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SOLID WASTE SECTION
ASHEVILLE REGIONAL OFFICE

Fac/Perm/Co ID #	Date	Doc ID#
44-07	7/6/16	26425

SANTEK WasteServices

650 25th Street, N.W., Suite 100
Cleveland, Tennessee 37311
(423) 303-7101

Email: mail@santekenviro.com
Internet: www.santekenviro.com

July 1, 2016

Mr. Allen Gaither
North Carolina Dept. of Environment and
Natural Resources
Asheville Regional Office
2090 U.S. 70 Highway
Swannanoa, NC 28778

RE: Haywood County White Oak MSW Landfill
Phase 4 and 5 Permit to Construct
Permit No.: 4407-MSWLF-1993

Dear Mr. Gaither:

In accordance with our pre-submitted meeting on Tuesday, June 28th, Santek Waste Services, Inc. (Santek) is submitting this Phase 4 and Permit to Construct application and in addition, we would like to request a "life of site" permit for the White Oak MSW Landfill. Please find attached for your review the Facility Plan, Engineering Plan, Construction Quality Assurance Plan, Operations Plan, Closure/Post Closure Plan, facility drawings and engineering drawings.

If you have any questions or require addition information, please feel free to call at (423) 303-7101.

Sincerely,

Ron E. Vail, P.E.
Vice President of Engineering

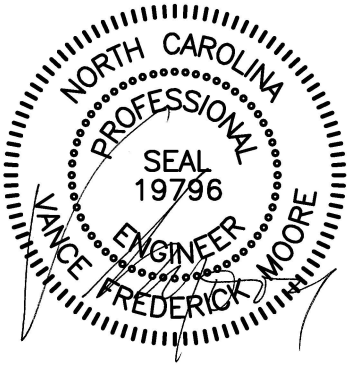
cc: Matt Dillard, Executive V.P. of Operations, Santek
David Francis, Administrator, Haywood County
John Preston, Landfill Manager, Santek
Vance Moore, Garret and Moore

Phase 4 and 5 Permit to Construct

Haywood County White Oak MSWLF
Haywood County, North Carolina
NC Solid Waste Permit No.44-07

Prepared for:

SANTEK WasteServices



June 2016

June 20, 2016

Prepared By

GARRETT & MOORE
Engineering for the Power and Waste Industries
1100 Crescent Green Drive, Suite 208
Cary, North Carolina 27518 • O: 919-792-1900 • F: 866-311-7206
NC FIRM C-2910

June 23, 2016

North Carolina Department of Environment Quality
Asheville Regional Office
Division of Waste Management
Solid Waste Section
2090 US 70 Highway
Swannanoa, NC 28778

Attention: Mr. Allen Gaither

RE: Phase 4 and 5 Permit to Construct Application
Haywood County White Oak MSWLF

Mr. Gaither:

On behalf of Santek Waste, Inc. Garrett & Moore, Inc. is please to submit the Phase 4 and 5 Permit to Construct Application for the Haywood County White Oak MSWLF (Permit 44-07) located in Haywood County, N.C. Please contact us should you have any questions or require additional information. Thank you for your consideration.

Respectfully submitted,

GARRETT & MOORE, INC.

Vance F. Moore, P.E.
President

Attachments:

1) Phase 4 and 5 Permit to Construct Application
Haywood County White Oak MSWLF

Phase 4 and 5 Permit to Construct
Haywood County White Oak MSWLF
Haywood County, North Carolina

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2	Water Quality Monitoring Plan
3	Facility Plan
4	Engineering Plan
5	Construction Quality Assurance Plan
6	Operations Plan
7	Closure/Post-closure Plan

Section 1 - Design Hydrogeologic Report
(Submitted Under Separate Cover)

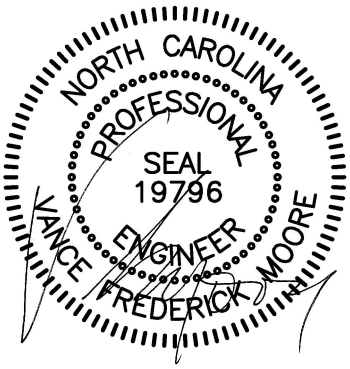
Section 2 - Water Quality Monitoring Plan
(Submitted Under Separate Cover)

Facility Report

Haywood County White Oak MSWLF

Haywood County, North Carolina

June 2016



June 20, 2019

GARRETT & MOORE
Engineering for the Power and Waste Industries
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NC FIRM C-2910

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Facility Report

The Facility Plan Report for the Phases 4 & Phase 5 Expansion of the Haywood County White Oak MSWLF is prepared in accordance with 15A NCAC 13B .1619(e) of the North Carolina Solid Waste Management Regulations. The Facility Plan Report present the long-term, general design concepts related to construction, operation, and closure of the MSWLF unit(s), including leachate management.

1.0 Waste Stream

This section details a discussion of the characteristics of the wastes received at the facility and facility specific management plans for the Haywood County White Oak MSWLF.

1.1 Types of Waste

The Haywood County Haywood County White Oak MSWLF currently accepts mixed municipal solid waste C&D waste, as well as approved special wastes as defined and permitted by the State of North Carolina Department of Environment Quality (NC DEQ) Division of Waste Management (DWM) originating from residential, commercial, industrial sources. Hazardous wastes, liquid wastes, as well as other materials subject to disposal bans are not, and will not be accepted.

1.2 Average Monthly Disposal Rates

The average monthly disposal rate expected over the life of the Phase 4 and Phase 5 Areas is estimated to be approximately 12,500 tons, or approximately 146,000 tons per year, with an estimated variance of 10 percent.

1.3 Service Area

The service area for the Haywood County White Oak MSWLF will include businesses and municipalities located within Haywood County in addition to the following North Carolina Counties: Avery County, Buncombe County, Burke County, Cherokee County, Clay County, Graham County, Henderson County, Jackson County, Macon County, Madison County, McDowell County, Mitchell County, Polk County, Rutherford County, Swain County, Transylvania County, and Yancey County. Waste from other counties will not be accepted at the facility.

1.4 Procedures for Segregation Management at Different On-site Facilities

A discussion of Procedures for Segregation Management at different On-site Facilities is presented in the Operations Plan

1.5 Equipment Requirements

A discussion of the Equipment Requirements is presented in the Operations Plan.

2.0 Landfill Capacity

An analysis of landfill capacity and soil resources is described below.

2.1 Total Operating Capacity

The Haywood County White Oak MSWLF has a permitted limits of waste area of 75.1 acres and has a total available net airspace capacity of 9,380,078 cubic yards for the disposal of wastes as measured from the bottom of waste to the top of the intermediate cover layer. Please note, waste disposal operations began October 1993. As of May 4, 2015, approximately 1,956,473 cubic yards of the total available net airspace capacity had been consumed.

2.2 Operating Capacity for Each Phase of Development

The Haywood County White Oak MSWLF permitted limits of waste area of 75.1 acres is comprised of Phases 1 – 7. The operating capacity for each phase of development is identified on Table 1-1 included at the end of this section.

Please note it is estimated the MSW Phase 1- 3 area had approximately 816,965 cubic yards net airspace capacity remaining beyond the date of most-recent topographical survey for the facility completed on May 4, 2015.

2.3 In-place Ratio of Waste to Soil

Daily cover and intermediate cover soil volumes are estimated at approximately 15% of the net airspace capacity.

2.4 Available Soil Resources

The required and available soil resources for each phase of development is identified on Table 1-2 included at the end of this section.

2.5 Required Quantities of Soil

The required and available soil resources for each phase of development is identified on Table 1-2 included at the end of this section.

2.6 Estimated Operating Life of all MSWLF Units

The operating life for each phase of development is identified on the attached Table 1-1 included at the end of this section. The operating life is based on an Operational Disposal Efficiency (ODE) of 1,500 pounds waste per cubic yard airspace and the permitted waste disposal rate of 146,000 tons per year, plus a 10% variance totaling 160,600 tons, per

year.

Please note it is estimated the MSW Phase 1- 3 area had approximately 816,965 cubic yards net airspace capacity remaining beyond the date of most-recent topographical survey for the facility completed on May 4, 2015 which is estimated to provide approximately 3.1 years capacity beyond May 4, 2015.

3.0 Containment and Environmental Control Systems

3.1 Leachate Migration

The downward migration of the leachate into the natural ground will be prevented by the composite liner system and the LCRS.

3.2 Methane Gas Migration

Methane gases will be controlled such that concentrations will be less than 25 percent of the lower explosive limit (LEL) in site structures and below the LEL at the property boundary. In order to detect such occurrences, gas monitoring wells will be installed at strategic locations around the site as outlined in the Landfill Gas Monitoring Plan.

3.3 Nuisance and Vectors

Blowing litter will be minimized by placing daily cover over the waste, wind-fences, and frequent policing.

Dust will be minimized by use of road surfaces with aggregate and regular spraying with water.

Potential vectors that include rodents, birds, and other scavengers will be minimized by providing cover material that will limit access of such vectors to waste.

3.4 Surface Water and Sedimentation Control

The flow of surface water adjacent to the landfill will be controlled by diverting water away from disturbed areas of the site. Surface water flowing from disturbed areas will be routed into ditches that lead to sediment basins. The sediment basins are designed to remove the majority of the sediment from the surface water prior to discharge.

4.0 Leachate Management

4.1 Performance and Design Concept

Leachate is described as the water that infiltrates through the landfill and potentially leaches contaminants from the refuse. Leachate is produced as precipitation falls on the surface of the landfill and infiltrates through the refuse. The leachate collection system (LCS) is designed to collect and convey the maximum quantity of leachate generated

over the life of the landfill. Leachate collected in the leachate sumps will be pumped through a force main to the leachate storage lagoon.

The leachate collection system above the geomembrane liner will consist of a drainage layer with a network of HDPE perforated pipes with gravel collection zones wrapped in a nonwoven geotextile. The pipe spacing is designed to limit leachate head on the geomembrane to less than 12 inches. The pipe network and sumps have been designed to handle the leachate generated from the 25-year, 24-hour storm. The base slopes draining to the pipes (cross-flow to pipes) will be no less than 2.0 percent to account for base grade settlement. HDPE header piping will connect to sumps located at low points in each phase. The sumps will have side-slope riser pipes for system cleanout. Leachate collected in the leachate sumps will be pumped through a force main to the leachate storage lagoon.

4.2 Stormwater Segregation

Daily and intermediate covers will be used to shed precipitation during development of the landfill. Positive drainage will be maintained on the daily and intermediate cover surfaces. The surface will be graded to drain toward ditches and berms and routed to the stormwater system. During operation of the landfill, daily and intermediate cover may be removed to the extent possible prior to placing additional refuse vertically. This will promote percolation downward to the leachate collection and removal system (LCRS).

Final cover will be established as soon as possible to aid in diverting precipitation from the refuse. The final cover slope will have a maximum 3.5H:1V side slope with a minimum five (5) percent top slope. Stormwater benches and downdrains will be located on the final slopes to slow, collect, and direct the flow of run-off from the landfill cover to perimeter channels and perimeter sediment basins.

4.3 Normal Operating Conditions

Leachate generation rates have been estimated using the HELP Model for an initial lift condition and three (3) intermediate operational conditions. The leachate collection system, sumps and discharge system are sized to collect and remove the leachate generated from the 25-year, 24-hour storm event. The design parameters and assumptions used in the analyses, in addition to modeling outputs, are presented in the Engineering Plan.

Based on the HELP Model analyses, average leachate generation rates range from approximately 500 to 1,110 gallons per acre per day (gpad) and peak leachate generation rates range from approximately 3,300 to 12,100 gpad for the various combinations of operating conditions and liner system options. The actual leachate generation rates will be evaluated during the first few years of landfill operations to assess the need for

additional leachate storage capacity.

Based on volume projections throughout the landfill life, the proposed leachate storage tanks generally have capacity for 6 days of average leachate generation or 1 day of peak leachate generation through Phase 4 & 5.

4.4 Contingency Plan

In emergency situations, such as a force main break, pumping to the leachate lagoon would be stopped. If necessary, leachate will be allowed to back up into the sump areas within the landfill. When this occurs, the Operator will notify the State within 24 hours and submit a written report to the State within three days that provides the reason for the occurrence.

TABLE 1-1
Haywood County White Oak MSWLF
Operating Capacity for Each Phase of Development

Phase	Phase Area AC	Phase Gross Airspace[1] YD3	Phase Net Airspace[2] YD3	Cumulative Net Airspace YD3	Phase Tonnage Tn[3]	Cumulative Tonnage Tn	Phase Life Expectancy[4] YR	Cumulative Remaining Life Expectancy[5] Beyond May 2015 YR	Status
Phase 1-3	30.3	2,944,532	2,773,438	2,773,438	1,664,063	1,664,063	24.3	3.3	Previous Application - Active
Phase 4	4.4	564,771	539,926	3,313,364	410,344	2,074,407	2.6	5.8	Current Application - Not Constructed
Phase 5a	6.7	540,176	502,343	3,815,707	381,781	2,456,187	2.4	8.2	Current Application - Not Constructed
Phase 5b	3.2	1,008,065	989,996	4,805,703	752,397	3,208,584	4.7	12.9	Current Application - Not Constructed
Phase 6	16.2	3,103,441	3,011,965	7,817,668	2,289,093	5,497,678	14.3	27.1	Future Application - Not Constructed
Phase 7	14.3	1,643,157	1,562,410	9,380,078	1,187,432	6,685,109	7.4	34.5	Future Application - Not Constructed
Phase 1 - 7	75.1	9,804,143	9,380,078		6,685,109		55.5		

Footnotes:
1. "Gross Airspace" is airspace between bottom of waste to the top of final cover elevations.
2. "Net Airspace" is airspace between bottom of waste to the top of intermediate cover elevations.
3. Phase 1 - 3 Tonnage based on 0.60 ODE Factor. Phase 4 - 7 Tonnage based on 0.76 ODE Factor
4. Phase 1 - 3 initiated operations October 1993.
5. Life Expectancy beyond May 4, 2015 based on permitted waste disposal rate of 146,000 tons, plus a 10% variance totaling 160,600 tons, per year.

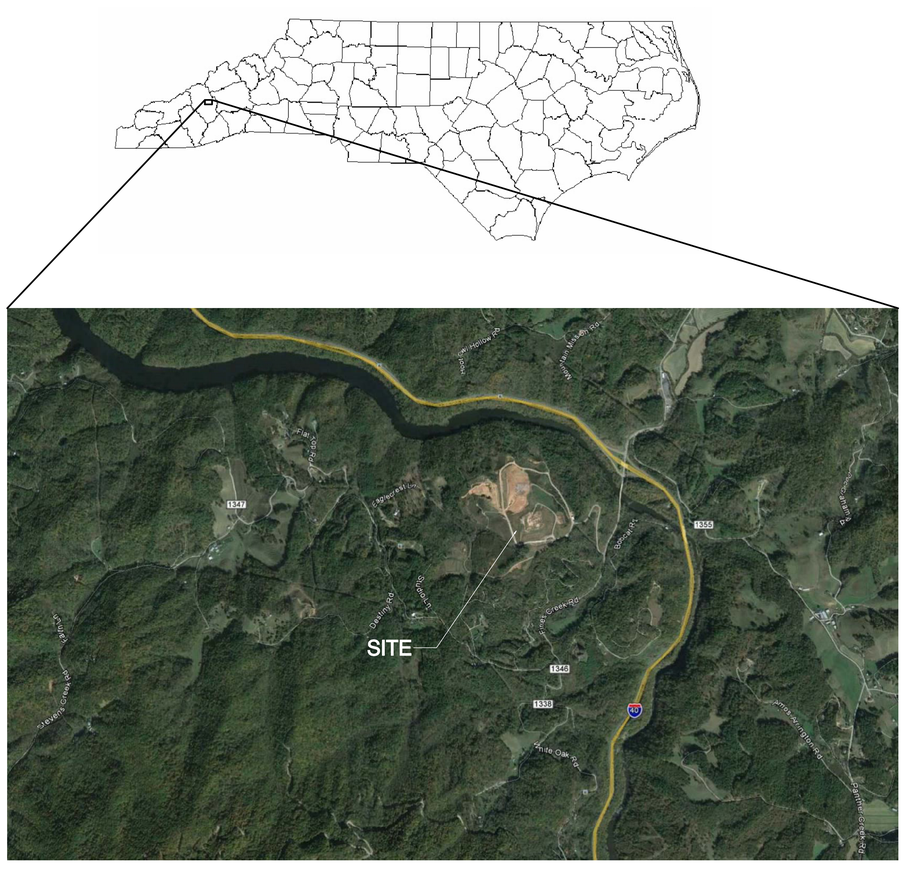
TABLE 1-2
Haywood County White Oak MSWLF
Available and Required Soil Analysis

Phase	Phase Area AC	Excavation YD3	Backfill YD3	Base Liner[1] Low-Permeable Soil Layer YD3	Daily Cover 15% Net Airspace YD3	42-Inch Final Cover Vegetative Soil Layer YD3	Excess (Deficit)
Phase 1	11.4	NA	NA	NA	NA	64,316	(64,316)
Phase 2	10.1	NA	NA	NA	NA	57,257	(57,257)
Phase 3	8.8	NA	NA	NA	NA	49,465	(49,465)
Phase 4	4.4	200,000	5,000	10,648	80,989	24,845	78,518
Phase 5	9.9	700,000	0	23,958	75,351	55,902	544,789
Phase 6	16.2	425,000	95,000	39,204	148,499	91,476	50,821
Phase 7	14.3	260,000	100,000	34,606	451,795	80,747	(407,148)
Total	75.1	1,585,000	200,000	108,416	756,635	424,008	95,941

1. Assumes 18" Thick Alternative Base Liner System. Protective Material from off-site sources.

FACILITY DRAWINGS
HAYWOOD COUNTY WHITE OAK MSWLF
HAYWOOD COUNTY, NORTH CAROLINA

LOCATION MAP



INDEX OF DRAWINGS	
FD-1	OVERALL SITE PLAN
FD-2	PHASES 1 - 3 TOP OF INTERMEDIATE COVER GRADES PHASE 4 TOP OF FML GRADES & LCS
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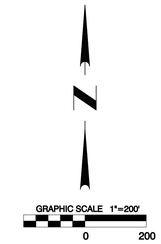
FD-4	PHASE 5 TOP OF INTERMEDIATE COVER GRADES PHASE 6 & 7 CONCEPTUAL SUBGRADE PLAN
FD-5	FACILITY PLAN TOP OF INTERMEDIATE COVER ELEVATIONS, GAS RELIEF, AND LEACHATE BREAKOUT COLLECTION LAYER
FD-6	FACILITY PLAN TOP OF FINAL COVER ELEVATION, TERRACE BERMS, AND DOWNDRAIN PIPES
FD-7	CROSS SECTION
FD-8	DETAILS

JUNE 2016

PREPARED BY:

GARRETT & MOORE
Engineering for the Power and Waste Industries
1100 CRESCENT GREEN DRIVE, SUITE 208
CARY, NORTH CAROLINA 27518
TEL: 919 - 792 - 1900 FAX: 866 - 311 - 7206
www.garrett-moore.com

NORTH CAROLINA PROFESSIONAL SEAL 19196 ENGINEER
JAMES FREDERICK MOORE
June 20, 2016



LEGEND

- PROPERTY LINE
- EXISTING INTERMEDIATE CONTOUR
- EXISTING INDEX CONTOUR
- PHASE LIMIT
- BENCHMARK
- GROUNDWATER MONITORING WELL
- LANDFILL GAS MONITORING PROBE ID
- SURFACE WATER MONITORING LOCATION
- PRIVATE POTABLE WELL
- PHASE 4 & 5 TEST WELL
- PHASE 3 TEST WELL (ABANDONED)

NOTES:
1) FACILITY BOUNDARYS RUNS CONCURRENT WITH PROPERTY LINE.
2) DATE OF AERIAL TOPOGRAPHY MAY 4, 2015.

Survey Benchmark Coordinates			
Point #	Northing	Easting	Elevation
9001	720,465.67	812,588.26	2576.21
9005	719,539.08	811,641.5	2637.92
9008	719,817.95	810,022.81	2658.42
9014	720,108.45	811,418.83	2608.46
9017	721,429.25	810,572.00	2614.09
9019	722,068.25	811,363.19	2527.40
9022	722,240.50	812,019.36	2431.63
9029	720,895.83	813,202.36	2490.38

LOCATION RESTRICTION NOTES

1. THE FACILITY LIMITS OF THE MSWLF IS NOT LOCATED WITHIN 10,000 FEET OF AIRPORT RUNWAYS.
2. THE FACILITY LIMITS OF THE MSWLF IS NOT LOCATED WITHIN A 100-YEAR FLOODPLAIN.
3. THE FACILITY LIMITS OF THE MSWLF MAY CONTAIN WETLANDS. ALL WETLAND IMPACTS WILL BE PERMITTED IN ACCORDANCE WITH SECTION 404 AND 401 OF THE CLEAN WATER ACT.
4. THE FACILITY LIMITS OF THE MSWLF IS NOT LOCATED WITHIN FAULT AREAS.
5. THE FACILITY LIMITS OF THE MSWLF IS NOT LOCATED WITHIN UNSTABLE AREAS.
6. THE FACILITY LIMITS OF THE MSWLF IS LOCATED WITHIN A SEISMIC IMPACT ZONE. SEE ENGINEERING REPORT.
7. THE FACILITY LIMITS OF THE MSWLF IS IS NOT LOCATED WITHIN AREAS OF CULTURAL RESOURCES.
8. THE FACILITY LIMITS OF THE MSWLF IS NOT LOCATED WITHIN A STATE NATURE AD HISTORIC PRESERVE.
9. THE FACILITY LIMITS OF THE MSWLF IS NOT LOCATED WITHIN A CRITICAL AREA OF WATER SUPPLY.
10. THE FACILITY LIMITS OF THE MSWLF IS NOT LOCATED WITHIN AREAS OF ENDANGERED AND THREATENED SPECIES.
11. THE FACILITY LIMITS OF THE MSWLF IS NOT LOCATED WITHIN 300-FEET OF PROPERTY LINES.
12. THE FACILITY LIMITS OF THE MSWLF IS LOCATED WITHIN 50-FEET OF WATER FEATURES. ALL STREAM IMPACTS WILL BE PERMITTED IN ACCORDANCE WITH SECTION 404 AND 401 OF THE CLEAN WATER ACT.

June 20, 2016

REVISION	DATE
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6)	

GARRETT & MOORE
Engineering for the Power and Waste Industries
1100 CRESCENT GREEN DRIVE
SUITE 208
CARY, NORTH CAROLINA 27518
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www.garrett-moore.com

FACILITY DRAWINGS
HAYWOOD COUNTY WHITE OAK MSWLF

OVERALL SITE PLAN

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FD-1

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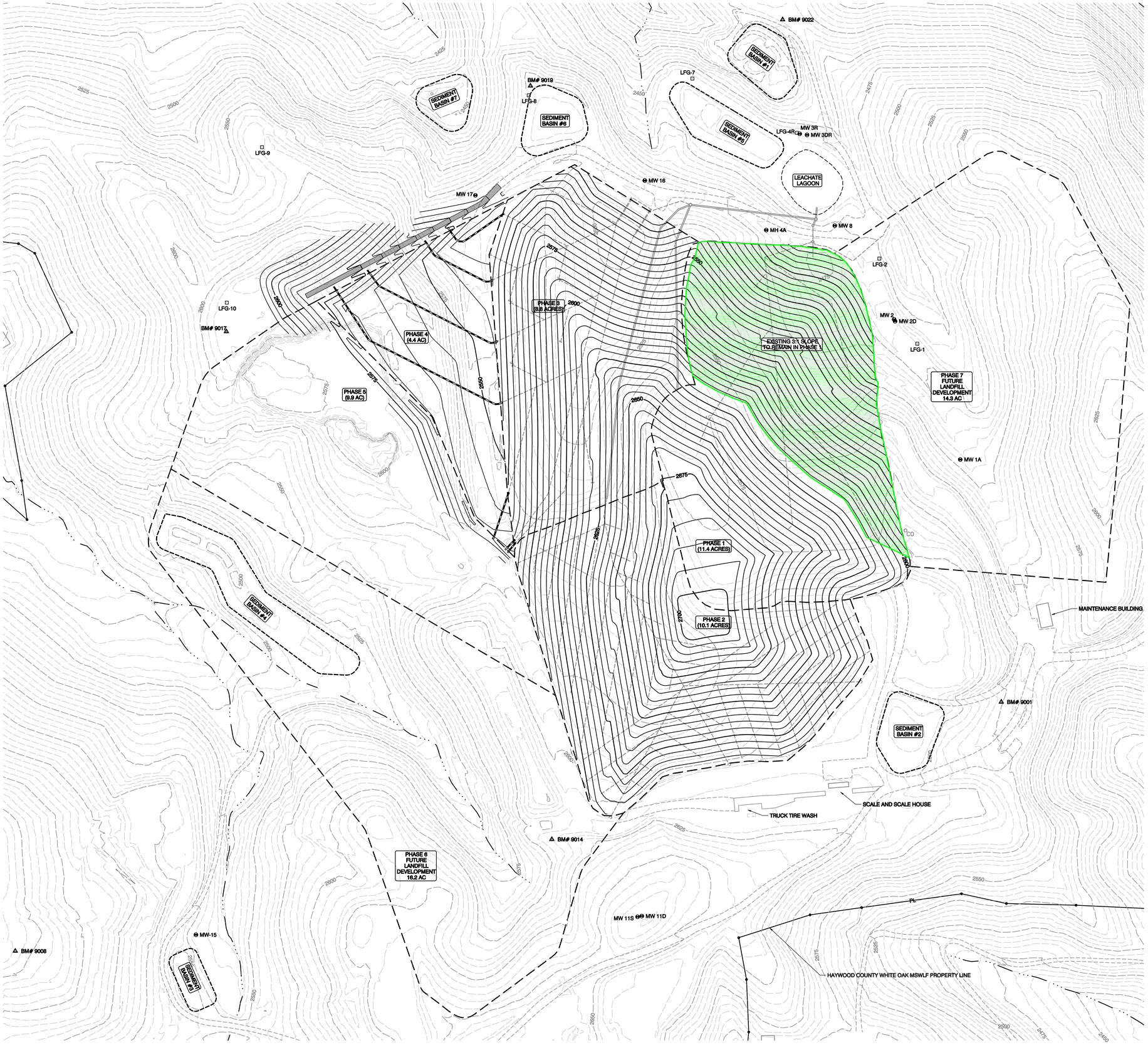

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NORTH CAROLINA PROFESSIONAL SEAL 19796 ENGINEER WAYNE FREDERICK MOORE

June 20, 2016

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FACILITY DRAWINGS
HAYWOOD COUNTY WHITE OAK MSWLF

PHASES 1-3 TOP OF INTERMEDIATE COVER GRADES
PHASE 4 TOP OF FML GRADES & LCS

SHEET
FD-2

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NORTH CAROLINA PROFESSIONAL SEAL 19796 ENGINEER VINCENT FREDERICK MOORE

June 20, 2016

REVISION	DATE
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FACILITY DRAWINGS
HAYWOOD COUNTY WHITE OAK MSWLF

PHASE 4 TOP OF INTERMEDIATE COVER GRADES
PHASE 5 TOP OF FML GRADES & LCS

SHEET
FD-3

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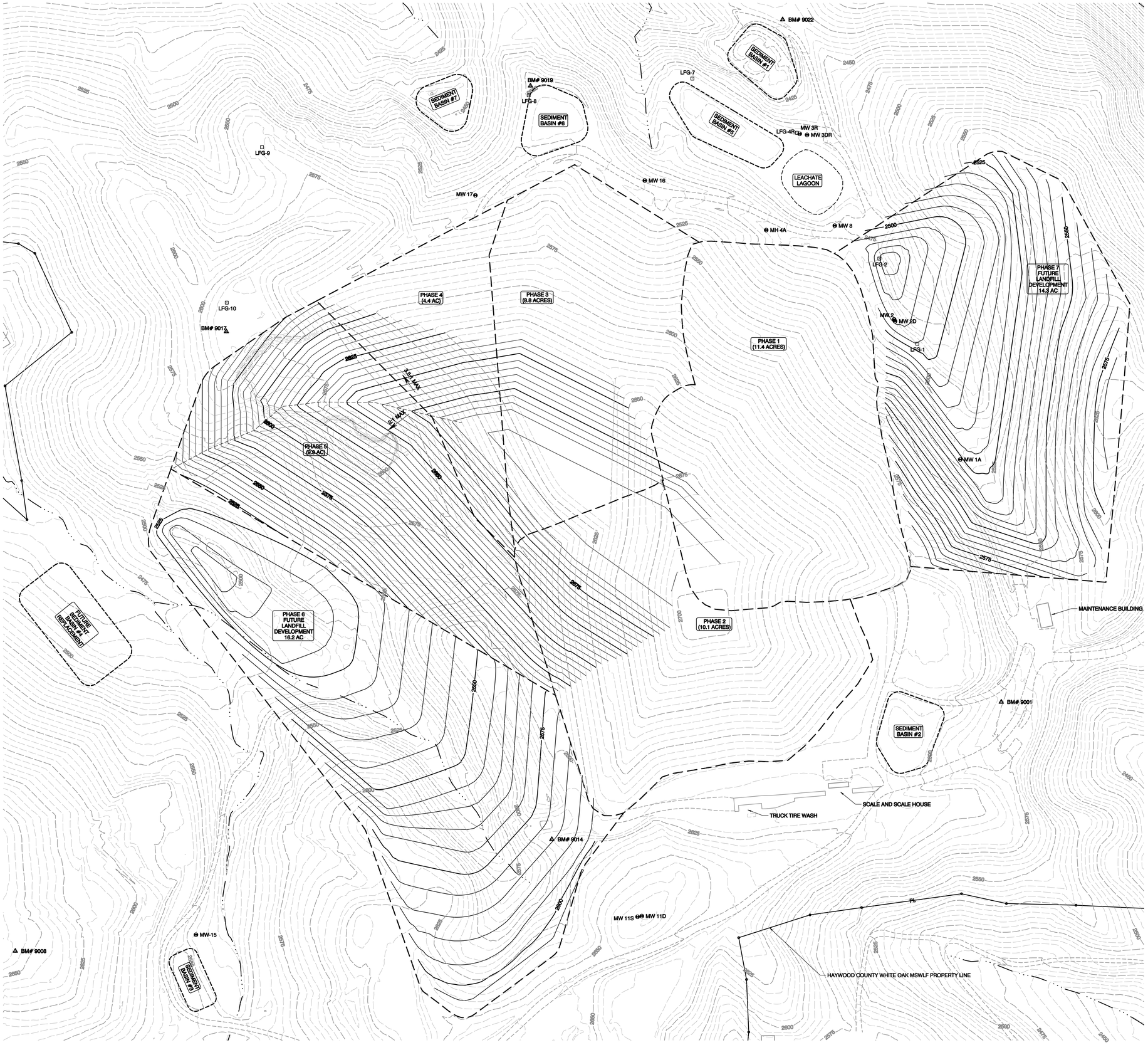

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9008	719,817.95	810,022.81	2658.42
9014	720,108.45	811,418.83	2608.46
9017	721,429.25	810,572.00	2614.09
9019	722,068.25	811,363.19	2527.40
9022	722,240.50	812,019.36	2431.63
9029	720,895.83	813,202.36	2490.38

NORTH CAROLINA PROFESSIONAL SEAL 19795 ENGINEER VINCENT FREDERICK MOORE

June 20, 2016

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FACILITY DRAWINGS
HAYWOOD COUNTY WHITE OAK MSWLF

PHASE 5 TOP OF INTERMEDIATE COVER GRADES
PHASE 6 & 7 CONCEPTUAL SUBGRADE PLAN

SHEET
FD-4

Path: V:\Santek\Haywood County\Phase 4&5\Drawing\WOLF-06-20-16.pro Plot Date/Time: Mon Jun 20,2016 / 15:04:22

GRAPHIC SCALE 1"=100'

0 100

LEGEND

- PROPERTY LINE
- EXISTING INTERMEDIATE CONTOUR
- EXISTING INDEX CONTOUR
- PROPOSED INTERMEDIATE CONTOUR
- PROPOSED INDEX CONTOUR
- PHASE LIMIT
- GAS VENTING & LEACHATE BREAKOUT GEOCOMPOSITE
- BENCHMARK
- GROUNDWATER MONITORING WELL
- LANDFILL GAS MONITORING PROBE ID
- SURFACE WATER MONITORING LOCATION
- PRIVATE POTABLE WELL
- PHASE 4 & 5 TEST WELL
- PHASE 3 TEST WELL (ABANDONED)

NOTES:

1) FACILITY BOUNDARYS RUNS CONCURRENT WITH PROPERTY LINE.
2) DATE OF AERIAL TOPOGRAPHY MAY 4, 2015.
3) ALL EXTERIOR SLOPES TO BE CONSTUCTED AT A 3.5:1 MAXIMUM SLOPE.
4) GAS VERNTING AND LEACHATE BREAKOUT COLLECTION GEOCOMPOSITE LOCATION SHOWN FOR CONCEPTUAL PURPOSES ONLY AND MAY BE MODIFIED BASE DON ACTUAL WASTE FILL CONDITIONS.

Survey Benchmark Coordinates			
Point #	Northing	Easting	Elevation
9001	720,465.67	812,588.26	2576.21
9005	719,539.08	811,641.5	2637.92
9008	719,817.95	810,022.81	2658.42
9014	720,108.45	811,418.83	2608.46
9017	721,429.25	810,572.00	2614.09
9019	722,068.25	811,363.19	2527.40
9022	722,240.50	812,019.36	2431.63
9029	720,895.83	813,202.36	2490.38

NORTH CAROLINA PROFESSIONAL SEAL 39796 ENGINEER VINCE FREDERICK MOORE

June 20, 2016

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FACILITY DRAWINGS
HAYWOOD COUNTY WHITE OAK MSWLF

FACILITY PLAN (PHASE 1 - 7)
TOP OF INTERMEDIATE COVER ELEVATIONS, GAS RELIEF, & LEACHATE BREAKOUT COLLECTION LAYER

SHEET
FD-5

Path: V:\Santek\Haywood County\Phase 4&5\Drawing\WOLF-06-20-16.pro Plot Date/Time: Mon Jun 20,2016 / 15:06:21

GRAPHIC SCALE 1"=100'

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LEGEND

- PROPERTY LINE
- EXISTING INTERMEDIATE CONTOUR
- EXISTING INDEX CONTOUR
- PROPOSED INTERMEDIATE CONTOUR
- PROPOSED INDEX CONTOUR
- PHASE LIMIT
- TERRACE BERM ALIGNMENT
- TERRACE DOWNDRAIN PIIPE
- BENCHMARK
- GROUNDWATER MONITORING WELL
- LANDFILL GAS MONITORING PROBE ID
- SURFACE WATER MONITORING LOCATION
- PRIVATE POTABLE WELL
- PHASE 4 & 5 TEST WELL
- PHASE 3 TEST WELL (ABANDONED)

NOTES:

1) FACILITY BOUNDARYS RUNS CONCURRENT WITH PROPERTY LINE.
2) DATE OF AERIAL TOPOGRAPHY MAY 4, 2015.
3) ALL EXTERIOR SLOPES TO BE CONSTUCTED AT A 3.5:1 MAXIMUM SLOPE.
4) TERRACE BERMS AND DOWNDRAIN PIPES LOCATIONS SHOWN FOR CONCEPTUAL PURPOSES ONLY AND MAY BE MODIFIED BASED ON ACTUAL WASTE FILL CONDITIONS.

Survey Benchmark Coordinates			
Point #	Northing	Easting	Elevation
9001	720,465.67	812,588.26	2576.21
9005	719,539.08	811,641.5	2637.92
9008	719,817.95	810,022.81	2658.42
9014	720,108.45	811,418.83	2608.46
9017	721,429.25	810,572.00	2614.09
9019	722,068.25	811,363.19	2527.40
9022	722,240.50	812,019.36	2431.63
9029	720,895.83	813,202.36	2490.38

NORTH CAROLINA PROFESSIONAL SEAL 19796 ENGINEER MARK FREDERICK MOORE

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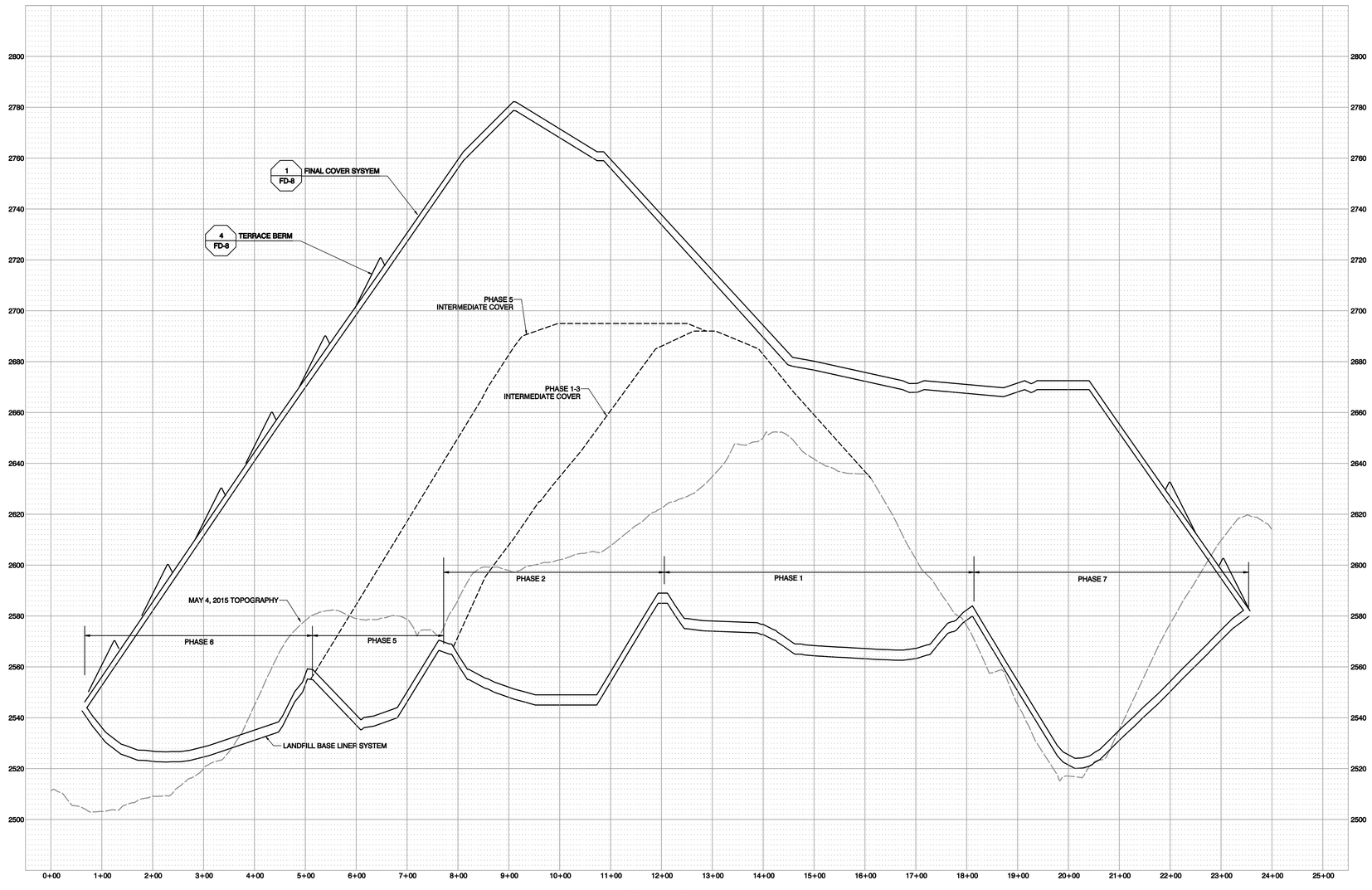
FACILITY DRAWINGS
HAYWOOD COUNTY WHITE OAK MSWLF

FACILITY PLAN (PHASE 1- 7)
TOP OF FINAL COVER SYSTEM

SHEET
FD-6

Path: V:\Santek\Haywood County\Phase 4&5\Drawing\WOLF-06-20-16.pro Plot Date/Time: Mon Jun 20,2016 / 15:07:50



SECTION D - D'
1" = 100' HORIZONTAL
1" = 20' VERTICAL

NORTH CAROLINA PROFESSIONAL SEAL 19796 ENGINEER VINCE FREDERICK MOORE
June 20, 2016

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FACILITY DRAWINGS
HAYWOOD COUNTY WHITE OAK MSWLF

CROSS SECTION

SHEET
FD-7

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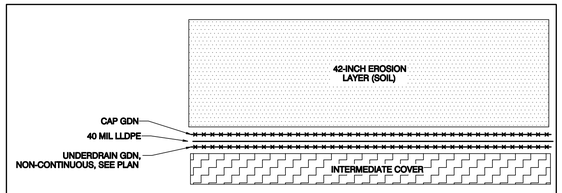
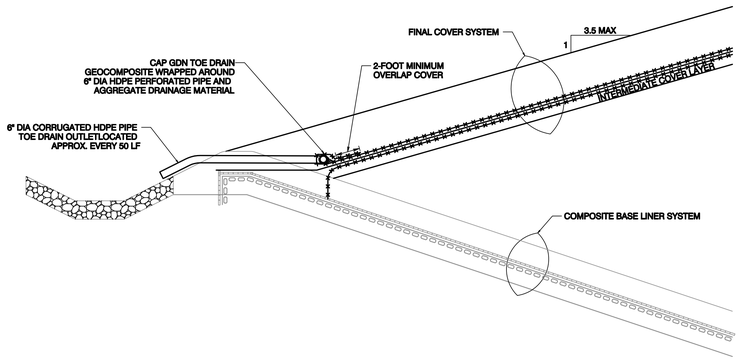


FINAL COVER SYSTEM (1 / FD-8)
1" = 5'



FINAL COVER LOWER TERMINATION & TOE DRAIN (2 / FD-8)
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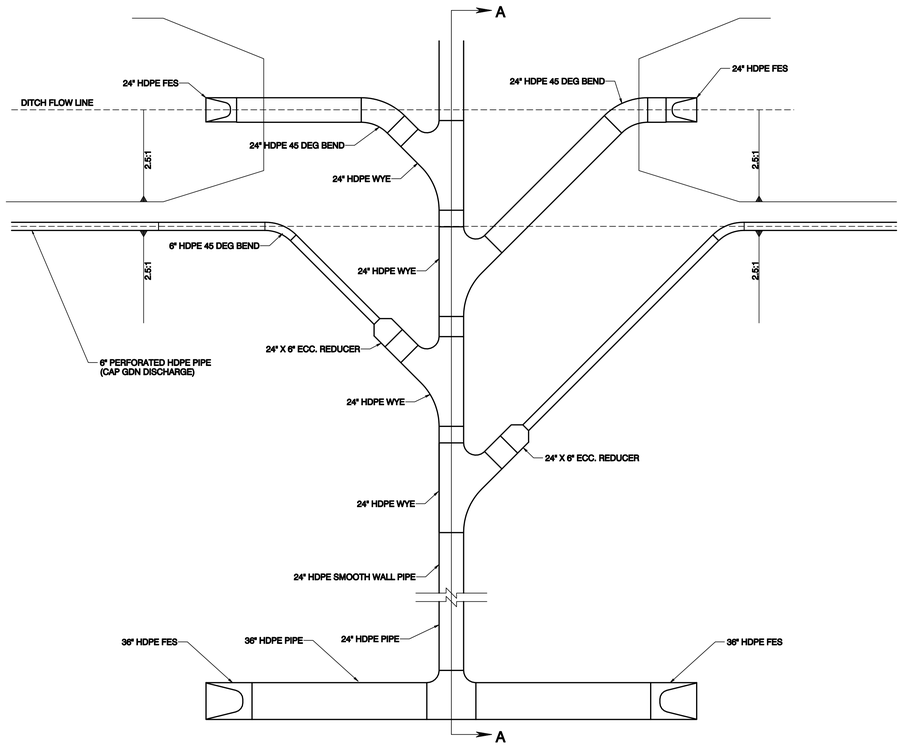
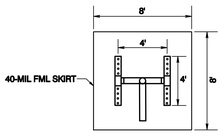
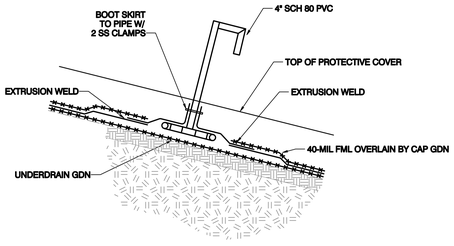


PLAN

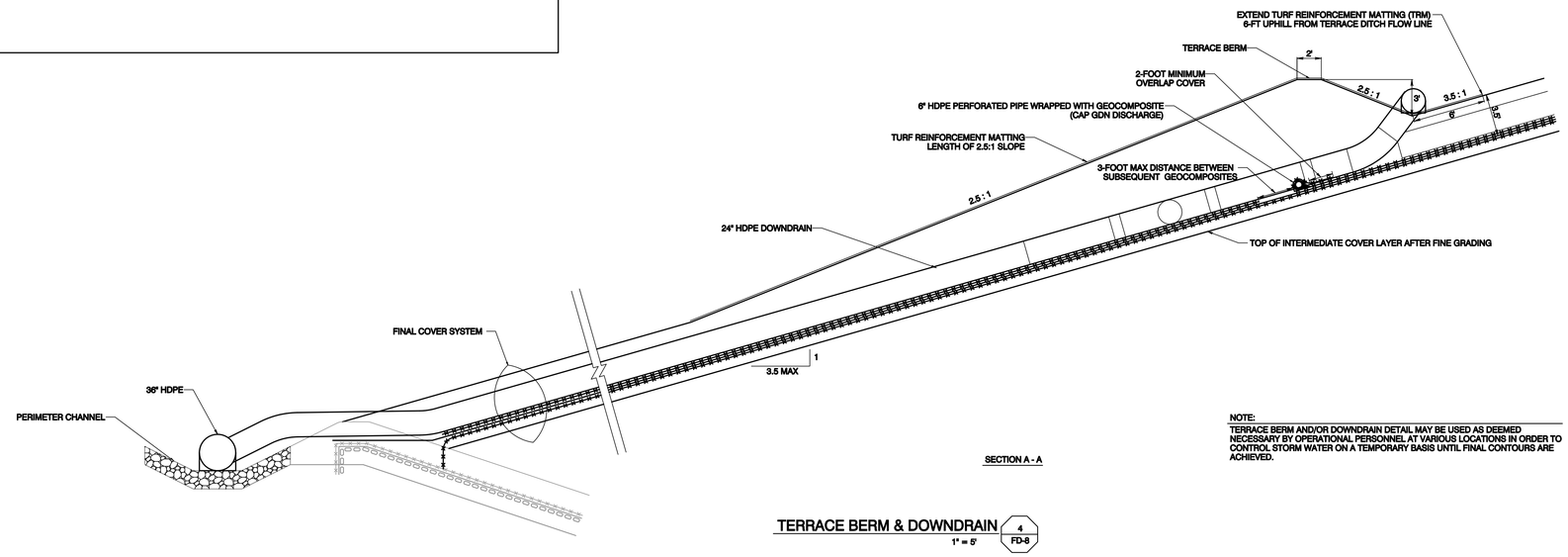


PLAN VIEW



PROFILE VIEW

SHALLOW GAS VENT (3 / FD-8)
1" = 5'



SECTION A - A

NOTE:
TERRACE BERM AND/OR DOWNDRAIN DETAIL MAY BE USED AS DEEMED NECESSARY BY OPERATIONAL PERSONNEL AT VARIOUS LOCATIONS IN ORDER TO CONTROL STORM WATER ON A TEMPORARY BASIS UNTIL FINAL CONTOURS ARE ACHIEVED.

TERRACE BERM & DOWNDRAIN (4 / FD-8)
1" = 5'

NORTH CAROLINA PROFESSIONAL SEAL 19796 ENGINEER VINCE FREDERICK MOORE
June 20, 2016

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FACILITY DRAWINGS
HAYWOOD COUNTY WHITE OAK MSWLF

DETAILS

SHEET
FD-8

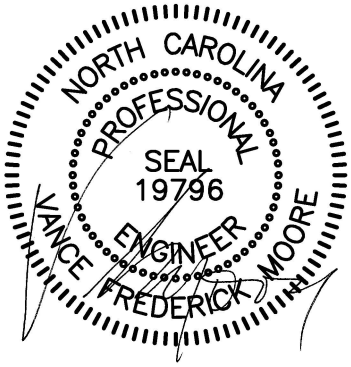
Path: V:\Santek\Haywood County\Phase 4&5\Drawing\WOLF-06-20-16.pro Plot Date/Time: Mon Jun 20,2016 / 15:10:23

Engineering Report

Phases 4 & 5 Permit to Construct Haywood County White Oak MSWLF

Haywood County, North Carolina

June 2016



June 20, 2016

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NC FIRM C-2910

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1.2 Standards for the Base Liner System 1
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1.2.2 LCS Design Criteria 3
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TABLES

Table 1A – 1F - Estimated Volume of Liquid Generated

APPENDICES

Appendix A – Analysis of Foundation Settlement

Appendix B – Analysis of the Base Liner System

Appendix C – Slope Stability Analysis & Factor of Safety for Seismic Impact Zone

Appendix D – Analysis of Final Cover System

Engineering Plan Report

This Engineering Plan Report for the Phase 4 & Phase 5 Expansion of the White Oak MSWLF was developed in accordance with 15A NCAC 13B .1620(d) of the North Carolina Solid Waste Management Regulations.

1.0 Standards for the Foundation and the Base Liner System

Standards for the Foundation and the Base Liner System are discussed below.

1.1 Standards for the Foundation

Refer to Appendix A for the foundation analysis.

1.2 Standards for the Base Liner System

The base liner system is constructed on the landfill subgrade and shall be designed to efficiently contain, collect and remove leachate generated by the MSWLF unit. As allowed under the North Carolina regulations, the base liner system for the landfill as will consist of either:

1. A “standard” composite liner that consists of a 60 mil HDPE geomembrane liner installed above and in direct and uniform contact with a 24 inch thick compacted clay liner with a permeability of no more than 1.0 x 10^{-7} cm/sec.

Or;

2. An “alternative” composite liner that consists of a 60 mil HDPE geomembrane liner installed above and in uniform contact with a GCL overlying a compacted clay liner with a minimum thickness of 18 inch thick compacted clay liner with a permeability of no more than 1.0 x 10^{-5} cm/sec. The GCL will consist of a layer of sodium bentonite bonded between two geotextiles and will provide a maximum hydraulic conductivity of 5 x 10-9 cm/sec when hydrated as further described in the CQA Plan.

The alternative composite liner system has been previously approved for the White Oak MSWLF.

The leachate collection system (LCS) for the landfill will consists of:

- A 24 inch thick leachate collection layer constructed of washed stone installed above and in uniform contact with a 16-once geotextile cushion designed to provide a zone of protection at least 24 inches separating the composite liner from landfilling activities. The leachate collection layer will be installed on the base and side slopes of the landfill.

- A leachate collection pipe network to conduct the leachate from the leachate collection layer to the sumps. All major collection/discharge piping will be high density polyethylene (HDPE) piping. The leachate collection pipes will covered by "gravel columns" consisting of coarse aggregate. The "gravel columns" are designed to be resistant to biological clogging.
- Leachate collection sumps. Leachate collection sumps are filled with coarse aggregate in order to maximize storage and fluid removal rates.
- Sump risers. Each leachate collection sump will have two 24" HDPE risers. Each side riser can accommodate one leachate pump.
- Leachate pump. The leachate pump will be a Leachate Sideslope type, or equal, that is rated at a minimum flow. The pump and control system will include alarms for power outage, high level, and no-flow conditions. A flow meter will be included to monitor leachate production.
- Leachate force main. Leachate will flow from the leachate pump to the leachate storage lagoon via a dual containment HDPE force main.
- Leachate storage lagoon. The existing leachate storage lagoon is located north of Phase 1 and has a total storage volume of 1,017,000 gallons.

1.2.1 LCS Leachate Generation Rates

The volume of leachate generated at a landfill is highly dependent on waste fill depths over the leachate collection system and precipitation amounts.

The volume of leachate generated at a landfill can be estimated by multiplying the anticipated percolation rate into the LCS by the contributing area for each MSW fill depth condition scenario.

Leachate generation rates can be predicted using the HELP model for both average annual rates (normal) and peak daily rates (peak).

Normal leachate generation rates are typically used to predict the total volume of leachate that will be stored and discharged over a month or a year at the landfill.

Peak leachate generation rates are used in the sizing of the leachate collection system components and in analyzing the adequacy of on-site leachate storage system.

The table below presents a summary of the waste fill depths and leachate generation rates used in the design of the leachate collection system.

Leachate Generation Rates Based on 25-year, 24-hour Storm [1]

Scenario	Peak Daily Flow from Drainage Layer, p_{eak} (in/day-acre)	Peak Daily Leachate Generation Rate, $r_{required}$ (gal/day-acre)
Active Cell Condition w/10' waste, no cover	0.47	12,851
Active Cell Condition w/ 10' to 30' waste, no cover	0.27	7,331
Active Cell Condition w/30' or more waste, no cover	0.21	5,702

[1] Reference: HELP Model Analysis, White Oak MSW Landfill, Phase 3 & 4, Haywood County, North Carolina prepared by McGill Associates and dated September 2008

The leachate generation rate for the active cell condition with 10 feet of waste was used in the design of the leachate collection system, discussed in 1.2.2 LCS Design Criteria.

The open cell condition was not considered as part of this analysis because rain covers will be utilized to prevent rainfall from contacting waste until at least a 10-foot lift of waste is in place on the landfill floor. The Operations Report provides the operational criteria that will be implemented during initial lift placement.

The existing LCS for the Phase 1 and Phase 2 area gravity flows directly to the Liquid storage lagoon. The existing Phase 3 Sump collects leachate from the existing Phases 3 and proposed Phase 4 area. The Phase 5 Sump area collects leachate from the proposed Phases 5 area. The existing Phase 3 sump and proposed Phase 5 sump areas consists of a recessed area double-lined with HDPE geomembrane.

Table 1, included at the end of the section, presents an analysis of development scenarios for Phases 4 and 5 and the resulting leachate generated. The results of the analysis in Table 1 is used in the design of the leachate collection system as follows:

1. Determination of a sump pump pumping rate required for the sumps in Phase 3 and Phase 5.
2. Determination of the adequacy of the existing leachate storage pond for the proposed Phases 4 and 5.

1.2.2 LCS Design Criteria

The LCS design shall satisfy the following criteria:

1. The geometry of the landfill and the leachate collection system shall be designed to control and contain the volume of leachate generated by the 24-hour, 25-year

storm

2. The LCS flow capacity shall be designed to reduce the head on the liner system generated by the 24-hour, 25-year storm to less than one foot within 72 hours after the storm event.
3. The leachate collection system shall be hydraulically designed to efficiently collect and remove leachate generated by the MSWLF unit in order to ensure that the leachate head on the composite liner does not exceed one foot under normal operating conditions.

Appendix B provides the following calculations demonstrating compliance with the LCS design criteria:

- B.1 Flow Capacity of Leachate Collection System
- B.2 Geotextile Soil Retention Criteria
- B.3 Maximum Head Calculations
- B.4 Leachate Collection Pipe Calculations
- B.5 Leachate Collection Pipe Loading Evaluation
- B.6 Leachate Collection Pipe Structural Calculations
- B.7 Leachate Sump Pumps and Force Main

The proposed Phase 5 sump utilizes a dual side-slope riser pumping station constructed of 24-inch perforated HDPE pipe that each houses a submersible leachate pump. The side-slope risers rest on the 16-ounce geotextile cushion along the slope and lies between the sump and the top of the perimeter berm. The submersible pump are lowered into the leachate collection sump through the side-slope riser by means of a steel cable and a rolling carriage.

The existing Phase 3 and proposed Phase 5 sump areas are designed with 2 leachate sump pumps in order to provide redundancy and to increase the safety factor against a pump failure and leachate spill. Both pumping stations are located at the lowest points of the sumps.

2.0 Standards for the Cap System

The final cover cap system shall be designed and constructed to:

(A) Have a permeability less than or equal to the permeability of any base liner system or the in-situ subsoils underlaying the landfill.

(B) Minimize infiltration through the closed MSWLF by the use of a low-permeability barrier that contains a minimum 18 inches of earthen material.

(C) Minimize erosion of the cap system and protect the low-permeability barrier from root penetration by use of an erosion layer that contains a minimum of six inches of earthen material that is capable of sustaining native plant growth.

The Division may approve an alternative cap system if the owner or operator can adequately demonstrate the following:

(A) The alternative cap system will achieve an equivalent or greater reduction in infiltration as the low-permeability barrier specified in Subparagraph (1) of this Paragraph; and

(B) The erosion layer will provide equivalent or improved protection as the erosion layer specified in Subparagraph (3) of this Paragraph.

The Haywood County White Oak MSWLF proposes to utilize an “alternative” final cover system as described in the Closure and Post-closure Plan which consists of the following components:

The “alternative” final cap system consists of the following components (from lowest to highest):

(1) The cap foundation consisting of a minimum thickness of 12 inches of compacted soil over the placed waste materials.

(2) A leachate breakout and gas venting or collection system consisting of strips of geocomposite drainage layer consisting of geonet bonded on both sides with a non-woven geotextile fabric laid in a grid pattern to minimize pressures exerted on the low-permeability barrier.

(3) A 40-mil Linear Low-density Polyethylene (LLDPE) textured geomembrane.

(4) A geocomposite drainage layer consisting of geonet bonded on both sides with a non-woven geotextile fabric.

(5) A minimum of 42 inches of earthen material that is capable of sustaining native plant growth. The final cover surface will be vegetated upon completion of the final cover installation according to the project seeding specifications

(6) Surface water control devices including terrace berms and downdrain pipes.

(7) Vertical LFG extraction wells and lateral extraction wells (where feasible).

The Alternative cap system is proposed to be constructed with post-settlement surface slopes shall be a minimum of five percent and a maximum of 3.5:1.

Engineering analyses were performed to demonstrate proper function of each component of the “alternative” final cover system to assess the flow capacity of the drainage geocomposite collection layer, cap component (slope) stability, and the ability of the vegetative cover soil layer to resist erosion. The calculations and detailed summary for the analyses are contained in Appendix D. Each analysis includes:

(A) A discussion of the analytical methods used to evaluate the design.

(B) Definition of the critical conditions evaluated and assumptions made.

(C) A list of technical references used in the evaluation.

3.0 Standards for the Leachate Storage Facilities

A 1-million gallon leachate storage pond is in operation at the landfill. The analysis presented in Table 1, predicts that a total leachate volume of about 275,000 gallons will be generated once Phase 5 is in operation. The volume of the existing leachate storage pond is adequate, provided that the landfill meets certain operational criteria. No expansion of the leachate storage pond is planned for Phases 4 and 5. Refer to the operational criteria for the leachate storage facilities included in the Operations Plan Report.

4.0 Location Restrictions Demonstrations

The report "MSWLF Facility Site Study, Haywood County White Oak MSWLF", prepared by Municipal Engineering and dated November 4, 1998, demonstrated compliance with location restrictions for the 75.1 acre landfill footprint for the following location restrictions:

- Airport Safety
- Floodplains
- Cultural Resources
- State Nature and Historic Preserves
- Water Supply Watersheds
- Endangered and Threatened Species

The remaining locations restrictions, which are specific to each phase of development, include the following:

- Wetlands
- Seismic Impact Zones
- Unstable Areas

Compliance with the location restriction demonstrations for the landfill is discussed below.

4.1 Airport Safety

There are no Public Use Airports within the two-mile perimeter of the Haywood County White Oak MSWLF. The closest airport is located just over nine miles north of the Facility.

4.2 Floodplains

The Haywood County White Oak MSWLF has a permitted limits of waste area of 75.1 acres, comprised of Phases 1 thru Phase 7 which is located outside the 100-year floodplain. The nearest 100-year floodplain is approximately 1,000 feet to the north of existing Phase 3 along the Pigeon River.

4.3 Wetlands

There are no wetlands within the Phases 4 and 5 of the Haywood County White Oak MSWLF.

4.4 Fault Areas

Refer to Design Hydrogeological Report for Phase 4 and 5 Expansion of the Haywood County White Oak MSWLF, prepared by BLE, Inc., to be submitted under separate cover.

4.5 Seismic Impact Zones

The Haywood County White Oak MSWLF has a permitted limits of waste area of 75.1 acres, comprised of Phases 1 thru Phase 7, which is located within a Seismic Impact Zone.

Seismic Impact Zones Analysis and associated safety factors are include in Appendix C.

The analysis demonstrates all containment structures, including liners, leachate collection systems, and surface water control systems, are designed to resist the maximum horizontal acceleration in lithified earth material for the site.

4.6 Unstable Areas

The Haywood County White Oak MSWLF has a permitted limits of waste area of 75.1 acres, comprised of Phases 1 thru Phase 7 which is not located within Unstable Areas.

Refer to Design Hydrogeological Report for Phase 4 and 5 Expansion of the Haywood County White Oak MSWLF, prepared by BLE, Inc. to be submitted under separate cover.

4.7 Cultural Resources

Six historical sites on the Haywood County White Oak MSWLF property were identified

and examined during the preparation of the "MSWLF Facility Site Study, Haywood County White Oak MSWLF", prepared by Municipal Engineering and dated November 4, 1998. Four of the sites are prehistoric and two are historic. Three of the sites were to be impacted during the construction of the originally proposed Phases 3 & 4 expansion. None of the sites are recommended as eligible for inclusion on the National Register of Historic Places. The Site Study report concludes that no additional work is necessary at the sites. For an extensive discussion of Cultural Resources in the vicinity of the Haywood County White Oak MSWLF, see Section 4.7 of the "MSWLF Facility Site Study, Haywood County White Oak MSWLF".

4.8 State Nature and Historic Preserve

The Haywood County White Oak MSWLF has a permitted limits of waste area of 75.1 acres, comprised of Phases 1 thru Phase 7 which will not have an adverse impact on any lands included in the State Nature and Historic Preserve.

4.9 Water Supply Watersheds

The Haywood County White Oak MSWLF has a permitted limits of waste area of 75.1 acres, comprised of Phases 1 thru Phase 7 which is not located in the critical area of a water supply watershed or in the watershed for a stream segment classified as WS-I, in accordance with the rules codified at 15A NCAC 2B .0200 - "Classifications and Water Quality Standards Applicable To Surface Waters Of North Carolina."

4.10 Endangered and Threatened Species

The Haywood County White Oak MSWLF has a permitted limits of waste area of 75.1 acres, comprised of Phases 1 thru Phase 7 which will not jeopardize the continued existence of endangered or threatened species or result in the destruction or adverse modification of a critical habitat, protected under the Federal Endangered Species Act of 1973.

5.0 Horizontal Separation Requirements

Horizontal separation requirements from the Haywood County White Oak MSWLF permitted limits of waste area of 75.1 acres, comprised of Phases 1 thru Phase 7 is discussed below.

5.1 Property Lines

The Haywood County White Oak MSWLF permitted limits of waste area of 75.1 acres, comprised of Phases 1 thru Phase 7 maintains a minimum 300-foot buffer between all property lines.

5.2 Private Residences and Wells

The Haywood County White Oak MSWLF permitted limits of waste area of 75.1 acres, comprised of Phases 1 thru Phase 7 maintains a minimum 500-foot buffer from existing private residences and wells.

5.3 Surface Waters

The Haywood County White Oak MSWLF has a permitted limits of waste area of 75.1 acres, comprised of Phases 1 thru Phase 7.

The proposed Phase 4 and Phase 5 Expansion of the Haywood County White Oak MSWLF maintains a minimum buffer distance of 50 feet from adjacent streams, rivers, or lakes.

Future Phase 6 and Phase 7 may require impacts of a spring-feed stream. Permits for this impacts from the United States Army Corps of Engineers and North Carolina Department of Environment Quality will be obtained and provided to the Solid Waste Section prior to the issuance of the Phase 6 Permit to Construct.

5.4 Existing Landfill Units

The Haywood County White Oak MSWLF permitted limits of waste area of 75.1 acres, comprised of Phases 1 thru Phase 7 has an adequate buffer to establish a ground-water monitoring system independent of the onsite closed C&DLF, and LCID Landfill.

5.5 Existing Facility Buffers

The Haywood County White Oak MSWLF permitted limits of waste area of 75.1 acres, comprised of Phases 1 thru Phase 7 conforms to the requirements of the effective permit.

6.0 Vertical Separation Requirements

The Phase 4 and Phase 5 Expansion of the Haywood County White Oak MSWLF is constructed so that the post settlement bottom elevation of the base liner system is a minimum of four feet above the seasonal high ground-water table and bedrock datum plane contours established in the Design Hydrogeological Report for Phase 4 and 5 Expansion of the Haywood County White Oak MSWLF, prepared by BLE, Inc. dated July 2016.

7.0 Survey Control

One permanent benchmark of known elevation measured from a U.S. Geological Survey benchmark shall be established and maintained for each 50 acres of developed landfill, or part thereof, at the landfill facility. This benchmark shall be the reference point for

establishing vertical elevation control.

The Phase 4 and Phase 5 Expansion of the Haywood County White Oak MSWLF will result in 44.6-acres of developed landfill. Therefore at least one permanent benchmark will be established and maintained.

8.0 Location Coordinates

The North Carolina State Plane (NCSP) coordinates will be established and one of its points shall be the benchmark of known NCSP coordinates.

9.0 Special Engineering Structures

Engineering structures incorporated in the design and necessary to comply with the requirements of this Section shall be specified in the engineering plan. Material, construction, and certification requirements necessary to ensure that the structure is constructed according to the design and acceptable engineering practices shall be included in the Division approved plan.

10.0 Sedimentation and Erosion Control

Adequate structures and measures shall be designed and maintained to manage the run-off generated by the 24-hour, 25-year storm event, and conform to the requirements of the Sedimentation Pollution Control Law (15A NCAC 4).

The erosion control structures were designed and will be maintained to manage the run-off generated by the 24-hour, 25-year storm event and conformed to the requirements of the Sedimentation Pollution Control Law (15A NCAC 4). A copy of the approved erosion control plan was forwarded to the Solid Waste Section prior to the issuance of the Permit to Construct for Phase 3. Erosion control measures for the construction of Phase 3 are shown on Sheet C5 of the Permit Amendment drawings. Final erosion control measures are shown on Sheet C-11 of the Permit Amendment drawings.

In addition to the existing sediment basin located near the leachate lagoon north of the Phase 1 waste area, three additional sediment basins were constructed to the north and west of Phase 3 These basins were utilized to control sedimentation during construction and are used to control stormwater runoff during the operation of Phase 3. Stormwater runoff is directed to these basins prior to release to nearby streams. An additional sediment basin was constructed to the south of the soil stockpile area located to the south of Phase 3 and the originally proposed location of Phase 4. In all cases, ditches, piping, and sediment basins were sized to accommodate the greatest flow that will be encountered throughout the lifetime of the landfill phase. Often, the greatest flow will be realized as the landfill reaches its capacity when the slopes are steepest, many years into

the future. A copy of the erosion control permits associated with the development of Phases 3 & 4 was forwarded to the Solid Waste Section. The White Oak Landfill is being operated under a general stormwater permit that was issued in November of 2007.

The erosion and sedimentation control law is performance based and although existing erosion control permits and measures are in-place, it is still the responsibility of the landfill operator to ensure that the erosion control systems are functioning properly. Existing and proposed erosion/sedimentation control structures include sediment basins, storm drains, temporary slope drains, check dams, and diversion ditches. Sediment basins will be checked after periods of significant runoff. Sediment will be removed from the basin to its original dimension when sediment accumulates to one half of the design depth. The sedimentation basins, embankments, ditches, inlets and outlets will also be inspected for erosion damage. All necessary repairs will be made immediately. Any trash or debris within the riser pipes will be removed. Storm drain outlets and diversion ditches will be inspected for damage after each runoff event. Rip rap will be placed in ditches and at pipe outlets to prevent erosion and wash outs. Provisions for a vegetative ground cover sufficient to control erosion must be accomplished within fifteen days upon completion of any phase of grading. Embankment slopes shall be periodically inspected for erosion. The embankment slopes shall be mowed at a frequency sufficient to maintain a good stand of vegetation. The slopes shall be mowed once in any one (1) year period. The embankment slopes shall be re-fertilized in the second year unless vegetation growth is fully adequate. Any damaged areas will be reseeded, fertilized, and mulched immediately. Seeding, fertilizing and mulching shall be in accordance with the North Carolina Erosion and Sedimentation Control Guidelines.

11.0 Construction Quality Assurance (CQA) Report

Please refer to the CQA Plan.

12.0 Materials and Construction Practices

Please refer to the CQA Plan.

13.0 Design Hydrogeologic Report

Please refer to the Design Hydrogeologic Report prepared by BLE, Inc., to be submitted to the Solid Waste Section under separate cover

Table 1 - A
Phase 1 - 3 Operational
Estimated Volume of Leachate Generated
Phase 4 and 5 Permit to Construct
Haywood County White Oak MSWLF

Landfill Phase	Total Drainage Area (ac)	MSW Depth (ft)	Percent Phase at MSW Depth (%)	Area at MSW Depth (ac)	Normal Daily Perculation Thru Waste (In/Day)	Normal Daily Leachate Generation Rate (gpapd)	Normal Monthly Leachate Generation (gal)	Peak Perculation Thru Waste (In/Day)	Peak Daily Leachate Generation Rate (gpapd)	Peak Daily Leachate Generation Rate (gpd)
Phase 1 - 2	21.5	>30'	100%	21.5	0.015	407	262,699	0.210	5,702	122,593
Phase 3	8.8	>30'	100%	8.8	0.015	407	107,524	0.210	5,702	50,178
Phase 4A	1.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 4A	0.0		Total 4A	0		Total 4A	0
Phase 4B	1.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 4B	0.0		Total 4B	0		Total 4B	0
Phase 4C	1.3	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 4B	0.0		Total 4B	0		Total 4B	0
			Sump 3 DA	8.8		Sump 3 Monthly Flow	107,524		Sump 3 Max Daily Flow	50,178
									Pumping Peaking Factor	1
						Sump 3 Avg. Pumping GPM	2.5		Sump 3 Pump Rate GPM	34.8
Phase 5A	2.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5A	0.0		Total 5A	0		Total 5A	0
Phase 5B	2.2	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5B	0.0		Total 5B	0		Total 5B	0
Phase 5C	2.5	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5C	0.0		Total 5C	0		Total 5C	0
Phase 5D	2.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5D	0.0		Total 5D	0		Total 5D	0
			Sump 5 DA	0.0		Sump 5 Monthly Flow	0		Sump 5 Max Daily Flow	0
									Pumping Peaking Factor	2
						Sump 5 Avg. Pumping GPM	0.0		Sump 5 Pump Rate GPM	0.0
						Total Gal. to Leachate Pond	370,223		Total Gal. to Leachate Pond	172,771

Table 1 - B
Phase 1 - 4A Operational
Estimated Volume of Leachate Generated
Phase 4 and 5 Permit to Construct
Haywood County White Oak MSWLF

Landfill Phase	Total Drainage Area (ac)	MSW Depth (ft)	Percent Phase at MSW Depth (%)	Area at MSW Depth (ac)	Normal Daily Perculation Thru Waste (In/Day)	Normal Daily Leachate Generation Rate (gpapd)	Normal Monthly Leachate Generation (gal)	Peak Perculation Thru Waste (In/Day)	Peak Daily Leachate Generation Rate (gpapd)	Peak Daily Leachate Generation Rate (gpd)
Phase 1 - 2	21.5	>30'	100%	21.5	0.015	407	262,699	0.210	5,702	122,593
Phase 3	8.8	>30'	100%	8.8	0.015	407	107,524	0.210	5,702	50,178
Phase 4A	1.6	<10'	100%	1.6	0.132	3,584	172,038	0.470	12,762	20,419
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 4A	1.6		Total 4A	172,038		Total 4A	20,419
Phase 4B	1.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 4B	0.0		Total 4B	0		Total 4B	0
Phase 4C	1.3	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 4B	0.0		Total 4B	0		Total 4B	0
			Sump 3 DA	10.4		Sump 3 Monthly Flow	279,561		Sump 3 Max Daily Flow	70,596
									Pumping Peaking Factor	1
						Sump 3 Avg. Pumping GPM	6.5		Sump 3 Pump Rate GPM	49.0
Phase 5A	2.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5A	0.0		Total 5A	0		Total 5A	0
Phase 5B	2.2	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5B	0.0		Total 5B	0		Total 5B	0
Phase 5C	2.5	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5C	0.0		Total 5C	0		Total 5C	0
Phase 5D	2.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5D	0.0		Total 5D	0		Total 5D	0
			Sump 5 DA	0.0		Sump 5 Monthly Flow	0		Sump 5 Max Daily Flow	0
									Pumping Peaking Factor	2
						Sump 5 Avg. Pumping GPM	0.0		Sump 5 Pump Rate GPM	0.0
						Total Gal. to Leachate Pond	542,261		Total Gal. to Leachate Pond	193,189

Table 1 - C
Phase 1 - 4B Operational
Estimated Volume of Leachate Generated
Phase 4 and 5 Permit to Construct
Haywood County White Oak MSWLF

Landfill Phase	Total Drainage Area (ac)	MSW Depth (ft)	Percent Phase at MSW Depth (%)	Area at MSW Depth (ac)	Normal Daily Perculation Thru Waste (In/Day)	Normal Daily Leachate Generation Rate (gpapd)	Normal Monthly Leachate Generation (gal)	Peak Perculation Thru Waste (In/Day)	Peak Daily Leachate Generation Rate (gpapd)	Peak Daily Leachate Generation Rate (gpd)
Phase 1 - 2	21.5	>30'	100%	21.5	0.015	407	262,699	0.210	5,702	122,593
Phase 3	8.8	>30'	100%	8.8	0.015	407	107,524	0.210	5,702	50,178
Phase 4A	1.6	<10'	10%	0.2	0.132	3,584	17,204	0.470	12,762	2,042
		10' > 30'	20%	0.3	0.046	1,249	11,990	0.270	7,331	2,346
		>30'	70%	1.1	0.015	407	13,685	0.210	5,702	6,386
			Total 4A	1.6		Total 4A	42,879		Total 4A	10,774
Phase 4B	1.6	<10'	100%	1.6	0.132	3,584	167,737	0.470	12,762	19,908
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 4B	1.6		Total 4B	167,737		Total 4B	19,908
Phase 4C	1.3	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 4B	0.0		Total 4B	0		Total 4B	0
			Sump 3 DA	12.0		Sump 3 Monthly Flow	318,139		Sump 3 Max Daily Flow	80,860
									Pumping Peaking Factor	1
						Sump 3 Avg. Pumping GPM	7.4		Sump 3 Pump Rate GPM	56.2
Phase 5A	2.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5A	0.0		Total 5A	0		Total 5A	0
Phase 5B	2.2	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5B	0.0		Total 5B	0		Total 5B	0
Phase 5C	2.5	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5C	0.0		Total 5C	0		Total 5C	0
Phase 5D	2.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5D	0.0		Total 5D	0		Total 5D	0
			Sump 5 DA	0.0		Sump 5 Monthly Flow	0		Sump 5 Max Daily Flow	0
									Pumping Peaking Factor	2
						Sump 5 Avg. Pumping GPM	0.0		Sump 5 Pump Rate GPM	0.0
						Total Gal. to Leachate Pond	580,839		Total Gal. to Leachate Pond	203,453

Table 1 - D
Phase 1 - 4C Operational
Estimated Volume of Leachate Generated
Phase 4 and 5 Permit to Construct
Haywood County White Oak MSWLF

Landfill Phase	Total Drainage Area (ac)	MSW Depth (ft)	Percent Phase at MSW Depth (%)	Area at MSW Depth (ac)	Normal Daily Perculation Thru Waste (In/Day)	Normal Daily Leachate Generation Rate (gpapd)	Normal Monthly Leachate Generation (gal)	Peak Perculation Thru Waste (In/Day)	Peak Daily Leachate Generation Rate (gpapd)	Peak Daily Leachate Generation Rate (gpd)
Phase 1 - 2	21.5	>30'	100%	21.5	0.015	407	262,699	0.210	5,702	122,593
Phase 3	8.8	>30'	100%	8.8	0.015	407	107,524	0.210	5,702	50,178
Phase 4A	1.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	100%	1.6	0.015	407	19,550	0.210	5,702	9,123
			Total 4A	1.6		Total 4A	19,550		Total 4A	9,123
Phase 4B	1.6	<10'	10%	0.2	0.132	3,584	16,774	0.470	12,762	1,991
		10' > 30'	20%	0.3	0.046	1,249	11,691	0.270	7,331	2,287
		>30'	70%	1.1	0.015	407	13,343	0.210	5,702	6,227
			Total 4B	1.6		Total 4B	41,807		Total 4B	10,505
Phase 4C	1.3	<10'	100%	1.3	0.132	3,584	137,630	0.470	12,762	16,335
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 4B	1.3		Total 4B	137,630		Total 4B	16,335
			Sump 3 DA	13.2		Sump 3 Monthly Flow	306,510		Sump 3 Max Daily Flow	86,140
									Pumping Peaking Factor	1.5
						Sump 3 Avg. Pumping GPM	7.1		Sump 3 Pump Rate GPM	89.7
Phase 5A	2.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5A	0.0		Total 5A	0		Total 5A	0
Phase 5B	2.2	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5B	0.0		Total 5B	0		Total 5B	0
Phase 5C	2.5	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5C	0.0		Total 5C	0		Total 5C	0
Phase 5D	2.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5D	0.0		Total 5D	0		Total 5D	0
			Sump 5 DA	0.0		Sump 5 Monthly Flow	0		Sump 5 Max Daily Flow	0
									Pumping Peaking Factor	2.0
						Sump 5 Avg. Pumping GPM	0.0		Sump 5 Pump Rate GPM	0.0
						Total Gal. to Leachate Pond	569,210		Total Gal. to Leachate Pond	208,734

Table 1 - E
Phase 1 - 5A Operational
Estimated Volume of Leachate Generated
Phase 4 and 5 Permit to Construct
Haywood County White Oak MSWLF

Landfill Phase	Total Drainage Area (ac)	MSW Depth (ft)	Percent Phase at MSW Depth (%)	Area at MSW Depth (ac)	Normal Daily Perculation Thru Waste (In/Day)	Normal Daily Leachate Generation Rate (gpapd)	Normal Monthly Leachate Generation (gal)	Peak Perculation Thru Waste (In/Day)	Peak Daily Leachate Generation Rate (gpapd)	Peak Daily Leachate Generation Rate (gpd)
Phase 1 - 2	21.5	>30'	100%	21.5	0.015	407	262,699	0.210	5,702	122,593
Phase 3	8.8	>30'	100%	8.8	0.015	407	107,524	0.210	5,702	50,178
Phase 4A	1.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	100%	1.6	0.015	407	19,550	0.210	5,702	9,123
			Total 4A	1.6		Total 4A	19,550		Total 4A	9,123
Phase 4B	1.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	100%	1.6	0.015	407	19,061	0.210	5,702	8,895
			Total 4B	1.6		Total 4B	19,061		Total 4B	8,895
Phase 4C	1.3	<10'	10%	0.1	0.132	3,584	13,763	0.470	12,762	1,633
		10' > 30'	20%	0.3	0.046	1,249	9,592	0.270	7,331	1,877
		>30'	70%	0.9	0.015	407	10,948	0.210	5,702	5,109
			Total 4B	1.3		Total 4B	34,303		Total 4B	8,619
			Sump 3 DA	13.2		Sump 3 Monthly Flow	180,437		Sump 3 Max Daily Flow	76,815
									Pumping Peaking Factor	1
						Sump 3 Avg. Pumping GPM	4.2		Sump 3 Pump Rate GPM	53.3
Phase 5A	2.6	<10'	100%	2.6	0.132	3,584	283,862	0.470	12,762	33,691
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5A	2.6		Total 5A	283,862		Total 5A	33,691
Phase 5B	2.2	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5B	0.0		Total 5B	0		Total 5B	0
Phase 5C	2.5	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5C	0.0		Total 5C	0		Total 5C	0
Phase 5D	2.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5D	0.0		Total 5D	0		Total 5D	0
			Sump 5 DA	2.6		Sump 5 Monthly Flow	283,862		Sump 5 Max Daily Flow	33,691
									Pumping Peaking Factor	2
						Sump 5 Avg. Pumping GPM	6.6		Sump 5 Pump Rate GPM	46.8
						Total Gal. to Leachate Pond	726,999		Total Gal. to Leachate Pond	233,099

Table 1 - F
Phase 1 - 5B Operational
Estimated Volume of Leachate Generated
Phase 4 and 5 Permit to Construct
Haywood County White Oak MSWLF

Landfill Phase	Total Drainage Area (ac)	MSW Depth (ft)	Percent Phase at MSW Depth (%)	Area at MSW Depth (ac)	Normal Daily Perculation Thru Waste (In/Day)	Normal Daily Leachate Generation Rate (gpapd)	Normal Monthly Leachate Generation (gal)	Peak Perculation Thru Waste (In/Day)	Peak Daily Leachate Generation Rate (gpapd)	Peak Daily Leachate Generation Rate (gpd)
Phase 1 - 2	21.5	>30'	100%	21.5	0.015	407	262,699	0.210	5,702	122,593
Phase 3	8.8	>30'	100%	8.8	0.015	407	107,524	0.210	5,702	50,178
Phase 4A	1.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	100%	1.6	0.015	407	19,550	0.210	5,702	9,123
			Total 4A	1.6		Total 4A	19,550		Total 4A	9,123
Phase 4B	1.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	100%	1.6	0.015	407	19,061	0.210	5,702	8,895
			Total 4B	1.6		Total 4B	19,061		Total 4B	8,895
Phase 4C	1.3	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	100%	1.3	0.015	407	15,640	0.210	5,702	7,299
			Total 4B	1.3		Total 4B	15,640		Total 4B	7,299
			Sump 3 DA	13.2		Sump 3 Monthly Flow	161,774		Sump 3 Max Daily Flow	75,495
									Pumping Peaking Factor	1
						Sump 3 Avg. Pumping GPM	3.7		Sump 3 Pump Rate GPM	52.4
Phase 5A	2.6	<10'	10%	0.3	0.132	3,584	28,386	0.470	12,762	3,369
		10' > 30'	20%	0.5	0.046	1,249	19,784	0.270	7,331	3,871
		>30'	70%	1.8	0.015	407	22,580	0.210	5,702	10,537
			Total 5A	2.6		Total 5A	70,750		Total 5A	17,777
Phase 5B	2.2	<10'	100%	2.2	0.132	3,584	233,326	0.470	12,762	27,693
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5B	2.2		Total 5B	233,326		Total 5B	27,693
Phase 5C	2.5	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5C	0.0		Total 5C	0		Total 5C	0
Phase 5D	2.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5D	0.0		Total 5D	0		Total 5D	0
			Sump 5 DA	4.8		Sump 5 Monthly Flow	304,076		Sump 5 Max Daily Flow	45,470
									Pumping Peaking Factor	2
						Sump 5 Avg. Pumping GPM	7.0		Sump 5 Pump Rate GPM	63.2
						Total Gal. to Leachate Pond	728,550		Total Gal. to Leachate Pond	243,558

Table 1 - G
Phase 1 - 5C Operational
Estimated Volume of Leachate Generated
Phase 4 and 5 Permit to Construct
Haywood County White Oak MSWLF

Landfill Phase	Total Drainage Area (ac)	MSW Depth (ft)	Percent Phase at MSW Depth (%)	Area at MSW Depth (ac)	Normal Daily Perculation Thru Waste (In/Day)	Normal Daily Leachate Generation Rate (gpapd)	Normal Monthly Leachate Generation (gal)	Peak Perculation Thru Waste (In/Day)	Peak Daily Leachate Generation Rate (gpapd)	Peak Daily Leachate Generation Rate (gpd)
Phase 1 - 2	21.5	>30'	100%	21.5	0.015	407	262,699	0.210	5,702	122,593
Phase 3	8.8	>30'	100%	8.8	0.015	407	107,524	0.210	5,702	50,178
Phase 4A	1.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	100%	1.6	0.015	407	19,550	0.210	5,702	9,123
			Total 4A	1.6		Total 4A	19,550		Total 4A	9,123
Phase 4B	1.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	100%	1.6	0.015	407	19,061	0.210	5,702	8,895
			Total 4B	1.6		Total 4B	19,061		Total 4B	8,895
Phase 4C	1.3	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	100%	1.3	0.015	407	15,640	0.210	5,702	7,299
			Total 4B	1.3		Total 4B	15,640		Total 4B	7,299
			Sump 3 DA	13.2		Sump 3 Monthly Flow	161,774		Sump 3 Max Daily Flow	75,495
									Pumping Peaking Factor	1
						Sump 3 Avg. Pumping GPM	3.7		Sump 3 Pump Rate GPM	52.4
Phase 5A	2.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	100%	2.6	0.015	407	32,257	0.210	5,702	15,053
			Total 5A	2.6		Total 5A	32,257		Total 5A	15,053
Phase 5B	2.2	<10'	10%	0.2	0.132	3,584	23,333	0.470	12,762	2,769
		10' > 30'	20%	0.4	0.046	1,249	16,262	0.270	7,331	3,182
		>30'	70%	1.5	0.015	407	18,560	0.210	5,702	8,661
			Total 5B	2.2		Total 5B	58,155		Total 5B	14,612
Phase 5C	2.5	<10'	100%	2.5	0.132	3,584	272,034	0.470	12,762	32,287
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5C	2.5		Total 5C	272,034		Total 5C	32,287
Phase 5D	2.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5D	0.0		Total 5D	0		Total 5D	0
			Sump 5 DA	7.3		Sump 5 Monthly Flow	362,446		Sump 5 Max Daily Flow	61,953
									Pumping Peaking Factor	2
						Sump 5 Avg. Pumping GPM	8.4		Sump 5 Pump Rate GPM	86.0
						Total Gal. to Leachate Pond	786,920		Total Gal. to Leachate Pond	260,040

Table 1 - H
Phase 1 - 5D Operational
Estimated Volume of Leachate Generated
Phase 4 and 5 Permit to Construct
Haywood County White Oak MSWLF

Landfill Phase	Total Drainage Area (ac)	MSW Depth (ft)	Percent Phase at MSW Depth (%)	Area at MSW Depth (ac)	Normal Daily Perculation Thru Waste (In/Day)	Normal Daily Leachate Generation Rate (gpapd)	Normal Monthly Leachate Generation (gal)	Peak Perculation Thru Waste (In/Day)	Peak Daily Leachate Generation Rate (gpapd)	Peak Daily Leachate Generation Rate (gpd)
Phase 1 - 2	21.5	>30'	100%	21.5	0.015	407	262,699	0.210	5,702	122,593
Phase 3	8.8	>30'	100%	8.8	0.015	407	107,524	0.210	5,702	50,178
Phase 4A	1.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	100%	1.6	0.015	407	19,550	0.210	5,702	9,123
			Total 4A	1.6		Total 4A	19,550		Total 4A	9,123
Phase 4B	1.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	100%	1.6	0.015	407	19,061	0.210	5,702	8,895
			Total 4B	1.6		Total 4B	19,061		Total 4B	8,895
Phase 4C	1.3	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	100%	1.3	0.015	407	15,640	0.210	5,702	7,299
			Total 4B	1.3		Total 4B	15,640		Total 4B	7,299
			Sump 3 DA	13.2		Sump 3 Monthly Flow	161,774		Sump 3 Max Daily Flow	75,495
									Pumping Peaking Factor	1
						Sump 3 Avg. Pumping GPM	3.7		Sump 3 Pump Rate GPM	52.4
Phase 5A	2.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	100%	2.6	0.015	407	32,257	0.210	5,702	15,053
			Total 5A	2.6		Total 5A	32,257		Total 5A	15,053
Phase 5B	2.2	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	100%	2.2	0.015	407	26,514	0.210	5,702	12,373
			Total 5B	2.2		Total 5B	26,514		Total 5B	12,373
Phase 5C	2.5	<10'	10%	0.3	0.132	3,584	27,203	0.470	12,762	3,229
		10' > 30'	20%	0.5	0.046	1,249	18,960	0.270	7,331	3,710
		>30'	70%	1.8	0.015	407	21,639	0.210	5,702	10,098
			Total 5C	2.5		Total 5C	67,803		Total 5C	17,037
Phase 5D	2.6	<10'	100%	2.6	0.132	3,584	274,185	0.470	12,762	32,542
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5D	2.6		Total 5D	274,185		Total 5D	32,542
			Sump 5 DA	9.9		Sump 5 Monthly Flow	400,759		Sump 5 Max Daily Flow	77,005
									Pumping Peaking Factor	2
						Sump 5 Avg. Pumping GPM	9.3		Sump 5 Pump Rate GPM	80.2
						Total Gal. to Leachate Pond	825,232		Total Gal. to Leachate Pond	275,093

Table 1 - I
Phase 1 - 5E Operational
Estimated Volume of Leachate Generated
Phase 4 and 5 Permit to Construct
Haywood County White Oak MSWLF

Landfill Phase	Total Drainage Area (ac)	MSW Depth (ft)	Percent Phase at MSW Depth (%)	Area at MSW Depth (ac)	Normal Daily Perculation Thru Waste (In/Day)	Normal Daily Leachate Generation Rate (gpapd)	Normal Monthly Leachate Generation (gal)	Peak Perculation Thru Waste (In/Day)	Peak Daily Leachate Generation Rate (gpapd)	Peak Daily Leachate Generation Rate (gpd)
Phase 1 - 2	21.5	>30'	100%	21.5	0.015	407	262,699	0.210	5,702	122,593
Phase 3	8.8	>30'	100%	8.8	0.015	407	107,524	0.210	5,702	50,178
Phase 4A	1.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	100%	1.6	0.015	407	19,550	0.210	5,702	9,123
			Total 4A	1.6		Total 4A	19,550		Total 4A	9,123
Phase 4B	1.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	100%	1.6	0.015	407	19,061	0.210	5,702	8,895
			Total 4B	1.6		Total 4B	19,061		Total 4B	8,895
Phase 4C	1.3	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	100%	1.3	0.015	407	15,640	0.210	5,702	7,299
			Total 4B	1.3		Total 4B	15,640		Total 4B	7,299
			Sump 3 DA	13.2		Sump 3 Monthly Flow	161,774		Sump 3 Max Daily Flow	75,495
									Pumping Peaking Factor	1
						Sump 3 Avg. Pumping GPM	3.7		Sump 3 Pump Rate GPM	52.4
Phase 5A	2.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	100%	2.6	0.015	407	32,257	0.210	5,702	15,053
			Total 5A	2.6		Total 5A	32,257		Total 5A	15,053
Phase 5B	2.2	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	100%	2.2	0.015	407	26,514	0.210	5,702	12,373
			Total 5B	2.2		Total 5B	26,514		Total 5B	12,373
Phase 5C	2.5	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	100%	2.5	0.015	407	30,913	0.210	5,702	14,426
			Total 5C	2.5		Total 5C	30,913		Total 5C	14,426
Phase 5D	2.6	<10'	10%	0.3	0.132	3,584	27,418	0.470	12,762	3,254
		10' > 30'	20%	0.5	0.046	1,249	19,110	0.270	7,331	3,739
		>30'	70%	1.8	0.015	407	21,810	0.210	5,702	10,178
			Total 5D	2.6		Total 5D	68,339		Total 5D	17,171
			Sump 5 DA	9.9		Sump 5 Monthly Flow	158,023		Sump 5 Max Daily Flow	59,024
									Pumping Peaking Factor	2
						Sump 5 Avg. Pumping GPM	3.7		Sump 5 Pump Rate GPM	82.0
						Total Gal. to Leachate Pond	582,496		Total Gal. to Leachate Pond	257,112

ENGINEERING REPORT

APPENDIX A
ANALYSIS OF FOUNDATION SETTLEMENT

(PREPARED BY OTHERS, TO BE SUBMITTED UNDER SEPARATE COVER)

ENGINEERING REPORT

APPENDIX B
LEACHATE COLLECTION SYSTEM DESIGN

Part	Description	Page
B.1	Flow Capacity of Leachate Collection System	B-1
B.2	Geotextile Soil Retention Criteria	B-18
B.3	Maximum Head Calculations	B-27
B.4	Leachate Collection Pipe Calculations	B-30
B.5	Leachate Collection Pipe Loading Evaluation	B-37
B.6	Leachate Collection Pipe Structural Calculations	B-49
B.7	Leachate Removal and Transmission Design	B-52

APPENDIX B.1
FLOW CAPACITY OF LEACHATE COLLECTION SYSTEM

Rule 15A NCAC 13B .1624 sets requirements for the leachate collection system as follows.

