closed to waste in 2011
- On the National Priorities list under CERCLA (also known as "Superfund")
- Came under Federal Receivership in 2008
- Guam is in US EPA Region 9

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Existing Site Conditions

- Unlined dump with minimal cover soil
- Overly steepened waste slopes
  - Some as steep as 0.5 horizontal to 1 vertical
- Numerous leachate seeps
- Uncontrolled landfill gas migration
- Encroachment into wetlands

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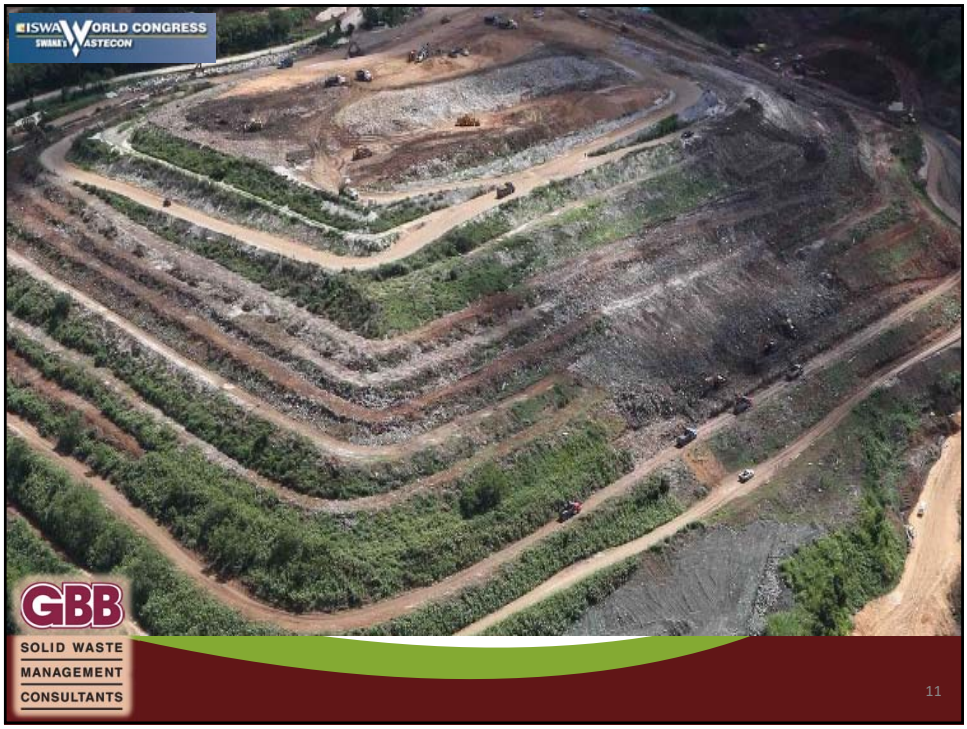
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Detailed Site Investigation and Closure Design

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

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Cover System Evaluation

- Regulatory Overview:
  - Under Guam Environmental Protection Agency oversight
  - Adopted CFR Title 40, Part 258 Regulations (also known as "RCRA")
  - Prescriptive final cover must have a permability of $\leq 1 \times 10^{-5}$ cm/sec as a barrier layer
  - Guam EPA may approve alternative cover with equivalency

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Factors Considered in the Analysis

- Final waste limits
- Dump geometry and grading
- Stormwater control and management facilities
- Highest seismicity (Zone 4)
- High winds (175 mph / 281 kph)
- High rainfall (95 inches /241.3 cm per yr)
- Erosion
- Landfill gas and leachate generation
- Costs, including long term maintenance
- End-use goals for the site

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Final Cover Alternatives

- Prescriptive soil cover system
- Exposed geomembrane system
- Covered Geomembrane system (soil/geocell covered)

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Alternative - Prescriptive Soil Cover System

- From top to bottom:
  - 6-inch (15.24 cm) thick erosion layer,
  - 18-inch-thick barrier layer with a permeability of ($k < 1.0 \times 10^{-5}$ cm/sec),
  - 12-inch (30.48 cm) thick foundation layer

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Alternative - Exposed Geomembrane System