The leachate collection system shall be hydraulically designed to remove leachate from the landfill and ensure that the leachate head on the composite liner does not exceed one foot. A means of quantitatively assessing the performance of the leachate collection system must be provided in the engineering plan. The performance analysis must evaluate the flow capacities of the drainage network necessary to convey leachate to the storage facility or off-site transport location. The engineering evaluation shall incorporate the following criteria:

- At a minimum, the geometry of the landfill and the leachate collection system shall be designed to control and contain the volume of leachate generated by the 24-hour, 25-year storm.

- The performance analysis shall evaluate the leachate collection system for the flow capacities during conditions when the maximum impingement rate occurs on the LCS. The LCS flow capacity shall be designed to reduce the head on the liner system generated by the 24-hour, 25-year storm to less than one foot within 72 hours after the storm event.

- The leachate collection system shall be designed to provide a zone of protection at least 24 inches separating the composite liner from landfilling activities, or shall be subject to approval from the division upon a demonstration of equivalent protection for the liner system.

- The leachate collection system shall be designed to resist clogging and promote leachate collection and removal from the landfill.

- The leachate collection system shall be operated to remove leachate from the landfill in such a way as to ensure that the leachate head on the composite liner does not exceed one foot under normal operating conditions.

INTRODUCTION

The proposed leachate collection zone will consist of a double-sided drainage geocomposite on base and side slopes overlain by 24 inches of protective cover sand. Perforated leachate collection piping will collect all flow from the base slope areas. This

collection piping will be encased in a well-graded stone aggregate. The allowable flow capacity of the 24”-thick protective cover (sand) layer will be evaluated herein.

DESIGN LEACHATE IMPINGEMENT RATE

Based on the previously approved design, the leachate impingement rate was utilized as follows:

$$q_{(\text{peak daily})} = 1718\ \frac{\text{ft}^3}{\text{day} - \text{acre}}$$

* The max. peak daily leachate flow determined for $k_{(sand)} \geq 1.0 \times 10^{-4}$ cm/sec and 10 ft. waste w/no cover condition.

The design leachate impingement rate, $q_{(required)}$, is:

$$q_{(\text{required})} = 1718\,\frac{\text{ft}^3}{\text{day} - \text{acre}} \times \frac{\text{acre}}{43{,}560\ \text{ft}^2} \times \frac{\text{day}}{24\ \text{hr}} \times \frac{\text{hr}}{3{,}600\ \text{sec}} \times \frac{12\ \text{in}}{\text{ft}} \times \frac{2.54\ \text{cm}}{\text{in}}$$

or

$$q_{(\text{required})} = 1.39 \times 10^{-5}\ \text{cm/sec} = 4.56 \times 10^{-7}\ \text{ft/sec}$$

I. ALLOWABLE FLOW CAPACITY OF THE PROTECTIVE COVER MATERIAL

The flow capacity of the protective cover is evaluated in the following calculations. Based on the results of the analyses and the design leachate impingement rate of 4.56×10^{-7} ft/sec, the proposed protective cover material must possess a required flow rate ($Q_{required}$) of 2.05×10^{-4} gpm/ft^2. Calculations show that the protective cover has an allowable flow capacity (Q_{allow}) of 8.08×10^{-3} gpm/ft^2. Thus, the protective cover material can convey 39 times the minimum required flow rate of 2.05×10^{-4} gpm/ft^2 as determined from the leachate impingement rate.

OBJECTIVE

I. Evaluate the flow capacity of the 24”-thick protective cover (sand) layer.

METHODOLOGY

I. A. Determine the allowable flow rate, Q_{allow}, of the protective cover material based on the minimum required permeability of 1.0×10^{-4} cm/sec.
   B. Determine the required in-plane leachate flowrate, $Q_{required}$, needed within the protective cover material by using the design leachate impingement rate, q.
   C. Compare Q_{allow} vs. $Q_{required}$ by calculating a factor of safety in which the adequacy of the 24” protective cover layer may be evaluated.

ANALYSIS

- Design Leachate Impingement Rate

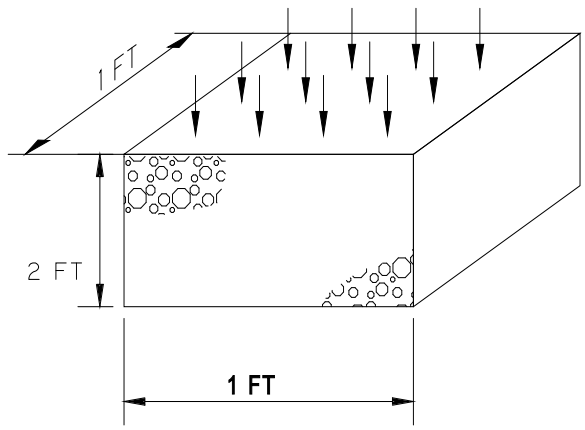
  Dimensional analysis can be used to convert the maximum peak daily leachate flow value (ft³/day-acre) to cm/sec and ft/sec.

$$q_{(required)} = 1.39 \times 10^{-5} \text{ cm /sec} = 4.56 \times 10^{-7} \text{ ft/sec}$$

- Proposed Liner System Configuration

I. FLOW CAPACITY OF THE 24" THICK PROTECTIVE COVER (SAND) LAYER

$q_{required} = 1.39 \times 10^{-5}$ cm/sec
$= 4.56 \times 10^{-7}$ ft/sec



Q req'd = q req'd (A)

WHERE:

Q req'd = REQUIRED LEACHATE FLOW RATE IN PROTECTIVE COVER (gpm)

q req'd = DESIGN LEACHATE INPINGEMENT RATE (ft/s)

A = CROSS-SECTIONAL AREA (ft^2) of flow

A. Calculate $Q_{required}$ of the Protective Cover

$A = (1.0')(1.0') = 1.0\ ft^2$

$Q_{required} = q_{required}\ A = (4.56 \times 10^{-7}\ ft/sec)(1.0\ ft^2) = 4.56 \times 10^{-7}\ ft^3/sec$

$= 4.56 \times 10^{-7}\ ft^3/sec\ (7.48\ gal/ft^3)(60\ s/min)$

$= 2.05 \times 10^{-4}$ gpm

$Q_{required} = 2.05 \times 10^{-4}$ gpm

B. Calculate Q_{allow} for 24"-Thick Protective Cover Material

From Darcy's Law: $Q = k\,i\,A$

$$= \frac{Q}{A} = k\,i = q$$

* Assume an average k since k of the actual sand used in the field may vary.

$$\text{or} \quad Q = k\left(\frac{\Delta h}{L}\right)(l \times w)$$

where: k = saturated hydraulic conductivity

$$k = k_{avg} = \frac{1\times10^{-3} + 1\times10^{-4}}{2} = 5.5\times10^{-4}\ \text{cm/sec} = 1.8\times10^{-5}\ \text{ft/sec}$$

$$\frac{\Delta h}{L} = \text{hydraulic gradient (slope)}$$

$$l = \text{length of cross-sectional area} = 1.0\ \text{ft}$$

$$w = \text{width of cross-sectional area} = 1.0\ \text{ft}$$

Thus,

Q_{allow} = (1.8 x 10^{-5} ft/sec)(1 ft/ft)(1 ft)(1 ft)

= 1.8 x 10^{-5} ft^3/sec

= 1.8 x 10^{-5} ft^3/sec (7.48 gal/ft^3)(60 sec/min)

= 8.08 x 10^{-3} gpm

C. Determine a Factor of Safety (FS) for Flow in the Protective Cover Layer

$$FS = \frac{Q_{allow}}{Q_{required}} = \frac{8.08\times10^{-3}\ gpm}{2.05\times10^{-4}\ gpm} = 39$$

CONCLUSION

From above, it has been shown that the protective cover material will possess sufficient flow capacity to adequately convey the design leachate impingement rate.

II. ALLOWABLE FLOW CAPACITY OF THE TOP LAYER OF NONWOVEN GEOTEXTILE

The protective cover will allow free and continuous flow if its hydraulic conductivity is greater than the design leachate impingement rate. This same requirement applies to the top layer of nonwoven geotextile in the leachate collection zone (on base and side slopes) that lies directly beneath the protective cover material. The design leachate impingement rate is 1.39×10^{-5} cm/sec.

Flow capacity of the nonwoven geotextile filter can be determined from Darcy's law assuming saturated conditions:

$$Q = k\,i\,A \qquad \text{(Equation 1)}$$

where:
- Q = flow rate (cm^3/sec)
- k = saturated hydraulic conductivity of geotextile (cm/sec)
- i = hydraulic gradient (cm/cm)
- A = cross sectional area (cm^2)

Analyzing a unit cross-plane area, Equation 1 becomes:

$$\frac{Q}{A} = q = ki \qquad \text{(Equation 2)}$$

Assuming flow is vertical (approximately the case when saturated), the hydraulic gradient would be 1.0.

$$q = k\,i = k(1) = k \qquad \text{(Equation 3)}$$

$$q_{ult} = k = \Psi t$$

where:
- q_{ult} = ultimate flow capacity of the nonwoven geotextile
- Ψ = permittivity (sec^{-1})
- t = thickness of nonwoven geotextile (cm)

Thus, the ultimate flow capacity of the nonwoven geotextile alone is equal to its hydraulic conductivity and subsequently, the permittivity times its thickness. The following table evaluates the available flow capacity for typical 6 and 8 ounce per square yard (oz/sy) nonwoven geotextiles. The factor of safety is obtained by dividing the ultimate flow capacity, q_{ult}, by the design impingement rate (or required rate), $q_{required}$, of 1.39×10^{-5} cm/sec.

For example:

For Serrot International, Inc. (Transnet Series) Transnet TN3002/651 nonwoven geotextile (6 oz/sy),

$\Psi = 1.3\ sec^{-1}$
$t = 0.20\ cm$

therefore: $q_{ult} = \Psi t = (1.64\ sec^{-1})(0.21\ cm) = 0.26\ cm/sec$
$q_{required} = 1.39 \times 10^{-5}\ cm/sec$

$$\therefore FS = \frac{q_{ult}}{q_{required}} = \frac{0.26\ cm/sec}{1.39 \times 10^{-5}\ cm/sec} = 18{,}705$$

Manufacturer Name	Nonwoven Geotextile Type	Permittivity, Ψ (sec^{-1}) ASTM D4491	Thickness, t (cm)	q_{ult} (cm/sec)	FS = $\frac{q_{ult}}{q_{required}}$
Serrot International, Inc. (Tex-Net Series)	TN3002/651 (6 oz/sy)	1.3	0.20	0.260	18,705
	TN3002/861 (8 oz/sy)	1.5	0.22	0.330	23,741
GSE, Inc. (TS Series)	NW6 (6 oz/sy)	1.3	0.20	0.260	18,705
	NW8 (8 oz/sy)	1.5	0.22	0.330	23,741

Referring to the results in the above table, it can be seen that the 6 and 8 oz/sy candidate nonwoven geotextiles possess more than sufficient cross-plane flow capacity to insure free and continuous flow of leachate into the double-sided heat-bonded geocomposite (HDPE geonet) leachate collection zone. The fact that the ultimate flow capacities are approximately 15,000 to 25,000 times greater than required, means that the allowable flow capacity should remain sufficiently high even with partial clogging and reduction in flow capacity due to overburden stresses that may occur with the passage of time.

CONCLUSION

Since the results of the above table show that the proposed nonwoven geotextiles (6 oz/sy or 8 oz/sy) possess a flow capacity greater than the design leachate impingement rate, it can be concluded that they can safely convey the design (required) flow rate of 1.39×10^{-5} cm/sec.

Based on the extremely high range of factors of safety shown in the above table (15,000-25,000), the upper nonwoven geotextile of the heat-bonded geocomposite leachate collection layer will possess, at a minimum, an ultimate flow capacity (q_{ult}) of at least 40,000 times (for 6 oz/sy material) the maximum design leachate impingement rate ($q_{required}$).

III. ALLOWABLE FLOW RATE OF THE HEAT-BONDED GEOCOMPOSITE

A. Allowable Flow Rate (Q_{allow})

The calculations that follow contain flow rate and transmissivity test results for two types of double-sided heat-bonded geocomposites. These tests include: 1) GSE, Inc. (GSE) FabriNet HDPE geonet heat-bonded to combinations of 6 and 8 oz/sy nonwoven geotextiles manufactured by GSE, Inc; and 2) Serrot International, Inc. Poly-Net PN3000 HDPE geonet heat-bonded to combinations of 6 and 8 oz/sy nonwoven geotextiles manufactured by SI Geosolutions. The trade names for the proposed materials are double-sided Fabrinet (GSE) and Tex-Net (Serrot), respectively.

Both flow rate and transmissivity tests were conducted over a range of hydraulic gradients (0.02 to 1.0) and normal stresses (500 to 20,000 psf) in a laboratory. The hydraulic gradients for the proposed landfill will be between 0.025 and 0.020 for the base slopes and 0.25 (4H:1V) for the side slopes. A value of 0.020 was used for the base slope's hydraulic gradient for conservative measures. The maximum normal stress anticipated at capacity will be approximately 6,800 psf. (80 feet of waste and cap). Thus, the laboratory results contained herein sufficiently bracket the gradients and normal stresses that are anticipated in the landfill area.

Referring to the published test results, it can be seen that the ultimate flow capacity (Q_{ult}) of the heat-bonded geocomposites (at gradients of 0.02 and 0.25, under normal stresses ranging from 14,000 to 15,000 psf), ranges from 0.09 to 0.40 gallons per minute per foot of width (gpm/ft). These values represent the range of ultimate flow capacity for these types of heat-bonded geocomposites.

Koerner (1994) recommends that the ultimate flow capacity be reduced by the use of partial factors of safety to account for elastic deformation, creep deformation, chemical clogging and biological clogging, to arrive at an allowable flow capacity (q_{allow}). The equation to achieve the allowable flow capacity is as follows:

$$Q_{allow} = Q_{ult}\left[\frac{1}{(FS_{IN} \times FS_{CR} \times FS_{CC} \times FS_{BC})}\right] \quad \text{(Equation 1)}$$

where: FS_{IN} = the factor of safety for elastic deformation, or intrusion of the adjacent geosynthetics into the geonet's core space;

FS_{CR} = the factor of safety for creep deformation of the geonet and adjacent geosynthetics into the geonet's core space;

FS_{CC} = the factor of safety for chemical clogging and/or precipitation of chemicals in the geonet's core space;

FS_{BC} = the factor of safety for biological clogging in the geonet's core space; and

All other variables previously defined.

Typical values for these partial factors of safety are included in the calculations contained in this Appendix. The calculations assumed a value of 1.5 for each partial factor of safety. Using this assumption, the following allowable flow capacities for the heat-bonded geocomposite leachate collection zone are obtained:

Slope	Q_{ult}	Product of Partial FS	Q_{allow}	FS = $Q_{allow}/Q_{required}$
2%	0.09 gpm/ft	5.06	0.018 gpm/ft	88
25%	0.40 gpm/ft	5.06	0.079 gpm/ft	386

Referring to the above table, it can be concluded that the allowable flow capacity (Q_{allow}) for the double-sided heat-bonded geocomposite leachate collection zone should conservatively range from about 0.02 to 0.08 gpm/ft.

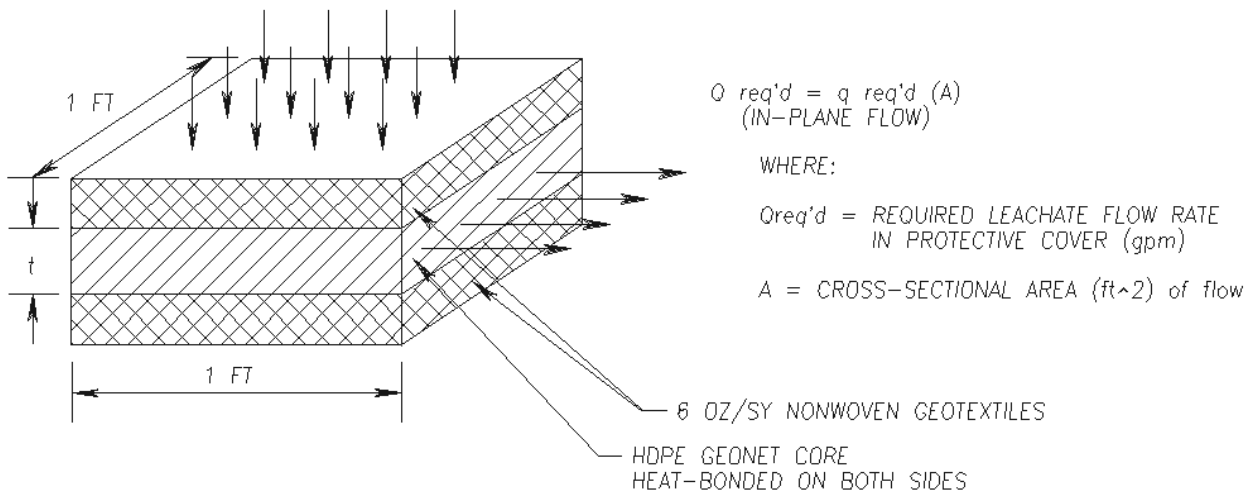
The maximum peak daily leachate flow is 1,718 ft^3/day-acre. Based on this flow, the design leachate impingement rate of $q_{required}$ = 1.39 x 10^{-5} cm/sec (4.56 x 10^{-7} ft/sec) may be obtained.

This value then equates to a design (required) flow rate ($Q_{required}$) of 2.05 x 10^{-4} gpm/ft for the HDPE geonet. This required flow rate ($Q_{required}$ = 2.05 x 10^{-4} gpm/ft) was calculated by multiplying the area of flow (A = 1.0 ft^2 per unit width) by the design leachate impingement rate ($q_{required}$) of 4.56 x 10^{-7} ft/sec. Calculations for comparing the allowable flow capacity (Q_{allow}) to the required in-plane flow rate ($Q_{required}$) are contained in the

appendix. In these calculations, the entire area was assumed to contribute leakage to the collection zone. As shown by the high factors of safety, the HDPE geonet possesses sufficient flow capacity to convey the design (required) flow rate.

Schematic $q_{required}$= 1.39 x 10^{-5} cm/sec (design leachate impingement rate)

= 4.56 x 10^{-7} ft/sec



1) Calculate $Q_{required}$

$$Q_{required} = (q_{required})(A)$$

$$A = 1\frac{ft^2}{width(ft)}$$

$$q_{required} = 4.56 \times 10^{-7} \text{ ft/sec}$$

$$Q_{required} = (q_{required})(A) = \left(4.56 \times 10^{-7}\frac{\text{ft}}{\text{sec}}\right)(1.0\frac{\text{ft}^2}{ft})\left(7.48\frac{\text{gal}}{\text{ft}^3}\right)\left(\frac{60\text{ sec}}{\text{min}}\right)$$

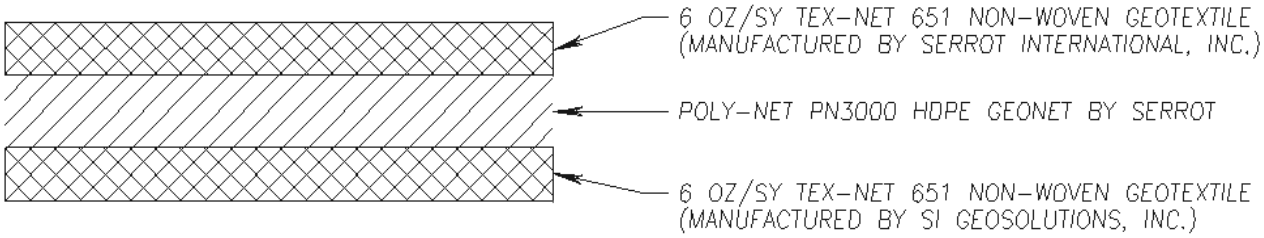
$$= 2.05 \times 10^{-4} \text{ gpm/ } ft$$

$Q_{required}$ = 2.05 x 10^{-4} gpm/ft → min. req'd leachate flow rate in geonet

2) Proposed Drainage Geocomposites

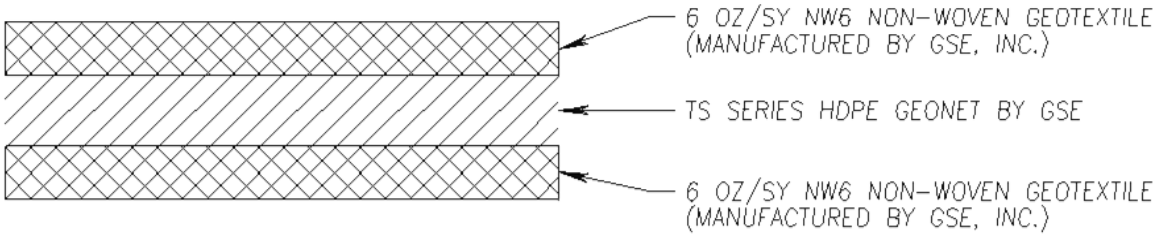
A) Geocomposite Manufacturer: Serrot International, Inc.

Product Name: Poly-Net PN 3000



B) Geocomposite Manufacturer: GSE, Inc.

Product Name: FabriNet



3) Anticipated Field Conditions at the Haywood County White Oak MSW Landfill are:

— Hydraulic Gradient: i = 0.025 (base slope) to 0.25 (side slopes)
* Use i = 0.02 for base slope (conservative)

— Normal Stresses: σ_n = 13,000 psf (max)

4) Calculate Q_{allow} Using Partial Factors of Safety

As recommended by R.M. Koerner (1990), partial factors of safety must be applied when determining an allowable flow rate (Q_{allow}) as follows:

$$Q_{allow} = \frac{Q_{ult}}{FS_p}$$

$$\text{where: } FS_p = \text{partial factors of safety}$$

$$= (FS_{IN} \times FS_{CR} \times FS_{CC} \times FS_{BC})$$

where: FS_{IN} = the factor of safety for elastic deformation, or intrusion of the adjacent geosynthetics into the geonet's core space

FS_{CR} = the factor of safety for creep deformation of the geonet and adjacent geosynthetics into the geonet's core space

FS_{CC} = the factor of safety for chemical clogging and/or precipitation of chemicals in the geonet's core space

FS_{BC} = the factor of safety for biological clogging in the geonet's core space

Below is a chart of recommended preliminary factor of safety values for determining allowable flow rate or transmissivity of geonets:

TABLE 4.2 RECOMMENDED PRELIMINARY FACTORY OF SAFETY VALUES FOR DETERMINING ALLOWABLE FLOW RATE OR TRANSMISSIVITY OF GEONETS

Application area	Factor of safety value in Equation 4.3			
	FS_{IN}	FS_{CR}*	FS_{CC}	FS_{BC}
Sport fields	1.0 to 1.2	1.0 to 1.2	1.0 to 1.2	1.1 to 1.3
Capillary breaks	1.1 to 1.3	1.0 to 1.2	1.1 to 1.5	1.1 to 1.3
Roof and plaza decks	1.2 to 1.4	1.0 to 1.2	1.0 to 1.2	1.1 to 1.3
Retaining walls, seeping rock and soil slopes	1.3 to 1.5	1.2 to 1.4	1.1 to 1.5	1.0 to 1.5
Drainage blankets	1.3 to 1.5	1.2 to 1.4	1.0 to 1.2	1.0 to 1.2
Surface water drains for landfill caps	1.3 to 1.5	1.2 to 1.4	1.0 to 1.2	1.2 to 1.5
Secondary leachate collection (landfill)	1.5 to 2.0	1.4 to 2.0	1.5 to 2.0	1.5 to 2.0
Primary leachate collection (landfill)	1.5 to 2.0	1.4 to 2.0	1.5 to 2.0	1.5 to 2.0

* These values assume that the q_{ult} value was obtained using an applied normal pressure of 1.5 to 2 times the field-anticipated maximum value. If not, the values must be increased.

Reference: Koerner, R.M. (1994), Designing With Geosynthetics, Third Edition.

In reference to the above table:

1) The values for each of these FS_p's generally range from 1.5 to 2.0 for the leachate collection zone.

2) Assuming a value of 1.5 for each FS_p, the total result will be:

$$FS_p = 1.5 \times 1.5 \times 1.5 \times 1.5 = 5.06$$

$$FS_p = 5.06$$

$$Q_{allow} = \frac{Q_{ult}}{FS_p} \qquad FS = \frac{Q_{allow}}{Q_{required}}$$

where: Q_{ult} = results from laboratory testing
$Q_{required} = 2.05 \times 10^{-4}$ gpm/ft

Slope	Q_{ult} (gpm/ft)	Product of FS_p	Q_{allow} (gpm/ft)	$FS = Q_{allow}/Q_{required}$
2% base slopes	0.09	5.06	0.018	88
4H:1V (25%) side slopes	0.40	5.06	0.079	386

B. Allowable Transmissivity (Θ_{allow})

As stated above in part III.A, the calculations that follow in Appendix B.1 contain flow rate and transmissivity test results for two types of double-sided heat-bonded geocomposites. These tests include: 1) GSE, Inc. (GSE) FabriNet HDPE geonet heat-bonded to combinations of 6 and 8 oz/sy nonwoven geotextiles manufactured by GSE, Inc; and 2) Serrot International, Inc. Polynet PN3000 HDPE geonet heat-bonded to combinations of 6 and 8 oz/sy nonwoven geotextiles manufactured by SI Geosolutions.

Transmissivity tests were conducted over a range of hydraulic gradients (0.02 to 1.0) and normal stresses (500 to 20,000 psf). The hydraulic gradients for the proposed landfill will range from 0.02 to 0.25, depending upon location. The maximum normal stress anticipated at capacity will be approximately 6,800 psf (80 feet of waste and cap). Thus, the laboratory results contained herein sufficiently bracket the gradients and normal stresses that are anticipated in the landfill area.

Referring to the transmissivity test results for the double-sided Tex-Net geocomposite against sand only in this case, it can be concluded that ultimate transmissivity (Θ_{ult}) (for hydraulic gradients of 0.02 and 0.25, under normal stresses ranging from 14,000 to 20,000 psf), ranges from 7.7×10^{-4} square meters per second (m^2/sec) to 8.0×10^{-4}

m^2/sec. These values represent the range of ultimate transmissivity for these types of heat-bonded geocomposites.

Koerner (1994) recommends that the ultimate transmissivity be reduced by the use of partial factors of safety to account for elastic deformation, creep deformation, chemical clogging and biological clogging, to arrive at an allowable transmissivity (Θ_{allow}). From part A, above, the product of the partial factors of safety is approximately 5.06, thus resulting in a minimum allowable transmissivity value of 1.52×10^{-4} m^2/sec.

For the Poly-Net PN 3000 material (see page 11 for schematic):

Material Properties

Source	Thickness	Transmissivity
A. Manufacturer's Product Literature	– Geonet = 220 mils = 0.22” – Geotex 651 (6 oz/sy) nonwoven geotextile = 90 mils = 0.09” – Total = 400 mils (0.40”)	– Geonet (θ) = 1.0×10^{-3} m²/sec @ σ_n = 15,000 psf Geotex 651 (6 oz/sy) nonwoven geotextile (each layer) k_p = 0.24 cm/sec t = 90 mils = 0.090 in $\theta = k_p t$ = (0.24 m/sec)(0.090 in) = 0.0549 cm²/sec = 5.49×10^{-4} m²/sec

The allowable transmissivity can be determined as follows, as recommended by R.M. Koerner (1994).

Thus, $q = k_P\, i\, A$

$q = k_P\, (\Delta h)/L\, (W)(t)$

or

$k_P t = \theta = (qL)/(\Delta h W) = q/iW$

where: θ = transmissivity
k_P= permeability coefficient (hydraulic conductivity) in the plane of the fabric
t = the thickness of the fabric
I = the hydraulic gradient
Q = flow rate
L = length of the fabric
Δ = head lost
W = width of the fabric

therefore: $\theta_{Allow} = \theta/FS_P$

and FS_P = partial factors of safety = (FS_{IN} x FS_{CR} x FS_{CC} x FS_{BC})

in which: $FS_P \approx 5.06$ (see previous calculations)

From above table, the ultimate transmissivity value (determined for a hydraulic gradient, *i* = 0.25, and a normal stress range of σ_n = 14,000 - 20,000 psf) to be used in this analysis will be:

$\Theta_{ult} = 7.7 \times 10^{-4}$ m²/sec

NOTE: The lower of the two values will be used to provide a "minimum" result.

therefore:

$$\Theta_{allow} = \frac{\Theta_{ult}}{FS_p} = \frac{7.7 \times 10^{-4}\ m^2/sec}{5.06} = 1.52 \times 10^{-4}\ m^2/sec$$

$$\Theta_{allow} = 1.52 \times 10^{-4}\ m^2/sec$$

C. <u>Maximum In-Plane Permeability</u> ($k_{p(max)}$)

The following two cases were evaluated in determination of the maximum in-plane permeability. Case 1 assumed that the drainage geocomposite thickness remains the same as its original dimensions and Case 2 assumed that the two layers of nonwoven geotextile have been fully deformed by the applied normal stresses and thus, the total compressed thickness of the geocomposite is equivalent to the thickness of the HDPE geonet alone.

Using an allowable transmissivity of 1.52×10^{-4} m²/sec (Part III.B), and a maximum thickness, t_{max}, of 400 mils (0.40 in.) for Case 1, and a minimum thickness, t_{min}, of 220 mils (0.22 in.) for Case 2, the resulting permeabilities were 1.50 cm/sec (Case 1) and 2.72 cm/sec (Case 2). Since the maximum permeability of 2.72 cm/sec resulted from assuming the geonet thickness of 220 mils, it was assumed that this would be a more realistic condition in the field due to the geotextiles intruding into the core space of the geonet; hence, a more realistic permeability value to be used in designing with the geocomposite. Based upon manufacturer's laboratory data, permeabilities of 3.51 and 2.63 cm/sec were utilized in the analysis.

The 2.63 cm/sec value is achieved during a closed cell condition as the weight of approximately 160 feet of waste is imposed on the geonet [approximately equal to 6,800 psf (normal stress)]. It is important to note that the geonet permeability of 2.63 cm/sec would not be experienced during an open cell condition because the stresses caused by

24 inches of protective cover material are considered negligible. Instead, the manufacturer's specified permeability of 10 cm/sec was used for an open cell condition. For conservative purposes, however, the permeability of 2.63 cm/sec was used to simulate the geonet during a closed phase condition, while the 3.51 value was used for the active and interim cell condition, with 10' and 30' of MSW, respectively.

Calculate "k"$_P$ for the following two cases:

Case 1 – Determine k_{min} by assuming that the geocomposite thickness remains the same as its original dimensions (t_{max})

Case 2 – Determine k_{max} by assuming that the two layers of nonwoven geotextile have been fully deformed by the applied normal stresses and the thickness of the geocomposite is equal to the thickness of the HDPE geonet (t_{min})

<u>Case 1</u>:

$$k_{p(min)} = \frac{\Theta_{allow}}{t_{max}}$$

where: t_{max} = 400 mils (0.40 in)
Θ_{allow} = 1.52 x 10^{-4} m²/sec

$$k_{p(min)} = \frac{1.52 \times 10^{-4}\ m^2/sec\ (100\ cm/m)^2}{0.40\ in\left(2.54\ \frac{cm}{in}\right)}$$

$$k_{p(min)} = 1.496\ cm/sec$$

<u>Case 2</u>:

$$k_{p(max)} = \frac{\Theta_{allow}}{t_{min}}$$

where: t_{min} = 220 mils (0.22 in)
Θ_{allow} = 1.52 x 10^{-4} m²/sec

$$k_{p(max)} = \frac{1.52 \times 10^{-4}\ m^2/sec\,(100\ cm/m)^2}{0.22\ in\left(2.54\ \frac{cm}{in}\right)}$$

$$k_{p(max)} = 2.72\ cm/sec$$

RECOMMENDED k_p VALUES

From above, the range of k_P values is:

$$1.496\ cm/sec \le k_P \le 2.72\ cm/sec$$

Most likely, the nonwoven geotextiles will intrude into the HDPE geonet's core space as a result of the normal stresses induced by the weight of the MSW. This will cause the thickness of the geocomposite to resemble that of the geonet alone. Therefore, the thickness of the geocomposite will be a minimum (t_{min}) where the in-plane permeability (k_P) will be at a maximum.

$$\therefore \quad k_{P(max)} = 2.72\ cm/sec$$

CONCLUSIONS

A. Based on the above range of factors of safety (88 to 356), it is evident that the HDPE geonet component of the heat-bonded geocomposite leachate collection zone possesses more than sufficient capacity to convey the design flow rate in the collection system.

B. Based on actual laboratory testing results, it has been shown that the drainage composite, when subjected to high normal stresses (σ_n = 500 - 20,000 psf), still retains its original shape and ability to convey flow. Although the nonwoven geotextile layers tend to intrude on the core space of the HDPE geonet, the flow capacity/transmissivity of the composite is virtually unaffected by the deformations. Thus, as shown, the ultimate transmissivity of the material (under σ_n = 14,000 to 20,000 psf) @ i = 0.25 is approximately 7.7 x 10^{-4} m²/sec. When reduced by a partial factor of safety, FS_p = 5.06, the resulting allowable transmissivity, Θ_{allow}, is about 1.52 x 10^{-4} m²/sec.

C. As shown above, the range of in-place permeability (k_p) will be between 1.5 cm/sec and 2.7 cm/sec, depending on the state of normal stress, composite thickness, and hydraulic gradient. This is determined as a function of Θ_{allow} = 1.52 x 10^{-4} m²/sec (above).

APPENDIX B.2
LEACHATE COLLECTION SYSTEM DESIGN
GEOTEXTILE SOIL RETENTION CRITERIA OF LEACHATE COLLECTION SYSTEM

PURPOSE

Perform appropriate analyses to determine the compatibility between the Protective Cover soils and the underlying nonwoven geotextile fabric. Perform the analyses using multiple industry standard design approaches to determine if the nonwoven geotextile fabric is susceptible to clogging.

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DISCUSSION

According to Koerner [1], as one allows greater flow of liquid through a geotextile, the void spaces in it must be made larger. The limit to which the void spaces can be increased is governed by the point in which the upstream soil particles pass through the geotextile voids along with the flowing liquid. This phenomenon is referred to as "soil piping", in

which the finer soil particles are carried through the geotextile, leaving larger soil voids behind. As the velocity of the liquid increases, this process will accelerate until the soil structure begins to collapse.

This undesirable "soil piping" process can be prevented by making the voids in the geotextile small enough to retain the soil on the upstream side of the fabric. The coarser soil fraction must be initially retained, which happens to be the targeted soil size in the design process. These coarser-sized particles eventually block the finer-sized particles and build up a stable upstream soil structure.

There are a number of design process for the retention of soil in a geotextile, all of which are accomplished by comparing the soil particle size characteristics to the 95% opening size of the geotextile (defined as O_{95} of the geotextile). The Table 2.3 [1] outlines the various the retention criteria.

Table 2.3 Existing geotextile retention criteria, after Christopher and Fischer [3]

Source	*Criterion*	*Remarks*
Task Force #25 (1986)	50% ≤ 0.074 mm, $O_{95} < 0.59$ mm 50% > 0.074 mm, $O_{95} < 0.30$ mm	No limitations on geotextile type or soil type
Calhoun (1972)	$O_{95}/d_{85} \leq 1$	Wovens, soils with ≤50% passing No. 200 sieve
	$O_{95} \leq 0.2$ mm	Wovens, cohesive soils
Zitscher (1975)	$O_{50}/d_{50} \leq 1.7$–2.7	Wovens, soils with CU ≤ 2, d_{50} = 0.1 to 0.2 mm
	$O_{50}/d_{50} \leq 2.5$ to 3.7	Nonwovens, cohesive soil
Ogink (1975)	$O_{90}/d_{90} \leq 1$	Wovens
	$O_{90}/d_{90} \leq 1.8$	Nonwovens
Sweetland (1977)	$O_{15}/d_{85} \leq 1$	Nonwovens, soils with CU = 1.5
	$O_{15}/d_{15} \leq 1$	Nonwovens, soils with CU = 4.0
Rankilor (1981)	$O_{50}/d_{85} \leq 1$	Nonwovens, soils with $0.2 \leq d_{85} \leq 0.25$ mm
	$O_{15}/d_{15} \leq 1$	Nonwovens, soils with $d_{85} >$ 0.25 mm
Schober & Teindl (1979)	$O_{90}/d_{50} \leq 2.5$–4.5	Woven and thin nonwovens, dependent on CU
	$O_{90}/d_{50} \leq 4.5$–7.5	Thick nonwovens, dependent on CU, silt and sand soils
Giroud (1982)	$O_{95}/d_{50} \leq (9$–$18)/\mathrm{CU}$	Dependent on soil CU and density Assumes fines in soil migrate for large CU values
Carroll (1983)	$O_{95}/d_{85} \leq 2$–3	Wovens and nonwovens
Christopher and Holtz (1985)	$O_{95}/d_{85} \leq 1$–2 $O_{95}/d_{15} \leq 1$ or $O_{50}/d_{85} \leq 0.5$	Dependent on soil type and CU Dynamic, pulsating, and cyclic flow, if soil can move beneath geotextile
French Committee on Geotextiles and Geomembranes (1986)	$O_f/d_{85} \leq 0.38$–1.25	Dependent on soil type, compaction, hydraulic and application conditions
Fischer et al. (1990)	$O_{50}/d_{85} \leq 0.8$ $O_{50}/d_{15} \leq 1.8$–7.0 $O_{50}/d_{50} \leq 0.8$–2.0	Based on geotextile pore size distribution, dependent on CU of soil

O_x = geotextile opening size corresponding to x particle size based on dry glass bead sieving.
O_f = filtration opening size based on hydrodynamic sieving.
d_y = soil particle size corresponding to y percent passing.
CU = coefficient of uniformity = d_{60}/d_{10}.

In addition to the Retention criterion, the filter must be sufficiently permeable to ensure that the liquid flow is as free as possible, Permeability criterion. The following sections evaluate the combination of the existing operational cover layer soils and nonwoven geotextile fabric with regards to select (1) Soil Retention criterion and Permeability criterion.

A) Soil Retention Criterion – AASHTO M288-96 Method

"It is recommended that AASHTO M288-96 minimum hydraulic requirements as shown in the table below be also considered in the selection of a geotextiles filter"[2]

Geotextile Criteria for Subsurface Drainage (after AASHTO M288-96)			
Filter Criteria	Percent Soil Passing No. 200 (0.075mm) Sieve		
	<15	15 - 50	>50
Minimum Permittivity, ASTM D-4491	0.5 sec^{-1}	0.2 sec^{-1}	0.1 sec^{-1}
Maximum AOS, ASTM D-4751	0.43 mm	0.25 mm	0.22 mm

Given: Use 6 oz/sy nonwoven geotextile for:

AOS = O_{95} = 0.137 mm (SKAPS TransNet 220-2-6)
Permittivity = 1.47 sec^{-1} (SKAPS TransNet 220-2-6)

Percent Soil Passing No. 200 = 30% (per specifications, see Section 6)

Solution: Since 30% or less passing No. 200 sieve, then geotextile must have a minimum permittivity of 0.2 sec^{-1} and a maximum AOS of 0.25mm. For example, the given geotextile satisfies this criterion.

B) Retention Criterion – Task Force 25 Method

This simplest method of accomplishing soil retention uses the soil particle size characteristics and compares them to the O_{95} size (AOS test) of the fabric. According to Task Force 25, the following is recommended [3]:

1. Soil $\leq$ 50% passing the No. 200 sieve:
   AOS of the fabric $\geq$ No. 30 sieve (i.e., O_{95} < 0.59 mm)
2. Soil $\geq$ 50% passing the No. 200 sieve:
   AOS of the fabric $\geq$ No. 50 sieve (i.e., O_{95} < 0.297 mm)

where: O_{95} = 95% opening size of the geotextile

Given Use 6 oz/sy nonwoven geotextile for:

AOS = O_{95} = 0.137 mm (SKAPS TransNet 220-2-6)
Permittivity = 1.47 sec^{-1} (SKAPS TransNet 220-2-6)

Percent Soil Passing No. 200 = 30% (per specifications, see Section 5)

Solution: Since 30% or less passing No. 200 sieve, then AOS of the fabric must be less than of 0.59mm. For example, the given geotextile satisfies this criterion.

C) Retention Criterion – Carroll Method

"Slightly more restrictive than the Task Force 25 method is the recommendation of Carroll for the AOS which is the following [4]:

$$O_{95} < (2 \text{ or } 3)\ d_{85}$$

where O_{95} = 95% opening size of the geotextile
d_{85} = particle size in millimeters for which 85% of sample is finer". [1]

Given: Use 6 oz/sy nonwoven geotextile for:

AOS = O_{95} = 0.137 mm (SKAPS TransNet 220-2-6)

D85 of a typical 1 x 10^{-4} cm/sec protective sand layer is 1.0 mm

$$\frac{O_{95}}{D_{85}} = \frac{0.137\ mm}{1.0\ mm}$$

$$= 1.37$$

Solution: Since this ratio is less than 2, the geotextile should filter the soil material without clogging.

D) Retention Criterion – Giroud Method

The most conservative method is Giroud [1]. "Giroud uses a linearization of the particle distribution curve that, when plotted with the classical log scale horizontal axis, is as close

as possible to the actual particle distribution curve (Figure 1). A least variance approach was used to determine the best linearization of the central portion (Equation 1 & 2). It should be noted in Figure 1 that there is greater uncertainty on the two extremities (d_0 and d_{100}) of the actual particle size distribution. This justifies the use of the linear particle size distribution curve. The result obtained using Giroud's retention criterion is not affected by the truncation of the particle size distribution curve. A coefficient of determination (R2) is calculated to indicate the effectiveness of the linearization (Equation 3)"[2].

$m = \frac{n(\sum xy) - (\sum x)(\sum y)}{n(\sum(x^2)) - (\sum x)^2}$	$b = \frac{(\sum y)(\sum(x^2)) - (\sum x)(\sum xy)}{(\sum(x^2)) - (\sum x)^2}$	$R^2 = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]}}$
Eq. 1 - Slope determination by the method of the least squares	Eq. 2 - Intercept determination by the method of the least squares	Eq. 3 - The r-squared value can be interpreted as the proportion of the variance in y attributable, to the variance in x

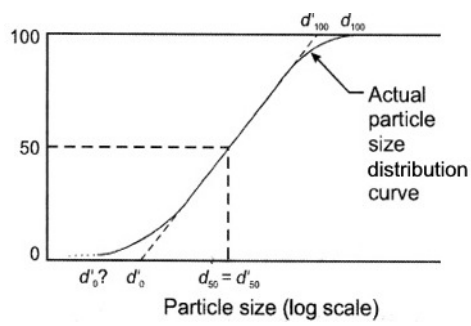


Figure 1 - Linearization of Particle Size Distribution Curve (after Giroud, 2000)

Retention Criterion Equations:

Retention Criterion for the Hyperstable Case (C'_{cu} = 3) expressed using d'_{85S}				
Soil Density	Density Index (Relative Density) I_D	Relative Compaction (R_C)	Linear coefficient of uniformity of the soil, C'_u	
			$1 \leq C'_u \leq 3$	$C'_u > 3$
loose	$I_D \leq 35\%$	$R_C \leq 86\%$	$O_F \leq (C'_u)^{0.3}\ d'_{85S}$	$O_F \leq (9/C'^{1.7}_u)\ d'_{85S}$
medium dense	$35\% < I_D \leq 65\%$	$86\% < R_C \leq 92\%$	$O_F \leq 1.5\ (C'_u)^{0.3}\ d'_{85S}$	$O_F \leq (13.5/C'^{1.7}_u)\ d'_{85S}$
dense	$I_D > 65\%$	$R_C > 92\%$	$O_F \leq 2\ (C'_u)^{0.3}\ d'_{85S}$	$O_F \leq (18/C'^{1.7}_u)\ d'_{85S}$

Retention Criterion for the Hyperstable Case (C'_{cu} = 3) expressed using d'_{50S}				
Soil Density	Density Index (Relative Density) I_D	Relative Compaction (R_C)	Linear coefficient of uniformity of the soil, C'_u	
			$1 \leq C'_u \leq 3$	$C'_u > 3$
loose	$I_D \leq 35\%$	$R_C \leq 86\%$	$O_F \leq (C'_u)\ d'_{50S}$	$O_F \leq (9/C'_u)\ d'_{50S}$
medium dense	$35\% < I_D \leq 65\%$	$86\% < R_C \leq 92\%$	$O_F \leq 1.5\ (C'_u)\ d'_{50S}$	$O_F \leq (13.5/C'_u)\ d'_{50S}$
dense	$I_D > 65\%$	$R_C > 92\%$	$O_F \leq 2\ (C'_u)\ d'_{50S}$	$O_F \leq (18/C'_u)\ d'_{50S}$

where:

C'_u = linear coefficient of uniformity of the soil = d'_{60S} / d'_{10S}
I_D = relative density or density index of the soil
d'_{ms} = the particle size such that m% (on the linear particle size distribution curve) of the linear soil particles by mass are smaller than d'_{ms}
R_C = relative compaction
O_F = maximum filter opening size

Retention Criterion Solutions:

Entering the following input parameters into the geotextile filter calculation [2]:

Typical Particle Distribution Curve for min. 1 x 10^{-4} cm/sec (in millimeters)

Soil d_{10} = 0.01

Soil d_{20} = 0.15

Soil d_{50} = 0.35

Soil d_{60} = 0.45

Soil d_{85} = 1.0

w factor:2

w Factor		
loose	medium dense	dense
1	1.5	2

Yields the following output parameters from the geotextile filter calculation [2]:

Values of the Linear Particle Distribution Curve

Soil d'_0 = 0.082

Soil d'_{10} = 0.110

Soil d'_{20} = 0.147

Soil d'_{50} = 0.352

Soil d'_{60} = 0.470

Soil d'_{85} = 0.973

Soil d'_{100}= 1.505

Maximum Filter Opening Size 1.484 mm

Solution: The AOS of the fabric must be less than of 1.484 mm. For example, the given geotextile satisfies this criterion.

E) Permeability Criteria

$k_f \geq k_s * I_s$	-> against excessive pore water pressure
$k_f \geq k_s$	-> against excessive reduction of flow rate

where:

k_f - Hydraulic conductivity of the geotextile filter

k_s - Hydraulic conductivity of the soil

I_s - Hydraulic gradient in the soil (typical values presented below)

Typical Hydraulic Gradients in the Soil in the Vicinity of the Filter	
Application	Typical hydraulic gradient
Ordinary dewatering trench	1
Vertical wall drain	1.5
Pavement edge drain	1
Landfill leachate collection/detection removal system	1
Landfill closure surface water collection removal system	1
Dam toe drains	2
Dam clay cores	3 to 10
Island channel protection	1
Shoreline protection	10
Liquid impoundment with clay liners	>10

Given:

k_f = 0.433 cm/sec. (minimum, SKAPS TransNet 220-2-6)
$k_s = 1.0 \times 10^{-4}$ cm/sec. (minimum)
$I_s = 1$

Solution:. $0.433 > 1.0 \times 10^{-4}$. Therefore, provided the permeability of the fabric is greater than the permeability of the soil, this criterion is satisfied.

APPENDIX B.3
LEACHATE COLLECTION SYSTEM DESIGN
MAXIMUM HEAD CALCULATIONS OF LEACHATE COLLECTION SYSTEM

The method of estimating the maximum hydraulic head on the proposed liner system is the Moore equation provided by Richardson, et al., 1987. This equation is as follows:

$$h_{max} = \frac{L\sqrt{(c)}}{2}\left(\frac{\tan^2\alpha}{c} + 1 - \frac{\tan\alpha}{c}\sqrt{\tan^2\alpha + c}\right) \qquad \text{(Equation 1)}$$

where:
- h_{max} = maximum head on liner [L]
- c = q/k
- q = leachate impingement rate [L/T]
- k = hydraulic conductivity of collection zone [L/T]
- L = length of longest flow path [L]
- α = slope (degrees)

A hydraulic conductivity of the geocomposite drainage layer (leachate collection zone) was assumed to be equal to 3.94 cm/sec. The length of the maximum flow path on the base slopes is approximately 200 feet and the minimum slope angle is generally 2.00%. Using Equation 1 and a design leachate impingement rate of 1.39 x 10^{-5} cm/sec, the maximum hydraulic head estimated by Moore's equation is approximately 1.13 inches.

In summary, the two methods presented herein indicate that the maximum anticipated hydraulic head on the proposed liner system should range between 0.41 and 1.13 inches. As such, it is concluded that the proposed leachate collection system shall maintain the hydraulic head below one foot within the proposed landfill expansion area.

OBJECTIVE

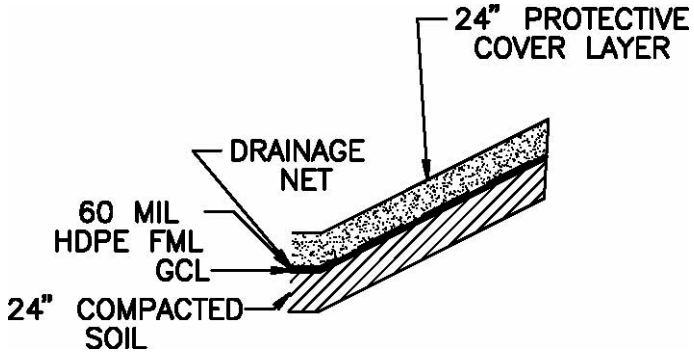
Determine the maximum head on the primary HDPE geomembrane liner.

METHODOLOGY

Use Moore's Equation

ANALYSIS

- <u>Proposed Liner System Configuration</u>



- <u>Design Leachate Impingement Rate</u>

  Dimensional analysis can be used to convert the maximum peak daily leachate flow value (ft³/day-acre) to cm/sec and ft/sec.

$$q_{(required)} = 1.39 \times 10^{-5} \text{ cm/sec} = 4.56 \times 10^{-7} \text{ ft/sec}$$

- Moore's Equation

For a given liner slope, protective cover (drainage layer) permeability percolation rate, and spacing of lateral collection pipes, the location in the landfill with the largest head will be at the lowest point along the longest flow path. Leachate heads on the primary HDPE geomembrane liner can be calculated using the following equation (Richardson, 1987), commonly referred to as Moore's equation:

$$h_{max} = \frac{L\sqrt{(c)}}{2}\left(\frac{\tan^2\alpha}{c} + 1 - \frac{\tan\alpha}{c}\sqrt{\tan^2\alpha + c}\right) \qquad \text{(Equation 1)}$$

where:
- h_{max} = maximum head on liner [L]
- c = q/k
- q = leachate impingement rate [L/T]
- k = hydraulic conductivity of collection zone [L/T]
- L = length of longest flow path [L]
- α = slope (degrees)

for:

$$q_{required} = 1.39 \times 10^{-5} \text{ cm/sec}$$

$$k = 3.94 \text{ cm/sec}$$

$$c = \frac{q_{required}}{k}$$

$$c = 3.53x10^{-6}$$

$$L = 200 \text{ ft}$$

$$\alpha = 2.00\% \Rightarrow 1.15°$$

$$\therefore h_{max} = \frac{(200')\sqrt{3.53\times10^{-6}}}{2}\left(\frac{\tan^2 1.15°}{3.53\times10^{-6}} + 1 - \frac{\tan 1.15°}{3.53\times10^{-6}}\sqrt{\tan^2 1.15° + 3.53\times10^{-6}}\right)$$

$$= (0.188)'\,(113.31 + 1 - 113.81)$$

$$= 0.094' = 1.13''$$

$$h_{max} = 1.13 \text{ inch}$$

CONCLUSION

This method shows that the maximum head on the liner should be less than 12 inches.

APPENDIX B.4
LEACHATE COLLECTION SYSTEM DESIGN
PERFORATED LEACHATE COLLECTION PIPE CALCULATIONS

INTRODUCTION

Leachate collection piping must be incorporated in the leachate collection system so as to effectively and quickly remove any leachate migrating through the leachate collection system. The sizing of these pipes is critical to achieving this goal.

The leachate flow produced will infiltrate through the waste, flow through the protective cover material, collect within the geocomposite leachate collection zone, and gravity flow into the perforated leachate collection pipe network. Subsequently, the leachate will be collected and routed into a leachate header pipe and conveyed to a sump area in each phase.

SPACING OF LEACHATE COLLECTION PIPES

The proposed spacing of the leachate collection pipes for bi-planar drainage net is 200-feet on center (maximum) and oriented at an angle to the flow in the leachate collection zone. The only piping that will be placed on the side slopes of the liner system will be cleanouts for the leachate collection pipes. Otherwise, the perforated leachate collection pipes will be placed on a minimum 0.5 percent post-settlement base slopes.

SIZING OF LEACHATE COLLECTION PIPES

The proposed 8-inch diameter SDR 11 HDPE perforated leachate collection pipes have been evaluated in the attached calculations and may be summarized as follows:

- Part 1 evaluates the available flow capacity of one pipe perforation using the orifice flow equation;
- Part 2 evaluates the required flow rate of the pipes as a result of the design leachate impingement rate {$q_{required} = 1.56 \times 10^{-6}$ cm/sec based on a $q_{(peak\ daily)}$ of 1,718 ft^3/day-acre}
- Part 3 determines the available full flow rates of the pipes; and
- Part 4 determines the maximum area that can be serviced by a single pipe

1) Available Flow Capacity of Pipe Perforations

In reference to Part (1) of the calculations contained herein, it was determined, via the orifice equation, that for heads of 0.33, 0.66 and 1.00 feet, the available flow rate of one 0.5-inch diameter perforation within the leachate collection pipes will be approximately 1.71, 2.38 and 2.92 gallons per minute (gpm), respectively. Thus, for a 4-inch head of leachate overlying the pipe, a 0.5-inch diameter perforation will permit 1.71 gpm of leachate to enter the pipe.

Assuming that there are at least 2 perforations per foot of pipe, each foot of pipe will allow a minimum of 3.4 gpm of leachate to enter under minimal head conditions. With pipes spaced 550 ft on center, the design leachate impingement rate is 0.006 gpm/ft of pipe. This indicates that the perforation diameter is more than adequate to convey leachate during the worst-case condition during the life of the facility.

METHODOLOGY

1) Use the orifice flow equation.

2) Use Manning's equation to calculate $Q_{available}$.

DESIGN CRITERIA/ASSUMPTIONS

1) 1/2" diameter perforations @ 6" OC staggered @ 3" spaced at 4 and 8 o'clock positions.

2) Use Driscopipe manual to obtain Manning's roughness coefficient

   — Use SDR 11 HDPE pipe

   — Average slope → 0.5% to 5.0%

3) Design leachate impingement rate:

$$q_{required} = 1.39 \times 10^{-5} \text{ cm/sec}$$
$$= 4.56 \times 10^{-7} \text{ ft/sec}$$

$$q_{peak\ daily} = 1718 \text{ ft}^3\text{/day} - \text{acre}$$

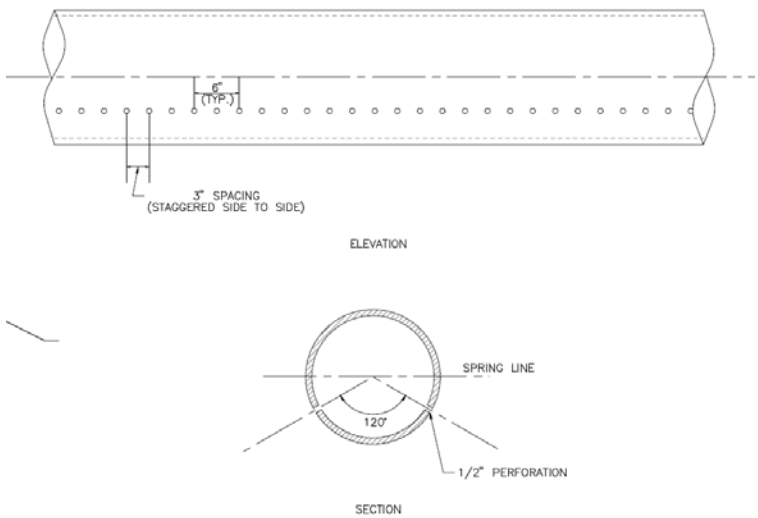
ANALYSIS

1) <u>Flow Capacity of One Pipe Perforation</u>

The leachate collection system piping will consist of 8-inch diameter SDR 11 pipe, with ½" dia. perforations spaced every 6 inches along the pipe at 4 and 8 o'clock positions.

The flow capacity of a pipe perforation can be estimated using the orifice equation:

$$Q = 0.6\,(a)\sqrt{2\,gh}$$



where:
Q = flow capacity of 1 perforation (cfs)
0.6 = orifice coefficient for sharp-edged inlets
a = area of perforation (ft²)
g = acceleration of gravity = 32.2 ft²/sec
h = head of liquid acting on orifice

- For a ½" dia. perforation:

$$a = \frac{\pi D^2}{4}$$

$$= \pi \frac{\left(\frac{0.5}{12}\right)^2}{4} = 1.36 \times 10^{-3}\,ft^2$$

— Evaluating the above equation for different heads:

h (in)	h (ft)	Q (cfs)	Q (gpm)
4	0.33	0.0038	1.71
8	0.66	0.0053	2.38
12	1.00	0.0065	2.92

— Thus, for a 4" head of leachate, a ½" dia. perforation will allow 1.71 gpm to enter the pipe.

– There are at least 2 perforations per foot of pipe, thus, each foot of pipe allows 3.4 gpm to enter under minimal head conditions.

2) Required Flow Rate ($Q_{required}$) of the Leachate Collection Pipes

The design flow rate is based on a leachate impingement rate of 1,718 cubic feet per day per acre or 8.92 gallons per minute per acre.

Design leachate inpingement rate ($q_{required}$)

$$q_{(peak\ daily)} = 1718\ \frac{ft^3}{day - acre}$$

$$q_{required} = \left(1718\frac{ft^3}{day - acre}\right)\left(7.48\frac{gal}{ft^3}\right)\left(\frac{day}{24\ hrs}\right)\left(\frac{hr}{60\ min}\right)$$

$$q_{required} = 8.92\ gpm/acre$$

3) Available Full Flow Capacity ($Q_{available}$) of the Leachate Collection Pipes

Again, the leachate collection system piping will consist of 8-inch nominal diameter (OD) Standard Dimension Ratio (SDR) 11 HDPE pipe. The pipe will be perforated with 1/2-inch diameter holes placed every six inches along the length of

the pipe at 4 and 8 o'clock positions. "Full" flow capacity of these pipes was determined from Manning's equation, given as:

$$Q = \frac{1.49}{n} R^{2/3} S^{1/2} A$$

where:
- Q = flow rate (ft^3/sec)
- n = friction factor (dimensionless)
- R = hydraulic radius (ft)
- S = minimum slope (ft/ft)
- A = cross-sectional area of pipe (ft^2)

The full flow capacity of the pipe itself is evaluated in the attached calculations. Referring to these calculations, the 8-inch diameter DR 11 leachate collection system piping possesses an available full flow capacity ($Q_{f(available)}$) of approximately 292.3 gallons per minute (gpm) when flowing full.

$$Q_{f(available)} = \frac{1.49}{n} R^{2/3} S^{1/2} A$$

$$A = \pi \frac{D^2}{4} = \frac{\pi (6.936''/12'')^2}{4} = 0.264\ ft^2 \text{ (for full flow)}$$

$$R = d/4 = \frac{6.963''(ft/12'')}{4} = 0.145\ ft$$

$$S = 0.5\%$$

4) <u>Available Flow Capacity ($Q_{f(available)}$)</u>

A. Determine Full Flow "$Q_{f(available)}$" of 8” dia. Pipes

- For 8” dia. DR 11 HDPE pipe, the following properties apply (from Driscopipe):

  <u>For DR 11</u>:
  - O.D. = 8.625 inches
  - I.D. = 6.963 inches
  - Manning's n value = 0.015 (aged pipe)

The flow capacity can be approximated by Manning's equation for full pipe flow:

where:
- $Q_{f(available)}$ = full pipe flow flowrate (cfs)
- R = hydraulic radius (ft)
- S = average minimum slope (ft/ft)

A = area of pipe (ft²)

$$Q_{f(available)} = \frac{1.49}{(0.015)}(0.145)^{2/3}(0.005)^{1/2}(0.264\,ft^2)$$

Therefore, $$= 0.512\,cfs\left(7.48\,\frac{gal}{ft^3}\right)\left(\frac{60\,sec}{min}\right) = 229\,gpm$$

$$Q_{f(available)} = 229\,gpm \;\; (\text{for full pipe flow@}0.5\%)$$

$$Q_{f(available)} = \frac{1.49}{(0.015)}(0.145)^{2/3}(0.05)^{1/2}(0.264\,ft^2)$$

$$= 1.62\,cfs\left(7.48\,\frac{gal}{ft^3}\right)\left(\frac{60\,sec}{min}\right) = 726\,gpm$$

$$Q_{f(available)} = 726\,gpm \;\; (\text{for full pipe flow@}5\%)$$

5) <u>Maximum Area That Can Be Serviced</u>

The maximum area that can be adequately serviced by a single leachate pipe was determined for 8-inch diameter pipes at both 0.5% and 5% slopes.

Determine the maximum area that can be serviced

8" Diameter Pipe Flowing Full at 0.5% and 5% Slope

For 0.5% Slope:

q (required) = 8.92 gpm/acre
q (available) = 229 gpm
FS = 1.5
285 gpm/[(8.92 gpm/acre)(1.5)] = 17.1 acres

For 5% Slope:

q (required) = 8.92 gpm/acre
q (available) = 726 gpm
FS = 1.5
726 gpm/[(8.92 gpm/acre)(1.5)] = 54.3 acres

The 8-inch diameter pipe can service up to 17.1 acres and 54.3 acres at 0.5% and 5% slopes, respectively, under full flow conditions.

CONCLUSION

The proposed 8” dia. SDR 11 HDPE perforated leachate collection pipes will adequately convey leachate under partial or full pipe flow conditions for each phase without causing the build-up of head on the liner system under the worst-case conditions (i.e. flat slopes, large cell with 10’ waste and no daily/intermediate cover overlying the waste).

APPENDIX B.5
LEACHATE COLLECTION SYSTEM DESIGN
PERFORATED LEACHATE COLLECTION PIPE LOADING EVALUATION

The leachate collection system will be comprised of 2.0 feet of protective cover sand overlying a double-sided heat-bonded geocomposite drainage layer on base slopes and side slopes and a leachate collection perforated piping system embedded in stone. Each of these components must be able to withstand anticipated loads and stresses exerted on it to insure proper functioning of the leachate collection system. This attachment will evaluate the anticipated loads and determine their effect on the leachate collection system piping.

MAXIMUM ANTICIPATED LOADING CONDITIONS

(1) Static Loading Calculations

The leachate collection system will be exposed to several different loading conditions. The leachate collection system must be able to withstand and function under the maximum anticipated load and stresses. This section will determine the maximum anticipated load created by construction equipment during liner construction, loading during initial waste placement, and loading due to the maximum height of proposed waste.

The maximum anticipated load applied to the leachate collection system was estimated by considering three different cases:

CASE I
Load created by a low ground pressure (LGP) dozer operating on top of the liner system during placement of the 24" thick protective cover.

CASE II
Load created by the weight of a loaded, heavy garbage truck operating on top of a 3-foot layer of select waste overlying the protective cover.

CASE III
Load created by 233 feet of waste and cap system, which is the maximum thickness of waste lying above the subbase.

The load generated at the level of the liner system is evaluated below for each case. The case that results in the highest load was assumed to represent the worst case, and this load is used in the evaluation for bearing capacity.

CASE I:

The load is assumed to be generated by the weight of a LGP D5H Dozer while placing the protective cover plus the weight of 24 inches of protective cover material. Data regarding the applied loads are as follows:

- Dozer operating weight = 33,000 lb.
- Dozer contact pressure = 571 psf = q
- Dozer track width = 34 inches
- Unit weight of protective cover = 125pcf
- Thickness of protective cover = 2.0 feet

The dozer tracks can be considered as a strip load with a width of 34 inches. The vertical stress applied to the liner system was estimated using stress bulb contours for a strip loading. (Adapted from Soil Mechanics, Lambe and Whitman, 1979.)

Referring to the maximum anticipated load calculations contained herein, the stress applied by a LGP dozer, combined with the self-weight of the protective cover soil is approximately 515 pounds per square foot (psf).

Contact Pressure (q) = 571 psf (See below)

$$a = \frac{34''}{2} = 17 inches$$

Depth (z) = 3.5 feet = 42 inches (See below)

$$\frac{z}{a} = \frac{42''}{17''} = 2.47$$

Using Figure 2 @ z/a = 2.47;

$$\frac{\Delta\sigma_1}{\Delta q} = 0.46$$

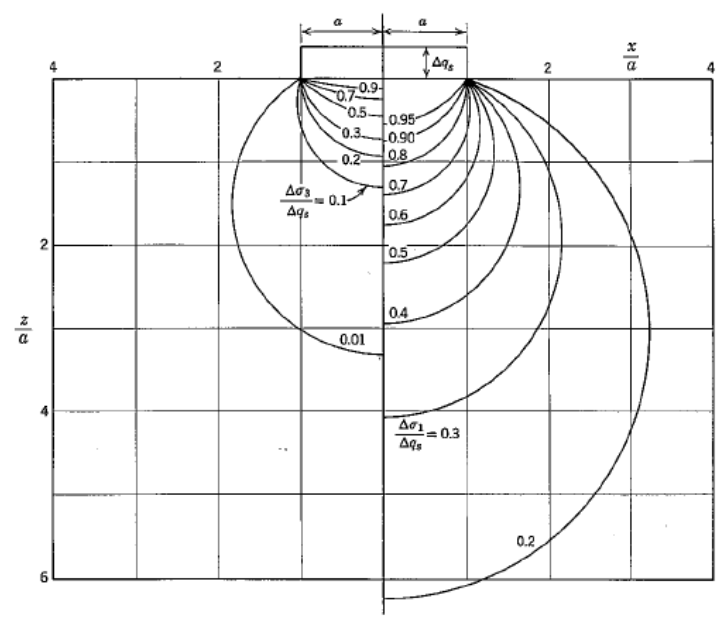


Fig. 8.7 Principal stresses under strip load.

Figure 2 – Principal Stress Under Strip Load (Lambe and Whitman, 1979)

•Determine The Vertical Stress Applied by the Dozer to the Liner Directly Beneath the Center of the Dozer Tread, ($\Delta\sigma_1$);

From above:

$$\frac{\Delta\sigma_1}{\Delta q} = 0.46$$

Thus,

$$\Delta\sigma_1 = \frac{\Delta\sigma_1}{\Delta q} x\, q$$

$$\Delta\sigma_1 = 0.46 \; x \; 571 \; psf = 263 \; psf = \underline{265 \; psf}$$

•Determine The Vertical Stress Applied to the Liner Due to the Weight of the Protective Cover (σ_{vo1}):

Thus;

$$\sigma_{vo1} = \gamma \;\; x \;\; H_{soil}$$

Where:
γ=Unit Weight of Protective Cover Soil
H_{soil}=Thickness of Protective Cover Soil

$$\sigma_{vo1} = (125 \text{ pcf}) \text{ x } (2.0 \text{ ft.}) = 250 \underline{\text{ psf}}$$

•Determine The Total Applied Stress for Case I, (σ_{Total}):

Thus;

$$\sigma_{Total} = \Delta\sigma_1 + \sigma_{vo1}$$
$$\sigma_{Total} = 265 \text{ psf} + 250 \text{ psf} = \underline{515 \text{ psf}}$$

CASE II:

Case II assumes the load to be generated by the weight of the loaded, on-highway dump truck, operating on top of a 3-foot layer of waste overlying the protective cover. This represents the initial lift of waste loading conditions.

Data regarding the applied loads are as follows:

- Truck operating weight (Full) = 100,000 lb.
- Truck tire pressure = 12,960 psf or 90 psi
- Maximum load distribution percentage on axles = 55%
- Unit weight and thickness of protective cover = 125 pcf and 2.0 feet
- Unit weight and thickness of waste = 75 pcf and 3 feet

The vertical stress generated for this case was estimated using methodology proposed by Giroud and Noiray, 1981, for unpaved road design and elastic theory. Calculations to determine the load for Case II are provided herein. Referring to the results of these calculations, the load applied by a loaded heavy garbage truck operating on top of a 3-foot layer of select waste overlying the protective cover, combined with the self-weight of the protective cover soil is approximately 2,160 psf.

Therefore, the Max. Axle Load, (P) = 0.55 x (100,000 lb.) = 55,000 lb.

The rear axle of the truck is assumed to have dual wheels. An equivalent rectangular area can be found for dual wheel axles using the following equation given by:
(Referenced from Giroud and Noiray (1981))

$$2y = x = \sqrt{\sqrt{2}x\frac{P}{P_t}}$$

Where: P = Axle Load (lbs.)
P_t = Tire Pressure (psi)
x = Equiv. Rectangular Length (in.)
y = Equiv. Rectangular Width (in.) For:

For: P = 55,000 lb.
P_t = 90 psi = 12,960 psf

$$2y = x = \sqrt{\sqrt{2}x\frac{55000}{90}}$$

For: x = 29.4 inches

y = 14.7 inches (Equivalent Rectangular Dimensions)

z = 60.0 inches (3' Waste + 2.0' Protective Cover)

The vertical stress applied to the liner can be estimated using stress contours for a rectangular loading (Lambe and Whitman, 1979).

$$m = \frac{x}{z} = \frac{29.4''}{60.0''} = 0.490$$

$$n = \frac{y}{z} = \frac{14.7''}{60.0''} = 0.245$$

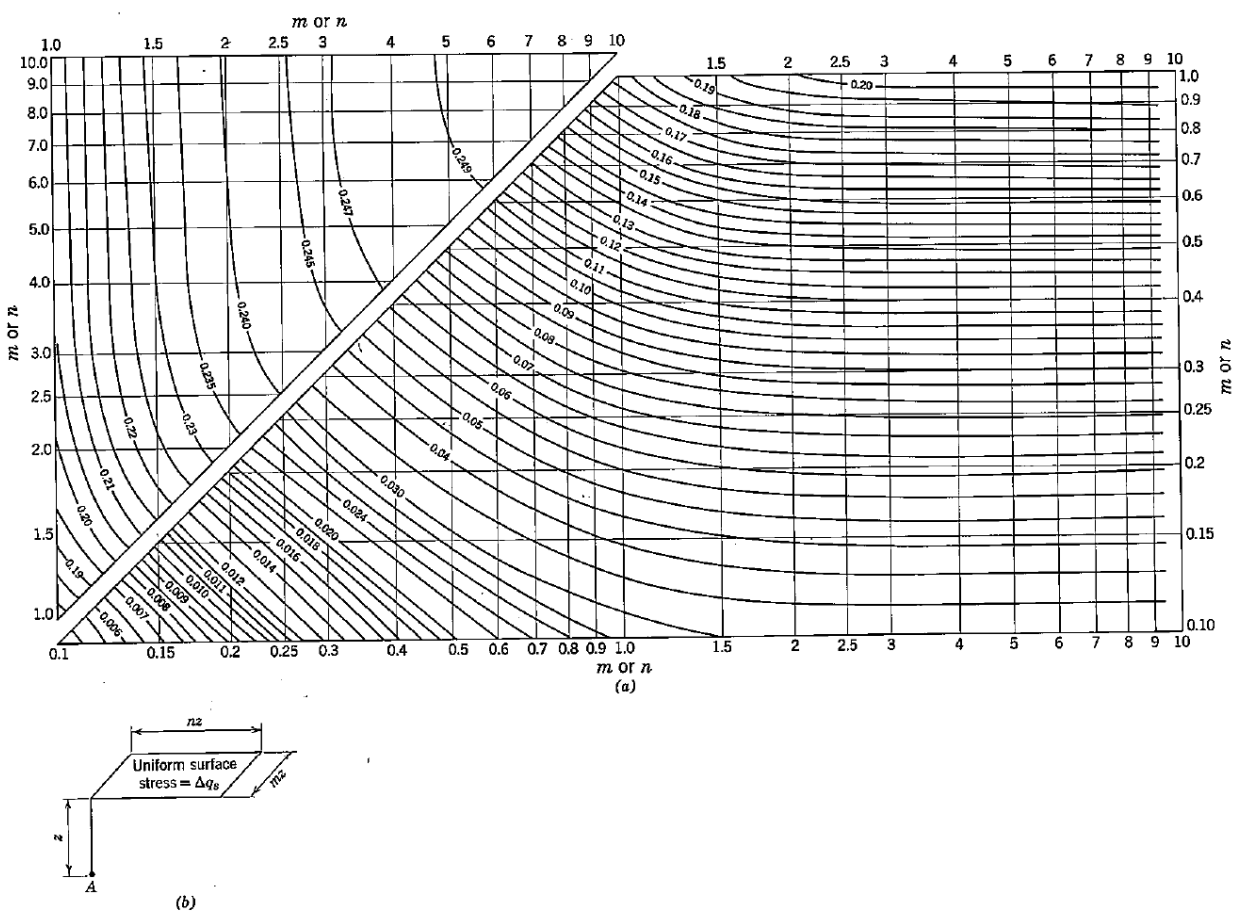


Fig. 8.6 (a) Chart for use in determining vertical stresses below corners of loaded rectangular surface areas on elastic, isotropic material. Chart gives $f(m, n)$. (b) At point A, $\Delta\sigma_v = \Delta q_s \times f(m, n)$. (From Newmark, 1942)

Figure 3 – Vertical Stress Below Corner of Loaded Rectangle (Lambe and Whitman, 1979)

Using m = 0.49 and n = 0.25 and Figure 3, the influence value, I_3, is:

$$I_3 = 0.046$$

(Note: This influence value is for only 1/4 of the equivalent rectangular area.)

The applied stress, σ, is:

$$\sigma_{1/4} = q \times I_3$$

Where: I_3 = Influence Value

$\sigma_{1/4}$ = Vertical stress at top of liner (psf)

q = Equivalent Contact Pressure (psf)

$$q = \frac{P_t}{\sqrt{2}} = \frac{12960}{\sqrt{2}} = 9{,}164\ psf$$

For the loaded rectangular area:

$$\sigma = 4 \times [q \times I_3] = 4 \times [(9{,}164\ \text{psf}) \times (0.046)]$$
$$= \underline{1{,}686\ \text{psf}}$$

$$\sigma_{vo1} = (65\ \text{pcf}) \times (3\ \text{ft})$$
$$= 195\ \text{psf}$$ (Stress due to initial waste thickness of 3 feet)

From Case I calculations:

σ_{vo2} = 250 psf (Stress due to weight of the 2.0-foot protective cover)

From Above Case II calculations:

σ = 1,686 psf (Stress due to weight of the loaded, on highway dump truck)

•Determine The Total Applied Stress for Case II, (σ_{Total}):

Thus;

$$\sigma_{Total} = \sigma + \sigma_{vo1} + \sigma_{vo2}$$

$$\sigma_{Total} = 1{,}686 \text{ psf} + 225 \text{ psf} + 250 \text{ psf} = 2{,}130 \text{ psf}$$

=<u>2,160 psf</u> (Total Applied Stress for Case II)

<u>CASE III:</u>

Case III considers the load on the subbase after closure of the landfill. At this time, the maximum thickness of waste will exist, resulting in the maximum load from the weight of the waste. The pertinent data regarding this case are:

- Maximum Waste Thickness = 233 feet
- Average Unit Weight of Waste = 75 pcf
- Unit weight and thickness of protective cover = 125 pcf and 2 feet
- Unit weight and thickness of closure system cover = 125 pcf and 3.5 feet

Calculations to determine the load for Case III are provided herein. Referring to the results of these calculations, the load applied by the maximum thickness of waste, combined with the self-weight of the protective cover material is approximately 12,688 psf or 88 psi.

Therefore;

$$\Delta\sigma_{max} = \gamma_{waste} \times H_{waste}$$

Where:

γ_{waste} =Average Unit Weight of Waste
H_{waste} =Maximum Waste Thickness

$$\Delta\sigma_{max} = 75 \text{ pcf} \times 233 \text{ feet}$$
$$\Delta\sigma_{max} = \underline{17{,}475 \text{ psf}}$$

From Case I calculations:

σ_{vo1}= 250 psf (Stress due to weight of the 2.0 foot protective cover)

Vertical stress due to final closure system:

σ_{vo2}= 125 psf x 3.5 ft = 438 (Stress due to weight of the 3.5 foot closure s ystem)

•Determine The Total Applied Stress for Case III, (σ_{Total}):

Thus;

$$\sigma_{Total} = \Delta\sigma_{max} + \sigma_{vo1} + \sigma_{vo2}$$

$$\sigma_{Total} = 17{,}475 \text{ psf} + 250 \text{ psf} + 438 \text{ psf}$$

=<u>18,163 psf</u> or <u>126 psi</u> (Total Applied Stress for Case III)

SUMMARY OF LOADING CONDITIONS

CASE	MAXIMUM ANTICIPATED STRESS ON SUBBASE, σ_{Total} (psf)
I	515
II	2,160
III	18,163

Based on the results of the analyses for the above loading conditions (Case I through Case III), the maximum or critical loading condition occurs after closure when the maximum thickness of waste exists. Thus, this load will be used in the subsequent analysis for evaluating the structural integrity of the leachate piping system.

(2) Dynamic Loading Calculations

The leachate collection system will be exposed to dynamic loading conditions as well. This section has evaluated the maximum anticipated dynamic load created by construction equipment during an empty-cell condition and a full-cell condition. Results from the calculations indicate that approximately 5,097 psf of dynamic pressure will be exerted on the leachate collection system during the empty-cell condition whereas only 0.26 psf of dynamic pressure will occur during the full-cell condition, due to the high thickness of waste during this condition.

When the total stress (static plus dynamic) was determined for each condition, the stress on the leachate collection system totaled 5,612 psf and 6,688 psf for the empty- and full-cell conditions, respectively. Since the full-cell scenario is a worst-case condition, a stress of 6,688 psf (47 psi) was used to evaluate the pipe structural capacity described below.

Objective:

Determine the Maximum Anticipated Dynamic Loading Pressure applied to the leachate collection system of the proposed liner system, as shown in the preceding calculations

Analysis:

$$P_D = \frac{3\,wz^3}{2\pi\,R^5}$$

Where:

W = 1.5 x Superimposed dynamic load
Z = Vertical distance from the point of load to the top of the pipe
R = Straight line distance from point of load to the top of the pipe

$$R = \sqrt{x^2 + y^2 + z^2}$$

Assume H20 Highway Loading: Two 16,000 lb. concentrated loads applied to two 18" x 20" areas, one located over the point in question, and the other located at a distance of 72" away.
Where: $W = 1.5(16{,}000) = 24{,}000\ lbs$

$$R_1 = \sqrt{0^2 + 0^2 + 1.5^2} = 1.5\ ft\ (empty)$$
$$= 160\ ft\ (full)$$

$$R_2 = \sqrt{0^2 + 6^2 + 1.5^2} = 6.18\ ft\ (empty)$$
$$= 160.1\ ft\ (full)$$

P(D,e) = Dynamic Loading for Empty Cell
P(D,f) = Dynamic Loading for Full Cell
σ(s,e) = Static Loading for Empty Cell (due to bulldozer operating weight)
σ(s,f) = Static Loading for Full Cell (due to 200 ft. of waste)
P(T) = Total (Static + Dynamic) Loading

Note: All static loading values referenced from preceding calculations.

$$P_{D_{1e}} = \frac{3(24{,}000)(1.5)^3}{2\pi(1.5)^5} = 5{,}093\,\frac{lb}{ft^2} = 35\ psi$$

$$P_{D_{2e}} = \frac{3(24{,}000)(1.5)^3}{2\pi(6.18)^5} = 4.29\,\frac{lb}{ft^2} = 0.03\ psi$$

$$P_{D_{1f}} = \frac{3(24{,}000)(160.1)^3}{2\pi(160.1)^5} = 0.44\,\frac{lb}{ft^2} = 0.003\ psi$$

$$P_{D_{2f}} = \frac{3(24{,}000)(160.1)^3}{2\pi(160.1)^5} = 0.44\,\frac{lb}{ft^2} = 0.003\ psi$$

Summary:

For Empty Cell Condition

$$P_{D_e} = 5{,}093\,\frac{lb}{ft^2} + 4.29\,\frac{lb}{ft^2} = 5{,}097\,\frac{lb}{ft^2}$$

$$P_T = \sigma_{s_e} + P_{D_e} = 515\,\frac{lb}{ft^2} + 5{,}097\,\frac{lb}{ft^2} = \underline{5{,}612\,\frac{lb}{ft^2}}$$

For Full Cell Condition

$$P_{D_f} = 0.44\,\frac{lb}{ft^2} + 0.44\,\frac{lb}{ft^2} = 0.88\,\frac{lb}{ft^2}$$

$$P_T = \sigma_{s_f} + P_{D_f} = 18{,}163\,\frac{lb}{ft^2} + 0.88\,\frac{lb}{ft^2} = \underline{18{,}164\,\frac{lb}{ft^2}}$$

For purposes of the design, the maximum loading pressure that would be applied to the leachate collection system is the full cell static condition at 18,164 psf (126 psi). The 0.88 psf dynamic loading is very small in comparison to the static loading calculation and is therefore ignored.

EVALUATION OF MAXIMUM ANTICIPATED LOAD ON COLLECTION PIPES

The leachate collection piping system will be subjected to a maximum static and dynamic loading of 18,164 psf (126 psi) at closure. The proposed collection pipes (located on the base slopes) are 8-inch nominal diameter HDPE Standard Dimension Ratio (SDR) 11 pipes. Based on the calculations in Appendix C.6, it was concluded that the proposed SDR 11 HDPE leachate collection piping will withstand anticipated loads. Since a maximum waste height of 233 feet was

used in the calculations for maximum load, it can be concluded that the average waste thickness will be less detrimental to the pipe system.

CONCLUSIONS

In conclusion, the leachate collection piping system proposed for the proposed landfill will be able to withstand anticipated loads, stresses, and disturbances from overlying waste, waste cover materials, and equipment operation. The stone backfill should limit deflection of the HDPE pipe to within acceptable values. An SDR 11 pipe is specified since it has sufficient strength to resist crushing and buckling, and it should allow the development of a more pronounced soil arch relative to a thinner pipe wall dimension. This soil arch helps to reduce the load applied to the pipe. This attachment has shown that the entire leachate collection system will be able to withstand anticipated loads, stresses, and disturbances from overlying waste, waste cover materials, and equipment operation.

REFERENCES:

1.) Giroud, J.P. and Noirary, L. (1981). "Geotextile-Reinforced Unpaved Road Design," Journal of Geotechnical Engineering Division, Vol. 107, No. GT9, September, 1981, pp. 1233-1254.

2.) Holtz and Kovacs. (1981).

3.) Lambe and Whitman, Soil Mechanics, 1979.

4.) Das, B.M. (1990). Principles of Geotechnical Engineering, Second Edition, p. 199.

5.) Caterpillar Performance Handbook, Editon 19, p. 21.

APPENDIX B.6
LEACHATE COLLECTION SYSTEM DESIGN
PERFORATED LEACHATE COLLECTION PIPE
STRUCTURAL CALCULATIONS

Proposed HDPE pipes and existing HDPE pipes are evaluated for structural stability under the proposed landfill loading. Evaluation methods for deflection, wall buckling, and wall compressive stresses are described in AWWA M55 PE Pipe – Design and Installation.

Based on the structural evaluations presented on the following pages, DR11 pipe is structurally adequate to carry the anticipated loads imposed by the landfill.

JOB NAME	Haywood County White Oak MSWLF Phase 4&5 Expansion		
SUBJECT	HDPE Pipe Structural Evaluation - Buckling		
DATE	13-May-16	**Computed By**	Craig Fortner
NO. PAGES	1	**Checked By**	Stefan Bray

Objective:

Evaluate the structural stability of HDPE pipe in buried application in the proposed Class Three Landfill

Method:

Design methods are outlined in AWWA M55, PE Pipe Design and Installation as indicated.

Pipe Properties:

D:	8	in. Nominal diameter
DR:	11	dim
Do:	8.625	in. (Table 3-1)
t:	0.784	in. (Table 3-1)
Di:	6.963	in. (Table 3-1)
Dm:	**7.841**	in. (discussed in Eq. 5-8)
E:	28,250	psi, Apparent modulus of elasticity, 100,000 short-term, 28,250 long-term (Table 5-6)
E:	110,000	psi, Apparent modulus of elasticity, 100,000 short-term, 28,250 long-term (Table 5-6)
v:	0.45	dim, Poisson ratio, 0.45 for long term stress, 0.35 short term (AWWA M55, p. 110)
v:	0.35	dim, Poisson ratio, 0.45 for long term stress, 0.35 short term (AWWA M55, p. 110)

Pipe Properties:

PE =	126	earth load at crown, psi - SEE APPENDIX B.5
PL =	0	live load at crown, psi
PES =	0	surcharge load at crown, psi

Backfill Properties:

H_w =	0	ft, height of water above pipe-->Assume 0 due to pipe being perforated
H =	50	ft, depth of cover-->Assume bridging effect from initial lift of waste

Wall Buckling Equation:

$$P_{CA} = \frac{5.65}{N}\sqrt{R_b B' E' \frac{E}{12(DR-1)^3}}$$

Eq. 5-10

Where:

N =	2.0	safety factor
R_b =	1	buoyancy reduction factor (Eq 5-11)
B' =	0.865728	soil elastic support factor (Eq 5-12)
E' =	4000	design modulus of soil reaction, psi (USBR M-25 Second Edition)

P_{CA} =	255.0691	psi allowable
P_E =	126	psi applied (see App. B.5)
OK		

Wall Compressive Stress Equation:

$$S = \frac{P_E(DR-1)}{2}$$

Eq. 5-15

Per AWWA M55, the allowable long-term compressive stress for PE3408 pipe is 1,000 psi

S =	630	psi	<1,000 -->OK

GARRETT & MOORE
Engineering for the Power and Waste Industries

JOB NAME	Haywood County White Oak MSWLF Phase 4&5 Expansion		
SUBJECT	HDPE Pipe Structural Evaluation - Deflection		
DATE	13-May-16	**Computed By**	Craig Fortner
NO. PAGES	1	**Checked By**	Stefan Bray

Objective:

Evaluate the structural stability of HDPE pipe in buried application in the proposed Class Three Landfill

Method:

Design methods are outlined in AWWA M55, PE Pipe Design and Installation as indicated.

Pipe Properties:

D:	8	in. Nominal diameter
DR:	11	dim
Do:	8.625	in. (Table 3-1)
t:	0.784	in. (Table 3-1)
Di:	6.963	in. (Table 3-1)
Dm:	**7.841**	in. (discussed in Eq. 5-8)
E:	28,250	psi, Apparent modulus of elasticity, 110,000 short-term, 28,250 long-term (Table 5-6)
E:	110,000	psi, Apparent modulus of elasticity, 110,000 short-term, 28,250 long-term (Table 5-6)
v:	0.45	dim, Poisson ratio, 0.45 for long term stress, 0.35 short term (AWWA M55, p. 110)
v:	0.35	dim, Poisson ratio, 0.45 for long term stress, 0.35 short term (AWWA M55, p. 110)

Pipe Properties:

PE =	126	earth load at crown, psi - SEE APPENDIX B.5
PL =	0	live load at crown, psi
PES =	0	surcharge load at crown, psi

Deflection Equation:

$$\%\frac{\Delta Y}{D_M} = \frac{K(T_L P_E + P_L + P_{ES})}{\frac{2E}{3(DR-1)^3} + 0.061E'}(100) \quad \text{Eq. 5-8}$$

18.9	numerator
18.833333	pipe stiffness term
244	soil stiffness term

7.2 %, Calculated Deflection[2]
<7.5% -->OK

Where:

K =	0.1	bedding constant, 0.1
T_L =	1.5	time lag factor
P_E =	126	earth load at crown, psi
P_L =	0	live load at crown, psi
P_{ES} =	0	surcharge load at crown, psi
E =	28,250	apparent modulus of elasticity, psi[1]
DR =	11	dimension ratio
E' =	4000	design modulus of soil reaction, psi (USBR M-25 Second Edition)

Notes:

[1] Per AWWA M55, "for non-pressure applications, a rule-of-thumb is to use the long-term modulus if the first term in the denominator of Eq. 5-8 (pipe stiffness term) is greater than 25% of the second term in the denominator (soil stiffness term)."

[2] Per AWWA M55, "for non-pressure applications, a 7.5 percent deflection limit provides a large safety factor against instability and is considered a safe design deflection."

APPENDIX B.7
LEACHATE COLLECTION SYSTEM DESIGN
LEACHATE REMOVAL AND TRANSMISSION

Proposed leachate pump and discharge system design is presented on the following pages.

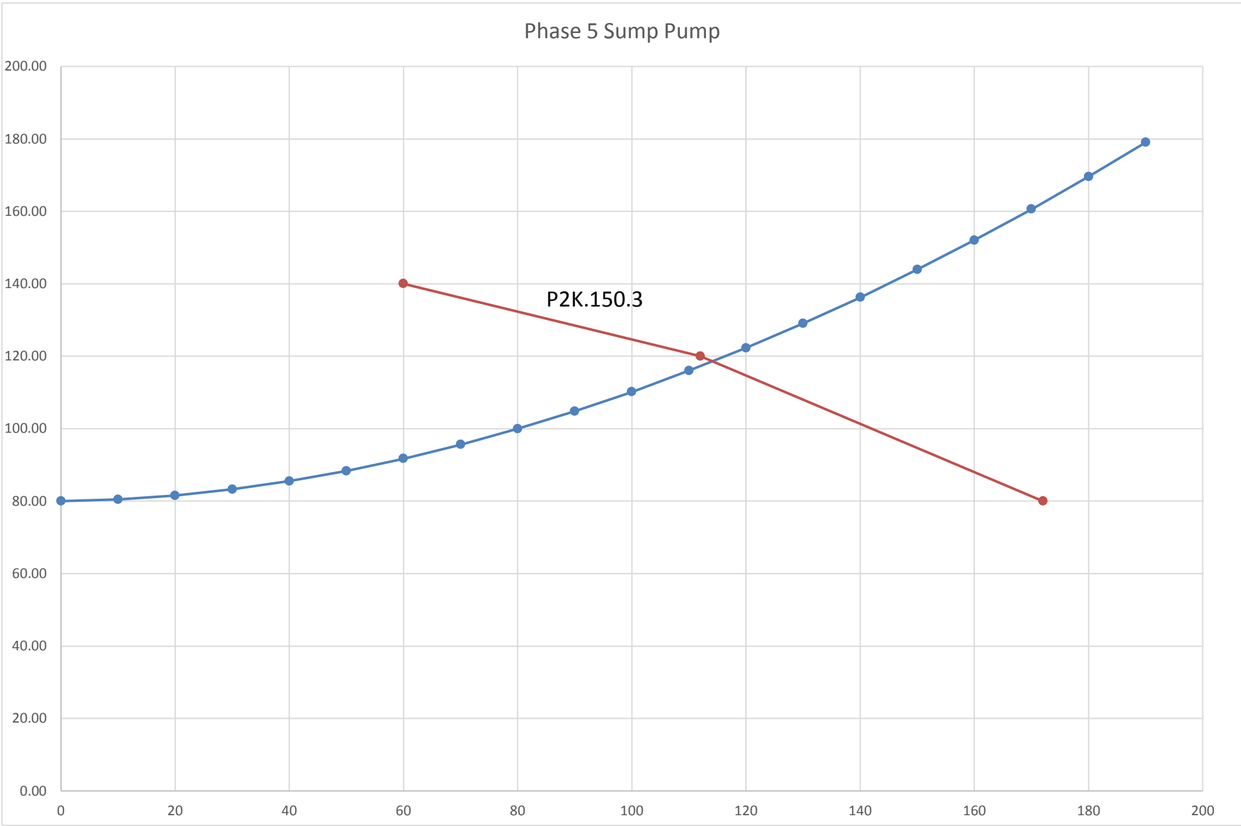
Calculate System Curve and Plot Pump Curves

Pump Station - Phase 5 Sump

Increment 10

Pump Station

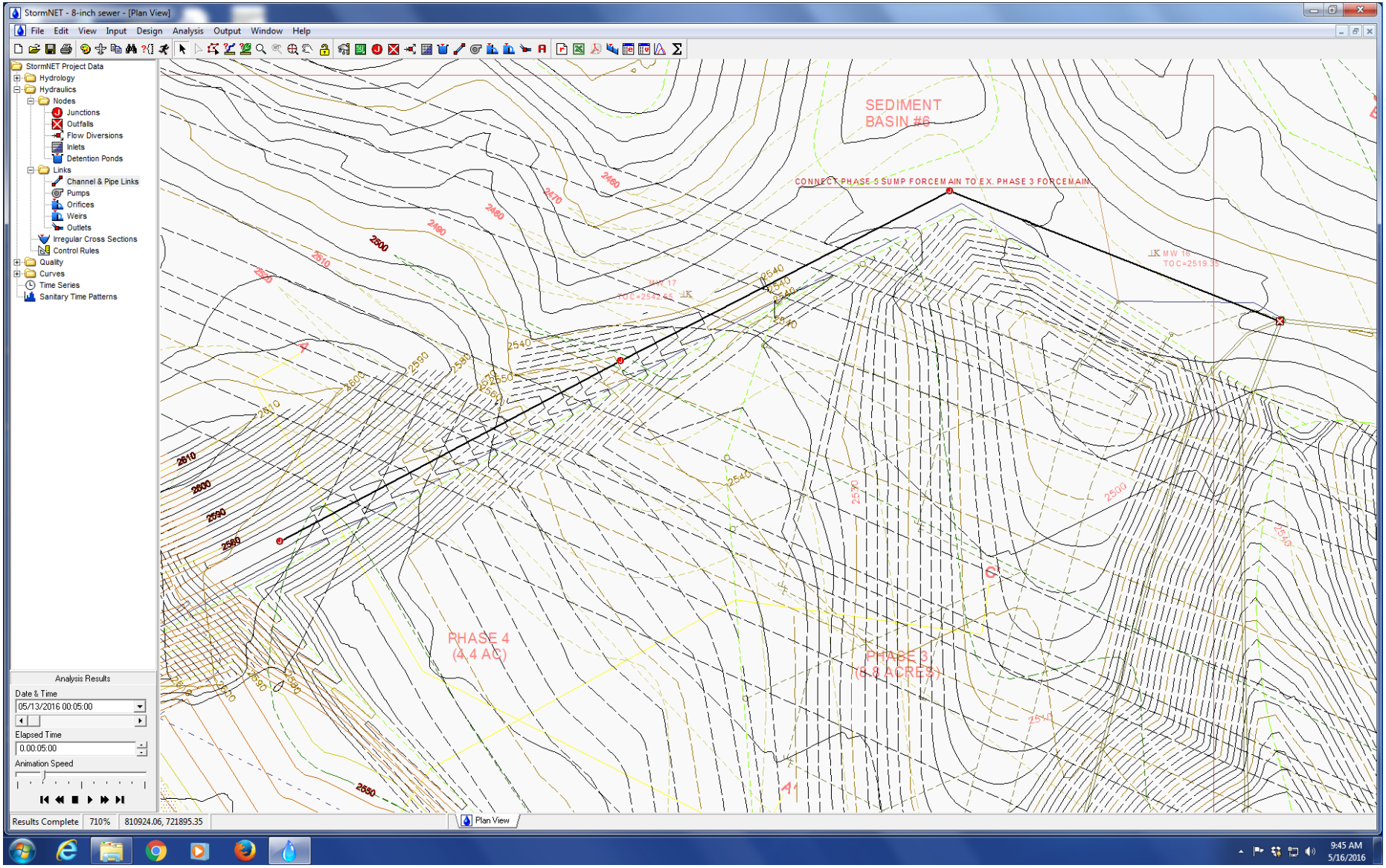
q = volume flow (gal/min)	**0**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**	**130**	**140**	**150**	**160**	**170**	**180**	**190**
l = length of pipe (ft)	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800
c = Hazen-Williams roughness constant	**140**	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140
dh = inside or hydraulic diameter (inches)	**2.8**	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
Calculated Pressure Loss																				
f = friction head loss in feet of water per 100 feet of pipe (ft H20 per 100 ft pipe)	0.00	0.05	0.19	0.41	0.69	1.04	1.46	1.95	2.49	3.10	3.77	4.50	5.29	6.13	7.03	7.99	9.00	10.07	11.20	12.38
f = friction head loss in psi of water per 100 feet of pipe (psi per 100 ft pipe)	0.00	0.02	0.08	0.17	0.30	0.45	0.63	0.84	1.07	1.33	1.62	1.93	2.27	2.64	3.02	3.44	3.87	4.33	4.82	5.32
Head loss (ft H20)	0.00	0.42	1.53	3.24	5.53	8.36	11.71	15.58	19.95	24.82	30.16	35.99	42.28	49.04	56.25	63.92	72.03	80.59	89.59	99.03
Static Head	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
Total Dynamic Head	**80.00**	**80.42**	**81.53**	**83.24**	**85.53**	**88.36**	**91.71**	**95.58**	**99.95**	**104.82**	**110.16**	**115.99**	**122.28**	**129.04**	**136.25**	**143.92**	**152.03**	**160.59**	**169.59**	**179.03**
Calculated Flow Velocity																				
v = flow velocity (ft/s)	0.00	0.52	1.04	1.56	2.09	2.61	3.13	3.65	4.17	4.69	5.21	5.73	6.26	6.78	7.30	7.82	8.34	8.86	9.38	9.90
Operating Pressure (psi)	34.632035	34.81564	35.29486	36.03653	37.02483	38.24932	39.70226	41.37751	43.27004	45.37559	47.69046	50.21141	52.93555	55.86027	58.983207	62.302201	65.81525	69.520523	73.41629	77.50094



3-Pt Curve P2K.150.3

GPM	TDH
60	140
112	120
172	80

SN	Element ID	From (Inlet) Node	To (Outlet) Node	Length	Inlet Invert Elevation	Inlet Invert Offset	Outlet Invert Elevation	Outlet Invert Offset	Average Slope	Pipe Shape	Pipe Diameter or Height	Manning's Roughness	Entrance Losses	Exit/Bend Losses	Initial Flow	Flap Gate	Lengthening Factor	Peak Flow	Max Flow Velocity	Design Flow Capacity	Max Flow / Design Flow Ratio	Max Flow Depth / Total Depth Ratio	Max Flow Depth
				(ft)	(ft)	(ft)	(ft)	(ft)	(%)		(inches)				(cfs)			(cfs)	(ft/sec)	(cfs)			(ft)
1	Pipe 3 to 2	MH 3	EX MH 2	312.00	2509.00	0.00	2500.00	0.00	2.8846	Circular	8.000	0.0150	0.5000	0.5000	0.00	NO	1.00	0.33	3.89	1.78	0.19	0.29	0.19
2	Pipe 4 to 3	MH 4	MH 3	386.00	2531.00	0.00	2509.00	0.00	5.6995	Circular	8.000	0.0150	0.5000	0.5000	0.00	NO	1.00	0.33	4.97	2.50	0.13	0.25	0.16
3	Pipe 5 to 4	MH 5	MH 4	390.00	2567.00	0.00	2531.00	0.00	9.2308	Circular	8.000	0.0150	0.5000	0.5000	0.00	NO	1.00	0.33	5.89	3.18	0.10	0.22	0.15


StormNET - 8-inch sewer - [Plan View]
File Edit View Input Design Analysis Output Window Help
StormNET Project Data
Hydrology
Hydraulics
Nodes
Junctions
Outfalls
Flow Diversions
Inlets
Detention Ponds
Links
Channel & Pipe Links
Pumps
Orifices
Weirs
Outlets
Irregular Cross Sections
Control Rules
Quality
Curves
Time Series
Sanitary Time Patterns
Analysis Results
Date & Time
05/13/2016 00:05:00
Elapsed Time
0.00:05:00
Animation Speed
SEDIMENT BASIN #6
CONNECT PHASE 5 SUMP FORCEMAIN TO EX. PHASE 3 FORCEMAIN
PHASE 4 (4.4 AC)
PHASE 3 (6.8 ACRES)
Results Complete
710%
810924.06, 721895.35
Plan View
9:45 AM
5/16/2016

ENGINEERING REPORT

APPENDIX C
SLOPE STABILITY ANALYSIS & FACTOR OF SAFETY FOR SEISMIC IMPACT ZONE

(PREPARED BY OTHERS, TO BE SUBMITTED UNDER SEPARATE COVER)

ENGINEERING REPORT

APPENDIX D
ANALYSIS OF FINAL COVER SYSTEM

Part	Description	Page
D.1	Alternate Final Cover Equivalency Demonstration	D-1
D.2	Final Cover Stormwater Design	D-27

APPENDIX D

ALTERNATE FINAL COVER EQUIVALENCY DEMONSTRATION

Purpose

One final cover system is proposed as part of the Haywood County White Oak MSWLF permit application. Demonstration 1 is a final cover system that meets the current solid waste regulations, presented for the purpose of comparing the proposed design to a regulatory standard cover system. The proposed final cover system is designed to meet or exceed the performance of the regulatory prescribed final cover system, but which does not conform to the regulatory specified system and is therefore considered an “alternate” system. The solid waste regulations, which are based on EPA’s Subtitle D regulations, provide for other landfill closure designs provided there is adequate information to demonstrate the proposed design meet or exceeds the environmental and public health protection standards established in the solid waste regulations.

The purpose of this report is to demonstrate the proposed alternate final cover system, the alternate final cover system, as proposed in the permit application, meets the regulatory standards.

Regulatory Requirements

Rule 15A NCAC 13B .1627 establishes criteria for the closure of all MSWLF units. Regarding closure criteria, Rule .1627 states:

(1) New and existing MSWLF units and lateral expansions shall install a cap system that is designed to minimize infiltration and erosion. The cap system shall be designed and constructed to:

(A) Have a permeability less than or equal to the permeability of any base liner system or the in-situ subsoils underlaying the landfill, or the permeability specified for the final cover in the effective permit, or a permeability no greater than 1 x 10-5 cm/sec, whichever is less;

(B) Minimize infiltration through the closed MSWLF by the use of a low-permeability barrier that contains a minimum 18 inches of earthen material; and

(C) Minimize erosion of the cap system and protect the low-permeability barrier from root penetration by use of an erosion layer that contains a minimum of six inches of earthen material that is capable of sustaining native plant growth.

(2) The Division may approve an alternative cap system if the owner or operator can adequately demonstrate the following:

(A) The alternative cap system will achieve an equivalent or greater reduction in infiltration as the low-permeability barrier specified in Subparagraph (1) of this Paragraph; and

(B) The erosion layer will provide equivalent or improved protection as the erosion layer specified in Subparagraph (3) of this Paragraph.

(1) Construction of the cap system for all MSWLF units shall conform to the requirements set forth in Subparagraphs (b)(8), (b)(9) and (b)(15) of Rule .1624 and the following requirements:

(A) Post-settlement surface slopes shall be a minimum of five percent and a maximum of 25 percent; and

(B) A gas venting or collection system shall be installed below the low-permeability barrier to minimize pressures exerted on the barrier.

As shown on Figure 1, the prepared “regulatory cap” is comprised of an 18-inch-thick low permeable Infiltration Layer, which is overlain by a flexible membrane liner (FML). The Infiltration Layer and FML are overlain by a 12-inch-thick Drainage Layer a 24-inch-thick layer of soil capable of supporting native vegetation.

Much has been learned in recent years about the predicted performance, constructability and liner integrity, stability, and long-term maintenance of final cover systems for lined landfills. This is primarily due to the fact that only recently have some of the landfills that were initially permitted upon the promulgation of the Subtitle D rules have entered into the facility’s closure and post-closure care periods. Based on lessons learned by others and as allowed by Rule .1627 of the regulations, Haywood County wishes to permit a proposed “alternate” final cover system, as shown on Figure 2, for the White Oak MSWLF.

REGULATORY CAP

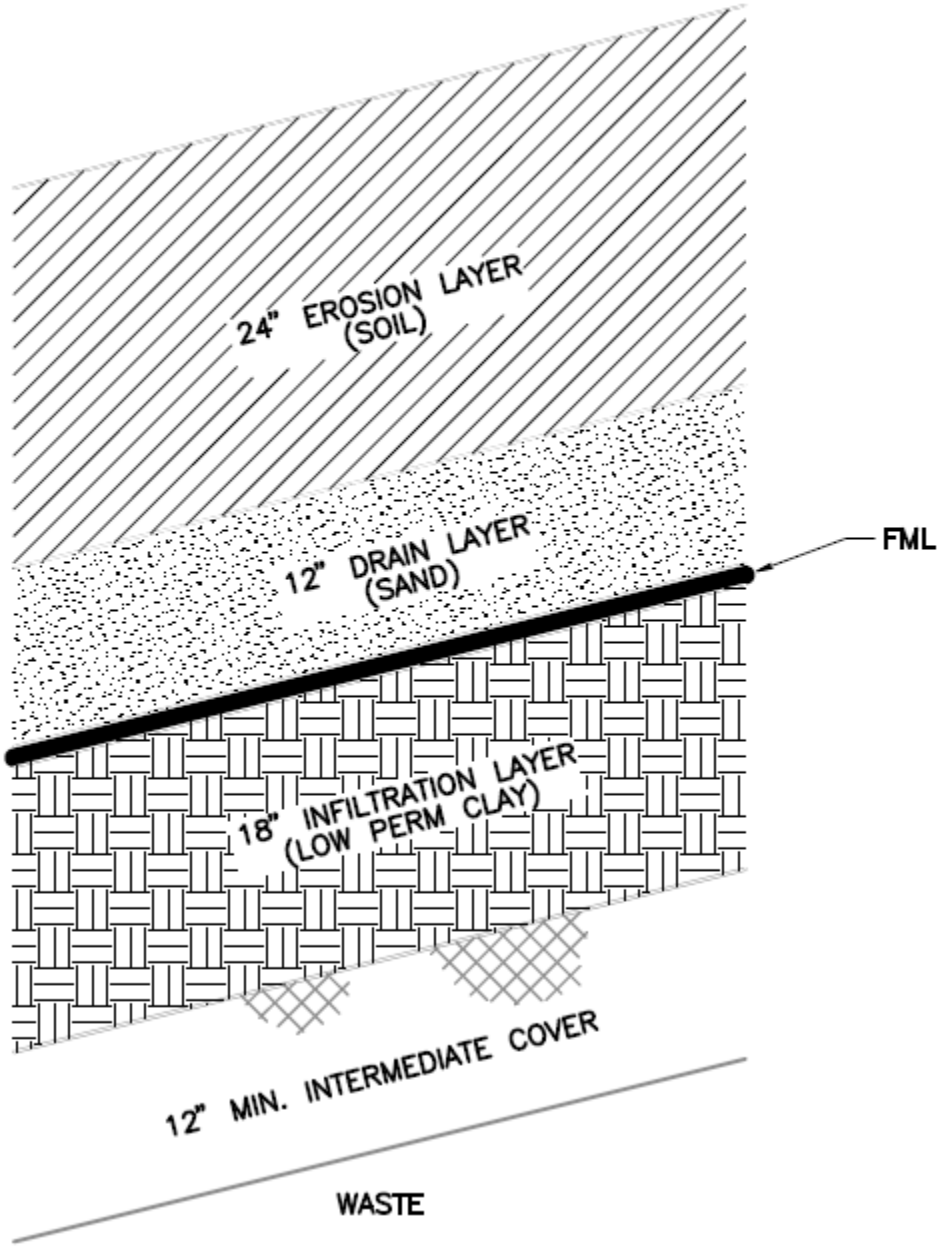


Figure 1 – Regulatory Cap

PROPOSED CAP

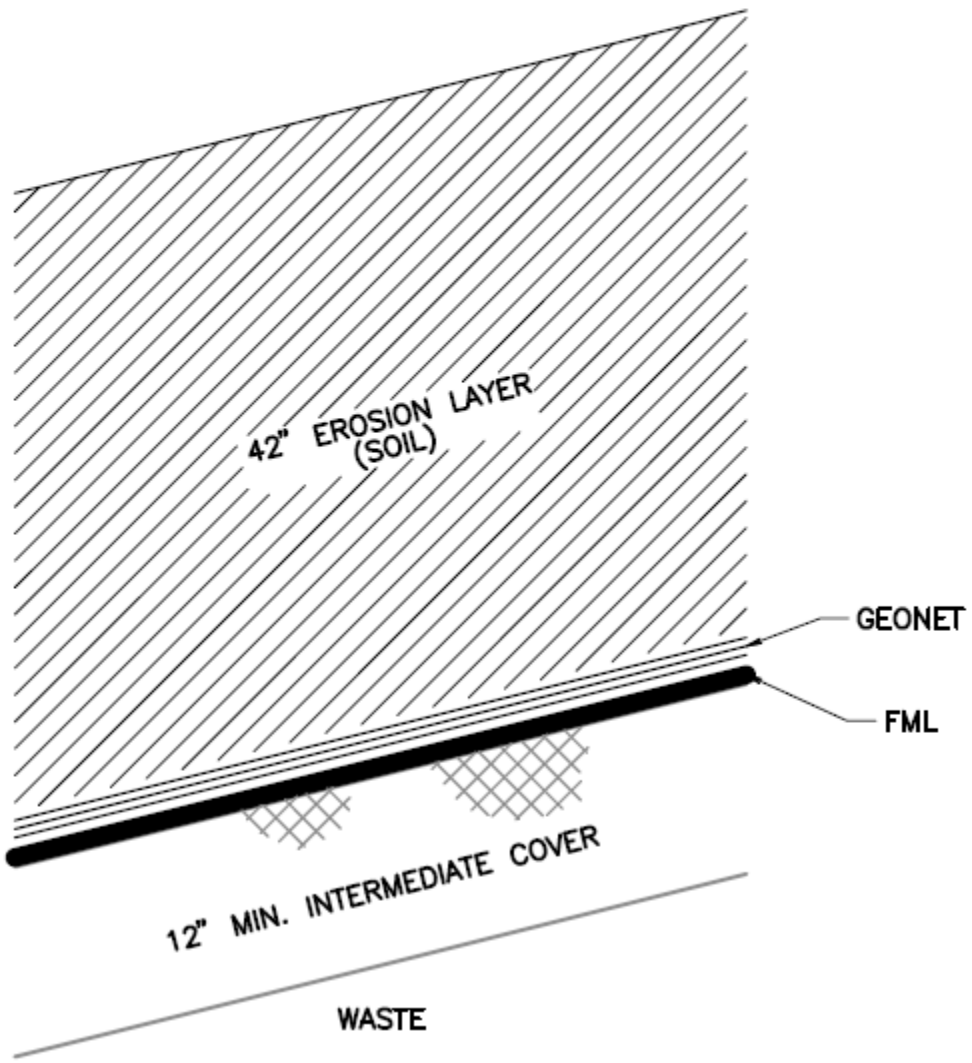


Figure 2 – Proposed Cap

Comparison of Figures 1 and 2 show the proposed alternate final cover system differs from the "regulatory" final cover system. The proposed cap differs from the regulatory cap by the elimination of the 18"-thick infiltration layer, the increase of the thickness of the erosion layer by an additional 18", and the use of a geocomposite drainage net in lieu of the 12-inch soil drainage layer.

The proposed alternate final cover system offers numerous advantages over the regulatory cap, particularly when evaluated on the 4:1 slope. Advantages of the proposed alternate final cover systems include:

- Superior FML Integrity;
- Better cap stability;
- Comparative infiltration reduction;
- Better long-term vegetative growth;

Each of these advantages is described in detail below.

Flexible Membrane Liner (FML) Integrity

FML's are susceptible to damage during the installation of cover soil materials above the FML, with damage typically associated and/or resulting from earth moving equipment (dozers) used during placement of the cover materials. To minimize the chance of damage, low ground pressure dozers are typically used and a "bridge" of soil cover is maintained between the dozer tracks and blade and the underlying FML. As a general rule, likelihood of FML damage during cover soil placement decreases as the soil cover, and consequential soil bridge, thickness increases.

The regulatory prescribed final cover system, as depicted in Figure 1, would necessitate the installation of a relatively thin 12-inch soil drainage layer above the FML. The regulatory prescribed final cover system would then require the installation of another relatively thin 24-inch-thick soil erosion layer above the drainage layer and FML. The placement of the lower 12-inch-thick soil drainage layer provides minimal soil bridge thicknesses and would be difficult to install above the FML and may result in increased installation defects.

On the other hand, the proposed cap nearly doubles the thickness of soil cover over the FML compared to the regulatory allowed system, and therefore increases the soil bridge thickness and thereby reduces the likelihood of damage to the FML during cover soil layer placement. Compared with the regulatory final cover, the proposed final cover system reduces the possibility of damage to the FML. As with any geosynthetic final cover system, the quality of FML placement (i.e., installation damage) is critical to the infiltration reduction potential of the system, as discussed later in this study.

Cap Stability

Final cover systems are typically designed and constructed in layers. The stability of the final cover system depends on the internal shear strength of each layer's components as well as the interface friction between each layer material comprising the final cover system. The layer with the lowest internal shear strength and the interface between materials with the lowest interface friction are "critical" when evaluating final cover system stability. The component which has the lowest factor of safety against failure (e.g. sliding down the slope) will fail prior to other components with higher strengths.

Internal shear strength means the ability of a material to resist slump. Internal shear strength values are typically reported for materials in an unsaturated condition. Internal shear strength for saturated materials is typically significantly lower than internal shear strength for unsaturated materials. Interface friction is the measure of resistance of the upper layer component sliding over a lower layer component. Interface friction values are typically reported for materials in an unsaturated condition. Interface friction values for saturated materials are typically significantly lower than interface friction values for unsaturated materials.

The slope of the proposed final cover system is 4:1 (14 degrees). Therefore, all layer of the final cover system must have a suitable Factor of Safety (F.S.) against failure for all anticipated conditions on 4:1 slope.

With regards to internal shear strength, the layer with the lowest internal shear strength used for the regulatory cap system is typically the 18-inch-thick Infiltration Layer (clay liner) due to the relatively high fines (clay and silt) content necessary to achieve the layer's necessary low permeability. The typical next lowest internal strength material in the cap system is the Erosion Layer, which typically contains less fines (and more sand) and has resultant internal strengths significantly higher than the clay liner. Therefore, elimination of the Infiltration Layer as proposed in the proposed will remove the weakest internal strength material and significantly improve the slope stability of the cap.

With regards to interface shear strength, the interface with the lowest shear strength used for the regulatory cap system is the Infiltration Layer/textured FML interface. The typical next lowest strength interface in the cap system is the FML/geocomposite interface, which is both stronger and more predictable (due to consistency of manufactured material versus soil variability). Therefore, elimination of the Infiltration Layer as proposed will also remove the weakest strength interface and significantly improve the slope stability of the cap.

For both of the critical internal and interface shear strength examples discussed above for the regulatory cap, the critical failure plane is associated with the infiltration layer which is <u>below</u> the FML liner. If slope stability failure were to occur for the regulatory final cover system, the failure of the infiltration layer or infiltration/FML interface would also impact all components above the failure plane including the infiltration layer, FML, composite drainage

layer (geonet), and erosion layer. A final cover system failure as described here would cause significant final cover system damage.

Alternately, the critical failure plane for the proposed cap is above the FML liner. A final cover failure in the proposed cap would likely occur above the FML and result in a much less overall cap damage.

Compared with the regulatory final cover system, the proposed cap improves slope stability and the ability of the final cover system to resist sliding below and above the liner, and therefore exceeds the protection standards specified in the regulations.

Infiltration Reduction

The quantity of infiltration through a geosynthetically-lined final cover system is directly proportional to the quality of the manufacturing and installation of the FML as well as hydraulic head over the FML. If there were no manufacturing and installation defects, then the infiltration through the system would be virtually zero regardless of the head. Discussions of minimizing FML installation defects has previously been discussed. Assuming some manufacturing or installation defects occur in the FML, the quantity of infiltration through the final cover system is then proportional to the hydraulic head acting over and forcing water through the FML defects. The greater the head above the FML defects, the higher the amount of water that will infiltrate through the FML defects.

To evaluate the performance of the final cover systems, the Hydrologic Evaluation of Landfill Performance (HELP) was used to estimate the maximum hydraulic head on the liner and rate of infiltration through the final cover system. The HELP Model is a United States Environmental Protection Agency (U.S. EPA) accepted method for estimating the volumes of runoff, evapotranspiration, lateral drainage, and infiltration through the final cover system at landfill facilities. The HELP Model is a mathematical simulation that routes precipitation along various flow paths that can exist within the landfill. Essentially, three types of data are required by the HELP Model including climatological data, soil data, and design data concerning the geometry and drainage program of the landfill. For this study, the software VisualHELP version 2.2.0.3 by Waterloo Hydrogeological, Inc. was used. Climitological data used in our analysis was synthetically generated by the HELP model for a period of 25 years. Soil input data including porosity, field capacity, wilting point, saturated hydraulic conductivity, and thickness were estimated using HELP Model default values, published literature values, and engineering judgment. Design data inputs were obtained from the proposed final cover system design, and the drainage length was assumed to be a maximum of 190 feet.

Results of HELP modeling predict the performance of the proposed final cover system will exceed the performance of the regulatory final cover system. Results of HELP modeling predicts the annual average and peak maximum daily heads on the FML for the regulatory final cover system to be 0.4 inches and 13.2 inches, respectively. For the proposed cap, the HELP model predicts the annual average and peak maximum daily heads on the FML to be

0.002 inches and 0.19 inches, respectively. Clearly, the head on the FML for the proposed final cover systems is substantially less than that of the regulatory final cover system, which is attributed to the increase thickness soil cover and presence of the geocomposite drainage net in the proposed system. As a result, the reduced head pressures observed in the proposed final cover system yields a reduced rate of infiltration through the final cover system as compared to that of the regulatory final cover system. Results of HELP modeling predicts the annual average and peak maximum daily leakage though the regulatory final cover system to be 20.4 cubic feet per acre and 0.81 cubic feet per acre, respectively. The HELP model predicts the annual average and peak daily leakage though the proposed cap to be 6.75 cubic feet per acre and 0.43 cubic feet per acre, respectively.

Based on the results of the HELP model, the proposed alternate final cover system reduces the rate of infiltration through the final cover system as compared to the regulatory final cover system, and therefore exceeds the protection standards specified in the regulations.

Better Long-Term Vegetative Growth

As stated above, internal shear strength and interface friction for saturated materials is typically significantly lower than for unsaturated materials. For stability purposes, it is important to maintain the erosion layer in an unsaturated condition. The drainage layer serves this important role by draining water from the bottom of the erosion layer faster than water can infiltrate through the erosion layer, thereby preventing the layer from becoming saturated.

For the regulatory final cover, a 12-inch-thick sand drainage layer is used for the drainage layer. For the two (2) proposed final cover systems, a geocomposite drainage net is used for the drainage layer.

However, the drainage layer can have the undesirable effect of drying the erosion layer. The “drying” effect the drainage layer has on the erosion layer is a function of the thickness of the erosion layer over the drainage layer.

The regulatory cover system, includes an erosion layer which is only 24” thick and may lead to a situation where the erosion layer is too dry to support vegetative growth. The lack of vegetation could lead to soil loss of the erosion layer and damage to the final cover system.

The proposed final cover system, increases the erosion layer to 42” thick. The proposed final cover system is anticipated to provide the advantages of keeping the erosion layer unsaturated while also providing greater soil moisture retention and minimizing the undesirable effect of excessively drying the erosion layer to the point the erosion layer cannot support vegetation.

On a previous equivalency demonstration for the proposed alternate final cover system, as presented herein, Garrett & Moore engaged Mr. Eric Lappala to perform an evapotranspiration and drainage analysis for the proposed final cover system. Mr. Lappala

is a registered Professional Hydrologist by the American Institute of Hydrology and a registered Professional Engineer. In that analysis, Mr. Lappala used the USDA/ARS Soil and Water Assessment Tool (SWAT) model to assess the likely differences in actual evapotranspiration and drainage to the drainage net layer. The regulatory final cover system's 24-inch-thick erosion layers, as well as the proposed cover system's 42-inch-thick erosion layer, were simulated in the model. Due to limitations in the model, the landfill slopes were modeled to range from 7%-12%, and no effort was made to artificially generate a 25% slope. The SWAT model was used to compute monthly water balances totals for the 100-year simulation period for each of the final cover systems. The SWAT database of climatic data reported an average simulated precipitation of 47.6 inches per year for the landfill. Results of the model indicated the proposed cover system, as compared with the regulatory final cover system, would result in a 7.5 inch/year increase in actual rate of evapotranspiration while still maintaining unsaturated soil conditions. This means that an additional 7.5 inches of precipitation per year, or about 15.7% of the annual precipitation, is temporarily stored in the erosion layer soil and made available for use by the vegetative cover plants. The results of the analysis demonstrate that the thicker cover soil in the proposed final cover system should maintain a healthier cover crop than the regulatory final cover system.

The proposed final cover system will promote a healthier stand of grass as compared with the regulatory final cover systems, thereby reducing erosion and damage to the final cover system, and therefore exceeding the protection standards specified in the regulations.

Other Considerations

In addition to the technical issues discussed above, the use of the proposed final cover system also has some practical advantages. The regulatory and permitted final cover systems requires an 18"-thick infiltration layer that has to be constructed in at least three lifts, meet a $1x10^{-5}$ cm/sec permeability requirement, and be constructed on a 4:1 slope. The installation of the infiltration layer is very weather dependent. In addition, a successfully constructed 18"-thick infiltration layer has to be covered by the flexible membrane liner (FML) in a timely manner to protect the layer from becoming too wet or too dry. The usually means the FML must be installed over smaller areas which may require numerous liner crew mobilization to complete the project.

The proposed final cover system offers the advantage of eliminating the 18"-thick infiltration layer altogether which greatly reduces the impact of weather on the project and allows the FML to be installed over larger areas at one time minimizing the need for multiple liner crew mobilizations.

Conclusion

Based on the analysis presented herein, the proposed alternate final cover system offers numerous advantages over the regulatory final cover system, including:

- Superior FML integrity. The proposed cap system nearly doubles the thickness of soil cover over the FML compared to the regulatory system, and therefore increases the soil bridge thickness and thereby reduces the likelihood of damage to the FML during cover soil layer placement
- Improved slope stability. The proposed final cover system improves slope stability and the ability of the final cover system to resist sliding below and above the liner, and therefore exceeds the protection standards specified in the regulations.
- Improved infiltration reduction. Based on the HELP model runs, the annual average rate of infiltration for the proposed final cover system is 6.184 cubic feet per year per acre verses 43.064 cubic feet per year per acre for the regulatory cap system. This means with respect to infiltration reduction, the proposed cap system is about thirty (30) times more restrictive than the regulatory cap system.
- Improved long-term vegetative growth. The proposed final cover system is anticipated to provide the advantages of keeping the erosion layer unsaturated while also providing greater soil moisture retention and minimizing the undesirable effect of excessively drying the erosion layer to the point the erosion layer cannot support vegetation.
- Less weather-dependant construction. The proposed final cover system offers the advantage of eliminating the 18”-thick infiltration layer altogether which greatly reduces the impact of weather on the project and allows the FML to be installed over larger areas at one time minimizing the need for multiple liner crew mobilizations.

It is our opinion that the proposed final cover system exceeds the protection standards specified in the regulations.

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**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07 (1 November 1997)                 **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:    C:\WHI\VHELP22\data\P1758.VHP\_weather1.dat
TEMPERATURE DATA FILE:      C:\WHI\VHELP22\data\P1758.VHP\_weather2.dat
SOLAR RADIATION DATA FILE:  C:\WHI\VHELP22\data\P1758.VHP\_weather3.dat
EVAPOTRANSPIRATION DATA:    C:\WHI\VHELP22\data\P1758.VHP\_weather4.dat
SOIL AND DESIGN DATA FILE:  C:\WHI\VHELP22\data\P1758.VHP\I_387920.inp
OUTPUT DATA FILE:           C:\WHI\VHELP22\data\P1758.VHP\O_387920.prt


TIME:  13:55     DATE:  5/ 13/2016


******************************************************************************

     TITLE:  Final - Regulatory Cap - (233' Waste)

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   7
           THICKNESS                   =     60.96   CM
           POROSITY                    =      0.2450 VOL/VOL
           FIELD CAPACITY              =      0.2440 VOL/VOL
           WILTING POINT               =      0.1360 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.2153 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.120000000000E-03 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  5.00
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                   LAYER  2
                                   --------

                       TYPE 2 - LATERAL DRAINAGE LAYER
                         MATERIAL TEXTURE NUMBER   1
           THICKNESS                   =     30.48   CM
           POROSITY                    =      0.4170 VOL/VOL
           FIELD CAPACITY              =      0.0450 VOL/VOL
           WILTING POINT               =      0.0180 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.0866 VOL/VOL
```

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EFFECTIVE SAT. HYD. COND.   =  0.250000000000E-01 CM/SEC
SLOPE                       =     28.00   PERCENT
DRAINAGE LENGTH             =     57.9    METERS


                        LAYER  3
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  36
THICKNESS                   =      0.10   CM
POROSITY                    =      0.0000 VOL/VOL
FIELD CAPACITY              =      0.0000 VOL/VOL
WILTING POINT               =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.400000000000E-12 CM/SEC
FML PINHOLE DENSITY         =      2.00   HOLES/HECTARE
FML INSTALLATION DEFECTS    =      4.00   HOLES/HECTARE
FML PLACEMENT QUALITY       =  3 - GOOD


                        LAYER  4
                        --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER  14
THICKNESS                   =     45.72   CM
POROSITY                    =      0.4730 VOL/VOL
FIELD CAPACITY              =      0.2220 VOL/VOL
WILTING POINT               =      0.1040 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.4730 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000000000E-04 CM/SEC


                        LAYER  5
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  18
THICKNESS                   =   4114.80   CM
POROSITY                    =      0.6710 VOL/VOL
FIELD CAPACITY              =      0.2920 VOL/VOL
WILTING POINT               =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2920 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000224000E-02 CM/SEC


                        LAYER  6
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   2
THICKNESS                   =     60.96   CM
POROSITY                    =      0.4370 VOL/VOL
FIELD CAPACITY              =      0.0620 VOL/VOL
WILTING POINT               =      0.0240 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0622 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000000000E-03 CM/SEC
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                         LAYER  7
                         --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER  34
THICKNESS                   =      0.60   CM
POROSITY                    =      0.8500 VOL/VOL
FIELD CAPACITY              =      0.0100 VOL/VOL
WILTING POINT               =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =   3.94000000000     CM/SEC
SLOPE                       =      2.00   PERCENT
DRAINAGE LENGTH             =     61.0    METERS


                         LAYER  8
                         --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  43
THICKNESS                   =      0.15   CM
POROSITY                    =      0.0000 VOL/VOL
FIELD CAPACITY              =      0.0000 VOL/VOL
WILTING POINT               =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.200000000000E-12 CM/SEC
FML PINHOLE DENSITY         =      2.00   HOLES/HECTARE
FML INSTALLATION DEFECTS    =      2.00   HOLES/HECTARE
FML PLACEMENT QUALITY       =  4 - POOR


                         LAYER  9
                         --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER  16
THICKNESS                   =     60.96   CM
POROSITY                    =      0.4790 VOL/VOL
FIELD CAPACITY              =      0.3710 VOL/VOL
WILTING POINT               =      0.2510 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.4790 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000000000E-06 CM/SEC


          GENERAL DESIGN AND EVAPORATIVE ZONE DATA
          ----------------------------------------

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE # 7 WITH A
          GOOD STAND OF GRASS, A SURFACE SLOPE OF 28.%
          AND A SLOPE LENGTH OF   58. METERS.

SCS RUNOFF CURVE NUMBER             =     70.51
FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE  =      0.4047 HECTARES
EVAPORATIVE ZONE DEPTH              =     22.9    CM
INITIAL WATER IN EVAPORATIVE ZONE   =      4.582  CM
UPPER LIMIT OF EVAPORATIVE STORAGE  =      5.601  CM
LOWER LIMIT OF EVAPORATIVE STORAGE  =      3.109  CM
INITIAL SNOW WATER                  =      0.000  CM
INITIAL WATER IN LAYER MATERIALS    =   1271.911  CM
TOTAL INITIAL WATER                 =   1271.911  CM
TOTAL SUBSURFACE INFLOW             =      0.00   MM/YR
```

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
Asheville NC

STATION LATITUDE	=	35.59 DEGREES
MAXIMUM LEAF AREA INDEX	=	4.50
START OF GROWING SEASON (JULIAN DATE)	=	96
END OF GROWING SEASON (JULIAN DATE)	=	298
EVAPORATIVE ZONE DEPTH	=	9.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	7.60 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	71.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	75.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	84.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	77.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Asheville NC

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
3.48	3.60	5.13	3.84	4.19	4.20
4.43	4.79	3.96	3.29	3.29	3.51

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Asheville NC

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
36.80	39.10	46.40	55.70	63.30	69.80
73.20	72.60	66.90	56.00	46.40	39.30

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Asheville NC
AND STATION LATITUDE = 34.99 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 25

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.52	3.57	4.50	4.08	4.83	4.68
	4.29	4.73	3.26	3.43	3.31	3.47
STD. DEVIATIONS	1.48	1.64	2.24	2.25	1.62	1.84
	1.81	2.15	1.82	2.39	2.39	1.91
RUNOFF						
TOTALS	0.081	0.190	0.050	0.000	0.000	0.002
	0.000	0.003	0.000	0.004	0.100	0.000
STD. DEVIATIONS	0.275	0.766	0.251	0.000	0.001	0.007
	0.000	0.012	0.001	0.015	0.485	0.000
EVAPOTRANSPIRATION						
TOTALS	1.000	1.089	1.681	1.816	2.165	2.614
	2.519	2.128	1.332	1.055	0.854	0.710
STD. DEVIATIONS	0.237	0.293	0.520	0.802	0.524	0.708
	0.725	0.630	0.546	0.313	0.233	0.144
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	2.8205	2.3658	2.8379	2.3230	2.6486	2.2080
	1.7149	2.4903	1.8801	2.4120	2.3857	2.2410
STD. DEVIATIONS	1.4241	1.4201	1.7991	1.4928	1.2484	1.3338
	1.2395	1.6747	1.2715	1.8376	1.8730	1.2783
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0006	0.0005	0.0006	0.0005	0.0005	0.0004
	0.0004	0.0005	0.0004	0.0005	0.0005	0.0004
STD. DEVIATIONS	0.0003	0.0003	0.0003	0.0003	0.0002	0.0002
	0.0002	0.0003	0.0002	0.0003	0.0003	0.0002
LATERAL DRAINAGE COLLECTED FROM LAYER 7						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 9						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	0.4698	0.4328	0.4727	0.3998	0.4411	0.3800
	0.2856	0.4148	0.3236	0.4017	0.4106	0.3733
STD. DEVIATIONS	0.2372	0.2603	0.2997	0.2569	0.2079	0.2296
	0.2064	0.2789	0.2188	0.3061	0.3224	0.2129

DAILY AVERAGE HEAD ON TOP OF LAYER 8

AVERAGES	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 25

	INCHES		CU. FEET	PERCENT
PRECIPITATION	47.68	(5.000)	173070.3	100.00
RUNOFF	0.430	(1.3328)	1562.39	0.903
EVAPOTRANSPIRATION	18.964	(1.7377)	68836.10	39.773
LATERAL DRAINAGE COLLECTED FROM LAYER 2	28.32760	(4.74371)	102826.951	59.41341
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00563	(0.00086)	20.432	0.01181
AVERAGE HEAD ON TOP OF LAYER 3	0.400	(0.067)		
LATERAL DRAINAGE COLLECTED FROM LAYER 7	0.00001	(0.00001)	0.035	0.00002
PERCOLATION/LEAKAGE THROUGH LAYER 9	0.00000	(0.00000)	0.001	0.00000
AVERAGE HEAD ON TOP OF LAYER 8	0.000	(0.000)		
CHANGE IN WATER STORAGE	-0.043	(1.7189)	-155.20	-0.090

```
******************************************************************************

                PEAK DAILY VALUES FOR YEARS    1 THROUGH   25       and their dates (DDDYYYY)
    ----------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------   -------------
       PRECIPITATION                             6.75         24501.96595   3210012

       RUNOFF                                    2.292         8319.09588   3210012

       DRAINAGE COLLECTED FROM LAYER  2          1.37237       4981.61138   3220012

       PERCOLATION/LEAKAGE THROUGH LAYER  4      0.000223         0.81044   3220012

       AVERAGE HEAD ON TOP OF LAYER  3           7.086

       MAXIMUM HEAD ON TOP OF LAYER  3          13.274

       LOCATION OF MAXIMUM HEAD IN LAYER  2
             (DISTANCE FROM DRAIN)               0.0 FEET

       DRAINAGE COLLECTED FROM LAYER  7          0.00000          0.00107   3650025

       PERCOLATION/LEAKAGE THROUGH LAYER  9      0.000000         0.00002   3650025

       AVERAGE HEAD ON TOP OF LAYER  8           0.000

       MAXIMUM HEAD ON TOP OF LAYER  8           0.000

       LOCATION OF MAXIMUM HEAD IN LAYER  7
             (DISTANCE FROM DRAIN)               0.0 FEET

       SNOW WATER                                6.34         23023.4682   3590013


       MAXIMUM VEG. SOIL WATER (VOL/VOL)                 0.2450

       MINIMUM VEG. SOIL WATER (VOL/VOL)                 0.1360


        ***  Maximum heads are computed using McEnroe's equations.  ***

             Reference:  Maximum Saturated Depth over Landfill Liner
                         by Bruce M. McEnroe, University of Kansas
                         ASCE Journal of Environmental Engineering
                         Vol. 119, No. 2, March 1993, pp. 262-270.

******************************************************************************
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****

FINAL WATER STORAGE AT END OF YEAR 25

LAYER	(INCHES)	(VOL/VOL)
1	4.4373	0.1849
2	0.5600	0.0467
3	0.0000	0.0000
4	8.5140	0.4730
5	473.0400	0.2920
6	1.6339	0.0681
7	0.0024	0.0100
8	0.0000	0.0000
9	11.4960	0.4790
SNOW WATER	0.000	

****
****

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07 (1 November 1997)                 **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:    C:\WHI\VHELP22\data\P1758.VHP\_weather1.dat
TEMPERATURE DATA FILE:      C:\WHI\VHELP22\data\P1758.VHP\_weather2.dat
SOLAR RADIATION DATA FILE:  C:\WHI\VHELP22\data\P1758.VHP\_weather3.dat
EVAPOTRANSPIRATION DATA:    C:\WHI\VHELP22\data\P1758.VHP\_weather4.dat
SOIL AND DESIGN DATA FILE:  C:\WHI\VHELP22\data\P1758.VHP\I_387476.inp
OUTPUT DATA FILE:           C:\WHI\VHELP22\data\P1758.VHP\O_387476.prt


TIME:  14:12     DATE:  5/ 13/2016


******************************************************************************

     TITLE:  Final - Alternative Cap - Geonet (233’ Waste)

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   6
           THICKNESS                   =    106.68   CM
           POROSITY                    =      0.4530 VOL/VOL
           FIELD CAPACITY              =      0.1900 VOL/VOL
           WILTING POINT               =      0.0850 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.2626 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.400000000000E-03 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  5.00
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.



                                  LAYER  2
                                  --------

                       TYPE 2 - LATERAL DRAINAGE LAYER
                         MATERIAL TEXTURE NUMBER  34
           THICKNESS                   =      0.60   CM
           POROSITY                    =      0.8500 VOL/VOL
           FIELD CAPACITY              =      0.0100 VOL/VOL
           WILTING POINT               =      0.0050 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.0149 VOL/VOL
```

```
EFFECTIVE SAT. HYD. COND.   =   3.94000000000     CM/SEC
SLOPE                       =     28.00   PERCENT
DRAINAGE LENGTH             =     57.9    METERS


                        LAYER  3
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  36
THICKNESS                   =      0.10   CM
POROSITY                    =      0.0000 VOL/VOL
FIELD CAPACITY              =      0.0000 VOL/VOL
WILTING POINT               =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.400000000000E-12 CM/SEC
FML PINHOLE DENSITY         =      2.00   HOLES/HECTARE
FML INSTALLATION DEFECTS    =      4.00   HOLES/HECTARE
FML PLACEMENT QUALITY       =  4 - POOR


                        LAYER  4
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  18
THICKNESS                   =   4114.80   CM
POROSITY                    =      0.6710 VOL/VOL
FIELD CAPACITY              =      0.2920 VOL/VOL
WILTING POINT               =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2920 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000224000E-02 CM/SEC


                        LAYER  5
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   2
THICKNESS                   =     60.96   CM
POROSITY                    =      0.4370 VOL/VOL
FIELD CAPACITY              =      0.0620 VOL/VOL
WILTING POINT               =      0.0240 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0621 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000000000E-03 CM/SEC


                        LAYER  6
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER  34
THICKNESS                   =      0.60   CM
POROSITY                    =      0.8500 VOL/VOL
FIELD CAPACITY              =      0.0100 VOL/VOL
WILTING POINT               =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =   3.94000000000     CM/SEC
SLOPE                       =      2.00   PERCENT
DRAINAGE LENGTH             =     61.0    METERS
```

```
                          LAYER  7
                          --------

               TYPE 4 - FLEXIBLE MEMBRANE LINER
                 MATERIAL TEXTURE NUMBER  43
   THICKNESS                   =      0.15   CM
   POROSITY                    =      0.0000 VOL/VOL
   FIELD CAPACITY              =      0.0000 VOL/VOL
   WILTING POINT               =      0.0000 VOL/VOL
   INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
   EFFECTIVE SAT. HYD. COND.   =  0.200000000000E-12 CM/SEC
   FML PINHOLE DENSITY         =      2.00   HOLES/HECTARE
   FML INSTALLATION DEFECTS    =      2.00   HOLES/HECTARE
   FML PLACEMENT QUALITY       =  4 - POOR


                          LAYER  8
                          --------

                 TYPE 3 - BARRIER SOIL LINER
                 MATERIAL TEXTURE NUMBER  16
   THICKNESS                   =     60.96   CM
   POROSITY                    =      0.4790 VOL/VOL
   FIELD CAPACITY              =      0.3710 VOL/VOL
   WILTING POINT               =      0.2510 VOL/VOL
   INITIAL SOIL WATER CONTENT  =      0.4790 VOL/VOL
   EFFECTIVE SAT. HYD. COND.   =  0.100000000000E-06 CM/SEC


           GENERAL DESIGN AND EVAPORATIVE ZONE DATA
           ----------------------------------------

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE # 6 WITH A
          GOOD STAND OF GRASS, A SURFACE SLOPE OF 28.%
          AND A SLOPE LENGTH OF   58. METERS.

SCS RUNOFF CURVE NUMBER             =     65.33
FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE  =      0.4047 HECTARES
EVAPORATIVE ZONE DEPTH              =     22.9    CM
INITIAL WATER IN EVAPORATIVE ZONE   =      7.482  CM
UPPER LIMIT OF EVAPORATIVE STORAGE  =     10.356  CM
LOWER LIMIT OF EVAPORATIVE STORAGE  =      1.943  CM
INITIAL SNOW WATER                  =      0.000  CM
INITIAL WATER IN LAYER MATERIALS    =   1262.531  CM
TOTAL INITIAL WATER                 =   1262.531  CM
TOTAL SUBSURFACE INFLOW             =      0.00   MM/YR


            EVAPOTRANSPIRATION AND WEATHER DATA
            -----------------------------------

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          Asheville            NC

     STATION LATITUDE                      =  35.59 DEGREES
     MAXIMUM LEAF AREA INDEX               =   4.50
     START OF GROWING SEASON (JULIAN DATE) =     96
     END OF GROWING SEASON (JULIAN DATE)   =    298
     EVAPORATIVE ZONE DEPTH                =   9.0  INCHES
     AVERAGE ANNUAL WIND SPEED             =   7.60 MPH
     AVERAGE 1ST QUARTER RELATIVE HUMIDITY =  71.00 %
```

AVERAGE 2ND QUARTER RELATIVE HUMIDITY = 75.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 84.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 77.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Asheville NC

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
3.48	3.60	5.13	3.84	4.19	4.20
4.43	4.79	3.96	3.29	3.29	3.51

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Asheville NC

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
36.80	39.10	46.40	55.70	63.30	69.80
73.20	72.60	66.90	56.00	46.40	39.30

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Asheville NC
AND STATION LATITUDE = 34.99 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 25

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.52	3.57	4.50	4.08	4.83	4.68
	4.29	4.73	3.26	3.43	3.31	3.47
STD. DEVIATIONS	1.48	1.64	2.24	2.25	1.62	1.84
	1.81	2.15	1.82	2.39	2.39	1.91
RUNOFF						
TOTALS	0.067	0.139	0.054	0.000	0.001	0.001
	0.000	0.005	0.002	0.009	0.043	0.000
STD. DEVIATIONS	0.219	0.599	0.262	0.000	0.003	0.003
	0.000	0.024	0.009	0.037	0.198	0.002
EVAPOTRANSPIRATION						
TOTALS	1.125	1.394	2.542	2.795	3.829	4.095
	3.649	3.409	2.100	1.276	1.042	0.790
STD. DEVIATIONS	0.237	0.291	0.444	0.978	0.873	1.172
	1.195	0.999	0.849	0.294	0.169	0.140
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	2.6285	2.3192	2.4104	1.7522	1.3923	0.9173
	0.7763	0.9302	0.9164	1.5064	2.0155	1.8356

STD. DEVIATIONS	1.4259	1.1962	1.5833	1.1085	0.9739	0.5724
	0.5236	1.2133	0.8194	1.5233	1.7974	1.2602

PERCOLATION/LEAKAGE THROUGH LAYER 3

TOTALS	0.0002	0.0002	0.0002	0.0002	0.0001	0.0001
	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002
STD. DEVIATIONS	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000
	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001

LATERAL DRAINAGE COLLECTED FROM LAYER 6

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 8

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	0.0028	0.0027	0.0025	0.0019	0.0015	0.0010
	0.0008	0.0010	0.0010	0.0016	0.0022	0.0019
STD. DEVIATIONS	0.0015	0.0014	0.0017	0.0012	0.0010	0.0006
	0.0006	0.0013	0.0009	0.0016	0.0020	0.0013

DAILY AVERAGE HEAD ON TOP OF LAYER 7

AVERAGES	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

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*******************************************************************************

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   25
-------------------------------------------------------------------------------
                                       INCHES            CU. FEET       PERCENT
                                  -------------------   -------------   ---------
 PRECIPITATION                     47.68    (   5.000)     173070.3     100.00

 RUNOFF                             0.321   (  0.8783)       1165.62      0.673

 EVAPOTRANSPIRATION                28.047   (  2.5236)     101809.45     58.825

 LATERAL DRAINAGE COLLECTED        19.40045 (  4.65018)     70422.084   40.68988
   FROM LAYER  2

 PERCOLATION/LEAKAGE THROUGH        0.00186 (  0.00035)         6.755     0.00390
   LAYER  3

 AVERAGE HEAD ON TOP                0.002 (    0.000)
   OF LAYER  3

 LATERAL DRAINAGE COLLECTED         0.00001 (  0.00000)         0.032    0.00002
   FROM LAYER  6

 PERCOLATION/LEAKAGE THROUGH        0.00000 (  0.00000)         0.001     0.00000
   LAYER  8

 AVERAGE HEAD ON TOP                0.000 (    0.000)
   OF LAYER  7

 CHANGE IN WATER STORAGE           -0.090   (  2.1837)       -326.91     -0.189
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*******************************************************************************

                PEAK DAILY VALUES FOR YEARS    1 THROUGH   25       and their dates (DDDYYYY)
    ----------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------   -------------
       PRECIPITATION                             6.75         24501.96595   3210012

       RUNOFF                                    1.313         4765.17795    620018

       DRAINAGE COLLECTED FROM LAYER  2          2.91059      10565.20398   3220012

       PERCOLATION/LEAKAGE THROUGH LAYER  3      0.000117         0.42547   3220012

       AVERAGE HEAD ON TOP OF LAYER  3           0.095

       MAXIMUM HEAD ON TOP OF LAYER  3           0.190

       LOCATION OF MAXIMUM HEAD IN LAYER  2
             (DISTANCE FROM DRAIN)               0.0 FEET

       DRAINAGE COLLECTED FROM LAYER  6          0.00000          0.00107   3040017

       PERCOLATION/LEAKAGE THROUGH LAYER  8      0.000000         0.00002   3040017

       AVERAGE HEAD ON TOP OF LAYER  7           0.000

       MAXIMUM HEAD ON TOP OF LAYER  7           0.000

       LOCATION OF MAXIMUM HEAD IN LAYER  6
             (DISTANCE FROM DRAIN)              18.9 FEET

       SNOW WATER                                6.34         23023.4682   3590013


       MAXIMUM VEG. SOIL WATER (VOL/VOL)                 0.3866

       MINIMUM VEG. SOIL WATER (VOL/VOL)                 0.0850


        ***  Maximum heads are computed using McEnroe's equations.  ***

             Reference:  Maximum Saturated Depth over Landfill Liner
                         by Bruce M. McEnroe, University of Kansas
                         ASCE Journal of Environmental Engineering
                         Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 25

LAYER	(INCHES)	(VOL/VOL)
1	8.7311	0.2079
2	0.0027	0.0116
3	0.0000	0.0000
4	473.0400	0.2920
5	1.5357	0.0640
6	0.0024	0.0100
7	0.0000	0.0000
8	11.4960	0.4790
SNOW WATER	0.000	

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PROJECT	Haywood County White Oak MSWLF Phase 4&5 Expansion		
SUBJECT	Landfill Closure Stormwater Design		
COMPUTED BY	CMF	**CHECKED BY**	GM
DATE	5/13/2016		

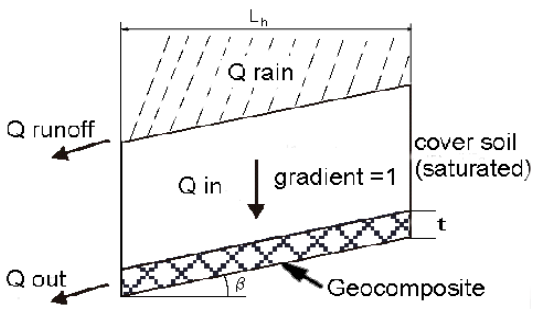
Determine Allowable Flow Length of Geocomposite

User Input Data
Calculated Value

Purpose:
Stability of a geosynthetic-lined slope can be substantially affected by saturation of the cover soils. Slope stability analyses performed as part of this application assume un-saturated conditions in the cover soils. To ensure un-saturated conditions in the cover soil, flow in the drainage layer must be confined to the thickness of the drainage layer.

The purpose of this analysis is to identify the combination of cover soil permeability and geocomposite drainage capacity that will result in no unsaturated cover soil conditions.

Discussion:



The quantity of water, Qin, infiltrating into a unit width of drainage composite having a length L is given by:

$$Q_{in} = k_{veg} \times L \times 1 \times \cos\beta$$

The flow capacity of a drainage layer is solved for using Darcy's Law as follows:

$$Q_{out} = kiA = ki(t*1) = [kt]i = \Theta i$$

where t is the thickness of the drainage layer, i is the flow gradient, and $[kt]$ is transmissivity. For slopes, the gradient i is equal to sin β, where β is the slope angle.

A factor of safety for drainage capacity, FS, of the drainage geocomposite drainage layer can be defined as follows:

$$FS = \frac{Q_{out}}{Q_{in}} = \frac{\Theta i}{k_{veg} L \cos\beta} = \frac{\Theta \tan\beta}{k_{veg} L}$$

where Θ is the transmissivity of the geocomposite and k_{veg} is the permeability of the cover soil.

To account creep deformation of the drainage core, biological clogging of the geotextile, etc., an additional reduction factor is applied to Q_{out}.

$$Q_{out} = \frac{Q_{req}}{FS_p}$$

$$\text{where : } FS_p = \text{partial factors of safety}$$

$$= (FS_{IN} \times FS_{CR} \times FS_{CC} \times FS_{BC})$$

where:
FS_{IN} = the factor of safety for elastic deformation, or intrusion of the adjacent geosynthetics into the geonet's core space
FS_{CR} =the factor of safety for creep deformation of the geonet and adjacent geosynthetics into the geonet's core space
FS_{CC} =the factor of safety for chemical clogging and/or precipi-tation of chemicals in the geonet's core space
FS_{BC} =the factor of safety for biological clogging in the geonet's core space

PROJECT	Haywood County White Oak MSWLF Phase 4&5 Expansion
SUBJECT	Landfill Closure Stormwater Design
COMPUTED BY	CMF **CHECKED BY** GM
DATE	5/13/2016

TABLE 4.2 RECOMMENDED PRELIMINARY FACTORY OF SAFETY VALUES FOR DETERMINING ALLOWABLE FLOW RATE OR TRANSMISSIVITY OF GEONETS

Application area	Factor of safety value in Equation 4.3			
	FS_{IN}	FS_{CR}*	FS_{CC}	FS_{BC}
Sport fields	1.0 to 1.2	1.0 to 1.2	1.0 to 1.2	1.1 to 1.3
Capillary breaks	1.1 to 1.3	1.0 to 1.2	1.1 to 1.5	1.1 to 1.3
Roof and plaza decks	1.2 to 1.4	1.0 to 1.2	1.0 to 1.2	1.1 to 1.3
Retaining walls, seeping rock and soil slopes	1.3 to 1.5	1.2 to 1.4	1.1 to 1.5	1.0 to 1.5
Drainage blankets	1.3 to 1.5	1.2 to 1.4	1.0 to 1.2	1.0 to 1.2
Surface water drains for landfill caps	1.3 to 1.5	1.2 to 1.4	1.0 to 1.2	1.2 to 1.5
Secondary leachate collection (landfill)	1.5 to 2.0	1.4 to 2.0	1.5 to 2.0	1.5 to 2.0
Primary leachate collection (landfill)	1.5 to 2.0	1.4 to 2.0	1.5 to 2.0	1.5 to 2.0

* These values assume that the q_{ult} value was obtained using an applied normal pressure of 1.5 to 2 times the field-anticipated maximum value. If not, the values must be increased.

Reference: Koerner, R.M. (1994), Designing With Geosynthetics, Third Edition.

FS_P = partial factors of safety = (FS_{IN} x FS_{CR} x FS_{CC} x FS_{BC})

FS_{total} = FS_P x Drainage Safety Factor

Richardson, Giroud, and Zhao (2000) recommend a minimum factor of safety of 8 (overall drainage safety factor plus
\

Input:

1.5	FS_{IN}
1.5	FS_{CR}
1.5	FS_{CC}
1.5	FS_{BC}
1.5	Drainage Safety Factor (1.5) ≥

Slope Input/Calculator:

3.5	H:1V =	15.95	degrees

Input:

			Conversion from English to SI Units				
3.5	ft	Thickness of cover soil, h	1.07	m		106.68	cm
4.00E-04	cm/sec	Permeabililty of the cover soil, K	4.0E-04	cm/sec		4.0E-06	m/sec
15.95	degrees	Slope angle, β	15.95	degrees	=	0.2783	radians
120	ft	Length of slope, L	36.58	m		3657.6	cm
0.2362	inch	Thickness of drainage layer, t*	0.60	cm		0.0060	m

* - Tenax Tendrain geocomposite

PROJECT	Haywood County White Oak MSWLF Phase 4&5 Expansion
SUBJECT	Landfill Closure Stormwater Design
COMPUTED BY	CMF **CHECKED BY** GM
DATE	5/13/2016

Solution:

					For FS_{total} = 8		
Variable k	Q_{in} (cm/sec)	FS_p	FS_{total}	Q_{out} (cm/sec)	Q_{out} (cm/sec)	Θ (cm2/sec)	Θ (m2/sec)
5.00E-05	0.176	5.0625	7.6	1.335312	1.406748	5.1	5.1E-04
1.00E-04	0.352	5.0625	7.6	2.670623	2.813496	10.2	1.0E-03
2.00E-04	0.703	5.0625	7.6	5.341246	5.626992	20.5	2.0E-03
4.00E-04	1.407	5.0625	7.6	10.68249	11.253984	41.0	4.1E-03
8.00E-04	2.813	5.0625	7.6	21.36499	22.507968	81.9	8.2E-03
1.60E-03	5.627	5.0625	7.6	42.72997	45.015936	163.9	1.6E-02
3.20E-03	11.254	5.0625	7.6	85.45994	90.031872	327.7	3.3E-02

Conclusion:

The above sensitivity analysis (variable cover soil k's) demonstrates substantial variability with regards to the permeability of the cover soils. Based on available literature, the long-term in-soil transmissivity of Tenax Tenflow is in the order of 6 x 10-3 m2/s at a gradient of 0.1, and 4 x 10-3 m2/s at a gradient of 0.33.

Therefore, provided the cover soil has a permeability of less than about 2 x 10^{-4} cm/s, the cover soil should remain unsaturated and no pore pressure is anticipated todevelop within the cover soil (i.e., flow contained to thickness of geocomposite). With no pore pressures present within the cover soil, the critical interface friction between the textured liner and geocomposite of 20 degrees shall provide an adequate factor of safety against slope instability.

References:

G.N. Richardson, J-P Giroud, A. Zhao, 2000. "Design of Lateral Drainage Systems for Landfills"

PROJECT	Haywood County White Oak MSWLF Phase 4&5 Expansion
SUBJECT	Landfill Closure Stormwater Design
COMPUTED BY	CMF **CHECKED BY** GM
DATE	5/13/2016

Estimate runoff to terrace ditches using the Rational Method.

User Input Data
Calculated Value

Site Location: Waynesville, NC

The rational formula is:

$$Q = CIA$$

where:

Q = peak rate of runoff in cubic feet per second (cfs)
C = runoff coefficient, an empirical coefficient representing the relationship between rainfall rate and runoff rate
I = average intensity of rainfall in inches/hour, for a storm duration equal to the time of concentration, T_C
A = drainage area in acres

The general procedure for determining peak discharge using the rational formula is presented below and illustrated in Sample Problem 8.03a.

Step 1. Determine the drainage area in acres.

Total Drainage Area (ac): 1 ac

Step 2. Determine the runoff coefficient, C, for the type of soil/cover in the drainage area (Table 8.03b).

If the land use and soil cover is homogenous over the drainage area, a C value can be determined directly from Table 8.03b. If there are multiple soil cover conditions, a weighted average must be calculated, or the area may be subdivided.

Subarea A (acres)	1
Subarea A Runoff Coefficient	0.45
Subarea B (acres)	
Subarea B Runoff Coefficient	
Weighted Runoff Coefficient	**0.45**

Step 3. Determine rainfall intensity
Due to the relatively small drainage area, time of concentration is assumed to be 5 minutes.

Select precipitation intensity from National Weather Service:
http://hdsc.nws.noaa.gov\hdsc\pfds\pfds_map_cont.html?bkmrk=sc

25-year, Rainfall Intensity (5 min) 7.73 in/hr

Step 4. Determine 25-year peak discharge, Q=CiA

Q_{25} = 3.4785 cfs

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PROJECT	Haywood County White Oak MSWLF Phase 4&5 Expansion		
SUBJECT	Landfill Closure Stormwater Design		
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DATE	5/13/2016		

Land Use	C
Business:	
Downtown areas	0.70-0.95
Neighborhood areas	0.50-0.70
Residential:	
Single-family areas	0.30-0.50
Multi units, detached	0.40-0.60
Multi units, Attached	0.60-0.75
Suburban	0.25-0.40
Industrial:	
Light areas	0.50-0.80
Heavy areas	0.60-0.90
Parks, cemeteries	0.10-0.25
Playgrounds	0.20-0.35
Railroad yard areas	0.20-0.40
Unimproved areas	0.10-0.30
Streets:	
Asphalt	0.70-0.95
Concrete	0.80-0.95
Brick	0.70-0.85
Drives and walks	0.75-0.85
Roofs	0.75-0.85

Land Use	C
Lawns:	
Sandy soil, flat, 2%	0.05-0.10
Sandy soil, ave.,	0.10-0.15
2-7%	0.15-0.20
Sandy soil, steep,	0.13-0.17
7%	0.18-0.22
Heavy soil, flat, 2%	0.25-0.35
Heavy soil, ave.,	
2-7%	
Heavy soil, steep,	
7%	0.30-0.60
	0.20-0.50
Agricultural land:	
Bare packed soil	0.30-0.60
Smooth	0.20-0.50
Rough	0.20-0.40
Cultivated rows	0.10-0.25
Heavy soil no crop	
Heavy soil with	0.15-0.45
crop	0.05-0.25
Sandy soil no crop	0.05-0.25
Sandy soil with	
crop	0.10-0.25
Pasture	
Heavy soil	0.15-0.45
Sandy soil	0.05-0.25
Woodlands	0.05-0.25

NOTE: The designer must use judgement to select the appropriate C value within the range for the appropriate land use. Generally, larger areas with permeable soils, flat slopes, and dense vegetation should have lowest C values. Smaller areas with slowly permeable soils, steep slopes, and sparse vegetation should be assigned highest C values.

Source: American Society of Civil Engineers

PROJECT	Haywood County White Oak MSWLF Phase 4&5 Expansion
SUBJECT	Landfill Closure Stormwater Design
COMPUTED BY	CMF **CHECKED BY** GM
DATE	5/13/2016

Evaluate Capacity of Grass Portion of Terrace Ditch

A. Discharge,Q, using Manning Equation with calculated maximum depth of flow, y.

	Input Data	
max depth of flow (ft), y:	0.74062758	
longitudinal slope (ft/ft), S:	0.01	
bottom width (ft), b:	0	
channel side slope (m:1):	3	
design Q (cfs):	3.4785	From Rational Method

TEMPORARY LINING: Bare channel with North American Green Blanket, C125/C150BN.
roughness coefficient, *n* : 0.025
max. shear stress (psf), Td: 2.25

Temporary lining flow capacity, Q (cfs) = 4.87

PERMANENT LINING: Tall Fescue
max. velocity of lining (ft/s): 4.5 From Table 8.05a

VR (max velocity x R): 1.6
Manning's *n* : 0.035 (rough channel with grass)

Permanent lining flow capacity, Q (cfs) = 3.48 CONTROLS

Channel design controlled by permanent lining flow capacity.

A, area (sf)	P, wetted perimeter (ft)	R, hydraulic radius (ft)	S, slope (ft/ft)	Q, flow (cfs)	V, velocity (ft/s)
1.645587634	4.68	0.35	0.01	3.48	2.11

B. Normal Depth and Shear Stress using Normal-Depth Procedure (known Q)

Discharge (cfs), Q: 3.48 (design max. Q of controlling lining system, from above)
longitudinal slope (ft/ft), S: 0.01
bottom width (ft), b: 0
channel side slope (m:1): 3

Input
TEMPORARY LINING: Bare channel with North American Green Blanket, C125/C150BN.
roughness coefficient, *n* : 0.025
max. shear stress (psf), Td: 2.25 Iterate y to make Zav = Zreg

Temp. Lined Channel:	y-var. (ft)	A (ft)	P (ft)	R (ft)	Zav	Zreq	V (ft/s)	Td (psf)
	0.652159984	1.27593794	4.12	0.31	0.58	0.58	2.73	0.41
								OK

PERMANENT LINING: Tall Fescue
max. velocity of lining (ft/s): 4.5
retardance class for lining: 0 (table 8.05a)
VR (max velocity x R): 1.6 (including one retardance class increase)
Manning's *n* : 0.035 (rough channel with grass)
Flow capacity controlling lining: permanent

Perm. Lined Channel:	y-var. (ft)	A (ft)	P (ft)	R (ft)	Zav	Zreq	V (ft/s)	Td (psf)
	0.739864685	1.64219925	4.68	0.35	0.82	0.82	2.12	0.46
							V OK	

Referenced Tables and Figures from *North Carolina Erosion and Sediment Control Planning and Design Manual (1988).*

PROJECT	Haywood County White Oak MSWLF Phase 4&5 Expansion
SUBJECT	Landfill Closure Stormwater Design
COMPUTED BY	CMF **CHECKED BY** GM
DATE	5/13/2016

Table 8.05a - Maximum Allowable Velocities for Vegetated Channels

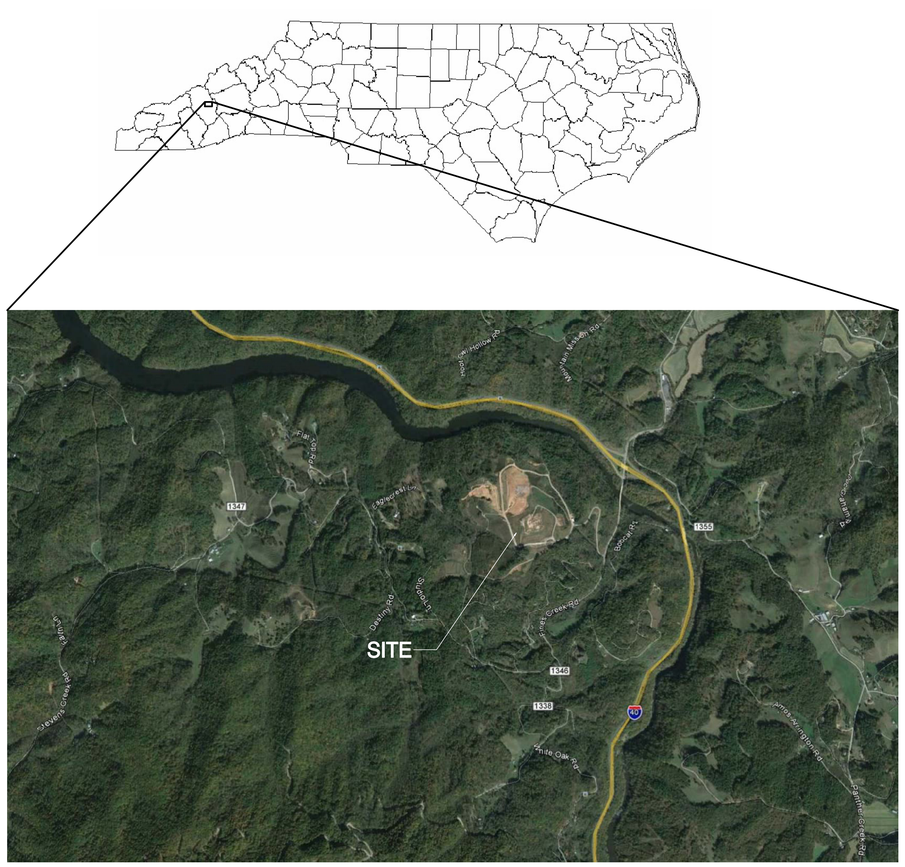
Typical Channel Slope Application	Soil Characteristics[2]	Grass Lining	Permissible Velocity[3] for Established Grass Lining (ft/sec)
0-5%	Easily Erodible Non-plastic (Sands & Silts)	Bermudagrass	5.0
		Tall fescue	4.5
		Bahiagrass	4.5
		Kentucky bluegrass	4.5
		Grass-legume mixture	3.5
	Erosion Resistant Plastic (Clay mixes)	Bermudagrass	6.0
		Tall fescue	5.5
		Bahiagrass	5.5
		Kentucky bluegrass	5.5
		Grass-legume mixture	4.5
5-10%	Easily Erodible Non-plastic (Sands & Silts)	Bermudagrass	4.5
		Tall fescue	4.0
		Bahiagrass	4.0
		Kentucky bluegrass	4.0
		Grass-legume mixture	3.0
	Erosion Resistant Plastic (Clay mixes)	Bermudagrass	5.5
		Tall fescue	5.0
		Bahiagrass	5.0
		Kentucky bluegrass	5.0
		Grass-legume mixture	3.5
>10%	Easily Erodible Non-plastic (Sands & Silts)	Bermudagrass	3.5
		Tall fescue	2.5
		Bahiagrass	2.5
		Kentucky bluegrass	2.5
	Erosion Resistant Plastic (Clay mixes)	Bermudagrass	4.5
		Tall fescue	3.5
		Bahiagrass	3.5
		Kentucky bluegrass	3.5

Source: USDA-SCS Modified

NOTE: [1]Permissible Velocity based on 10-year storm peak runoff
[2]Soil erodibility based on resistance to soil movement from concentrated flowing water.
[3]Before grass is established, permissible velocity is determined by the type of temporary liner used.

ENGINEERING DRAWINGS
PHASES 4 & 5 PERMIT TO CONSTRUCT
HAYWOOD COUNTY WHITE OAK MSWLF
HAYWOOD COUNTY, NORTH CAROLINA

LOCATION MAP



	INDEX OF DRAWINGS
ED-1	EXISTING CONDITIONS
ED-2	BEDROCK ELEVATION MAP
ED-3	SEASONAL HIGH WATER TABLE ELEVATION MAP
ED-4	PHASE 4 TOP OF 60 MIL HDPE FML GRADES & LCS
ED-5	PHASE 5 TOP OF 60 MIL HDPE FML GRADES & LCS
ED-6	PHASE 4 AND 5 TOP OF INTERMEDIATE COVER GRADE
ED-7	CROSS SECTIONS
ED-8	CROSS SECTIONS
ED-9	DETAILS
ED-10	DETAILS

JUNE 2016

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June 20, 2016

LEGEND

- PROPERTY LINE
- EXISTING INTERMEDIATE CONTOUR
- EXISTING INDEX CONTOUR
- PHASE LIMIT
- BENCHMARK
- GROUNDWATER MONITORING WELL
- LANDFILL GAS MONITORING PROBE ID
- SURFACE WATER MONITORING LOCATION
- PRIVATE POTABLE WELL
- PHASE 4 & 5 TEST WELL
- PHASE 3 TEST WELL (ABANDONED)

GRAPHIC SCALE 1"=200'
0 200

NOTES:
1) FACILITY BOUNDARYS RUNS CONCURRENT WITH PROPERTY LINE.
2) DATE OF AERIAL TOPOGRAPHY MAY 4, 2015.

Survey Benchmark Coordinates

Point #	Northing	Easting	Elevation
9001	720,465.67	812,588.26	2576.21
9005	719,539.08	811,641.5	2637.92
9008	719,817.95	810,022.81	2658.42
9014	720,108.45	811,418.83	2608.46
9017	721,429.25	810,572.00	2614.09
9019	722,068.25	811,363.19	2527.40
9022	722,240.50	812,019.36	2431.63
9029	720,895.83	813,202.36	2490.38

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ENGINEERING PLAN DRAWINGS
PHASES 4 & 5 PERMIT TO CONSTRUCT
HAYWOOD COUNTY WHITE OAK MSWLF

EXISTING CONDITIONS

SHEET
ED-1

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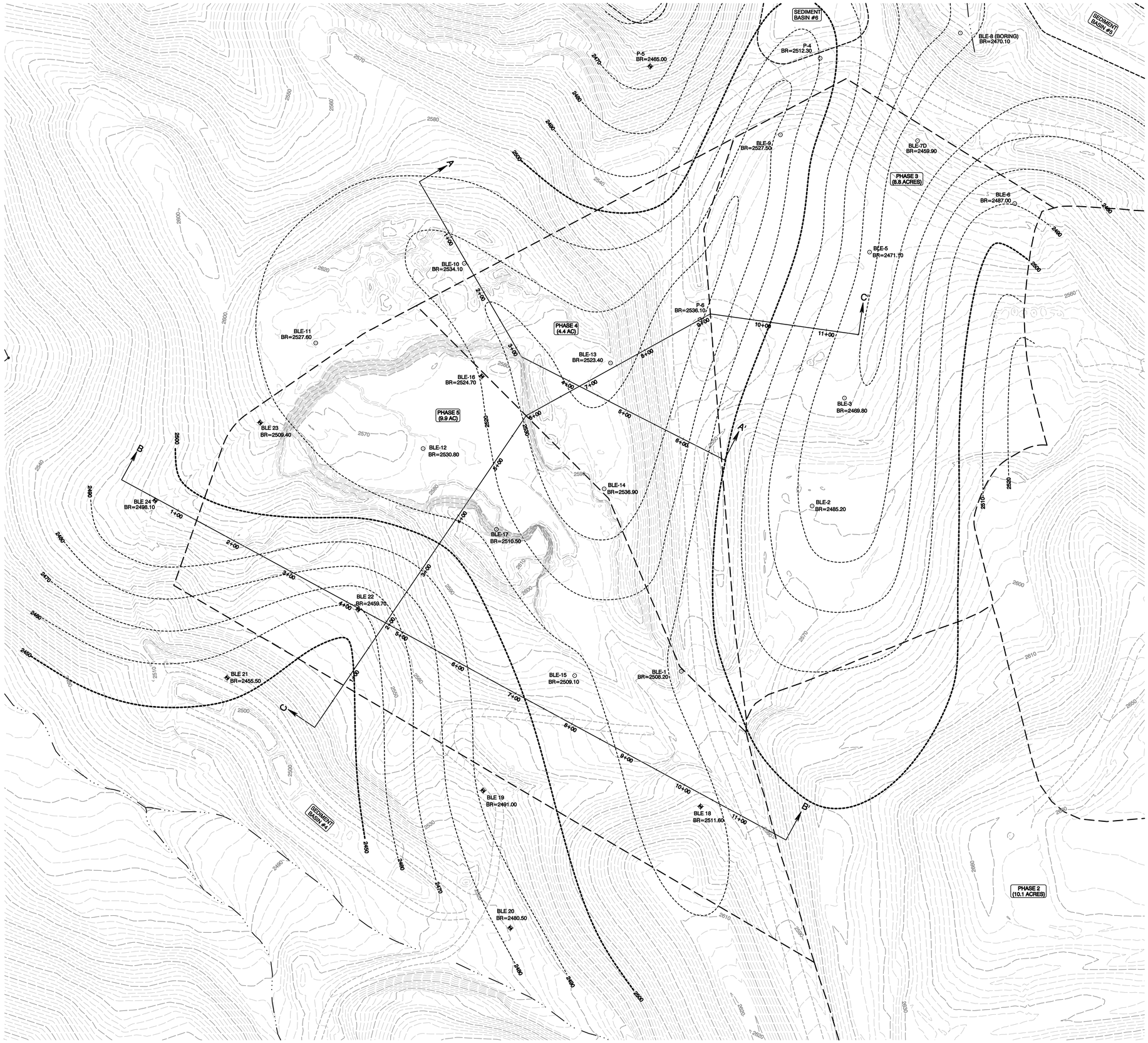

GRAPHIC SCALE 1"=60'

0 60

LEGEND

- PROPERTY LINE
- EXISTING INTERMEDIATE CONTOUR
- EXISTING INDEX CONTOUR
- BEDROCK ELEVATION TABLE INTERMEDIATE CONTOUR
- BEDROCK ELEVATION TABLE INDEX CONTOUR
- PROPOSED INTERMEDIATE CONTOUR
- PROPOSED INDEX CONTOUR
- PHASE LIMIT
- PROPOSED HDPE LCS PIPE
- EXISTING LCS PIPE
- STORM PIPE
- GROUNDWATER MONITORING WELL
- LANDFILL GAS MONITORING PROBE ID
- SURFACE WATER MONITORING LOCATION
- PRIVATE POTABLE WELL
- PHASE 4 & 5 TEST WELL
- PHASE 3 TEST WELL (ABANDONED)

NOTES:
1) EXISTING TOPOGRAPHY MAY 5, 2015.

Survey Benchmark Coordinates			
Point #	Northing	Easting	Elevation
9001	720,465.67	812,588.26	2576.21
9005	719,539.08	811,641.5	2637.92
9008	719,817.95	810,022.81	2658.42
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9029	720,895.83	813,202.36	2490.38

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ENGINEERING PLAN DRAWINGS
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HAYWOOD COUNTY WHITE OAK MSWLF

BEDROCK ELEVATION MAP

SHEET
ED-2

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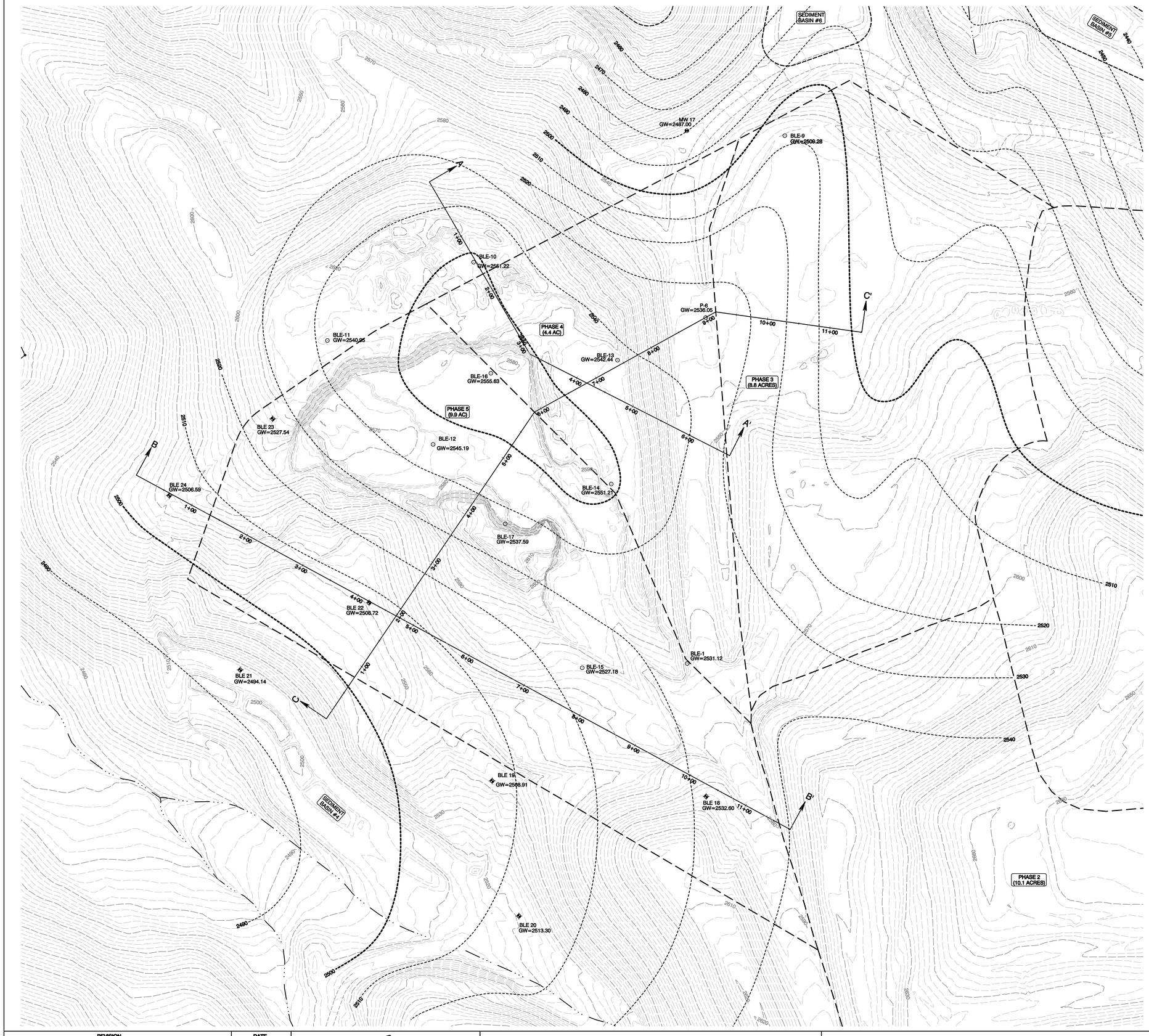

GRAPHIC SCALE 1"=60'

0 60

LEGEND

- PROPERTY LINE
- EXISTING INTERMEDIATE CONTOUR
- EXISTING INDEX CONTOUR
- SEASONAL HIGH WATER TABLE INTERMEDIATE CONTOUR
- SEASONAL HIGH WATER TABLE INDEX CONTOUR
- PROPOSED INTERMEDIATE CONTOUR
- PROPOSED INDEX CONTOUR
- PHASE LIMIT
- PROPOSED HDPE LCS PIPE
- EXISTING LCS PIPE
- STORM PIPE
- GROUNDWATER MONITORING WELL
- LANDFILL GAS MONITORING PROBE ID
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NOTES:
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9022	722,240.50	812,019.36	2431.63
9029	720,895.83	813,202.36	2490.38

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SEASONAL HIGH WATER TABLE ELEVATION MAP

SHEET
ED-3

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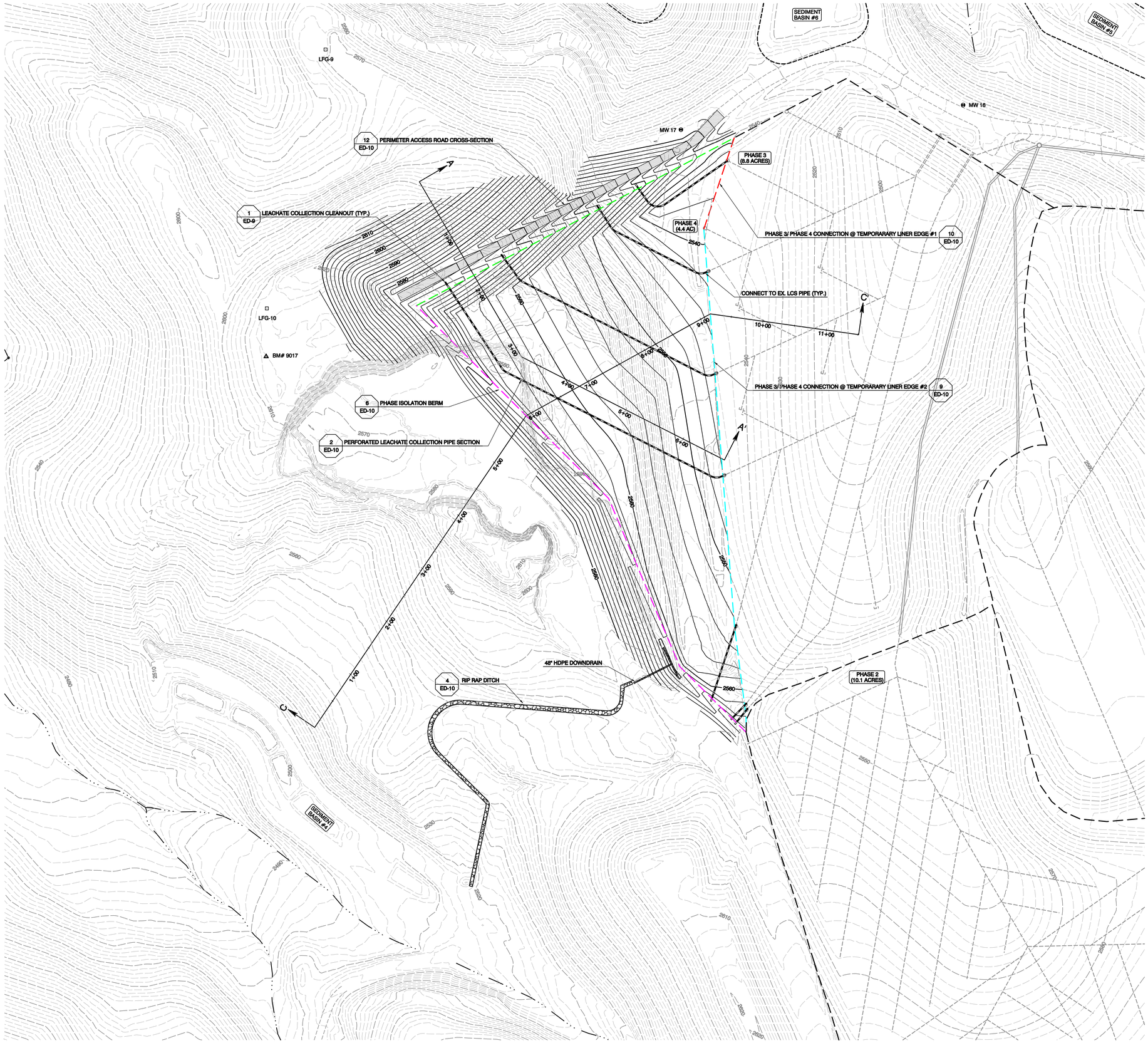

GRAPHIC SCALE 1"=60'

0 60

LEGEND

- PROPERTY LINE
- EXISTING INTERMEDIATE CONTOUR
- EXISTING INDEX CONTOUR
- SEASONAL HIGH WATER TABLE INTERMEDIATE CONTOUR
- SEASONAL HIGH WATER TABLE INDEX CONTOUR
- PROPOSED INTERMEDIATE CONTOUR
- PROPOSED INDEX CONTOUR
- PHASE LIMIT
- PROPOSED HDPE LCS PIPE
- EXISTING LCS PIPE
- STORM PIPE
- GROUNDWATER MONITORING WELL
- LANDFILL GAS MONITORING PROBE ID
- SURFACE WATER MONITORING LOCATION
- PRIVATE POTABLE WELL

NOTES:

1) EXISTING TOPOGRAPHY MAY 5, 2015.
2) GRADES WITHIN PHASE 1 - 4 LINER LIMITS REPRESENT TOP OF 60 MIL FML ELEVATIONS.
3) OPERATOR MAY CONSTRUCT PHASE 4 AND/OR PHASE 5 IN MULTIPLE PHASES.
4) OPERATOR WILL UTILZE RAIN FLAPS AND/OR RAIN COVERS TO ELIMINATE AREAS WITH LESS THAN TEN FEET OF WASTE FROM DRAINING TO LCS SUMPS.