- From top to bottom:
  - Top-deck and Benches: 24-inch (60.96 cm) thick erosion/protection layer (coral sand/gravel)
  - Side slopes: Geogrid to support vegetation
  - Geocomposite drainage/protection layer
  - Geomembrane layer
  - Geocomposite landfill gas/leachate interception layer
  - 12-inch (30.48 cm) thick soil foundation layer
- Also considered other alternatives

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Alternative Covered Geomembrane System (Soil/Geocell Covered)

- From top to bottom:
  - Top-deck: 24-inch (60.96 cm) thick erosion/protection layer (coral sand/gravel)
  - Side slopes: 6- to 8-inch (15.24 to 20.32 cm) thick erosion/protection layer (geocell with coral sand/gravel infill)
  - Geocomposite drainage/protection layer
  - Geomembrane layer
  - Geocomposite landfill gas/leachate interception layer
  - 12-inch (30.48 cm) thick soil foundation layer

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Equivalency Demonstration

Help Model Results

Simulated Cover System		Cover Percolation/Leakage Predictions (per year)					
		Year 1	Year 2	Year 3	Year 4	Year 5	Average Annual
Prescriptive Soil Cover	in	57.6	63.1	44.9	44.0	59.2	53.8
	cm	146.3	160.3	114.0	111.8	150.4	136.7
Alternative Geomembrane Cover (with Soil Cover)	in	2.3	2.4	1.8	1.9	2.2	2.1
	cm	5.8	6.1	4.6	4.8	5.6	5.3

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Selection of Final Cover System

- Selected: Soil/Geocell covered geomembrane
  - 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
  - Requires re-grading of existing waste slopes

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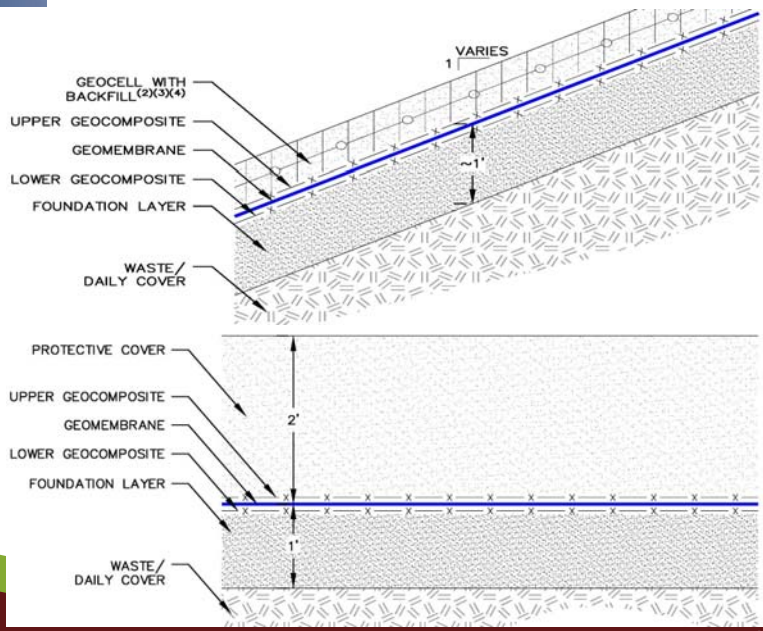

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Geocell design parameters

- 8-inch (20.32 cm) thick geocell used on upper slopes for wind uplift
- 6-inch (15.24 cm) thick geocell used on lower slopes
- Kevlar® 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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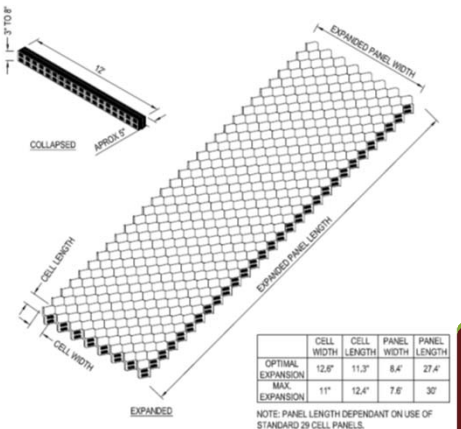
Geocell material and physical properties

- 50-60 mil thick HDPE sheets welded into panels
- 12 x 11in (30.48 x 27.9 cm) nominal expanded cell size
- 8 x 27 ft (2.4 x 8.2 m) nominal expanded panel size



	CELL WIDTH	CELL LENGTH	PANEL WIDTH	PANEL LENGTH
OPTIMAL EXPANSION	12.8"	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 construction aspects

- Geocell is initiated at each bench from an anchor of 2-inch (5 cm) schedule 80 PVC pipe to which tendons are tied. Geocell on each bench is infilled and then first few rows of geocell filled with concrete as anchor for geocell deployment.
- Geocell deployed in panels with tendons weaved through each panel and panels side by side stapled together with stainless steel staples.
- Geocell panels and tendons are deployed together and 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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Steep slope – installation progression
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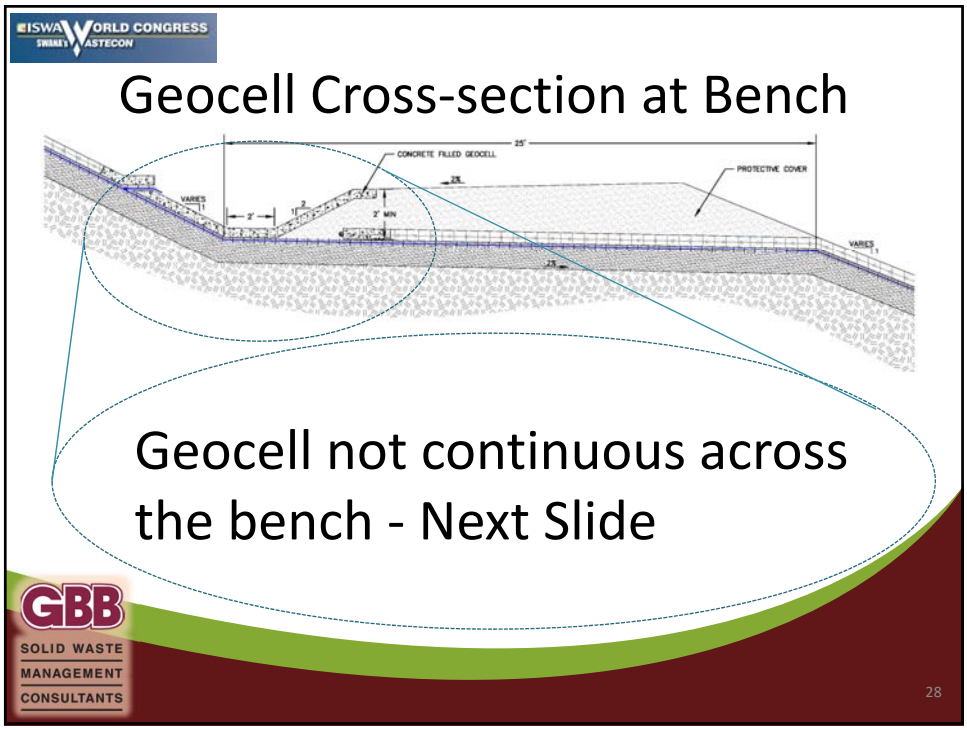
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Geocell Cross-section at Bench
CONCRETE FILLED GEOCELL
PROTECTIVE COVER
VARIES
2' MIN
Geocell not continuous across the bench - Next Slide
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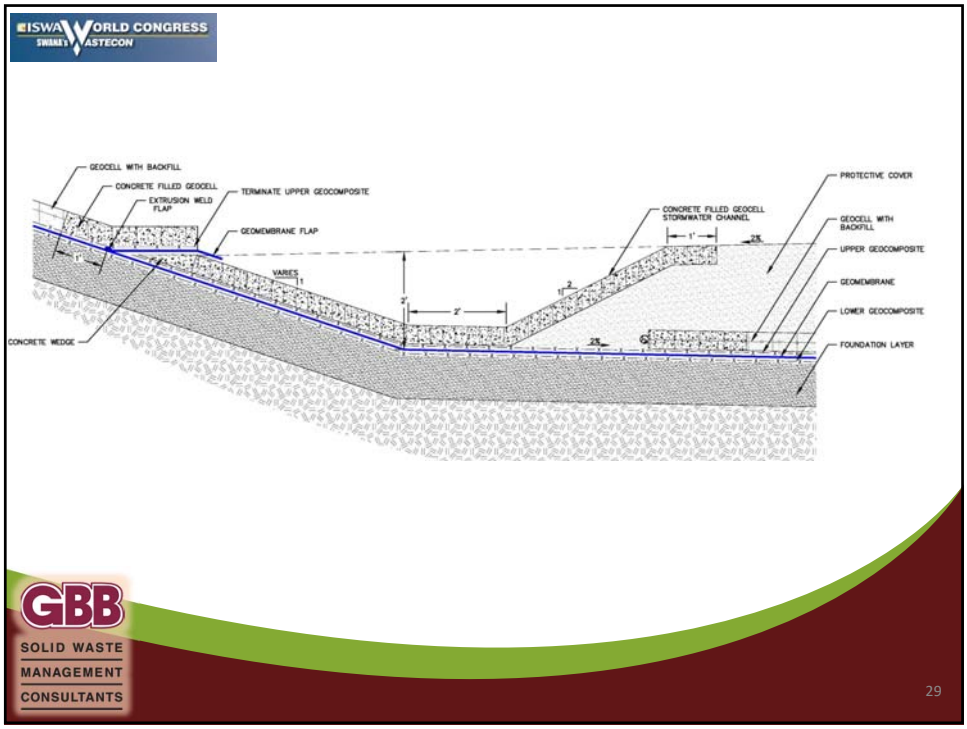