Survey Benchmark Coordinates			
Point #	Northing	Easting	Elevation
9001	720,465.67	812,588.26	2576.21
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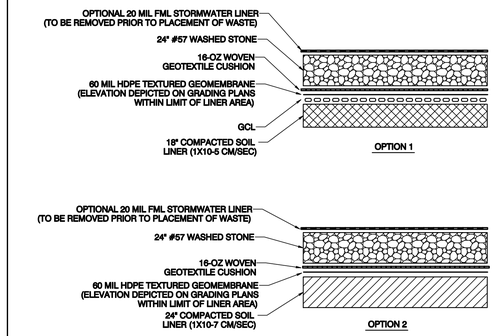

COMPOSITE BASE LINER SYSTEM 1 ED-10

NTS

NORTH CAROLINA PROFESSIONAL SEAL 19796 ENGINEER JAMES FREDERICK MOORE III

June 20, 2016

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ENGINEERING PLAN DRAWINGS
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PHASE 4 TOP OF 60 MIL HDPE FML GRADES & LCS

SHEET

ED-4

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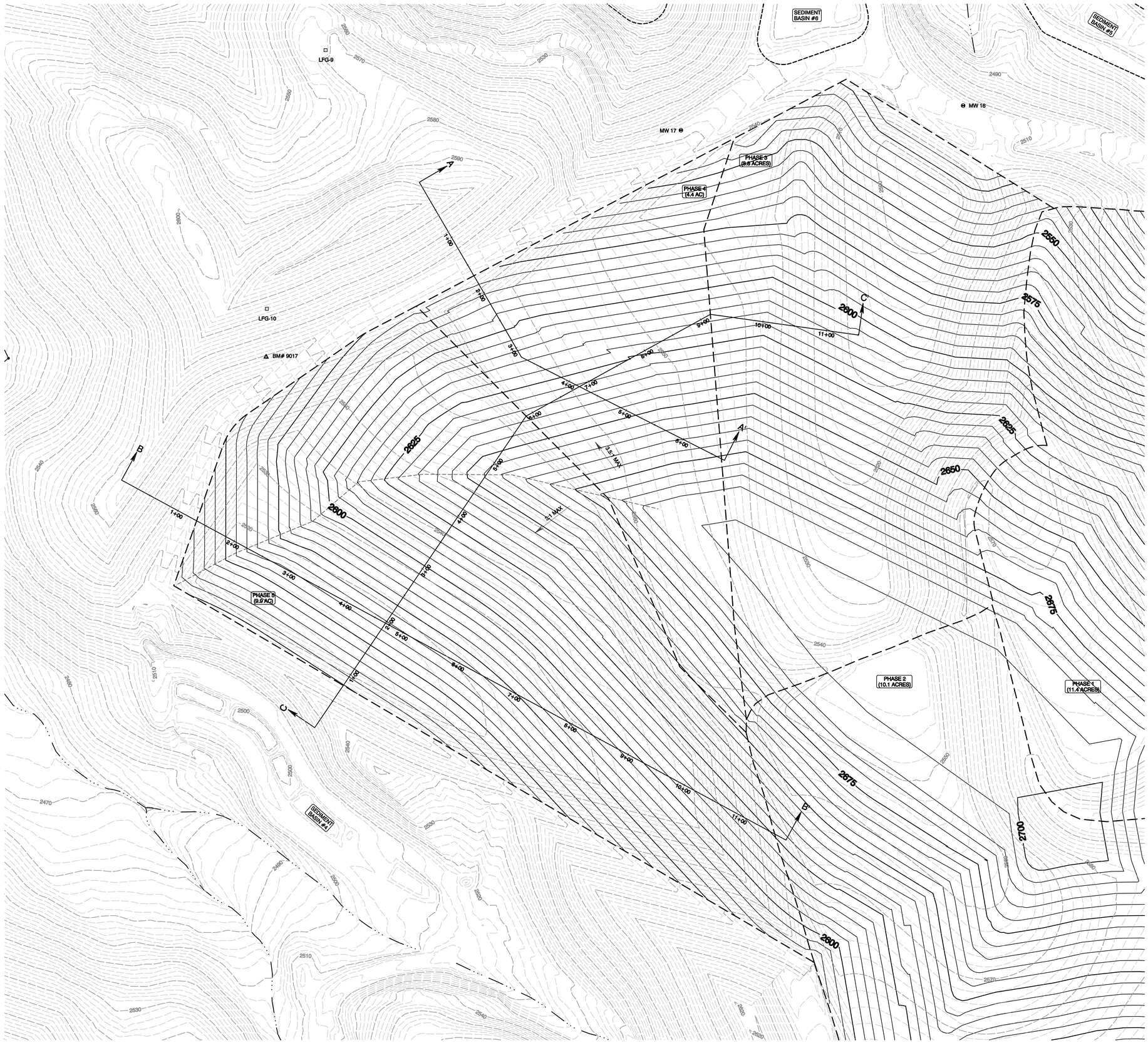

GRAPHIC SCALE 1"=60'

0 60

LEGEND

- PROPERTY LINE
- EXISTING INTERMEDIATE CONTOUR
- EXISTING INDEX CONTOUR
- SEASONAL HIGH WATER TABLE INTERMEDIATE CONTOUR
- SEASONAL HIGH WATER TABLE INDEX CONTOUR
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- PROPOSED INDEX CONTOUR
- PHASE LIMIT
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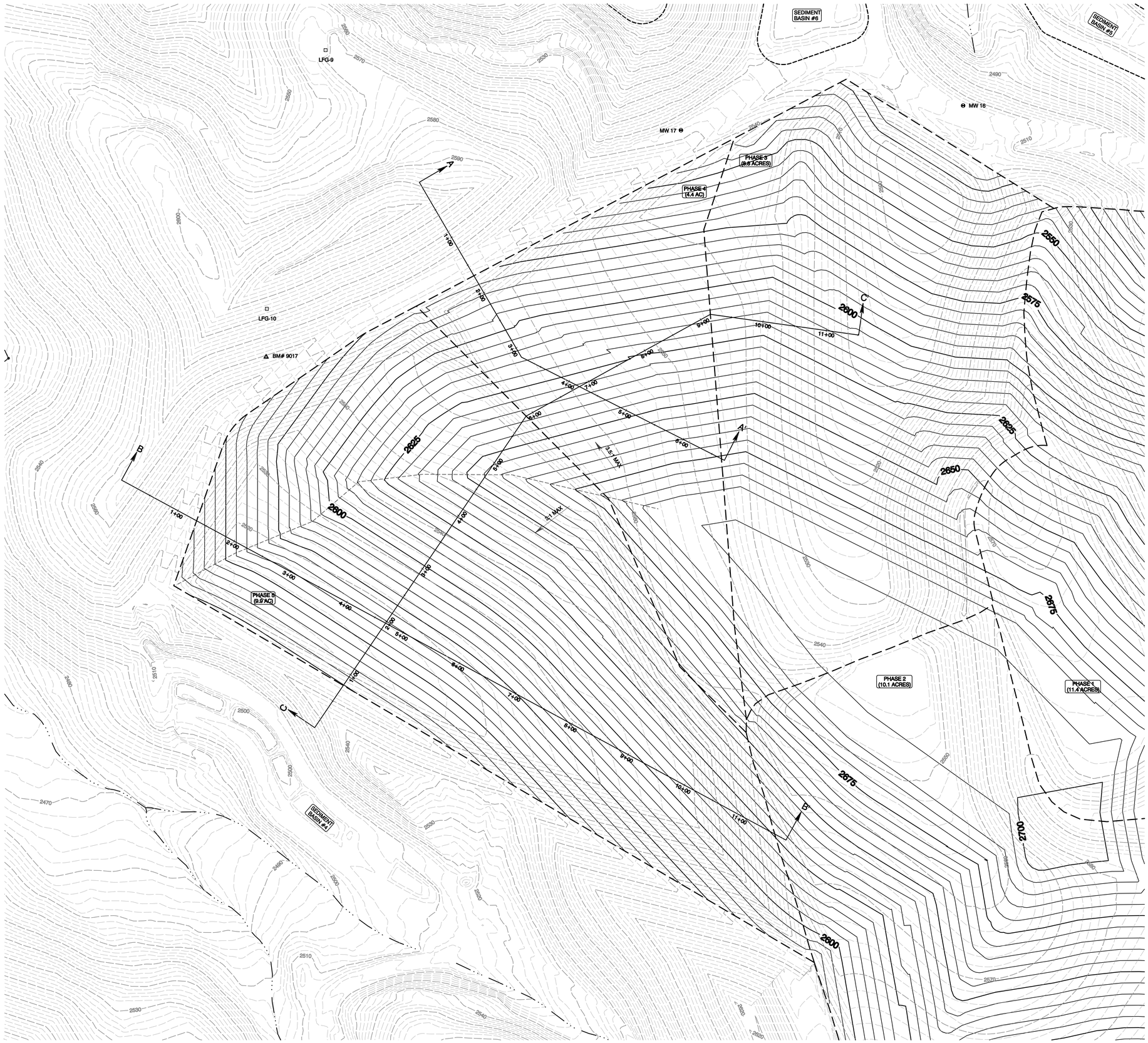
PHASES 4 & 5 PERMIT TO CONSTRUCT
HAYWOOD COUNTY WHITE OAK MSWLF

PHASE 4 AND 5
TOP OF INTERMEDIATE COVER GRADE

SHEET
ED-6



GRAPHIC SCALE 1"=60'

0 60

LEGEND

- PROPERTY LINE
- EXISTING INTERMEDIATE CONTOUR
- EXISTING INDEX CONTOUR
- SEASONAL HIGH WATER TABLE INTERMEDIATE CONTOUR
- SEASONAL HIGH WATER TABLE INDEX CONTOUR
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NOTES:
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NORTH CAROLINA PROFESSIONAL SEAL 19796 ENGINEER JAMES FREDERICK MOORE, III

June 20, 2016

REVISION	DATE

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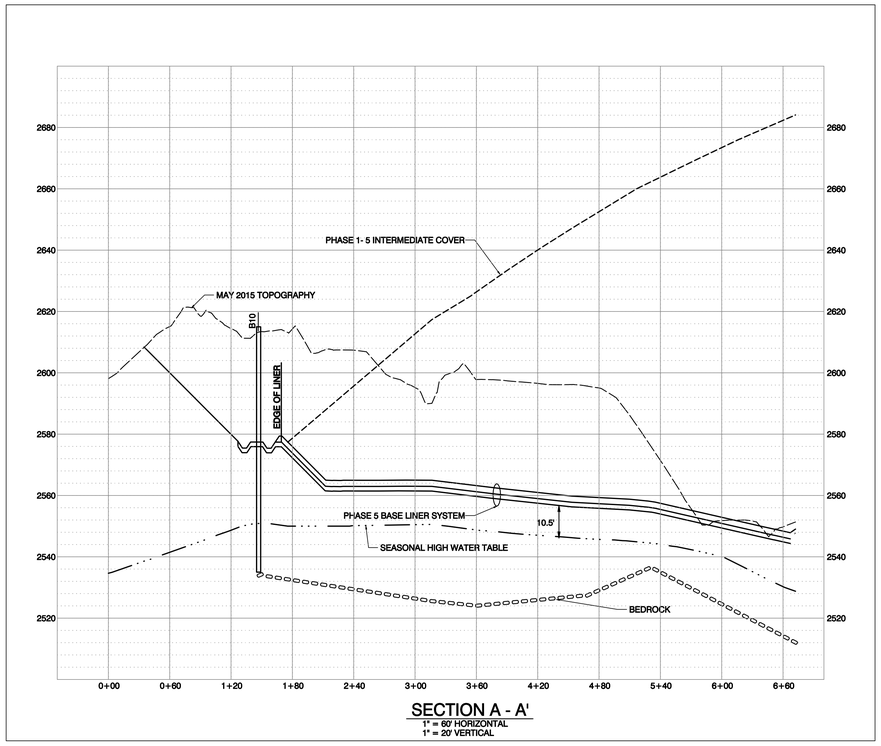
ENGINEERING PLAN DRAWINGS
PHASES 4 & 5 PERMIT TO CONSTRUCT
HAYWOOD COUNTY WHITE OAK MSWLF

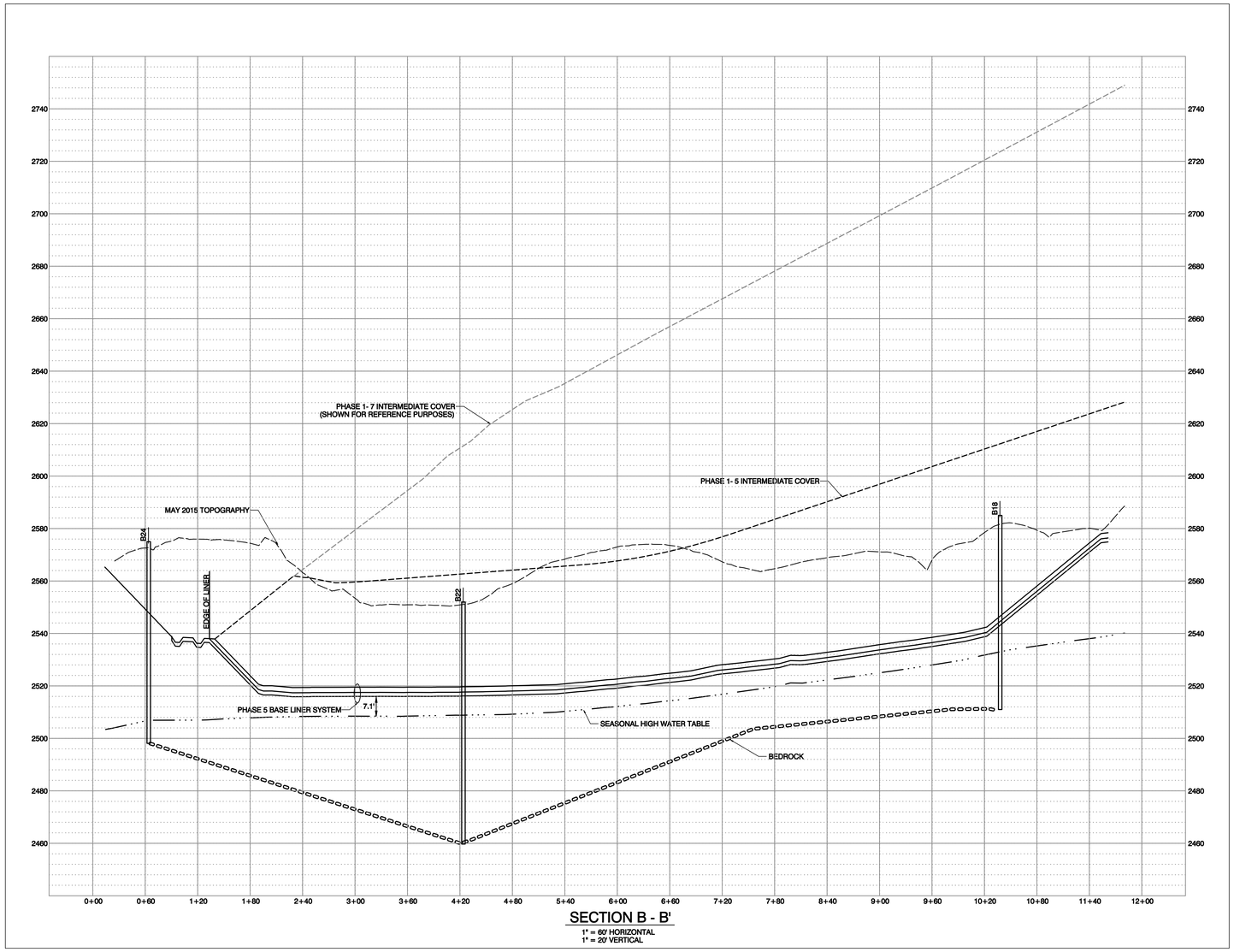
PHASE 4 AND 5
TOP OF INTERMEDIATE COVER GRADE

SHEET
ED-6



SECTION A - A'

1" = 60' HORIZONTAL
1" = 20' VERTICAL



SECTION B - B'

1" = 60' HORIZONTAL
1" = 20' VERTICAL

NORTH CAROLINA PROFESSIONAL SEAL 19796 ENGINEER MICHAEL FREDERICK MOORE

June 20, 2016

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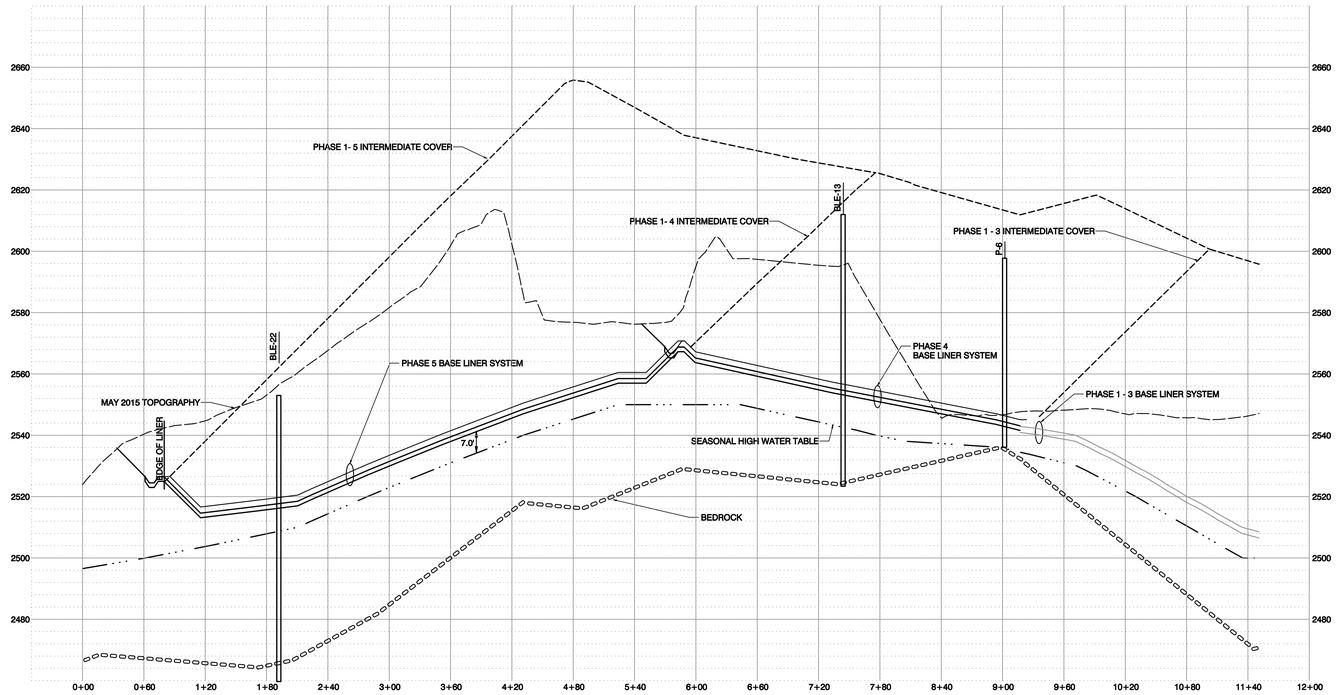
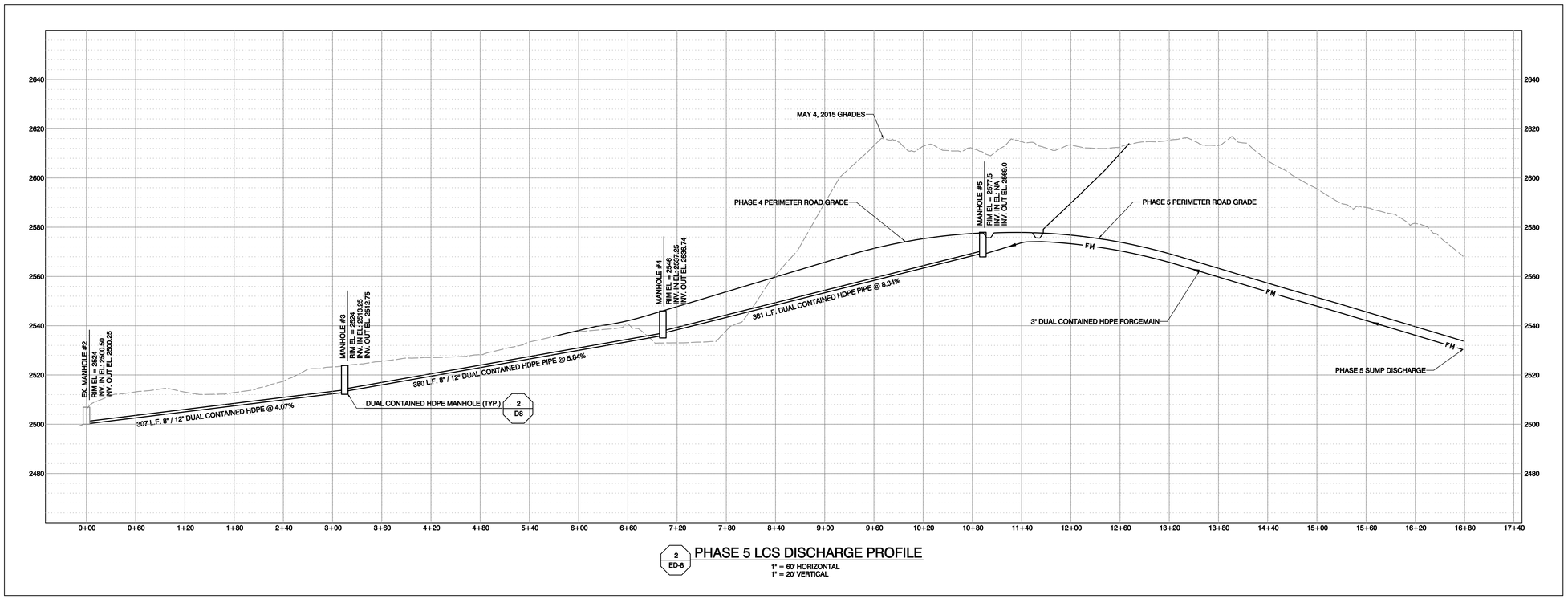
CROSS SECTIONS

SHEET
ED-7



SECTION C - C'

1" = 60' HORIZONTAL
1" = 20' VERTICAL



PHASE 5 LCS DISCHARGE PROFILE

2
ED-8

1" = 60' HORIZONTAL
1" = 20' VERTICAL

NORTH CAROLINA PROFESSIONAL SEAL 19796 ENGINEER FRED FREDERICK MOORE III

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CROSS SECTIONS

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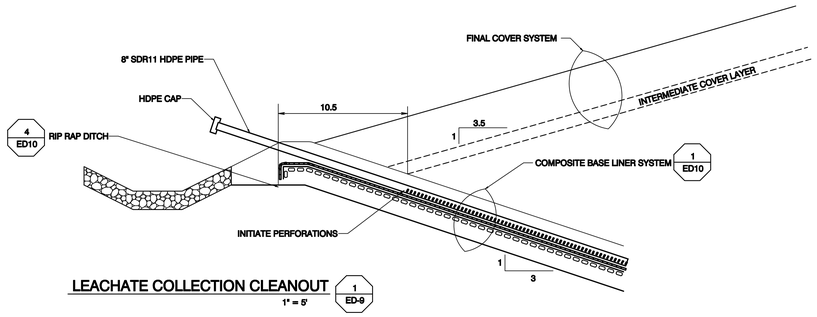
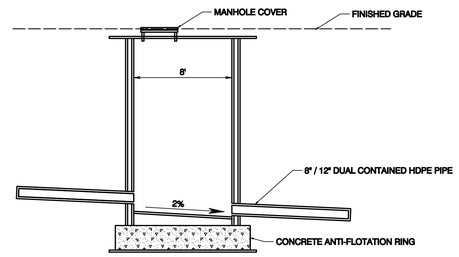
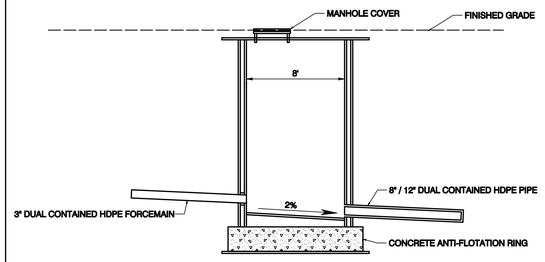


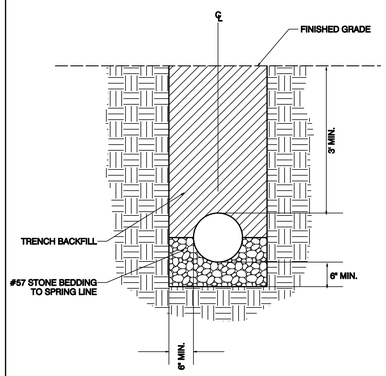
LEACHATE COLLECTION CLEANOUT 1 ED-9
1" = 5'



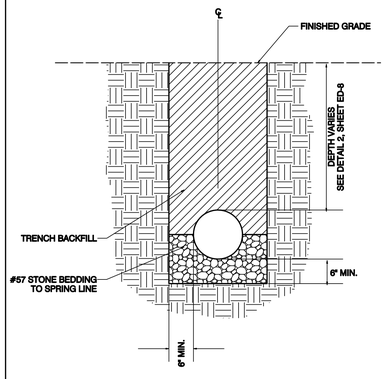
DUAL CONTAINED HDPE MANHOLE 2 ED-9
1" = 5'



FORCE MAIN INTO DUAL CONTAINED HDPE MANHOLE 3 ED-9
1" = 5'

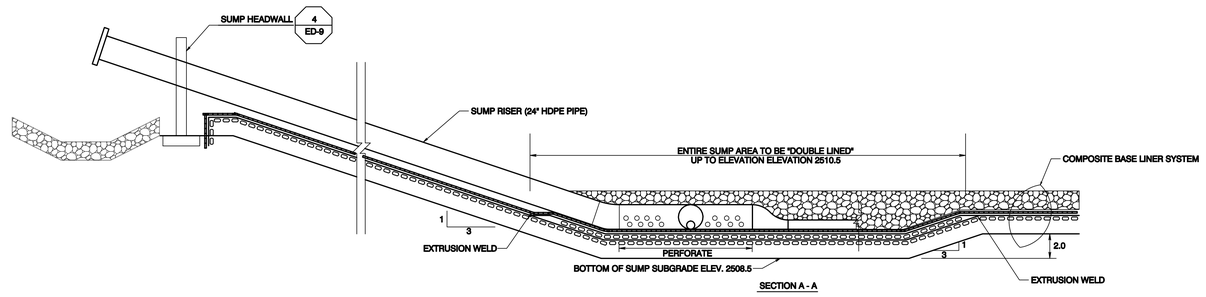


FORCEMAIN

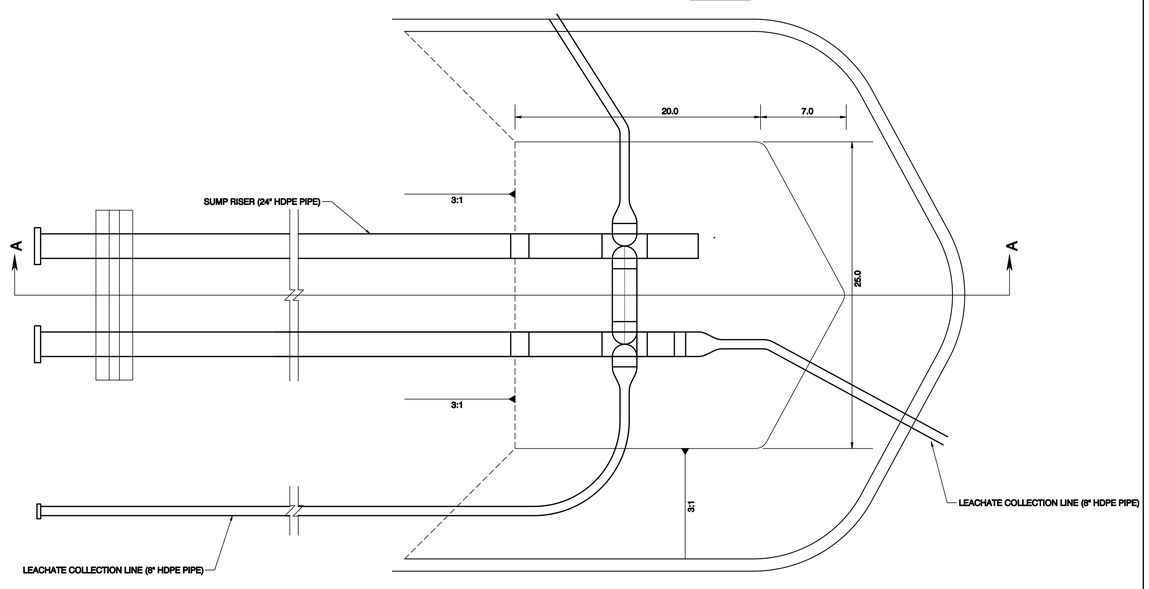


GRAVITY SEWER

FORCEMAIN AND GRAVITY PIPE BEDDING 6 ED-9
1" = 1/4'

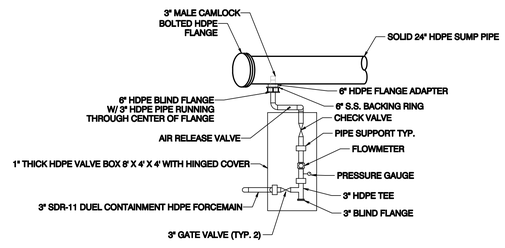


SECTION A - A

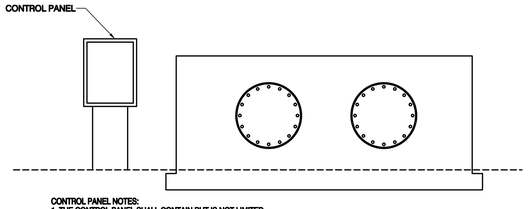


PLAN

PHASE 5 LEACHATE COLLECTION SUMP 5 ED-9
1" = 5'



PLAN VIEW



CONTROL PANEL NOTES:
1. THE CONTROL PANEL SHALL CONTAIN BUT IS NOT LIMITED TO A DIGITAL FLOW METER, REMOTE LOCK OUT, TOP MOUNTED RED HIGH ALARM LEVEL LIGHT, OVERLOAD RESET, PUMP RUN LIGHT, PUMP OVERLOAD LIGHT, PHASE LOSS/VOLTAGE FAULT LIGHT, PUMP HOUR METER, AND LIQUID HEAD LEVEL INDICATOR.

SUMP HEADWALL 4 ED-9
1" = 5'

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HAYWOOD COUNTY WHITE OAK MSWLF

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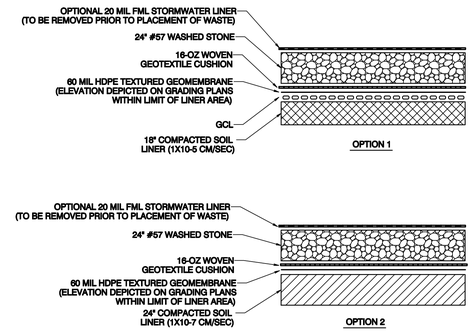
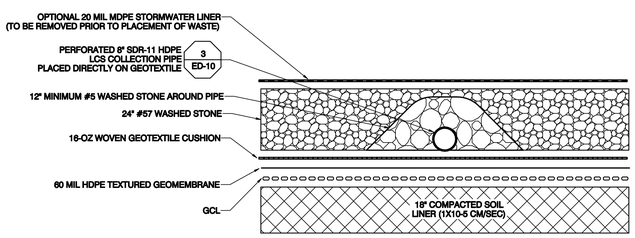
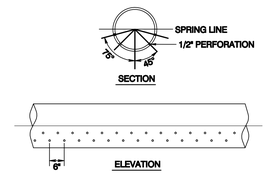


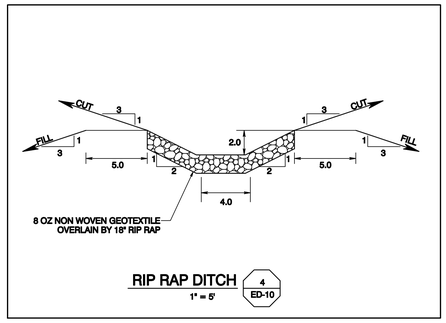
COMPOSITE BASE LINER SYSTEM (1 / ED-10)
NTS



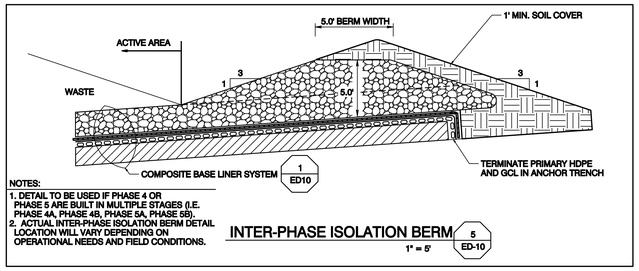
PERFORATED LEACHATE COLLECTION PIPE SECTION (2 / ED-10)
NTS



LEACHATE COLLECTION PIPE PERFORATION PATTERN (3 / ED-10)
NTS

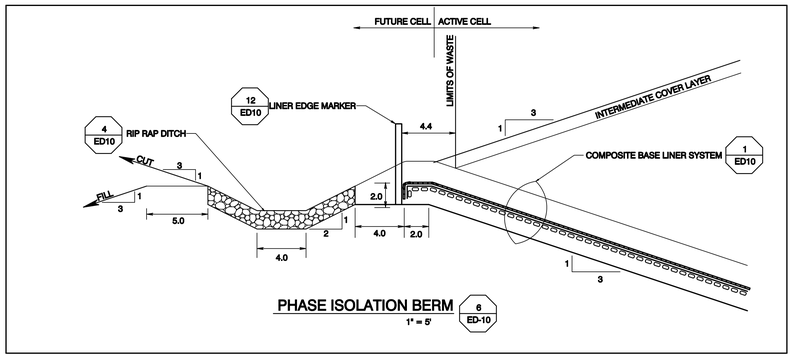


RIP RAP DITCH (4 / ED-10)
1" = 5'

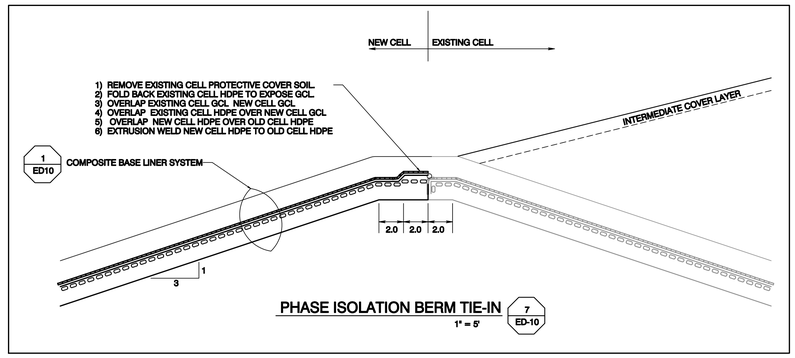


NOTES:
1. DETAIL TO BE USED IF PHASE 4 OR PHASE 5 ARE BUILT IN MULTIPLE STAGES (I.E. PHASE 4A, PHASE 4B, PHASE 5A, PHASE 5B).
2. ACTUAL INTER-PHASE ISOLATION BERM DETAIL LOCATION WILL VARY DEPENDING ON OPERATIONAL NEEDS AND FIELD CONDITIONS.

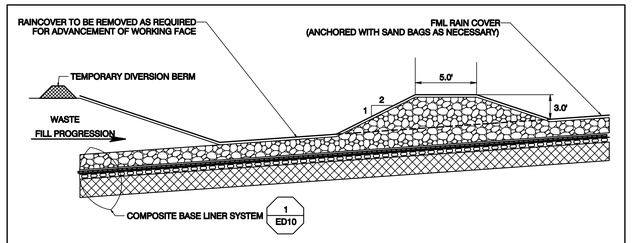
INTER-PHASE ISOLATION BERM (5 / ED-10)
1" = 5'



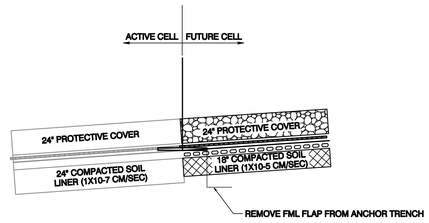
PHASE ISOLATION BERM (6 / ED-10)
1" = 5'



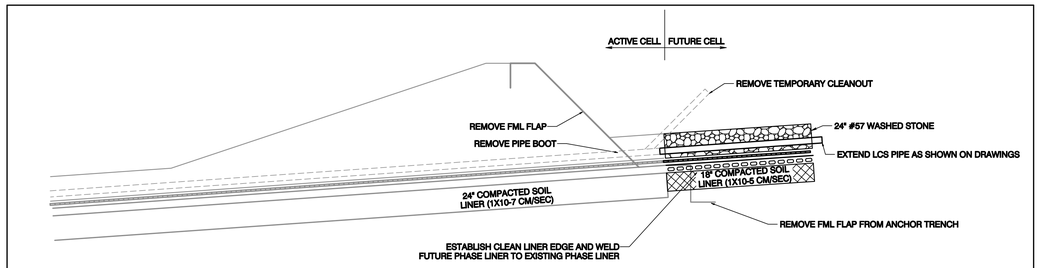
PHASE ISOLATION BERM TIE-IN (7 / ED-10)
1" = 5'



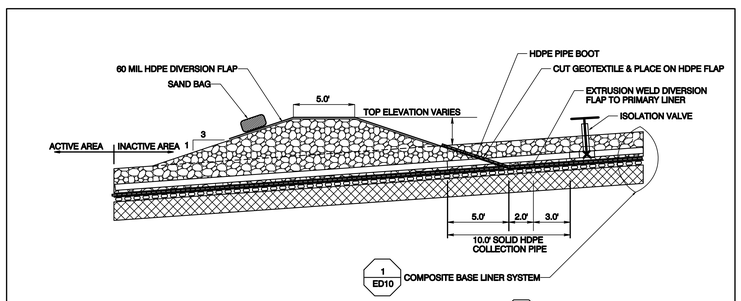
RAIN COVER STORMWATER CONTROL BERM (8 / ED-10)
1" = 5'



PHASE 3 / PHASE 4 CONNECTION @ TEMPORARY LINER EDGE #2 (9 / ED-10)
NTS

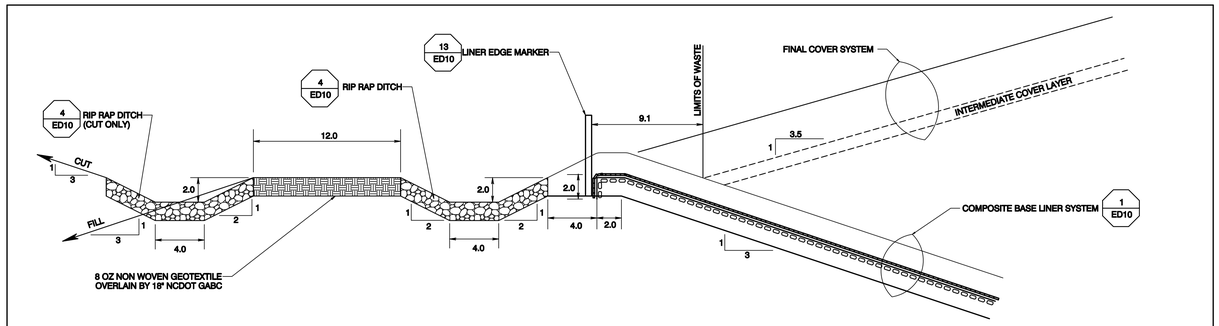


PHASE 3 / PHASE 4 CONNECTION @ TEMPORARY LINER EDGE #1 (10 / ED-10)
1" = 5'

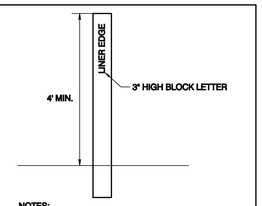


INTER-PHASE STORWATER DIVERSION RAIN FLAP (11 / ED-10)
1" = 5'

NOTES:
1. PRIOR TO WASTE PLACEMENT UPSTREAM OF RAIN FLAP, THE HDPE DIVERSION FLAP WILL BE CUT & REMOVED, THE VALVE BE OPENED, AND #57 WASHED STONE MATERIAL IN EXCESS OF 2-FEET MAY BE REMOVED.



PERIMETER ACCESS ROAD CROSS-SECTION (12 / ED-10)
1" = 5'



NOTES:
1) MARKER SHALL BE HIGHLY VISIBLE.
2) MARKERS SHALL BE INSTALLED AT 200' MAXIMUM INTERVAL.

LINER EDGE MARKER (13 / ED-10)
NTS

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June 20, 2016

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HAYWOOD COUNTY WHITE OAK MSWLF

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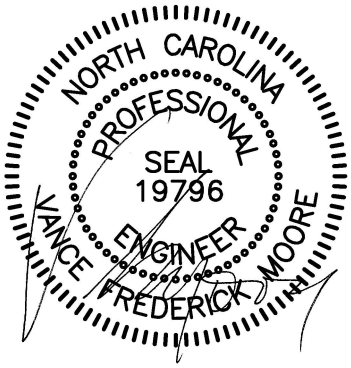
CQA PLAN

Phase 4 and 5
White Oak MSW Landfill

Haywood County, North Carolina



June 20, 2016

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NC FIRM C-2910

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APPENDICES

Appendix 1 – Technical Specifications

1.0 INTRODUCTION

This CQA Plan for the Phase 4 & 5 Phase Expansion of the White Oak MSWLF was developed in accordance with Section .1621 (CONSTRUCTION QUALITY ASSURANCE PLAN) of the Solid Waste management Rules (15 NCAC 13B). The purpose of the CQA Plan is to describe the observations and tests that will be used before, during, and upon completion of construction to ensure that the construction materials meet the design specifications and the construction and certification requirements set forth in Rule .1624, Construction Requirements for MSWLF Facilities. The CQA plan also describes the procedures to ensure that the integrity of the landfill systems will be maintained prior to waste placement.

1.1 Elements of the CQA Plan

The following defines the elements of the CQA Plan as required by Section .1621:

- *Responsibility and Authority* – The responsibility and authority of organizations and key personnel (by title) involved in permitting, designing, and constructing the landfill facility.
- *Inspection Activities* – The observations and tests that will be used to ensure that the construction or installation meets or exceeds all design criteria, plans, specifications, and regulations for each landfill component of the construction project. Inspection activities are discussed in sections for each specific work item that is presented in the CQA Plan.
- *Sampling Strategies* – The sampling activities, sample size, methods for determining sample locations, frequency of sampling, acceptance and rejection criteria, and methods for ensuring that corrective measures are implemented as addressed in the design criteria, plans, specifications, and regulations. Sampling strategies are discussed in section for each specific work item.
- *Documentation* – Reporting requirements for CQA activities including daily field reports, inspection data sheets, problem identification and corrective measures reporting, acceptance reporting and final documentation.

1.2 Definitions Relating to Construction Quality

In the context of this CQA Plan, Construction Quality Assurance and Construction Quality Control are defined as follows:

- *Construction Quality Assurance* refers to the means and methods employed by the Owner to assure conformity of construction of the landfill (compacted soil liner,

geomembrane liners, protective cover layers, etc.) and their materials, workmanship and installation with this CQA Plan, Contract Drawings, and the Specifications. CQA is provided by the CQA Officer as a representative of the Owner and independent from construction and installation.

- *Construction Quality Control* refers to those actions taken by manufacturers, installers, Quality Control Agency, and/or Contractor to ensure that the materials and the workmanship meet the requirements of this CQA Plan and the Specifications.

2.0 RESPONSIBILITIES AND AUTHORITIES

The following sections define and describe the responsibilities and authorities for the construction management organization. Parties to the CQA plan are defined and project meeting requirements are established in accordance with Section .1621(a)(1).

2.1 Parties to CQA Plan

The principal parties involved in the CQA Plan for the landfill facility include the Owner, Permitting Agency, Engineer, CQA Officer, Quality Assurance Laboratory, Contractor, Quality Control firm, Quality Control Laboratory, Manufacturers, and Installers. The general responsibilities, authorities and qualifications, as applicable, of each of these parties are described in the following paragraphs. The responsibility and/or authority of a given party may be modified or expanded as dictated by specific project needs during the Pre-construction Conference. The changes shall be incorporated into the CQA Plan prior to construction.

2.1.1 Owner

The Owner is Haywood County.

The Owner is responsible for the design, construction, and operation of the landfill facility. This responsibility includes compliance with the permit and submission of CQA documentation demonstrating that the facility was constructed in accordance with the permit documents and the design plans and specifications.

The Owner has the authority to select and dismiss parties charged with design, CQA, and construction activities. The Owner also has the authority to accept or reject design plans and specifications, CQA plans, reports and recommendations of the CQA Officer or CQC Officer, and the materials and workmanship of Contractors.

2.1.2 Permitting Agency

The Permitting Agency is the North Carolina Department of Environmental Quality, Division of Waste Management, Solid Waste Section.

As construction progresses, NCDEQ has the responsibility and authority to review and accept or reject design revisions or requests for variance submitted by the Owner.

2.1.3 Engineer

For this project, the Engineer is Garrett and Moore, Inc., who was retained by the Owner to perform the engineering design and prepare the associated drawings and specifications.

2.1.3.1 Responsibilities

The Engineer is responsible for approving all design and specification changes, clarifying the design, reviewing and approving shop drawings, and other tasks as required during construction. The Engineer is also responsible for preparing the permit documents for acceptance by the Permitting Agency. The permit documents include forms, narratives, CQA Plan, design plans, and specifications that support construction and closure of the landfill. During construction, the Engineer may be requested to clarify inconsistencies or contradictions in the construction and contract documents or the CQA Plan.

During construction, the Engineer may approve substantive changes to the design plans or specifications of the facility. Substantive changes may require NCDEQ notification and/or approval prior to making any changes in the field. Substantive changes include any changes that modify or impact the technical basis for any engineered component of the facility design.

2.1.3.2 Qualifications

The Engineer shall be a Professional Engineer licensed by the State of North Carolina. The Engineer shall be familiar with general earthwork, low permeability soils and soil liners, geosynthetics including detailed design methods and procedures, and all applicable regulatory requirements.

2.1.4 CQA Officer

The CQA Officer is an entity, independent of the Contractor, responsible for observing, testing, and documenting activities related to the permit documents and the CQA Plan as well as the overall construction quality assurance of the project. The CQA Officer is also responsible for issuing a certification report, sealed by a Professional Engineer registered in the State of North Carolina. The CQA Officer may be the Engineer.

The CQA Officer is represented on-site by supporting CQA monitoring personnel (RPR, Engineering Technicians) as appropriate but generally during all construction activities including but not limited to earthwork, soil liner, geosynthetics, protective cover layers, leachate collection systems and critical landfill components.

2.1.4.1 Responsibilities

The CQA Officer will report directly to the Engineer during construction. In general, the responsibilities and authorities of the CQA Officer include:

- Complete understanding of the permit documents, design plans, and specifications in relation to all aspects of the CQA Plan;

- Scheduling, coordinating and performing CQA activities;
- Performing independent on-site observation of the work in progress to assess compliance with the CQA Plan, permit documents, design plans, and specifications;
- Recognizing and reporting deviations from the CQA Plan, permit documents, design plans, and/or specifications to the Engineer. Secure documents from the Engineer, which approve the changes;
- Verifying that the testing equipment meets testing and calibration requirements, and that tests are conducted according to standardized procedures defined in the CQA Plan or the specifications;
- Verifying that the raw data are properly recorded, validated, reduced, summarized, and interpreted;
- Recording and maintaining test data accurately;
- Identifying CQA-tested work that should be accepted, rejected, or further evaluated;
- Verifying that corrective measures are implemented;
- Documenting and reporting CQA activities;
- Collecting data needed for record documentation.
- Maintaining open line of communications with other parties involved in the construction.

The CQA Officer is also responsible for approving the work for major construction activities associated with the landfill construction and closure construction.

Approvals shall be issued by a Professional Engineer attesting that construction and all test evaluations are in compliance with North Carolina Rules and Application specifications and bear the seal of the Professional Engineer licensed in the state of North Carolina.

2.1.4.2 Qualifications

The CQA Officer shall be a Professional Engineer licensed by the State of North Carolina. The CQA Officer shall be experienced in the field of solid waste management and lined landfill construction and closure techniques and all applicable regulatory requirements.

The CQA Officer shall be pre-qualified and approved by the Owner. The CQA Officer shall be an engineering firm with experience in construction quality assurance and quality

control, particularly on projects involving similar landfill construction systems. The CQA Officer shall be capable of assigning technically qualified personnel to the project, including an on-site CQA Resident Project Representative (RPR). The CQA RPR shall possess a thorough knowledge of all aspects of earthwork, low permeability soil liners and geosynthetics construction.

2.1.5 Quality Assurance Laboratory

Quality Assurance Laboratory is a firm or firms, independent from the Contractor, Manufacturer, and Installer, responsible for conducting tests on samples of geosynthetics (geomembrane, geocomposites and geotextiles) and soils proposed for use or used in construction at the site.

2.1.5.1 Soils CQA Laboratory

The Soils CQA Laboratory shall be a qualified laboratory with experience in performing laboratory tests to determine soils characteristics as required by the specifications. The Soils CQA Laboratory shall demonstrate that it follows the standard test methods listed in the specifications and maintains the appropriate, calibrated equipment to perform the tests. The Soils CQA Laboratory shall also demonstrate to the CQA Officer that it adheres to a formal in-house QA/QC program and can provide the required analytical documentation and reports.

2.1.5.2 Geosynthetics CQA Laboratory

The Geosynthetics CQA Laboratory shall be a qualified laboratory with experience in performing laboratory tests to determine geosynthetics characteristics as required by these specifications. The Geosynthetics CQA Laboratory shall demonstrate that it follows the standard test methods listed in the specifications and maintains the appropriate, calibrated equipment to perform the tests. The Geosynthetics CQA Laboratory shall also demonstrate the CQA Officer that it adheres to a formal in-house QA/QC program and can provide the required analytical documentation and reports. The Geosynthetics CQA Laboratory shall hold current accreditation from the Geosynthetic Accreditation Institute (GAI) for all pertinent test methods.

The Quality Assurance Laboratory shall be responsible for conducting the appropriate laboratory tests as directed by the CQA Officer and in accordance with the project plans and specifications.

2.1.6 Contractor

The Contractor is the party with which the Owner has entered into agreement to construct the project.

2.1.6.1 Responsibilities

The Contractor is responsible for meeting the requirements of the contract documents and the successful completion of the landfill construction project. The Contractor is responsible for all items of work on the project including but not limited to earthwork, erosion and sedimentation control, soil liners, geosynthetic (HDPE) liners, geocomposite drainage nets, protective cover and drainage layers, piping and installation of roads, and all other associated appurtenances. The Contractor shall be responsible for the quality of the materials and installation of the materials in conformance with the contract documents. The Contractor shall be responsible for the quality of work and materials supplied by all of its subcontractors. Contractor shall be responsible for the quality of work and materials supplied by manufacturers.

It is the Contractor's sole responsibility to provide adequate CQC measures for the work to be performed. The Contractor shall not rely on the Owner’s CQA services for determining compliance with the contract specifications. The Contractor's specific responsibilities include but are not limited to: providing qualified personnel to perform quality control, providing the CQC Officer, providing acceptable submittals for the various materials as required by the specifications, scheduling and coordinating the work with suppliers and subcontractors, providing a competent resident construction superintendent and an on-site CQC representative at all times during construction, providing licensed land surveying services well-versed in landfill construction, furnishing progress reports, drawings and record drawings, attending progress meetings, providing monthly updated schedules at minimum, and notifying the Owner of design inconsistencies or contradictions. The Contractor shall be appropriately licensed by the State of North Carolina and local municipality.

2.1.6.2 Qualifications

The Contractor's Project Manager and Superintendent shall have a minimum of 10 years of progressive experience with landfill construction work and specifically with construction of low permeability soil liners and geosynthetic liners.

2.1.7 Quality Control Officer

The Contractor shall directly employ and pay for the services of an independent CQC Firm. The CQC Firm shall directly employ and designate a CQC Officer with minimum qualifications as described in Article 2.1.7.2 of this CQA Plan.

The QC Officer may employ a firm to provide QC field testing and laboratory testing services, however it shall be clear that CQC field personnel shall report to and work directly under the supervision and management of the QC Officer.

2.1.7.1 Responsibilities

The CQC Officer shall be solely responsible for the CQC personnel and their activities, as well as the preparation of a certification report to certify the project has been constructed in accordance with the CQA Plan, permit documents, design plans, and specifications.

The CQC Officer shall be responsible for identifying and coordinating quality control activities, testing and reporting requirements of the contract documents, and advising the Contractor of discrepancies in the construction that do not meet the requirements of the contract documents (including report preparation and repair plan reports) as specified herein.

Additional responsibilities include:

- Complete understanding of the permit documents, design plans, and specifications in relation to all aspects of the CQA Plan.
- Recognizing and reporting deviations from the CQA Plan, permit documents, design plans, and/or specifications to the Contractor and Engineer.
- Documenting and reporting CQC activities.

2.1.7.2 Qualifications

The CQC Officer shall have a minimum of 10 years of progressive engineering and construction experience with work associated with landfill construction, including earthwork and geosynthetics installation. The CQC Officer shall be a Professional Engineer licensed in the State of North Carolina.

Qualifications of the CQC firm and Resumes for the CQC Officer and CQC field personnel must be submitted to the Owner and CQA Officer for approval prior to commencement of the Project. The CQC firm and Officer shall demonstrate experience and familiarity with the installation of geosynthetics, low permeable soil liners and construction of lined landfill facilities in general. Field personnel shall have a minimum of 4 years of field experience with the material/operation being inspected and/or tested, and specifically with the construction of low permeable soil liners and geosynthetic installations. QC and QC Field personnel shall not be replaced unless approved by the Owner and Engineer.

2.1.8 Quality Control Laboratory

The Quality Control Laboratory is a firm, independent from the Contractor, Manufacturer, and Installer, responsible for conducting tests on samples of geosynthetics (geomembrane, geocomposites and geotextiles) and soils used in the construction of the

facility.

The Quality Control Laboratory shall be responsible for conducting the appropriate laboratory tests as directed by the CQC Officer and in accordance with the project plans and specifications.

The Quality Control Laboratory shall be responsible for providing all tests results to the CQC Officer in written form within 24 hours of receipt of test samples results. Written test results shall be in an easily readable format and include references to the standard test methods used.

2.1.8.1 Soils Quality Control Laboratory

The Soils CQC Laboratory shall be a qualified laboratory with experience in performing laboratory tests to determine soils characteristics as required by the specifications. The Soils CQC Laboratory shall demonstrate that it follows the standard test methods listed in the specifications and maintains the appropriate, calibrated equipment to perform the tests. The Soils CQC Laboratory shall also demonstrate to the CQA Officer that it adheres to a formal in-house QA/QC program and can provide the required analytical documentation and reports.

2.1.8.2 Geosynthetics CQC Laboratory

The Geosynthetics CQC Laboratory shall be a qualified laboratory with experience in performing laboratory tests to determine geosynthetics characteristics as required by the specifications. The Geosynthetics CQC Laboratory shall demonstrate that it follows the standard test methods listed in the specifications and maintains the appropriate, calibrated equipment to perform the tests. The Geosynthetics CQC Laboratory shall also demonstrate to the CQA Officer’s satisfaction that it adheres to a formal in-house QA/QC program and can provide the required analytical documentation and reports. The CQC Geosynthetics Laboratory shall hold current accreditation from the Geosynthetic Accreditation Institute (GAI) for all pertinent test methods.

2.1.9 Geosynthetics Manufacturer

The Geosynthetics Manufacturer is the firm or corporation responsible for production of geosynthetic materials to be used in the project.

2.1.9.1 Responsibilities

The Geosynthetics Manufacturer shall produce a consistent product meeting the project specifications and shall provide quality control documentation for its product as specified in the construction specifications.

2.1.9.2 Qualifications

Each Geosynthetic Manufacturer shall provide sufficient production capacity and qualified personnel to meet the demands of the project as identified in the specification. Each Manufacturer shall have an internal quality control program for its product that meets the specified requirements.

Each Geosynthetic Manufacturer shall meet the following requirements and submit the following information:

- Corporate background and information
- A list of material properties including certified test results, which are attached to geosynthetic samples, if applicable.
- For liner systems, a list of at least 10 completed landfill or surface impoundment facilities totaling a minimum of 3,000,000 SF for which the Manufacturer has manufactured a geosynthetic product. For each facility, the following information shall be provided: Name and purpose of facility, its location, and date of installation, name of owner, project manager, designer, fabrication (if any), and installer, type of geosynthetic and the surface area of installed geosynthetic, available information of the performance of the lining system and the facility.
- The Manufacturer's Quality Control Manual, including a description of the quality control laboratory facilities and pertinent accreditation.
- The Manufacturer's Field Installation Quality Control Manual. The Manufacturer's and Installer's QC Manual shall comply with the Contract Documents. At a minimum, the manual shall contain procedures and recommendations for the following: Geosynthetics deployment, field panel placement, geosynthetics field seaming, seam testing (destructive, non-destructive for field and laboratory settings), repair of defects
- The origin (supplier's name and production plant, and identification (brand name and number) or resin used to manufacture the product.

Pre-installation: Prior to the installation of any geosynthetic material, each Manufacturer must submit to the Engineer and CQA Officer all quality control documentation required by the appropriate section of the specifications. This documentation shall be reviewed and approved by the Engineer and CQA Officer before installation can begin.

2.1.10 Geosynthetics Installer

The Geosynthetics Installer is the company responsible for the installation of a particular component of the landfill containment system such as the geosynthetic liner, geosynthetics, leachate collection piping, manholes, pumps and systems. The Geosynthetics Installer is a Manufacturer or an approved installer trained and certified to install a Manufacturer's product.

The Geosynthetics Installer shall be trained and certified to install the material used, and shall be able to provide qualified personnel to meet the demands of the project.

2.1.10.1 Responsibilities

The Geosynthetics Installer shall be responsible for field handling, storing during the installation process, deploying, seaming, curing, temporary restraining, and all other aspects of the product installation. The Installer shall be responsible for submittal of the documentation listed to the Contractor.

Pre-installation: Prior to commencement of the installation, the Geosynthetics Installer must submit to the CQA Officer through the Contractor:

- Resume of the Installation Supervisor to be assigned to this project, including dates and duration of employment, and relevant experience and qualifications.
- A preliminary (panel) layout drawing showing the installation layout identifying field seams (or connections) as well as any variance or additional details, which deviate from the engineering drawings. The layout shall be adequate for use as a construction plan and shall include dimensions, details, etc.
- Deviation from the layout plan must be approved by the CQA Officer prior to installation.
- Installation schedule
- A list of personnel performing field (seaming) operations along with pertinent experience information and certifications
- All required (HDPE, geosynthetic, etc.) quality control certificates
- Certification that HDPE extrudate to be used is comprised of the same resin as the geomembrane to be used for the geosynthetic phase of the project

This CQA Plan shall be reviewed by the Geosynthetics Installer before installation during the applicable phase of construction (geosynthetics, piping, etc.) begins.

Installation (geomembrane liner): During the installation, the Geosynthetics Installer shall be responsible for the submission of subgrade surface acceptance certificates for each area to be covered by the lining system, signed by the Installation Supervisor.

Completion: Upon completion of the installation, the Geosynthetics Installer shall submit:

- The warranty obtained from the Manufacturer.
- The installation warranty
- Record drawings clearly delineating panels, seams, repairs, repair patches, and location of destructive samples
- All QC field reports and documents

The drawings shall be reviewed and certified by the CQC Officer for accuracy. The QC field report documents and drawings shall be submitted to the CQA Officer for review and acceptance.

The Installation Supervisor is the individual provided and assigned by the Installer to be the field representative providing supervision and guidance to the installation crew.

The Installation Supervisor is responsible for coordinating the installation of the material or system (geomembrane liner, geosynthetics, piping, connections, seaming, etc.). The Installation Supervisor is responsible for obtaining samples for field testing and for coordinating testing activities with the Contractor and CQA Officer. The Installation Supervisor is responsible for keeping a daily log of all activities related to geosynthetic products installation and testing and for attending all related project meetings.

2.1.10.2 Qualifications

The Geosynthetics Installer shall provide, through the Contractor, the Engineer and CQA Officer with the information demonstrating qualifications as follow:

- Corporate background and information
- Description of installation capabilities:
- Information on equipment (numbers and types), and personnel (number of site managers and number of crews)
- Average daily production anticipated.
- Samples of field geomembrane seams and a list of minimum values for geomembrane seam properties.
- Experience as required by individual Specification Sections. For each installation, the following information shall be provided:
- Name and purpose of facility, its location, and date of installation
- Name of owner, project manager, designer, manufacturer, fabricator (if any), and

name of contact at the facility who can discuss the project

- Name and qualifications of the Superintendent(s) of the Installer's crew(s)
- Type of geosynthetic and surface area installed.
- Type of seaming and type of seaming apparatus used
- Duration of installation
- Available information on the performance of the lining system and the facility
- The Installer's quality control manual. Should the manual be in conflict with the specifications or drawings, the specifications and drawings shall control.
- A copy of a letter of recommendation supplied by the geomembrane Manufacturer

The Installation Supervisor must be qualified based on previously demonstrated experience, management ability, and authority. The Geosynthetic Installation Supervisor shall have previously managed the installation of seaming apparatus to be used at the site. The Drainage Net Supervisor must have installed at least one net system. The pipe installer must have completed manufacturers training for fusing pipe.

2.2 CQA Meetings

To achieve a high degree of quality during construction and to assure a final product that meets all project requirements, clear, open channels of communication are essential; it is essential that lines of communication are open and active in addition to conducting regular project meetings at the site.

2.2.1 Pre-Construction Conference

A Pre-Construction Conference shall be held prior to commencement of the work. At a minimum, the meeting shall include the Owner, Engineer, CQA Officer, Contractor (Project Manager and Superintendent); CQC Officer and Installers as applicable. The Permitting Agency will be notified of the meeting will attend as deemed appropriate.

The meeting will include, but not be limited to, a review of the project site, project documents, modifications of these documents, the responsibilities and duties of each party, lines of authority and communication, the construction work plan, the proposed schedule and critical path, a discussion of the procedures and schedule for periodic reporting for testing and construction activities, testing protocols, locations of soils, stockpiling, etc.. The Contractor shall present and distribute schedules at the meeting.

2.2.2 Progress Meetings

At minimum, monthly progress meeting shall be held between the Owner, Engineer, CQA

Officer, Contractor, CQC Officer, and other involved parties. Weekly or bi-weekly progress meetings will be held as needed. Those attending will discuss current progress, planned activities for the next week, and new business or revisions to the work. The Engineer will log problems, decisions, or questions arising at this meeting. Minutes of these meeting will be submitted by the Engineer to the Owner for approval and distributed to the appropriate parties.

2.2.3 Geosynthetics CQA Meeting

A Geosynthetics CQA Meeting shall be held at the site prior to deployment of geosynthetics. The meeting shall be attended by the Engineer, Owner, CQA Officer, Contractor, and Geosynthetics Installer superintendent.

The purpose of this meeting is to begin planning for coordination of tasks, anticipate any problems which might cause difficulties and delays in construction, and review the CQA Manual with all of the parties involved.

The meeting shall be documented by the Engineer and minutes will be transmitted to all parties.

2.2.4 Problem or Work Deficiency Meeting

A special meeting may be held when and if a problem or work deficiency is present or likely to occur. At a minimum, the meeting should be attended by the Owner, Engineer, CQA Officer, Contractor, and the CQC Officer as appropriate. The purpose of the meeting is to define and resolve the problem or work deficiency as follows:

A. Define and discuss the problem or deficiency;

B. Review alternate solutions; and

C. Implement an action plan to resolve the problem or deficiency.

The Engineer shall document the meeting and minutes shall be transmitted to the parties involved.

3.0 INSPECTION ACTIVITIES

A description of all field observations, tests, equipment, calibration procedures for field testing equipment that will be used to ensure that the construction and installation meets or exceeds all design criteria established in accordance with Rules .1620 and .1624 of this Section must be presented in the CQA plan.

Inspection activities for each of the following components of construction are described in the following subsections, with additional detail provided in the project Technical Specifications included in Appendix 1 of this CQA Plan:

- Earthwork
  - Section 02200, Appendix 1
- Compacted Clay Liner
  - Section 02275, Appendix 1
- Geosynthetic Clay Liner (GCL)
  - Section 02277, Appendix 1
- Geomembrane Liner
  - Section 02776, Appendix 1
- Leachate Collection Pipes
  - Section 02623, Appendix 1
- Drainage Layers
  - Section 02274, Appendix 1
  - Section 02700, Appendix 1
- Filter Layer
  - Section 02272, Appendix 1

3.1 Earthwork

This section of the CQA Plan addresses earthwork (embankment construction) and outlines the soils CQA program to be implemented with regard to material approval, subgrade approval, CQA testing, CQC testing and resolution of deficiencies.

3.1.1 Material Approval

Conformance testing shall be performed by the CQC Laboratory on samples from each source of backfill material. Materials identified for use as backfill shall be tested at the frequency indicated in the project Technical Specifications included in Appendix 1 of this CQA Plan.

Proposed materials shall be reviewed and approved by the CQA Officer prior to use in earthwork construction.

3.1.2 Subgrade Approval

Compacted fill and backfill operations shall be performed only after the subgrade has been properly prepared and has been observed and approved by CQA Officer.

3.1.3 Earthwork Construction Requirements

Earthwork construction shall be directed by the CQC Officer and monitored by the CQA Engineer. Only soil approved by the CQA Engineer shall be used in construction. Unsuitable material shall be removed prior to acceptance by the CQA Engineer. All required field testing shall be completed before the overlying lift of soil is placed. Surface preparation shall be completed before the CQA Engineer will allow placement of subsequent lifts.

Earthwork construction shall be tested according to the methods and frequency indicated in the project Technical Specifications included in Appendix 1 of this CQA Plan.

3.1.4 Deficiencies

The CQA Engineer will determine the extent and nature of all deficiencies and report them to the Owner and Engineer. All deficiencies will be documented by the CQA Engineer, including the nature and extent of deficiency, corrective measures taken by the Contractor, and testing verifying that deficiencies have been corrected in accordance with project specifications.

3.2 Compacted Soil Liner

This section of the CQA Plan addresses compacted soil liner construction and outlines the CQA program to be implemented with regard to material approval, subgrade approval, evaluation of construction methods, CQA testing, CQC testing and resolution of problems.

3.2.1 Material Approval

Conformance testing shall be performed by the CQC Laboratory on samples from each source of compacted soil liner material. Materials identified for use as compacted soil liner shall be tested at the frequency indicated in the project Technical Specifications

included in Appendix 1 of this CQA Plan.

Proposed materials shall be reviewed and approved by the CQA Officer prior to use in earthwork construction.

3.2.2 Subgrade Approval

Compacted Soil Liner subgrade shall be verified to conform to project specifications and approved by the CQA Engineer.

3.2.3 Compacted Soil Liner Construction Requirements

Construction methods of the compacted soil liner shall be based upon the type and quality of the borrow source and shall be verified in the field by constructing test pad(s). The CQA Engineer shall ensure that the compacted soil liner installation conforms to the requirements indicated in the project Technical Specifications included in Appendix 1 of this CQA Plan.

3.2.3.1 Test Pad Construction

A test pad shall be constructed prior to beginning installation of the compacted clay liner and whenever there is a significant change in soil material properties. The area and equipment, liner thickness, and subgrade slope and conditions shall be representative of full scale construction. Test pad requirements are indicated in the project Technical Specifications included in Appendix 1 of this CQA Plan.

3.2.3.2 Soil Handling

Soil conditioning, placement, and compaction shall be maintained within the range identified in the moisture-density-permeability relation developed in accordance with Subparagraph (b)(8)(C) of Rule .1624, and the project Technical Specifications included in Appendix 1 of this CQA Plan.

3.2.3.3 Lift Thickness

The final compacted thickness of each lift shall be a maximum of six inches as required by Rule .1624 and the project Technical Specifications included in Appendix 1 of this CQA Plan.

3.2.3.4 Successive Lifts

Prior to placement of successive lifts, the surface of the lift in place shall be scarified or otherwise conditioned to eliminate lift interfaces as required by Rule .1624 and the project Technical Specifications included in Appendix 1 of this CQA Plan.

3.2.3.5 Lift Surface Protection

The final lift shall be protected from environmental degradation as required by Rule .1624 and the project Technical Specifications included in Appendix 1 of this CQA Plan.

3.2.4 Deficiencies

The CQA Engineer will determine the extent and nature of all deficiencies and report them to the Owner and Engineer. All deficiencies will be documented by the CQA Engineer, including the nature and extent of deficiency, corrective measures taken by the Contractor, and testing verifying that deficiencies have been corrected in accordance with project specifications.

3.3 Geosynthetic Clay Liners

Geosynthetic clay liners are geosynthetic hydraulic barriers manufactured in sheets and installed by field seaming techniques. This section of the CQA Plan addresses geosynthetic clay liner construction and outlines the CQA program to be implemented with regard to manufacturer and installer approval, material approval, subgrade approval, evaluation of construction methods, CQA testing, CQC testing and resolution of deficiencies.

3.3.1 Manufacturer and Installer Approval

The Manufacturer and Installer shall meet the requirements specified in Section 2.1.9 and 2.1.10 of this CQA Plan, and shall be approved by the CQA Engineer.

3.3.2 Material Approval

Geosynthetic clay liners shall consist of natural sodium bentonite clay or equivalent, encapsulated between two geotextiles or adhered to a geomembrane. The liner material and any seaming materials shall have chemical and physical resistance not adversely affected by environmental exposure, waste placement, leachate generation and subgrade moisture composition. Accessory bentonite, used for seaming, repairs and penetration seaming shall be made from the same sodium bentonite as used in the geosynthetic clay liner or as recommended by the manufacturer. The type of geosynthetic clay liner shall be approved by the Division according to the criteria set forth in Rule .1624 and the project Technical Specifications included in Appendix 1 of this CQA Plan. Proposed materials shall be approved by the CQA Engineer.

3.3.3 Design and Construction Requirements

The Engineer shall ensure that the design of the geosynthetic clay liner installation conforms to the requirements of the Manufacturer's recommendations, the Division

approved plans, and the Division approved Technical Specifications. The Division approved plans shall provide for and include the following provisions:

3.3.3.1 Supporting Surface

The surface of the supporting soil upon which the geosynthetic clay liner will be installed shall be reasonably free of stones, organic matter, protrusions, loose soil, and any abrupt changes in grade that could damage the geosynthetic clay liner in accordance with Rule .1624 and the project Technical Specifications included in Appendix 1 of this CQA Plan.

3.3.3.2 Overlying Materials

Materials placed on top of the GCL shall be placed in accordance with the plans incorporated into the permit to construct in accordance with Rule .1604(b). Equipment used to install additional geosynthetics shall be specified by the design engineer and as recommended by the manufacturer. A minimum of 12 inches of separation between the application equipment and the geosynthetic clay liner shall be provided when applying soil materials in accordance with Rule .1624 and the project Technical Specifications included in Appendix 1 of this CQA Plan.

3.3.3.3 Premature Hydration of Materials

Materials that become prematurely hydrated shall be removed, repaired, or replaced, as specified by the project engineer and in accordance with Rule .1624 and the project Technical Specifications included in Appendix 1 of this CQA Plan.

3.3.3.4 Seaming Conditions

Field seaming preparation and methods, general orientation criteria, and restrictive weather conditions are indicated in accordance with Rule .1624 and the project Technical Specifications included in Appendix 1 of this CQA Plan.

3.3.3.5 Engineering Design

The anchor trench design, critical tensile forces, and slope stability, including seismic design, are documented in the Engineering Plan, with construction techniques specified on the Department approved plans.

3.3.3.6 Protection from Environmental Damage

Methods of protection from environmental damage are specified in accordance with Rule .1624 and the project Technical Specifications included in Appendix 1 of this CQA Plan.

3.3.3.7 Protection from Physical Damage

Methods of protection from physical damage from the materials installed directly above

geosynthetic clay liner are specified in accordance with Rule .1624 and the project Technical Specifications included in Appendix 1 of this CQA Plan.

3.3.4 Deficiencies

The CQA Engineer will determine the extent and nature of all deficiencies and report them to the Owner and Engineer. All deficiencies will be documented by the CQA Engineer, including the nature and extent of deficiency, corrective measures taken by the Contractor, and testing verifying that deficiencies have been corrected in accordance with project specifications.

3.4 Geomembrane Liner

Geomembrane liners are geosynthetic hydraulic barriers manufactured in sheets and installed by field seaming techniques. This section of the CQA Plan addresses geomembrane liner construction and outlines the CQA program to be implemented with regard to manufacturer and installer approval, material approval, subgrade approval, evaluation of construction methods, CQA testing, CQC testing and resolution of deficiencies.

3.4.1 Manufacturer and Installer Approval

The Manufacturer and Installer shall meet the requirements specified in Section 2.1.9 and 2.1.10 of this CQA Plan, and shall be approved by the CQA Engineer.

3.4.2 Material Approval

The liner material and any seaming materials shall have chemical and physical resistance not adversely affected by environmental exposure, waste placement and leachate generation. The type of geomembrane shall be approved by the Division according to the criteria set forth in Rule .1624 and the project Technical Specifications included in Appendix 1 of this CQA Plan. Proposed materials shall be approved by the CQA Engineer.

3.4.3 Geomembrane Liner Construction Requirements

The Engineer shall ensure that the design of the geomembrane liner installation conforms to the requirements of the Manufacturer's recommendations, the Division approved plans, and the Division approved Technical Specifications. The Division approved plans shall provide for and include the following provisions:

3.4.3.1 Supporting Surface

The surface of the supporting soil upon which the geomembrane will be installed shall be

reasonably free of stones, organic matter, protrusions, loose soil, and any abrupt changes in grade that could damage the geomembrane in accordance with Rule .1624 and the project Technical Specifications included in Appendix 1 of this CQA Plan.

3.4.3.2 Seaming Conditions

Field seaming preparation and methods, general orientation criteria, and restrictive weather conditions are indicated in accordance with Rule .1624 and the project Technical Specifications included in Appendix 1 of this CQA Plan.

3.4.3.3 Engineering Design

The anchor trench design, critical tensile forces, and slope stability, including seismic design, are documented in the Engineering Plan, with construction techniques specified on the Department approved plans.

3.4.3.4 Protection from Environmental Damage

Methods of protection from environmental damage are specified in accordance with Rule .1624 and the project Technical Specifications included in Appendix 1 of this CQA Plan.

3.4.3.5 Protection from Physical Damage

Methods of protection from physical damage from the materials installed directly above geosynthetic clay liner are specified in accordance with Rule .1624 and the project Technical Specifications included in Appendix 1 of this CQA Plan.

3.4.4 Deficiencies

The CQA Engineer will determine the extent and nature of all deficiencies and report them to the Owner and Engineer. All deficiencies will be documented by the CQA Engineer, including the nature and extent of deficiency, corrective measures taken by the Contractor, and testing verifying that deficiencies have been corrected in accordance with project specifications.

3.5 Leachate Collection Pipes

A leachate collection pipe network shall be a component of the leachate collection system and shall be hydraulically designed to convey leachate from the MSWLF unit to an appropriately sized leachate storage or treatment facility or a point of off-site transport. This section of the CQA Plan addresses leachate collection pipe construction and outlines the CQA program to be implemented with regard to material approval, evaluation of construction methods, and resolution of deficiencies.

3.5.1 Material Approval

Leachate pipe materials shall be specified according to the criteria set forth in Rule .1624 and the project Technical Specifications included in Appendix 1 of this CQA Plan. The leachate collection piping shall have a minimum nominal diameter of six inches. The chemical properties of the pip and any materials use in installation hall not be adversely affected by waste placement or leachate generated by the landfill. The physical properties of the pipe shall provide adequate structural strength to support the maximum static and dynamic loads and stresses imposed by the overlying materials and any equipment used in construction and operation of the landfill. Proposed materials shall be approved by the CQA Engineer.

3.5.2 Leachate Collection Line Construction Requirements

Leachate collection lines shall be constructed according to the requirements set forth in Rule .1624 and as indicated in the Project Technical Specifications included in Appendix 1 of this CQA Plan. Minimum construction requirements per Rule .1624 include:

- Leachate collection piping shall be installed according to the plans and technical specifications incorporated into the permit to construct.
- The location and grade of the piping network shall provide access for periodic cleaning.
- The bedding material for the leachate collection pipe shall consist of a coarse aggregate installed in direct contact with the pipe. The aggregate shall be chemically compatible with the leachate generated and shall be placed to provide adequate support to the pipe. The bedding material for main collector lines shall be extended to and in direct contact with the waste layer or a graded soil or granular filter. Requirements for graded granular filters are discussed in detail in Section 3.7 of this CQA Plan.

3.5.3 Deficiencies

The CQA Engineer will determine the extent and nature of all deficiencies and report them to the Owner and Engineer. All deficiencies will be documented by the CQA Engineer, including the nature and extent of deficiency, corrective measures taken by the Contractor, and testing verifying that deficiencies have been corrected in accordance with project specifications.

3.6 Drainage Layers

Any soil, aggregate, or geosynthetic drainage nets used in the leachate collection system shall conform to the requirements described in this Section of the CQA Plan and as indicated in the project Technical Specifications included in Appendix 1. For the purpose

of this CQA Plan, the drainage layer components include geocomposite drainage net and protective cover soils.

3.6.1 Material Approval

Drainage layer materials shall be specified according to the criteria set forth in Rule .1624 and the project Technical Specifications included in Appendix 1 of this CQA Plan. The chemical properties of the drainage layer materials shall not be adversely affected by waste placement or leachate generated by the landfill. The physical and hydraulic properties of the drainage layer materials shall promote lateral drainage of leachate through a zone of relatively high permeability or transmissivity under the predicted loads imposed by overlying materials. Proposed materials shall be approved by the CQA Engineer.

3.6.2 Drainage Layer Construction Requirements

The drainage layer shall be constructed according to the requirements set forth in Rule .1624 and as indicated in the Project Technical Specifications included in Appendix 1 of this CQA Plan. Minimum construction requirements per Rule .1624 include:

- The drainage layer materials shall be placed in accordance with the approved plans and technical specifications, and in a manner that prevents equipment from working directly on the geomembrane.
- The drainage layer materials shall be stable on the slopes specified on the engineering drawings.

3.6.3 Deficiencies

The CQA Engineer will determine the extent and nature of all deficiencies and report them to the Owner and Engineer. All deficiencies will be documented by the CQA Engineer, including the nature and extent of deficiency, corrective measures taken by the Contractor, and testing verifying that deficiencies have been corrected in accordance with project specifications.

3.7 Filter Layer Criteria

All filter collection layers used in the leachate collection system shall be designed to prevent the migration of fine soil particles into a courser grained material, and permit water or gases to freely enter a drainage medium (pipe or drainage layer) without clogging. Any aggregate or geosynthetic filter material shall conform to the requirements described in this Section of the CQA Plan and as indicated in the project Technical Specifications included in Appendix 1. For the purpose of this CQA Plan, the filter layer

components include graded aggregate leachate collection stone and filter fabric associated with geocomposite drainage net.

3.7.1 Material Approval

Filter layer materials shall be specified according to the criteria set forth in Rule .1624 and the project Technical Specifications included in Appendix 1 of this CQA Plan. Proposed materials shall be approved by the CQA Engineer.

3.7.1.1 Graded Cohesionless Soil Filters

The granular soil material used as a filter shall have no more than five percent by weight passing the No. 200 sieve and no soil particles larger than three inches in any dimension in accordance with the requirements of Rule .1624 and the project Technical Specifications included in Appendix 1 of this CQA Plan.

3.7.1.2 Geosynthetic Filters

Geosynthetic filter materials shall demonstrate adequate permeability and soil particle retention, and chemical and physical resistance which is not adversely affected by waste placement, any overlying material or leachate generated by the landfill in accordance with the requirements of Rule .1624 and the project Technical Specifications included in Appendix 1 of this CQA Plan.

3.7.2 Filter Layer Construction Requirements

All filter layers shall be installed in accordance with the engineering plan and specifications incorporated into the permit to construct according to the requirements set forth in Rule .1624 and as indicated in the Project Technical Specifications included in Appendix 1 of this CQA Plan. Geosynthetic filter materials shall not be wrapped directly around leachate collection piping.

3.7.3 Deficiencies

The CQA Engineer will determine the extent and nature of all deficiencies and report them to the Owner and Engineer. All deficiencies will be documented by the CQA Engineer, including the nature and extent of deficiency, corrective measures taken by the Contractor, and testing verifying that deficiencies have been corrected in accordance with project specifications.

4.0 Sampling Strategies

The CQA Plan is required contain a description of all sampling protocols, sample size, methods for determining sample locations, and frequency of sampling in accordance with Rule .1621. Sampling protocols, sample size, sampling methods, and frequency are discussed in the Technical Specifications included in Appendix 1 of this CQA Plan.

5.0 DOCUMENTATION

Reporting requirements for CQA activities must be described in detail in the CQA plan. Progress and troubleshooting meetings, daily and monthly, must be addressed in the plan and the contents of the meetings must be documented.

The ultimate value of a CQA plan depends to a large extent on recognition of all of the construction activities that should be inspected and the assignment of responsibilities to CQA and CQC inspection personnel for the inspection of each activity. This is most effectively accomplished by documenting CQA activities. The CQA Officer and CQC Officer shall provide the Engineer with signed descriptive remarks, data sheets, and logs to verify that all monitoring activities have been carried out. The CQA Officer and CQC Officer shall also maintain a complete file of design plans, permit specifications, the CQA Plan, checklists, test procedures, daily logs, and other pertinent documents.

5.1 Daily Record Keeping

Standard daily reporting procedures should include preparation of the following documents:

- Daily Summary Report from the field (CQA and CQC)
- Observation Logs and Test Data Sheets (CQA and CQC)
- Construction Problem and Solution Report (Engineer or CQA Officer)
- Photographic Reporting (CQA and Contractor)

5.1.1 Daily Summary Report

Daily summary reports shall be prepared daily by the CQA Officer and CQC Officer and/or their designated representative in the field. This daily report provides the chronological framework for identifying and recording all other reports. At a minimum, the summary reports should include the following information:

- An identifying sheet number for cross-referencing and document control as applicable;
- Date, project day, project name, location, and other identification;
- Data on weather conditions;
- Reports on any meetings held and their results;
- A reduced-scale site plan showing all proposed work areas and test locations;
- Descriptions and locations of ongoing construction;

- Descriptions and specific locations of areas, or units, of work being tested and/or observed and documented;
- Locations where tests and samples were taken or reference to specific observation logs and/or test data sheets where such information can be found;
- A summary of field/laboratory test results or reference to specific observation log and/or test data sheets;
- Calibrations or recalibrations of test equipment and actions taken as a result of recalibration, or reference to specific observation logs and/or test data sheets;
- Off-site materials received, including quality and quantity verification documentation;
- Decisions made regarding approval of units of material or of work, and/or corrective actions to be taken in instances of substandard quality;
- The CQA representative's and/or the CQC Officer and his/her on-site representative's signature as appropriate.

5.1.2 Observation Logs and Test Data Sheets

All observations, and field and/or laboratory tests, should be recorded on project-specific logs and data sheets. Recorded observations may take the form of notes, charts, sketches, photographs, or any combination of these. Where possible, a checklist may be useful to ensure that no pertinent factors of a specific observation are overlooked. These logs and data sheets may include the following information:

- An identifying sheet numbered for cross referencing and document control;
- Date, project name, location, and personnel involved in the inspection activity.
- Description or title of activity monitored;
- Location of inspection activity and locations of samples collected;
- Type of inspection activity; procedure used (reference to standard method when appropriate);
- Results of laboratory tests received;
- Results of monitoring activity in comparison to specifications; and
- The CQA monitor's or CQC Officer's signature as appropriate.

5.1.3 Problem Identification and Solution Reports

A problem is defined herein as material or workmanship that does not meet the specified design. Problem Identification and Solution Reports should be cross-referenced to specific observation logs (or daily filed reports) and test data sheets (or summary tables). The report shall include the following information, as applicable:

- An identifying sheet number for cross-referencing and document control;
- A detailed description of the situation or deficiency;
- The location and probable cause of the situation or deficiency;
- How and when the situation or deficiency was found or located; Documentation of the response to the situation or deficiency;
- Final results of any responses;
- Any measures taken to prevent a similar situation from occurring in the future; and
- The signature of the Engineer.

The Owner shall be made aware of any significant recurring nonconformance with the permit specifications. The Engineer shall then determine the cause of the non-conformance and recommend appropriate changes in procedures or specifications. Any changes will be submitted to the Owner for approval. When this type of evaluation is necessary, the results shall be documented and any revision to procedures or permit specifications will be approved by the Owner, Engineer, and, if necessary, the Permitting Agency.

5.1.4 Photographic Reporting

Photographic reporting may be cross-referenced with observation logs and test data sheets and/or construction problem and solution reports. Photographic reporting should include the following information:

- Identification for cross-referencing and document control;
- The size, scale, and orientation of the subject matter photographed; Location and description and date of the work;
- The purpose of the photograph;
- The name of the photographer.

These photographs will serve as a photographic record of work progress, issues, and corrective measures. They should be kept in a permanent protective file in the order in which they were taken.

5.2 Final Documentation

A CQA certification shall be prepared by the CQA Engineer:

(a) After completing landfill construction in order to qualify the constructed MSWLF unit for a permit to operate;

(b) After completing construction of the cap system in accordance with the requirements of Rule .1629; and

(c) According to the reporting schedule developed in accordance with Rule .1621.

The CQA report shall contain:

- documentation of any failed test results, descriptions of procedures used to correct the improperly installed material and results of all retesting performed.
- as-built drawings noting any deviation from the approved engineering plans and shall also contain a comprehensive narrative including but not limited to daily reports from the project engineer and a series of color photographs of major project features.

The following sections describe the primary components of landfill construction requiring certification per Rules .1621 and .1624. It shall be noted that all items listed below may not apply for each construction activity requiring CQA certification.

5.2.1 Liner Subgrade

At a minimum, the liner subgrade surface shall be inspected in accordance with the following requirements and as specified in the project Technical Specifications included in Appendix 1 of this CQA Plan.

(a) Before beginning construction of the base liner system, the CQA Engineer shall visually inspect the exposed surface to evaluate the suitability of the subgrade and document that the surface is properly prepared and that the elevations are consistent with the approved engineering plans incorporated into the permit to construct;

(b) The subgrade shall be proof-rolled using procedures and equipment specified by the Engineer; and

(c) The subgrade shall be tested for density and moisture content at a minimum

frequency as specified in the plans incorporated into the permit to construct.

5.2.2 Compacted Soil Liner

The CQA Engineer shall include in the construction quality assurance report a discussion of all quality assurance and quality control testing required in the permit to construct. The results of all testing shall be included in the construction quality assurance report including documentation of any failed test results, descriptions of the procedures used to correct the improperly installed material, and statements of all retesting performed in accordance with the Division approved plans including the following requirements:

(a) At a minimum, the quality control testing for accepting materials prior to and during construction of a compacted clay liner shall include: particle size distribution analysis, Atterberg limits, triaxial cell laboratory permeability, moisture content, percent bentonite admixed with soil, and the moisture-density-permeability relation. The project engineer shall certify that the materials used in construction were tested according to the Division approved plans.

(b) At a minimum, the quality assurance testing for evaluating each lift of the compacted clay liner shall include: moisture content and density, and permeability testing. For each location the moisture content and density shall be compared to the appropriate moisture-density-permeability relation. The project engineer shall certify that the liner was constructed using the methods and acceptance criteria consistent with test pad construction and tested in accordance with the plans incorporated into the permit to construct in accordance with Rule .1604(b) of this Section.

(c) Any tests resulting in the penetration of the compacted clay liner shall be repaired using bentonite or as approved by the Division.

5.2.3 Geosynthetic Clay Liner

The CQA Engineer shall include in the construction quality assurance report a discussion of all quality assurance and quality control activities required in the permit to construct, to include the following:

(a) A discussion of the approved data resulting from the quality assurance and quality control testing required in Rule .1624 and the Technical Specifications included in Appendix 1 of this CQA Plan.

(b) The results of all testing, including documentation of any failed test results, descriptions of the procedures used to correct the improperly installed material, and performance documentation of all retesting, in accordance with the plans

incorporated into the permit to construct, including the following:

(I) Quality control testing of the raw materials and manufactured product.

(II) Field and independent laboratory destructive testing of geosynthetic clay liner samples.

(III) Documentation prepared by the CQA Engineer in accordance with Subpart (b)(9)(C)(i) of Rule .1624 that, prior to installation, the exposed surface was visually inspect the to evaluate the suitability of the subgrade and documented that the surface was properly prepared and that the elevations are consistent with the approved engineering plans incorporated into the permit to construct.

5.2.4 Geomembrane Liner

The CQA Engineer shall include in the construction quality assurance report a discussion of all quality assurance and quality control activities required in the permit to construct. The testing procedures and protocols for field installation shall be submitted in accordance with Rule .1621, the Technical Specifications included in Appendix 1 of this CQA Plan, and approved by the Division. The results of all testing shall be included in the construction quality assurance report including documentation of any failed test results, descriptions of the procedures used to correct the improperly installed material, and statements of all retesting performed in accordance with the approved plans incorporated into the permit to construct, including the Technical Specifications included Appendix 1 of this CQA Plan.

5.2.5 Leachate Collection Piping

The CQA Engineer shall include in the construction quality assurance report a discussion of the quality assurance and quality control testing to ensure that the material was placed according to the approved plans. The testing procedures and protocols for field installation shall be submitted in accordance with Rule .1621, the Technical Specifications included in Appendix 1 of this CQA Plan, and approved by the Division. The results of all testing shall be included in the construction quality assurance report including documentation of any failed test results, descriptions of the procedures used to correct the improperly installed material, and statements of all retesting performed in accordance with approved plans incorporated into the permit to construct, including the Technical Specifications included Appendix 1 of this CQA Plan, including the following:

(i) All leachate piping installed from the MSWLF unit to the leachate storage or treatment facility shall be watertight.

(ii) The seal where the piping system penetrates the geomembrane shall be inspected and non-destructively tested for leakage.

5.2.6 Drainage Layers

The CQA Engineer shall include in the construction quality assurance report a discussion of the quality assurance and quality control testing to ensure that the drainage layer material was placed according to the approved plans. The testing procedures and protocols for field installation shall be submitted in accordance with of Rule .1621, the Technical Specifications included in Appendix 1 of this CQA Plan, and approved by the Division. The results of all testing shall be included in the construction quality assurance report including documentation of any failed test results, descriptions of the procedures used to correct the improperly installed material, and statements of all retesting performed in accordance with the approved plans incorporated into the permit to construct, including the Technical Specifications included Appendix 1 of this CQA Plan.

5.2.7 Filter Layer Criteria

The CQA Engineer shall include in the construction quality assurance report a discussion of the quality assurance and quality control testing to ensure that the filter layer materials were placed according to the approved plans. The testing procedures and protocols for field installation shall be submitted in accordance with of Rule .1621, the Technical Specifications included in Appendix 1 of this CQA Plan, and approved by the Division. The results of all testing shall be included in the construction quality assurance report including documentation of any failed test results, descriptions of the procedures used to correct the improperly installed material, and statements of all retesting performed in accordance with the approved plans incorporated into the permit to construct, including the Technical Specifications included Appendix 1 of this CQA Plan.

CQA PLAN
APPENDIX 1
TECHNICAL SPECIFICATIONS

Phase 4 and 5
White Oak MSW Landfill

Haywood County, North Carolina

May 2016

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NC FIRM C-2910

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SECTION 02200

EXCAVATION, BACKFILL, AND COMPACTION

PART 1: GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals necessary to perform all excavation, backfill, compaction and grading required to complete the work shown on the Drawings and specified herein. The work shall include, but not necessarily be limited to excavation, backfilling, grading, compaction, disposal of waste and surplus materials, placing crushed stone, construction of berms, and all related work such as sheeting, bracing and de-watering.

B. All excavation, trenching, and related sheeting, bracing, etc. shall comply with the requirements of OSHA excavation safety standards 29 CFR Part 1926.650 Subpart P and State requirements. Where conflict between OSHA and State regulations exists, the more stringent requirements shall apply.

C. Excavated topsoil and excess cut material will be stockpiled in locations approved by the OWNER. Excess topsoil material shall not be used unless otherwise authorized by the OWNER.

1.02 RELATED WORK

A. Section 01050: Field Engineering

B. Section 01410: Construction Quality Assurance / Quality Control Plan

C. Section 02100: Site Preparation

D. Section 02276: Erosion and Sedimentation Control

E. Section 02985: Stabilization

1.03 SUBMITTALS

A. A signed certification letter, with all necessary permits, that the borrow source is in full compliance with State, County and local laws and regulations <u>for each source.</u>

B The CONTRACTOR shall furnish a representative sample weighing approximately 75 pounds of <u>each fill material</u>, stone and crushed stone to the CQA Officer for approval, at least 15 calendar days prior to the date of anticipated use of such material.

C. Excavation support designs shall be prepared by a licensed professional engineer, registered in the State of North Carolina, having a minimum of five years of professional experience in the design and construction of excavation support systems.

D. De-watering and drainage system designs shall be prepared by a licensed professional engineer, registered in the State of North Carolina, having a minimum of five years of professional experience in the design and construction of dewatering and drainage systems.

1.04 QUALITY ASSURANCE / QUALITY CONTROL

A. OWNER shall employ a CQA Officer and Quality Assurance Laboratory to perform soils observation and testing services for quality assurance of the fill material. CONTRACTOR shall employ Quality Control Officer and a Quality Control Laboratory to perform soils inspection and testing services for quality control of the placement of fill material.

1.05 PROTECTION

A. Sheeting and Bracing (if required)

1. Furnish, put in place and maintain such sheeting and bracing as may be required by Federal, State and local safety requirements to support the sides of excavations; to prevent any movement which could in any way diminish the width of the excavation below that necessary for proper construction; and to protect adjacent structures from undermining or other damage. If the Engineer is of the opinion that at any location sufficient or proper supports have not been provided, he/she may order additional supports put in, and compliance with such order shall not relieve or release the CONTRACTOR from his/her responsibility for the sufficiency of such supports. Care shall be taken to prevent voids outside of the sheeting, but if voids are formed, they shall be immediately filled and rammed. Where soil cannot be properly compacted to fill a void, lean concrete shall be used as backfill. All voids shall be filled to the satisfaction of the CQA Officer.

2. Construct the sheeting outside the neat lines of the foundation, unless indicated otherwise, to the extent deemed desirable for the method of operation. Sheeting shall be plumb and securely braced and tied in position. Sheeting and bracing shall be adequate to withstand all pressures to which the structure or trench will be subjected. Any movement or bulging which may occur shall be corrected to provide the necessary clearances and dimensions.

3. All sheeting and bracing shall be carefully removed in such manner as not to endanger the construction or other structures, utilities, or property. All

voids left or caused by withdrawal of sheeting shall be immediately re-filled with sand, which must be approved by the CQA Officer, by ramming with tools especially adapted to that purpose, or otherwise as may be directed.

4. The right of the CQA Officer to order sheeting and bracing left in place shall not be construed as creating any obligation on his/her part to issue such orders and his/her failure to exercise his/her right to do so shall not relieve the CONTRACTOR from liability for damages to persons or property occurring from or upon the work occasioned by negligence or otherwise, growing out of a failure on the part of the CONTRACTOR to leave in place sufficient sheeting and bracing to prevent any caving or moving of the ground.

5. No sheeting is to be withdrawn if driven below mid-diameter of any pipe and under no circumstances shall any sheeting be cut off at a level lower than 1-ft above the top of any pipe.

B Drainage and De-watering

1. De-watering shall be performed as specified during the excavation of organics and unstable soils from the site. Limited dewatering may be required during the excavation and filling of ponds, ditches and where the topsoil layer extends below the water table.

2. At all times during construction provide and maintain proper equipment and facilities to remove all water entering excavations and keep such excavations dry so as to obtain a satisfactory undisturbed subgrade condition until the fills, structures or pipes to be built thereon have been completed to such extent that they will not be floated or otherwise damaged by allowing water into the excavated areas. Groundwater shall be lowered to at least 1 foot below the bottom of excavations.

3. De-watering shall at all times be conducted in such a manner as to preserve the undisturbed bearing capacity of the subgrade soils at proposed bottom of excavation. Well or sump installations shall be constructed with proper sand filters to prevent drawing of finer grained soil from the surrounding ground.

4. Surface runoff shall be collected, drained to sumps and pumped from the disposal unit to maintain a excavation bottom free from standing water.

5. De-watering of ponds or ditches filled with water shall be performed in such a manner as to control discharge water by use of sediment basins and/or check dams or other erosion control structures approved by NCDEQ.

6. Take all additional precautions to prevent uplift of any structure during construction.

7. Drainage shall be disposed of so that flow or seepage back into the excavated area will be prevented.

8. Flotation shall be prevented by maintaining a positive and continuous operation of the dewatering system. The CONTRACTOR shall be fully responsible and liable for all damages which may result from failure of this system.

9. Remove the dewatering equipment after the system is no longer required.

10. Take all necessary precautions to preclude the accidental discharge of fuel, oil, etc in order to prevent adverse effects on groundwater or surface water quality.