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GEOCELL WITH BACKFILL
CONCRETE FILLED GEOCELL
EXTRUSION WELD FLAP
TERMINATE UPPER GEOCOMPOSITE
GEOMEMBRANE FLAP
VARIES
CONCRETE WEDGE
CONCRETE FILLED GEOCELL STORMWATER CHANNEL
PROTECTIVE COVER
GEOCELL WITH BACKFILL
UPPER GEOCOMPOSITE
GEOMEMBRANE
LOWER GEOCOMPOSITE
FOUNDATION LAYER
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Anchoring of geocell on bench
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Bench backfill and concrete to anchor
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Bench backfill, reverse slope, shape swale
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Shape swale, formwork, geomembrane flap
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Geocell placement swale
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Concrete infill, swale reticulation
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Termination of geocell at toe of slope
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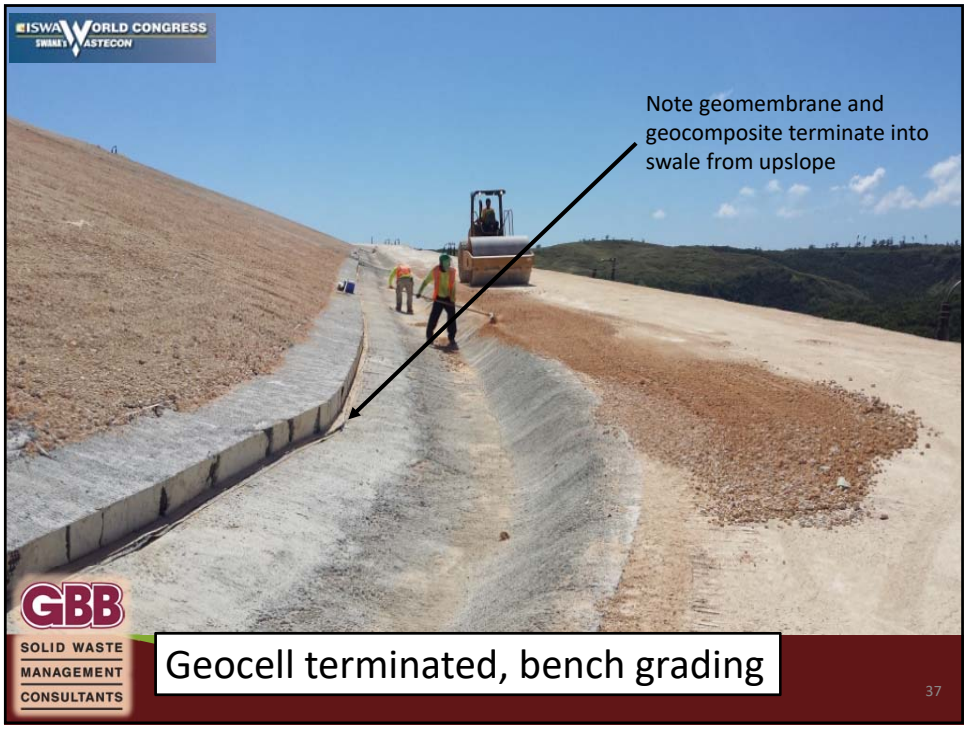
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Note geomembrane and geocomposite terminate into swale from upslope
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Geocell terminated, bench grading
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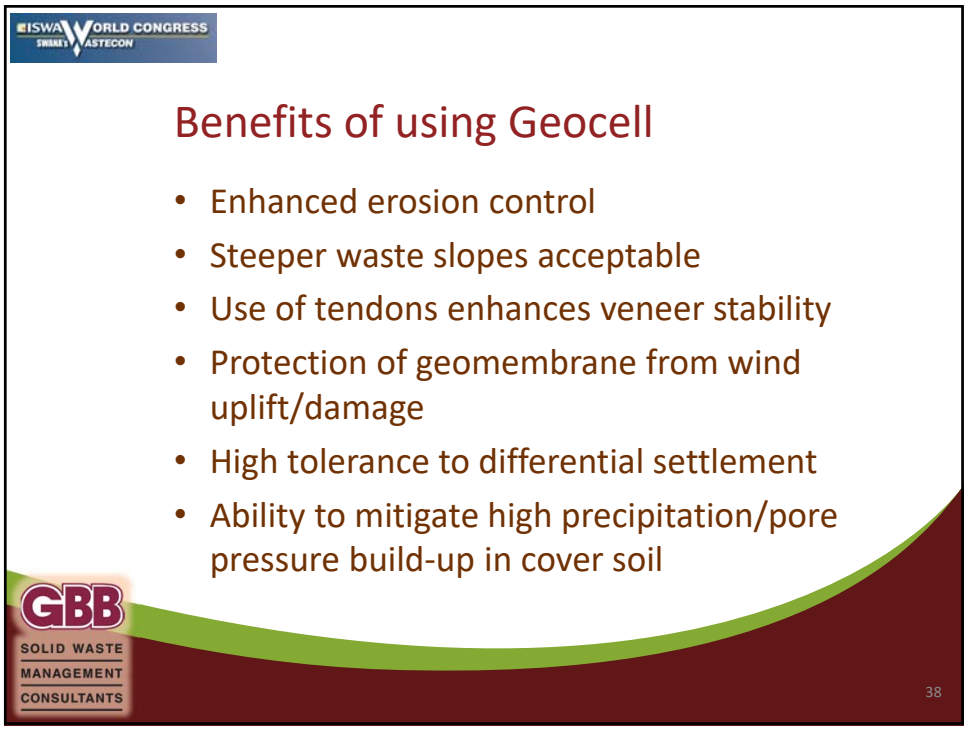
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Benefits of using Geocell
• Enhanced erosion control
• Steeper waste slopes acceptable
• Use of tendons enhances veneer stability
• Protection of geomembrane from wind uplift/damage
• High tolerance to differential settlement
• Ability to mitigate high precipitation/pore pressure build-up in cover soil
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Geocell install, staples and tendons
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Downchute for stormwater
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Geocell construction difficulties

- Placing coralline infill on long slopes
- Anchoring geocell on downslope ridges
- Width of access benches made installation more difficult
- Forming geocell at toe of benches to construct concrete filled stormwater channels

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Takeaways and Lessons Learned

- Overfill of geocell with either soil or concrete causes issues
- There are faster installation techniques depending on manufacturer
- Any construction crew can be trained to install

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