C. SLOPE STABILITY

1. The CONTRACTOR shall be solely responsible for the stability of roadway embankments, unbalanced fills, stockpiles, and all other construction operations.

1.06 SOIL TESTING

A. Previous to the placement of the fill and during such placement, the CQA Officer may select areas within the limits of the fill for testing. The CONTRACTOR shall cooperate fully in obtaining the information desired.

PART 2: PRODUCTS

2.01 MATERIALS

A. Materials for use as fill shall be as described below. The CONTRACTOR shall notify the CQA Officer of the source of each material. Off-site materials shall be furnished as required from approved off-site sources (see 1.03.A) and hauled to the site. All local, state and federal regulations shall apply. The CONTRACTOR shall submit copies of all applicable permits and approval to the OWNER prior to commencement of the work.

B. Backfill shall consist of mineral soil free from organic materials, loam, wood, trash and other objectionable materials which may be compressible or which cannot be properly compacted. Common fill shall not contain stones larger than 4 inches in largest diameter and shall have at least 60 percent passing the No. 4 sieve, a maximum of 60 percent passing No. 200 Sieve, a maximum liquid limit of 60, and a maximum plasticity index of 25. Common Fill shall not contain granite blocks, broken concrete, masonry rubble or other similar materials. It

shall have physical properties such that it can be readily spread and compacted during filling. Snow, ice and frozen soil will not be permitted. Common Fill shall be compacted to at least 95% of the standard Proctor (ASTM D698) maximum dry density or as otherwise shown on the drawings.

C. Select Fill shall be as specified above for Backfill except that the material shall contain no stones larger than two inches in largest dimension, a maximum of 50 percent passing the No. 200 Sieve, a maximum liquid limit of 50 and a maximum plasticity index of 15. Select Fill shall be compacted to 98% of the standard Proctor (ASTM D698) maximum dry density.

D. The soils shall be wetted or dried as necessary so that the moisture content during compaction is within 3% of the optimum moisture content as determined by ASTM D698.

E. Highly micaceous and elastic silts shall not be used for Common, Select Fill or Structural Fill.

F. Crushed Stone

1. All crushed stone shall be silica material that is sound, hard, durable, resistant to weathering, as defined by ASTM D2488 and shall be free of overburden, spoil, shale, limestone and organic material. The stone shall be free of deleterious materials such as flat, elongated, friable, decomposed, or micaceous pieces. Broken pieces of concrete, asphalt, or brick are not acceptable. Crushed stone shall be of the size and type shown on the drawings.

G. Not used.

H. Not used.

2.02 CONFORMANCE TESTING

Conformance testing shall be performed by the CONTRACTOR's QC Laboratory on samples from each source of backfill material. Material identified for use as backfill shall be tested at the frequency specified in Table 1 and at every change in the material, identified by the CQC Officer of CQA Officer:

TABLE 1

Test	Method	Frequency
Grain Size	ASTM D422	Every 10,000 cy
Atterberg Limits	ASTM D4318	Every 10,000 cy
Moisture/Density	ASTM D698	Every 20,000 cy

Natural Moisture	ASTM D2216	Every 10,000 cy

Results of the tests will be submitted to the OWNER's CQA Officer within 24 hours of test completion. The CQA Officer reserves the right to reject material based on the results of the conformance tests.

PART 3: EXECUTION

3.01 GENERAL EXCAVATION

A. General Excavation is expected to consist of removing unsuitable soils identified during proofrolling (Section 3.01.E) and as required as part of the work represented on the Drawings. The bottom of the excavations shall be rendered firm and dry and in all respects acceptable to the CQA Officer.

B. Excavation and de-watering shall be accomplished by methods that preserve the undisturbed state of subgrade soils. Soils which become soft, loose, "quick", or otherwise unsatisfactory for support of structures, earthen or man-made, as a result of inadequate excavation, de-watering, proofrolling, or other construction methods shall be removed and replaced as required by the CQA Officer at the CONTRACTOR's expense.

C. De-watering shall lower the groundwater to at least 1-foot below excavation subgrade and prevent "boiling" condition or detrimental underseepage at the base of the excavation as specified herein.

D. Excavation equipment shall be satisfactory for carrying out the work in accordance with the Specifications.

E. In the presence of the CQA Officer, proofroll exposed subgrades after stripping topsoil and organics with a minimum of two complete passes of a rubber tired heavy machine by methods approved by the CQA Officer. All proofrolling shall be conducted in the presence of the CQA Officer or designated representative. The CQA Officer may require excavation and replacement or other remediation as necessary to provide a firm, stable subgrade in areas that appear to be rutting, pumping, or otherwise appear unstable while proofrolling. The repair procedure shall be determined by the CQA Officer.

3.02 TRENCH EXCAVATION

A. Excavation for all trenches required for the installation of pipes shall be made to the depths indicated on the Drawings and in such a manner and to such widths as will give suitable room for laying the pipe within the trenches, for bracing and supporting the trench sides and for pumping and drainage facilities. CONTRACTOR shall render the bottom of the excavations firm and stable and in all respects acceptable to the CQA Officer.

B. The trench may be excavated by machinery to, or just below the designated subgrade provided that the material remaining in the bottom of the trench is not disturbed.

C. Where pipe is to be installed in fill, fill shall be placed and compacted to at least 2 ft. above the top of the pipe (rough grade elevation) and then trenches re-excavated for pipe installation.

3.03 MISCELLANEOUS EXCAVATION

A. The CONTRACTOR shall perform all excavations necessary for the placing of seeding and plants, for constructing roadways, and any other miscellaneous earth excavation required under this Contract.

3.04 GENERAL BACKFILL

A. Materials placed in fill areas shall be placed to the lines and grades shown on the Drawings. Unless otherwise specified, Common Fill shall be used for backfill.

B. Fill shall be placed in accordance with the Contract Document.

C. Material conforming to the requirements of Backfill shall be placed in layers having a maximum compacted thickness of 8-inches measured before compaction and shall be compacted to at least 95 percent of its maximum density as determined by ASTM D698. The minimum frequency of testing shall be 1 test per lift per 10,000 square feet or as directed by the CQA Officer in irregular-shaped fill areas. CQC personnel shall perform testing of Backfill.

D. The surfaces of filled areas shall be graded to smooth true lines, conforming to grades indicated on the grading plan and no soft spots or un-compacted areas will be allowed in the work.

E. No compacting shall be done when the material is covered with frost or is frozen or is too wet either from rain or from excess application of water. At such times, work shall be suspended until the previously placed and new materials have thawed and/or dried sufficiently to permit proper compaction.

F. All backfill material shall be placed with a moisture content within 3% of Standard Proctor (ASTM D698) optimum moisture content.

3.05 TRENCH BACKFILL

A. Backfilling over pipes shall begin as soon as practicable after the pipe has been laid, jointed, and inspected. All backfilling shall be performed expeditiously.

1. Backfill shall be placed around the lower half of the pipe and thoroughly rodded and tamped to fill all voids and provide uniform support of the pipe in the bedding zone. Backfill shall be thoroughly compacted by machine tamping in 6-inch layers as required to provide 98% of the Standard Proctor maximum dry density per ASTM D-698.

2. Backfill shall be placed around the upper half of the pipe and to a minimum depth of 12-inches over the top of the pipe. Backfill shall be thoroughly compacted by machine tamping in 6-inch layers as required to provide 98% of the Standard Proctor maximum dry density per ASTM D-698.

3. The remainder of the trench shall be backfilled with Backfill in loose layers not to exceed 8-inches and thoroughly compacted with mechanical tampers as required to obtain the specified 95% compaction.

4. Backfilling under haunches shall be performed manually by tamping rods or similar hand equipment to eliminate voids underneath sides of the pipe or haunch.

5. The minimum frequency for density tests shall be 1 test per lift per 50 feet of trench for all material types or as specified by the CQA Officer. CQC Laboratory personnel shall perform testing of Trench Backfill

3.06 ROAD SUBGRADE

A. The road subgrade for bituminous, concrete, and crushed stone pavement areas in fill sections shall consist of a two-foot thick layer of Backfill compacted to a minimum 98% of the Standard Proctor maximum dry density per ASTM D-698. CQC personnel shall perform testing of Road Subgrade Backfill.

B. The road subgrade for bituminous, concrete, and crushed stone pavement areas in cut sections shall consist of firm natural soils as approved by the CQA Officer.

C. Road subgrades shall be proofrolled as described in Section 02200, 3.01 E.

3.07 HANDLING OF SURPLUS MATERIAL

A. Excavated materials shall not be removed from the site except as specified by the OWNER. Materials shall be neatly stockpiled on-site at locations directed by the OWNER. Excess materials shall be compacted and stockpiled in accordance with the CONTRACTOR's fill placement plan. CONTRACTOR shall provide erosion and sedimentation control measures as shown on the drawings and specified in the Contract Documents.

3.08 GRADING

A. Grading in preparation for placing soil liner material shall be performed to the elevations shown and otherwise as directed by the Engineer. During the process of grading, the subgrade shall be maintained in such condition that it will be well drained at all times. When required, temporary drains and drainage ditches shall be installed to intercept or divert surface water that may affect the performance or condition of the work.

B. If at the time of grading it is not possible to place material in its final location, it shall be stockpiled in approved areas. Stockpiled material shall be placed, compacted and smooth-rolled at the end of each day to deter water infiltration. No extra payment will be made for the stockpiling or double handling of excavated material.

C. Engineer reserves the right to make minor adjustments in lines or grades if deemed necessary as the work progresses, in order to obtain satisfactory construction.

D. Stones or rock fragments larger than 3-inches in their greatest dimensions will not be permitted in the top 6-inches of the finished subgrade of all fills or embankments.

3.09 INSPECTION/TESTING

A. The CQA Plan – Inspection and testing will be a joint effort between the CONTRACTOR and the OWNER.

B. Construction QA/QC observation, inspection and testing – OWNER shall employ a CQA Officer and Quality Assurance Laboratory to perform discretionary soils observation and confirmation testing services for quality assurance of the fill material. CONTRACTOR shall employ Quality Control Officer and a Quality Control Laboratory to perform soils inspection and testing services for quality control of the placement of fill material. CONTRACTOR shall factor the Quality Assurance observations and confirmation testing and Quality Control testing into its schedule and sequence of operations.

C. Coordination – CONTRACTOR shall be responsible for coordination of field services with the CONTRACTOR's CQC Officer, Quality Control Laboratory, and with the OWNER's CQA Officer.

D. Initial Observation – Compacted fill and backfill operations shall be performed after the surface has been properly prepared and has been observed and approved by CQA Officer. No Compacted fill shall be placed unless the CQA Officer approves the operation. Any fills placed without CQA Officer's observation and prior approval shall be removed in a manner to avoid damage or disturbance to the existing approved work, and the

excavation shall be filled as specified herein, at no additional cost to OWNER.

E. Field Control – The minimum testing frequencies for field tests to be performed by the CONTRACTOR's Quality Control personnel are identified in Sections 3.04, 3.05, and 3.06. The intent of the field tests is to insure that the specified density and moisture contents are being obtained.

One-point compaction tests shall be performed to interpolate between laboratory compaction (ASTM D 698) curves for at least every 5 in-place density tests or per change in material. The one-point compaction tests shall be performed on either the field density test sample or soil from a location immediately adjacent to the field density test sample, using the ASTM D 698 procedure. The results of the one-point tests shall then be compared with the full compaction curves of similar soils to estimate the maximum dry density applicable to the field density test sample.

Note: A nuclear density test gauge can be used to provide the required density testing. However, the in-situ density shall be determined using the sand cone method (ASTM D 1556) and/or the drive cylinder method (ASTM D 2937) of a minimum of one test per ten nuclear density tests or one per day, whichever is greater. The sand cone and/or drive cylinder test should be performed at the same location as a nuclear density test. The sand cone and/or drive cylinder tests shall be continued until a correlation between the density and moisture contents obtained by the nuclear density gauge and the sand cone and/or drive cylinder tests has been demonstrated.

F. The CONTRACTOR's CQC Firm shall provide a final Construction Quality Control Report at the end of the project. The report shall certify that the work associated with Excavation, Backfill and Compaction was performed in accordance with the Contract Documents and be prepared and sealed by a Professional Engineer registered in the State of North Carolina. The report shall include a narrative of construction methods and QC procedures employed, summary tables of all field test results, including locations and notations regarding any re-work performed, identification of failed tests, and documentation of re-worked areas with passing tests, as appropriate.

G. Submittal of an administratively complete Construction Quality Control Report shall be required for the Work to be considered Substantially Complete.

END OF SECTION

SECTION 02272

FILTER FABRIC

PART 1: GENERAL

1.01 SCOPE OF WORK

A Furnish all labor, materials, equipment and incidentals required to install filter fabric complete as shown on the Drawings and as specified herein.

1.02 RELATED WORK

A Section 02200: Excavation, Backfill and Compaction

B Section 02700: Protective Cover

C Section 02276: Erosion and Sedimentation Control

D Section 02274: Geocomposite Drainage Net

E Section 02505: Crushed Stone Paving

1.03 SUBMITTALS

A At least 30 calendar days prior to filter fabric installation, submit the following information in accordance with Section 01340:

1. Manufacturer's background information.

2. List of material properties and samples of filter fabric with attached certified test results.

3. Manufacturer's quality control program and manual including description of laboratory facilities.

4. A list of ten completed facilities where the filter fabric is used including:

   a. Name and purpose of facility, its location and date of installation.

   b. Name of Owner, project manager, design engineer and installer.

   c. Fabric thickness and surface area.

   d. Specific application and information on performance of the facility.

5. Shop Drawings, including:

   a. Proposed panel layout showing the installation layout identifying field seams as well as any variance or additional details which deviate from the Drawings, if applicable.

   b. Details of overlap, seaming, anchoring, connections and other construction details.

6. Installation schedule and locations of areas designated for installation

7. A manual that specifically defines the quality control and quality assurance program during installation including manufacturer's installation guidelines.

8. Copy of quality control certificates in conformance with Paragraph 2.02.

1.04 REFERENCE STANDARDS

A American Society for Testing and Materials (ASTM)

1. ASTM D5199 - Standard Test Method for Measuring Thickness of Textile Materials.

2. ASTM D5261 - Standard Test Method for Mass per Unit Area (Weight) of Woven Fabric.

3. ASTM D3786 - Standard Test Method for Hydraulic Bursting Strength of Knitted Goods and Nonwoven Fabrics - Diaphragm Bursting Strength Tester Method.

4. ASTM D4491 - Standard Test Methods for Water Permeability of Geotextiles by Permittivity.

5. ASTM D4533 - Standard Test Method for Trapezoid Tearing Strength of Geotextiles.

6. ASTM D4632 - Standard Test Method for Breaking Load and Elongation of Geotextiles (Grab Method).

7. ASTM D4751 - Standard Test Method for Determining Apparent Opening Size of a Geotextile.

8. ASTM D4833 - Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products.

B Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 FABRIC APPLICATIONS

The filter fabric is to be used for placement beneath erosion control stone and structures, beneath crushed stone paving where called for; bonded to both sides of drainage net for geocomposite; and, installed as operational cover over the leachate collection lines as shown on the Drawings. The unit weights of the filter fabric for each use are specified herein.

1.06 DELIVERY, STORAGE AND HANDLING

A The filter fabric shall be shipped, stored and handled in accordance with manufacturer's recommendations and as specified herein.

B The fabric shall be stored with a cover so that it is protected from exposure to sunlight and shall be elevated from the ground (a minimum of 3-in) to protect the fabric from stones and other sharp objects and saturation.

1.07 REQUIREMENTS PRIOR TO INSTALLATION

A For use in erosion control structures, the subgrade shall be inspected and approved by the CQA Officer (RPR) prior to installation of the filter fabric. The subgrade shall be smooth, uniform and compacted for the installation of the fabric.

B For the leachate collection system installation whereas an area is excavated in the protective layer, the area shall be inspected and approved by the CQA Officer prior to installation of the filter fabric to ensure against damage to the drainage net and liner system.

C Prior to installation of the geocomposite, the material shall be inspected and conformance tested by the CQA Officer and Quality Assurance Laboratory to ensure the filter fabric is sufficiently bonded to the net.

1.08 MATERIAL WARRANTY

A The manufacturer shall warrant the material, against manufacturing defects and material degradation for a period of five years from the date of installation. The manufacturer shall replace any material which fails within the warranty period. The manufacturer shall furnish a written warranty covering the requirements of this Paragraph.

1.09 GUARANTEE

A The Contractor shall guarantee the filter fabric against defects in installation and workmanship for the period of two years commencing with the date of Final Acceptance. The guarantee shall include the services of qualified service technicians and all materials required for the repairs at no expense to the Owner.

PART 2: PRODUCTS

2.01 GENERAL

A The use of a manufacturer's name and model or catalog number is for the purpose of establishing the standard of quality and general configuration.

2.02 MATERIALS

A Nonwoven Fabric

1. All fabric shall be a nonwoven needle punched polypropylene fabric consisting of filaments formed into a stable network, such as SKAPS GE-160 or equal.

2. A nominal 8 oz/yd^2 unit weight fabric shall be used as bedding for rip-rap lined stormwater structures, ditches, outlets and operational cover. The 6 oz/yd^2 unit weight fabric shall be heat bonded to both sides of the drainage net as specified in Section 02274.

3. The fabric shall be non-biodegradable, nonreactive within a pH range of 2 to 13, resistant to ultraviolet light exposure, and resistant to insects and rodents. Test results from any sampled roll in the lot, when tested in accordance with ASTM D4759, shall meet or exceed the values listed in Table 1.

TABLE 1
MINIMUM AVERAGE ROLL VALUES (MARV)
GEOTEXTILE FABRICS

PROPERTIES	TEST METHOD	MARV		
		UNIT	6 OZ.	8 OZ.
Fabric Weight	ASTM D5261	oz./yd2	5.7	7.3
Thickness	ASTM D1777	mils	80	90
Grab Tensile Strength	ASTM D4632	lbs	150	205
Grab Elongation	ASTM D4632	%	50	50
Puncture Resistance	ASTM D4833	lbs	85	110
Mullen Burst Strength	ASTM D3786	PSI	220	320
Permittivity	ASTM D4491	gal/min/ft^2	110	110
Apparent Opening Size	ASTM D4751	US Sieve	70	80

2.03 QUALITY CONTROL DOCUMENTATION

A Prior to installation, the Contractor shall provide to the Owner the following information certified by the manufacturer for the delivered fabric.

1. Each roll delivered to the Project site shall have the following identification information:

   - Manufacturer's name
   - Product identification
   - Thickness
   - Roll number
   - Roll dimensions

2. Quality control certificates, signed by the manufacturer's quality assurance manager. Each certificate shall have roll identification number, sampling procedures, testing frequency and test results. At a minimum the following test results shall be provided every 50,000 square feet of manufactured fabric in accordance with test requirements specified in Paragraph 2.02.

   - Thickness
   - Grab Tensile Strength
   - Grab Elongation
   - Puncture Resistance

- Mullen Burst Strength

2.04 CONFORMANCE TESTING

A Conformance testing may be performed at the discretion of the CQA Officer. An independent Quality Assurance Laboratory (QAL) approved by the Owner will test samples obtained by the CQA Officer from the material proposed. The machine direction and identification number will be identified. The Owner shall pay for conformance testing at the frequency of one test per 100,000 square feet. For every change in Lot number, the Contractor shall perform conformance testing on the initial roll at the Contractor's expense. The samples shall be taken across the entire roll width and shall not include the first 3-ft. The following conformance tests shall be conducted at the laboratory.

1. Mass per unit area (ASTM D5261)
2. Mullen burst strength (ASTM D3786)
3. Puncture resistance (ASTM D4833)
4. Grab tensile (ASTM D4632)
5. Permittivity (ASTM D4491)
6. Apparent opening size (ASTM D4751)

B These conformance tests shall be performed in accordance with test requirements Paragraph 2.02.

C All conformance test results shall be reviewed by the CQA Officer and accepted, prior to the deployment of the fabric. All test results shall meet, or exceed, the property values listed in Paragraph 2.02.

D The manufacturer may obtain samples from rolls manufactured immediately before and after the failing roll and request testing by the QAL at the manufacturer's expense. If these rolls pass, then only the failing roll will be rejected. If they fail, then the entire lot will be rejected.

E The cost of a first-run conformance testing shall be borne by the Owner and shall be performed by the CQA Officer or his/her representative and an independent Quality Assurance Laboratory (QAL) selected by the Owner. If the fabric fails the first-run unit conformance tests, the contractor shall pay for the cost of subsequent conformance testing until all conformance tests are passed and the fabric is accepted by the CQA Officer.

PART 3: EXECUTION

3.01 PREPARATION

A General

1. Preparation of the subgrade shall be in accordance with Section 02200, or otherwise depending on the specific application.

2. The subgrade shall be inspected by the CQA Officer (RPR) prior to installation of the filter fabric.

3.02 INSTALLATION

A Fabric Placement

1. The subgrade shall be maintained in a smooth, uniform and compacted condition during installation of the filter fabric beneath the erosion control stone.

2. No mechanical equipment shall be driven directly on top of the filter fabric.

3. Granular fill materials shall be installed in accordance with Section 02700.

4. Protective Cover Layer materials shall be placed with mechanical equipment; however, no mechanical equipment shall be allowed directly on top of the filter fabric. Equipment shall be driven on pre-deposited material at approved thicknesses.

5. Protective Cover Layer materials shall be brought to the work area with earth-carrying equipment, deposited on the previously spread soil cover (minimum of 2-ft. thick), then pushed onto the uncovered portion of the filter fabric with bulldozers or excavator loaders.

6. Protective cover soils for the side slopes of the filter fabric shall be placed at the bottom and pushed uphill to reduce any tension in the fabric or underlying 60 mil textured HDPE liner.

7. Damage to the filter fabric occurring during the placement of protective cover shall be repaired immediately at no additional expense to the Owner.

B Field Overlap

1. The fabric shall be overlapped according to the manufacturers recommended installation guidelines for a particular application.

3.03 FIELD QUALITY CONTROL

A Two duplicate documentation files for fabric placement shall be maintained. One shall be maintained by the Contractor and the other by the Engineer. At the end of each work week, the files shall be updated and checked to assure that all copies of pertinent project information are included in each file. The Contractor shall submit daily copies of the documentation to the Engineer.

B The filter fabric installation and related work shall be inspected by the Engineer. All work in the system therein being inspected shall be complete, clean and ready for use. All work shall meet the requirements of cleanliness and workmanship, as determined by the Engineer.

C Discrepancies shall be noted and repaired at no additional expense. Final acceptance of the system shall be contingent upon the approval of the Engineer.

END OF SECTION

SECTION 02274

GEOCOMPOSITE DRAINAGE NET – DRAINAGE LAYER

PART 1: GENERAL

1.01 SCOPE OF WORK

A Furnish all labor, materials, equipment and incidentals required and install geocomposite drainage net consisting of high quality polyethylene (HDPE) drainage net with nonwoven filter fabric bonded to both sides in the locations shown on the Drawings and as specified herein. [Note: Specifications for the nonwoven filter fabric that is bonded to both side of the drainage net are included in Section 02272.

1.02 RELATED WORK

A Section 02200 Excavation, Backfill and Compaction

B Section 02700 Protective Cover

C Section 02271 Fabric Cushion

D Section 02272 Filter Fabric

E Section 02276 Compacted Soil Liner

G Section 02776 Textured High Density Polyethylene (HDPE) Liner.

1.03 SUBMITTALS

A At least 60 prior to geocomposite drainage net installation submit the following information in accordance with Section 01340:

1. Manufacturer's background information.

2. List of material properties and samples of geocomposite drainage net with attached certified test results.

3. Manufacturer's quality control program and manual including description of laboratory facilities.

4. A list of ten completed facilities where the geocomposite drainage net is used including:

   a. Name and purpose of facility, its location and date of installation.

b. Name of Owner, project manager, design engineer and installer.

c. Geocomposite drainage net thickness and surface area.

d. Information on performance of the facility.

5. Shop Drawing, including:

a. Proposed panel layout or plan showing the installation layout identifying field seams as well as any variance or additional details that deviate from the Drawings.

b. Details of overlap and seaming of the geocomposite drainage net, anchoring, connections and other reconstruction details.

6. Installation schedule.

7. A manual that specifically defines the quality control and quality assurance program during installation including manufacturer's installation instructions.

8. Copy of quality control certificates in conformance with Paragraph 2.02.

1.04 REFERENCE STANDARDS

A American Society for Testing and Materials (ASTM)

1. ASTM D1505 - Standard Test Method for Density of Plastics by the Density-Gradient Technique.

2. ASTM D1238 - Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer.

3. ASTM D1603 - Standard Test Method for Carbon Black in Olefin Plastics.

4. ASTM D1777 - Standard Method for Measuring Thickness of Textile Materials.

5. ASTM D3776 - Standard Test Method for Mass Per Unit Area (Weight) of Woven Fabric.

6. ASTM D4716 - Standard Test Method for Constant Head Hydraulic Transmissivity (In Plane Flow) of Geotextile and Geotextile Related Products.

7. ASTM D751 - Standard Method for Testing Coated Fabrics

B Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 DELIVERY, STORAGE AND HANDLING

A The drainage net shall be shipped, stored and handled in accordance with manufacturer's recommendations.

B The geocomposite drainage net shall be stored such that it is protected from exposure to sunlight and it shall be elevated from the ground (a minimum of 3-in) to protect the geocomposite drainage net from puncture and soil staining.

1.06 PROJECT/SITE REQUIREMENTS

A The underlying geomembrane material shall be inspected and found acceptable by the CQA Officer (RPR) prior to installation of the geocomposite drainage net.

1.07 MATERIAL WARRANTY

A The geocomposite drainage net manufacturer shall warrant the material, against manufacturing defect and material degradation (prorated basis) for a period of five years from the date of installation. The manufacturer shall replace any material which fails from the above causes within the warranty period. The manufacturer shall furnish a written warranty covering the requirements of this Paragraph.

1.08 GUARANTEE

A The Contractor shall guarantee the drainage net against defects in installation and workmanship for the period of two years commencing with the date of Final Acceptance. The guarantee shall include the services of qualified service technicians and all materials required for the repairs at no expense to the Owner.

PART 2: PRODUCTS

2.01 GENERAL

A The use of a manufacturer's name and model or catalog number is for the purpose of establishing the standard of quality and general configuration.

2.02 MATERIALS

A The drainage net shall be manufactured by extruding two sets of polyethylene strands to form a three dimensional structure to provide planar water flow.

B A geotextile filter fabric shall be heat bonded to both sides of the drainage net. Heat bonding shall be performed by the manufacturer prior to shipping to the site. The geotextile filter fabric shall be 6 oz/yd^2 nonwoven needle punched polypropylene fabric as specified in Section 02272 (QC testing for the geotextile is specified therein).

C The geocomposite drainage net shall contain UV inhibitors.

D The geonet and geocomposite shall conform to the following minimum properties:

Property	Test Method	Required Value
Density	ASTM D1505	0.940 g/cm^2
Melt Flow Index (Condition 0/2.16)	ASTM D1238	1.0 g/10 min. (max)
Carbon Black Content (Net)	ASTM D4218	2 - 3%
Thickness (Net)	ASTM D5199	200 mils
Tensile Strength (Net)	ASTM D5035	45 lbs/in
Ply Adhesion (composite)	ASTM 7005	1.0 lb/in.
Transmissivity [1]	ASTM D4716	2.5 x 10^{-5} m^2/s
Transmissivity [2]		3.5 x 10^{-5} m^2/s

Notes: [1] Transmissivity measured using water at 21 +/- 2° C (70 + 4° F) with a gradient of 0.1 and a confining pressure of 2088 psf between steel plates after 15 minutes.
[2] Transmissivity measured using water at 21 +/- 2° C (70 + 4° F) with a gradient of 0.1 and a confining pressure of 208 psf between steel plates after 15 minutes.

E Geocomposite drainage net shall be SKAPS TRANSNET 220-2-6, AGRU America 200-mil. geocomposite or equivalnent.

2.03 QUALITY CONTROL DOCUMENTATION

A Prior to installation of any drainage net material, the Contractor shall provide to the Owner the following information certified by the manufacturer for the delivered drainage net.

1. Each roll delivered to the Project site shall have the following identification information:

Manufacturer's name
Product identification
Thickness
Roll number
Roll dimensions

2. Quality control certificates, signed by the manufacturer's quality assurance manager. Each certificate shall have roll identification number, sampling procedures, testing frequency and test results. At a minimum the following test results shall be provided every 50,000 square feet of manufactured drainage net in accordance with test requirements specified in Paragraph 2.02.

   # Resin Density
   # Melt Flow Index
   # Thickness
   # Carbon Black Content
   # Tensile Strength
   # Ply Adhesion
   # Transmissivity

2.04 CONFORMANCE TESTING

A Conformance testing shall be performed by the CQA Officer and an independent Quality Assurance Laboratory (QAL) as approved by the Owner. CQA Representative shall obtain samples from the delivered material, mark the machine direction and identification number. One sample shall be taken per 100,000 square feet, or one sample per lot, whichever results in the greater number of conformance tests. A Lot number will be defined as a continuous production process without changes to raw material or manufacturing methods. This sampling frequency may be increased as deemed necessary by the Engineer. The Owner shall pay for conformance testing at the frequency of one test per 100,000 square feet. For every change in Lot number, the Contractor shall pay for conformance testing on the initial roll at the Contractor's expense. The samples shall be taken across the entire roll width and shall not include the first 3-ft. The following conformance tests shall be conducted at the laboratory:

1.	Resin Density	(ASTM D1505)
2.	Carbon Black Content	(ASTM D1603)
3.	Melt Index	(ASTM D1238)
4.	Thickness	(ASTM D5199)
5.	Transmissivity	(ASTM D4716)
6.	Mass per Unit Area	(ASTM D3776)

B These conformance tests shall be performed in accordance with test requirements specified in Paragraph 2.02.

C All conformance test results shall be reviewed by the Engineer and accepted or rejected, prior to the deployment of the geocomposite drainage net. All test results shall meet, or exceed, the property values listed in Paragraph 2.02. In case of failing test results, the Contractor may request that another sample be retested by the QAL with manufacturer’s technical representative present

during the testing procedures. The costs for retesting including engineering, analyses and all associated expenses shall be paid for by the Contractor. The Contractor may also have the sample retested at two different laboratories approved by the Owner. If both laboratories report passing results the material shall be accepted; if both laboratories do not report passing results, all material from the lot representing the failing sample will be considered out of specification and rejected. The manufacturer may obtain additional samples from rolls immediately before and after the failing roll or as directed by the Engineer and have them tested by the QAL at his/her own expense. If these rolls pass, then only the failing roll will be rejected. If they fail, then the entire lot will be rejected.

PART 3: EXECUTION

3.01 PREPARATION

A General

Prior to installation, the following actions shall occur:

1. The underlying liner or geomembrane shall be swept clean of debris, waste material, equipment, and other miscellaneous objects.

2. The underlying liner or geomembrane shall be inspected by the CQA Representative and the installer prior to installation of the drainage net to check for damage such as; tears, punctures, scratches, and defects.

3. The CQA Officer shall confirm with the installer that all seams and patches have been tested and approved and that all necessary survey information has been obtained.

3.02 INSTALLATION

A Panel Placement

1. Care shall be taken to keep the geocomposite drainage net clean and free from debris prior to installation.

2. The geocomposite drainage net shall be installed in such a manner as to ensure that it is not damaged in any way, and the following shall be complied with during installation:

    a. Geocomposite drainage net shall be anchored as shown on the Drawings.

    b. On slopes, the geocomposite drainage net shall be secured and rolled down the slope in such a manner as to continually keep the geocomposite drainage net sheet in tension. If necessary, the

geocomposite drainage net shall be positioned by hand after being unrolled to minimize wrinkles.

c. In order to protect against wind uplift, all geocomposite drainage net shall be weighted with sandbags or by other means. Such sandbags shall be installed during placement and shall remain until replaced with cover material.

d. Geocomposite drainage net shall only be cut using scissors or J-hook blades. Care shall be taken not to leave tools on the drainage net.

e. Necessary precautions shall be taken to prevent damage to underlying layers during placement of the drainage net.

f. During placement of geocomposite drainage net, care shall be taken not to entrap soil in the geocomposite drainage net or stones that could damage the underlying liner. If soil is entrapped in the drainage net, it should be hosed clean or replaced. In this regard, care shall be taken in handling the sandbags, to prevent rupture of the sandbag.

B Field Seams and Overlaps

1. The following requirements shall be met during installation of the drainage net:

a. The geocomposite drainage net of adjacent panels shall be overlapped by at least 4-in. For end widths of panels, the geocomposite drainage net shall overlapped a minimum of 4-inches with the upslope panel placed over the downslope panel.

b. Seams shall be secured by tying. Tying can be achieved by plastic fasteners or polymer braid. Tying devices shall be a color that contrasts with black for easy inspection. Metallic devices are not allowed.

c. Tying shall be every 5-ft along seams, at minimum.

d. The unbonded fabric on the top side of the geocomposite drainage net shall be sewn or hot-wedge welded along side seams of adjacent panels.

e. For end width seams and patches, a 24-inch strip of fabric shall be placed over the seam and held in place with soil.

f. Horizontal seams on 4 to 1 slopes shall not be allowed unless it is demonstrated to the CQA Officer that it is absolutely necessary.

3.03 FIELD QUALITY CONTROL

A Two duplicate documentation files for panel placement shall be maintained. One shall be maintained by the Contractor and the other by the CQA Officer. At the end of each work week, the files shall be updated and checked to assure that all copies of pertinent project information are included in each file. The Contractor shall submit daily copies of the documentation to the CQA Officer.

B Any holes or tears in the geocomposite drainage net shall be repaired by placing a patch extending 1-ft beyond the edges of the hole or tear. The patch shall be secured to the original geocomposite drainage net by placing ties every 6-in. Tying devices shall be as specified in Paragraph 3.02B. All repairs and patches shall be approved by the CQA Officer.

C Damage to the geocomposite drainage net occurring during the placement of the material overlying the geocomposite drainage net shall be repaired immediately at no additional expense to the Owner.

3.04 DISPOSAL OF WASTE MATERIAL

A Upon completion of installation, the Contractor shall dispose of all trash, waste material and equipment used in connection with the performed work and shall leave the premises in a neat and acceptable condition.

END OF SECTION

SECTION 02274

GEOCOMPOSITE DRAINAGE NET – LANDFILL CLOSURE

PART 1: GENERAL

1.01 SCOPE OF WORK

A Furnish all labor, materials, equipment and incidentals required and install geocomposite drainage net (GDN) consisting of high quality polyethylene (HDPE) drainage net with nonwoven filter fabric bonded to both sides in the locations shown on the Drawings and as specified herein. [Note: *Specifications for the nonwoven filter fabric that is bonded to both side of the drainage net are included in Section 02272*].

1.02 RELATED WORK

A Section 02200 Excavation, Backfill and Compaction

B Section 02290 Protective Cover Layer

C Section 02272 Filter Fabric

D Section 02777 Linear Low Density Polyethylene (LLDPE) Liner

1.03 SUBMITTALS

A At least 60 prior to geocomposite drainage net installation submit the following information in accordance with Section 01340:

1. Manufacturer's background information.

2. List of material properties and samples of geocomposite drainage net with attached certified test results.

3. Manufacturer's quality control program and manual including description of laboratory facilities.

4. A list of ten completed facilities where the geocomposite drainage net is used including:

   a. Name and purpose of facility, its location and date of installation.

   b. Name of Owner, project manager, design engineer and installer.

   c. Geocomposite drainage net thickness and surface area.

d. Information on performance of the facility.

5. Shop Drawing, including:

a. Proposed panel layout or plan showing the installation layout identifying field seams as well as any variance or additional details that deviate from the Drawings.

b. Details of overlap and seaming of the geocomposite drainage net, anchoring, connections and other re-construction details.

6. Installation schedule and work plan.

7. A manual that specifically defines the quality control and quality assurance program during installation including manufacturer's installation instructions.

8. Copy of quality control certificates in conformance with Paragraph 2.02.

1.04 REFERENCE STANDARDS

A American Society for Testing and Materials (ASTM)

1. ASTM D1505 - Standard Test Method for Density of Plastics by the Density-Gradient Technique.

2. ASTM D1238 - Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer.

3. ASTM D1603 - Standard Test Method for Carbon Black in Olefin Plastics.

4. ASTM D1777 - Standard Method for Measuring Thickness of Textile Materials.

5. ASTM D3776 - Standard Test Method for Mass Per Unit Area (Weight) of Woven Fabric.

6. ASTM D4716 - Standard Test Method for Constant Head Hydraulic Transmissivity (In Plane Flow) of Geotextile and Geotextile Related Products.

7. ASTM D751 - Standard Method for Testing Coated Fabrics

B Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 DELIVERY, STORAGE AND HANDLING

A The drainage net shall be shipped, stored and handled in accordance with manufacturer's recommendations.

B The geocomposite drainage net shall be stored such that it is protected from exposure to sunlight and it shall be elevated from the ground (a minimum of 3-in) to protect the geocomposite drainage net from puncture and soil staining.

1.06 PROJECT REQUIREMENTS

A The underlying geomembrane material shall be inspected and found acceptable by the CQA Officer (RPR) prior to installation of the geocomposite drainage net; the QC documentation and the Record Drawing of the installed HDPE Liner should be substantially complete, submitted and accepted by the ENGINEER prior to installation of the geocomposite drainage net.

1.07 MATERIAL WARRANTY

A The geocomposite drainage net manufacturer shall warrant the material, against manufacturing defect and material degradation (prorated basis) for a period of five years from the date of installation. The manufacturer shall replace any material which fails from the above causes within the warranty period. The manufacturer shall furnish a written warranty covering the requirements of this Paragraph.

1.08 GUARANTEE

A The Contractor shall guarantee the drainage net against defects in installation and workmanship for the period of two years commencing with the date of Final Acceptance. The guarantee shall include the services of qualified service technicians and all materials required for the repairs at no expense to the OWNER.

PART 2: PRODUCTS

2.01 GENERAL

A The use of a manufacturer's name and model or catalog number is for the purpose of establishing the standard of quality and general configuration.

2.02 MATERIALS

A The drainage net shall be manufactured by extruding two sets of polyethylene strands to form a three dimensional structure to provide planar water flow.

B A geotextile filter fabric shall be heat bonded to both sides of the drainage net. Heat bonding shall be performed by the manufacturer prior to shipping to the site. The geotextile filter fabric shall be 6 oz/yd^2 nonwoven needle punched

polypropylene fabric as specified in Section 02272 (QC testing for the geotextile is specified therein).

C The geocomposite drainage net shall contain UV inhibitors.

D The geonet and geocomposite shall conform to the following minimum properties:

Property	Test Method	Required Value
Density	ASTM D1505	0.940 g/cm^2
Melt Flow Index (Condition 0/2.16)	ASTM D1238	1.0 g/10 min. (max)
Carbon Black Content (Net)	ASTM D4218	2 - 3%
Thickness (Net)	ASTM D5199	200 mils min.
Tensile Strength (Net)	ASTM D5035	45 lbs/in
Ply Adhesion (composite)	ASTM 7005	1.0 lb/in.
Underdrain GDN Transmissivity[1]	ASTM D4716	3.5 x 10^{-5} m^2/s
Cap GDN Transmissivity[2]		1.4 x 10^{-3} m^2/s or as required by Table 1[3]
Interface Shear Strength[4]	ASTM D5321	23.5º min.
Roll Width		14.5 ft min.

Notes: [1] Transmissivity with a gradient of 0.1 and a confining pressure of 208 psf.
[2] Transmissivity with a gradient of 0.25 and a confining pressure of 450 psf (or greater)
[3] Table 1 provides transmissivity based on the max. permeability of Protective Cover soil
[4] Cap GDN against Protective Cover Soil, tested at one test for each Protective Cover soil used (Note: GDN against LLDPE liner interface shear testing specified in 02777)

2.03 QUALITY CONTROL DOCUMENTATION

A Prior to installation of any drainage net material, the Contractor shall provide to the Owner the following information certified by the manufacturer for the delivered drainage net.

1. Each roll delivered to the Project site shall have the following identification information:

   # Manufacturer's name
   # Product identification
   # Thickness
   # Roll number
   # Roll dimensions

2. Quality control certificates, signed by the manufacturer's quality assurance manager. Each certificate shall have roll identification number, sampling procedures, testing frequency and test results. *At a minimum the following test results shall be provided every 50,000 square feet of manufactured drainage net in accordance with test requirements specified in Paragraph 2.02*.

   # Resin Density
   # Melt Flow Index
   # Thickness
   # Carbon Black Content
   # Tensile Strength
   # Ply Adhesion
   # Transmissivity
   # Mass per Unit Area

2.04 CONFORMANCE TESTING

A Conformance testing shall be performed by the CQA Officer and an independent Quality Assurance Laboratory (QAL) as approved by the Owner. CQA Representative shall obtain samples from the delivered material, mark the machine direction and identification number. *One sample shall be taken per 100,000 square feet, or one sample per lot, whichever results in the greater number of conformance tests.* A Lot number will be defined as a continuous production process without changes to raw material or manufacturing methods. This sampling frequency may be increased as deemed necessary by the Engineer. The Owner shall pay for conformance testing at the frequency of one test per 100,000 square feet. For every change in Lot number, the Contractor shall pay for conformance testing on the initial roll at the Contractor's expense. The samples shall be taken across the entire roll width and shall not include the first 3-ft. The following conformance tests shall be conducted at the laboratory:

1.	Resin Density	(ASTM D1505)
2.	Carbon Black Content	(ASTM D1603)
3.	Melt Index	(ASTM D1238)
4.	Thickness	(ASTM D5199)
5.	Transmissivity	(ASTM D4716)

B These conformance tests shall be performed in accordance with test requirements specified in Paragraph 2.02.

C All conformance test results shall be reviewed by the Engineer and accepted or rejected, prior to the deployment of the geocomposite drainage net. All test results shall meet, or exceed, the property values listed in Paragraph 2.02. In case of failing test results, the Contractor may request that another sample be retested by the QAL with manufacturer’s technical representative present

during the testing procedures. The costs for retesting including engineering, analyses and all associated expenses shall be paid for by the Contractor. The Contractor may also have the sample retested at two different laboratories approved by the Owner. If both laboratories report passing results the material shall be accepted; if both laboratories do not report passing results, all material from the lot representing the failing sample will be considered out of specification and rejected. The manufacturer may obtain additional samples from rolls immediately before and after the failing roll or as directed by the Engineer and have them tested by the QAL at his/her own expense. If these rolls pass, then only the failing roll will be rejected. If they fail, then the entire lot will be rejected.

PART 3: EXECUTION

3.01 PREPARATION

A General

Prior to installation, the following actions shall occur:

1. The underlying *subgrade and/or geomembrane* shall be swept clean and maintained free of any debris, rocks, waste material, equipment, and other miscellaneous objects.

2. The underlying subgrade or geomembrane shall be inspected by the CQA Representative and the installer prior to installation of the drainage net to check for damage such as tears, punctures, scratches, and defects in the liner or the presence of objects in the subgrade that may be disturb or damage the geocomposite. **The Subgrade and geomembrane respectively, shall be inspected and accepted by the CQA Officer prior to any installations of geocomposite (overlying).**

3. The CQA Officer shall confirm with the installer that all liner seams and patches have been tested and approved and that all necessary survey information has been obtained.

3.02 INSTALLATION

A Panel Placement

1. Care shall be taken to keep the geocomposite drainage net clean and free from debris prior to installation.

2. The geocomposite drainage net shall be installed in such a manner as to ensure that it is not damaged in any way, and the following shall be complied with during installation:

a. Geocomposite drainage net shall be anchored as shown on the Drawings.

b. On slopes, the geocomposite drainage net shall be secured and rolled down the slope in such a manner as to continually keep the geocomposite drainage net sheet in tension. If necessary, the geocomposite drainage net shall be positioned by hand after being unrolled to minimize wrinkles.

c. In order to protect against wind uplift, all geocomposite drainage net shall be weighted with sandbags or by other means. Such sandbags shall be installed during placement and shall remain until replaced with cover material.

d. Geocomposite drainage net shall only be cut using scissors or J-hook blades. Care shall be taken not to leave tools on the drainage net.

e. Necessary precautions shall be taken to prevent damage to underlying layers during placement of the drainage net.

f. During placement of geocomposite drainage net, care shall be taken not to entrap soil in the geocomposite drainage net or stones that could damage the underlying liner. If soil is entrapped in the drainage net, it should be hosed clean or replaced. In this regard, care shall be taken in handling the sandbags, to prevent rupture of the sandbag.

B Field Seams and Overlaps

1. The following requirements shall be met during installation of the drainage net:

a. The geocomposite drainage net of adjacent panels shall be overlapped by at least 4-in. For end widths of panels, the geocomposite drainage net shall overlapped a minimum of 4-inches with the upslope panel placed over the downslope panel.

b. Seams shall be secured by tying. Tying can be achieved by plastic fasteners or polymer braid. Tying devices shall be a color that contrasts with black for easy inspection. Metallic devices are not allowed.

c. Tying shall be every 5-ft along seams, at minimum.

d. The unbonded fabric on the top side of the geocomposite drainage net shall be sewn or hot-wedge welded along side seams of adjacent panels.

e. For end width seams and patches, a 24-inch strip of fabric shall be placed over the seam and held in place with soil.

f. Horizontal seams on 4 to 1 slopes shall not be allowed unless it is demonstrated to the CQA Officer that it is absolutely necessary.

3.03 FIELD QUALITY CONTROL

A Two duplicate documentation files for panel placement shall be maintained. One shall be maintained by the Contractor (installer) and the other by the CQA Officer. At the end of each work week, the files shall be updated and checked to assure that all copies of pertinent project information are included in each file. The Contractor shall submit daily copies of the documentation to the CQA Officer.

B Any holes or tears in the geocomposite drainage net shall be repaired by placing a patch extending 1-ft beyond the edges of the hole or tear. The patch shall be secured to the original geocomposite drainage net by placing ties every 6-in. Tying devices shall be as specified in Paragraph 3.02B. All repairs and patches shall be approved by the CQA Officer.

C Damage to the geocomposite drainage net occurring during the placement of the material overlying the geocomposite drainage net shall be repaired immediately at no additional expense to the OWNER.

3.04 DISPOSAL OF WASTE MATERIAL

A Upon completion of installation, the Contractor shall dispose of all trash, waste material and equipment used in connection with the performed work and shall leave the premises in a neat and acceptable condition.

TABLE 1

Protective Cover Permeability
versus
Geocomposite Drainage Net Transmissivity

Protective Cover Soil Maximum Permeability[1] (cm/sec)	Required Cap GDN Minimum Transmissivity[2] (m^2/sec)
1.0E-04	1.4E-03
9.0E-05	1.2E-03
8.0E-05	1.1E-03
7.0E-05	9.5E-04
6.0E-05	8.2E-04
5.0E-05	6.8E-04
4.0E-05	5.4E-04
3.0E-05	4.1E-04
2.0E-05	2.7E-04
1.0E-05	1.4E-04
9.0E-06	1.2E-04
8.0E-06	1.1E-04
7.0E-06	9.5E-05
6.0E-06	8.2E-05
5.0E-06	6.8E-05
4.0E-06	5.4E-05
3.0E-06	4.1E-05
2.0E-06	2.7E-05
1.0E-06	1.4E-05

[1] Remolded, compacted to minimum 93% standard proctor at material's optimum moisture content.

[2] 0.25 hydraulic gradient, confining pressure 450 psf (or greater)

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END OF SECTION

SECTION 02275

COMPACTED SOIL LINER (1.0×10^{-5} cm/s)

PART 1: GENERAL

1.01 SCOPE OF WORK

A Furnish all labor, materials, equipment and incidentals required to install compacted soil liner with a maximum in-place permeability of 1.0×10^{-5} cm/s and minimum thickness shown on the Drawings as measured perpendicular to the slope as shown on the Drawings and as specified herein. Associated work includes quality control testing, borrow source excavation, hauling, screening, constructing a test pad, placement, moisture conditioning, harrowing, compaction, and grading of natural soil or soil-bentonite materials for compacted soil liner construction of the wastewater pond, perimeter ditches and landfill.

1.02 RELATED WORK

A Section 01040: CQA Plan

B Section 01050: Field Engineering

C Section 02200: Excavation, Backfill, and Compaction

D Section 02776: Textured High Density Polyethylene (HDPE) Liner.

1.03 SUBMITTALS

A At least 45 days prior to test pad construction, the CONTRACTOR shall submit the following information in accordance with Section 01340:

1. Identification of the compacted soil liner type (natural soil or CONTRACTOR prepared soil-bentonite mix.)

2. If a natural soil is proposed, submit the following documentation:

   a. Name and location of the proposed natural soil borrow source,

   b. Test results and other documentation as necessary to verify that the proposed natural soil meets the requirements of 2.01A of this Section, and

   c. Anticipated volume of suitable natural soil available to the project.

3. If a soil-bentonite mixture is proposed, submit the following documentation:

    a. Name and location of the proposed soil source,

    b. Test results and other documentation as necessary to verify that the proposed soil meets the requirements of 2.01B of this Section,

    c. Name and location of the bentonite supplier,

    d. Test results and other documentation as necessary to verify that the proposed bentonite meets the requirements of 2.01C of this Section,

    e. Anticipated bentonite application rate, and

    f. Manufacturer's literature describing the pugmill to be used for preparing the soil-bentonite mix.

4. A signed certification letter, with all necessary permits, that the material source is in full compliance with State, County, and local laws and regulations.

5. A description and schedule of the installation procedure and a list of installation equipment.

6. A Construction Quality Control (CQC) Plan for the compacted soil liner installation including:

    a. Names and qualifications of the construction quality control firm and laboratory including the CQC Officer to be retained by the CONTRACTOR

    b. Number, names and qualifications of CQC field personnel.

    c. CQC procedures for borrow excavation and test pad construction.

    d. CQC procedures for installation including exclusion and removal of oversized particles and organic matter from the compacted soil liner material, moisture control, placement, mixing, compaction and lift thickness control.

    e. Site plan or map with 1-acre grid blocks to track and demonstrate field Quality Control testing described in Paragraph 3.04 of this Section.

f. Procedure for protection of liner from adverse weather conditions (precipitation, frost, or intense heat) and all other relevant procedures.

7. Experience and performance credentials, resumes, etc. in conformance with Paragraph 1.06A.

8. Samples from the material source to be used in the liner installation, to be collected by CQC.

9. Subgrade elevations acceptable by the Engineer in accordance with Section 01050.

B. At least 21 calendar days prior to test pad construction, submit the results of testing conducted by CQC that demonstrates the proposed compacted soil liner material meets the requirements of Paragraphs 2.01A and 2.01B.

C. At least 21 calendar days prior to test pad construction, submit at least 100 lbs of the proposed compacted soil liner material contained in sealed 5-gallon pails and at least a 10 sf. section of the approved textured high density polyethylene (HDPE) liner (Section 02776) to the Engineer.

1.04 REFERENCE STANDARDS

1. ASTM D422 - Standard Test Method for Particle-Size Analysis of Soils.

2. ASTM D698 - Standard Test Method for Moisture-Density Relations of Soil and Soil Aggregate Mixtures Using 5.5-lb (2.49 kg) Hammer and 12-in (305 mm) Drop.

3. ASTM D854 - Standard Test Method for Specific Gravity of Soils.

4. ASTM D1140 - Standard Test Method for Amount of Material in Soils Finer Than the Number 200 (75 micrometer) Sieve.

5. ASTM D1556 - Standard Test Methods for Density and Unit Weight of Soil In Place by Sand-Cone Method.

6. ASTM D2216 - Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock.

7. ASTM D2487 - Standard Test Method for Classification of Soils for Engineering Purposes.

8. ASTM D2488 - Standard Practice for Description and Identification of Soils (Visual-Manual Procedures).

9. ASTM D2937 - Standard Test Method for Density of Soils in Place by the Drive-Cylinder Method.

10. ASTM D2922 - Density of Soil in Place by Nuclear Methods (Shallow Depth).

11. ASTM D3017 - Standard Test Method for Water Content of Soil in Place by Nuclear Methods (Shallow Depth).

12. ASTM D4318 - Standard Test Method for Liquid Limit, Plastic Limit and Plasticity Index of Soils.

13. ASTM D4767 - Test method for Consolidated - Undrained Triaxial Compression Test on Cohesive Soils.

14. ASTM D5084 - Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.

15. ASTM D5321 - Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic friction by the Direct Shear Method.

B Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE AND QUALITY CONTROL

A The OWNER will retain a geotechnical CQA Officer who is experienced in the construction of compacted soil liners. The CQA Officer and his/her representatives shall observe the CONTRACTORs work and perform tests as specified to provide assurance that the liner meets the requirements of this specification.

B The CONTRACTOR will retain an independent geotechnical CQC Officer that is experienced in the construction of compacted soil liners and who is capable of performing the tests specified herein and who has sufficient hydraulic conductivity testing equipment to provide test results in a timely manner (5-7 days) in accordance with the Specification. The CQC Officer shall provide direction and testing as necessary to control the quality of the borrow material (material property requirements specified in Paragraphs 2.01A and B) mixing procedures and thoroughness, bentonite application rate, moisture control for the pugmill operation, and proper construction of the test pad and the compacted soil liner.

C An “acceptable zone” and testing shall be submitted as detailed in Section 2.02C by the CQC Officer.

D After the acceptable zone testing has been performed and approved by the CQA Officer, a test pad shall be constructed on site using the same equipment and installation procedures that will be used during full-scale liner construction.

The purpose of the test pad is to assure that the construction procedures proposed for full scale liner installation will produce an acceptable liner. Construction requirements and testing procedures for the test pad are specified in Paragraph 3.01.

1.06 QUALIFICATIONS

A The work shall be performed by personnel that have experience in processing and installation of a low permeability soil liners.

1.07 DELIVERY, STORAGE AND HANDLING

A Materials may be stockpiled on-site in designated approved areas. Each type of material shall be stockpiled separately. Removal and placement of material shall be done in a manner to minimize mixing with soils adjacent to and beneath the stockpile.

B If a soil-bentonite mixture is used, both the stockpiled soil to be used in the mix and the soil-bentonite mixture, if stockpiled, shall be sealed or covered with an impermeable cover at the end of each day and during rain events.

C The bentonite storage sites should be cleared and level. Bentonite material shall be contained and covered to preserve the fitness and quality of the material.

D The CONTRACTOR shall protect the natural soil or the soil-bentonite mixture materials delivered to the site from inclement weather conditions and any traffic that may occur near the stockpile.

PART 2: PRODUCT

2.01 MATERIALS

A Compacted soil liner materials, **whether natural soil or soil-bentonite mixtures**, shall conform to the properties listed in Table 1:

TABLE 1

PROPERTY	TEST METHOD	REQUIREMENT
USCS Soil Classification	ASTM D2488	CH, CL, MH, ML, SC
Hydraulic Conductivity	ASTM D5084	1.0×10^{-5} cm/s maximum
Interface Effective Friction Angle (w/Textured HDPE)	ASTM D5321	To Be Determined[1]
Internal Effective Friction Angle	ASTM D4767	To Be Determined[1]
Organic Content	ASTM D2974	1% maximum

[1]Parameter to be determined by others in Slope Stability Analysis & Factor of Safety for Seismic Impact Zone.

B If a soil-bentonite mixture is used for the compacted soil liner, the soil to be used for the mixture shall consist of a natural mineral soil that is free from fill materials, organic materials, loam, wood, trash, snow, ice and other objectionable materials and shall conform to the properties in Table 1:

C If a soil-bentonite mixture is used for the compacted soil liner, the bentonite used in the mixture shall be a free flowing, high swelling, sodium-based, Wyoming bentonite. The bentonite shall conform to all items of this specification. Certified test data shall be submitted to the Engineer for approval. The requirements are as follows:

1. The bentonite shall meet the contamination resistance criterion defined as the ability of the bentonite, when pre-hydrated with fresh water for a minimum of 72 hours, and tested at the rate of 2.5 lbs. per square foot mixed into a 2-inch layer of SP type sand to maintain hydraulic conductivity for a minimum of 200 days after introduction of a solution containing 3% ammonium chloride into the testing device, or equivalent certification that meets the approval of the Engineer.

2. The bentonite shall be covered by the manufacturer's warranty against defects in material and workmanship and shall have a useful life of 30 years under normal weathering and normal use conditions.

D The natural soil or soil-bentonite mixture material proposed for liner construction shall be uniform in character, and after compaction, shall have an

in-place saturated hydraulic conductivity of 1.0 x 10^{-5} cm/s or less based on testing according Paragraph 3.01H.

E If a soil-bentonite mixture is used for the compacted soil liner, the soil-bentonite blending shall be accomplished using a pugmill and the CONTRACTOR shall demonstrate to the satisfaction of the Engineer that the proposed blending method will produce a consistent end product.

F. The CONTRACTOR shall show evidence of an adequate, homogenous supply of material within a designated area which is properly permitted by the appropriate local, State and Federal agencies.

2.02 CONFORMANCE TESTING

A Initial conformance testing shall be performed by CQC on samples from the natural soil source, or soil source for a soil-bentonite mixture, to assure compliance with the Specifications. The samples will be obtained from multiple test pits to be dug by the CONTRACTOR under the direction of CQC. The following tests shall be performed on the samples. For soil to be used in a soil-bentonite mix, tests 5, 8 and 9 are to be performed on the soil-bentonite mixture. Normal stresses representing field conditions should be used for the internal and interface shear tests. The effective and total shear strength friction angle should be reported.

1. Soil Classification (ASTM D2487)
2. Sieve Analysis (ASTM D422) – *including hydrometer analysis*
3. Atterberg Limits (ASTM 4318)
4. Moisture-Density Relationship Curves (ASTM D698)
5. Laboratory Hydraulic Conductivity (ASTM D5084, except as modified in Paragraph 3.01H)
6. Natural Moisture (ASTM D2216)
7. Specific Gravity (ASTM D854)
8. Shear Tests for compacted soil liner material (ASTM D4767 or as approved by the Engineer)
9. Interface Shear Tests (soil/synthetic liner or soil-bentonite/synthetic liner) – *using a direct shear, rotational shear, or as approved by Engineer*

B If a soil-bentonite mixture is proposed for the compacted soil liner, the CONTRACTOR shall be responsible for establishing the percentage of bentonite to be used for the test pad construction based on the results of laboratory testing conducted by CQC specified in 2.02A, above, on the soil-bentonite mixture. This testing shall be completed with the results furnished to the Engineer at least 21 calendar days prior to beginning test pad construction.

C For natural soil sources, the CQC Officer shall determine an acceptable zone of moisture contents and dry unit weights for which permeabilities are less than or equal to 1.0×10^{-5} cm/s by performing the following testing and analysis procedures:

1. Using the samples extracted from the proposed soil source, perform a Standard Proctor compaction test to develop a moisture-density curve for a representative sample of material. Use five specimens at incremental moisture contents to develop the compaction curve showing dry density for each molding water content.

2. Permeate compacted specimens, compaction to different moisture contents and densities, to determine their hydraulic conductivity. The compacted soil liner shall be compacted to a dry density equal to or greater than 95 percent of the compacted soil liner's maximum dry density and wet of the material's optimum moisture content as determined by ASTM D698

3. On the graph of dry density vs. moisture content, identify the samples which have hydraulic conductivities less than or equal to 1.0×10^{-5} cm/s.

4. Draw an "acceptable zone" of water content and dry density around the passing samples.

5. Perform Internal Shear Tests (ASTM D4767) and Interface Shear Tests (ASTM D5321 and Paragraph 2.01E) on one specimen of the compacted soil liner material. The sample for each test should be remolded wet of the optimum moisture content and within the acceptable zone for the percent compaction and the moisture content that is anticipated for construction. The CQA Officer may require additional internal shear tests and interface shears tests if the compacted soil liner's proposed placement moisture content and percent compaction differs substantially from the shear test result's moisture content and percent compaction presented above. Additional shear strength tests will be at the cost of the CONTRACTOR.

   For Internal Shear Tests (ASTM D4767), use the following parameters:

   A. Strain rate/shear rate required: As recommended in ASTM D4767

   B. Consolidation pressures required: 1.5 psi, 5 psi, 40 psi

   C. Consolidation/seat time for samples: As recommended in ASTM D4767

For Interface Shear Tests (ASTM D5321), use the following parameters:

A. Strain rate/shear rate required: See ASTM D5321, Paragraph 8.2 and Paragraph 11.6. Due to varying soil types, if strain rate adjustments to the above referenced Paragraphs are required due

to pore pressure dissipation problems, submit recommended adjustments for review by Engineer.

B. Normal stresses required: 1.5 psi, 5 psi, 40 psi

C. Consolidation/seat time for samples: As recommended in ASTM D5321, typically, 16-24 hours per normal stress application prior to initiating shear rate

6. Based on the shear test results and other pertinent factors such as constructability, shrink/swell potential, potential for desiccation cracks, and consolidation, the CQC Officer shall modify the acceptable zone as required.

7. CQC shall provide the graphs described above to the CONTRACTOR. If additional sources are used, the tests described above shall be performed by the CQC and the costs will be paid by the CONTRACTOR.

D For soil-bentonite mixes, once the CONTRACTOR has selected the bentonite application rate and completed the testing and submitted the test data and results as indicated in 2.02B, above, CQC shall perform the acceptable testing described in 2.02C above, prior to constructing the test pad.

E The natural soil or soil (for soil-bentonite mixture) source shall be tested by the CQC at the minimum frequencies specified in Table 2. If changes in material, as identified by the CQA Officer or CQC representative, occur within the frequency prescribed below, additional tests shall be performed at the expense of the CONTRACTOR.

TABLE 2

TEST	METHOD	FREQUENCY
Grain Size w/Hydrometer	ASTM D422	Every 2,500 cy
Atterberg Limits	ASTM D4318	Every 2,500 cy
Moisture/Density	ASTM D698	Every 5,000 cy
Natural Moisture	ASTM D2216	Every 2,500 cy

Results of the tests shall be submitted to the CQA Officer within 24 hours of test completion. The Engineer reserves the right to reject material based on the results of the conformance tests.

PART 3: EXECUTION

3.01 TEST PAD

A A test pad of a dimension of no less than 40-ft by 60-ft, installed in lifts to full thickness of 24-inches as shown on the Drawings shall be constructed on-site using the same equipment, processing and installation procedures that will be used during full-scale liner construction. The compacted soil liner material to be used for the test pad shall be the same material that the CONTRACTOR proposes to use for construction of the base liner. If approved by the Engineer, the test pad may be installed within the liner limits and incorporated in the work, provided the pad passes all testing requirements. Test pad soils tests shall be independent of and not be included in the full-scale soil liner testing results.

B The construction of the pad shall be directed by the CQC Engineer. The CQC Engineer shall use the acceptable zone established to set moisture contents and percent compaction. CQC shall perform tests as needed to assist in the construction of the test pad. Both the CQC and CQA field and laboratory testing will be evaluated for determining the performance of the test pad

C The compacted soil liner in the test pad shall be compacted to a dry density equal to or greater than 95 percent of the compacted soil liner's maximum dry density and wet of the material's optimum moisture content as determined by ASTM D698.

D The final compacted thickness of each lift shall be a maximum 6" lift thickness. For each lift, the CQC shall perform testing of moisture content and density at a minimum of three test locations. Two thin-wall tube samples shall be obtained per lift by the CQC. One tube will be used to perform a permeability test. The second tube will be kept as a backup in case of damage to the first sample.

E If the initial test pad does not provide the specified results, additional test pad(s) shall be performed, at the CONTRACTOR's cost (including CQA costs), until the specified requirements are met.

F For compacted soil liner consisting of a soil-bentonite mix, the bentonite content used for the test pad shall be set by the CONTRACTOR and written notification of the mix ratio will be submitted to the Engineer prior to constructing the test pad.

G The CONTRACTOR may construct test pads for more than one source of compacted soil liner material or soil-bentonite mix ratios. However, only one test pad will be tested and evaluated at the OWNER's cost as a part of the specified construction quality assurance (CQA). All costs associated with subsequent test pads shall be paid for by the CONTRACTOR. If the CONTRACTOR changes the source of natural soil or soil (for the soil-bentonite mixture) or if the characteristics of the natural soil or the soil within the selected source changes significantly, the Engineer may order the construction of additional test pads and subsequent tests as specified above as may be necessary to evaluate the performance of the compacted soil or soil-bentonite

liner. Construction of additional test pads and the related CQA work shall be paid for by the CONTRACTOR.

H One triaxial hydraulic conductivity test (ASTM D5084) will be performed on each lift of the test pad. These tests will be performed on undisturbed thin-wall tube samples collected by CQC in accordance with ASTM D1587. The samples shall be trimmed if needed, encapsulated within a flexible latex membrane, and mounted in permeameters conforming to the requirements of ASTM D5084. Each test specimen shall be consolidated under an effective stress of 8 to 12 psi and permeated under a backpressure as recommended in paragraph 8.3 of ASTM D5084 to achieve saturation. The maximum hydraulic gradient across the sample shall not exceed thirty (30) as per paragraph 8.5.1 of ASTM D5084 or as specified by Engineer. The hydraulic gradient shall be increased slowly in increments with careful observations of the test sample for consolidation, piping, etc. Test samples that are consolidated in volume by more than 5 percent during the test shall be voided. The inflow and outflow from the sample shall then be monitored and the hydraulic conductivity calculated for each recorded flow increment. The tests will continue until steady state flow is achieved as specified in paragraph 8.5 of ASTM D5084.

I The compacted soil liner thickness shall be determined from three test locations per lift selected by CQC per test pad using a method consisting of hand augering or push tube sampling (with a minimum of a 3/4" diameter sample) or as approved by the Engineer. Holes in the compacted soil liner shall be backfilled by the CONTRACTOR with dry powdered or chipped bentonite.

3.02 SUBGRADE PREPARATION

A The subgrade shall be graded to elevations in accordance with the plans.

B The compacted soil liner subgrade shall be proofrolled by the CONTRACTOR in accordance with Section 02200 and examined by the CQA Officer or the RPR to detect unstable or loose soils. Based on observation during the proofrolling operation, the CQA Officer and the RPR reserves the right to select the number and direction of passes to be used. Any unsuitable soils encountered at subgrade elevation shall be removed and replaced as directed by the CQA Officer and/or the RPR at no additional cost to the OWNER.

C The subgrade surface shall not be smooth rolled. The subgrade surface shall be left in a roughened condition to allow good adherence between the subgrade and the initial lift of the compacted soil liner.

D The CQA Officer shall observe and approve the subgrade and the survey plan of subgrade elevation submitted by the CONTRACTOR before installation of the compacted soil liner can proceed. It shall be the CONTRACTOR's

responsibility to properly prepare and maintain the subgrade in a uniform and compacted condition during installation of the liner.

E If the subgrade is damaged during liner installation, the CONTRACTOR shall restore and re-compact the area; CQC shall re-test the subgrade in accordance with ASTM D1556, D2922, or D2937 prior to installing the liner. All costs related to the re-test and restoration of the subgrade shall be paid for by the CONTRACTOR.

3.03 SOIL OR SOIL-BENTONITE LINER PLACEMENT

A The CQC Officer and his/her site representatives shall supervise the liner installation. Work shall not be performed by the CONTRACTOR without the CQA Officer and/or the RPR onsite. CQA and CQC shall perform field tests (i.e. moisture content, densities, etc.) as required to ensure proper installation. CQA and CQC shall perform tests as described in section 3.04 to determine acceptance of the in-place liner.

B. The compacted soil liner material shall be compacted to a dry density equal to or greater than 95 percent of its maximum dry density and wet of the material's optimum moisture content as determined by ASTM D698.

C The placement moisture content shall be within the acceptable zone of moisture content as determined by the CQC Officer during the conformance testing of the natural soil or soil-bentonite mixture described in paragraph 2.02C. The acceptable zone may be modified by the Engineer based on results and observations of the test pad.

D Water for Construction of the Soil Liner

1. The CONTRACTOR shall make arrangements to provide water as required to achieve the required moisture content, unless otherwise specified in the Contract Documents.

2. The water shall be from an approved source.

3. Prior to installing the liner, the CONTRACTOR shall inspect the subgrade to ensure that it has been sufficiently wetted to prevent excessive absorption of moisture from the installed material.

4. Should the compacted soil liner material be stockpiled for any length of time, the CONTRACTOR shall slope, seal and compact the stockpile to prevent erosion and oversaturation.

5. Should the material become oversaturated, the CONTRACTOR shall spread and dry the material as needed to adjust the moisture to the proper percentage.

E The materials shall be uniformly compacted to no less than the minimum dry density of the acceptable zone that corresponds to the placement moisture content or 95 percent of its maximum dry density, whichever is greater. The acceptable zone shall be as specified by the CQC Officer in accordance with the procedures outlined in 2.02C. Density shall be uniformly obtained throughout the entire thickness of the liner. The compacted soil liner shall be constructed in lifts with a maximum compacted thickness of 6 inches per lift. The surface of a lower lift shall be scarified, if needed, prior to placement of an upper lift. During placement of the initial lift care should be taken to avoid mixing of the liner material and subgrade material.

F To achieve the specified compaction the CONTRACTOR shall use a self-propelled compactor (CAT 815 or equivalent) equipped with steel kneading feet capable of fully penetrating the loose lift and into the previously compacted lift. A smooth wheel compactor shall be used with sufficient number of passes to smooth the upper surface of the compacted soil liner. A smooth wheel compactor shall be used only for final smoothing of the surface and not be used for achieving the specified compaction.

G Liner material shall be mixed, disced, harrowed, tilled and kneaded as necessary to break down all clods and produce a uniform homogenous layer that is free of clods. A clod is defined for the purposes of construction as any subrounded ball of soil exceeding 1/2" in diameter, typically with the core containing less than the specified moisture. If the CQA Officer or the RPR observe that all clods have not been broken down, the CONTRACTOR shall re-work the material to the satisfaction of the CQA Officer and/or the RPR.

H The surface of each lift shall be scarified prior to placement of subsequent lifts.

I Liner material which has been contaminated with clusters of rock or gravel, sand lenses, organic debris or other deleterious material shall be removed and replaced with uncontaminated soil materials.

J In the case of soil-bentonite mix for the compacted soil liner, the CONTRACTOR shall use a pugmill to blend the soil-bentonite mix at the required moisture content. Soil borrow material to be used for soil-bentonite compacted soil liner construction shall be shredded and screened by power methods to provide a uniform soil free of roots, stumps, and other organic materials, rocks, and debris and to provide particle sizes to be used in the compacted soil liner less than 1.5 inches in its longest dimension for natural soil and 1.5 inches in its longest dimension for soil-bentonite mixes.

K For the final lift, the CONTRACTOR shall employ a crew of laborers to remove all rocks prior to smooth rolling.

L No liner material shall be placed, spread, or compacted while the ground or the liner material is frozen/thawing, saturated, desiccated, during unfavorable weather conditions or periods of precipitation. The liner surface must be made smooth and free from ruts or indentations at the end of any working day when significant precipitation is forecast and/or at the completion of the compaction operations in that area in order to prevent saturation of the liner material. Any re-grading due to the above conditions or final preparation should be re-tested at those locations for liner thickness prior to placement of the next lift or HDPE liner. Thickness measurements should be performed as indicated in Section 3.04 A. Areas previously meeting the conformance test requirements that are re-worked in excess of the top 3-inch per lift shall be re-tested. Re-testing will be at the cost of the CONTRACTOR.

M Should desiccation cracks develop, the liner shall be scarified, disced, re-wetted, re-homogenized and re-compacted in accordance with the Specifications to the depth of any such cracks or as instructed by the Engineer and/or the RPR. If desiccation extends below half of the lift thickness, the entire lift shall be reworked and retested as described above. Re-testing will be at the expense of the CONTRACTOR.

N During construction, the CONTRACTOR shall make all necessary provisions to deal with inclement weather conditions. The CONTRACTOR shall be fully responsible for control of stormwater during installation of the liner system and for moisture control and protection of the compacted soil liner.

O After finish grading and smooth rolling is completed, the compacted soil liner shall not be less than 24-inches thick. Liner thickness will be tested by CQA and CQC personnel on a per lift basis at a frequency specified in 3.04A using a method of hand augering or push tube sampling (minimum 3/4" sample). This testing is primarily to estimate liner lift thickness and shall not be used to verify total dry liner thickness. The final compacted soil liner thickness will be determined from the CONTRACTOR's survey. Areas not meeting the thickness requirements shall be augmented with additional soil material. The CONTRACTOR's surveyor shall be available to assist in determining the areal extent of compacted soil liner that is not meeting the minimum required thickness. Any additional testing or CQA services associated with corrective action for achieving the required soil liner thickness requirement will be at the cost of the CONTRACTOR. The added material shall be worked into the in-place liner to ensure homogeneity and proper bonding. This shall be done by scarification of the surface prior to addition of the new material. As a minimum, the top 3-inches of the liner shall be wetted, kneaded, compacted and re-worked with the additional material to obtain the required thickness.

3.04 QUALITY ASSURANCE DURING PLACEMENT

A The CQC/CQA personnel shall conduct tests during installation of the compacted soil liner at the minimum frequencies specified in Table 3. The

CQC Officer will provide direction and testing as necessary to the CONTRACTOR to control quality of the compacted soil liner materials to meet the specifications listed in Section 2.01; however, the results of CQC and CQA testing will both be considered in accepting or rejecting compacted soil liner materials.

TABLE 3

TEST	METHOD	FREQUENCY	
		CQC	CQA
Grain Size w/Hydrometer	ASTM D422	1/acre/lift	1/acre
Atterberg Limits	ASTM D4318	1/acre/lift	1/acre
Undisturbed Permeability	ASTM D5084	1/acre/lift	1/acre
Density[1]	ASTM D2937 ASTM D2922 ASTM D1556	4/acre/lift	2/acre
Natural Moisture[1]	ASTM D2216 ASTM D3017 ASTM D1556	4/acre/lift (at density location)	2/acre
Liner thickness	Hand Auger or push tube	4/acre/lift	Discretionary

B The minimum testing frequencies for field tests to be performed by the CONTRACTOR's Quality Control personnel and the OWNER's Quality Assurance personnel are identified in Sections 3.04. A. The intent of the field tests is to insure that the specified density and moisture contents are being obtained.

One-point compaction tests shall be performed to interpolate between laboratory compaction (ASTM D 698) curves for at least every 5 in-place density tests. The one-point compaction tests shall be performed on either the field density test sample or soil from a location immediately adjacent to the field density test sample, using the ASTM D 698 procedure. The results of the one-point tests shall then be compared with the full compaction curves of similar soils to estimate the maximum dry density applicable to the field density test sample.

Note[1]: A nuclear density test gauge can be used to provide the required density testing. However, the in-situ density shall be determined using the sand cone method (ASTM D 1556) and/or the drive cylinder method (ASTM D 2937) of a minimum of one test per ten nuclear density tests or one per day, whichever is greater. The sand cone and/or drive cylinder test should

be performed at the same location as a nuclear density test. The sand cone and/or drive cylinder tests shall be continued until a correlation between the density and moisture contents obtained by the nuclear density gauge and the sand cone and/or drive cylinder tests has been demonstrated.

C All holes made as a result of depth measurements, permeability samples, density tests, grade stakes or other means shall be completely filled by the CONTRACTOR and/or CQC Officer with dry powdered or chipped bentonite, as instructed by the CQA Officer and the RPR.

D The CQA Officer shall have the authority to request additional permeability tests in areas that, in the CQA Officer's judgment, may be suspect or deficient. Hydraulic conductivity tests shall be conducted in accordance with ASTM D5084 except as modified in Paragraph 3.01G. For each sample tested, one back-up sample will be extracted in the proximity of the sample location. This sample will be held in a controlled environment at the CQA/CQA laboratories as a precautionary measure. If adequate demonstration is presented that a sample was not representative of the compacted soil liner or that an error in testing occurred, the backup sample will be tested and the original test will be disregarded.

E If applicable, Grade stakes for liner construction shall be numbered by the CONTRACTOR and located on an inventory map. The inventory map shall be submitted to the CQA Officer. Upon completion of an area, the removed stakes will be compared to the inventory map to ensure that none were left in-place.

F The CONTRACTOR shall submit a survey plan with final elevation of top of compacted soil liner for CQA Officer's approval in accordance with Section 01050 prior to installing the geomembrane liner.

3.05 Corrective Action

A If soil has been desiccated to a depth less than or equal to the thickness of a single lift, the desiccated lift shall be disced, moistened, and re-compacted. However, discing may produce large, hard clods of soil that will require pulverization. Also, it should be recognized that if the soil is wetted, time must be allowed for water to be absorbed into the clods of soil and hydration to take place uniformly. For this reason it will be necessary to remove the desiccated soil from the construction area, to process the lift in a separate processing area, and to replace the soil accordingly.

B Any sample or area tested shall be rejected, removed and replaced if it does not meet the requirements of the technical specifications. Reconstructed areas shall have feathered, overlapping edges that tie into adjacent liner areas.

3.06 Reporting

A The CONTRACTOR's CQC Officer shall provide a final Construction Quality Control Report at the end of the project. The report shall certify that the Work associated with Compacted Soil Liner was performed in accordance with the Contract Documents and shall be prepared and sealed by a Professional Engineer registered in the State of North Carolina. The report shall include a narrative describing construction methods and QC procedures employed, summary tables of all field test results, including location and notations regarding any re-work performed, identification of failed tests, and discussions and documentation of re-worked areas with passing tests, as appropriate.

B Submittal of an administratively complete Construction Quality Control Report shall be required for the Work to be considered Substantially Complete.

END OF SECTION

SECTION 02275

COMPACTED SOIL LINER (1.0 x 10-7 cm/s)

PART 1: GENERAL

1.01 SCOPE OF WORK

A Furnish all labor, materials, equipment and incidentals required to install compacted soil liner with a maximum in-place permeability of 1.0×10^{-7} cm/s of minimum thickness as measured perpendicular to the slope as shown on the Drawings and as specified herein. Associated work includes quality control testing, borrow source excavation, hauling, screening, constructing a test pad, placement, moisture conditioning, harrowing, compaction, and grading of natural soil or soil-bentonite materials for bottom liner construction in the disposal unit.

1.02 RELATED WORK

A Section 01040: CQA Plan

B Section 01050: Field Engineering

C Section 02200: Excavation, Backfill, and Compaction

D Section 02776: Textured High Density Polyethylene (HDPE) Liner.

1.03 SUBMITTALS

A At least 45 days prior to test pad construction, the Contractor shall submit the following information in accordance with Section 01340:

1. Identification of the compacted soil liner type (natural soil or Contractor prepared soil-bentonite mix.)

2. If a natural soil is proposed, submit the following documentation:

   a. Name and location of the proposed natural soil borrow source,

   b. Test results and other documentation as necessary to verify that the proposed natural soil meets the requirements of 2.01A of this Section, and

   c. Anticipated volume of suitable natural soil available to the project.

3. If a soil-bentonite mixture is proposed, submit the following documentation:

a. Name and location of the proposed soil source,

b. Test results and other documentation as necessary to verify that the proposed soil meets the requirements of 2.01B of this Section,

c. Name and location of the bentonite supplier,

d. Test results and other documentation as necessary to verify that the proposed bentonite meets the requirements of 2.01C of this Section,

e. Anticipated bentonite application rate, and

f. Manufacturer's literature describing the pugmill to be used for preparing the soil-bentonite mix.

4. A signed certification letter, with all necessary permits, that the material source is in full compliance with State, County, and local laws and regulations.

5. A description and schedule of the installation procedure and a list of installation equipment.

6. A Construction Quality Control (CQC) Plan for the compacted soil liner installation including:

a. Names and qualifications of the construction quality control firm and laboratory including the CQC Officer to be retained by the Contractor

b. Number, names and qualifications of CQC field personnel.

c. CQC procedures for borrow excavation and test pad construction.

d. CQC procedures for installation including exclusion and removal of oversized particles and organic matter from the compacted soil liner material, moisture control, placement, mixing, compaction and lift thickness control.

e. Site plan or map with 1-acre grid blocks to track and demonstrate field Quality Control testing described in Paragraph 3.04 of this Section.

f. Procedure for protection of liner from adverse weather conditions (precipitation, frost, or intense heat) and all other relevant procedures.

7. Experience and performance credentials, resumes, etc. in conformance with Paragraph 1.06A.

8. Samples from the material source to be used in the liner installation, to be collected by CQC.

9. Subgrade elevations in a form acceptable by the Engineer.

B. At least 21 calendar days prior to test pad construction, submit the results of testing conducted by CQC that demonstrates the proposed compacted soil liner material meets the requirements of Paraqraphs 2.01A and 2.01B.

C. At least 21 calendar days prior to test pad construction, submit at least 100 lbs of the proposed compacted soil liner material contained in sealed 5-gallon pails and at least a 10 sf. section of the approved textured high density polyethylene (HDPE) liner (Section 02776) to the Engineer.

1.04 REFERENCE STANDARDS

1. ASTM D422 - Standard Test Method for Particle-Size Analysis of Soils.

2. ASTM D698 - Standard Test Method for Moisture-Density Relations of Soil and Soil Aggregate Mixtures Using 5.5-lb (2.49 kg) Hammer and 12-in (305 mm) Drop.

3. ASTM D854 - Standard Test Method for Specific Gravity of Soils.

4. ASTM D1140 - Standard Test Method for Amount of Material in Soils Finer Than the Number 200 (75 micrometer) Sieve.

5. ASTM D1556 - Standard Test Methods for Density and Unit Weight of Soil In Place by Sand-Cone Method.

6. ASTM D2216 - Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock.

7. ASTM D2487 - Standard Test Method for Classification of Soils for Engineering Purposes.

8. ASTM D2488 - Standard Practice for Description and Identification of Soils (Visual-Manual Procedures).

9. ASTM D2937 - Standard Test Method for Density of Soils in Place by the Drive-Cylinder Method.

10. ASTM D2922 - Density of Soil in Place by Nuclear Methods (Shallow Depth).

11. ASTM D3017 - Standard Test Method for Water Content of Soil in Place by Nuclear Methods (Shallow Depth).

12. ASTM D4318 - Standard Test Method for Liquid Limit, Plastic Limit and Plasticity Index of Soils.

13. ASTM D4767 - Test method for Consolidated - Undrained Triaxial Compression Test on Cohesive Soils.

14. ASTM D5084 - Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.

15. ASTM D5321 - Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic friction by the Direct Shear Method.

B Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE AND QUALITY CONTROL

A The Owner will retain a geotechnical CQA Officer who is experienced in the construction of compacted soil liners. The CQA Officer and his/her representatives shall observe the Contractors work and perform tests as specified to provide assurance that the liner meets the requirements of this specification.

B The Contractor will retain an independent geotechnical CQC Officer that is experienced in the construction of compacted soil liners and who is capable of performing the tests specified herein and who has sufficient hydraulic conductivity testing equipment to provide test results in a timely manner (5-7 days) in accordance with the Specification. The CQC Officer shall provide direction and testing as necessary to control the quality of the borrow material (material property requirements specified in Paragraphs 2.01A and B) mixing procedures and thoroughness, bentonite application rate, moisture control for the pugmill operation, and proper construction of the test pad and the compacted soil liner.

C An “acceptable zone” and testing shall be submitted as detailed in Section 2.02C by the CQC Officer.

D After the acceptable zone testing has been performed and approved by the CQA Officer, a test pad shall be constructed on site using the same equipment and installation procedures that will be used during full-scale liner construction.

The purpose of the test pad is to assure that the construction procedures proposed for full scale liner installation will produce an acceptable liner. Construction requirements and testing procedures for the test pad are specified in Paragraph 3.01.

1.06 QUALIFICATIONS

A The work shall be performed by personnel that have experience in processing and installation of a low permeability soil liners.

1.07 DELIVERY, STORAGE AND HANDLING

A Materials may be stockpiled on-site in designated approved areas. Each type of material shall be stockpiled separately. Removal and placement of material shall be done in a manner to minimize mixing with soils adjacent to and beneath the stockpile.

B If a soil-bentonite mixture is used, both the stockpiled soil to be used in the mix and the soil-bentonite mixture, if stockpiled, shall be sealed or covered with an impermeable cover at the end of each day and during rain events.

C The bentonite storage sites should be cleared and level. Bentonite material shall be contained and covered to preserve the fitness and quality of the material.

D The Contractor shall protect the natural soil or the soil-bentonite mixture materials delivered to the site from inclement weather conditions and any traffic that may occur near the stockpile.

PART 2: PRODUCT

2.01 MATERIALS

A Compacted soil liner materials, **whether natural soil or soil-bentonite mixtures**, shall conform to the properties listed in Table 1:

TABLE 1

PROPERTY	TEST METHOD	REQUIREMENT
Passing the 1.5-inch Sieve (%)	ASTM D422	100% minimum
Passing the 10 Sieve (%)	ASTM D422	90% minimum
Passing the 200 Sieve (%)	ASTM D1140	50% minimum
Liquid Limit	ASTM D4318	40% minimum
Plasticity Index	ASTM D4318	15% minimum
USCS Soil Classification	ASTM D2488	CH, CL, MH, ML, SC
Hydraulic Conductivity	ASTM D5084	1.0×10^{-7} cm/s
Interface Effective Friction Angle (w/Textured HDPE)	ASTM D5321	To Be Determined[1]
Internal Effective Friction Angle	ASTM D4767	To Be Determined[1]
Organic Content	ASTM D2974	3% maximum

[1]Parameter to be determined by others in Slope Stability Analysis & Factor of Safety for Seismic Impact Zone.

B If a soil-bentonite mixture is used for the compacted soil liner, the soil to be used for the mixture shall consist of a natural mineral soil that is free from fill materials, organic materials, loam, wood, trash, snow, ice and other objectionable materials and shall conform to the properties in Table 1:

C If a soil-bentonite mixture is used for the compacted soil liner, the bentonite used in the mixture shall be a free flowing, high swelling, sodium-based, Wyoming bentonite. The bentonite shall conform to all items of this specification. Certified test data shall be submitted to the Engineer for approval. The requirements are as follows:

1. The bentonite shall meet the contamination resistance criterion defined as the ability of the bentonite, when pre-hydrated with fresh water for a minimum of 72 hours, and tested at the rate of 2.5 lbs. per square foot mixed into a 2-inch layer of SP type sand to maintain hydraulic conductivity for a minimum of 200 days after introduction of a solution containing 3% ammonium chloride into the testing device, or equivalent certification that meets the approval of the Engineer.

2. The bentonite shall be covered by the manufacturer's warranty against defects in material and workmanship and shall have a useful life of 30 years under normal weathering and normal use conditions.

D The natural soil or soil-bentonite mixture material proposed for liner construction shall be uniform in character, and after compaction, shall have an in-place saturated hydraulic conductivity of 1.0 x 10^{-7} cm/s or less based on testing according Paragraph 3.01H.

E If a soil-bentonite mixture is used for the compacted soil liner, the soil-bentonite blending shall be accomplished using a pugmill and the Contractor shall demonstrate to the satisfaction of the Engineer that the proposed blending method will produce a consistent end product.

F. The Contractor shall show evidence of an adequate, homogenous supply of material within a designated area which is properly permitted by the appropriate local, State and Federal agencies.

2.02 CONFORMANCE TESTING

A Initial conformance testing shall be performed by CQC on samples from the natural soil source, or soil source for a soil-bentonite mixture, to assure compliance with the Specifications. The samples will be obtained from multiple test pits to be dug by the Contractor under the direction of CQC. The following tests shall be performed on the samples. For soil to be used in a soil-bentonite mix, tests 5, 8 and 9 are to be performed on the soil-bentonite mixture. Normal stresses representing field conditions should be used for the internal and interface shear tests. The effective and total shear strength friction angle should be reported.

1. Soil Classification (ASTM D2487)
2. Sieve Analysis (ASTM D422) – *including hydrometer analysis*
3. Atterberg Limits (ASTM 4318)
4. Moisture-Density Relationship Curves (ASTM D698)
5. Laboratory Hydraulic Conductivity (ASTM D5084, except as modified in Paragraph 3.01H)
6. Natural Moisture (ASTM D2216)
7. Specific Gravity (ASTM D854)
8. Shear Tests for compacted soil liner material (ASTM D4767 or as approved by the Engineer)
9. Interface Shear Tests (soil/synthetic liner or soil-bentonite/synthetic liner) – *using a direct shear, rotational shear, or as approved by Engineer*

B If a soil-bentonite mixture is proposed for the compacted soil liner, the Contractor shall be responsible for establishing the percentage of bentonite to be used for the test pad construction based on the results of laboratory testing conducted by CQC specified in 2.02A, above, on the soil-bentonite mixture.

This testing shall be completed with the results furnished to the Engineer at least 21 calendar days prior to beginning test pad construction.

C For natural soil sources, the CQC Officer shall determine an acceptable zone of moisture contents and dry unit weights for which permeabilities are less than or equal to 1.0×10^{-7} cm/s by performing the following testing and analysis procedures:

1. Using the samples extracted from the proposed soil source, perform a Standard Proctor compaction test to develop a moisture-density curve for a representative sample of material. Use five specimens at incremental moisture contents to develop the compaction curve showing dry density for each molding water content.

2. Permeate compacted specimens, compaction to different moisture contents and densities, to determine their hydraulic conductivity. The compacted soil liner shall be compacted to a dry density equal to or greater than 95 percent of the compacted soil liner's maximum dry density and wet of the material's optimum moisture content as determined by ASTM D698

3. On the graph of dry density vs. moisture content, identify the samples which have hydraulic conductivities less than or equal to 1.0×10^{-7} cm/s.

4. Draw an "acceptable zone" of water content and dry density around the passing samples.

5. Perform Internal Shear Tests (ASTM D4767) and Interface Shear Tests (ASTM D5321 and Paragraph 2.01E) on one specimen of the compacted soil liner material. The sample for each test should be remolded wet of the optimum moisture content and within the acceptable zone for the percent compaction and the moisture content that is anticipated for construction. The CQA Officer may require additional internal shear tests and interface shears tests if the compacted soil liner's proposed placement moisture content and percent compaction differs substantially from the shear test result's moisture content and percent compaction presented above. Additional shear strength tests will be at the cost of the Contractor.

   For Internal Shear Tests (ASTM D4767), use the following parameters:

   A. Strain rate/shear rate required: As recommended in ASTM D4767

   B. Consolidation pressures required: 1.5 psi, 5 psi, 40 psi

   C. Consolidation/seat time for samples: As recommended in ASTM D4767

For Interface Shear Tests (ASTM D5321), use the following parameters:

A. Strain rate/shear rate required: See ASTM D5321, Paragraph 8.2 and Paragraph 11.6. Due to varying soil types, if strain rate adjustments to the above referenced Paragraphs are required due to pore pressure dissipation problems, submit recommended adjustments for review by Engineer.

B. Normal stresses required: 1.5 psi, 5 psi, 40 psi

C. Consolidation/seat time for samples: As recommended in ASTM D5321, typically, 16-24 hours per normal stress application prior to initiating shear rate

6. Based on the shear test results and other pertinent factors such as constructability, shrink/swell potential, potential for desiccation cracks, and consolidation, the CQC Officer shall modify the acceptable zone as required.

7. CQC shall provide the graphs described above to the Contractor. If additional sources are used, the tests described above shall be performed by the CQC and the costs will be paid by the Contractor.

D For soil-bentonite mixes, once the Contractor has selected the bentonite application rate and completed the testing and submitted the test data and results as indicated in 2.02B, above, CQC shall perform the acceptable testing described in 2.02C above, prior to constructing the test pad.

E The natural soil or soil (for soil-bentonite mixture) source shall be tested by the CQC at the minimum frequencies specified in Table 2. If changes in material, as identified by the CQA Officer or CQC representative, occur within the frequency prescribed below, additional tests shall be performed at the expense of the Contractor.

TABLE 2

TEST	METHOD	FREQUENCY
Grain Size w/Hydrometer	ASTM D422	Every 2,500 cy
Atterberg Limits	ASTM D4318	Every 2,500 cy
Moisture/Density	ASTM D698	Every 5,000 cy
Natural Moisture	ASTM D2216	Every 2,500 cy

Results of the tests shall be submitted to the CQA Officer within 24 hours of test completion. The Engineer reserves the right to reject material based on the results of the conformance tests.

PART 3: EXECUTION

3.01 TEST PAD

A A test pad of a dimension of no less than 40-ft by 60-ft and 24-inch thickness shall be constructed on-site using the same equipment, processing and installation procedures that will be used during full-scale liner construction. The compacted soil liner material to be used for the test pad shall be the same material that the Contractor proposes to use for construction of the base liner. If approved by the Engineer, the test pad may be installed within the liner limits and incorporated in the work, provided the pad passes all testing requirements. Test pad soils tests shall be independent of and not be included in the full-scale soil liner testing results.

B The construction of the pad shall be directed by the CQC Engineer. The CQC Engineer shall use the acceptable zone established to set moisture contents and percent compaction. CQC shall perform tests as needed to assist in the construction of the test pad. Both the CQC and CQA field and laboratory testing will be evaluated for determining the performance of the test pad

C The compacted soil liner in the test pad shall be compacted to a dry density equal to or greater than 95 percent of the compacted soil liner's maximum dry density and wet of the material's optimum moisture content as determined by ASTM D698.

D The final compacted thickness of each lift shall be a maximum 6" lift thickness. For each lift, the CQC shall perform testing of moisture content and density at a minimum of three test locations. Two thin-wall tube samples shall be obtained per lift by the CQC. One tube will be used to perform a permeability test. The second tube will be kept as a backup in case of damage to the first sample.

E If the initial test pad does not provide the specified results, additional test pad(s) shall be performed, at the Contractor's cost (including CQA costs), until the specified requirements are met.

F For compacted soil liner consisting of a soil-bentonite mix, the bentonite content used for the test pad shall be set by the Contractor and written notification of the mix ratio will be submitted to the Engineer prior to constructing the test pad.

G The Contractor may construct test pads for more than one source of compacted soil liner material or soil-bentonite mix ratios. However, only one test pad will be tested and evaluated at the Owner's cost as a part of the specified construction quality assurance (CQA). All costs associated with subsequent test pads shall be paid for by the Contractor. If the Contractor changes the source of natural soil or soil (for the soil-bentonite mixture) or if the characteristics of the natural soil or the soil within the selected source changes significantly, the Engineer may order the construction of additional test pads

and subsequent tests as specified above as may be necessary to evaluate the performance of the compacted soil or soil-bentonite liner. Construction of additional test pads and the related CQA work shall be paid for by the contractor.

H One triaxial hydraulic conductivity test (ASTM D5084) will be performed on each lift of the test pad. These tests will be performed on undisturbed thin-wall tube samples collected by CQC in accordance with ASTM D1587. The samples shall be trimmed if needed, encapsulated within a flexible latex membrane, and mounted in permeameters conforming to the requirements of ASTM D5084. Each test specimen shall be consolidated under an effective stress of 8 to 12 psi and permeated under a backpressure as recommended in paragraph 8.3 of ASTM D5084 to achieve saturation. The maximum hydraulic gradient across the sample shall not exceed thirty (30) as per paragraph 8.5.1 of ASTM D5084 or as specified by Engineer. The hydraulic gradient shall be increased slowly in increments with careful observations of the test sample for consolidation, piping, etc. Test samples that are consolidated in volume by more than 5 percent during the test shall be voided. The inflow and outflow from the sample shall then be monitored and the hydraulic conductivity calculated for each recorded flow increment. The tests will continue until steady state flow is achieved as specified in paragraph 8.5 of ASTM D5084.

I The compacted soil liner thickness shall be determined from three test locations per lift selected by CQC per test pad using a method consisting of hand augering or push tube sampling (with a minimum of a 3/4" diameter sample) or as approved by the Engineer. Holes in the compacted soil liner shall be backfilled by the Contractor with dry powdered or chipped bentonite.

3.02 SUBGRADE PREPARATION

A The subgrade shall be graded to elevations in accordance with the plans.

B The compacted soil liner subgrade shall be proofrolled by the Contractor in accordance with Section 02200 and examined by the CQA Officer and/or the RPR to detect unstable or loose soils. Based on observation during the proofrolling operation, the CQA Officer and the RPR reserves the right to select the number and direction of passes to be used. Any unsuitable soils encountered at subgrade elevation shall be removed and replaced as directed by the CQA Officer and/or the RPR at no additional cost to the Owner.

C The subgrade surface shall not be smooth rolled. The subgrade surface shall be left in a roughened condition to allow good adherence between the subgrade and the initial lift of the compacted soil liner.

D The CQA Officer shall observe and approve the subgrade and the survey plan of subgrade elevation submitted by the Contractor before installation of the compacted soil liner can proceed. It shall be the Contractor's responsibility to

properly prepare and maintain the subgrade in a uniform and compacted condition during installation of the liner.

E If the subgrade is damaged during liner installation, the Contractor shall restore and re-compact the area; CQC shall re-test the subgrade in accordance with ASTM D1556, D2922, or D2937 prior to installing the liner. All costs related to the re-test and restoration of the subgrade shall be paid for by the Contractor.

3.03 SOIL OR SOIL-BENTONITE LINER PLACEMENT

A The CQC Officer and his/her site representatives shall supervise the liner installation. Work shall not be performed by the Contractor without the CQA Officer and/or the RPR onsite. CQA and CQC shall perform field tests (i.e. moisture content, densities, etc.) as required to ensure proper installation. CQA and CQC shall perform tests as described in section 3.04 to determine acceptance of the in-place liner.

B. The compacted soil liner material shall be compacted to a dry density equal to or greater than 95 percent of its maximum dry density and wet of the material's optimum moisture content as determined by ASTM D698.

C The placement moisture content shall be within the acceptable zone of moisture content as determined by the CQC Officer during the conformance testing of the natural soil or soil-bentonite mixture described in paragraph 2.02C. The acceptable zone may be modified by the Engineer based on results and observations of the test pad.

D Water for Construction of the Soil Liner

1. The Contractor shall provide water as required to achieve the required moisture content, unless otherwise specified in the Contract Documents.

2. The water shall be from an approved source.

3. Prior to installing the liner, the Contractor shall inspect the subgrade to ensure that it has been sufficiently wetted to prevent excessive absorption of moisture from the installed material.

4. Should the compacted soil liner material be stockpiled for any length of time, the Contractor shall slope, seal and compact the stockpile to prevent erosion and oversaturation.

5. Should the material become oversaturated, the Contractor shall spread and dry the material as needed to adjust the moisture to the proper percentage.

E The materials shall be uniformly compacted to no less than the minimum dry density of the acceptable zone that corresponds to the placement moisture content or 95 percent of its maximum dry density, whichever is greater. The acceptable zone shall be as specified by the CQC Officer in accordance with the procedures outlined in 2.02C. Density shall be uniformly obtained throughout the entire thickness of the liner. The compacted soil liner shall be constructed in lifts with a maximum compacted thickness of 6 inches per lift. The surface of a lower lift shall be scarified, if needed, prior to placement of an upper lift. During placement of the initial lift care should be taken to avoid mixing of the liner material and subgrade material.

F To achieve the specified compaction the Contractor shall use a self-propelled compactor equipped with steel kneading feet capable of fully penetrating the loose lift and into the previously compacted lift. A smooth wheel compactor shall be used with sufficient number of passes to smooth the upper surface of the compacted soil liner. A smooth wheel compactor shall be used only for final smoothing of the surface and not be used for achieving the specified compaction.

G Liner material shall be disced, harrowed, and kneaded as necessary to break down all clods and produce a uniform material that is free of clods. A clod is defined for the purposes of construction as any subrounded ball of soil exceeding 1/2" in diameter, typically with the core containing less than the specified moisture. If the CQA Officer and/or the RPR observe that all clods have not been broken down, the Contractor shall rework the material to the satisfaction of the CQA Officer and/or the RPR.

H Liner material which has been contaminated with clusters of rock or gravel, sand lenses, organic debris or other deleterious material shall be removed and replaced with uncontaminated soil materials.

I In the case of soil-bentonite mix for the compacted soil liner, the Contractor shall use a pugmill to blend the soil-bentonite mix at the required moisture content. Soil borrow material to be used for soil-bentonite compacted soil liner construction shall be shredded and screened by power methods to provide a uniform soil free of roots, stumps, and other organic materials, rocks, and debris and to provide particle sizes to be used in the compacted soil liner less than 1.5 inches in its longest dimension for natural soil and 1.5 inches in its longest dimension for soil-bentonite mixes.

J For the final lift, the contractor shall employ a crew of laborers to remove all rocks 1-inch or larger prior to smooth rolling.

K No liner material shall be placed, spread, or compacted while the ground or the liner material is frozen/thawing, saturated, desiccated, during unfavorable weather conditions or periods of precipitation. The liner surface must be made smooth and free from ruts or indentations at the end of any working day when significant precipitation is forecast and/or at the completion of the compaction

operations in that area in order to prevent saturation of the liner material. Any re-grading due to the above conditions or final preparation should be retested at those locations for liner thickness prior to placement of the next lift or HDPE liner. Thickness measurements should be performed as indicated in Section 3.04 A. Areas previously meeting the conformance test requirements that are reworked in excess of the top 3-inch per lift shall be retested. Retesting will be at the cost of the Contractor.

L Should desiccation cracks develop, the liner shall be scarified, disced, rewetted, re-homogenized and re-compacted in accordance with the Specifications to the depth of any such cracks or as instructed by the Engineer and/or the RPR. If desiccation extends below half of the lift thickness, the entire lift shall be reworked and retested as described above. Retesting will be at the expense of the Contractor.

M During construction, the Contractor shall make all necessary provisions to deal with inclement weather conditions. The Contractor shall be fully responsible for control of stormwater during installation of the liner system and for moisture control and protection of the compacted soil liner.

N After finish grading and smooth rolling is completed, the compacted soil liner shall not be less than 24-inches in any location. Liner thickness will be tested by CQA and CQC personnel on a per lift basis at a frequency specified in 3.04A using a method of hand augering or push tube sampling (minimum 3/4" sample). This testing is primarily to estimate liner lift thickness and shall not be used to verify total dry liner thickness. The final compacted soil liner thickness will be determined from the Contractor's survey. Areas not meeting the thickness requirements shall be augmented with additional soil material. The Contractor's surveyor shall be available to assist in determining the areal extent of compacted soil liner that is not at least 24-inches thick. Any additional testing or CQA services associated with corrective action for achieving the 24-inch liner thickness requirement will be at the cost of the Contractor. The added material shall be worked into the in-place liner to ensure homogeneity and proper bonding. This shall be done by scarification of the surface prior to addition of the new material. As a minimum, the top 3-inches of the liner shall be wetted, kneaded, compacted and re-worked with the additional material to obtain the required thickness.

3.04 QUALITY ASSURANCE DURING PLACEMENT

A The CQC/CQA personnel shall conduct tests during installation of the compacted soil liner at the minimum frequencies specified in Table 3. The CQC Officer will provide direction and testing as necessary to the Contractor to control quality of the compacted soil liner materials to meet the specifications listed in Section 2.01; however, the results of CQC and CQA testing will both be considered in accepting or rejecting compacted soil liner materials.

TABLE 3

TEST	METHOD	FREQUENCY	
		CQC	CQA
Grain Size w/Hydrometer	ASTM D422	1/acre/lift	1/acre
Atterberg Limits	ASTM D4318	1/acre/lift	1/acre
Undisturbed Permeability	ASTM D5084	1/acre/lift	1/two acres
Density[1]	ASTM D2937 ASTM D2922 ASTM D1556	4/acre/lift	2/acre
Natural Moisture[1]	ASTM D2216 ASTM D3017 ASTM D1556	4/acre/lift (at density location)	2/acre
Liner thickness	Hand Auger or push tube	4/acre/lift	N/A

B The minimum testing frequencies for field tests to be performed by the Contractor's Quality Control personnel and the Owner's Quality Assurance personnel are identified in Sections 3.04. A. The intent of the field tests is to insure that the specified density and moisture contents are being obtained.

One-point compaction tests shall be performed to interpolate between laboratory compaction (ASTM D 698) curves for at least every 5 in-place density tests. The one-point compaction tests shall be performed on either the field density test sample or soil from a location immediately adjacent to the field density test sample, using the ASTM D 698 procedure. The results of the one-point tests shall then be compared with the full compaction curves of similar soils to estimate the maximum dry density applicable to the field density test sample.

Note[1]: A nuclear density test gauge can be used to provide the required density testing. However, the in-situ density shall be determined using the sand cone method (ASTM D 1556) and/or the drive cylinder method (ASTM D 2937) of a minimum of one test per ten nuclear density tests or one per day, whichever is greater. The sand cone and/or drive cylinder test should be performed at the same location as a nuclear density test. The sand cone and/or drive cylinder tests shall be continued until a correlation between the density and moisture contents obtained by the nuclear density gauge and the sand cone and/or drive cylinder tests has been demonstrated.

C All holes made as a result of depth measurements, permeability samples, density tests, grade stakes or other means shall be completely filled by the

Contractor and/or CQC Officer with dry powdered or chipped bentonite, as instructed by the CQA Officer and the RPR.

D The CQA Officer shall have the authority to request additional permeability tests in areas that, in the CQA Officer's judgment, may be suspect or deficient. Hydraulic conductivity tests shall be conducted in accordance with ASTM D5084 except as modified in Paragraph 3.01G. For each sample tested, one back-up sample will be extracted in the proximity of the sample location. This sample will be held in a controlled environment at the CQA/CQA laboratories as a precautionary measure. If adequate demonstration is presented that a sample was not representative of the compacted soil liner or that an error in testing occurred, the backup sample will be tested and the original test will be disregarded.

E If applicable, Grade stakes for liner construction shall be numbered by the Contractor and located on an inventory map. The inventory map shall be submitted to the CQA Officer. Upon completion of an area, the removed stakes will be compared to the inventory map to ensure that none were left in-place.

F The Contractor shall submit a survey plan with final elevation of top of compacted soil liner for CQA Officer's approval in accordance with Section 01050 prior to installing synthetic liner.

3.05 Corrective Action

A If soil has been desiccated to a depth less than or equal to the thickness of a single lift, the desiccated lift shall be disced, moistened, and re-compacted. However, discing may produce large, hard clods of soil that will require pulverization. Also, it should be recognized that if the soil is wetted, time must be allowed for water to be absorbed into the clods of soil and hydration to take place uniformly. For this reason it will be necessary to remove the desiccated soil from the construction area, to process the lift in a separate processing area, and to replace the soil accordingly.

B Any sample or area tested shall be rejected, removed and replaced if it does not meet the requirements of the technical specifications. Reconstructed areas shall have feathered, overlapping edges that tie into adjacent liner areas.

3.06 Reporting

A The Contractor’s CQC Officer shall provide a final Construction Quality Control Report at the end of the project. The report shall certify that the Work associated with Compacted Soil Liner was performed in accordance with the Contract Documents and shall be prepared and sealed by a Professional Engineer registered in the State of North Carolina. The report shall include a narrative describing construction methods and QC procedures employed,

summary tables of all field test results, including location and notations regarding any re-work performed, identification of failed tests, and documentation of re-worked areas with passing tests, as appropriate.

B Submittal of an administratively complete Construction Quality Control Report shall be required for the Work to be considered Substantially Complete.

END OF SECTION

SECTION 02277

GEOSYNTHETIC CLAY LINER (GCL)

PART 1: GENERAL

1.01 SCOPE OF WORK

A Furnish all labor, materials, equipment and incidentals required to install bentonite contained reinforced geosynthetic clay liner (GCL) as shown on the Drawings and as specified herein. Associated work includes sample collection, testing, loading, delivery, storage and handling and placement. All work shall be in accordance with the procedures provided herein and in the contract drawings.

1.02 RELATED WORK

A Section 02200 Excavation, Backfill and Compaction

B Section 02275 Compacted Soil Liner

C Section 02776 HDPE Liner

1.03 SUBMITTALS

A 45 days prior to the materials scheduled installation, submit the following information in accordance with Section 01340:

1. Identification of the GCL manufacturer.

2. Documentation that the GCL manufacturer and installer meet the requirements of Paragraph 2.01 of this Section.

2. A signed certification from the manufacturer stating that materials are first quality products designed and manufactured specifically for the purposes of this work and which has been satisfactorily demonstrated by prior use to be suitable and durable for such use.

3. A description of the installation procedures and a schedule to include GCL installation and a list of installation equipment.

4. A Quality Control Plan for the GCL manufactured product and installation.

5. Three samples of the GCL material to be used for laboratory testing.

1.04 REFERENCE STANDARDS

A American Society for Testing Materials (ASTM)

1. ASTM D5890 - Standard Test Method for Swell Index of Clay Mineral Component of Geosynthetic Clay Liners.

2. ASTM D5891 - Standard Test Method for Fluid Loss of Clay Component of Geosynthetic Clay Liners.

3. ASTM D5993 - Standard Test Method for Measuring Mass Per Unit of Geosynthetic Clay Liners.

4. ASTM D6768 - Standard Test Method for Tensile Strength of Geosynthetic Clay Liners.

5. ASTM D6496 - Standard Test Method for Determining Average Bonding Peel Strength between the Top and Bottom Layers of Needle-Punched Geosynthetic Clay Liners.

6. ASTM D5887 - Standard Test Method for Measurement of Index Flux through Saturated Geosynthetic Clay Liner Specimens Using a Flexible Wall Permeameter.

7. ASTM D6243 - Standard Test Method for Determining the Internal and Interface Shear Resistance of Geosynthetic Clay Liner by the Direct Shear Method

B GRI-GCL3 – test methods, required properties and testing frequencies of Geosynthetic Clay Liners (GCL's)

C Where reference is made to one of the above standards, the revision in effect at the time of bid opening will apply.

1.05 QUALITY ASSURANCE

A Quality control and quality assurance consists of laboratory conformance testing of samples supplied from the manufacturer and observation and quality control during installation.

B The CONTRACTOR will retain an independent geotechnical Quality Assurance Laboratory (QAL) who has specific permeability equipment to provide test results in a timely manner in accordance with the Specifications. The CONTRACTOR shall coordinate and schedule all tests as required by the Drawings and Specifications.

C Conformance testing requirements are specified in Paragraph 2.01. The purpose of conformance testing is to assure that the supplied material conforms to the

Specifications and specified permeability.

D Field quality control requirements are specified in Paragraph 3.04. The purpose of field quality control procedures is to assure that the GCL has been installed in accordance with the specifications and achieved the specified hydraulic conductivity.

1.06 QUALIFICATIONS

A Material shall be supplied and the work shall be performed by a firm that has experience in processing and installation of GCL.

B Manufacturer

1. The manufacturer of the GCL shall have a minimum of 3 years of continuous experience in the manufacture of similar GCL products.

2. The manufacturer must demonstrate, by submitting a list of previous projects, a minimum of 2 million square feet of manufacturing experience of similar GCL products.

3. The manufacturer shall submit a list of not less than 10 previous jobs. The list shall include the following for each project:

- Name of Project/Date Installed
- Brief Description of Project
- Quantity of GCL
- Owner's Name, Address, Contact and Phone
- CQA Officer's Name, Address, Contact and Phone
- Installer's Name, Address, Contact and Phone

C Installer

1. The installer must demonstrate previous GCL experience for projects totaling at least 1 million square feet. A project reference list and the same information as listed in Paragraph 1.06.B.3 shall be submitted.

1.07 DELIVERY, STORAGE AND HANDLING

A Delivery, Storage and Handling of GCL shall be the responsibility of the Contractor. A dedicated storage area shall be selected at the job site that is away from high traffic areas and is level, dry and well drained.

B The GCL shall be shipped, stored, and handled in accordance with the manufacturer's recommendations , but at a minimum shall be protected from UV exposure and elevated from the ground a minimum of three inches. All stored GCL

materials and the accessory bentonite must be covered with a plastic sheet or tarpaulin until their installation.

1.08 MATERIAL WARRANTY

A The GCL Manufacturer shall warrant the material against manufacturing defects for a period of at least five years from the date of installation. The manufacturer shall replace any material that fails from the above causes within the warranty period. The manufacturer shall furnish a written warranty covering the requirements of this paragraph.

1.09 GUARANTEE

A The Contractor shall guarantee the GCL against defects in installation and workmanship for a period of two years commencing with the date of Final Acceptance. The guarantee shall include the services of qualified service technicians and all materials required for the repairs at no expense to the Owner.

PART 2: PRODUCTS

2.01 GENERAL

A. The GCL shall consist of a layer of granular sodium bentonite clay needle punched between two geotextiles and shall comply with all of the criteria listed in this Section.

B. Bentonite shall be a high-swelling sodium bentonite, with a minimum swell index of 24 mL/2g and a maximum fluid loss of 18 mL. Bentonite shall be CG-50 granular bentonite, mined and processed by American Colloid Company.

C. Bentonite shall have a granular consistency (1 percent max. passing a No. 200 sieve [75 μm]), to ensure uniform distribution throughout the GCL and minimal edge loss during handling and installation.

D. Acceptable GCL products are Bentomat ST as manufactured by CETCO, Arlington Heights, IL, or approved equal.

E. Prior to using an alternate GCL, the Contractor must furnish independent test results demonstrating that the proposed alternate material meets all requirements of this specification. Contractor must also provide evidence of successful use of the proposed alternate material on past similar projects. This evidence can include past direct shear results against similar materials under similar site conditions, and/or past permeability/compatibility test results with a similar leachate or waste stream. The CQA Officer must approve any alternate GCL materials.

F. Reinforced GCL shall be used for the entire project.

G. No desiccation of GCL components from the bentonite core shall occur.

H. GCL panels shall be a minimum of 4 feet wide.

J. The GCL shall be rolled onto a substantial core, clearly labeled, and enclosed in a waterproof wrapper that is resistant to photo-degradation by ultraviolet (UV) light. Packaging must be adequate for safe transportation to the point of delivery.

D The label should include manufacturer, style, lot and/or roll number, weight, length and width.

K. The GCL shall comply with the following properties as listed in Table 1.

TABLE 1

MATERIAL PROPERTY	TEST METHOD	REQUIRED VALUES (1)
Bentonite Swell Index	ASTM D5890	24 mL/2g min.
Bentonite Fluid Loss	ASTM D5891	18 mL max.
Bentonite Mass/Area(2)	ASTM D5993	0.75 lb/sf min.
GCL Tensile Strength (3)	ASTM D6768	30 lbs/in. MARV
GCL Peel Strength	ASTM D6496	3.5 lbs/in min.
GCL Hydraulic Conductivity (4)	ASTM D5887	5×10^{-9} cm/sec max.
GCL Internal Hydrated Sheer Strength(5)	ASTM D5321	500psf

Notes:

(1) All values are minimum average roll values unless otherwise noted.
(2) Reported at 0-percent moisture content
(3) Performed in the machine direction
(4) De-aired, distilled tap water @ 80psi cell pressure, 77psi headwater pressure, 75 tailwater pressure
(5) Measured at 200psf normal stress; hydrated at 48-hours.

2.02 MANUFACTURERS QUALITY CONTROL DOCUMENTATION

A Prior to installation of any GCL, the Contractor shall provide to the CQA Officer, the following information certified by the manufacturer for the proposed GCL:

1. Each roll delivered to the Project site shall have the following identification information:

a. Manufacturer's name
b. Product information
c. Roll dimensions
d. Lot and roll number

2. Quality control certificates, signed by the manufacturer's quality assurance manager. Each certificate shall have roll identification number, sampling procedures, testing frequency and test results. At minimum, the following test results shall be provided in accordance with the requirements specified in Section 2.01.

a. Bentonite free swell and fluid loss (1 test every 50 tonnes, which corresponds to about 1 test every 130,000 square feet)
b. Bentonite Fluid Loss (1 test every 50 tonnes)
c. Bentonite mass/area (1 test every 40,000 square feet)
d. GCL tensile strength (1 test every 200,000 square feet)
e. GCL peel strength (1 test every 40,000 square feet)
f. GCL permeability (1 test per lot)
g. GCL hydrated internal shear strength (per manufacturer’s standard test frequency)

2.03 CONFORMANCE TESTING

A Conformance testing shall be performed by an approved Independent Quality Assurance Laboratory (QAL) approved by the Owner and CQA Officer. The Laboratory (prior to shipping) or RPR (upon delivery) shall obtain samples from the proposed material, mark the machine direction, lot number and roll identification number. One sample shall be taken per 100,000 square feet, or one sample per lot, whichever results in the greater number of conformance tests. A Lot number will be defined as a continuous production process without changes to raw material or manufacturing methods. This sampling frequency may be increased as deemed necessary by the CQA Officer. The Contractor shall pay for the initial test for every change in Lot number. The samples shall be taken across the entire roll width and shall not include the first three feet. The following conformance tests shall be conducted on the GCL samples at the QAL.

1. Bentonite mass per unit area (ASTM D5993)
2. Bentonite Swell Index (ASTM D5890)
3. GCL Grab Strength (ASTM D6768)
4. GCL Peel Strength (ASTM D6496)

B All conformance test results shall be reviewed by the CQA Officer and accepted, prior to the deployment of the GCL. All test results shall meet, or exceed, the property values listed in Section 2.01. The course of action implemented for retesting a failed test shall be approved by the CQA OFFICER.

PART 3: EXECUTION

3.01 SUBGRADE PREPARATION

A Preparation of the subgrade shall be as specified Sections 02275.

B The CONTRACTOR and the CQA Officer or RPR shall inspect and approve the subgrade before installation of the GCL can proceed. The CONTRACTOR is responsible for properly preparing and maintaining the subgrade free of water, rocks and debris and in a smooth, clean, uniform, and compacted condition during installation of the GCL.

3.02 GCL PLACEMENT

A Panel Placement

1. At minimum, the Manufacturer's recommended installation procedures shall be followed.

2. GCL rolls shall be brought to the area to be lined in their original packaging. Only immediately prior to deployment, the packaging should be carefully removed. Unless otherwise specified, the GCL shall be installed such that the side of the GCL with the lamination on it faces up.

3. Rolls shall be handled utilizing a solid steel bar inserted through the core and slings or chains attached to the ends of a spreader bar. The core bare shall be suspended from the spreader bar so that the edges of the liner are not damaged by the suspending straps or chains.

4. Dragging of the GCL panels over the surface shall be minimized. A slip or rub sheet shall be used to minimize friction during placement. In addition, during installation of the HDPE liner over the GCL, a slip or rub sheet shall also be used to allow the HDPE liner to move more freely into place.

5. The GCL will be placed over the prepared surface in such a manner as to assure minimum handling.

6. The GCL panels shall be placed parallel to the direction of the slope.

7. All GCL panels should lie flat on the underlying surface, with no wrinkles or fold, especially at the exposed edges of the panels.

8. The GCL shall not be wet prior to installation or installed in standing water or during rain. The GCL must be dry when installed, dry when covered and not get wet while exposed. Only as much GCL shall be deployed as can be

covered at the end of the working day with soil or a temporary waterproof tarpaulin. The GCL shall not be left uncovered overnight. If the GCL is hydrated when no confining stress is present, it may be necessary to remove and replace the hydrated material.

9. The GCL seams are constructed by overlapping their adjacent edges. Care should be taken to ensure that the overlap zone is not contaminated with loose soil or other debris. Bentonite-enhanced seams are required.

10. The minimum dimension of the longitudinal overlap should be 6 inches. End-of-roll overlapped seams should be similarly constructed, but the minimum overlap should measure 24 inches.

11. Seams at the ends of the panels should be constructed such that they are shingled in the direction of the grade to prevent the potential for runoff flow to enter the overlap zone.

12. Bentonite-enhanced seams are constructed between the overlapping adjacent panels described above. The underlying edge of the longitudinal overlap is exposed and then a continuous bead of granular sodium bentonite is applied along a zone defined by the edge of the underlying panel and the 6-inch line. A similar bead of granular sodium bentonite is applied at the end-of-roll overlap.

13. The granular bentonite shall be applied at a minimum application rate of one quarter pound per lineal foot (0.4 kg/m). The granular bentonite sealing clay used for overlap seaming, penetration sealing and repairs shall be made from the same natural sodium bentonite as used in the GCL and shall be as recommended by the GCL manufacturer. Seaming of GCLs shall be conducted in accordance with the manufacturer's specifications for each particular GCL.

14. Only as much GCL shall be deployed as can be covered at the end of the working day with a geomembrane, or a temporary waterproof tarpaulin. The GCL shall not be left uncovered overnight.

B Cover Placement

1. Cover soils shall be free of angular stones or other foreign matter that could damage the Geomembrane and underlying GCL.

2. Cyclical wetting and drying of GCL covered with geomembrane can cause overlap separation. Soil cover should be placed promptly to avoid this problem. Geomembranes should be covered with a white geotextile and/or operations layer without delay to prevent the geomembrane from absorbing heat and desiccating the bentonite in the GCL. If the GCL is covered only

with a geomembrane for an extended period, the overlapping of the longitudinal seams needs to be increased to 12”.

3.04 FIELD QUALITY CONTROL

A Construction Inspection Procedures

1. The field quality control (QC) documentation shall be reviewed by the CQA Officer to ensure the finished GCL meets or exceeds all of the criteria listed in Table 1 with the testing frequency listed.

2. All delivered GCL rolls shall be visually inspected and approved by the CQA Officer prior to installation. Defects or damage from shipping and handling shall be grounds for rejection at the discretion of the CQA Officer.

3. Each day, the Contractor's and/or installer's superintendent and the CQA Officer should inspect and provide written certification that the subgrade for the GCL has been prepared in accordance with the specifications.

4. As each GCL panel is being deployed, the Contractor and/or installer's superintendent and CQA Representative shall provide inspection of the installation. This shall include:

    a. Inspection of overlap

    b. Visual inspection of geotextile quality, bentonite uniformity, and the degree of hydration, if any, on the GCL; marking of any areas as appropriate for repair.

    c. If the GCL is damaged (torn, punctured, perforated, etc.) during installation, it may be possible to repair it by cutting a patch to fit over the damaged area. The patch shall be obtained from a new GCL roll and shall be cut to size such that a minimum overlap of 12 inches is achieved around all of the damaged area. Granular bentonite or bentonite mastic should be applied around the damaged area prior to placement of the patch. An adhesive shall be used to affix the patch in place so that it is not displaced during cover placement

END OF SECTION

SECTION 02290

PROTECTIVE COVER – LANDFILL CLOSURE

PART 1: GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required to install the Protective Cover of minimum thickness as shown on the Drawings and as specified herein. Associated work includes quality control testing, borrow source excavation, hauling, installation, compaction, and grading of Protective Cover Layer.

1.02 RELATED WORK

A. Section 01050: Field Engineering

B. Section 01340: Shop Drawings, Product Data, Working Drawings, Samples

C. Section 01410: Construction Quality Assurance and Quality Control

D. Section 02200: Excavation, Backfill, and Compaction

E. Section 02274: Geocomposite Drainage Net

F. Section 02985: Stabilization

1.03 SUBMITTALS

A. Identification of the proposed protective cover soil source. A signed certification letter, with copies of all necessary permits, stating that the source is in full compliance with State, County, and local laws and regulations.

B. The CONTRACTOR shall furnish representative samples of proposed Protective Cover soils, each weighing approximately 75 pounds to the CQA OFFICER for approval at least 14 calendar days prior to the date of anticipated use of such material.

C. A description and schedule of the installation procedure and a list of installation equipment.

1.04 REFERENCE STANDARDS

A. ASTM - American Society for Testing and Materials:

1. ASTM D422 - Standard Test Method for Particle-Size Analysis of Soils.

2. ASTM D698 - Standard Test Method for Moisture-Density Relations of Soil and Soil Aggregate Mixtures Using 5.5-lb (2.49 kg) Hammer and 12-in (305 mm) Drop.

3. ASTM D854 - Standard Test Method for Specific Gravity of Soils.

4. ASTM D1140 - Standard Test Method for Amount of Material in Soils Finer than the Number 200 (75 micrometer) Sieve.

5. ASTM D1556 - Standard Test Methods for Density and Unit Weight of Soil In-Place by Sand-Cone Method.

6. ASTM D2216 - Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock.

7. ASTM D2487 - Standard Test Method for Classification of Soils for Engineering Purposes.

8. ASTM D2488 - Standard Practice for Description and Identification of Soils (Visual-Manual Procedures).

9. ASTM D2922 - Density of Soil in Place by Nuclear Methods (Shallow Depth).

10. ASTM D3017 - Standard Test Method for Water Content of Soil in Place by Nuclear Methods (Shallow Depth).

11. ASTM D4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

12. ASTM D5268 - Standard Specifications for Topsoil Used for Landscaping Purposes

13. ASTM D2974 - Standard Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils

B. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE AND QUALITY CONTROL

A. The quality control consists of laboratory conformance testing of samples supplied from each soil source and quality control and quality assurance sampling and testing of the placed protective cover.

B. Conformance testing requirements are specified in Paragraph 1.07

1.06 PROTECTION

A. The CONTRACTOR is solely responsible for protection of the work. Completed work that is damaged by weather or other means shall be repaired by the CONTRACTOR at no additional cost to the OWNER.

1.07 SOIL TESTING

A. Prior to the placement of the Protective Cover and during such placement, the CQA OFFICER shall select areas within the limits of the work for testing. The CONTRACTOR shall cooperate fully in obtaining the information desired.

B. The CONTRACTOR'S CQC OFFICER shall perform the following laboratory soil testing in accordance with the standards listed in paragraph 1.04.

1. Perform particle size distribution test (ASTM D422) and Atterberg limits (ASTM D4318) for every 10,000 cubic yards (or change in material) of Protective Cover soil used. Organic Content (loss on ignition, ASTM D2974) tests shall be performed for every 4,000 cubic yards of soil to be used in the top 6 inches.

2. Perform Standard Proctor compaction test (5 point curve, ASTM D 698), Internal Effective Friction (ASTM D4767) and Hydraulic Conductivity (ASTM D5084) for each soil type proposed for use as Protective Cover soils and for every 40,000 cubic yards (or change in material) of Protective Cover soil used.

C. Protective Cover Soil Analysis: CONTRACTOR shall furnish a soil analysis made by a qualified independent soil-testing agency stating percentages of organic matter, inorganic matter (silt, clay, and sand), deleterious material, pH, and mineral and plant-nutrient content of topsoil. Report suitability of Protective Cover for lawn growth, recommended quantities of nitrogen, phosphorus, and potash nutrients and any limestone, aluminum sulfate, or other soil amendments to be added to produce a satisfactory growth layer.

1.08 DELIVERY, STORAGE AND HANDLING

A. Stockpiled materials shall be located at designated areas within the limits of construction. At the end of each day, the material shall be sloped, tracked and secured to minimize erosional impact on the stockpile. Removal of stockpile material shall be done in a manner to minimize intrusion of soils adjacent to and beneath the stockpile.

PART 2: PRODUCTS

2.01 MATERIALS

A. Materials for use as Protective Cover soils shall be as described below. The CONTRACTOR shall notify the ENGINEER of the source of each material. **Materials shall be furnished as required from approved off-site sources and hauled to the site.**

B. The soil used to construct the Protective Cover shall be capable of maintaining vegetation and conform to the following criteria.

1. The soil shall have 100% passing the 3-inch sieve.
2. Soil shall be classified according to the USCS as SC, SM, ML, ML-CL, or CL.
3. The organic content shall be at least 4% (upper 6" only).
4. pH range of 5.5 to 7
5. Free of extraneous materials harmful to plant growth
6. Internal Friction Angles no less than 23.5° or as approved by the ENGINEER as determined by ASTM D4767 (unconsolidated undrained, 3 point series, remolded)
7. Maximum Permeability of 1.0×10^{-4} cm/s (re-compacted to 93% of the material's maximum dry density and optimum moisture content)

2.02 SOIL AMENDMENTS

A. Lime: ASTM C 602, Class T, agricultural limestone containing a minimum 80 percent calcium carbonate equivalent, with a minimum 99 percent passing a No. 8 (2.36 mm) sieve and a minimum 75 percent passing a No. 60 (250 micrometer) sieve.

1. Provide lime in the form of dolomitic limestone.

B. Aluminum Sulfate: Commercial grade, unadulterated.

C. Sand: Clean, washed, natural or manufactured sand, free of toxic materials.

D. Perlite: Horticultural perlite, soil amendment grade.

E. Peat Humus: Finely divided or granular texture, with a pH range of 6 to 7.5, composed of partially decomposed moss peat (other than sphagnum), peat humus, or reed-sedge peat.

F. Sawdust or Ground-Bark Humus: Decomposed, nitrogen-treated, of uniform texture, free of chips, stones, sticks, soil, or toxic materials.

1. When site treated, mix with at least 0.15 lb of ammonium nitrate or 0.25 lb of ammonium sulfate per cu. ft. of loose sawdust or ground bark.

G. Manure: Well-rotted, unleached stable or cattle manure containing not more than 25 percent by volume of straw, sawdust, or other bedding materials; free of toxic substances, stones, sticks, soil, weed seed, and material harmful to plant growth.

H. Herbicides: EPA registered and approved, of type recommended by manufacturer.

I. Water shall be obtained and used from an ENGINEER approved source only

PART 3: EXECUTION

3.01 PROTECTIVE COVER PLACEMENT

A. Placement of the Protective Cover Layer shall not initiate until the underlying liner and geocomposite drainage net is accepted by the CQA Officer and all required surveying and testing is completed by the CONTRACTOR and/or CQA Officer and accepted by the CQA Officer.

B. During the placement of the Protective Cover soil material, no construction equipment shall be allowed directly on the liner or GDN. Any damage to these components shall be repaired immediately in accordance with the specifications and under the observation of the CQA Officer. A 4-foot-thick traffic surface shall be constructed over the liner to support haul trucks and other non-low ground pressure equipment. A minimum 1.5-foot-thick layer of Protective Cover material shall be maintained for low ground pressure equipment. No equipment will be allowed on Protective Cover Layer that is less than 1.5 feet thick. Soil for the Protective Cover Layer shall be compacted to at least 93% of its maximum dry density as determined by ASTM D698. Subsequent lifts of protective cover material shall not exceed 10-inches loose measure

C. Care shall be taken to protect the liner. Sand ramps shall be provided on slope locations used for entry and exit and in other heavily traveled areas. Only large radius turns by equipment shall be permitted as sharp turns may damage the liner.

D. Only low-ground-pressure equipment (6 psi maximum contact pressure) shall be used for spreading and grading of the Protective Cover.

E. Protective Cover soil shall be placed on the side slopes starting at the toe of the slope and working toward the top of the slope.

F. Protective Cover material can only be spread when the liner is taut or stretched evenly over the landfill soil cover. The Protective Cover soil material shall not be spread when the liner is elongated due to higher daytime temperatures and exposure to sun. The CONTRACTOR must make provisions to cover the liner under non-elongated conditions.

G. The surfaces of filled areas shall be graded to smooth true lines, strictly conforming to grades indicated on the grading plan and no soft spots or uncompacted areas will be allowed in the work.

H. No compacting shall be done when the material is too wet either from precipitation, surface water runoff, or from excess application of water. At such times, work shall be suspended until the previously placed and new materials have dried sufficiently to permit proper compaction.

I. Water for Compaction

1. The CONTRACTOR shall utilize water as required to guarantee constructability and protection of the in-place and stored soil.

2. The water shall be of suitable quality from an approved source

J. During construction, the CONTRACTOR shall make all necessary provisions to deal with inclement weather conditions. The CONTRACTOR shall be fully responsible for control of stormwater during installation of the Protective Cover.

K. No material shall be placed, spread, or compacted while the ground or the soil material is frozen/thawing, saturated, desiccated, during unfavorable weather conditions or periods of precipitation. The Protective Cover surfaces must be made smooth and free from ruts or indentations at the end of any working day when significant precipitation is forecast and/or at the completion of the compaction operations in that area in order to prevent saturation of the material. Any regrading due to the above conditions or final preparation shall require retesting at those locations for thickness and density and shall be at the cost of the CONTRACTOR.

L. Prior to seeding and mulching the CONTRACTOR shall scarify the finished surface of the Protective Cover to a depth of 3 inches. The surface shall be mechanically or hand raked to remove any loose roots or rocks.

3.02 FIELD QUALITY CONTROL AND QUALITY ASSURANCE

A. CQA Plan: Inspection/testing will be a joint effort between the CONTRACTOR's CQC Firm and the OWNER's CQA Firm.

B. Coordination: CONTRACTOR shall be responsible for coordination of field services with the CONTRACTOR's CQC' Firm and with the OWNER's CQA Firm.

C. Initial Observation: Protective Cover layer placement operations shall be performed after the surface has been properly prepared and has been observed and approved by CQA OFFICER. No protective cover layer materials shall be placed unless the CQA OFFICER approves the operation. Any fills placed without CQA OFFICER's observation and prior approval shall be removed in a manner to avoid damage or disturbance to the existing approved work, and the excavation shall be filled as specified herein, at no additional cost to OWNER.

D. Field Control: The minimum testing frequencies for field tests to be performed are provided in the following table.

TEST METHOD	METHOD	FREQUECY	
		CQC	CQA
Density[1]	ASTM D2937 ASTM D2922 ASTM D1556	2/acre/lift	*discretionary*
Moisture Content[1]	ASTM D2216 ASTM D3017 ASTM D1556	2/acre/lift *At density test location*	*discretionary*

Note[1]: A nuclear density test gauge can be used to provide the required density testing. However, the in-situ density shall be determined using the sand cone method (ASTM D 1556) and/or the drive cylinder method (ASTM D 2937) of a minimum of one test per ten nuclear density tests or one per day, whichever is greater. The sand cone and/or drive cylinder test should be performed at the same location as a nuclear density test. The sand cone and/or drive cylinder tests shall be continued until a correlation between the density and moisture contents obtained by the nuclear density gauge and the sand cone and/or drive cylinder tests has been demonstrated.

E. One-point compaction tests shall be performed to interpolate between laboratory compaction (ASTM D 698) curves for at least every 5 in-place density tests. The one-point compaction tests shall be performed on either the field density test sample or soil from a location immediately adjacent to the field density test sample, using the ASTM D 698 procedure. The results of the one-point tests shall then be compared with the full compaction curves of similar soils to estimate the maximum dry density applicable to the field density test sample.

F. The CONTRACTOR'S CQC Officer shall provide a final Construction Quality Control Report at the end of the project. The report shall certify that the Work, as associated with Protective Cover was performed in accordance with the Contract Documents and shall be prepared and sealed by a Professional Engineer registered in the State of North Carolina. The report shall include a narrative describing construction methods and QC procedures employed, summary tables of all field test results, including location and notations regarding any re-work performed, identification of failed tests, and discussions and documentation of re-worked areas with passing tests, as appropriate.

G. The CONTRACTOR shall submit a survey plan with final elevation of top of Protective Cover Layer for CQA Officer's approval in accordance with Section 01050.

H. Submittal and acceptance of an administratively complete Construction Quality Control Report shall be required for the Work to be considered Substantially Complete.

3.03 DISPOSAL OF SURPLUS MATERIAL

A. No excavated materials shall be removed from the site of the work or disposed of by the CONTRACTOR except as specified by the CQA Officer. Materials shall be neatly piled on-site at locations directed by the ENGINEER so as not to inconvenience the public and adjoining property owners until used or otherwise disposed of as specified below.

B. Surplus Protective Cover soil shall become the property of the OWNER and be stockpiled as directed by the ENGINEER.

3.04 GRADING

A. Grading shall be performed at all places that are indicated on the Drawings, to the lines, grades and elevations shown and otherwise as directed by the ENGINEER. During the process of grading, the subgrade shall be maintained in such condition that it will be well drained at all times. When directed, temporary drains and drainage ditches shall be installed to intercept or divert surface water which may affect the performance or condition of the work.

B. If at the time of grading it is not possible to place material in its final location, it shall be stockpiled for later use in areas approved by the ENGINEER. Stockpiled material shall be smooth rolled at the end of each day to promote runoff of stormwater. No extra payment will be made for the stockpiling or double handling of excavated material.

C. The ENGINEER reserves the right to make minor adjustments or revisions in lines or grades if found necessary as the work progresses, in order to obtain satisfactory construction.

END OF SECTION

SECTION 02623

HIGH DENSITY POLYETHYLENE (HDPE) PIPE

PART 1: GENERAL

1.01 SCOPE OF WORK

A Furnish all labor, materials, equipment and incidentals required and install high density polyethylene leachate pipe, fittings and appurtenances as shown on the Drawings and as specified herein.

1.02 RELATED WORK

A Section 02776: High Density Polyethylene (HDPE) Liner

B Section 02700: Protective Cover

C Section 02271: Fabric Cushion

D Section 02200: Excavation, Backfill, and Compaction

1.03 SUBMITTALS

A Within 30 days following the Effective Date of the Agreement, submit the following information in accordance with Section 01340:

1. List of materials to be furnished, the names of the suppliers and the scheduled date of delivery of materials to the site.

2. The origin of the resin to be used in the manufacturing of the pipe including the suppliers name and production plant, as well as brand name and number.

3. Documentation from the resin's manufacturer showing results of tests for resin identification, including:

   a. Melt Flow Index ASTM D1238

   b. Density ASTM D1505

4. Manufacturer quality control manual describing implementation of quality control procedures during pipe manufacturing process.

5. Pipe Manufacturer's Certification of compliance with these Specifications.

6. Complete, detailed shop drawings of all polyethylene pipe and appurtenances, including the location of all fittings, joints and connections to structures.

7. Manufacturer's recommendations for handling, storing and installing pipe and fittings.

8. For each shipment of pipe a manufacturer's certification that the pipe was manufactured from the same resin identified in Paragraph 1.03.A1.

9. Certification demonstrating that the joining technician was trained by the pipe manufacturer and is qualified to perform heat fusion welding.

1.04 REFERENCE STANDARDS

A American Society for Testing and Materials (ASTM)

1. ASTM D1238 - Standard Test Method for Flow Rates Thermoplastics by Extrusion Plastometer.

2. ASTM D1248 - Standard Specification for Polyethylene Plastic Molding and Extrusion Materials.

3. ASTM D1505 - Standard Test Method for Density of Plastic by the Density Gradient Technique.

4. ASTM D2837 - Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials.

5. ASTM D3350 - Specification for Polyethylene Plastic Pipe and Fitting Materials.

6. ASTM F714 - Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter.

B Where reference is made to one of the above standards, the revision in effect at the time of construction shall apply.

1.05 QUALITY ASSURANCE

A Resin Evaluation

1. All incoming resin shall be sampled for conformance testing against test results supplied by the resin manufacturer. Samples shall be taken from the top and bottom of each compartment from every hopper car received. The following conformance tests shall be performed on the sample:

a.	Melt Flow Index	ASTM D1238
b.	Density	ASTM D1505

The results of these tests shall become part of the manufacturer's permanent quality control records.

B Finished Product Evaluation

1. Each length of pipe produced shall be checked by production staff for the items listed below. The results of all measurements shall be recorded on production sheets which become part of the manufacturer's permanent records.

   a. Pipe in process shall be checked visually, inside and out for cosmetic defects (grooves, pits, hollows, etc).

   b. Pipe outside diameter shall be measured using a suitable periphery tape to ensure conformance with ASTM F714.

   c. Pipe wall thickness shall be measured at 12 equally spaced locations around the circumference at both ends of the pipe to ensure conformance with ASTM F714.

   d. Pipe length shall be measured.

   e. Pipe marking shall be examined and checked for accuracy.

   f. Pipe ends shall be checked to ensure they are cut square and clean.

   g. Subject inside surface to a "reverse bend test" to ensure the pipe is free of oxidation (brittleness).

C Stress Regression Testing

1. The polyethylene pipe manufacturer shall provide certification that stress regression testing has been performed on the specific polyethylene resin being utilized in the manufacture of this product. This stress regression testing shall have been done in accordance with ASTM D2837 and the manufacturer shall provide a product supplying a minimum Hydrostatic Design Basis (HDB) of 1,600 psi as determined in accordance with ASTM D2837.

1.06 WARRANTY

A The pipe material manufacturer shall provide an unconditional extended warranty for the pipe covering the cost of materials for repair or replacement plus installation manpower should the pipe fail within the warranty period. The manufacturer's extended warranty shall be for ten years after the final acceptance of the project by the OWNER. The manufacturer shall guarantee that the pipe furnished is suitable for the purpose intended and free from

defects of material and workmanship for the duration of the extended warranty. In the event the pipe fails to perform as specified, the pipe manufacturer shall promptly replace defective pipe without any cost to the OWNER.

PART 2: PRODUCT

2.01 HIGH DENSITY POLYETHYLENE (HDPE) PIPE

A The pipe supplied shall be high density, high molecular weight, polyethylene (HDPE) pipe. The pipe shall conform to ASTM D3350 with a minimum cell classification value of 345434C.

B All fittings shall be made from polyethylene resin which meets this same specification as in 2.01A.

C HDPE pipe shall be of size and Standard Dimension Ratio (SDR) as identified on the Drawings

D All polyethylene pipes shall meet the requirements of ASTM F714.

E Pipe shall be furnished in standard laying lengths not exceeding 50 feet.

2.02 PIPE IDENTIFICATION

A The following shall be continuously printed on the pipe or spaced at intervals not exceeding 5-ft:

1. Name and/or trademark of the pipe manufacturer.
2. Nominal pipe size.
3. Dimension ratio.
4. The letters PE followed by the polyethylene grade in accordance with ASTM D1248, followed by the hydrostatic design basis in 100's of psi, e.g., PE 3408, PE 4710.
5. Manufacturing standard reference, e.g., ASTM F714.
6. A production code from which the date and place of manufacture can be determined.

2.03 PERFORATIONS

A PERFORATED PIPE: locations for perforated pipe, perforation sizes and hole patterns are detailed in the Contract Drawings.

B For accuracy and uniformity, the pipe shall be drilled to design specifications by machines designed for perforating pipe.

PART 3: EXECUTION

3.01 INSTALLATION

A High Density Polyethylene (HDPE) Pipe shall be installed in accordance with the instruction of the manufacturer, as shown on the Drawings and as specified herein. All heat fusion joints shall be done by a qualified joining technician as designated by the pipe manufacturer.

B Pipe shall be laid to lines and grade shown on the Drawings with bedding and backfill as shown on the Drawings.

C PERFORATED PIPE: Tape covering perforations shall be removed during installation. The pipe shall be installed such that perforations face the bottom of trench. The perforations of pipe sections shall be aligned when connected. The pipe shall be joined by butt fusion or by a method of coupling as approved by the ENGINEER.

D When installation is not in progress, including breaks in work, the open ends of the pipe shall be closed by fabricated plugs, or by other approved means.

E HANDLING OF PIPE: Pipe shall be stored on clean level ground to prevent undue scratching or gouging. The handling of the pipe shall be in such a manner that the pipe is not damaged by dragging it over sharp or rough objects and/or areas. The maximum allowable depth of cuts, scratches or gouges on the exterior of the pipe is 10 percent of wall thickness. The interior pipe surface shall be free of cuts, gouges or scratches.

F REPAIR OF PIPE: Sections of pipe with cuts, scratches or gouges deeper than allowed shall be removed completely and the undamaged sections of the pipe re-joined.

G JOINING: The pipe shall be joined by the method of thermal butt fusion, as outlined in ASTM D2657. All joints shall be made in strict compliance with the manufacturer's recommendations. In locations where butt fusion cannot be achieved (ex. tie-in to bootless pipe penetration), a thermal coupling such as electro-fusion connections may be used as approved by the ENGINEER. Hot air welding is not permitted.

H MECHANICAL CONNECTIONS: Flange adaptors shall be used to connect pipe to auxiliary equipment such as valves, pumps and tanks, and shall consist of the following:

1. A stainless steel back-up, polyethylene flange shall be thermally butt-fused to the stub end of the pipe.

2. A 316 stainless steel back up ring on both sides of the connection shall be used as approved by the ENGINEER.

3. Flange connections shall be provided with a full face neoprene gasket.

I Fused segments of the pipe shall be handled so as to avoid damage to the pipe. Chains or cable type chokers must be avoided when lifting fused sections of pipe. Nylon slings are preferred. Spreader bars are recommended when lifting long fused sections.

J BACKFILLING: All HDPE pipe must be at the temperature of the surrounding soil at the time of backfilling and compaction. Marking tape shall be installed in the backfill of all piping installed outside the lined areas, i.e. force main.

K Installation of pipe shall be observed and accepted by the CQA Officer prior to backfilling.

3.02 TESTING

A All non-perforated pipe shall be field tested (with the exception of non-perforated cleanouts). The CONTRACTOR shall supply all labor, equipment, material, gages, pumps, meters and incidentals required for testing.

B All non-perforated pipe shall be tested at a pressure of 130 psi. The test pressure shall be measured at the highest point along the test section by a recording type pressure gage and a copy of the readout shall be submitted to the ENGINEER upon completion of the test. All testing shall be conducted in the presence of the ENGINEER or the RPR.

C Testing shall be conducted after backfilling has been completed and before placement of permanent surface.

D Testing procedure shall be as follows:

1. Fill line slowly with water; maintain flow velocity less than two feet per second.

2. Expel air completely from the line during filling and again before applying test pressure.

3. Apply initial test pressure and allow to stand without makeup pressure for three hours, to allow for diametric expansion or pipe stretching to stabilize.

4. After this equilibrium period, apply the specified test pressure and turn the pump off. The final test pressure shall be held for three hours.

5. Upon completion of the test, the pressure shall be bled off from a location other than the point where the pressure is monitored. The pressure drop shall be witnessed by the RPR. The point where the

pressure is being monitored shall show on the recorded pressure read-out submitted to the ENGINEER.

E Allowable amount of makeup water for expansion during the pressure test shall conform to Table 5, Allowance for Expansion Under Test Pressure, Technical Report TR 31/88, published by the Plastic Pipe Institute (PPI). If there are no visual leaks or significant pressure drops during the final test period, the installed pipe passes the test.

F If any test of pipe laid disclosed leakage or significant pressure drop greater than that allowed, the CONTRACTOR shall, at his/her own expense, locate and repair the cause of leakage and retest the line.

G All visible leaks are to be repaired by an approved method, regardless of the amount of leakage.

3.03 CLEANING

A At the conclusion of the work, thoroughly clean all of the new pipelines to remove all dirt, stones, and pieces of wood or other material that may have entered during the construction period. Debris cleaned from the lines shall be removed from the job site. If, after this cleaning, any obstructions remain, they shall be removed.

B Special attention shall be given to clean free and remove HDPE shavings and particles resultant of fusion welding activities. Any area where these activities occurred shall be inspected by the CQA Representative and Contractor prior to acceptance of the Work; this includes sump areas, header line areas and low points of drainage.

END OF SECTION

SECTION 02700

PROTECTIVE COVER – DRAINAGE LAYER

PART 1: GENERAL

1.01 SCOPE OF WORK

A Furnish all labor, materials, equipment and incidentals required to furnish and install the protective cover soil materials associated with the leachate collection system and protective cover layer over the textured HDPE base liner as shown on the Drawings and as specified herein. Associated work includes sample collection and testing, excavation, loading, hauling, and installation of granular fill materials and quality control.

B The protective cover layer consists of 24-inches of material placed over a geocomposite drainage net (filter fabric bonded to both sides of drainage net). Leachate collection pipes surrounded by NCDOT No. 57 stone, No. 789 stone and C-33 sand will be constructed in the protective cover layer. The locations of leachate collection pipes and details showing the protective cover layer are indicated on the Contract Drawings. The protective cover soil, granular materials and sand are specified in this Section. The leachate collection pipes, fabric cushion, and composite drainage net are specified in the Sections listed in paragraph 1.02.

1.02 RELATED WORK

A Section 02200: Excavation, Backfill, and Compaction

B Section 02271: Fabric Cushion

C Section 02274: Geocomposite Drainage Net

D Section 02623: High Density Polyethylene Pipe

E Section 02776: Textured High Density Polyethylene (HDPE) Liner

1.03 SUBMITTALS

A Within 30 calendar days following the Effective Date of the Agreement and before installing the protective cover materials, the CONTRACTOR shall submit the following information in accordance with Section 01340:

1. Identification of the suppliers for each protective cover soil material.

2. A signed certification letter, with all necessary permits, that the material source or sources, is in full compliance with State, County, and local laws and regulations.

3. A schedule and description of the procedures and equipment for installation of the protective cover layer and leachate collection system.

4. A Quality Control Plan for the protective cover layer and leachate collection system installation.

5. Documentation and related past experience in accordance with Paragraph 1.06.

6. One 75-pound sample for laboratory testing from each soil material to be used for the protective cover layer and leachate collection system.

7. A substantially complete record drawing of the installed HDPE liner approved by the ENGINEER.

B Within two weeks after completion of the protective cover layer and leachate collection system installation, the CONTRACTOR shall submit to the ENGINEER a survey plan certified by a Land Surveyor Registered in the State of South Carolina showing the elevations of the top of the protective cover layer.

1.04 REFERENCE STANDARDS

A American Society for Testing and Materials (ASTM)

1. ASTM C33 - Standard for Fine Concrete Aggregate.

2. ASTM D422 - Standard Test Method for Particle-Size Analysis of Soils.

3. ASTM D698 - Standard Test Methods for Moisture-Density Relationship of Soil and Soil-Aggregate Mixtures Using 5.5-lb (2.49 kg) Hammer and 12-in (305 mm) Drop.

4. ASTM D854 - Standard Test Method for Specific Gravity of Soils.

5. ASTM D2992 - Density of soil in place by nuclear methods (Shallow Depth).

6. ASTM D3017 - Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).

7. ASTM D4254 - Standard Test Methods for Minimum Index Density of Soils and Calculation of Relative Density.

8. ASTM C40 - Standard Test Method for Organic Impurities in Fine Aggregates for Concrete.

9. ASTM C136 - Standard Method for Sieve Analysis of Fine and Coarse Aggregates.

10. ASTM C289 - Standard Test Method for Potential Reactivity of Aggregates (Chemical Method).

11. ASTM D75 - Standard Practice for Sampling Aggregates.

12. ASTM D3042 - Standard Test Method for Insoluble Residue in Carbonate Aggregate.

13. ASTM D4373 - Standard Test Method for Calcium Carbonate Content of Soils.

14. ASTM 2434 - Permeability of granular soils by constant head tests.

B Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE / QUALITY CONTROL

A The Quality Control and Quality Assurance consists of laboratory conformance testing of samples supplied from each soil material and quality control testing during installation.

B The CONTRACTOR will retain a CQC Officer and a Quality Control Laboratory (QCL) that has appropriate equipment and experience to conduct and provide the test results in a timely manner in accordance with the Specifications. The CONTRACTOR shall coordinate and schedule all tests as required.

C Conformance testing requirements are specified in Paragraph 2.02. The purpose of conformance testing is to assure that the supplied samples from each source conform to the Specifications.

D Field quality control requirements are specified in Paragraph 3.02. The purpose of field quality control procedures is to assure that the protective cover and leachate collection system have been installed in accordance with the specifications meeting the specified hydraulic conductivity.

1.06 QUALIFICATIONS

A The work shall be performed by a contractor with whom is and provides project management and field management that has experience in installation of leachate collection systems and protective cover soil materials over geosynthetic liners. The CONTRACTOR shall demonstrate proven experience by providing a minimum of one similar completed project with the following information:

1. Types and thicknesses of installed materials.

2. Name and purpose of facility, its location, and date of installation.

3. Name of owner and design engineer. Name and telephone number of contact at the facility that can discuss the project.

B The CONTRACTOR demonstrate that material suppliers or sources will provide adequate supplies of each soil material to be provided within the schedule of construction and evidence that each source area can provide homogenous material and is properly permitted by the appropriate local, State and Federal agencies.

1.07 DELIVERY, STORAGE AND HANDLING

A If materials are delivered to the site prior to placement approval, materials shall be stockpiled on site in areas as approved by the OWNER and/or CQA Officer. Provisions shall be implemented to minimize surface water impact on the stockpile. Removal and placement of granular fill material shall be done in a manner to minimize intrusion of soils adjacent to and beneath the stockpile.

PART 2: PRODUCT

2.01 MATERIAL

A NCDOT No. 57 Stone and NCDOT No. 789 Stone

Washed rounded or sub-rounded stone meeting the gradation requirements of North Carolina Department of Transportation (NCDOT) No. 57 and No. 789 Stone to be used for filtration around the leachate collection pipes, as shown on the Drawings. NCDOT No. 57 and No. 789 Stone shall be sound, hard, durable and resistant to weathering, and shall be free of overburden, spoil, shale, limestone and organic material.

B C-33 Sand

C-33 Sand shall be used for filtration near the leachate collection pipes, as shown in the Drawings. C-33 sand shall be inorganic, non-calcareous

granular soil material, free from organic matter and other deleterious material with particle size gradation (ASTM D422) within the limits in Table 1:

TABLE 1

Sieve Size	Percent Passing by Weight (%)
3/8"	100
No. 4	95-100
No. 8	80-100
No. 16	45-95
No. 30	25-75
No. 50	8-30
No. 100	0.5-10
No. 200	0-3

C-33 Sand shall have a minimum permeability of $1x10^{-3}$ cm/sec or greater when compacted to 90 percent of standard Proctor maximum dry density (ASTM D698).

C Protective Cover

Protective Cover shall be inorganic, non-calcareous granular soil material, free from organic matter and other deleterious materials with particle size gradation (ASTM D422) within the limits in Table 2:

TABLE 2

Sieve Size	Percent Passing by Weight (%)
3/8"	100
No. 4	80-100
No. 200	0-20

Protective Cover shall have a minimum permeability of 1×10^{-4} cm/sec when compacted to 95 percent of standard Proctor maximum dry density (ASTM D698).

2.02 CONFORMANCE TESTING

A The CONTRACTOR shall collect samples of protective cover material and C-33 sand for testing by the CQC Laboratory. If the samples do not meet the specified criteria, the CONTRACTOR may submit additional samples from other sources for conformance testing by the CQC Laboratory at the CONTRACTOR's expense.

B The protective cover material shall be tested by the CONTRACTOR'S CQC Officer at the frequencies specified in Table 3. If changes in material, as identified by the CQA Officer or CQC Officer, occur within the frequency prescribed below, additional tests shall be performed at the expense of the CONTRACTOR.

TABLE 3

TEST	METHOD	FREQUENCY
Grain Size w/Hydrometer	ASTM D422	1 per acre
Moisture/Density	ASTM D698	1 per 2-acres
Natural Moisture	ASTM D2216	1 per 2-acres
Permeability (remolded)	ASTM D2434	1 per 2-acres

Results of the tests shall be submitted to the ENGINEER within 24 hours of test completion. The ENGINEER reserves the right to reject material based on the results of the conformance tests.

C **The tests listed in Table 3 shall be performed by the CONTRACTOR'S CQC Laboratory on samples from each source of C-33 sand at a minimum frequency of 1 test per 3,000 cubic yards** to assure compliance with the Specifications. If changes in material, as identified by the CQA Officer or CQC Officer, occur within the frequency prescribed below, additional tests shall be performed at the expense of the CONTRACTOR.

D Gradation analyses shall be performed by the CONTRACTOR'S CQC Laboratory on samples from each source of VCDOT No. 57 and VCDOT No.789 stone to assure compliance with the Specifications. If changes in material, as identified by the CQA Officer or CQC Officer, occur within the frequency prescribed below, additional tests shall be performed at the expense of the CONTRACTOR.

PART 3: EXECUTION

3.01 PROTECTIVE COVER SOIL MATERIAL PLACEMENT

A After installation, completion and acceptance of the HDPE liner (and HDPE Record Drawing), geocomposite drainage net and related work activities, place the protective cover soil materials to thicknesses and areal extent as shown on the Drawings.

B During the placement of the protective cover soil material, no construction equipment shall be allowed directly on the liner or drainage net. Any damage to these components shall be repaired immediately in accordance with the specifications. A minimum 4-foot-thick traffic surface shall be constructed over the liner to support haul trucks.

C Care shall be taken to protect the liner. Sand ramps (minimum 4-foot thick) shall be installed on slope locations used for entry and exit and otherwise as necessary (heavy traffic areas, etc.). Only large radius turns by loader and other equipment shall be permitted; sharp turns may damage the liner.

D A low-ground-pressure dozer (6 psi maximum contact pressure) shall be used for spreading and grading of the protective cover soil layer.

E Protective cover soil shall be placed on the side slopes starting at the toe of the slope and working toward the top of the slope.

F Protective cover soil layer material can only be spread when the liner is taut or stretched evenly over the base of the landfill. The protective cover soil layer material shall not be spread when the liner is elongated due to higher daytime temperatures and exposure to sun. The CONTRACTOR must make provisions to cover the liner under non-elongated conditions.

G The final grade shall be laid to elevations as shown on the Drawings.

H No protective cover soil material shall be placed or spread while the ground or protective cover soil material is frozen or thawing or during freezing or heavy wet weather conditions. The sand surface shall be made smooth and free from ruts or indentation at the end of any working day when significant precipitation is forecast and/or at the completion of the compaction operations in that area.

I Protective cover materials shall not be installed when and if the materials are saturated or not suitable for supporting equipment.

J If areas for piping are first covered where shown on the Drawings, trenches for leachate collection pipes shall be excavated through the protective cover soil material. The CONTRACTOR shall exercise special care not to disturb or cause damage to the fabric cushion, drainage net or HDPE liner. If a backhoe is used to construct the trench, a blade modification (i.e. rubber) section shall be installed on the bucket to protect the liner. Any liner damage shall be immediately repaired as directed by the ENGINEER at no additional cost to the Owner.

Note: Any and all excavations or removal of protective cover soil materials from over the lined area shall be observed by the CQA Officer (RPR). It is the responsibility of the CONTRACTOR to coordinate this work and provide adequate lead time notification.

K A 2-in minimum layer of protective cover soil material shall be maintained in the bottom of the trench followed by pipe. Locations for leachate piping (and fabric cushion) shall be survey located and installed to the lines shown on the Drawings, and shall be backfilled with NCDOT No. 57 Stone to the depth and width shown on the Drawings. Care shall be taken during backfilling of the pipe to assure the pipe will not be crushed or otherwise damaged or shifted.

L Following placement of the NCDOT No. 57 Stone, NCDOT No. 789 Stone shall be installed to the dimensions shown on the Drawings.

M Following placement of the NCDOT No. 789, the C-33 sand shall be placed to the dimensions indicated on the drawings.

N Following construction of the leachate piping, the protective cover soil material shall be brought to final grade and compacted as specified herein.

O Alternate installation plans may be submitted as referred to in 1.03.A.3 and .4 of the Section and implemented with prior approval by the CQA Officer.

3.02 FIELD QUALITY CONTROL

A. CQA Plan: Inspection/testing will be a joint effort between the CONTRACTOR and the OWNER.

B. Testing and Inspection Services: OWNER shall employ a CQA Officer and Quality Assurance Laboratory to perform soils observation and testing services for quality assurance of the protective cover layer. CONTRACTOR shall employ Quality Control Officer and a Quality Control Laboratory to perform soils inspection and testing services for quality control of the placement of the protective cover layer. CONTRACTOR shall factor this quality assurance verification and testing and quality control testing into its schedule and sequence of operations.

C. Coordination: CONTRACTOR shall be responsible for coordination of field services with the CONTRACTOR's CQC Officer, Quality Control Laboratory, and with the OWNER's CQA Officer.

D. Initial Observation: Protective cover layer placement operations shall be performed after the surface has been properly prepared and has been observed and approved by CQA Officer. No protective cover layer materials

shall be placed unless the CQA Officer approves the operation. Any fills placed without CQA Officer's observation and prior approval shall be removed in a manner to avoid damage or disturbance to the existing approved work, and the excavation shall be filled as specified herein, at no additional cost to OWNER.

E. Field Control: The minimum testing frequencies for field tests to be performed by the CONTRACTOR's Quality Control personnel are provided in the Table 4

TABLE 4

TEST	METHOD	FREQUENCY
Density [1]	ASTM D2937 ASTM D2922 ASTM D1556	2/acre
Moisture Content [1]	ASTM D2216 ASTM D3017 ASTM D1556	2/acre

Note[1]: A nuclear density test gauge can be used to provide the required density testing. However, the in-situ density shall be determined using the sand cone method (ASTM D 1556) and/or the drive cylinder method (ASTM D 2937) of a minimum of one test per ten nuclear density tests or one per day, whichever is greater. The sand cone and/or drive cylinder test should be performed at the same location as a nuclear density test. The sand cone and/or drive cylinder tests shall be continued until a correlation between the density and moisture contents obtained by the nuclear density gauge and the sand cone and/or drive cylinder tests has been demonstrated.

One-point compaction tests shall be performed to interpolate between laboratory compaction (ASTM D 698) curves for at least every 5 in-place density tests. The one-point compaction tests shall be performed on either the field density test sample or soil from a location immediately adjacent to the field density test sample, using the ASTM D 698 procedure. The results of the one-point tests shall then be compared with the full compaction curves of similar soils to estimate the maximum dry density applicable to the field density test sample.

F. Any sample or area tested shall be rejected, removed and replaced or otherwise corrected if it does not meet the requirements of the technical specifications. Re-constructed areas shall have feathered, overlapping edges that tie into adjacent fill material to the satisfaction of the CQA Officer.

3.03 REPORTING

A The Contractor's CQC Officer shall provide a final Construction Quality Control Report at the end of the project. The report shall certify that the Work, as associated with Protective Cover was performed in accordance with the Contract Documents and shall be prepared and sealed by a Professional Engineer registered in the State of North Carolina. The report shall include a narrative describing construction methods and QC procedures employed, summary tables of all field test results, including location and notations regarding any re-work performed, identification of failed tests, and discussions and documentation of re-worked areas with passing tests, as appropriate.

B Submittal and acceptance of an administratively complete Construction Quality Control Report shall be required for the Work to be considered Substantially Complete.

END OF SECTION

SECTION 02776

TEXTURED HIGH DENSITY POLYETHYLENE (HDPE) LINER

PART 1: GENERAL

1.01 SCOPE OF WORK

A Furnish all labor, materials, equipment and incidentals required to manufacture, supply and install Textured High Density Polyethylene (HDPE) liner as shown on the Drawings and as specified herein. This specification sets forth a set of minimum, physical, mechanical and chemicalc properties that must be met, or exceeded by the geomembrane being manufactured.

1.02 RELATED WORK

A Section 02275: Compacted Soil Liner

B Section 02274: Geocomposite Drainage Net

C Section 02700: Protective Cover

D Section 02985: Geomembrane Leak Location Survey

1.03 SUBMITTALS

A At least 60 calendar days prior to HDPE liner installation, submit the following information in accordance with Section 01340:

1. Submittals relating to liner manufacturer and liner

a. Corporate Background

b. Manufacturing capabilities:

(1) Information on factory size, equipment, personnel, number of shifts per day and production capacity per shift.

(2) List of material properties and samples of liner with attached certified test results.

(3) Manufacturer's quality control program and manual including description of laboratory facilities.

(4) A list of ten completed facilities totaling a minimum of three million square feet, for which the manufacturer has

manufactured a textured HDPE liner. The following information shall be provided for each facility.

- Name and purpose of facility, its location and date of installation
- Name of Owner, project manager, design engineer and installer.
- Liner thickness and surface area
- Information on performance of the facility

c. The origin of the resin to be used in the manufacturing of liner including the supplier's name and production plant, as well as brand name and number.

d. A fingerprint of the manufacturer's resin properties as listed in Appendix A, Table A1. The purpose of these tests is to identify the manufacturer's liner product. The results of these tests shall be submitted to the Engineer for approval of the product. Once the product is approved, all HDPE liner to be supplied for the Project shall be manufactured using the same resin type identified through fingerprinting tests.

e. Certification that all resin used in the manufacture of textured HDPE liner for this Project meets the approved fingerprinting protocol.

f. Copy of quality control certificates in conformance with Paragraphs 2.01 and 2.02.

g. Certification that the textured HDPE liner and extrudate produced for this project has the same properties.

2. Submittals relating to installation Contractor

a. Background Information

b. Installation capabilities:

(1) Information on equipment (including tensiometer certification) and personnel.

(2) Anticipated average daily production (Complete including QC measures).

(3) A minimum of three field seam samples and a list of minimum values for seam properties.

c. A list of five completed facilities totaling two million square feet for which the installer has installed textured HDPE liner. The following information shall be provided for each facility:

(1) Name and purpose of facility, its location and date of installation.

(2) Name of Owner, design engineer, manufacturer and name and telephone number of contact at the facility who can discuss the project.

(3) Thickness of liner and surface area of the installed liner.

(4) Type of seaming, patching and tacking equipment.

(5) A copy of the manufacturer's certification or approval letter.

(6) And, prior to installation, provide resume(s) of the qualifications of the Installation Supervisor and Master Seamer, and Quality Control personnel to be assigned to this project.

d. Shop drawings, including:

(1) Proposed (preliminary) panel layout showing the installation layout identifying field seams as well as any variance or additional details which deviate from the Drawings.

(2) Details of seaming the liner, anchoring, connections, penetrations and other construction details.

e. Installation schedule

f. A quality control manual that specifically defines the quality assurance program during installation. The manual shall include daily procedures, welding techniques, field testing procedures, lab testing procedures, specific steps that are to be taken in the event of a failure or defect, personnel requirements, levels of authority and all other information necessary to ensure a high quality liner installation.

1.04 REFERENCE STANDARDS

A American Society for Testing and Materials (ASTM)

1. ASTM D792 – Specific Standard Test Method for Tensile Properties of Plastics by Displacement.

2. ASTM D746 - Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact.

3. ASTM D751 - Standard Test Methods for Testing Coated Fabrics.

4. ASTM D792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.

5. ASTM D1004 - Standard Test Method for Initial Tear Resistance of Plastic Film and Sheeting.

6. ASTM D1204 - Standard Test Method for Linear Dimensional Changes of Nonrigid Thermoplastic Sheeting or Film at Elevated Temperature.

7. ASTM D1238 - Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer.

8. ASTM D1505 - Standard Test Method for Density of Plastics by the Density-Gradient Technique.

9. ASTM D1603 - Standard Test Method for Carbon Black in Olefin Plastics.

10. ASTM D5397 – Procedure to perform single point notched constant tneil load – Appendix (SP-NCTL)

11. ASTM D1898 – Sampling of Plastics

12. ASTM D4833 – Index puncture resistance of geotextiles, gemembranes and related products

13. ASTM D5596 – Test method for microscopic evaluation of the dispersion of carbon black in polyolefin geosynthetics

14. ASTM D3895 - Standard Test Method for Oxidative Induction Time of Polyolefins by Thermal Analysis.

15. ASTM D4437 - Standard Practice for Determining the Integrity of Field Seams Used in Joining Flexible Polymeric Sheet Geomembranes.

16. ASTM D7466 – Test method for measuring the asperity height of textured geomembranes

17. GRI Test Method GM13 - Test Methods, Test Properties and Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes

18. GRI Test Method GM19 - Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes

D Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A Quality Assurance activities are performed to provide assurance that the materials were constructed as specified in the contract specifications and may include manufacturing facility inspections, verifications, audits and evaluation of raw materials and geosynthetic products to assess the quality of the manufactured materials.

B In addition to manufacturer and installer requirements for qualifications and certification specified in Paragraph 1.03, the Quality Assurance Plan consists of conformance testing of the material manufactured for the project and delivered to the site, and field quality control during installation.

C Conformance testing requirements are specified in Paragraph 2.03. The purpose of conformance testing is to assure that the supplied material is constructed as specified in the contract specifications and to the manufacturer's quality control certificates.

D Field quality control requirements are specified in Paragraph 3.06. The purpose of field quality control procedures is to assure that the liner has been installed in accordance with the specifications and manufacturer's recommendations.

E Quality Control Plan

1. The forms in Appendix C for liner quality control documentation shall be used for field installation documentation. Alternative forms, which provide the same level of detail, may be used for documentation as approved by the Engineer.

F Geomembrane Quality Control Documentation

1. Pre-deployment Conference

a. Prior to commencing work, a pre-deployment conference shall be held and the following project personnel shall be identified by name and recorded in the project files:

- Contractor
- Contractor's Representative
- CQA Engineer
- Resident Project Representative (RPR)
- Installation Supervisor / Quality Control Personnel
- Installer
- CQC Personnel

b. Two duplicate project files shall be maintained. One shall be maintained by the CQA Representative or Resident Project Representative (RPR) and the other shall be maintained by the Installation Supervisor. At the end of each work week the files shall be updated and checked to assure that copies of all pertinent project information is included in each file.

c. Blank copies of the following nine (sample) project forms shall be available on-site throughout the duration of the project:

Form No.	Title
100	Liner Project QC Log
101	Subgrade Surface Acceptance
102	Receiving QC Log
103	Personnel QC Log
~~104~~	~~Daily Panel Placement Log~~
~~105~~	~~Daily Seaming QC Log~~
~~106~~	~~Daily QC Report Pre-Weld Testing~~
~~107~~	~~Daily QC Report Earthen Cover~~

G Record Drawings

1. The Contractor shall furnish record drawings in accordance with Section 01050 and showing changes, if any, from the approved installation drawings which are to include all destructive sample locations, any patches used to repair liner defects, all panels and panel seams and patch identifications assigned in the field; and a copy of complete documentation for final installation of the liner.

1.06 QUALIFICATIONS

A Manufacturer

1. The manufacturer of the lining material described hereunder shall have previously demonstrated their capability to produce this liner by having at least ten years continuous experience in the manufacture of textured HDPE liner and successfully manufactured a minimum of 50 million square feet of similar liner material for hydraulic lining installations.

B Installer

The installer shall be the manufacturer or an approved installer trained and certified to install the manufacturer's liner. Installation shall be performed under the constant direction of a single installation supervisor who shall remain on site and be in responsible charge, through the liner installation, for liner layout, seaming, patching, testing, repairs and all other activities required by the installer. The installation supervisor shall have installed or supervised the installation and seaming of a minimum of two million square feet of textured HDPE liner. The Installation contractor must be a manufacturer' approved installer for the product.

1.07 PACKAGING, DELIVERY, STORAGE AND HANDLING

A The geomembrane shall be rolled onto a substantial core held firm by dedicated straps, slings or other suitable means approved by the Engineer. The liner rolls shall be packaged and shipped by appropriate means to prevent damage of the liner rolls. Off-loading and storage of the liner is the responsibility of the Contractor. The liner rolls shall be unloaded in the presence of the CQA Officer or his designated CQA representative. The Contractor shall be responsible for replacing any damaged or unacceptable material at no cost to the Owner.

B Damage during off-loading shall be documented by the CQA Officer or CQA representative. Any damaged rolls must be separated from the undamaged rolls until the proper disposition of that material has been determined by the Engineer.

C The liner rolls shall be stored so as to be protected from puncture, dirt, grease, water, moisture, mud, mechanical abrasions and excessive heat that may damage the liner material. The rolls shall be stored on a prepared surface (not wooden pallets) and shall not be stacked more than two rolls high.

1.08 MATERIAL WARRANTY

A A warranty for the textured HDPE liner manufacturer shall be provided by the manufacturer. It shall include on a pro-rated basis, warranty against manufacturing defects and material degradation under outdoor exposure for a period of five years from the date of installation. The manufacturer shall replace at no expense, any material which fails from the above causes within the warranty period. The manufacturer shall furnish a written warranty covering the requirements of this Paragraph.

1.09 GUARANTEE

A The Contractor shall guarantee the textured HDPE liner against defects in installation and workmanship for the period of two years commencing with the date of final acceptance. The guarantee shall include the services of qualified service technicians and all materials required for the repairs at no expense to the Owner.

1.10 DEFINITIONS AND RESPONSIBILITIES

A Contractor

1. The Contractor is the firm or corporation with whom the Owner has entered into agreement to construct the project. The Contractor is responsible for scheduling and coordination of the required work with the Engineer, manufacturer and the installer to complete the project. The Contractor is responsible for furnishing as built drawings and a copy of the complete documentation of the liner system. The Contractor is also responsible for daily updating of the design drawings onsite and for any and all deviations from these drawings. **The Contractor is responsible for all submittals by the manufacturer and installer as required by the Specifications.**

B Manufacturer

1. The manufacturer is the firm or corporation responsible for production of the liner material to be used in the project. The manufacturer shall produce a consistent product meeting the project specifications, and shall provide quality control documentation for the product specified herein. **A Manufacturer's Certification that the material was manufactured and tested in accordance with this specification**, **together with a report of the test results shall be furnished prior to shipment.**

C Installer

1. The installer is the firm responsible for installation of the liner. The installer shall be the manufacturer or an approved installer trained and certified to install the manufacturer's geomembrane. The Installer shall be responsible for field handling, storing, placing, seaming, field testing and all other aspects of the liner installation.

PART 2: PRODUCTS

2.01 MATERIALS

A General

1. The liner shall be manufactured of new, prime first-quality products designed and manufactured specifically for the purpose of liquid

containment in hydraulic structures and chemically resistant to leachate. Product shall be *Agru America High Density Polyethylene Micro Spike® Liner* or equivalent.

2. The liner material shall be so produced as to be free of holes, blisters, undispersed raw materials, or any sign of contamination by foreign matter. The Engineer may reject all or portions of units (rolls) of geomembrane if significant quantities of production flaws are observed.

3. The sheets shall be manufactured to a minimum 22-ft seamless width. Labels on each roll shall be legible and identify the information listed in Part 2.02, A.4

4. The textured sheet must not delaminate during tensile testing (i.e., textured layers and "particles" of texture must not separate). The product shall be calendered structured, not blown film, or similar; it shall be free from agglomerated texturing material and such defects that would affect the specified properties of the geomembrane.

B Properties

1. The geomembrane liner rolls shall meet the minimum properties listed in Appendix B, Table B1.

C Other Materials

1. Extrudate welding rods shall be of the same compound as the liner and supplied by the manufacturer and shall be delivered in original sealed containers. Each container shall have a label bearing the brand name, manufacturer's lot number and complete directions as to proper storage. Manufacturer shall provide welding rod in an adequate quantity to complete the project.

2.02 QUALITY CONTROL DOCUMENTATION

A Prior to shipment and installation of any liner material, the Manufacturer shall provide the following information certified by the manufacturer for the delivered liner.

1. Origin, identification and production of the resin (supplier's name, brand name and production plant).

2. Copies of quality control certificates issued by the resin supplier.

3. Each roll delivered to the project site shall have the following identification information:

* Serial number

* Lot number
* Roll number
* Resin type
* Roll length
* Material width
* Weight
* Thickness
* Inspection identification

4. Quality control certificates, signed by the manufacturer's quality assurance manager. Each certificate shall have roll identification number, sampling procedures, frequency, and test results. At a minimum the following test results shall be provided in accordance with test requirements specified in Appendix B:

* Thickness
* Density
* Tensile properties
* Tear resistance
* Carbon black content
* Carbon black dispersion

2.03 CONFORMANCE TESTING

A Conformance testing shall be performed by the CQA Officer and an independent Quality Assurance Laboratory (QAL) as approved by the Owner. Engineer shall obtain samples from the delivered material, mark the machine direction and identification number. One sample shall be taken per 100,000 square feet, or one sample per lot, whichever results in the greater number of conformance tests. A Lot number will be defined as a continuous production process without changes to raw material or manufacturing methods. This sampling frequency may be increased as deemed necessary by the Engineer. The Owner shall pay for conformance testing at the frequency of one test per 100,000 square feet. For every change in Lot number, the Manufacturer shall pay for conformance testing on the initial roll at the Manufacturer's expense. The Engineer shall obtain the samples from the roll, and mark the machine direction and identification number. The following conformance tests shall be conducted at the laboratory:

* Thickness
* Density
* Tensile properties
* Tear resistance
* Carbon black content
* Carbon Black Dispersion

B These conformance tests shall be performed in accordance with Appendix B. All costs for the initial conformance testing will be paid by the Owner.

C All conformance test results shall be reviewed by Engineer and accepted or rejected, prior to the delivery and placement of the liner. All test results shall meet, or exceed, the property values listed in Appendix B. In case of failing test results, the manufacturer may request that another sample be retested by the independent laboratory with manufacturer's technical representative present during the testing procedures. This retesting shall be paid for by the manufacturer. The manufacturer may also have the sample retested at two different laboratories approved by the Owner. If both laboratories report passing results the material shall be accepted. If both laboratories do not report passing results, all liner material from the lot representing the failing sample will be considered out of specification and rejected.

PART 3: EXECUTION

3.01 COMPACTED SOIL LINER PREPARATION

A Preparation of the compacted soil liner surface shall be as specified in Section 02275.

B The surface of the compacted soil liner shall be smooth, uniform, and free from sudden changes in grade (such as vehicular ruts), rocks, stones, debris and deleterious materials. The moisture content of the compacted soil liner must be maintained within the project specifications until the synthetic liner has been installed. If excessive drying occurs, the contractor shall re-hydrate and compact the affected area to the Engineer's satisfaction. During actual placing and seaming of the liner, the compacted soil liner surface shall be kept free of all standing water. If the compacted soil liner surface below the liner becomes wet and unstable, it shall be dried and re-compacted to the Engineer's satisfaction. If drying and re-compacting the material is insufficient, the unstable material must be removed and replaced with approved material.

C Prior to liner installation, the Contractor and installer shall verify in writing and submit to the CQA Officer:

1. Lines and grades are in conformance with the Drawings and Specifications.

2. The surface area to be lined has been rolled and compacted, free of irregularities and abrupt changes in grade.

D The Contractor shall not proceed with liner installation until a complete report on the compacted soil liner thickness and hydraulic conductivity tests has been submitted and approved by the CQA Officer.

3.02 ANCHOR TRENCH

A The anchor trench shall be constructed as shown on the Drawings and as specified herein.

B Slightly rounded corners shall be provided in the trench to avoid sharp bends in the liner.

C The anchor trench shall be adequately drained to prevent water ponding and softening to adjacent soils. The anchor trench shall be backfilled with local fill material and compacted to 92 percent standard proctor density, ASTM D698 as specified in Section 02200.

D If the anchor trench is located in a clayey material susceptible to desiccation, the amount of trench open at any time shall be limited to one day of liner installation capacity.

3.03 LINER PLACEMENT

A Weather Conditions

1. Liner placement shall not proceed at an ambient temperature below 40 degrees F or above 104 degrees F unless otherwise authorized, in writing, by the CQA Officer or his/her field representative. Liner placement shall not be performed during precipitation, excessive moisture, in an area of ponded water, or excessive winds.

B Method of Placement

1. Each Liner panel shall be layed out in accordance with the approved shop drawings prepared by the Manufacturer. The layout shall be designed to keep field joining of the textured HDPE liner to a minimum and consistent with proper methods of textured HDPE liner installation.

2. Each liner panel shall be identified by panel number, roll number and date of deployment. The liner panel number shall be placed on the ends of each panel and in the middle.

3. For liner placed on 4 to 1 or steeper slopes, the seams shall be oriented in the direction of the slope. Horizontal seams on 4 to 1 slopes or steeper shall not be allowed except for cases in which it is unavoidable. In these instances, a cap strip shall be placed over the seam.

4. The equipment used to deploy the liner shall not cause rutting of the compacted soil liner surface. If rutting occurs, the Contractor shall suspend all liner placement activities and repair the ruts and immediately employ an alternative method for liner deployment. Liner rolls shall be

placed using spreader and rolling bars with cloth slings. If a sheet must be relocated a distance greater than its width, a slip sheet shall be used.

5. The RPR shall inspect each panel, after placement and prior to seaming, for damage and/or defects. Defective or damaged panels shall be replaced or repaired, as approved by the CQA Officer.

6. The installer shall not drag the liner panels over the compacted soil liner.

7. All liner shall be anchored as shown on the Drawings and consistent with manufacturer's recommendations. Sufficient liner shall be installed within the anchor trench to ensure proper installation prior to backfilling the trench.

8. Personnel working on the liner shall not smoke, wear damaging shoes or involve themselves in any activity that may damage the liner.

9. The liner shall be properly weighted with sand bags to avoid uplift due to wind.

10. Vehicular traffic across the liner shall not be allowed.

11. All damage shall be recorded and located on the record drawings.

12. When tying into existing liner, all excavation of previously installed liner shall be performed by hand to prevent damage.

13. The liner shall be kept free of debris, unnecessary tools and materials. In general, the liner area shall remain uncluttered in appearance. Any generators in use while on the liner shall have "drop" sheets place underneath.

14. Fuel shall not be stored on the liner.

15. To prevent a "trampoline effect" from forming, the Contractor shall place sufficient sand bags on the liner along the toe of slopes to ensure full contact of the geomembrane liner with the compacted soil liner surface. In addition, the horizontal seams nearest the toe of slope shall remain unwelded until all other seams in the area are completed. The final seam shall be welded when the liner is cool and fully contracted. Care shall be taken to ensure that the liner contacts the subgrade in all locations before completing the seam.

3.04 FIELD SEAMS

A Individual panels of liner shall be laid out and overlapped by a minimum of 4-in prior to welding. The area to be welded shall be cleaned and prepared in accordance with the installer's quality control welding procedures.

B Double track hot wedge fusion welder shall be used for straight welds.

C Extrusion welder shall be used for cross seam tees, patches, repairs, penetration boots and detailed work.

D The welding equipment used shall be capable of continuously monitoring and controlling the temperature speed, and pressure in the zone of contact where the machine is actually fusing the liner material so as to ensure that changes in environmental conditions will not affect the integrity of the weld.

E No "fish mouths" will be allowed within the seam area. Where "fish mouths" occur, the material shall be cut, overlapped and a patch fusion weld shall be applied. All welds upon completion of the work shall be tightly bonded. Any liner area showing injury due to excessive scuffing, puncture, or distress from any cause shall be replaced or repaired with an additional piece of liner. The number of patches per 100-ft length shall not exceed five. If more than five patches per 100-ft length are necessary, then the entire 100-ft length of seam shall be removed. Further welding will cease at this time and the CQA Officer shall be notified.

F All seams shall have a seam number that corresponds with the panel layout numbers. The numbering system shall be used in the development of the record drawings. Seam numbers shall be derived from the combination of the two panel numbers that are to be welded together.

G All fusion welded "T" seams (i.e., the result of the liner panels placed perpendicular to each other) shall be double welded where possible. The extrusion process shall be used for the second weld.

H All extrudate shall be free of dirt, dry and protected from damage.

I If an extrusion welder is stopped for longer than one minute, it shall be purged to remove heat-degraded extrudate. All purged extradite shall be placed on a sacrificial sheet and disposed of.

J All seams constructed on sloped surfaces shall be vertical seams. Where horizontal seams can't be avoided (due to compounded slopes) on sideslope surfaces, a 18" wide cap strip of the same synthetic material shall be placed on top of the horizontal seam and welded to the adjacent panels to provide additional structural integrity. All cap strip seams shall be non-destructively tested.

K All vertical panels placed on sloped surfaces shall extend 5-ft inward from the toe of slope or edge of trench.

L All end seams shall be staggered a minimum of 5-ft in length between contiguous panels.

M To prevent moisture buildup during fusion welding, it may be necessary to place a movable protective layer of plastic directly below each overlap of liner that is to be seamed.

N If required, a firm substrate shall be provided by using a flat board or similar hard surface directly under the seam overlap to achieve proper support.

O All seams shall extend to the full extent into the anchor trench.

P All factory seams, field seams and repair welds shall meet seam strength requirements specified in Appendix B, Table B2.

3.05 SEAMING WEATHER CONDITIONS

A Normal Weather Conditions

1. The normal required weather conditions for seaming are:

   a. Ambient temperature higher than 40 degrees F and lower than 104 degrees F.

   b. No precipitation or other excessive moisture, such as fog or dew.

   c. No excessive winds.

2. These weather conditions shall be fulfilled during seaming process.

B Cold Weather Conditions

1. If the ambient temperature is below 40 degrees F, the following conditions shall be met to ensure quality seaming process:

    a. Preheating the surface of the liner to achieve normal temperature range.

    b. Preheating may be waived by the CQA Officer or the RPR if the installer demonstrates that satisfactory welds of equivalent quality may be obtained without preheating at the expected temperature of installation.

    c. Preheating devices shall be approved by the manufacturer.

    d. Care shall be taken to assure that surface temperatures are not lowered below the minimum required surface temperature for welding due to winds.

    e. Additional destructive tests samples shall be taken at the discretion of the CQA Officer.

    f. Test seams, as described in Paragraph 3.06A, shall be performed under the same ambient temperature conditions as the actual seams.

C Warm Weather Conditions

1. If the ambient temperature is above 104 degrees F, no seaming of liner shall be permitted unless the installer can demonstrate to the satisfaction of the Engineer that liner seam quality is not adversely impacted.

2. Test seams shall be performed under the same ambient temperature conditions as the actual seams.

3. Additional destructive tests shall be taken at the discretion of the CQA Officer.

3.06 FIELD QUALITY CONTROL

A Pre-Weld Testing

1. A test weld 3-ft long from each welding machine shall be run upon the beginning of each shift and every four hours thereafter, under the same conditions as exist for the liner welding. The test weld shall be marked with date, ambient temperature and welder's name, temperature and speed, welding machine number. A tensiometer shall be required to be on-site before and during liner installation for the purpose of testing samples. Six specimens of welds 1-in wide shall be cut from the test

weld and tested on site with the presence of the RPR for shear and peel strength (3 each) in accordance with Appendix B, Table B-2. No welder may start work until the sample weld has been approved by the RPR.

2. Test seams shall be performed under the same conditions as the actual seams and shall be at least 3-ft long, 1-ft wide after seaming. Test seam for welding shall be cut out of the liner rolls.

B Non-destructive Seam Testing

1. The installer shall perform nondestructive test on all field seams over their full length. The purpose of this test is to assure continuity and integrity of the seams. Vacuum and air pressure tests shall be used for nondestructive testing. The vacuum test shall be used for extrusion welds and single track hot wedge welds. The air pressure test shall be used for double track hot wedge welds.

   If the CQA Officer at any time during the installation believes the seaming process may not be performing adequately, he may, to avoid destructive sampling of the actual liner system, request additional test seams. This shall be done by the Installer at no additional cost to the Owner.

2. Vacuum Testing

   a. Equipment for testing single wedge fusion seams and extrusion seams shall be comprised of the following:

      (1) A vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft rubber gasket attached to the bottom, port hole or valve assembly and a vacuum gage.

      (2) A vacuum tank and pump assembly equipped with a pressure controller and pipe connections.

      (3) A rubber pressure/vacuum hose with fittings and connections.

      (4) A plastic bucket and wide paint brush.

      (5) A soapy solution.

   b. The following procedures shall be followed by the installer:

      (1) Excess sheet overlap shall be trimmed away.

      (2) Clean the window, gasket surfaces and check for leaks.

(3) Energize the vacuum pump and reduce the tank pressure to approximately 5 psi.

(4) Wet a strip of liner approximately 12-in by 48-in (length of box) with the soapy solution.

(5) Place the box over the wetted area and compress.

(6) Close the bleed valve and open the vacuum valve.

(7) Ensure that a leak-tight seal is created.

(8) For a minimum period of ten seconds, examine the liner through the viewing window for the presence of soap bubbles.

(9) If no bubbles appear after ten seconds, close the vacuum valve and open the bleed valve, move the box over the next adjoining area with a minimum of 3-in overlap and repeat the process.

10) All areas where soap bubbles appear shall be marked and repaired in accordance with Paragraph 3.07G and then retested.

11) All test locations which have passed vacuum testing shall be marked with the test date and individual performing the test.

c. If the seam cannot be tested prior to final installation, the seaming operations shall be observed by the RPR for uniformity and completeness.

3. Air Pressure Testing.

a. The following procedures are applicable to those processes which produce a double seam with an enclosed space.

b. Equipment for testing double fusion seams shall be comprised of the following:

(1) An air pump equipped with pressure gage capable of generating and sustaining a pressure between 25 and 30 psi and mounted on a cushion to protect the liner.

(2) A manometer equipped with a sharp hollow needle, or other approved pressure feed device.

c. The following procedures shall be followed by the installer.

(1) Seal both ends of the seam to be tested.

(2) Insert needle or other approved pressure feed device into the tunnel created by the double wedge fusion weld.

(3) Energize the air pump to a pressure between 27 and 40 psi, close valve and sustain pressure for at least five minutes.

(4) If loss of pressure exceeds 3 psi, or pressure does not stabilize, locate faulty area, repair in accordance with Paragraph 3.07G and retest.

(5) If the faulty area cannot be isolated and repaired, the length of seam which can not be tested shall be capped with liner strip, extrusion welded and vacuum tested. The seam shall be documented as a failed seam indicating the corrective measure.

(6) If loss of pressure is 3 psi or less, release air pressure at the opposite end of where the pressure is applied to verify that the full seam was pressurized and that there was no blockage in the air channel.

(7) Remove needle or other approved pressure feed device and seal.

(8) All test locations which have passed air pressure testing shall be marked with the test date and individual performing the test.

C Destructive Seam Testing

1. At the discretion of the CQA Engineer and/or RPR, destructive seam testing shall be performed on samples of the installed liner.

a. At any given sampling location, two types of samples shall be taken by the Installer at the request of the CQA Engineer and/or RPR.

b. First, two specimens for field testing shall be taken. Each of these specimens will be 12 in. by 12 in. long (minimum), with the seam centered parallel to the width. If both specimens pass on-site field test for peel and shear in accordance with Appendix B, Table B-2, a sample for laboratory testing may be taken.

c. The sample for laboratory testing shall be located between the two specimens for the peel and shear field testing. The destructive

sample will be 12 in. wide by 42 in. long of the liner Installer requests a sample; otherwise, the destructive sample will be 30 inches with the seam centered lengthwise. The sample shall be cut into three parts and distributed as follows:

- One portion to the Installer for laboratory testing, if so requested, 12 in. x 12 in.;
- One portion to the Owner for archive storage, 12 in. x 12 in.; and
- One portion for CQA Laboratory testing, 12 in. x 18 in.

d. Destructive testing will include peel and shear testing. At least 5 specimens will be tested for each test method. A maximum of one non-FTB (Film Tear Bond) failure is acceptable provided that strength requirements are met on that sample.

e. The following procedures apply whenever a sample fails a destructive test, weather that test is conducted by the CQA Laboratory, the Installers laboratory, or by field tensiometer. The Installer has two options:

(1) The Installer can reconstruct the seam between any two passed destructive seam test locations, or

(2) The Installer can trace the seaming path to an intermediate location (at least 10 ft from the point of the failed test in each location) and take a small sample for an additional field test at each location. If these additional samples pass the field tensiometer testing, then full destructive laboratory samples are taken. If these destructive laboratory samples pass the tests, then the seam is reconstructed between these locations by capping for extrusion or fusion welds, at the direction of the Engineer. If either the field tensiometer or the laboratory sample fails, then the process is repeated to establish the zone in which the seam should be reconstructed.

3.07 ELECTRIC CONDUCTIVITY TESTING

Following installation of the drainage layer, electric conductivity testing may be performed to ensure no puncturing of the liner occurred during installation. The Contractor will fully cooperate with the testing including providing survey service and laborers to establish testing points and vacating areas designated by the testers. The laborers will also perform excavation of sand and removal of fabric at locations of investigation. Repair of damaged liner and replacement

of fabric and sand will be performed by the contractor at no additional cost to the Owner.

3.08 DISPOSAL OF WASTE MATERIAL

A Upon completion of installation, the Contractor shall dispose of all trash, waste material and equipment used in connection with the performed work and shall leave the premises in a neat and acceptable condition.

APPENDIX A

TABLE A1

PROPERTIES and TEST METHODS FOR TEXTURED HIGH DENSITY POLYETHYLENE (textured HDPE) LINER

PROPERTY	TEST METHOD
Density	ASTM D792 or ASTM D1505
Melt Index	ASTM D1238
Carbon Black Content	ASTM D1603
Oxidative Induction Time	ASTM 3895

The above tests shall be performed by the manufacturer of the textured HDPE liner for identification of the manufacturer's product. Test results shall be submitted to the Engineer for approval of the product. Properties shall meet listed test values listed in Appendix B1.

APPENDIX B

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TABLE B1

MATERIAL PROPERTIES
TEXTURED HIGH DENSITY POLYETHYLENE (HDPE) LINER

PROPERTY	UNIT	LIMIT	TEST METHOD	VALUE
Thickness[1]	mils	minimum	ASTM D5994	60
Density	g/cc	minimum	ASTM D1505; or ASTM D792	0.940
Tensile Properties (Each Direction)			ASTM D6693	
Yield Strength	lb/in	min. ave		126
Break Strength	lb/in	min. ave.		90
Elongation at Yield	%	min. ave.		12
Elongation at Break	%	min. ave.		100
Tear Resistance	lb.	min. ave.	ASTM D1004	42
Puncture Resistance	lb.	min. ave.	ASTM D4833	90
Carbon Black Content	%	Range	ASTM D1603; or ASTM D4218	2.0 to 3.0

Notes:
(1) – Value represents lowest individual value

TABLE B2

FACTORY AND FIELD SEAMS PROPERTIES
TEXTURED HIGH DENSITY POLYETHYLENE (HDPE) LINER

Property (ASTM D6392)	**Units**	**Value**
Hot Wedge Seams (1)		
- shear strength (2)	lb/in	120
- shear elongation at break (3)	%	50
- peel strength (2)	lb/in	91
- peel separation	%	25
Extrusion Fillet Seams		
- shear strength (2)	lb/in	120
- shear elongation at break (3)	%	50
- peel strength (2)	lb/in	78
- peel separation	%	25

Notes for Table B2:
1. Also for hot air and ultrasonic methods
2. Value listed for shear and peel strengths are 4 of 5 specimens; the 5th can be as low as 80% listed values
3. Elongation measurements should be omitted for field testing

APPENDIX C

SAMPLE GEOMEMBRANE QUALITY CONTROL or QUALITY ASSURANCE DOCUMENTATION FORMS

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The following forms are included and shall be completed by the responsible party as shown on the forms, unless otherwise approved by the Engineer:

Form No.	Title
CQC - 100	Liner Project QC Log
CQC - 101	Subgrade Surface Acceptance
CQC - 102	Receiving QC Log
CQC - 103	Personnel QC Log
CQC - 104	Daily Panel Placement QC Log
CQC - 105	Daily Seaming QC Log
CQC - 106	Daily QC Report Pre-weld Testing
CQC - 107	Damage and Failure Log

FORM CQC - 100
LINER PROJECT QC LOG
(one sheet per project)

PROJECT NAME: _____

PROJECT NUMBER: _____ INSTALLATION DATE: _____

PROJECT LOCATION: _____

PROJECT OWNER: _____

ADDRESS: _____

CONTACT: _____ PHONE: _____

ENGINEERING FIRM: _____

ADDRESS: _____

CONTACT: _____ PHONE: _____

GENERAL CONTRACTOR: _____

ADDRESS: _____

CONTACT: _____ PHONE: _____

SPECIFIED LINER MATERIALS: _____ THICKNESS & TYPE: _____

SUPPLIER OF LINER MATERIALS: _____

ADDRESS: _____

CONTACT: _____ PHONE: _____

MATERIAL CERTIFICATION RECEIVED: _____

DATE: _____ ACCEPTED: _____

FABRICATOR OF MATERIAL: _____

INSTALLER OF MATERIAL: _____

QC INSPECTION FIRM: _____

ADDRESS: _____

CONTACT: _____ PHONE: _____

LINER TESTING LABORATORY: _____

ADDRESS: _____

CONTACT: _____ PHONE: _____

FORM CQC - 101
SUBGRADE SURFACE ACCEPTANCE
(one sheet per Day of Liner Deployment)

PROJECT NAME: _____ DATE: _____ PROJECT NUMBER: _____

EARTH CONTRACTOR: _____

ADDRESS: _____

CITY: _____ STATE: _____ ZIP: _____

SUPERINTENDENT OF PROJECT: _____ PHONE: _____

GEOMEMBRANE INSTALLER: _____

ADDRESS: _____

CITY: _____ STATE: _____ ZIP: _____

SUPERINTENDENT OF PROJECT: _____ PHONE: _____

CERTIFICATE OF ACCEPTANCE
OF SUBGRADE SOIL BY INSTALLER

I the undersigned, duly authorized representative of _____ do hereby accept the soil surface as being acceptable for the placement of a geomembrane liner.

_____ _____ _____ _____

Name Signature Title Date

Certificate Accepted by Inspector - Company: _____

_____ _____ _____ _____

Name Signature Title Date

QC INSPECTOR: _____

SITE SUPERVISOR: _____

INSTALLING SUPERVISOR: _____

Use back for comments.

FORM CQC - 102
RECEIVING QC LOG
(one sheet per truck)

PROJECT NAME: _____

DATE: _____ TIME: _____ PROJECT NUMBER: _____

TRUCKERS ID: _____

NO. OF PIECES ON BOARD: _____ AGREE WITH PACKING LIST? _____

CONDITION OF PACKAGING: _____

VERIFY PROPER MATERIALS: _____ VERIFY PROPER THICKNESS: _____

IDENTIFY PANEL NUMBERS: _____

_____

IDENTIFY ACCESSORIES *(adhesive, battens, boots, etc.)*: _____

_____

IDENTIFY DAMAGED ITEMS: _____

_____

TYPE OF UNLOADING EQUIPMENT USED: _____

CONDITION: _____

OPERATOR: _____

COMMENTS: _____

_____

STORAGE AREA

CONDITION *(surface)*: _____

LOCATION TO PLACEMENT AREA: _____

MATERIAL PROPERLY COVERED: _____

WEATHER

CONDITIONS: _____ TEMP: _____

QC INSPECTOR: _____

SITE SUPERVISOR: _____

Use back for other comments.

FORM CQC - 103
PERSONNEL QC LOG
(installation & field seaming personnel)
(one sheet per mobilization or change of personnel)

PROJECT NAME: _____

DATE: _____ PROJECT NUMBER: _____

SAFETY MEETING CONDUCTED ON MATERIALS HANDLING: _____

GIVEN BY: _____ DATE: _____

SUPERINTENDENT OF INSTALLATION: _____

SEAMING CREW PERSONNEL

#1 CREW LEADER: _____ HELPER: _____

#2 CREW LEADER: _____ HELPER: _____

#3 CREW LEADER: _____ HELPER: _____

#4 CREW LEADER: _____ HELPER: _____

#5 CREW LEADER: _____ HELPER: _____

#6 CREW LEADER: _____ HELPER: _____

#7 CREW LEADER: _____ HELPER: _____

#8 CREW LEADER: _____ HELPER: _____

OTHER CREW MEMBERS

NAME: _____ NAME: _____

NAME: _____ NAME: _____

NAME: _____ NAME: _____

SIGNED: _____

QC Inspector

FORM CQC – 104
DAILY QC REPORT
PRE-WELD TESTING
(field seam test sample, one per day)

DATE _____ JOB NAME _____ JOB NO. _____ MATERIAL _____

TIME	AMBIENT TEMP.	WEATHER	WIND	SEAM TECH INIT.	MACHINE			DESTRUCTIVE TEST						PASS/FAIL	INSP. INITIALS
					ID NO.	TEMP	SPEED	PEEL			SHEAR				

FORM CQC – 105

PANEL PLACEMENT AND SEAMING LOG

DAILY TOTALS: Liner _____Sq. ft., Length Seamed _____ Ft., No. Destructs Marked _____, Anchor Trench: Dug _____ Accepted _____

DATE _____	JOB NAME _____	JOB NO. _____	MATERIAL _____

				SEAMS									
TIME	PANEL NO.	ROLL NO.	LENGTH	SEAM NO.	LENGH	TIME	SEAMER TECH.	MACHINE ID NO.	TEMP	SPEED	AMBIENT TEMP.	WIND	WEATHER

COMMENTS: _____

FORM CQC – 106
NON-DESTRUCTIVE TESTING

DATE _____ JOB NAME _____ JOB NO. _____ MATERIAL _____

DATE	TECH.	PANEL NO.	SEAM NO.	START FOOTAGE	END FOOTAGE	AIR TEST			AIR LANCE OR VACUUM TEST PASS/FAIL
						START PSI	FINISH PSI	DROP IN PSI OVER 5 MIN.	

FORM CQC – 107
DAMAGE AND FAILURE REPORT

DATE _____ JOB NAME _____ JOB NO. _____ PAGE _____

PANEL NO.	SEAM NO.	LOCATION OF REPAIR OR DAMAGE	TYPE OF DAMAGE	INSPECTION DATE	MFSM INITIALS	EFR INITIALS

COMMENTS: _____

END OF SECTION

SECTION 02777

LINEAR LOW DENSITY POLYETHYLENE (LLDPE) LINER

PART 1: GENERAL

1.01 SCOPE OF WORK

A Furnish all labor, materials, equipment and incidentals required to manufacture, supply and install textured (on both sides) Linear Low Density Polyethylene (LLDPE) liner for the closure cap system as shown on the Drawings and as specified herein. This specification sets forth a set of minimum, physical, mechanical and chemical properties for the geomembrane liner manufactured and installed on the Project.

1.02 RELATED WORK

A Section 01050: Field Engineering

B Section 02200: Excavation, Backfill and Compaction

C Section 02290: Protective Cover Layer

D Section 02274: Geocomposite Drainage Net

1.03 SUBMITTALS

A Within 15 calendar days following the Effective Date of the Agreement, submit the following information in accordance with Section 01340:

1. Submittals relating to liner manufacturer and liner
   a. Corporate Background
   b. Manufacturing capabilities:
      (1) Information on factory size, equipment, personnel, number of shifts per day and production capacity per shift.
      (2) List of material properties and samples of liner with attached certified test results.
      (3) Manufacturer's quality control program and manual including description of laboratory facilities.
      (4) A list of ten completed facilities totaling a minimum of three million square feet, for which the manufacturer has manufactured a LLDPE liner. The following information shall be provided for each facility:
         - Name and purpose of facility, its location and date of installation

- Name of Owner, project manager, design ENGINEER and installer.
- Liner thickness and surface area
- Information on performance of the facility

c. The origin of the resin to be used in the manufacturing of liner including the supplier's name and production plant, as well as brand name and number.

d. A fingerprint (sample) of the manufacturer's liner properties. The purpose of these tests is to identify the manufacturer's liner product. The test data shall be submitted to the CQA Officer for approval of the product. Once the product is approved, all LLDPE liner to be supplied for the Project shall be manufactured using the same resin type identified through fingerprinting tests.

e. Certification that all resin used in the manufacture of LLDPE liner for this Project meets the approved fingerprinting protocol.

f. **Certification from the Manufacturer that the material proposed for the project meets project specifications; identify and call out any variances from the specified.**

g. Copy of quality control certificates in conformance with Paragraphs 2.01 and 2.02.

h. Certification that the LLDPE liner and extrudate produced for this project has the same properties.

2. Submittals relating to installing Contractor

a. Background Information

b. Installation capabilities:

(1) Information on equipment (including tensiometer certification) and personnel.

(2) Anticipated average daily production (Complete, including QC measures).

c. A list of five completed facilities totaling two million square feet for which the installer has installed LLDPE liner. The following information shall be provided for each facility:

(1) Name and purpose of facility, its location and date of installation.

(2) Name of Owner, design ENGINEER, manufacturer and name and telephone number of contact at the facility who can discuss the project.

(3) Thickness of liner and surface area of the installed liner.

(4) Type of seaming, patching and tacking equipment.

(5) A copy of the manufacturer's certification or approval letter.

(6) Resume of the qualifications of the Installation Supervisor, Master Seamers, and Quality Control personnel to be assigned to this project.

d. Shop drawings, including:

(1) Proposed (preliminary) panel layout showing the installation layout identifying field seams as well as any variance or additional details which deviate from the Drawings.

(2) Details of seaming the liner, anchoring, connections, penetrations and other construction details.

e. Installation schedule (preliminary).

f. A quality control manual that specifically defines the quality assurance program during installation. The manual shall include daily procedures, welding techniques, field testing procedures, lab testing procedures, specific steps that are to be taken in the event of a failure or defect, personnel requirements, levels of authority and all other information necessary to ensure a high quality liner installation.

1.04 REFERENCE STANDARDS

A American Society for Testing and Materials (ASTM)

1. ASTM D5199 - Standard Test Method for Measuring the Nominal Thickness of Geosynthetics

2. ASTM D746 - Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact.

3. ASTM D5994 - Standard Test Methods for Measuring Core Thickness of Textured Geomembrane

4. ASTM D792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.

5. ASTM D1004 - Standard Test Method for Initial Tear Resistance of Plastic Film and Sheeting.

6. ASTM D1204 - Standard Test Method for Linear Dimensional Changes of Non-rigid Thermoplastic Sheeting or Film at Elevated Temperature.

7. ASTM D1238 - Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer.

8. ASTM D1505 - Standard Test Method for Density of Plastics by the Density-Gradient Technique.

9. ASTM D1603 - Standard Test Method for Carbon Black in Olefin Plastics.

10. ASTM D1693 - Standard Test Method for Environmental Stress - Cracking of Ethylene Plastics.

11. ASTM D3015 - Standard Practice for Microscopic Evaluation of the Dispersion of Carbon Black in Polylefin Geosynthetics.

12. ASTM D3895 - Standard Test Method for Copper-Induced Oxidative Induction Time of Polyolefins by Thermal Analysis.

13. ASTM D4437 - Standard Practice for Determining the Integrity of Field Seams Used in Joining Flexible Polymeric Sheet Geomembranes.

14. ASTM D6693 Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes.

B GRI Test Method GM17 – Test Methods, Test Properties and Testing Frequencies for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes.

C GRI Test Method GM19 – Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes

D Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A In addition to manufacturer and installer requirements for qualifications and certification specified in Paragraph 1.03 the Quality Assurance Plan consists of conformance testing of the material delivered to the site and field quality control during installation.

B Conformance testing requirements are specified in Paragraph 2.03. The purpose of conformance testing is to assure that the supplied material conforms to the specifications and to the manufacturer's quality control certificates.

C Field quality control requirements are specified in Paragraph 3.06. The purpose of field quality control procedures is to assure that the liner has been installed in accordance with the specifications and manufacturer's recommendations.

D Quality Control Plan

1. The forms in Appendix C for liner quality control documentation shall be used for field installation documentation. *Alternative forms, which provide the same level of detail, may be used for documentation as provided via submittal and approved by the ENGINEER.*

E Geomembrane Quality Control Documentation

1. Pre-installation Conference

a. Prior to commencing work, a pre-installation conference shall be held and the following project personnel shall be identified by name and recorded in the project record:

- Contractor and installation subcontractor (Primary on-site representatives of each)
- CQA Officer
- Liner QA personnel; on-site RPR
- Installation Supervisor
- Quality Control Personnel

b. Two duplicate project files shall be maintained. One shall be maintained by the Resident Project Representative (RPR) or lead liner QA technician, and the other shall be maintained by the Installation Supervisor/QC representative. At the end of each work week the files shall be updated and checked to assure that copies of all pertinent project information is included in each file.

c. Blank copies of the following project forms shall be available on-site throughout the duration of the project:

Form No.	Title
100	LINER PROJECT QC LOG
101	SUBGRADE SURFACE ACCEPTANCE
102	RECEIVING QC LOG
103	PERSONNEL QC LOG
104	PRE-WELD TESTING
105	DAILY PANEL PLACEMENT AND SEAMING QC LOG
106	NON-DESTRUCTIVE TESTING
107	DAMAGE AND FAILURE REPORT

F Record Drawings

1. The Contractor shall furnish record drawings showing changes, if any, from the approved installation drawings which are to include all destructive sample locations, any patches used to repair liner defects, all panels and panel seams; patch identifications assigned in the field; drawing shall be complete and in accordance with these requirements and Section 01050 and submitted to the ENGINEER for review and acceptance prior to installation of any overlying geosynthetic or layer. Contractor shall submit for review and acceptance, a copy of the complete QC documentation of the liner installation. *The drawing and QC submittal and review may occur as multiple events to provide for installations of overlying geosynthetics*.

1.06 QUALIFICATIONS

A Manufacturer

1. The manufacturer of the lining material described hereunder shall have previously demonstrated his/her ability to produce this liner by having at least five years continuous experience in the manufacture of LLDPE liner and successfully manufactured a minimum of 50 million square feet of similar liner material for hydraulic lining installations. The manufacturer must be certified and registered by GRI GM17 Standard as meeting all the requirements for manufacturing LLDPE liner.

B Installer

1. The installer shall be the manufacturer or an approved installer trained and certified to install the manufacturer's liner. Installation shall be performed under the constant direction of a single installation supervisor who shall remain on site and be in responsible charge, through the liner installation, for liner layout, seaming, patching, testing, repairs and all other activities required by the installer. The installation supervisor shall have installed or supervised the installation and seaming of a minimum of two million square feet of LLDPE liner or similar liner. The installation contractor must be a *manufacturer approved* installer of the product; documentation demonstrating shall be provided.

1.07 DELIVERY, STORAGE AND HANDLING

A The geomembrane shall be rolled onto a substantial core held firm by dedicated straps, slings or other suitable means approved by the ENGINEER. The liner rolls shall be packaged and shipped by appropriate means to prevent damage of the liner rolls. Off-loading and storage of the liner is the responsibility of the Contractor. The liner rolls shall be unloaded

in the presence of the CQA Officer or his designated CQA representative. The Contractor shall be responsible for replacing any damaged or unacceptable material at no cost to the Owner.

B Damage during off-loading shall be documented by the CQA Officer (RPR). All damaged rolls must be separated from the undamaged rolls until the proper disposition of that material has been determined by the ENGINEER.

C The liner rolls shall be stored so as to be protected from puncture, dirt, grease, water, moisture, mud, mechanical abrasions and excessive heat that may damage the liner material. The rolls shall be stored on a prepared surface (not wooden pallets) and shall not be stacked more than two rolls high.

1.08 MATERIAL WARRANTY

A The LLDPE liner manufacturer shall warrant the liner, on a prorated basis, against manufacturing defects and material degradation under outdoor exposure for a period of five years from the date of installation. The manufacturer shall replace at no expense any material which fails from the above causes within the warranty period. The manufacturer shall furnish a written warranty covering the requirements of this Paragraph.

1.09 GUARANTEE

A The Contractor shall guarantee the LLDPE liner against defects in installation and workmanship for the period of two years commencing with the date of final acceptance. The guarantee shall include the services of qualified service technicians and all materials required for the repairs at no expense to the OWNER.

1.10 DEFINITIONS AND RESPONSIBILITIES

A Contractor

1. The Contractor is the firm or corporation with whom the Owner has entered into agreement to construct the project. The Contractor is responsible for all submittals by the manufacturer and the installer as required by the Specifications. The Contractor is responsible for scheduling and coordination of the required work with the manufacturer and the installer to complete the project. The Contractor is responsible for furnishing as built drawings and a copy of the complete documentation of the liner system. The Contractor is also responsible for daily updating of the design drawings onsite and for any and all deviations from these drawings. **The Contractor is responsible for all submittals of the manufacturer and installer required by the Specifications.**

B Manufacturer

1. The manufacturer is the firm or corporation responsible for production of the liner material to be used in the project. The manufacturer shall produce a consistent product meeting the project specifications, and shall provide quality control documentation for the product specified herein. The Manufacturer shall produce a consistent product meeting the project specifications. **A Manufacturer's Certification that the material was manufactured and tested in accordance with this specification**, **together with a report of the test results shall be furnished prior to shipment.**

C Installer

1. The installer is the firm responsible for installation of the liner. The installer shall be the manufacturer or an approved installer trained and certified to install the manufacturer's geomembrane. The Installer shall be responsible for field handling, storing, placing, seaming, field testing and all other aspects of the liner installation.

PART 2: PRODUCTS

2.01 MATERIALS

A General

1. The textured (both sides) liner shall be manufactured of new, prime first-quality products designed and manufactured specifically for the purpose of liquid containment in hydraulic structures and chemically resistant to leachate.

2. The liner material shall be so produced as to be free of holes, blisters, undispersed raw materials, or any sign of contamination by foreign matter.

3. The sheets shall be manufactured in a minimum 22-ft seamless width. Labels on the roll shall identify the thickness, length, width, roll number and manufacturer's lot number.

4. The textured sheet must not delaminate during tensile testing (i.e., textured layers and "particles" of texture must not separate). The product shall be calendered structured, not blown film, or similar; it shall be free from agglomerated texturing material and such defects that would affect the specified properties of the geomembrane.

B Properties

1. The liner rolls shall meet the minimum properties listed in Appendix B, Table B1.

C Other Materials

1. Extrudate welding rods shall be of the same compound as the liner and supplied by the manufacturer and shall be delivered in the original sealed containers. Each container shall have a label bearing the brand name, manufacturer's lot number and complete directions as to proper storage.

2.02 QUALITY CONTROL DOCUMENTATION

A Prior to installation commencement of any liner material, the Contractor shall provide the following information certified by the manufacturer for the delivered liner.

1. Origin, identification and production of the resin (supplier's name, brand name and production plant).

2. Copies of quality control certificates issued by the resin supplier.

3. Manufacturer's certification verifying that the quality of the resin used to manufacture the liner meets the properties described herein.

4. Each roll delivered to the project site shall have the following identification information, at minimum:

   - Manufacturer's name
   - Product identification
   - Lot number
   - Thickness
   - Roll number

5. Quality control certificates, signed by the manufacturer's quality assurance manager. Each certificate shall have roll identification number, sampling procedures, frequency and test results. At a minimum the following test results shall be provided in accordance with test requirements specified in Appendix B:

   - Thickness
   - Density
   - Tensile properties
   - Tear resistance
   - Carbon black content

2.03 CONFORMANCE TESTING

A Conformance testing shall be performed by the CQA Officer and an independent Quality Assurance Laboratory (QAL) as approved by the Owner. ENGINEER shall obtain samples from the delivered material, mark the machine direction and identification number. One sample shall be taken per 100,000 square feet, or one sample per lot, whichever results in the

greater number of conformance tests. A Lot number will be defined as a continuous production process without changes to raw material or manufacturing methods. This sampling frequency may be increased as deemed necessary by the ENGINEER. The Owner shall pay for conformance testing at the frequency of one test per 100,000 square feet. For every change in Lot number, the Manufacturer shall pay for conformance testing on the initial roll at the Manufacturer's expense. The ENGINEER shall obtain the samples from the roll, and mark the machine direction and identification number. The following conformance tests shall be conducted at the laboratory:

- Thickness
- Density
- Tensile properties
- Tear resistance
- Carbon black content

B Conformance tests shall be performed in accordance with Appendix B. All costs for the initial conformance testing will be paid by the OWNER.

C All conformance test results shall be reviewed by ENGINEER and accepted or rejected, prior to the placement of the liner. All test results shall meet, or exceed, the property values listed in Appendix B. In case of failing test results, the manufacturer may request that another sample be retested by the independent laboratory with manufacturer's technical representative present during the testing procedures. This retesting shall be paid for by the manufacturer. The manufacturer may also have the sample retested at two different laboratories approved by the Owner. If both laboratories report passing results the material shall be accepted. If both laboratories do not report passing results, all liner material from the lot representing the failing sample will be considered out of specification and rejected.

PART 3: EXECUTION

3.01 SUBGRADE PREPARATION

A Preparation of the Subgrade surface shall be as specified in Section 02200 and herein.

B The surface of the Subgrade shall be smooth, uniform, free from sudden changes in grade (such as vehicular ruts), rocks, stones, debris and deleterious materials. The moisture content of the Subgrade must be maintained within the project specifications until the synthetic liner has been installed. If excessive drying occurs, the contractor shall rehydrate and compact the affected area to the ENGINEER's satisfaction. During actual placing and seaming of the liner, the Subgrade surface shall be kept free of all standing water. If the Subgrade surface below the liner becomes wet and unstable, it shall be dried and re-compacted to the ENGINEER's

satisfaction. If drying and re-compacting the material is insufficient, the unstable material must be removed and replace with approved material

C Before the liner installation initiates, the Contractor and installer shall verify in writing and submit to the ENGINEER:

1. Lines and grades are in conformance with the Drawings and Specifications.

2. The surface area to be lined has been rolled and compacted, free of irregularities and abrupt changes in grade.

D The Contractor shall not proceed with liner installation until a report on the Subgrade preparation has been submitted and approved by the ENGINEER. If the Contractor proceeds with liner installation and associated layers (drainage net, geotextile and protective cover) prior to completion of the report, the Contractor will do so at his/her own risk. Any liner system materials damaged during the repair work shall be replaced with new material. All costs associated with such actions will be paid for entirely by the Contractor including, but not limited to, labor, additional liner system material, testing, labor and material costs incurred by the ENGINEER to perform additional inspection services.

3.02 ANCHOR TRENCH

A The anchor trench shall be constructed as shown on the Drawings and as specified herein.

B Slightly rounded corners shall be provided in the trench to avoid sharp bends in the liner.

C The anchor trench shall be adequately drained to prevent water ponding and softening to adjacent soils. The anchor trench shall be backfilled with local fill material and compacted to 92 percent standard proctor density, ASTM D698 as specified in Section 02200.

D If the anchor trench is located in a clayey material susceptible to desiccation, the amount of trench open at any time shall be limited to one day of liner installation capacity.

3.03 LINER PLACEMENT

A Weather Conditions

1. Liner placement shall not proceed at an ambient temperature below 40 degrees F or above 104 degrees F unless otherwise authorized, in writing, by the ENGINEER or his/her field representative. Liner placement shall not be performed during precipitation, excessive moisture, in an area of ponded water, or excessive winds.

B Method of Placement

1. Each Liner panel shall be layed out in accordance with the approved shop drawings prepared by the Manufacturer. The layout shall be designed to keep field joining of the LLDPE liner to a minimum and consistent with proper methods of LLDPE liner installation.

2. Each liner panel shall be identified by panel number, roll number and date of deployment. The liner panel number shall be placed on the ends of each panel and in the middle.

3. For liner placed on 4 to 1 or steeper slopes, the seams shall be oriented in the direction of the slope. Horizontal seams on 4 to 1 slopes or steeper shall not be allowed except for cases in which it is unavoidable. In these instances, a cap strip shall be placed over the seam.

4. The equipment used to deploy the liner shall not cause rutting of the Subgrade surface. If rutting occurs, the Contractor shall suspend all liner placement activities and repair the ruts and immediately employ an alternative method for liner deployment. Liner rolls shall be placed using spreader and rolling bars with cloth slings. If a sheet must be relocated a distance greater than its width, a slip sheet shall be used.

5. The RPR shall inspect each panel, after placement and prior to seaming, for damage and/or defects. Defective or damaged panels shall be replaced or repaired, as approved by the ENGINEER.

6. All liner shall be anchored as shown on the Drawings and consistent with manufacturer's recommendations. Sufficient liner shall be installed within the anchor trench to ensure proper installation prior to backfilling the trench.

9. Personnel working on the liner shall not smoke, wear damaging shoes or involve themselves in any activity that may damage the liner.

10. The liner shall be properly weighted with sand bags to avoid uplift due to wind.

11. Vehicular traffic across the liner shall not be allowed.

12. All damage shall be recorded and located on the record drawings.

13. When tying into existing liner, all excavation of previously installed liner shall be performed by hand to prevent damage.

14. The liner shall be kept free of debris, unnecessary tools and materials. In general, the liner area shall remain uncluttered in appearance. Any

generators in use while on the liner shall have "drop" sheets place underneath.

15. Fuel shall not be stored on the liner.

16. To prevent a "trampoline effect" from forming, the Contractor shall place sufficient sand bags on the liner along the toe of slopes to ensure full contact of the geomembrane liner with the Subgrade surface. In addition, the horizontal seams nearest the toe of slope shall remain un-welded until all other seams in the area are completed. The final seam shall be welded when the liner is cool and fully contracted. Care shall be taken to ensure that the liner contacts the subgrade in all locations before completing the seam.

3.04 FIELD SEAMS

A Individual panels of liner shall be laid out and overlapped by a minimum of 4-in prior to welding. The area to be welded shall be cleaned and prepared in accordance with the installer's quality control welding procedures.

B Double track hot wedge fusion welder shall be used for straight welds.

C Extrusion welder shall be used for cross seam tees, patches, repairs, penetration boots and detailed work.

D The welding equipment used shall be capable of continuously monitoring and controlling the temperature speed, and pressure in the zone of contact where the machine is actually fusing the liner material so as to ensure that changes in environmental conditions will not affect the integrity of the weld.

E No "fish mouths" will be allowed within the seam area. Where "fish mouths" occur, the material shall be cut, overlapped and a patch fusion weld shall be applied. All welds upon completion of the work shall be tightly bonded. Any liner area showing injury due to excessive scuffing, puncture, or distress from any cause shall be replaced or repaired with an additional piece of liner. The number of patches per 100-ft length shall not exceed five. If more than five patches per 100-ft length are necessary, then the entire 100-ft length of seam shall be removed. Further welding will cease at this time and the ENGINEER shall be notified.

F All seams shall have a seam number that corresponds with the panel layout numbers. The numbering system shall be used in the development of the record drawings. Seam numbers shall be derived from the combination of the two panel numbers that are to be welded together.

G All fusion welded "T" seams (i.e., the result of the liner panels placed perpendicular to each other) shall be double welded where possible. The extrusion process shall be used for the second weld.

H All extrudate shall be free of dirt, dry and protected from damage.

I If an extrusion welder is stopped for longer than one minute, it shall be purged to remove heat-degraded extrudate. All purged extradite shall be placed on a sacrificial sheet and disposed of.

J All seams constructed on sloped surfaces shall be vertical seams. Where horizontal seams can't be avoided (due to compounded slopes) on sideslope surfaces, a 18" wide cap strip of the same synthetic material shall be placed on top of the horizontal seam and welded to the adjacent panels to provide additional structural integrity. All cap strip seams shall be non-destructively tested.

K All vertical panels placed on sloped surfaces shall extend 5-ft inward from the toe of slope or edge of trench.

L All end seams shall be staggered a minimum of 5-ft in length between contiguous panels.

M To prevent moisture buildup during fusion welding, it may be necessary to place a movable protective layer of plastic directly below each overlap of liner that is to be seamed.

N If required, a firm substrate shall be provided by using a flat board or similar hard surface directly under the seam overlap to achieve proper support.

O All seams shall extend to the full extent into the anchor trench.

P All factory seams, field seams and repair welds shall meet seam strength requirements specified in Appendix B, Table B2.

3.05 SEAMING WEATHER CONDITIONS

A Normal Weather Conditions

1. The normal required weather conditions for seaming are:

   a. Ambient temperature higher than 40 degrees F and lower than 104 degrees F.

   b. No precipitation or other excessive moisture, such as fog or dew.

   c. No excessive winds.

2. These weather conditions shall be fulfilled during seaming process.

B Cold Weather Conditions

1. If the ambient temperature is below 40 degrees F, the following conditions shall be met to ensure quality seaming process:

    a. Preheating the surface of the liner to achieve normal temperature range.

    b. Preheating may be waived by the ENGINEER or the RPR if the installer demonstrates that satisfactory welds of equivalent quality may be obtained without preheating at the expected temperature of installation.

    c. Preheating devices shall be approved by the manufacturer.

    d. Care shall be taken to assure that surface temperatures are not lowered below the minimum required surface temperature for welding due to winds.

    e. Additional destructive tests samples shall be taken at the discretion of the CQA ENGINEER.

    f. Test seams, as described in Paragraph 3.06A, shall be performed under the same ambient temperature conditions as the actual seams.

C Warm Weather Conditions

1. If the ambient temperature is above 104 degrees F, no seaming of liner shall be permitted unless the installer can demonstrate, to the satisfaction of the ENGINEER that liner seam quality is not adversely impacted.

2. Test seams shall be performed under the same ambient temperature conditions as the actual seams.

3. Additional destructive tests shall be taken at the discretion of the CQA ENGINEER.

3.06 FIELD QUALITY CONTROL

A Pre-weld Testing

1. A test weld 3-ft long from each welding machine shall be run upon the beginning of each shift and every four hours thereafter, under the same conditions as exist for the liner welding. The test weld shall be marked with date, ambient temperature and welder's name, temperature and speed, welding machine number. A tensiometer shall be required to be on-site before and during liner installation for the purpose of testing samples. Six specimens of welds 1-in wide shall be cut from the test weld and tested on site with the presence of

the RPR for shear and peel strength (3 each) in accordance with Appendix B, Table B-2. No welder may start work until the sample weld has been approved by the RPR.

2. Test seams shall be performed under the same conditions as the actual seams and shall be at least 3-ft long, 1-ft wide after seaming. Test seam for welding shall be cut out of the liner rolls.

B Non-destructive Seam Testing

1. The installer shall perform nondestructive test on all field seams over their full length. The purpose of this test is to assure continuity and integrity of the seams. Vacuum and air pressure tests shall be used for nondestructive testing. The vacuum test shall be used for extrusion welds and single track hot wedge welds. The air pressure test shall be used for double track hot wedge welds.

2. Vacuum Testing

a. Equipment for testing single wedge fusion seams and extrusion seams shall be comprised of the following:

(1) A vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft rubber gasket attached to the bottom, port hole or valve assembly and a vacuum gage.

(2) A vacuum tank and pump assembly equipped with a pressure controller and pipe connections.

(3) A rubber pressure/vacuum hose with fittings and connections.

(4) A plastic bucket and wide paint brush.

(5) A soapy solution.

b. The following procedures shall be followed by the installer:

(1) Excess sheet overlap shall be trimmed away.

(2) Clean the window, gasket surfaces and check for leaks.

(3) Energize the vacuum pump and reduce the tank pressure to approximately 5 psi.

(4) Wet a strip of liner approximately 12-in by 48-in (length of box) with the soapy solution.

(5) Place the box over the wetted area and compress.

(6) Close the bleed valve and open the vacuum valve.

(7) Ensure that a leak-tight seal is created.

(8) For a minimum period of ten seconds, examine the liner through the viewing window for the presence of soap bubbles.

(9) If no bubbles appear after ten seconds, close the vacuum valve and open the bleed valve, move the box over the next adjoining area with a minimum of 3-in overlap and repeat the process.

10) All areas where soap bubbles appear shall be marked and repaired in accordance with Paragraph 3.07G and then retested.

11) All test locations which have passed vacuum testing shall be marked with the test date and individual performing the test.

c. If the seam cannot be tested prior to final installation, the seaming operations shall be observed by the RPR for uniformity and completeness.

3. Air Pressure Testing.

a. The following procedures are applicable to those processes which produce a double seam with an enclosed space.

b. Equipment for testing double fusion seams shall be comprised of the following:

(1) An air pump equipped with pressure gage capable of generating and sustaining a pressure between 25 and 30 psi and mounted on a cushion to protect the liner.

(2) A manometer equipped with a sharp hollow needle, or other approved pressure feed device.

c. The following procedures shall be followed by the installer.

(1) Seal both ends of the seam to be tested.

(2) Insert needle or other approved pressure feed device into the tunnel created by the double wedge fusion weld.

(3) Energize the air pump to a pressure between 27 and 40 psi, close valve and sustain pressure for at least five minutes.

(4) If loss of pressure exceeds 3 psi, or pressure does not stabilize, locate faulty area, repair in accordance with Paragraph 3.07G and retest.

(5) If the faulty area cannot be isolated and repaired, the length of seam which can not be tested shall be capped with liner strip, extrusion welded and vacuum tested. The seam shall be documented as a failed seam indicating the corrective measure.

(6) If loss of pressure is 3 psi or less, release air pressure at the opposite end of where the pressure is applied to verify that the full seam was pressurized and that there was no blockage in the air channel.

(7) Remove needle or other approved pressure feed device and seal.

(8) All test locations which have passed air pressure testing shall be marked with the test date and individual performing the test.

C Destructive Seam Testing

1. At the discretion of the CQA Officer, destructive seam testing shall be performed on samples of the installed liner.

   a. At any given sampling location, two types of samples shall be taken by the Installer at the request of the CQA Officer.

   b. First, two specimens for field testing shall be taken. Each of these specimens will be 12 in. by 12 in. long (minimum), with the seam centered parallel to the width. If both specimens pass on-site field test for peel and shear in accordance with Appendix B, Table B-2, a sample for laboratory testing may be taken.

   c. The sample for laboratory testing shall be located between the two specimens for the peel and shear field testing. The destructive sample will be 12 in. wide by 42 in. long of the liner Installer requests a sample; otherwise, the destructive sample will be 30 inches with the seam centered lengthwise. The sample shall be cut into three parts and distributed as follows:

      - One portion to the Installer for laboratory testing, if so requested, 12 in. x 12 in.;
      - One portion to the Owner for archive storage, 12 in. x 12 in.; and
      - One portion for CQA Laboratory testing, 12 in. x 18 in.

d. Destructive testing will include peel and shear testing. At least 5 specimens will be tested for each test method. A maximum of one non-FTB (Film Tear Bond) failure is acceptable provided that strength requirements are met on that sample.

e. The following procedures apply whenever a sample fails a destructive test, weather that test is conducted by the CQA Laboratory, the Installers laboratory, or by field tensiometer. The Installer has two options:

(1) The Installer can reconstruct the seam between any two passed destructive seam test locations, or

(2) The Installer can trace the seaming path to an intermediate location (at least 10 ft from the point of the failed test in each location) and take a small sample for an additional field test at each location. If these additional samples pass the field tensiometer testing, then full destructive laboratory samples are taken. If these destructive laboratory samples pass the tests, then the seam is reconstructed between these locations by capping for extrusion or fusion welds, at the direction of the Engineer. If either the field tensiometer or the laboratory sample fails, then the process is repeated to establish the zone in which the seam should be reconstructed.

3.07 ELECTRIC CONDUCTIVITY TESTING

Following installation of the protective cover layer, electric conductivity testing may be performed to ensure no puncturing of the liner occurred during installation or previously. The Contractor will fully cooperate with the testing including providing survey service and laborers to establish testing points and excavating areas designated by the testers. The laborers will also perform excavation of sand and removal of fabric at locations of investigation. **Repair of liner and replacement of fabric and protective cover material will be responsibility of the CONTRACTOR at no additional cost to the OWNER.**

3.08 DISPOSAL OF WASTE MATERIAL

A Upon completion of installation, the Contractor shall dispose of all trash, waste material and equipment used in connection with the performed work and shall leave the premises in a neat and acceptable condition.

APPENDIX A

TABLE A1

FINGERPRINTING PROPERTIES FOR TEXTURED (BOTH SIDES)

LINEAR LOW DENSITY POLYETHYLENE (LLDPE) LINER

PROPERTY	TEST METHOD
Density	ASTM D1505 ASTM D792
Melt Flow Index	ASTM D1238
Carbon Black Content	ASTM D4218

The above tests shall be performed by the manufacturer of the textured LLDPE liner for identification of the manufacturer's product. The above test results shall be submitted to the ENGINEER for approval of the product. The resin to be supplied for the project shall meet the properties and test values as listed by GRI-GM17, or its latest version.

Note: The CONTRACTOR may submit a proposal(s) for the use of alternate test methods to determine required material properties specified in Table A1. Proposed alternate test methods shall conform to current industry standards. Proposals will be reviewed by ENGINEER and ENGINEER will notify CONTRACTOR, in writing, of decision to accept or reject the proposal(s). Requests for additional costs based on submission of, acceptance of, or rejection of proposal will not be allowed.

APPENDIX B

TABLE B1
MATERIAL PROPERTIES
TEXTURED LINEAR LOW DENSITY POLYETHYLENE (LLDPE) LINER

TEST

PROPERTY	UNIT	LIMIT	METHOD	VALUE
Thickness	mils	min. ave[1]	ASTM D5994	40
Density	g/cc	max.	ASTM D1505	0.939
Tensile Properties (Each Direction)			ASTM D6693	
1. Break Strength	lb/in	min.		60
2. Elongation at Break	%	min.		250
Tear Resistance	lb	min.	ASTM D1004	22
Puncture Resistance	lb	min.	ASTM D4833	44
Carbon Black Content	%	min.	ASTM D4218	2.0 - 3.0
Oxidative Induction Time	minutes	min.	ASTM D3895	≥100
Interface[2] Friction	deg.	min.	ASTM D5321	23.5°

Notes:

1. Refer to GRI Test Method GM17 for acceptable ranges and values
2. (Textured LLDPE to Geocomposite Drainage Net) Use same Geocomposite Drainage Nets (GDNs) as proposed by the Contractor for this project.

TABLE B2

FACTORY AND FIELD SEAMS PROPERTIES
LINEAR LOW DENSITY POLYETHYLENE (LLDPE) LINER

PROPERTY	UNIT	TEST METHOD	MINIMUM VALUE
Bonded Shear Strength:	lb/in	ASTM D6392	No AD Breaks and 60
Seam Peel Adhesion (hot wedge):	lb/in	ASTM D6392	No AD Breaks and 50
Seam Peel Adhesion (extrusion):	lb/in	ASTM D6392	No AD Breaks and 45

Note: Refer to GRI-GM19 in its latest version for properties and values

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APPENDIX C

GEOMEMBRANE
QUALITY CONTROL FIELD REPORTS

CQC FIELD REPORTS

The following forms are included and shall be completed by the responsible party as shown on the forms. *Alternate forms with pertinent content and format may be used as approved by the CQA Officer.*

Form No.	Title
CQC - 100	Liner Project QC Log
CQC - 101	Subgrade Surface Acceptance
CQC - 102	Receiving QC Log
CQC - 103	Personnel QC Log
CQC - 104	Pre-Weld Testing
CQC - 105	Daily Panel Placement and Seaming QC Log
CQC - 106	Non-destructive Testing Log
CQC - 107	Damage and Repair Report

FORM CQC - 100
LINER PROJECT QC LOG
(one sheet per project)

PROJECT NAME: _____

PROJECT NUMBER: _____ INSTALLATION DATE: _____

PROJECT LOCATION: _____

PROJECT OWNER: _____

ADDRESS: _____

CONTACT: _____ PHONE: _____

ENGINEERING FIRM: _____

ADDRESS: _____

CONTACT: _____ PHONE: _____

GENERAL CONTRACTOR: _____

ADDRESS: _____

CONTACT: _____ PHONE: _____

SPECIFIED LINER MATERIALS: _____ THICKNESS & TYPE: _____

SUPPLIER OF LINER MATERIALS: _____

ADDRESS: _____

CONTACT: _____ PHONE: _____

MATERIAL CERTIFICATION RECEIVED: _____

DATE: _____ ACCEPTED: _____

FABRICATOR OF MATERIAL: _____

INSTALLER OF MATERIAL: _____

QC INSPECTION FIRM: _____

ADDRESS: _____

CONTACT: _____ PHONE: _____

LINER TESTING LABORATORY: _____

ADDRESS: _____

CONTACT: _____ PHONE: _____

FORM CQC - 101
SUBGRADE SURFACE ACCEPTANCE
(one sheet per Day of Liner Deployment)

PROJECT NAME: _____ DATE: _____ PROJECT NUMBER: _____

EARTH CONTRACTOR: _____

ADDRESS: _____

CITY: _____ STATE: _____ ZIP: _____

SUPERINTENDENT OF PROJECT: _____ PHONE: _____

GEOMEMBRANE INSTALLER: _____

ADDRESS: _____

CITY: _____ STATE: _____ ZIP: _____

SUPERINTENDENT OF PROJECT: _____ PHONE: _____

CERTIFICATE OF ACCEPTANCE
OF SUBGRADE SOIL BY INSTALLER

I the undersigned, duly authorized representative of _____do hereby accept the soil surface as being acceptable for the placement of a geomembrane liner.

_____ _____ _____ _____

Name Signature Title Date

Certificate Accepted by Inspector - Company: _____

_____ _____ _____ _____

Name Signature Title Date

QC INSPECTOR: _____

SITE SUPERVISOR: _____

INSTALLING SUPERVISOR: _____

Use back for comments.

FORM CQC - 102
RECEIVING QC LOG
(one sheet per truck)

PROJECT NAME: _____

DATE: _____ TIME: _____ PROJECT NUMBER: _____

TRUCKERS ID: _____

NO. OF PIECES ON BOARD: _____ AGREE WITH PACKING LIST? _____

CONDITION OF PACKAGING: _____

VERIFY PROPER MATERIALS: _____ VERIFY PROPER THICKNESS: _____

IDENTIFY PANEL NUMBERS: _____

_____

IDENTIFY ACCESSORIES *(adhesive, battens, boots, etc.)*: _____

_____

IDENTIFY DAMAGED ITEMS: _____

_____

TYPE OF UNLOADING EQUIPMENT USED: _____

CONDITION: _____

OPERATOR: _____

COMMENTS: _____

_____

STORAGE AREA

CONDITION *(surface)*: _____

LOCATION TO PLACEMENT AREA: _____

MATERIAL PROPERLY COVERED: _____

WEATHER

CONDITIONS: _____ TEMP: _____

QC INSPECTOR: _____

SITE SUPERVISOR: _____

Use back for other comments.

FORM CQC - 103
PERSONNEL QC LOG
(installation & field seaming personnel)
(one sheet per mobilization or change of personnel)

PROJECT NAME: _____

DATE: _____ PROJECT NUMBER: _____

SAFETY MEETING CONDUCTED ON MATERIALS HANDLING: _____

GIVEN BY: _____ DATE: _____

SUPERINTENDENT OF INSTALLATION: _____

SEAMING CREW PERSONNEL

#1 CREW LEADER: _____ HELPER: _____

#2 CREW LEADER: _____ HELPER: _____

#3 CREW LEADER: _____ HELPER: _____

#4 CREW LEADER: _____ HELPER: _____

#5 CREW LEADER: _____ HELPER: _____

#6 CREW LEADER: _____ HELPER: _____

#7 CREW LEADER: _____ HELPER: _____

#8 CREW LEADER: _____ HELPER: _____

OTHER CREW MEMBERS

NAME: _____ NAME: _____

NAME: _____ NAME: _____

NAME: _____ NAME: _____

SIGNED: _____

QC Inspector

FORM CQC – 104
DAILY QC REPORT
PRE-WELD TESTING
(field seam test sample, one per day)

DATE _____ JOB NAME _____ JOB NO. _____ MATERIAL _____

TIME	AMBIENT TEMP.	WEATHER	WIND	SEAM TECH INIT.	MACHINE			DESTRUCTIVE TEST						PASS /FAIL	INSP. INITIALS
					ID NO.	TEMP	SPEED	PEEL			SHEAR				

FORM CQC – 105
PANEL PLACEMENT AND SEAMING LOG

DAILY TOTALS: Liner _____Sq. ft., Length Seamed _____ Ft., No. Destructs Marked _____, Anchor Trench: Dug _____ Accepted _____

DATE _____ JOB NAME _____ JOB NO. _____ MATERIAL _____

				SEAMS									
TIME	PANEL NO.	ROLL NO.	LENGTH	SEAM NO.	LENGH	TIME	SEAMER TECH.	MACHINE ID NO.	TEMP	SPEED	AMBIENT TEMP.	WIND	WEATHER

COMMENTS: _____

FORM CQC – 106
NON-DESTRUCTIVE TESTING

DATE _____ JOB NAME _____ JOB NO. _____ MATERIAL _____

DATE	TECH.	PANEL NO.	SEAM NO.	START FOOTAGE	END FOOTAGE	AIR TEST			AIR LANCE OR VACUUM TEST PASS/FAIL
						START PSI	FINISH PSI	DROP IN PSI OVER 5 MIN.	

FORM CQC – 107
DAMAGE AND FAILURE REPORT

DATE _____	JOB NAME _____	JOB NO. _____	PAGE _____			
PANEL NO.	SEAM NO.	LOCATION OF REPAIR OR DAMAGE	TYPE OF DAMAGE	INSPECTION DATE	MFSM INITIALS	EFR INITIALS

COMMENTS: _____

_____

_____

_____

_____

_____

END OF SECTION

SECTION 11323

SUBMERSIBLE LEACHATE PUMPS

PART 1: GENERAL

1.01 SCOPE OF WORK

A. The installation shall, at a minimum, consist of two submersible pumps and controls, 3-inch discharge piping and all appurtenances as shown on the Drawings and as specified herein. One complete system will be supplied for each of the three landfill sumps. The pumps will pump landfill leachate into a flexible pipe and solid HDPE pipe force main. Electrical work, except as specified herein, is included on the Electrical Drawings and/or in Division 16.

B. A 480 volt, 3 phase, 3-wire, 60 Hertz power supply will be furnished under the Electrical Drawings and/or Division 16, and connected to the Control Panel per Riser Diagram on Electrical Drawings. The control panel shall be furnished under this Section and installed under the Electrical Drawings and/or Division 16. The power and control for the pumps and level switches shall be furnished under this Section and installed under the Electrical Drawings and/or Division 16. All other necessary power and control wiring, equipment and appurtenances are to be furnished and installed under this Section.

1.02 SUBMITTALS

A. The following shall be submitted in accordance with Section 01300:

1. Shop and erection drawings showing all important details and dimensions.

2. Descriptive literature, bulletins and/or catalogs of the equipment.

3. Data on the characteristics and performance of each pump. Data shall include guaranteed performance curves, which show that they meet the specified requirement for total head, capacity, efficiency, NPSHR, submergence and horsepower. Curves shall be submitted on 8-2 inch x 11-inch sheets, at an adequate scale. Curves shall be plotted from zero flow at Shut Off Head to Pump Capacity at minimum specified total head.

4. Approximate total weight of the equipment including the weight of the single largest item.

5. Drawings showing the layout of the Control Panels. The layout shall show front and side elevations and shall indicate every device mounted on the inner door and subpanel with complete identification.

6. Complete wiring diagrams and schematics of all power and control systems showing wiring requirements between all system components, motors, sensors, control panels and related systems.

7. A complete list of the equipment ordered.

8. Manufacturer/supplier warranty.

9. Complete motor data.

B. In the event that it is impossible to conform with certain details of the Specifications due to different manufacturing techniques, the submittal shall describe completely all nonconforming aspects.

C. Operating and Maintenance Data.

1. Operating and Maintenance Manuals shall be furnished. The manuals shall be prepared specifically for equipment furnished and installed and shall include all required cross sections, drawings, equipment lists, description, etc., that are required to instruct operating and maintenance personnel unfamiliar with such equipment.

2. A factory representative, who has complete knowledge of proper operation and maintenance, shall be provided for one day to instruct representatives of the Owner on proper operation and maintenance.

1.03 QUALITY ASSURANCE

A. To assure unity of responsibility, the pump, control panel and other auxiliary equipment and materials specified in this Section shall be furnished and coordinated by the pump manufacturer. The Contractor and manufacturer shall assume responsibility for the satisfactory installation and operation of the entire pumping system including pumps and control as specified.

B. The submersible pump and other equipment covered by these Specifications are intended to be standard design and proven ability. The pump shall be designed for side slope riser leachate removal. The pump shall be equipped with level sensing system and wheels for ease of installation. The pump shall be Sidesloper as designed by GUNNCO, or equal. The furnished pump shall be designed, constructed and installed in accordance with the Hydraulic Institute Standards and shall operate satisfactorily when installed.

C. The control system shall have an established record of successful performance for similar service.

D. All equipment furnished under this Specification shall be new and unused, shall be the standard product of manufacturer having a successful record of manufacturing and serving the equipment and systems specified herein for a minimum of three years.

E. The pump furnished under this Specification shall be new and unused, shall be the standard product of a manufacturer having a successful record of manufacturing and serving the equipment and system specified herein for a minimum of five years.

1.04 DELIVERY, STORAGE AND HANDLING

A. All equipment and parts shall be properly protected so that no damage or deterioration will occur during a prolonged delay from the time of shipment until installation is complete and the units and equipment are ready for operation.

B. Factory assembled parts and components shall not be dismantled for shipment unless permission is received in writing from the ENGINEER.

C. Finished surfaces of all exposed pump openings shall be protected by wooden blanks, strongly built and securely bolted thereto.

D. After hydrostatic or other tests, all entrapped water shall be drained prior to shipment and proper care shall be taken to protect parts from the entrance of water during shipment, storage and handling.

E. Each box or package shall be properly marked to show its net weight in addition to its contents.

1.05 WARRANTY REQUIREMENTS

A. All equipment supplied under this section shall be warranted for a period of one year by the CONTRACTOR and the equipment manufacturers. Warranty period shall commence on the date of final acceptance.

B. The equipment shall be warranted to be free from defects in workmanship, design and materials. If any part of the equipment should fail due to manufacturing defects during the warranty period, it shall be replaced and the unit(s) shall be restored to service at no additional cost to the OWNER.

C. The manufacturer's warranty period shall run concurrently with the CONTRACTOR'S warranty period. No exception to this provision shall be allowed.

1.06 ADDITIONAL WARRANTY REQUIREMENTS

A. Pumps

1. The warranty shall cover defects in workmanship and materials and cover all costs for both labor and parts required to inspect and repair pumping equipment delivered to the pump manufacturer's authorized repair and maintenance service center. During the one year warranty period, the CONTRACTOR shall be responsible for removing and reinstalling the pumping equipment. The CONTRACTOR shall be responsible for all transportation and shipping costs for delivery of the pumping equipment to the service center and return to the site.

B. Control Panels

1. Control panel shall be provided with a warranty covering 100 percent of the cost for repair or replacement of defective equipment concurrent with warranty period for Pump, to include all equipment associated with pumps, level transmitters, and/or flow meters.

2. Warranty service to inspect defects in the control panel shall be performed at the pump station site by the CONTRACTOR and/or the pump

manufacturer/supplier. Repair and/or replacement of defective components to the greatest extent possible shall be performed at the project site; however, no major component, whose removal will render the equipment or pump station inoperable, shall be removed without providing a spare or "loaner" replacement component for use and operation of the pump station while the original component is being repaired.

C. AGREEMENT TO WARRANTY CONDITIONS

1. The pump manufacturer/supplier shall, as a part of the required shop drawing and product submittal data, deliver a certified statement of agreement and materials to be supplied and installed under this Section.

2. Operating and Maintenance Data, a type-written or printed copy of the product warranties, including the above provisions and applicable dates of commencement and expiration of each warranty period, shall be supplied with other required product data.

1.12 PATENTS AND LICENSES

A. The pumping equipment manufacturer shall be responsible for all patents or licenses that exist for the equipment provided.

B. The manufacturer shall assume all costs of patent fees or licenses for the equipment or process and shall safe-guard and save harmless the OWNER from all damages, judgements, claims and expenses arising from licenses fees, or claimed infringement of any letters, patent or patent rights, or fees for the use of any equipment of process, structural feature or arrangement of any of the component parts of the installation and the price bid shall be deemed to include payment of all such patent fees, licenses or other costs pertaining thereto.

PART 2: PRODUCTS

2.01 MATERIALS AND EQUIPMENT

A. The manufacturer shall submit a data sheet specific to each pump supplied, the data sheet shall have the name of the manufacturer, the rated capacity, total head, speed and all other pertinent data.

2.02 PUMPING SYSTEM - GENERAL

A. The pump shall be a 460 volt, 3 phase, 7.5 Hp, totally submersible multi-stage, centrifugal pump with submersible close coupled motors designed to pump landfill leachate such as GUNNCO, or equal. The pump shall be automatically connected to the discharge connection when lowered into place utilizing a stainless steel pitless adapter type quick connect or equal and shall be easily removed for inspection or service.

B. The pumps shall be able to pump 115 gallons per minute against a -foot total head. The pump curve shall satisfy the following:

- Primary operating point – 115 gpm at 118-ft. Total Head

- Shutoff head - 0 gpm at 150 ft. Total Head
- Curve shall be equivalent to pump curve as specified by GUNNCO Model P2K150.3.

The pump control shall be set as follows:

	Inches above level sensor
▪ Pump On	10.0
▪ Pump Off	4.0

C. Provide 2 pumps as follows:

- 1 pump in side-slope riser cell 5
- 1 pump in side-slope riser cell 5

2.03 PUMP CONSTRUCTION

A. The materials of pump construction shall be as follows:

Impeller	304 Stainless Steel
Impeller Seal Ring	Teflon
Motor Adaptor	304 Stainless Steel
Inlet Screen	304 Stainless Steel
Pump Shaft	304 Stainless Steel
Coupling	304 Stainless Steel
Check Valve Housing	304 Stainless Steel
Check Valve	304 Stainless Steel
Check Valve Seat	304 Stainless Steel
Diffuser Chamber	304 Stainless Steel
Fasteners	304 Stainless Steel
Bearing	Teflon or E-Glide7
Suspension Cables	304 Stainless Steel

2.04 SUBMERSIBLE MOTORS

A. Motors shall be 4-inch, high thrust, corrosion-resistant motors as manufactured by Franklin Electric or equal having the following characteristics:

1. Thrust Rating: 1500 pounds downthrust continuous, 100 pounds upthrust intermittent.

2. Temperature and Time Rating: Continuous duty with .25 ft/sec. flow past motor. Temperature 30°C ambient.

3. Enclosure: Hermetically sealed windings, corrosion-resistant materials. Filtered check valve plugged to prevent interchange with pumped fluids. Stainless steel, splined shaft.

4. Bearings: Radial sleeve bearings, kingsbury type thrust bearings.

5. Lubrication: Water based.

6. Overload Protection: Standard three phase magnetic starter with special ambient compensated quick trip overload relays in all three legs required for positive motor protection.

7. Motors shall be designed for operation in severe environments.

8. Motors shall be constructed of 316 stainless steel.

B. Motors shall comply with all requirements of the Electrical Drawings and/or Division 16 of these specifications.

C. The pumps shall be supplied with 480 volt, 3 phase, 60 Hertz power and sensor conductors. Pump motor cables shall be sized to meet the NEC (LATEST EDITION) requirements.

D. Pump electrical cables shall be provided of sufficient length so that the cables will be continuous between the pump and the control panel with no splices being allowed. The motor cable shall be CPE/XLP jacketed to meet industry standards for landfill, oil, gas, and sewerage resistance.

2.05 PUMP CONTROL SYSTEM

A. General

1. One pump controller shall be provided for each submersible leachate pump station location in a NEMA 4X STAINLESS STEEL Control Panel. The controller shall respond to the liquid level sensor to automatically start and stop pumps to remove leachate in response to changes in liquid levels.

2. The pump controller shall be the standard system of the manufacturer as modified for this application.

3. Provide four 20 amp, one pole circuit breaker for miscellaneous 120 volt equipment (i.e. heat trace, flow transmitter, etc.) with CPT sized for all equipment.

4. Provide control panel with lightning and surge protection.

5. Electric power to be furnished to the leachate control panel shall be 480 volts, three phase and shall be furnished by the distribution panel as shown on the drawings and specified in the Electrical Drawings and/or Division 16.

B. Operation Requirements

1. The control panels shall consist of a main circuit breaker, a motor circuit protector and magnetic starter for the pump motor, pump controller and circuit breakers as required.

   A high level alarm and pump shut-off shall be accomplished by the control system with all control components mounted in one common enclosure. Control switches shall provide means to operate the pump manually or automatically.

2. The manufacturer shall provide a complete and fully functional control system to manually or automatically operate the pumps as specified herein and in other applicable sections of these specifications. All manufacturer's recommended safety devices shall be furnished to protect operators. All control devices, unless specified otherwise, shall be mounted in the control panel.

3. Normally open dry contacts shall be provided on high alarm, failure alarm and normal run indicators for remote use.

4. A pressure sensor type liquid level control system shall continuously monitor liquid level and control operation of the pump. The pressure transmitter level sensor shall have a range of 0-138” using a 0-5 PSI transducer with a 4 to 20 MA output signal and shall be accurate to within 0.1-inch. Transducer shall have internal surge suppressor and include an panel mounted external surge suppressor. A digital display located in the control panel shall continuously indicate the liquid level. Controller settings shall be adjustable without use of punch or scroll buttons and shall be accomplished using a setting selection knob and use of screwdriver adjustable potentiometer adjustments.

C. Control Panel Construction

1. The electrical control equipment shall be mounted within a NEMA 4X dead front enclosure constructed of not less than 14 gauge 316 stainless steel. Access to operator controls shall be using a stainless handle with a three point latching mechanism with locking hasp and stainless sealing clamps. The enclosure shall be equipped with an inner door capable of opening a full 180 degree and shall incorporate a removable back panel on which control components shall be mounted. Back panel shall be secured to enclosure with collar studs.

2. Components

   a. All motor branch circuit breakers, motor starters and control relays shall be of highest industrial quality, securely fastened to the removable back panels with screws and lock washers. Back panels shall be tapped to accept all mounting screws. Self-tapping screws shall not be used to mount any component.

   b. A thermal-magnetic air circuit breaker, Type FH as manufactured by Square D Company, or equal, shall be furnished for each pump motor and main breaker. All circuit breakers shall be sealed by the manufacturer after calibration to prevent tampering. Each circuit breaker shall be adequately sized to meet the pump motor and station operating conditions. A motor circuit protector (MCP) shall be molded case with adjustable magnetic trip only "MagGard" as manufactured by Square D Company or equal. The main breaker shall be equipped with a lockable disconnect operating mechanism with 3” handle to turn off power when the interior door is opened, Square D Type L model or equal.

   c. A mechanical disconnect mechanism shall be installed on each circuit breaker to provide a means of disconnecting power to the pump motors.

d. An open frame, across-the-line, NEMA rates, magnetic motor starter, Class 8536 as manufactured by Square D Company, or equal, shall be furnished for each pump motor. All motor starters shall be equipped to provide under-voltage release and overload protection on all three phases. Motor starter contacts shall be easily replaceable without removing the motor starter from its mounted position. Overload reset push-buttons shall be located on the exterior of the control compartment door.

e. Phase monitors shall be Diversified Electronics Model No. SUA-440-ASA with relay socket for 480 volt three phase or equal.

f. A duplex GFCI utility receptacle providing 120 volts, 60 hertz, 20 AMP single phase current shall be side mounted in a weatherproof box and cover.

g. The control diagrams and overload tables shall be laminated to the inside of the exterior door.

h. Print storage pockets shall be provided on the side of each panel. Its size shall be of sufficient size to hold all of the prints required to service the equipment. Reduced drawings shall be provided to be stored in these pockets.

i. Digital Level Control: The level meter shall be mounted on the inner door. Meter shall have a digital readout to $1/10^{th}$ of an inch to control pump OFF and PUMP ON settings and a HIGH LEVEL ON and HIGH LEVEL OFF. Level control shall be accurate to within 0.1-inch.

j. Corrosion Inhibitor Emitter: Inclusion of an industrial corrosion inhibitor emitter that shall protect internal components of control panel from corrosion for up to one year. One spare emitter shall be provided for each control panel.

k. Digital Flow Meter Readout: A digital transmitter with LCD displays, showing both meter flow rate and totalized flow volume, shall be mounted on the inner door as well. The flow totalizer shall be a bi-directional, eight digit (minimum) digital display, resettable, with full capability for front panel programming for ease of field changes and troubleshooting. The system shall operate from a 24vdc power supply, and shall be equal to the E-Series flow metering system as manufactured by GUNNCO FT420 Model. The meter shall include a non-volatile memory to retain programming choices, presets and count values when power is discontinued, with menu-driven programming. The sensor and transmitter system shall maintain full function in temperatures between 0^0 and 50^0 C.

l. A failure alarm with horn and beacon light shall be provided. Silence and reset pushbuttons shall also be furnished. High Level beacon shall be day light visible LED with RED lens.

m. All exterior mounted equipment shall be NEMA 4X rated. Indicators and HOA switches shall be 30mm with push to test LED bulbs.

n. Lightning and surge protection shall be as manufactured by Advanced Protection Technologies or equal.

o. A light fixture (circuit breaker protected) and On/Off switch shall be provided to illuminate the interior of the panel during maintenance.

p. All control panel wiring shall be numbered at both ends with type written heat shrinkable wire markers.

q. Wiring shall be stranded copper, minimum size #14 AWG (except for shielded instrumentation cable), with 600 volt, 90 degree C, flame retardant, type MTW thermoplastic insulation.

r. All foreign voltage control wiring shall be yellow.

s. The control panel shall be provided with nameplates identifying each component, selector switches, pilot lights, etc. Nameplates shall be permanently affixed using an epoxy process (inner door nameplates shall be fastened with stainless steel screws). Nameplates shall be laminated plastic, engraved white letters with a black background.

t. All control panels shall be provided with a master nameplate located on the exterior door.

u. Provide a nameplate which reads as follows: "CAUTION - THIS PANEL CONTAINS A VOLTAGE FROM AN EXTERNAL SOURCE." Letters shall be black on a high visibility yellow background.

v. The completed control panel assembly shall be U.L. certified.

w. Refer to Section 16191 for additional control panel requirements.

3. Operating Controls and Instruments

a. All operating controls and instruments shall be securely mounted on the control compartment door. All controls and instruments shall be clearly labeled to indicate function.

b. Pump mode selector switches shall be Hand-Off-Auto type to permit over-ride of automatic level control and manual actuation of shutdown of pump motor. Operation of pumps in manual mode shall bypass all safety shutdown circuits except pump motor overload shutdown. Switches shall be NEMA 4X (800 H) as manufactured by Allen Bradley, Square D, or equal, providing three switch positions, each of which shall be clearly labeled according to function.

c. Indicator lamps shall be LED full voltage type and mounted in NEMA 4X (800 H) modules, as manufactured by Allen Bradley or equal. Lamp modules shall be equipped to operate at 120 volt input. Lamps shall be easily replaceable from the front of the control compartment door without removing lamp module from its mounted position.

d. A six-digit non-reset elapsed time meter shall be connected to each motor starter to indicate the total running time of each pump in "hours" and "tenth of hours". The elapsed time meters shall be Series T50 as manufactured by ENM Company or equal.

e. The following spare parts shall be furnished:

(1) 1 indicator light.
(2) 2 control relays of each type furnished.
(3) 5 fuses of each type furnished.
(4) 1 set of thermal overloads for each type furnished.
(5) 1 selector switch of each type furnished.

2.06 SHOP PAINTING

A. Before exposure to weather and prior to shop painting, all surfaces shall be thoroughly cleaned, dry and free from all mill-scale, rust, grease, dirt and other foreign matter.

B. Gears, bearing surfaces and other similar surfaces obviously not to be painted shall be given a heavy shop coat of grease or other suitable rust resistant coating. This coating shall be maintained as necessary to prevent corrosion during periods of storage and erection and shall be satisfactory to the Engineer up to the time of the final acceptance test.

2.07 DISCHARGE PIPING AND APPURTENANCES

A. 1. The pump discharge piping inside of the leachate pump riser pipe shall be flexible hose chemically compatible with landfill leachate and manufactured of polyvinyl chloride. The diameter shall be 3-inch inside diameter and have a working pressure of at least 150 psi at 104ºF. The hose shall be rated for full vacuum. Discharge piping shall be TigerPlex Series S or equal.

2. The flexible discharge piping shall include a stainless steel pitless adapter. All hose nipples shall be stainless steel. Pump and hose shall be equipped with stainless steel cam lock fittings with locking pins to allw quick release of the pump from the discharge hose assembly. Hose clamps shall be adjustable high torque, Dixon HTM or equal.

3. Flow sensor shall be a compatible sensor as required for a clamp on 3” saddle fitting suitable for use with HDPE piping, or a paddlewheel type flow meter sensor is installed in a special adaptor, mounted within a pipe tee section, located on the pump discharge line between the riser pipe and the access road. The sensor is made to fit a tee section on a 3-inch discharge pipe, in the location shown on the drawings, and shall be equal to model 52EP300 as manufactured by EPG Companies Inc or GUNNCO IP81. The sensor utilizes a dual magnet drum design, is constructed of Delvin, Kynar, or equal, and measures flow range from 1 to 500 gpm with a linearity and repeatability factor of +/- 0.5%.

4. Air release valves, 1-inch, Class 150, installed as shown on the drawings. The air valve shall have a cast iron body, cover and baffle, stainless steel float, bronze water diffuser, Viton seat and stainless steel trim. Valves shall be provided with vacuum check to prevent air from reentering the line. For 3-inch discharge line, orifice size shall be 3/32-inch. Valves shall be suitable for an operating pressure of 150 psi. The fittings shall be suitable for an operating pressure of 150 psi. The fittings shall be threaded. The air release valves shall be Model 22 by Val-Matic Valve and Manufacturing Corporation, Lyons, Illinois, or Apco, Shaumburg, Illinois, Model 50 or equal.

PART 3: EXECUTION

3.01 INSTALLATION

A. Installation shall be in strict accordance with the manufacturer's instructions and recommendations in the locations shown on the Drawings. Installation shall include furnishing oil and grease for initial operation, if required, in accordance with the manufacturer's recommendations.

B. The Contractor shall submit a certificate from the equipment manufacturer stating that the equipment is ready for operation and that the operating personnel have been suitably instructed in the operation, lubrication and care of each unit.

3.02 INSPECTION AND TESTING

A. General

1. The Engineer shall have the right to inspect, test or witness tests of all materials or equipment to be furnished under these Specifications, prior to their shipment from the point of assembly.

2. The Engineer shall be notified in writing prior to the initial shipment or testing, in ample time so that arrangements can be made for inspection by the Engineer.

3. The pump manufacturer shall perform the following test on each pump prior to shipment from the factory.

a. Megger motor and pump for insulation breaks or moisture.

b. Prior to submergence, the pump shall be run and checked for correction rotation.

c. Pump shall be run for a minimum of thirty minutes in a submerged condition.

d. The pump shall be removed from test tank, meggered immediately for moisture and upper and lower seal unit shall be checked for water intrusion.

e. A written certification test report regarding the above test shall be supplied with each pump at the time of shipment.

4. The services of a factory representative shall be furnished for a minimum of one-half day per pumping station and shall have complete knowledge of proper operation and maintenance to inspect the final installation and supervise the test run of equipment.

5. Field tests shall not be conducted until such time that the entire installation is complete and ready for testing.

6. In the event that the equipment does not meet the Final Acceptance Test, the Contractor shall, at his own expense, make such changes and adjustments in the equipment which he deems necessary and shall conduct further tests until full satisfaction is indicated by the Engineer and written certification is received thereof.

7. The Contractor shall supply an adequate volume of water to each pump station location to meet the requirements of this section.

8. All four pumps supplied shall be installed and tested, including the two backup pumps. Two pumps, one in each pump station location, shall remain operational after the Final Acceptance Tests.

B. PUMP

1. After each pump has been completely installed and working under the direction of the manufacturer, conduct in the presence of the Engineer such tests as are necessary to indicate that the pump conforms to the Specifications. Supply all electrical power, water, labor, equipment and incidentals required to complete the field tests.

2. The Final Acceptance Test shall demonstrate that all items of these Specifications have been met by the equipment as installed and shall include, but not be limited to, the following tests:

   a. That all units have been properly installed and are in correct alignment.

   b. That the units operate without overheating or overloading any parts without objectionable vibration.

   c. That there are no mechanical defects in any of the parts.

   d. That the pumps can deliver the specified pressure and quantity of landfill leachate.

   e. That the level sensor and pump control system operates as specified.

   f. That the flow meter sensor and transmitter system operates and records as specified.

3. If the pump performance does not meet the Specifications, corrective measures shall be taken or the pump shall be removed and replaced with a pump which

satisfies the conditions specified. A 24-hour operating period of the pump will be required before acceptance.

C. MOTORS

1. The Contractor shall check all motors for correct clearance and alignment in accordance with manufacturer's instructions. The Contractor shall check direction of rotation of all motors and reverse connections if necessary.

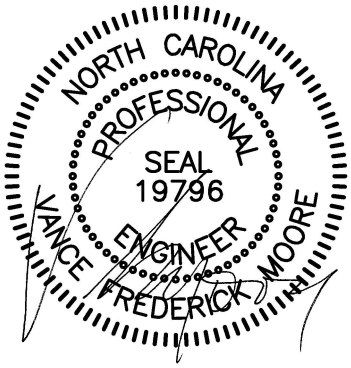
END OF SECTION

Operations Plan Report

Phase 4 and 5 Permit to Construct Haywood County White Oak MSWLF

Haywood County, North Carolina

June 2016



June 20, 2016

GARRETT & MOORE
Engineering for the Power and Waste Industries
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NC FIRM C-2910

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Operational Plan Report

This Operational Plan Report for the Phase 4 & Phase 5 of the White Oak MSWLF was developed in accordance with 15A NCAC 13B .1626 of the North Carolina Solid Waste Management Regulations.

Haywood County entered into a landfill management agreement with Santek Environmental of North Carolina, LLC, effective October 3, 2011. Haywood County will remain Owner and Santek will be the Operator.

Contact for Haywood County:
Mr. David Francis
Administrator
Haywood County Solid Waste
278 Recycle Road
Clyde, NC 28721
828-627-8042

Additional Contact for Haywood County:
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Contact for Santek Environmental of North Carolina, LLC:
Mr. John Preston
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650 25th Street NW Suite 100
Cleveland, Tennessee 37311
423-650-3095

Additional Contact for Santek Environmental of North Carolina, LLC:
Mr. Ron Vail
Vice President of Engineering
650 25th Street NW Suite 100
Cleveland, Tennessee 37311
423-303-7101

1.0 Waste Acceptance and Disposal Requirements

1.1 Acceptable Waste

The Municipal Solid Waste Landfill (MSWLF) will only accept those solid wastes which it is permitted to receive. Haywood County will notify the Division within 24 hours of attempted disposal of any waste the landfill is not permitted to receive. Signs are placed at the entrance to the White Oak Landfill stating that Hazardous and Liquid wastes are not accepted and that random waste screening is performed. The White Oak Landfill will receive wastes from the County's Solid Waste Processing Facility, located on Recycle Road in Clyde and the Citizen's Convenience Centers strategically located throughout the County. In addition to Haywood County, the White Oak Landfill may also receive waste from the following North Carolina Counties: Avery County, Buncombe County, Burke County, Cherokee County, Clay County, Graham County, Henderson County, Jackson County, Macon County, Madison County, McDowell County, Mitchell County, Polk County, Rutherford County, Swain County, Transylvania County, and Yancey County

1.2 Prohibited Waste

The following wastes are prohibited from disposal at the MSWLF.

1.2.1 Hazardous waste

Hazardous waste as defined within 15A NCAC 13A, to also include hazardous waste from conditionally exempt small quantity generators.

1.2.2 Polychlorinated biphenyls (PCB) wastes

Polychlorinated biphenyls (PCB) wastes as defined in 40 CFR 761.

1.2.3 Liquid Wastes

Bulk or non-containerized liquid waste will not be placed in the landfill unless:

(i) The waste is household waste other than septic waste and waste oil,

(ii) The waste is leachate or gas condensate derived from the landfill.

Containers holding liquid wastes may not be placed in the MSWLF unit unless:

(i) The container is a small container similar in size to that normally found in household waste;

(ii) The container is designed to hold liquids for use other than storage; or

(iii) The waste is household waste.

For the purpose of this paragraph:

- Liquid waste means any waste material that is determined to contain “free liquids” as defined by Method 9095 (Paint Filter Liquids Test), S. W. 846.
- Gas Condensate means the liquid generated as a result of gas recovery processes at the MSWLF unit.

1.2.4 Wastes Listed in G.S.130A-309.10(f)

Wastes listed in G.S.130A-309.10(f) will not be placed in the landfill:

(i) Repealed by Session Laws 1991, c. 375, s. 1.

(ii) Used oil.

(iii) Yard trash, except in landfills approved for the disposal of yard trash under rules adopted by the Commission. Yard trash that is source separated from solid waste may be accepted at a solid waste disposal area where the area provides and maintains separate yard trash composting facilities.

(iv) White goods.

(v) Antifreeze (ethylene glycol).

(vi) Aluminum cans.

(vii) Whole scrap tires, as provided in G.S. 130A-309.58(b). The prohibition on disposal of whole scrap tires in landfills applies to all whole pneumatic rubber coverings, but does not apply to whole solid rubber coverings.

(viii) Lead-acid batteries, as provided in G.S. 130A-309.70.

(ix) Repealed by Sessions Laws 2001-394, s. 4, effective July 1, 2011.

(x) Motor vehicle oil filters.

(xi) Recyclable rigid plastic containers that are required to be labeled as provided in subsection (e) of this section, that have a neck smaller than the body of the container, and that accept a screw top, snap cap, or other closure. The prohibition on disposal of recyclable rigid plastic containers in landfills does not apply to rigid plastic containers that are intended for use in the sale or distribution of motor oil or pesticides.

(xii) Wooden pallets, except that wooden pallets may be disposed of in a landfill that is permitted to only accept construction and demolition debris.

(xiii) Oyster shells.

(xiv) Discarded computer equipment, as defined in G.S. 130A-309.131.

(xv) Discarded televisions, as defined in G.S. 130A-309.131.

1.3 Spoiled Foods and Animal Carcasses

Spoiled foods, animal carcasses, abattoir waste, hatchery waste, and other animal waste delivered to the disposal site shall be covered upon receipt.

1.4 Asbestos Waste

Asbestos waste will be accepted. The wastes are taken to a designated area of the landfill for disposal. The landfill operator will immediately cover the asbestos wastes with a minimum of six inches of soil. A 24 hour notice will be given to the Landfill before any asbestos arrives, and records will be kept as to whom and what type of asbestos was buried.

Asbestos waste shall be managed in accordance with 40 CFR 61, which is hereby incorporated by reference including any subsequent amendments and additions. Copies of 40 CFR 61 are available for inspection at the Department of Environment, Health, and Natural Resources, Division of Solid Waste, 401 Oberlin Road, Raleigh, N.C. at no cost. The waste shall be covered upon receipt, with soil or waste, in a manner that will not cause airborne conditions and must be disposed of separate and apart from other solid wastes.

1.5 Wastewater Treatment Sludges

Wastewater treatment sludges may only be accepted for disposal in accordance with the following conditions:

- Utilized as a soil conditioner and incorporated into or applied onto the vegetative growth layer but, in no case greater than six inches in depth.
- Co-disposed if the facility meets all design requirements contained within Rule .1624, and approved within the permit, or has been previously approved as a permit condition. Wastewater treatment sludges may be accepted for disposal within the composite lined disposal area.

1.6 Waste Screening

Haywood County will continue a program at the Landfill for detecting and preventing the disposal of hazardous and liquid wastes. This program includes, at a minimum:

i. Random inspections of incoming loads or other comparable procedures;

ii. Records of any inspections;

iii. Training of facility operating personnel to recognize hazardous and liquid wastes.

iv. Development of a contingency plan to properly manage any identified hazardous and liquid wastes. The plan must address identification, removal, storage and final deposition of the waste.

v. Wastes listed in G.S. 130-A-309.10(f)

The Waste Screening Plan is included in **Appendix 3**.

1.7 Waste Placement

Waste placement shall be within the areal limits of the base liner system and in manner consistent with the effective permit. The limits of MSWLF are marked with 4-inch square concrete markers painted with a high visibility color, at maximum 200-foot intervals.

The Phase 4 and 5 Engineering Drawings include proposed top of intermediate cover fill grades for Phases 1 – 5. As a part of waste placement activities a certain degree of waste settlement is expected and anticipated over time. To compensate for anticipated settlement the initial placement of waste may exceed the fill grades for the top of waste by up to five feet (5') on the outer slopes and top of fill surfaces. The amount of anticipated overfill is contingent upon the location within the disposal unit, type of waste being received and operator experience. Elevations will be checked periodically to track progress and ensure general conformance with proposed final fill grades in addition to monitoring the extent of the anticipated settlement.

The Facility Drawings include proposed top of intermediate cover fill grades as well top of final cover grades for Phases 1 – 7. Prior to beginning final closure construction activities, the surface grades of the area to be closed will be surveyed and compared to the proposed final grades. Surface grades that present a uniform slope within reasonable conformance with the permitted final slope and allow the placement of the final cap grades to be within an average of+/- 2 feet of the permitted grades will be deemed in accordance with the permit drawings. Minor imperfections in the subgrade surface (i.e., areas of settlement and/or overfill) that are outside the allowable tolerances will be corrected prior to placing the final closure cap system.

2.0 Cover Material Requirements

2.1 Daily Soil Cover

All MSWLF units must cover disposed solid waste with six inches of earthen material at the end of each operating day, or at more frequent intervals if necessary, to control disease vectors, fires, odors, blowing litter, and scavenging.

Haywood County is also permitted to use a synthetic tarp system and/or a soil/mulch mixture as an alternate daily cover (ADC) in lieu of six-inches (6") of soil material. The use of these ADC's was approved on May 5, 2009. Appendix 2 provides a general operating plan for the use of the synthetic tarp system. When using the synthetic tarp system, soil cover material will be used at the end of the week's operation or more frequently as needed to control blowing waste, vectors or other conditions not suitable for the use of a tarp system. The soil/mulch ADC will generally consist of twenty-five percent (25%) mulched material combined with seventy-five percent (75%) soil for a total combined thickness of six-inches (6").

Landfill Staff may utilize one of two methods for producing the mulch/soil ADC mixture. One procedure will be to place in a line two (2) loads of dirt, one (1) load of mulch, and another load of dirt (all equal volume) in the area of the landfill to receive cover. The four piles will be walked into the surface by landfill equipment to create the desired cover depth. The landfill operator will work the loads to ensure an even distribution of mulch throughout the cover area. The second method is to pile three loads of dirt and one load of mulch (all equal volume) out of the way of landfill operations in an area of the landfill that can be utilized for a temporary stockpile. The four loads will be thoroughly mixed using landfill equipment to achieve an even distribution of the mulched material. The stockpiled ADC will be utilized as needed.

2.2 Intermediate Cover

Areas which will not have additional wastes placed on them for 12 months or more, but where final termination of disposal operations has not occurred, shall be covered with a minimum of one foot of intermediate cover.

The County is permitted (May 5, 2009) to utilize compost from the Composting Operation as a soil amendment when applying grass seed to any landfill area. See **Appendix 5** for the requirements of the use of compost on landfill slopes.

3.0 Disease Vector Control

Owners or operators of all MSWLF units must prevent or control on-site populations of disease vectors using techniques appropriate for the protection of human health and the environment. For purposes of this Item, "disease vectors" means any rodents, flies, mosquitoes, or other animals, including insects, capable of transmitting disease to humans.

At the end of every day, waste will be covered by approved daily cover. At a minimum soil will be used once a week at the end of the week's operation. Any waste that requires immediate cover will be covered immediately with soil.

In conjunction with the overall development of the White Oak Landfill, the County installed a chain-link "bear" fence.

4.0 Explosive Gases Control

Haywood County must ensure that:

i. The concentration of methane gas generated by the landfill does not exceed 25 percent of the lower explosive limit for methane in landfill structures (excluding gas control or recovery system components).

ii. The concentration of methane gas does not exceed 100 percent of the lower explosive limit for methane at the landfill property boundary.

Lower explosive limit" means the lowest percent by volume of a mixture of explosive gases in air that will propagate a flame at 25° C and atmospheric pressure.

Haywood County will implement a routine methane monitoring program to ensure that the explosive gases control standards are met. See Appendix 3 for the Explosive Gas Control Plan for Haywood County White Oak Landfill.

i. The type and frequency of monitoring must be determined based on the following factors:

   I. Soil conditions;

   II. The hydrogeologic conditions surrounding the facility;

   III. The hydraulic conditions surrounding the facility;

   IV. The location of facility structures and property boundaries.

ii. The minimum frequency of monitoring will be quarterly.

If methane gas levels exceeding the limits specified above are detected, the owner or operator will:

i. Immediately take all necessary steps to ensure protection of human health, i.e. no smoking, temporarily abandon the structure and notify the Division of Waste Management.

ii. Within seven days of detection, place in the operating record the methane gas levels detected and a description of the steps taken to protect human health; and

iii. Within 60 days of detection, implement a remediation plan for the methane gas releases, place a copy of the plan in the operating record, and notify the Division of Waste Management that the plan has been implemented.

The plan will describe the nature and extent of the problem and the proposed remedy.

5.0 Air Criteria

5.1 State Implementation Plan (SIP)

Owners or operators of all MSWLFs must ensure that the units do not violate any applicable requirements developed under a State Implementation Plan (SIP) approved or promulgated by the U.S. EPA Administrator pursuant to Section 110 of the Clean Air Act, as amended.

5.2 Open Burning of Solid Waste

Open burning of solid waste, except for the infrequent burning of land clearing debris generated on site or debris from emergency clean-up operations, as provided for in 40 CFR Part 258.24, is prohibited at all MSWLF units.

Any such infrequent burning must be approved by the Division.

5.3 Equipment to Control Accidental Fires

Earth moving equipment will be provided to control accidental fires and leachate tank trucks used for water or leachate that would be recirculated can also be used. Arrangements have been made with the local fire department to provide actual fire protection. The fire department has access at all times to the landfill to provide fire-fighting services when needed. Landfill operating personnel may use soil to isolate the fire so it will not spread any further; however, actual fighting of the fire should be the responsibility of the trained fire department.

5.4 Notification of Fires

Fires that occur at a MSWLF require verbal notice to the Division within 24 hours and written notification shall be submitted within 15 days.

6.0 Access and Safety Requirements

6.1 MSWLF shall be secured

The MSWLF shall be secured by means of gates, chains, berms, fences and other security measures approved by the Division to prevent unauthorized entry.

6.2 Attendant

An attendant shall be on duty at the site at all times while it is open for public use to ensure compliance with operational requirements.

Typically, the landfill is open Monday through Saturday from 7:30 a.m. to 3:30 p.m. However, the landfill may accept waste 24 hours a day, 7 days per week. A certified landfill operator must be present during operations.

6.3 Access Road

The access road to the site shall be of all-weather construction and maintained in good condition.

6.4 Dust Control Measures

Dust control measures shall be implemented. If dust problems should arise, the county will use any reasonable means necessary to reduce it. At a minimum the operator will spray water as necessary to prevent fugitive dust.

6.5 Site Entrance Signs

Signs providing information on dumping procedures, the hours during which the site is open for public use, the permit number and the information specified in the permit conditions shall be posted at the site entrance.

6.6 Signs Prohibiting Hazardous and Liquid waste

Signs shall be posted stating that no hazardous or liquid waste can be received.

6.7 Traffic Signs

Traffic signs or markers shall be provided as necessary to promote an orderly traffic pattern to and from the discharge area and to maintain efficient operating conditions.

6.8 Removal of Solid Waste

The removal of solid waste from the MSWLF is prohibited unless the owner or operator approves and the removal is not performed on the working face.

6.9 Barrels and Drums

Barrels and drums shall not be disposed of unless they are empty and perforated sufficiently to ensure that no liquid or hazardous waste is contained therein, except fiber drums containing asbestos.

7.0 Erosion and Sedimentation Control

Adequate sediment control measures (structures or devices), shall be utilized to prevent silt from leaving the MSWLF facility.

Adequate sediment control measures (structures or devices), shall be utilized to prevent on-site erosion.

Provisions for a vegetative ground cover sufficient to restrain erosion must be accomplished within 30 working days or 120 calendar days upon completion of any phase of MSWLF development.

8.0 Drainage Control and Water Protection Requirements

8.1 Surface Water Diversion

Surface water shall be diverted from the operational area.

8.2 Surface Water Impounded Over or In Waste

Surface water shall not be impounded over or in waste.

8.3 Solid Waste Disposal in Water

Solid waste shall not be disposed of in water.

8.4 Leachate Containment

Leachate shall be contained within a lined disposal cell or leachate collection and storage system. All leachate shall be treated, as required by the receiving facility, prior to discharge. An NPDES permit may be required prior to the discharge of leachate to surface waters, as provided by 40 CFR Parts 258.26 and 258.27. See Appendix 9.

8.5 Discharge of Pollutants into Waters of the United States

MSWLF units shall not cause a discharge of pollutants into waters of the United States, including wetlands, that violates any requirements of the Clean Water Act, including the National Pollutant Discharge Elimination System (NPDES) requirements, pursuant to Section 402.

MSWLF units shall not cause the discharge of a nonpoint source of pollution to waters of the United States, including wetlands, that violates any requirement of an area-wide or State-wide water quality management plan that has been approved under Section 208 or 319 of the Clean Water Act, as amended.

9.0 Liquids Restrictions

Bulk or non-containerized liquid waste may not be placed in MSWLF units unless:

- The waste is household waste other than septic waste and waste oil; or
- The waste is leachate or gas condensate derived from the MSWLF unit, whether it is a new or existing MSWLF unit or lateral expansion of the unit, is designed with a composite liner and leachate collection system as described within Rule .1624 of the Solid Waste Management Rules.

Containers holding liquid wastes may not be placed in the MSWLF unit unless:

- The container is a small container similar in size to that normally found in household waste;
- The container is designed to hold liquids for use other than storage; or
- The waste is household waste.

“Liquid waste” means any waste material that is determined to contain "free liquids" as defined by Method 9095 (Paint Filter Liquids Test), S.W. 846. See Appendix 7.

“Gas Condensate” means the liquid generated as a result of gas recovery processes at the MSWLF unit.

10.0 Recordkeeping Requirements

The owner or operator of a MSWLF unit must record and retain at the facility in an operating record the following information as it becomes available.

1. Inspection records, waste determination records, and training procedures per the “Waste Acceptance and Disposal Requirements” requirements;
2. Amounts by weight of solid waste received at the facility including source of generation;
3. Gas monitoring results and any remediation plans required by Item (4) of this Rule;
4. Any demonstration, certification, finding, monitoring, testing, or analytical data required by environmental monitoring rules;
5. Any monitoring, testing, or analytical data as required closure and post-closure rules
6. Any cost estimates and financial assurance documentation required by Financial Assurance rules.

All information contained in the operating record must be furnished upon request to the Division or be made available at all reasonable times for inspection by the Division.

The owner or operator must maintain a copy of the operation plan required by Rule .1625 of this Section at the facility.

11.0 Spreading and Compacting of Waste

MSWLF units shall restrict solid waste into the smallest area feasible.

The initial lift of solid waste will be placed loosely at a depth of 4 feet. Only low pressure

equipment (i.e., LGP tracked equipment) will be allowed on the protective cover or on areas that less than 4' of solid waste. As the initial lift is being placed, a spotter should be placed in the landfill to assure waste materials are not driven through the protective cover into the liner system. If an object were to penetrate the liner system, the protective cover must be removed and the penetration repaired. Heavy landfill equipment including articulating dump trucks, and compactors will only be allowed on areas that have a minimum of 4' of solid waste. Subsequent lifts constructed over area areas that have a minimum of 4' of solid waste shall be compacted as densely as practical into cells by having the compactor run over the area of solid waste a minimum of 6 times.

Methods such as fencing and diking shall be provided within the area to confine solid waste subject to be blown by the wind. At the conclusion of each day of operation, all windblown material resulting from the operation shall be collected and returned to the area by the owner or operator.

12.0 Leachate Management Plan

This Leachate Management Plan for the Haywood County White Oak MSWLF was developed in accordance with 15A NCAC 13B .1626(12) and 15A NCAC 13B .1680 of the North Carolina Solid Waste Management Regulations.

“Leachate" means a liquid that has passed through or emerged from solid waste and contains soluble, suspended, or miscible materials removed from such waste.

The LCS for the White Oak MSWLF consists of:

- Phase 1 – Phase 1 is an 11.24 acre which began receiving wastes in October of 1993. Leachate from Phase 1 flows through a gravity sewer system and discharge to the leachate storage lagoon.
- Phase 2 – Phase 2 is a 10.26 acre area granted a Permit to Operate on November 7, 2001. Leachate from Phase 1 flows through a gravity sewer system and discharge to the leachate storage lagoon.
- Phase 3 - Phase 3 is a 8.8 acres granted a Permit to Operate on May 10, 2011. Leachate from Phase 3 is collected in the Phase 3 sump located near the northern margin of Phase 3. The sump includes two side-slope riser pumping stations that will pump leachate over the northern periphery berm to a gravity sewer system prior to discharge to the leachate storage lagoon.
- Phase 4 – Phase 4 is a 4.4 acre area included as part of this Permit to Construct Application. Leachate from Phase 4 is collected in the Phase 3 sump described above.

- Phase 5 – Phase 5 is a 9.9 acre area included as part of this Permit to Construct Application. Leachate from Phase 5 is collected in the Phase 5 sump area located near the northern margin of Phase 5. The Phase 5 sump includes two side-slope riser pumping stations that will pump leachate over the northern periphery berm to a gravity sewer system prior to discharge to the leachate storage lagoon.

- Leachate Storage Lagoon. The existing leachate storage lagoon is a surface impoundment with a composite liner system located north of Phase 1. The existing leachate storage lagoon and has a total storage volume of approximately 1,017,000 gallons. Of this total storage, approximately 257,000 gallons is within the required minimum of two feet of freeboard maintained in the surface impoundment. The stage-storage table for the existing leachate storage lagoon is included in the table below.

Stage-Storage Existing Leachate Storage Lagoon				
Stage Elev. FOOT	Liquid Depth FOOT	Incremental Storage Volume GALLON	Cumulative Storage Volume GALLON	Reserve Storage Volume GALLON
2450	0	0	0	923,945
2452	2	75,787	75,787	1,105,596
2454	4	124,722	200,509	980,875
2456	6	161,224	361,733	819,651
2458	8	166,811	528,544	652,839
2460	10	178,929	707,473	473,910
2462	12	216,471	923,945	257,439[1]
2464	14	257,439	1,181,384	0

Notes:
1- A minimum of two feet of freeboard shall be maintained in the surface impoundment.

12.1 Periodic Maintenance of the LCS

The County will video inspect leachate lines annually until two years of clean lines are observed for an individual line. Periodic Jet cleaning will be performed on leachate lines that video inspections show the need for cleaning. .

The pump stations will be visually inspected for proper operation and run-time hours will be documented weekly. Documentation of the visible inspection is not required. The side-slope riser pumps shall be pulled and inspected as needed. Any worn or damaged parts will be replaced.

The leachate lagoon will be visually inspected on a monthly basis and a report generated and placed in the landfill records. The exposed leachate lagoon liner above the leachate level will be visually inspected for abrasions, possible stress cracks, or obvious punctures. The inspection report will include:

- the date the liner was inspected,
- the inspector,
- general observations since the last inspection; and,
- a summary of the current inspection.

Stress cracks may occur in wrinkles that are generated from heat expansion or contraction due to freezing. Also, the HDPE liner may deteriorate due to ultra violet light and this can appear as an abrasion where material can be scraped away with a hard object. I f any damage or possible weak spots due to ultra violet exposure are detected, a qualified HDPE installation company shall be notified immediately so that a repair patch can be installed. The leachate level shall not be allowed to exceed the depth of the damaged liner until it has been repaired and tested by the liner installation company. Once this has been accomplished, all testing documentation shall be placed in the operating records.

12.2 Estimated Volume of Liquid Generated and Recordkeeping

Table 1 in Appendix 6 presents the estimated “normal” and “peak” volume of liquid generated during development of the proposed Phase 4 and 5 of the Haywood County White Oak MSWLF.

12.2.1 Schedule for Liquid Removal

The schedule for liquid removal will be driven by the reserve storage volume required within the existing leachate storage lagoon for each stage of landfill development.

The Operator will remove leachate from the leachate storage lagoon at a rate to maintain

a typical (approximately 4 foot depth), or less, of leachate in the storage lagoon until all MSW fill areas contributing leachate to the leachate storage lagoon are covered by a minimum of 30-feet of waste. After all MSW fill areas contributing leachate to the leachate storage lagoon are covered by a minimum of 30-feet of waste, the Operator will remove leachate from the leachate storage lagoon at a rate to maintain a typical (approximately 8 foot depth), or less, of leachate in the storage lagoon.

12.2.2 Record Keeping

Haywood County will maintain records for the amount of leachate collected and transported to the wastewater treatment facility.

12.3 Semi-annual Leachate Quality Sampling

Haywood County will quality sample leachate bi-annually for Appendix I constituents, pH, BOD, COD, TDS, phosphate, nitrate, and sulfate. The sample will be obtained from the lagoon and sampled at the same time as the monitoring wells.

12.4 Description of the Final Treatment and Disposal of the Liquid Stored

Tanker trucks will transport the leachate to a discharge point at the Town of Waynesville and/or Town of Maggie Valley's wastewater treatment system.

Leachate is treated at the Town of Waynesville and/or Town of Maggie Valley's Waste Water Treatment Plant.

The leachate will have to be tested according to the pretreatment conditions outlined in the pre-treatment agreement.

12.5 Contingency Plan for Managing Unexpected Peaks in Liquid Quantities

The pumping of leachate will be on an as needed basis. During wet weather, the pump and hauling may have to be performed 24 hours a day for several days or until the leachate lagoon levels have been reduced.

Under extreme operational conditions Haywood County has the option temporarily storing leachate within the MSWLF units until such a time the flow of leachate can continue to the lagoon. If any rain or other event requires storage of leachate or storm water in the cell, the Division of Waste Management will be notified verbally and immediately followed by written communication. During wet weather, the pump and hauling may have to be performed 24 hours a day for several days until the leachate lagoon levels have been reduced.

The recirculation of leachate within the landfill is a viable alternative to the present pump

and haul leachate management operation and is considered a part of the overall Leachate Management Plan. Prior to actually beginning leachate recirculation, the County will prepare the appropriate plan for submission to and approval by the North Carolina Department of Environment and Natural Resources (NCDENR), Division of Waste Management.

Appendix 1

Waste Screening Plan

Waste Screening Plan

White Oak MSWLF

Haywood County, North Carolina

May 2016

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1.0 Introduction

The municipal solid waste stream is made up of wastes from all sectors of society. The waste is often categorized by its source or its characteristics. Terms used include commercial, industrial, residential, biomedical, hazardous, household, solid, liquid. demolition/construction, sludge, etc. Regardless of how one classifies wastes, the bottom line is that wastes are delivered to the landfill and a management decision must be made to either reject or accept them. This responsibility rests with the manager/operator of the landfill. Wastes which are not authorized to be accepted at the landfill create a number of potential problems including: (1) liability due to future releases of contaminants; (2) bad publicity if media learns of unacceptable waste entering the landfill; (3) potential for worker injury; (4) exposure to civil or criminal penalties; (5) damage to landfill environmental control systems.

2.0 HAZARDOUS WASTE REGULATIONS AND MANAGEMENT

In the United States, hazardous waste is regulated under RCRA, Subtitle C. A waste is hazardous if it is listed as a hazardous waste by the Administrator of the Environmental Protection Agency (EPA) in the Code of Federal Regulations, Title 40, Part 261, or if it meets one or more of the hazardous waste criteria as defined by EPA. These criteria are:

- Ignitability
- Corrosivity
- Reactivity
- Toxicity

2.1 Ignitability

Ignitable waste is a waste that burns readily, causes a fire by friction under normal circumstances, or is an oxidizer. Any waste having a flash point of <140 deg F falls in this category. Flash point is that temperature at which a liquid gives off vapors that will ignite when an open flame is applied. Under Department of Transportation (DOT) definitions, a flammable liquid has a flash point of>100 F. A combustible liquid has a flash point between 100 and 200 deg F. Therefore, a flammable liquid is always hazardous while a combustible liquid mayor may not be hazardous depending upon its flash point.

2.2 Corrosivity

A corrosive waste is one having a very high or a very low pH. The pH of a liquid is a measure of how acidic or basic (alkaline) the material is. The pH scale ranges from 0 to 14. High numbers are basic and low numbers are acidic. A substance having a pH ≤ 2.0 or ≥ 12.5 is defined as hazardous under RCRA.

2.3 Reactivity

A waste is reactive if it is normally unstable: reacts violently with water; forms an explosive mixture with water; contains quantities of cyanide or sulfur that could be released to the air; or can easily be detonated or exploded. These wastes may fall into anyone of several DOT categories.

2.4 Toxicity Characteristic Leaching Procedure (TCLP)

A waste is TCLP toxic if the concentration of any constituent in Table 1 exceeds the standard assigned to that substance. The TCLP is a methodology which attempts to simulate the conditions within a landfill. An acidic solution is passed through a sample of waste and the resultant "leachate" is analyzed for contaminants. The TCLP is designed to detect heavy metals, pesticides and a few other organic and inorganic compounds. The purpose of the test is to prevent groundwater contamination by highly toxic materials. TCLP tests the mobility of 40 different elements and compounds.

Except in certain specified circumstances, regulated quantities of hazardous waste must be disposed of at a permitted hazardous waste disposal facility. In accordance with 40 CFR Part 26 1.3, **any material contaminated by a hazardous waste is also deemed to be a hazardous waste and must be managed as such.** Hazardous waste from conditionally exempt small quantity generators are to be disposed of in a Hazardous waste disposal facility. RCRA permits are also required to store, transport, and treat hazardous waste.

3.0 POLYCHLORINATED BIPHENYL'S (PCBs)

PCBs are nonflammable and conduct heat without conducting electricity. These compounds were most frequently used as an additive to oil or other liquids in situations where heat was involved. The PCBs enhance the heat conducting properties of the liquid and thereby increase the heat dissipation or cooling effect obtained. They have also been used in lubricants and paint. In the United States one of the most common applications was in electric transformers. The only effective method for destroying PCBs is high Temperature incineration which is relatively expensive due to a shortage of PCB incineration capacity.

TABLE 1

T.C.I.P CONSITIUENTS & REGULATORY LEVELS (mg/L)			
CONSTITUENT	REG LEVEL	CONSTITUENT	REG LEVEL
Arsenic	5.0	Hexachlorobenzene	0.13
Barium	100	Hexachloro-1,3-	0.5
Benzene	0.5	Hexachloroethane	3.0
Cadmium	1.0	Lead	5.0
Carbon Tetrachloride	0.5	Lindane	0.4
Chlordane	0.03	Mercury	0.2
Chlorobenzene	100	Methoxychlor	10.
Chloroform	6.0	Methyl ethyl ketone	200
Chromium	5.0	Nitrobenzene	2.0
m-Cresol	200	Pentachlorophenol	100
o-Cresol	200	Pyridine	5.0
p-Cresol	200	Selenium	1.0
Cresol	200	Silver	5.0
1,4-Dichlorobenzene	10.0	Tetrachloroethylene	0.7
1,2-Dichloroethane	0.7	Toxaphene	0.5
1,1-Dichloroethylene	0.5	Trichloroethylene	0.5
2,4-Dichlorophenoxyacetic	0.7	2,4,5-Trichlorophenol	400
2,4-Dinitrotoluene	0.13	2,4,6-Trichlorophenol	2.0
Endrin	0.02	2,4,5-TP (Silvex)	1.0
Heptachlor (and its	0.008	Vinyl Chloride	0.2

By law PCB's are no longer used as dielectrics in transformers and capacitors manufactured after 1979. There are many millions of pounds of PCBs still in use or in storage. One example is the ballasts used in fluorescent light fixtures. It has been estimated that there are between 0.5 million and 1.5 billion ballasts currently in use in this country. Due to the long life of these units, about half of these may be of pre-1979 manufacture and contain PCBs. Since each ballast contains about one ounce of nearly pure PCB fluid, there are about **20 to 30 million pounds** of PCBs in existing lighting fixtures. These items are not subject to RCRA Subtitle D Waste Screening!

Commercial or industrial sources of PCB wastes that should be addressed by the program include:

- Mineral oil and dielectric fluids containing PCBs;
- Contaminated soil, dredged material, sewage sludge, rags, and other debris from a release of PCBs;
- Transformers and other electrical equipment containing dielectric fluids; and
- Hydraulic machines

3.1 PCB Regulatory Requirements

As contrasted to hazardous wastes, the Toxic Substance Control Act regulates PCBs based on the concentration of PCBs in the waste rather than the source or characteristic of the waste. The regulations concerning PCB disposal are spelled out in 40 CFR Pan 761. Subtitle D of RCRA merely requires that PCB waste not be disposed in a MSW landfill. PCB management requirements include:

Waste containing more than 500 ppm of PCBs must be incinerated. Waste containing from 50 to 500 ppm must be disposed of by incineration. approved burning, or in chemical waste landfill permitted to receive such wastes. The regulations are silent concerning wastes containing less than 50 ppm of PCBs; however, the regulations cannot be circumvented by diluting stronger wastes.

4.0 FUNDAMENTALS OF WASTE SCREENING

4.1 Know Your Generators and Haulers

Since the level of sophistication of your waste screening program will be a reflection of the likelihood of hazardous waste and PCB waste being in your incoming waste, **knowledge of the commercial industrial base of your service area is critical.** Some examples are the automotive industry, which generates solvents, paint wastes, lead acid batteries, grease and oil; the dry cleaning industry, which may generate filters containing dry cleaning solvents; metal platers which generate heavy metal wastes; and other

industries which generate a variety of undesirable wastes; e.g. chemical and related products, petroleum refining, primary metals, electrical and electronic machinery, etc.

Landfill managers/operators should also know the haulers and trucks serving the businesses in their community which are likely to carry unacceptable wastes.

Some local governments and solid waste management agencies have enacted legislation requiring haulers to provide a manifest showing the customers whose wastes make up that particular load. Such a manifest is an extremely useful tool when a load is found to contain prohibited wastes. It is unwise to accept wastes from unknown, unlicensed, or otherwise questionable haulers.

4.2 Inspections

An inspection is typically a visual observation of the incoming waste loads by an individual who is trained to identify regulated hazardous or PCB wastes that would not be acceptable for disposal at the MSWLF unit. The training of landfill personnel will be conducted by a local EMS official or a SWANA certification. An inspection is considered satisfactory if the inspector knows the nature of all materials received in the load and is able to discern whether the materials are potentially regulated hazardous wastes or PCB wastes.

Ideally, all loads should be screened; however, it is generally not practical to inspect in detail all incoming loads. Random inspections, therefore, can be used to provide a reasonable means to adequately control the receipt of inappropriate wastes. Random inspections are simply inspections made on less than every load. At a minimum the inspection frequency will not be less than one percent of the waste stream.

The frequency of random inspections may be based on the type and quantity of wastes received daily, and the accuracy and confidence desired in conclusions drawn from inspection observations. Because statistical parameters are not provided in the regulation, a reasoned, knowledge-based approach may be taken. A random inspection program may take many forms such as inspecting every incoming load one day out of every month or inspecting one or more loads from transporters of wastes of unidentifiable nature each day. If these inspections indicate that unauthorized wastes are being brought to the MSWLF site, the random inspection program should be modified to increase the frequency of inspections.

Inspection priority also can be given to haulers with unknown service areas, to loads brought to the facility in vehicles not typically used for disposal of municipal solid waste, and to loads transported by previous would-be offenders. For wastes of unidentifiable nature received from sources other than households (e.g., industrial or commercial establishments), the inspector should question the transporter about the

source/composition of the materials.

Loads may be inspected on the tipping floor at the Processing Facility prior to actual disposal of the waste at the working face of the landfill unit to provide the County the opportunity to refuse or accept the wastes.

An inspection flow chart to identify, accept, or refuse solid waste is provided as Figure 1.

Inspections of materials may be accomplished by discharging the vehicle load in an area designed to contain potentially hazardous wastes that may arrive at the facility. The waste should be carefully spread for observation using a front end loader or other piece of equipment. The Division of Waste Management recommends that waste should be hand raked to spread the load. Personnel should be trained to identify suspicious wastes. Some indications of suspicious wastes are:

- Hazardous placards or markings;
- Liquids;
- Powders or dusts;
- Sludges;
- Bright or unusual colors;
- Drums or commercial size containers; or
- Chemical odors.

Haywood County will follow these procedures when suspicious wastes are discovered.

- Segregate the wastes;
- Question the driver;
- Review the manifest (if applicable);
- Contact possible source;
- Call the State Solid Waste Management Department;
- Use appropriate protective equipment;
- Contact laboratory support if required; and
- Notify the local Hazardous Material Response Team.

Containers with contents that are not easily identifiable, such as unmarked 55-gallon drums, should be opened only by properly trained personnel. Because these drums could contain hazardous waste, they should be refused whenever possible. Upon verifying that the solid waste is acceptable, it may then be transferred to the working face for disposal.

Testing typically would include the Toxicity Characteristic Leaching Procedure (TCLP) and other tests for characteristics of hazardous wastes including corrosivity, ignitability, and reactivity. Wastes that are suspected of being hazardous should be handled and stored as a hazardous waste until a determination is made.

If the wastes temporarily stored at the site are determined to be hazardous, Haywood County is responsible for the management of the waste. If the wastes are to be transported from the facility, the waste must be: (1) stored at the MSWLF facility in accordance with requirements of a hazardous waste generator, (2) manifested, (3) transported by a licensed Treatment, Storage, or Disposal (TSD) facility for disposal.

5.0 RECORD KEEPING AND NOTIFICATION REQUIREMENTS

Records must be kept pursuant to an incident where regulated hazardous waste or prohibited waste is found at the landfill. It is also recommended that records be kept of all screening activities and incidents, whether or not, regulated or prohibited wastes are found. This will help prove that the landfill owner/operator has acted in a prudent and reasonable manner.

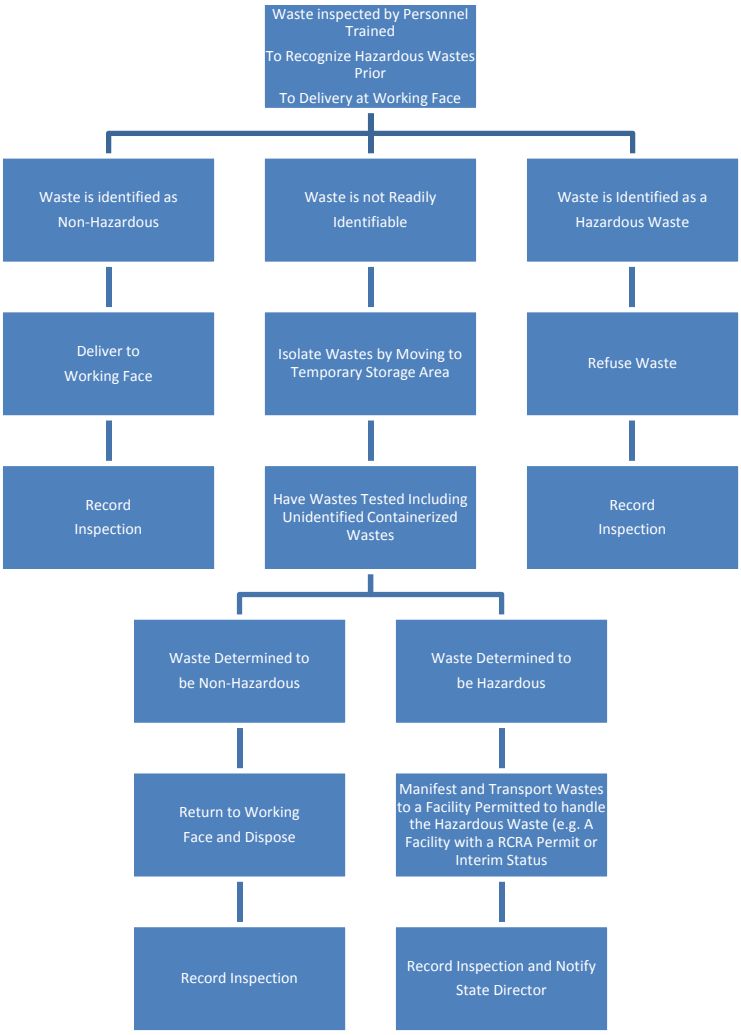
The best way to prove compliance with this requirement is to document each inspection including:

- Date and time of waste detection
- Hauler name (company and driver)
- Waste(s) detected
- Waste generator(s) if able to identity
- Action(s) taken to manage or return material(s)
- Efforts taken if extreme toxicity or hazard was discovered
- Landfill employee in responsible charge

40 CFR Part 258 requires that records should be maintained at or near the landfill site during its active life and as long after as may be required by the appropriate state or local regulations.

FIGURE 1

Hazardous Waste Inspection Decision Tree
Inspection Prior to Working Face



WASTE SCREENING CHECK LIST

CONTAINERS	**YES**	**NO**
FULL	_____	_____
PARTIALLY FULL	_____	_____
CRUSHED	_____	_____
PUNCTURED	_____	_____
POWDERS/DUSTS		
IDENTIFIED	_____	_____
UNKNOWN	_____	_____
SATURATION	_____	_____
LABEL/HAZARDOUS	_____	_____
ODOR/FUMES		
STRONG	_____	_____
FAINT	_____	_____
HEAT	_____	_____
ITEMS FOUND		
BATTERIES	_____	_____
OIL	_____	_____
BIOMEDICAL	_____	_____
RADIOACTIVE	_____	_____
ASHES/RESIDUE	_____	_____
SOD/SOIL	_____	_____
LIQUID	_____	_____
HAZARDOUS	_____	_____
PCB’S	_____	_____

CHECK ALL THAT APPLY

DETAILED SCREENING REPORT

WASTE SOURCE _____
ADDRESS _____
_____
_____

PROBABLE [ ] SUSPECTED [ ] CONFIRMED [ ]

WASTE HAULER _____
ADDRESS _____
_____
_____

DRIVER'S NAME _____
DETAIL _____
_____
_____

NOTIFIED:

WASTE SOURCE [ ] HAULING MANAGEMENT [ ] SITE MANAGEMENT [ ]

STATE [ ] FEDERAL [ ]

_____
NAME_____
WITNESS (IF ANY) _____
DATE_____ TIME_____ [ ]AM [ ]PM

ACTION REQUIRED

_____
_____
_____
_____
_____

Appendix 2

Haywood County Synthetic Cover Operation Plan and Demonstration Report

Synthetic Cover Operation Plan

White Oak MSWLF

Haywood County, North Carolina

May 2016

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NC FIRM C-2910

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1.0 Introduction

Haywood County has been approved to use Landfill/Synthetic Tarp Systems as Alternate Daily Cover (ADC) in lieu of six-inches (6") of soil cover. The tarps are pulled over the working face at the end of the day as described in the Operations section below. Variables affecting the use of the tarps include the location within the landfill and weather conditions (i.e., wet conditions, wind, etc.). The tarps are not generally used when the working face is near the permanent or temporary slopes because soil cover is used in these areas. The use of the tarps allow for a seamless integration from one day to the next.

2.0 Synthetic Cover Operation

1. At the end of each day of operations, the horizontal or lateral expansion of the working face will be covered with at least six (6) inches of earthen and/or soil/mulch material. The working face will be maintained at a minimum of a 4:1 slope and compacted to reach maximum waste density possible to minimize the size of the working face; preserve landfill space; and deter wind-blown litter. An ADC synthetic cover may be used in place of soil at the discretion of the landfill operator. At the end of the operating day, 50' x 50', 6.5 oz/sq.ft. tarps will be pulled over the slope of the working face. The tarp will cover all exposed portions of the working face, and the corners and sides of the tarp will be weighted with dirt, small stones, sandbags, tires with rims or other measures to prevent the wind from exposing any waste. At the beginning of the next operating day, the tarp will be carefully removed from the working face and stored in an adjacent area to the working face.

2. The proposed ADC will consist of at least three (3) Landfill Tarp systems. Each tarp will be approximately 50' x 50' in size, and 6.5-8.5 oz/sq.ft. The tarp is constructed of a woven polypropylene that is puncture, tear and U.V. resistant. The synthetic cover is shipped to the landfill site with panels folded accordion-type, and rolled up. Unroll the cover along the working face (depending upon operations), and attach the leading edge of the unrolled panel to existing landfill equipment with ropes (i.e., to the top of the blade).

3. Pull the sewn panels of cover across the compacted trash. The synthetic cover maybe pulled from any direction, which may vary from day to day. Keep the leading edge between the two machines (or people) as high as possible to eliminate drag.

4. Anchor the edges of synthetic cover at least every 20 feet with dirt, small stones, tires (with rims intact or filled with concrete), sandbags or other measures to hold the synthetic cover in place. If it is windy, more anchoring may be required.

5. On the next day of operations, remove the anchor system. Simply pull the synthetic cover across itself (to reduce drag) and off the refuse to an area that is inactive. Anchor the edges again to prevent wind from lifting the blanket. At the end of the day, pull the synthetic cover back across the refuse by repeating steps 3 and 4 until a new panel is needed.

The Synthetic Cover is designed to be used as landfill daily cover on a working face. For best results, it is recommended that the area to be covered be kept as close to a square shape as possible. Not only does this procedure allow for easier coverage, it allows for better management of the working face and saves time at the end of the working day.

Should the need arise, Haywood County will continue to use the plastic panel cover that is currently approved to cover the working face of stacked bales. At the end of the working day, the plastic panel will be secured in place similar to the proposed 6.5-oz. Synthetic Cover.

The working face is operated in this manner, brought to an intermediate grade and then covered with the required soil. The process will continue until a lift is completed. The process is then started over on the next lift until the landfill is filled to final grade and a section is closed. At a minimum six (6) inches of soil cover will be used once a week at the end of the week's operation.

3.0 Tips to Remember

1. Always pull the fabric across itself during installation and removal to make each panel last as long as possible.
2. Avoid driving on the panel(s) as this may cause punctures and tears.
3. Tie the panel(s) to the top of the dozer blade and raise the blade to minimize dragging on refuse.
4. Use tires (tires must be filled with concrete or include rims), sandbags, dirt, small stones or other measures to hold the panel(s) down overnight.
5. Minimize stress between dozer/compactors while pulling on the panel(s).

Appendix 3

Explosive Gas Control Plan For Haywood County White Oak Landfill

Explosive Gas Control Plan

White Oak MSWLF

Haywood County, North Carolina

May 2016

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1.0 Introduction

Quarterly the Haywood County landfill will monitor for methane and other explosive landfill gases within the landfill structures and at the landfill gas monitoring wells, as shown on attached Figure 1.

2.0 Permanent Landfill Gas Monitoring Wells

The permanent landfill gas monitoring wells (monitoring well) will consist of a plastic stand pipe similar to a piezometer used for groundwater detection. A typical permanent landfill gas monitoring well is detailed in the attached Figure 2. The permanent probe will be constructed at a minimum depth of six (6) feet. A minimum 6" diameter hole will contain a one (1) inch slotted PVC pipe. The bottom two (2) feet will be backfilled with non-carbonate pea gravel with a bentonite seal one (1) foot thick above it. The remaining three (3) feet will be backfilled with in situ soils. The one (1) inch PVC pipe will be approximately three (3) feet above the existing grade. The PVC pipe will be capped with a one (I) inch PVC cap, one quarter (1/4) inch NPT hose barb, and 1" tubing, plugged or capped to prevent contamination. A minimum four inch (4”) diameter schedule 40 PVC sleeve or aluminum/steel prefabricated well cover will be placed over the one inch (1”) pipe and filled with clean masonry sand to within four inches (4”) of the one inch (1”) schedule 40 PVC cap. The top of the PVC pipe sleeve or prefabricated well cover will be secured with a removable water tight cap. Where necessary, a marker post will be placed in close proximity to the landfill gas monitoring well. A permanent well I.D. will be placed/painted on the marker post or the well cover.

3.0 Landfill Gas Monitoring Locations

The migration of methane and other explosive landfill gases (landfill gas) is induced by pressure gradients. The landfill gases will move from areas of high pressure to those of low pressure following the path of least resistance. Landfill gas will generally migrate vertically until it reaches the landfill surface where it may begin to flow horizontally until it finds a pathway out through the permeable in situ soils or a landfill gas venting/extraction system. Given that Haywood County’s landfill is designed with a synthetic membrane base liner system there should be no landfill gas migration into or through the subsurface permeable in situ soils. The final cap system, once designed and installed, will also contain a synthetic membrane liner system with a landfill gas venting/extraction system. This type of cap system will also prevent the migration of landfill gas into or through the surrounding permeable in situ soils.

Since methane, a component of landfill gas, is lighter than air, it wants to escape into the atmosphere. Experience has shown that whenever gas is migrating no matter what the spacing or depth of the monitoring probes, the gas will fill the void created by the

monitoring well and an explosive gas detection meter will monitor the level of concentration. The six foot depth of the monitoring wells is to ensure a stable monitoring point. The only time a shallow monitoring well has not worked is in a very heavy, impermeable clay layer that acts as a seal to the migration of the gas. If a clay layer is encountered during the construction of a monitoring well, it will either be moved beyond the clay or excavated to a depth that is in the conductive zone below the clay.

The location and spacing of the landfill gas monitoring wells are strategically located in accordance with the approved Permit To Operate, White Oak Municipal Solid Waste Landfill and the Permit To Construct, Municipal Solid Waste Landfill Phase 3, Permit No. 44-07, dated October 7, 2009, Document I.D. 8720.

4.0 Landfill Gas Monitoring Equipment

The landfill gas can be detected by use of an instrument that reports the percent of lower explosive limit (% LEL) and the methane gas concentration (% CH4). The instrument being used is the LandGEM 2000.

5.0 Landfill Gas Monitoring Observations

Quarterly, a County employee or contractor for the County will visit

Each landfill gas monitoring well will be monitored quarterly. The County is also required to perform quarterly monitoring at all existing and future on-site structures. Currently, the on-site structures include the Maintenance Building and the Scale House. Each structure will be monitored for explosive landfill gas using the following general protocol:

1. All crawl spaces, if applicable, will be monitored;
2. All corners in the structure, if accessible, will be monitored;
3. Any observed holes, cracks and/or pipe penetrations through the foundation will be monitored;

Using the detection instrument, he/she will determine if landfill gas is present in the monitoring well and/or structures. Observations for the landfill gas monitoring wells AND for the on-site structures will be recorded on the attached form titled “Landfill Gas Measurements Field Worksheet, White Oak MSW Landfill, Haywood County, North Carolina”.

6.0 Landfill Gas Detection in Wells

If landfill gas is present and the level is detected at or above the lower explosive limit (100% LEL), it must then be determined if the landfill gas is migrating or has migrated beyond that particular monitoring well. If it is determined that explosive landfill gas has or may have migrated beyond the particular monitoring well then additional steps may be

implemented to delineate the extent of any suspected landfill gas migration. If it is determined that explosive landfill gas has or may have migrated across the landfill boundary then the facility will immediately take all necessary steps to ensure protection of human health. The North Carolina Department of Environment and Natural Resources (NCDENR) will be notified. Within seven (7) days of detection, the methane gas levels detected and a description of the steps taken to protect human health will be placed in the operating record. Within 60 days of the detection of suspected landfill gas migration at or beyond the landfill boundary, the County will prepare and implement a remediation plan for the suspected landfill gas releases. A copy of the remediation plan will be placed in the operating record and the NCDENR will be notified that the plan has been implemented. Resampling of the affected landfill gas monitoring wells will be performed as necessary to evaluate the effectiveness of the approved remediation plan.

7.0 Landfill Gas Detection in Structures

If methane gas is detected above 25% of its lower explosive limit (25% LEL) in any structure, excluding gas control or gas recovery system components, the monitoring technician will verify the field calibration of the detection instrument in accordance with the manufacturer's instructions and the structure will be resampled. If the reading is still above 25% LEL, evacuate the building and take all steps necessary to protect human health. The North Carolina Department of Environment and Natural Resources (NCDENR) will be notified as well as the Haywood County Solid Waste Director. Within seven (7) days of initial detection, the methane gas levels detected and a description of the steps taken to protect human health will be placed in the operating record. Upon taking the necessary safety precautions, attempt to determine the source of the explosive gas. If the source is found, initiate repairs to prevent re-infiltration of the landfill gas or remove the source. If the source of the landfill gas infiltration cannot be easily determined and/or promptly corrected then the structure must be closed and marked to prevent further occupancy. The County will then prepare and implement a remediation plan for the suspected landfill gas releases within sixty (60) days of initial detection. A copy of the remediation plan will be placed in the operating record and the NCDENR will be notified that the plan has been implemented. The structure will remain closed for occupancy until such time as the repairs and/or remediation plan have been implemented and the structure retested for the presence of landfill gas concentrations. The structure will be reopened for occupancy once the landfill gas concentrations are below the 25% LEL concentration.

Appendix 4

Mulching and Grinding Treatment and Processing Operations Plan

Mulching and Grinding Treatment and Processing Plan

White Oak MSWLF

Haywood County, North Carolina

May 2016

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5.7 Zoning 5

1.0 Introduction

This operations plan has been developed for the proposed Mulching and Grinding Treatment and Processing Facility located at the White Oak Landfill in Haywood County, North Carolina. This plan has been prepared in accordance with the requirements of the North Carolina Department of Environmental Quality (NCDEQ), Division of Waste Management, Solid Waste Rules (15A NCAC 13B).

The purpose of this plan is to provide the owner and operator with a reference manual that includes necessary information, procedures, and applicable rules for properly operating the Treatment & Processing Facility. All personnel involved with the management or supervision of operations at the facility will be required to review the Operations Plan and to maintain the facility in conformance with applicable requirements. A copy of the Operations Plan will be kept in the vicinity of the Mulching and Grinding Treatment and Processing Facility at all times.

2.0 Facility Location

The Mulching and Grinding Treatment and Processing Facility is located at the White Oak Landfill at 3898 Fines Creek Road, Waynesville, North Carolina 28785 and is operated by Haywood County. The Treatment and Processing Facility is currently located south of the Phase 2 MSW Landfill and east of the Phase 1 Construction/Demolition Landfill. However, the Treatment and Processing Facility may change to another on-site location pending approval from the NCDEQ, Division of Waste Management.

3.0 Service Area

The Mulching and Grinding Treatment and Processing Facility will provide service for all of the approved service area.

4.0 Siting Requirements

Siting requirements are described as follows:

1. The proposed Treatment and Processing Facilities are not located in the 100-year floodplain.
2. A 50-foot buffer between all property lines and the treatment and processing areas is maintained.
3. A 25-foot buffer shall be maintained between material stockpiles and berms and swales to allow for access of fire-fighting equipment.
4. A 200-foot buffer is maintained between treatment and processing facilities

and residences.

5. A 100-foot buffer is maintained between treatment and processing facilities and water supply wells.
6. Haywood County has no zoning requirements for the treatment and processing site property.
7. Diversion berms and drainage ditches are designed to ensure that there will be no standing water in the treatment and processing area and there will be no off-site drainage problems and also to divert runoff from processing areas to sediment basins.
8. An all-weather gravel access road to the site will be kept passable at all times.
9. An erosion control permit submittal for the site was provided to the NCDEQ-DWM.
10. Site screening of the treatment and processing site is not required.
11. Access to the treatment and processing facility is controlled by properly trained employees.
12. The area has diversion berms leading to a sediment basin. Both the ditches and the sediment basin can be utilized to control runoff from a potential fire.
13. An aerial photo illustrating the area within one-fourth mile of the site was submitted to NCDENR in the “White Oak Landfill MSWLF Site Study”, dated November 4, 1998.

5.0 Operations Procedures

The Mulching and Grinding Treatment and Processing Facility will consist of approximately 2.0 acres. Mulched material will be used as a part of the soil/mulch Alternate Daily Cover material approved on May 5, 2009. The soil/mulch ADC will be used on the MSW Landfill and in wet areas of gravel access roads. The soil/mulch ADC will be mixed with soil at a 3:1 soil/mulch ratio. A description of the procedures used for creating the soil/mulch ADC are included in Section 3(b) of the White Oak MSW Landfill Operations Plan. A portion of the mulched material may be used as a bulking agent in the adjacent composting facility.

Normal working hours for the Mulching and Grinding Treatment and Processing Facility will be in accordance with the Facility operating hours.

5.1 Personnel

The facility is owned by Haywood County and operated by Santek Environmental of North Carolina, LLC. Santek will provide the employees required for the daily operation of the Mulching and Grinding Treatment and Processing Facility. These employees are properly trained in safety procedures and the inspection of incoming wastes. Training material published by the Solid Waste Association of North America (SWANA) is utilized for initial training of on-site personnel and for continuing education. The employees also direct and coordinate the movement of collection vehicles into and out of the Mulching and Grinding Treatment and Processing Facility.

5.2 Technical Operational Requirements

On or before August 1st of each year, the owner or operator shall report to the North Carolina Solid Waste Section, for the previous year beginning July 1st and ending June 30th, the amount by weight of the solid waste that was received and processed at the facility and/or disposed of in a landfill, reused, recycled, or converted to fuel. To the maximum extent practicable, such reports shall indicate by weight the county of origin of all solid waste. The owner or operator shall transmit a copy of the report to the county in which the facility is located and to each county from which waste originated.

The following operational criteria shall be met at the Mulching and Grinding Treatment and Processing Facility:

1) Only clean unpainted untreated wood and brush will be used in the mulching process, including pallets.
2) Those items specified as “yard trash” as defined in Section .0101(55) of the Solid Waste Rules may not be included in the Mulching operation. Yard trash includes those materials resulting from landscaping and yard maintenance, such as brush, grass, tree limbs, and similar vegetative material.
3) Mulched materials will be removed from the site as needed.
4) Sludges may not be included in mulched materials.
5) Neither hazardous waste nor asbestos containing waste shall be accepted at the mulching facility.
6) Household hazardous waste shall not be accepted at the mulching facility.
7) The Mulching and Grinding Treatment and Processing Facility shall not

allow uncontrolled public access.

8) Alternate daily coverage materials will include only those materials specified as suitable for mulching, as described in C 1-6 herein.

9) Only clean, unpainted masonry, concrete, and asphalt may be ground for use as road base and ditch lining material.

10) Open burning of solid waste is prohibited.

11) Arrangements with the local fire protection agency to immediately provide fire-fighting services when needed is required (see Section F below).

12) Personnel training shall be provided to insure that all employees are trained in site specific safety, remedial, and corrective action procedures.

13) Signs providing information on waste that can be received, dumping procedures, the hours during which the site is open for public use, the permit number and other pertinent information shall be posted at the site entrance.

14) The County uses a multi-level waste screening procedure, as outlined in Appendix 1 of the White Oak MSW Landfill Operations Plan. Waste haulers are directed by the scale attendant to the appropriate disposal location. Also on site is the appropriate signage directing haulers to the correct disposal drop-off points, with information pertaining the types of allowable materials for each unit of the White Oak MSWLF. Additionally, landfill personnel are on-site to further inspect waste loads. In the event that inappropriate materials are disposed at the Mulching and Grinding Treatment and Processing Facility, these materials shall be segregated from the appropriate mulching materials and then disposed in the correct landfill unit.

5.3 Traffic Control

Access to the Mulching and Grinding Treatment and Processing Facility is controlled by properly trained employees who are located at the entrance of the facility. As vehicles arrive at the Mulching and Grinding Treatment and Processing Facility, site personnel will direct the driver to position the vehicle at the correct unloading location. When the contents of the vehicle are emptied, the driver is instructed to move the vehicle away from the Treatment and Processing area.

5.4 Housekeeping, Litter, and Vector Control

Incoming wastes will be transported to the Mulching and Grinding Treatment and

Processing Facility in covered or enclosed vehicles. Outgoing transfer trailers will also be covered or enclosed. Throughout the day and at the end of each working day, facility personnel will police the area for litter. Mosquitoes and rodents shall be controlled so as to protect the public health and welfare.

5.5 Fire Control

In the event that a fire occurs, the local authorities will be notified immediately. The telephone numbers of local fire, police, ambulance and hospital facilities are posted in and around the facility at all times. Additionally, the White Oak Landfill facility keeps a water tank truck on site at all times. In the event of a fire at the facility the DENR will be verbally notified within 24 hours and written notification will be submitted within 15 days.

5.6 Storm Water Management and Erosion Control

Standard erosion control practices, such as a sediment basin, silt fencing, vegetating slopes, and diversion ditches will be utilized at the site. Runoff from the processing area will be diverted through ditches to a sediment basin prior to discharge off the property.

5.7 Zoning

Haywood County has no zoning requirements for the Treatment and Processing Site property. A detailed discussion of the zoning requirements for Haywood County is included in the “White Oak Landfill, MSWLF Site Study”, dated November 4, 1998.

Appendix 5

Composting Operations Plan

Small Type 2
Compost Operations Plan

White Oak MSWLF

Haywood County, North Carolina

May 2016

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5.7 Zoning 5

1.0 Introduction

This operations plan has been developed for the proposed Small Type 2 Composting Facility located at the White Oak Landfill in Haywood County, North Carolina. This plan has been prepared in accordance with the requirements of the North Carolina Department of Environment, and Natural Resources (DENR), Division of Waste Management, Solid Waste Rules (15A NCAC 13B).

The purpose of this plan is to provide the owner and operator with a reference manual that includes necessary information, procedures, and applicable rules for properly operating the Composting Facility. All personnel involved with the management or supervision of operations at the facility will be required to review the Operations Plan and to maintain the facility in conformance with applicable requirements. A copy of the Operations Plan will be kept in the vicinity of the Composting Site at all times

2.0 Facility Location

The Small Type 2 Composting Facility is located at the White Oak Landfill at 3898 Fines Creek Road, Waynesville, North Carolina 28785 and is operated by Haywood County.

3.0 Service Area

The Composting Facility will provide service for all of the approved service area.

4.0 Siting Requirements

The proposed composting facility site is located south of the Phase 2 MSW cell and east of the Phase 1 Construction & Demolition cell. Siting requirements are described as follows:

1. The proposed Composting Facility is not located in the 100-year floodplain.
2. A 200-foot buffer is maintained between the composting facility and all residences.
3. A 100-foot buffer is maintained between the compositing facility and water supply wells.
4. A 50-foot buffer is maintained between all property lines and the composting facility.
5. A 25-foot minimum distance between compost areas and swales or berms will be maintained in order to allow for adequate access of fire-fighting equipment.
6. Haywood County has no zoning requirements for the composting site

property.

7. Diversion berms and drainage ditches are designed to ensure that there will be no standing water in the composting area and there will be no off-site drainage problems and also to divert runoff from composting areas to sediment basins.
8. A 50-foot minimum buffer between perennial streams and the compost area will be maintained.
9. An all-weather gravel access road to the site will be kept passable at all times.
10. An erosion control permit submittal for the site is pending and a copy of the permit will be sent to NCDENR-DWM prior to commencing grading of the site.
11. The depth from the composting pad to the seasonal high water table shall be maintained at least 24 inches.
12. Portions of the site used for waste receipt and storage, active composting, and curing shall have a soil texture finer than loamy sand, soils which are in abundance at the White Oak Landfill.
13. Access to the composting facility is controlled by properly trained employees.
14. The site will have diversion berms and ditches leading to two sediment control structures. Both the ditches and the sediment control structures can be utilized to control runoff from a potential fire.
15. An aerial photo illustrating the area within one-fourth mile of the site was submitted to NCDENR-DWM in the “White Oak Landfill MSWLF Site Study”, dated November 4, 1998.

5.0 Operations Procedures

The Small Type 2 Composting Site will consist of an area of approximately 1.5 acres where composting will take place. The County may use culls from pre-consumer agricultural activities as a material source for the composting operation. Additionally, there may be clean wood materials available at the landfill for composting as a result of the grinding operation. However, these materials will be typically mulched and used elsewhere rather than become available for composting. The County has been approved to use the compost as a soil amendment to facilitate the establishment of vegetative cover. The rate of compost used will be determined as the compost is developed and the

chemical constituency of the material is known.

Haywood County will use existing landfill equipment to manage and turn windrows of composting material.

Normal working hours for the Composting Site will be in accordance with the Facility operating hours.

5.1 Personnel

The facility is owned by Haywood County and operated by Santek Environmental of North Carolina, LLC. Santek will provide the employees required for the daily operation of the Composting Site. These employees are properly trained in safety procedures and the inspection of incoming wastes. Training material published by the Solid Waste Association of North America (SWANA) is utilized for initial training of on-site personnel and for continuing education. The employees also direct and coordinate the movement of collection vehicles into and out of the Composting Site.

5.2 Technical Operational Requirements

On or before August 1st of each year, the owner or operator shall report to the North Carolina Solid Waste Section, for the previous year beginning July 1st and ending June 30th, the amount by weight of the solid waste that was received and processed at the facility and/or disposed of in a landfill, recycled or reused. To the maximum extent practicable, such reports shall indicate by weight the county of origin of all solid waste. The owner or operator shall transmit a copy of the report to the county in which the facility is located and to each county from which waste originated.

The following operational criteria shall be met at the Composting Site:

1) Small Type 2 Composting Facilities shall process or store less than 1,000 cubic yards of material for composting per quarter, and occupy less than two acres of land.

2) Type 2 composting facilities may receive pre-consumer meat-free food processing waste, vegetative agricultural waste, source separated paper or other source separated specialty wastes, which are low in pathogens and physical contaminants

3) Waste acceptable for a Type 1 facility may be composted at a Type 2 facility. Type 1 wastes include yard and garden waste, silvicultural waste, untreated and unpainted wood waste or any combination thereof.

4) Sludges may not be included in a Type 2 Composting Facility.

5) Neither hazardous waste nor asbestos containing waste shall be accepted at the composting facility.

6) Household hazardous waste shall not be accepted at the composting facility.

7) The composting site shall not allow uncontrolled public access.

8) Compost shall be maintained at or above 104 degrees Fahrenheit for 14 days or longer and the average temperature for that time shall be higher than 113 degrees Fahrenheit. The temperature of all compost produced shall be monitored sufficiently to ensure that the pathogen reduction criteria is met. The data shall be recorded on the form included in the Appendices.

9) Nitrogen bearing wastes shall be incorporated as necessary to minimize odor and the migration of nutrients.

10) The finished compost shall meet the classification and distribution requirements outlined in Rule 15A NCAC 13B.1407 of the Solid Waste Regulations.

11) Open burning of solid waste is prohibited.

12) Arrangements with the local fire protection agency to immediately provide fire-fighting services when needed is required (see Section F below).

5.3 Traffic Control

Access to the Composting Site is controlled by properly trained employees who are located at the entrance of the landfill. As vehicles arrive at the Composting Site, site personnel will direct the driver to position the vehicle at the correct unloading location. When the contents of the vehicle are emptied, the driver is instructed to move the vehicle away from the Composting Site. Traffic signs/markers shall be provided as necessary to promote an orderly traffic pattern to and from the discharge area and to maintain efficient operation conditions.

5.4 Housekeeping, Litter, and Vector Control

Incoming wastes will be transported to the Composting Site in covered or enclosed vehicles. Outgoing transfer trailers will also be covered or enclosed. Throughout the day and at the end of each working day, facility personnel will police the area for litter. Mosquitoes and rodents shall be controlled so as to protect the public health and welfare.

5.5 Fire Control

In the event that a fire occurs, the local authorities will be notified immediately. The

telephone numbers of local fire, police, ambulance and hospital facilities are posted in and around the facility at all times. Additionally, the White Oak Landfill facility keeps a water tank truck on site at all times. In the event of a fire at the facility the NCDENR will be notified within 24 hours and written notification will be submitted within 15 days.

5.6 Storm Water Management and Erosion Control

Standard erosion control practices, such as a sediment basin, silt fencing, vegetating slopes, and diversion ditches will be utilized at the site. Runoff from the composting areas will be diverted to an existing sediment basin and a proposed sediment trap.

5.7 Zoning

Haywood County has no zoning requirements for the Scrap Tire Collection Site property. A detailed discussion of the zoning requirements for Haywood County is included in the "White Oak Landfill, MSWLF Site Study", dated November 4, 1998.

Composting Operations Data Log

Windrow Date of Formation:_____
(if more than one windrow is formed on the same date, add A,B,C designator. Note location of windrows for future identification. Add weight of materials if known.)

Materials used and source: _____

_____

Date	Temperature Noted	Date	Temperature Noted

Observations:_____

_____

_____

Materials used and source: _____

_____

Date	Temperature Noted	Date	Temperature Noted

Observations:_____

_____

_____

Appendix 6

Estimated Volume of Liquid Generated in the MSWLF Unit

Table 1 - A
Phase 1 - 3 Operational
Estimated Volume of Leachate Generated
Phase 4 and 5 Permit to Construct
Haywood County White Oak MSWLF

Landfill Phase	Total Drainage Area (ac)	MSW Depth (ft)	Percent Phase at MSW Depth (%)	Area at MSW Depth (ac)	Normal Daily Perculation Thru Waste (In/Day)	Normal Daily Leachate Generation Rate (gpapd)	Normal Monthly Leachate Generation (gal)	Peak Perculation Thru Waste (In/Day)	Peak Daily Leachate Generation Rate (gpapd)	Peak Daily Leachate Generation Rate (gpd)
Phase 1 - 2	21.5	>30'	100%	21.5	0.015	407	262,699	0.210	5,702	122,593
Phase 3	8.8	>30'	100%	8.8	0.015	407	107,524	0.210	5,702	50,178
Phase 4A	1.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 4A	0.0		Total 4A	0		Total 4A	0
Phase 4B	1.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 4B	0.0		Total 4B	0		Total 4B	0
Phase 4C	1.3	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 4B	0.0		Total 4B	0		Total 4B	0
			Sump 3 DA	8.8		Sump 3 Monthly Flow	107,524		Sump 3 Max Daily Flow	50,178
									Pumping Peaking Factor	1
						Sump 3 Avg. Pumping GPM	2.5		Sump 3 Pump Rate GPM	34.8
Phase 5A	2.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5A	0.0		Total 5A	0		Total 5A	0
Phase 5B	2.2	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5B	0.0		Total 5B	0		Total 5B	0
Phase 5C	2.5	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5C	0.0		Total 5C	0		Total 5C	0
Phase 5D	2.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5D	0.0		Total 5D	0		Total 5D	0
			Sump 5 DA	0.0		Sump 5 Monthly Flow	0		Sump 5 Max Daily Flow	0
									Pumping Peaking Factor	2
						Sump 5 Avg. Pumping GPM	0.0		Sump 5 Pump Rate GPM	0.0
						Total Gal. to Leachate Pond	370,223		Total Gal. to Leachate Pond	172,771

Table 1 - B
Phase 1 - 4A Operational
Estimated Volume of Leachate Generated
Phase 4 and 5 Permit to Construct
Haywood County White Oak MSWLF

Landfill Phase	Total Drainage Area (ac)	MSW Depth (ft)	Percent Phase at MSW Depth (%)	Area at MSW Depth (ac)	Normal Daily Perculation Thru Waste (In/Day)	Normal Daily Leachate Generation Rate (gpapd)	Normal Monthly Leachate Generation (gal)	Peak Perculation Thru Waste (In/Day)	Peak Daily Leachate Generation Rate (gpapd)	Peak Daily Leachate Generation Rate (gpd)
Phase 1 - 2	21.5	>30'	100%	21.5	0.015	407	262,699	0.210	5,702	122,593
Phase 3	8.8	>30'	100%	8.8	0.015	407	107,524	0.210	5,702	50,178
Phase 4A	1.6	<10'	100%	1.6	0.132	3,584	172,038	0.470	12,762	20,419
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 4A	1.6		Total 4A	172,038		Total 4A	20,419
Phase 4B	1.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 4B	0.0		Total 4B	0		Total 4B	0
Phase 4C	1.3	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 4B	0.0		Total 4B	0		Total 4B	0
			Sump 3 DA	10.4		Sump 3 Monthly Flow	279,561		Sump 3 Max Daily Flow	70,596
									Pumping Peaking Factor	1
						Sump 3 Avg. Pumping GPM	6.5		Sump 3 Pump Rate GPM	49.0
Phase 5A	2.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5A	0.0		Total 5A	0		Total 5A	0
Phase 5B	2.2	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5B	0.0		Total 5B	0		Total 5B	0
Phase 5C	2.5	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5C	0.0		Total 5C	0		Total 5C	0
Phase 5D	2.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5D	0.0		Total 5D	0		Total 5D	0
			Sump 5 DA	0.0		Sump 5 Monthly Flow	0		Sump 5 Max Daily Flow	0
									Pumping Peaking Factor	2
						Sump 5 Avg. Pumping GPM	0.0		Sump 5 Pump Rate GPM	0.0
						Total Gal. to Leachate Pond	542,261		Total Gal. to Leachate Pond	193,189

Table 1 - C
Phase 1 - 4B Operational
Estimated Volume of Leachate Generated
Phase 4 and 5 Permit to Construct
Haywood County White Oak MSWLF

Landfill Phase	Total Drainage Area (ac)	MSW Depth (ft)	Percent Phase at MSW Depth (%)	Area at MSW Depth (ac)	Normal Daily Perculation Thru Waste (In/Day)	Normal Daily Leachate Generation Rate (gpapd)	Normal Monthly Leachate Generation (gal)	Peak Perculation Thru Waste (In/Day)	Peak Daily Leachate Generation Rate (gpapd)	Peak Daily Leachate Generation Rate (gpd)
Phase 1 - 2	21.5	>30'	100%	21.5	0.015	407	262,699	0.210	5,702	122,593
Phase 3	8.8	>30'	100%	8.8	0.015	407	107,524	0.210	5,702	50,178
Phase 4A	1.6	<10'	10%	0.2	0.132	3,584	17,204	0.470	12,762	2,042
		10' > 30'	20%	0.3	0.046	1,249	11,990	0.270	7,331	2,346
		>30'	70%	1.1	0.015	407	13,685	0.210	5,702	6,386
			Total 4A	1.6		Total 4A	42,879		Total 4A	10,774
Phase 4B	1.6	<10'	100%	1.6	0.132	3,584	167,737	0.470	12,762	19,908
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 4B	1.6		Total 4B	167,737		Total 4B	19,908
Phase 4C	1.3	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 4B	0.0		Total 4B	0		Total 4B	0
			Sump 3 DA	12.0		Sump 3 Monthly Flow	318,139		Sump 3 Max Daily Flow	80,860
									Pumping Peaking Factor	1
						Sump 3 Avg. Pumping GPM	7.4		Sump 3 Pump Rate GPM	56.2
Phase 5A	2.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5A	0.0		Total 5A	0		Total 5A	0
Phase 5B	2.2	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5B	0.0		Total 5B	0		Total 5B	0
Phase 5C	2.5	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5C	0.0		Total 5C	0		Total 5C	0
Phase 5D	2.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5D	0.0		Total 5D	0		Total 5D	0
			Sump 5 DA	0.0		Sump 5 Monthly Flow	0		Sump 5 Max Daily Flow	0
									Pumping Peaking Factor	2
						Sump 5 Avg. Pumping GPM	0.0		Sump 5 Pump Rate GPM	0.0
						Total Gal. to Leachate Pond	580,839		Total Gal. to Leachate Pond	203,453

Table 1 - D
Phase 1 - 4C Operational
Estimated Volume of Leachate Generated
Phase 4 and 5 Permit to Construct
Haywood County White Oak MSWLF

Landfill Phase	Total Drainage Area (ac)	MSW Depth (ft)	Percent Phase at MSW Depth (%)	Area at MSW Depth (ac)	Normal Daily Perculation Thru Waste (In/Day)	Normal Daily Leachate Generation Rate (gpapd)	Normal Monthly Leachate Generation (gal)	Peak Perculation Thru Waste (In/Day)	Peak Daily Leachate Generation Rate (gpapd)	Peak Daily Leachate Generation Rate (gpd)
Phase 1 - 2	21.5	>30'	100%	21.5	0.015	407	262,699	0.210	5,702	122,593
Phase 3	8.8	>30'	100%	8.8	0.015	407	107,524	0.210	5,702	50,178
Phase 4A	1.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	100%	1.6	0.015	407	19,550	0.210	5,702	9,123
			Total 4A	1.6		Total 4A	19,550		Total 4A	9,123
Phase 4B	1.6	<10'	10%	0.2	0.132	3,584	16,774	0.470	12,762	1,991
		10' > 30'	20%	0.3	0.046	1,249	11,691	0.270	7,331	2,287
		>30'	70%	1.1	0.015	407	13,343	0.210	5,702	6,227
			Total 4B	1.6		Total 4B	41,807		Total 4B	10,505
Phase 4C	1.3	<10'	100%	1.3	0.132	3,584	137,630	0.470	12,762	16,335
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 4B	1.3		Total 4B	137,630		Total 4B	16,335
			Sump 3 DA	13.2		Sump 3 Monthly Flow	306,510		Sump 3 Max Daily Flow	86,140
									Pumping Peaking Factor	1.5
						Sump 3 Avg. Pumping GPM	7.1		Sump 3 Pump Rate GPM	89.7
Phase 5A	2.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5A	0.0		Total 5A	0		Total 5A	0
Phase 5B	2.2	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5B	0.0		Total 5B	0		Total 5B	0
Phase 5C	2.5	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5C	0.0		Total 5C	0		Total 5C	0
Phase 5D	2.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5D	0.0		Total 5D	0		Total 5D	0
			Sump 5 DA	0.0		Sump 5 Monthly Flow	0		Sump 5 Max Daily Flow	0
									Pumping Peaking Factor	2.0
						Sump 5 Avg. Pumping GPM	0.0		Sump 5 Pump Rate GPM	0.0
						Total Gal. to Leachate Pond	569,210		Total Gal. to Leachate Pond	208,734

Table 1 - E
Phase 1 - 5A Operational
Estimated Volume of Leachate Generated
Phase 4 and 5 Permit to Construct
Haywood County White Oak MSWLF

Landfill Phase	Total Drainage Area (ac)	MSW Depth (ft)	Percent Phase at MSW Depth (%)	Area at MSW Depth (ac)	Normal Daily Perculation Thru Waste (In/Day)	Normal Daily Leachate Generation Rate (gpapd)	Normal Monthly Leachate Generation (gal)	Peak Perculation Thru Waste (In/Day)	Peak Daily Leachate Generation Rate (gpapd)	Peak Daily Leachate Generation Rate (gpd)
Phase 1 - 2	21.5	>30'	100%	21.5	0.015	407	262,699	0.210	5,702	122,593
Phase 3	8.8	>30'	100%	8.8	0.015	407	107,524	0.210	5,702	50,178
Phase 4A	1.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	100%	1.6	0.015	407	19,550	0.210	5,702	9,123
			Total 4A	1.6		Total 4A	19,550		Total 4A	9,123
Phase 4B	1.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	100%	1.6	0.015	407	19,061	0.210	5,702	8,895
			Total 4B	1.6		Total 4B	19,061		Total 4B	8,895
Phase 4C	1.3	<10'	10%	0.1	0.132	3,584	13,763	0.470	12,762	1,633
		10' > 30'	20%	0.3	0.046	1,249	9,592	0.270	7,331	1,877
		>30'	70%	0.9	0.015	407	10,948	0.210	5,702	5,109
			Total 4B	1.3		Total 4B	34,303		Total 4B	8,619
			Sump 3 DA	13.2		Sump 3 Monthly Flow	180,437		Sump 3 Max Daily Flow	76,815
									Pumping Peaking Factor	1
						Sump 3 Avg. Pumping GPM	4.2		Sump 3 Pump Rate GPM	53.3
Phase 5A	2.6	<10'	100%	2.6	0.132	3,584	283,862	0.470	12,762	33,691
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5A	2.6		Total 5A	283,862		Total 5A	33,691
Phase 5B	2.2	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5B	0.0		Total 5B	0		Total 5B	0
Phase 5C	2.5	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5C	0.0		Total 5C	0		Total 5C	0
Phase 5D	2.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5D	0.0		Total 5D	0		Total 5D	0
			Sump 5 DA	2.6		Sump 5 Monthly Flow	283,862		Sump 5 Max Daily Flow	33,691
									Pumping Peaking Factor	2
						Sump 5 Avg. Pumping GPM	6.6		Sump 5 Pump Rate GPM	46.8
						Total Gal. to Leachate Pond	726,999		Total Gal. to Leachate Pond	233,099

Table 1 - F
Phase 1 - 5B Operational
Estimated Volume of Leachate Generated
Phase 4 and 5 Permit to Construct
Haywood County White Oak MSWLF

Landfill Phase	Total Drainage Area (ac)	MSW Depth (ft)	Percent Phase at MSW Depth (%)	Area at MSW Depth (ac)	Normal Daily Perculation Thru Waste (In/Day)	Normal Daily Leachate Generation Rate (gpapd)	Normal Monthly Leachate Generation (gal)	Peak Perculation Thru Waste (In/Day)	Peak Daily Leachate Generation Rate (gpapd)	Peak Daily Leachate Generation Rate (gpd)
Phase 1 - 2	21.5	>30'	100%	21.5	0.015	407	262,699	0.210	5,702	122,593
Phase 3	8.8	>30'	100%	8.8	0.015	407	107,524	0.210	5,702	50,178
Phase 4A	1.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	100%	1.6	0.015	407	19,550	0.210	5,702	9,123
			Total 4A	1.6		Total 4A	19,550		Total 4A	9,123
Phase 4B	1.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	100%	1.6	0.015	407	19,061	0.210	5,702	8,895
			Total 4B	1.6		Total 4B	19,061		Total 4B	8,895
Phase 4C	1.3	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	100%	1.3	0.015	407	15,640	0.210	5,702	7,299
			Total 4B	1.3		Total 4B	15,640		Total 4B	7,299
			Sump 3 DA	13.2		Sump 3 Monthly Flow	161,774		Sump 3 Max Daily Flow	75,495
									Pumping Peaking Factor	1
						Sump 3 Avg. Pumping GPM	3.7		Sump 3 Pump Rate GPM	52.4
Phase 5A	2.6	<10'	10%	0.3	0.132	3,584	28,386	0.470	12,762	3,369
		10' > 30'	20%	0.5	0.046	1,249	19,784	0.270	7,331	3,871
		>30'	70%	1.8	0.015	407	22,580	0.210	5,702	10,537
			Total 5A	2.6		Total 5A	70,750		Total 5A	17,777
Phase 5B	2.2	<10'	100%	2.2	0.132	3,584	233,326	0.470	12,762	27,693
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5B	2.2		Total 5B	233,326		Total 5B	27,693
Phase 5C	2.5	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5C	0.0		Total 5C	0		Total 5C	0
Phase 5D	2.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5D	0.0		Total 5D	0		Total 5D	0
			Sump 5 DA	4.8		Sump 5 Monthly Flow	304,076		Sump 5 Max Daily Flow	45,470
									Pumping Peaking Factor	2
						Sump 5 Avg. Pumping GPM	7.0		Sump 5 Pump Rate GPM	63.2
						Total Gal. to Leachate Pond	728,550		Total Gal. to Leachate Pond	243,558

Table 1 - G
Phase 1 - 5C Operational
Estimated Volume of Leachate Generated
Phase 4 and 5 Permit to Construct
Haywood County White Oak MSWLF

Landfill Phase	Total Drainage Area (ac)	MSW Depth (ft)	Percent Phase at MSW Depth (%)	Area at MSW Depth (ac)	Normal Daily Perculation Thru Waste (In/Day)	Normal Daily Leachate Generation Rate (gpapd)	Normal Monthly Leachate Generation (gal)	Peak Perculation Thru Waste (In/Day)	Peak Daily Leachate Generation Rate (gpapd)	Peak Daily Leachate Generation Rate (gpd)
Phase 1 - 2	21.5	>30'	100%	21.5	0.015	407	262,699	0.210	5,702	122,593
Phase 3	8.8	>30'	100%	8.8	0.015	407	107,524	0.210	5,702	50,178
Phase 4A	1.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	100%	1.6	0.015	407	19,550	0.210	5,702	9,123
			Total 4A	1.6		Total 4A	19,550		Total 4A	9,123
Phase 4B	1.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	100%	1.6	0.015	407	19,061	0.210	5,702	8,895
			Total 4B	1.6		Total 4B	19,061		Total 4B	8,895
Phase 4C	1.3	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	100%	1.3	0.015	407	15,640	0.210	5,702	7,299
			Total 4B	1.3		Total 4B	15,640		Total 4B	7,299
			Sump 3 DA	13.2		Sump 3 Monthly Flow	161,774		Sump 3 Max Daily Flow	75,495
									Pumping Peaking Factor	1
						Sump 3 Avg. Pumping GPM	3.7		Sump 3 Pump Rate GPM	52.4
Phase 5A	2.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	100%	2.6	0.015	407	32,257	0.210	5,702	15,053
			Total 5A	2.6		Total 5A	32,257		Total 5A	15,053
Phase 5B	2.2	<10'	10%	0.2	0.132	3,584	23,333	0.470	12,762	2,769
		10' > 30'	20%	0.4	0.046	1,249	16,262	0.270	7,331	3,182
		>30'	70%	1.5	0.015	407	18,560	0.210	5,702	8,661
			Total 5B	2.2		Total 5B	58,155		Total 5B	14,612
Phase 5C	2.5	<10'	100%	2.5	0.132	3,584	272,034	0.470	12,762	32,287
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5C	2.5		Total 5C	272,034		Total 5C	32,287
Phase 5D	2.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5D	0.0		Total 5D	0		Total 5D	0
			Sump 5 DA	7.3		Sump 5 Monthly Flow	362,446		Sump 5 Max Daily Flow	61,953
									Pumping Peaking Factor	2
						Sump 5 Avg. Pumping GPM	8.4		Sump 5 Pump Rate GPM	86.0
						Total Gal. to Leachate Pond	786,920		Total Gal. to Leachate Pond	260,040

Table 1 - H
Phase 1 - 5D Operational
Estimated Volume of Leachate Generated
Phase 4 and 5 Permit to Construct
Haywood County White Oak MSWLF

Landfill Phase	Total Drainage Area (ac)	MSW Depth (ft)	Percent Phase at MSW Depth (%)	Area at MSW Depth (ac)	Normal Daily Perculation Thru Waste (In/Day)	Normal Daily Leachate Generation Rate (gpapd)	Normal Monthly Leachate Generation (gal)	Peak Perculation Thru Waste (In/Day)	Peak Daily Leachate Generation Rate (gpapd)	Peak Daily Leachate Generation Rate (gpd)
Phase 1 - 2	21.5	>30'	100%	21.5	0.015	407	262,699	0.210	5,702	122,593
Phase 3	8.8	>30'	100%	8.8	0.015	407	107,524	0.210	5,702	50,178
Phase 4A	1.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	100%	1.6	0.015	407	19,550	0.210	5,702	9,123
			Total 4A	1.6		Total 4A	19,550		Total 4A	9,123
Phase 4B	1.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	100%	1.6	0.015	407	19,061	0.210	5,702	8,895
			Total 4B	1.6		Total 4B	19,061		Total 4B	8,895
Phase 4C	1.3	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	100%	1.3	0.015	407	15,640	0.210	5,702	7,299
			Total 4B	1.3		Total 4B	15,640		Total 4B	7,299
			Sump 3 DA	13.2		Sump 3 Monthly Flow	161,774		Sump 3 Max Daily Flow	75,495
									Pumping Peaking Factor	1
						Sump 3 Avg. Pumping GPM	3.7		Sump 3 Pump Rate GPM	52.4
Phase 5A	2.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	100%	2.6	0.015	407	32,257	0.210	5,702	15,053
			Total 5A	2.6		Total 5A	32,257		Total 5A	15,053
Phase 5B	2.2	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	100%	2.2	0.015	407	26,514	0.210	5,702	12,373
			Total 5B	2.2		Total 5B	26,514		Total 5B	12,373
Phase 5C	2.5	<10'	10%	0.3	0.132	3,584	27,203	0.470	12,762	3,229
		10' > 30'	20%	0.5	0.046	1,249	18,960	0.270	7,331	3,710
		>30'	70%	1.8	0.015	407	21,639	0.210	5,702	10,098
			Total 5C	2.5		Total 5C	67,803		Total 5C	17,037
Phase 5D	2.6	<10'	100%	2.6	0.132	3,584	274,185	0.470	12,762	32,542
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	0%	0.0	0.015	407	0	0.210	5,702	0
			Total 5D	2.6		Total 5D	274,185		Total 5D	32,542
			Sump 5 DA	9.9		Sump 5 Monthly Flow	400,759		Sump 5 Max Daily Flow	77,005
									Pumping Peaking Factor	2
						Sump 5 Avg. Pumping GPM	9.3		Sump 5 Pump Rate GPM	80.2
						Total Gal. to Leachate Pond	825,232		Total Gal. to Leachate Pond	275,093

Table 1 - I
Phase 1 - 5E Operational
Estimated Volume of Leachate Generated
Phase 4 and 5 Permit to Construct
Haywood County White Oak MSWLF

Landfill Phase	Total Drainage Area (ac)	MSW Depth (ft)	Percent Phase at MSW Depth (%)	Area at MSW Depth (ac)	Normal Daily Perculation Thru Waste (In/Day)	Normal Daily Leachate Generation Rate (gpapd)	Normal Monthly Leachate Generation (gal)	Peak Perculation Thru Waste (In/Day)	Peak Daily Leachate Generation Rate (gpapd)	Peak Daily Leachate Generation Rate (gpd)
Phase 1 - 2	21.5	>30'	100%	21.5	0.015	407	262,699	0.210	5,702	122,593
Phase 3	8.8	>30'	100%	8.8	0.015	407	107,524	0.210	5,702	50,178
Phase 4A	1.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	100%	1.6	0.015	407	19,550	0.210	5,702	9,123
			Total 4A	1.6		Total 4A	19,550		Total 4A	9,123
Phase 4B	1.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	100%	1.6	0.015	407	19,061	0.210	5,702	8,895
			Total 4B	1.6		Total 4B	19,061		Total 4B	8,895
Phase 4C	1.3	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	100%	1.3	0.015	407	15,640	0.210	5,702	7,299
			Total 4B	1.3		Total 4B	15,640		Total 4B	7,299
			Sump 3 DA	13.2		Sump 3 Monthly Flow	161,774		Sump 3 Max Daily Flow	75,495
									Pumping Peaking Factor	1
						Sump 3 Avg. Pumping GPM	3.7		Sump 3 Pump Rate GPM	52.4
Phase 5A	2.6	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	100%	2.6	0.015	407	32,257	0.210	5,702	15,053
			Total 5A	2.6		Total 5A	32,257		Total 5A	15,053
Phase 5B	2.2	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	100%	2.2	0.015	407	26,514	0.210	5,702	12,373
			Total 5B	2.2		Total 5B	26,514		Total 5B	12,373
Phase 5C	2.5	<10'	0%	0.0	0.132	3,584	0	0.470	12,762	0
		10' > 30'	0%	0.0	0.046	1,249	0	0.270	7,331	0
		>30'	100%	2.5	0.015	407	30,913	0.210	5,702	14,426
			Total 5C	2.5		Total 5C	30,913		Total 5C	14,426
Phase 5D	2.6	<10'	10%	0.3	0.132	3,584	27,418	0.470	12,762	3,254
		10' > 30'	20%	0.5	0.046	1,249	19,110	0.270	7,331	3,739
		>30'	70%	1.8	0.015	407	21,810	0.210	5,702	10,178
			Total 5D	2.6		Total 5D	68,339		Total 5D	17,171
			Sump 5 DA	9.9		Sump 5 Monthly Flow	158,023		Sump 5 Max Daily Flow	59,024
									Pumping Peaking Factor	2
						Sump 5 Avg. Pumping GPM	3.7		Sump 5 Pump Rate GPM	82.0
						Total Gal. to Leachate Pond	582,496		Total Gal. to Leachate Pond	257,112

Appendix 7

Open Cell Condition Operations Plan

Open Cell Condition Operations Plan

White Oak MSWLF

Haywood County, North Carolina

May 2016

GARRETT & MOORE
Engineering for the Power and Waste Industries

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NC FIRM C-2910

With regards to Statute 130A-295.6, the following criteria applies:

"A leachate collection system shall be designed to return the head of the liner to 30 centimeters or less within 72 hours. The design shall be based on the precipitation that would fall on an empty cell of the sanitary landfill as a result of the 25-year 24-hour storm event."

The following operational requirements shall be adhered to in order to comply with criteria stated:

1. Upon nearing the completion of Phase 3, the operator shall reserve airspace in Phase 3 equal to or greater than the airspace required to place an initial 10-foot lift of waste across Phase 4.
2. The reserve airspace will be designated as a "wet area" and will be used while filling operations are coinciding with rainfall.
3. Upon completion of construction of Phase 4, the operator shall install a rain cover over the entire phase. The rain cover shall prevent rainfall from entering the leachate collection system.
4. The operator shall implement temporary pumps as necessary to pump accumulated rainfall from the rain cover to a point outside of the landfill area.
5. The initial lift of waste in Phase 4 shall be placed only during dry weather.
6. The rain cover shall be in place at all time, preventing rainfall from contacting waste and entering the leachate collection system.

In summary, no waste fill operations will occur in Phase 4 during rainfall, until a 10-foot lift of waste is placed across the entire Phase 4. Phase 3 wet area shall be used at all times if rainfall occurs during this interim period.

The same procedures will apply to Phase 5 operations.

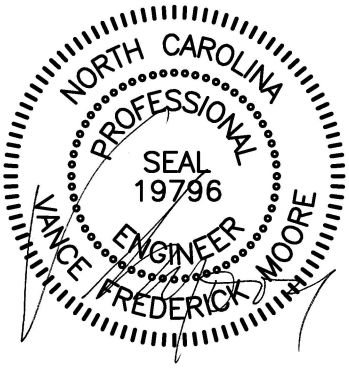
The operational requirements stated will result in the head on the liner at less than 30 centimeters within 72 hours based on the precipitation that would fall on an empty cell of the sanitary landfill as a result of the 25-year, 24 hour storm event.

Closure and Post-Closure Plan

Haywood County White Oak MSWLF

Haywood County, North Carolina

June 2016



June 20, 2016

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Table 1 – Engineer's Opinion of Closure Cost
Table 2 - Engineer's Opinion of Post-closure Cost

Closure and Post-closure Plan

This Closure and Post-closure Plan Report for the White Oak MSWLF was developed in accordance with 15A NCAC 13B .1627 of the North Carolina Solid Waste Management Regulations. This plan establishes criteria for the closure of all MSWLF units and subsequent requirements for post-closure compliance.

1.0 Closure Plan

Standards are established for the scheduling and documenting closure of all MSWLF units, and designing the cap system.

1.1 Description of the Final Cap System

With regard to cap system for all MSWLF units, 15A NCAC 13B .1627 (c)(2) states: The Division may approve an alternative cap system if the owner or operator can adequately demonstrate the following:

(A) The alternative cap system will achieve an equivalent or greater reduction in infiltration as the low-permeability barrier specified in Subparagraph (1) of this Paragraph; and

(B) The erosion layer will provide equivalent or improved protection as the erosion layer specified in Subparagraph (3) of this Paragraph.

The proposed final cap system consists of the following components (from lowest to highest):

(1) The cap foundation consisting of a minimum thickness of 12 inches of compacted soil over the placed waste materials.

(2) A leachate breakout and gas venting or collection system consisting of strips of geocomposite drainage layer consisting of geonet bonded on both sides with a non-woven geotextile fabric to minimize pressures exerted on the low-permeability barrier. The leachate breakout and gas venting and/or collection layer will be constructed in a non-continuous grid pattern.

(3) A 40-mil Linear Low-density Polyethylene (LLDPE) textured geomembrane.

(4) A geocomposite drainage layer consisting of geonet bonded on both sides with a non-woven geotextile fabric.

(5) A minimum of 42 inches of earthen material that is capable of sustaining native plant growth. The final cover surface will be vegetated upon completion of the final cover installation according to the project seeding specifications

(6) Surface water control devices including terrace berms and downdrain pipes.

(7) Vertical LFG extraction wells and lateral extraction wells (where feasible).

The proposed final cap systems is proposed to be constructed with post-settlement surface slopes shall be a minimum of five percent and a maximum of 3.5:1.

Construction quality assurance requirements for final cover system components can be found in CQA Plan. Final cover system details are shown on the Engineering Drawings.

1.2 Maximum Area Open

The Haywood County White Oak MSWLF has a permitted limits of waste area of 75.1 acres and has a total available net airspace capacity of 9,380,078 cubic yards for the disposal of wastes as measured from the bottom of waste to the top of the intermediate cover layer. Please note, waste disposal operations began October 1993. As of May 4, 2015, approximately 1,956,473 cubic yards of the total available net airspace capacity had been consumed.

The largest area requiring closure at any time will be the entire Phase 1 - 7 Area with a total area of 75.1-acre.

1.3 Maximum Inventory of Wastes

The Haywood County White Oak MSWLF has a permitted limits of waste area of 75.1 acres and has a total available net airspace capacity of 9,380,078 cubic yards for the disposal of wastes as measured from the top of the drainage/protective cover layer to top of the intermediate cover layer. Please note, waste disposal operations began October 1993. As of May 4, 2015, approximately 1,956,473 cubic yards of the total available net airspace capacity had been consumed.

The maximum inventory of wastes on-site over the active life of the landfill facility is the entire Phase 1 - 7 area is estimated with a total capacity of 9,380,078 cubic yards for the disposal of wastes as measured from the top of the drainage/protective cover layer to top of the intermediate cover layer.

1.4 Schedule for Completing All Closure Activities

1.4.1 Initiating Closure

The owner and operator must begin closure activities for that portion of each MSWLF unit meeting one or more of the following requirements, unless an extension has been granted by the Division. Extensions beyond the deadline for beginning closure may be granted by the Division if the owner or operator demonstrates that the portion of the MSWLF unit has the capacity to receive additional wastes and the owner and operator has taken and will continue to take all steps necessary to prevent threats to human health and the environment from the unclosed MSWLF unit:

(A) No later than 30 days after the date on which the MSWLF unit receives the known final receipt of wastes;

(B) No later than one year after the most recent receipt of wastes, if the MSWLF unit has remaining capacity.

Prior to beginning closure of each MSWLF unit as specified above, an owner or operator must notify the Division that a notice of the intent to close the unit has been placed in the operating record.

1.4.2 Completion of Closure

The owner and operator of all MSWLF units must complete closure activities of each MSWLF unit in accordance with the closure plan within 180 days following the beginning of closure as specified in Subparagraph (5) of this Paragraph. Extensions of the closure period may be granted by the Division if the owner or operator demonstrates that closure will, of necessity, take longer than 180 days and they have taken and will continue to take all steps to prevent threats to human health and the environment from the unclosed MSWLF unit.

1.4.3 Notification of Closure Completion

Following closure of each MSWLF unit, the owner or operator must notify the Division that a certification, signed by the project engineer verifying that closure has been completed in accordance with the closure plan, has been placed in the operating record.

1.4.4 Recordation of Closure

Following closure of all MSWLF units, the owner or operator must record a notation on the deed to the landfill facility property at the local county Register of Deeds office, or some other instrument that is normally examined during title search, and notify the Division that the notation has been recorded and a copy has been placed in the operating record.

The notation on the deed shall in perpetuity notify any potential purchaser of the property that the land has been used as a MSWLF unit or facility and its use is restricted under the closure plan approved by the Division.

1.5 Cost Estimate for Closure

A copy of the Closure Estimate is included in Table 1.

2.0 Post-Closure Plan

2.1 Description of the Monitoring and Maintenance Activities

Following closure of each MSWLF unit, the responsible party will monitor and provide

maintenance activities for the closed unit over the 30 year post-closure period. Condition of the facility will be recorded with notes, maps, and photographs. A report of findings, including recommendations for actions deemed necessary to ensure the site continues to meet the post-closure performance standard will be made to the responsible party and will be placed in the operating record.

If corrective actions are required to ensure the site continues to meet the post-closure performance standard, a report of any corrective actions undertaken and certifications by a registered engineer the closure plan has been followed will be placed in the operating record.

Following completion of the post-closure care period for each MSWLF unit, the owner or operator shall notify the Division that a certification, signed by a registered professional engineer, verifying that post-closure care has been completed in accordance with the post-closure plan, has been placed in the operating record.

2.1.1 Cap System

The cap system will be inspected twice per year.

The vegetative cover will be trimmed at least two times a year.

Fertilization and/or compost will be applied annually, or as needed.

Maintaining the integrity and effectiveness of any cap system, including making repairs to the cover as necessary to correct the effects of settlement, subsidence, erosion, or other events, and preventing run-on and run-off from eroding or otherwise damaging the cap system.

2.1.2 Leachate Collection System

The leachate collection and removal pipes will be video-inspected annually and/or cleaned on an as-needed basis.

The leachate will also be sampled semi-annually to determine the quality and constituents present. Leachate will be analyzed for Appendix 1 constituents as well as BOD, COD, phosphate, nitrate, sulfate, and pH.

Haywood County or the Landfill Operator shall complete the Leachate Storage Closure activities outlined in this plan within 180 days after liquid collection has ceased, as follows:

A. At Leachate Storage Closure, the liner and all solid waste shall be removed from the lagoon and connecting lines. The lagoon liner and all solid waste removed shall be properly handled and disposed of according to Federal and State requirements. All connecting lines shall be disconnected and securely capped or plugged.

B. The leachate storage lagoon site will be modified to act as a stormwater management feature.

2.1.3 Groundwater and Surface Water

Surface and ground water testing will occur semiannually or as directed by the Division of Waste Management, Solid Waste Section.

2.1.4 Gas Monitoring System

Explosive gas monitoring will occur on a quarterly basis according to the procedural outline contained in the Landfill Gas Monitoring Plan.

2.2 Responsible Person Contact

All correspondence and questions concerning the post-closure care of the unit should be directed to:

Haywood County Solid Waste Department
278 Recycle Road
Clyde, North Carolina 28786
Telephone (828) 627-8042

2.3 Planned Uses During the Post-closure Period

Preliminary proposals for the planned use of the facility, following Closure and During the Post-closure period includes developing exercise and bike trails along the periphery of the landfill property and a light industry associated with the combustion of methane gas. Any alternate use of the landfill after closure has been completed will be approved by the Division of Waste Management, Solid Waste Section prior to implementation.

2.4 Financial Assurance

A copy of the Post Closure Estimate is included in Table 2.

TABLE 1
ENGINEER'S OPINION OF COSTS
CLOSURE
HAYWOOD COUNTY WHITE OAK MSWLF

Max Area Open **74.1** **Acres**

Item	Description	Estimated Quantity	Unit	Unit Price FY '16 $'s	Extended Total FY '16 $'s	Cost per Acre	Comments
1	Surveys and Layout	74.1	AC	$ 250.00	$ 18,525	$ 250	G&M Historic Estimate
2	Traffic Control	-	HR	$ 75.00	$ -	$ -	25 hrs/Ac
3	Temporary Erosion Controls	74.1	AC	$ 1,000.00	$ 74,100	$ 1,000	G&M Historic Estimate
4			Subtotal - Misc Items		$ 92,625	$ 1,250	$1,250 per acre
5	Fine-Grade Intermediate Cover	74.1	AC	$ 2,000.00	$ 148,200	$ 2,000	G&M Historic Estimate
6	Excavate & Landfill Waste Material	3,705	CY	$ 10.00	$ 37,050	$ 500	50 CY / Acre Closure
7	Geogrid Fabric for Foundation Improvement	2,391	SY	$ 5.00	$ 11,955	$ 161	150 SY / AC Closure
8	Structural Backfill Material	37,050	CY	$ 4.00	$ 148,200	$ 2,000	Off-site Material - 500 YD3 /AC Closure
9			Subtotal - Site Prep		$ 345,405	$ 4,661	
10	Gas & Leachate Breakout Management Layer	53,797	SY	$ 7.00	$ 376,576	$ 5,082	Geonet Strips 15% Closure Coverage
11	Underdrain GDN Toe Drain	8,151	LF	$ 25.00	$ 203,775	$ 2,750	110 LF / AC Closure
12	Shallow LFG Gas Vent	38.0	EA	$ 2,000.00	$ 76,000	$ 1,026	Shallow Gas Vents (2 Acre Zone of Influence)
13	Subtotal - Breakout and LFG Management System				$ 656,351	$ 8,858	
14	40 Mil Geomembrane	358,644	SY	$ 5.00	$ 1,793,220	$ 24,200	
15	Geocomposite Drainage Net	358,644	SY	$ 4.50	$ 1,613,898	$ 21,780	
16		Subtotal - Geomembranes/Geotextile			$ 3,407,118	$ 45,980	
17	42" Thick Vegetative Soil Layer Place	418,418	CY	$ 4.00	$ 1,673,672	$ 22,587	**Alternative Final Cover System**
18		Subtotal - Erosion & Vegetative Layer			$ 1,673,672	$ 22,587	
19	Terrace Berms Soil	108,372	CY	$ 3.40	$ 368,465	$ 4,973	225 LF Berm /AC Closure * 6.5 YD3 soil/LF berm
20	Turf Reinforcement Matting on Terrace Berms	148,200	SY	$ 0.53	$ 78,546	$ 1,060	225 LF berm/AC * 80 SF matting /LF Berm
21	24" DIA. HDPE Downdrain Pipe	5,558	LF	$ 50.00	$ 277,900	$ 3,750	75 LF downdrain /Acre Closure
22	36" HDPE Downdrain Energy Dissapator	15.0	EA	$ 3,500.00	$ 52,500	$ 709	1 Dissapator/ 5AC
23	Toe Drain & Outlet Pipes	7,410	LF	$ 25.00	$ 185,250	$ 2,500	100 LF / AC Closure
24	Seeding & Mulching	74.1	AC	$ 1,800.00	$ 133,380	$ 1,800	
25		Subtotal - Stormwater Management			$ 1,096,041	$ 14,791	
26	Bonds, Insurance, Mobilization	3.00%	of Items Above		$ 218,136	$ 2,944	
27			Subtotal - Construction		$ 7,489,348	$ 101,071	<-- Cost Per Acre
28	Construction Documents & Bidding	2.0	EA	$ 100,000.00	$ 200,000	$ 2,699	Per Each Occurance (Assumes 2)
29	Field Monitoring	3,705	HR	$ 75.00	$ 277,875	$ 3,750	50 hrs/Ac
30	Lab Testing	74.1	AC	$ 3,000.00	$ 222,300	$ 3,000	G&M Historic Estimate
31	Engineering Certification	2.0	EA	$ 100,000.00	$ 200,000	$ 2,699	Per Each Occurance (Assumes 2)
32	Deed Notation	2.0	EA	$ 10,000.00	$ 20,000	$ 270	Per Each Occurance (Assumes 2)
33		Subtotal - Bidding, Engineering & CQA			$ 920,175	$ 12,418	<-- Cost Per Acre
34	Contingency	5.0%	of Items Above		$ 420,476	$ 5,674	<-- Cost Per Acre
35			**Total Closure Cost FY '16 $'s**		**$ 8,830,000**	**$ 119,163**	<-- Cost Per Acre

36	Phase 1 - 7 Total "Net" Airspace [YD3]	9,380,078
37	Phase 1 - 7 "Net" Airspace Used as of 6/30/2016 [YD3]	1,589,808
38	Percent Full as of 06/30/2016	17%
39	Funding Liability as of 06/30/2016	$ 1,496,576

TABLE 2
ENGINEER'S OPINION OF COSTS
POST-CLOSURE
HAYWOOD COUNTY WHITE OAK MSWLF

Max Area Open **74.1** Acres

Item Number	Description	Estimated Event Quantity		Unit Price Per Event 2016 $'s		Extended Event Total	Annual Quantity		Annual Costs 2016 $'s	30 Yr Cost 2016 $s
1	Administration/Recordkeeping	20	Hrs/Ev	$ 145	/Hr	$ 2,900	2	/Yr	$ 5,800	$ 174,000
2	Groundwater Monitoring	15	EA	$ 500	/EA	$ 7,500	2	/Yr	$ 15,000	$ 450,000
3	Surface Water Samples	6	EA	$ 550	/EA	$ 3,300	2	/Yr	$ 6,600	$ 198,000
4	Leachate Treatment Samples	1	EA	$ 350	/EA	$ 350	2	/Yr	$ 700	$ 21,000
5	Explosive Gas Monitoring	1	EA	$ 800	/EA	$ 800	4	/Yr	$ 3,200	$ 96,000
6	Leachate Collection System Maintenance	74.1	AC	$ 56	/AC	$ 4,150	1	/Yr	$ 4,150	$ 124,488
7	Leachate Haul & Treatment	74,100	GAL/YR	$ 0.05	GAL	$ 3,705	1	/Yr	$ 3,705	$ 111,150
8	Mowing	74.1	AC	$ 90	/AC	$ 6,669	2	/Yr	$ 13,338	$ 400,140
9	Stormwater Structures Maintenance	1.0	LS	$ 5,000	/EA	$ 5,000	1	/Yr	$ 5,000	$ 150,000
10	Final Cover System Repair	1.0	LS	$ 10,000	/EA	$ 10,000	1	/Yr	$ 10,000	$ 300,000
11	LF Gas System Maintenance	1	LS	$ 4,400	/LS	$ 4,400	1	/Yr	$ 4,400	$ 132,000
						Total Post-closure Cost FY '16			**$ 71,893**	**$ 2,156,778**

Phase 1 - 7 Total "Net" Airspace [YD3]	9,380,078
Phase 1 - 7 "Net" Airspace Used as of 6/30/2016 [YD3]	1,589,808
Percent Full as of 06/30/2016	17%
Funding Liability as of 06/30/2016	$ 365,547