Fac/Perm/Co ID #	Date	Doc ID#
97-04	2/1/11	12826

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PREPARED FOR:
WILKES COUNTY DEPARTMENT OF SOLID WASTE
9219 ELKIN HIGHWAY
ROARING RIVER, NORTH CAROLINA 28669

ROARING RIVER LANDFILL
WILKES COUNTY, NORTH CAROLINA
PERMIT No. 97-04

PHASE 4 EXPANSION

VOLUME 2
CONSTRUCTION PLAN APPLICATION
SECTION III – ENGINEERING PLAN
SECTION IV – CONSTRUCTION QUALITY ASSURANCE PLAN
SECTION V – OPERATIONS PLAN
SECTION VI – CLOSURE & POST CLOSURE PLAN

JANUARY 2011

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NORTH CAROLINA CORPORATE LIC: C-0782

NORTH CAROLINA PROFESSIONAL SEAL 035644 ENGINEER STEPHEN J. COWIE 11/27/11

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9219 ELKIN HIGHWAY
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PREPARED FOR:
WILKES COUNTY DEPARTMENT OF SOLID WASTE
9219 ELKIN HIGHWAY
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PHASE 4 EXPANSION

ENGINEERING PLAN

JANUARY 2011

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VOLUME 2, SECTION III
ENGINEERING PLAN

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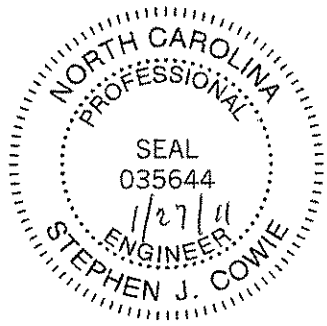
STATEMENT OF COMPLIANCE WITH ENGINEERING PLAN REQUIREMENTS

It is our opinion that the design described in this Engineering Plan for Phase 4 of the Roaring River Landfill meets the intent of the requirements of Rule .1620 of the North Carolina Solid Waste Management Rules, 15A NCAC 13B.

Respectfully Submitted
JOYCE ENGINEERING, INC.

Stephen Cowie, P.E.
Sr. Project Consultant



1.0 GENERAL OVERVIEW OF THE FACILITY DESIGN

This report contains detailed information on the design of Phase 4 of the subject facility. Phase 4 is vertical expansion located on the existing disposal area (Phase 3) consisting of approximately 6.7 acres. The design has been prepared in accordance with Section .1600 of the NC Solid Waste Management Rules, and is illustrated by a set of drawings that accompany this report. The drawings include the following:

Drawing No.	
EP-T	Title Sheet
EP-L	Legend and General Notes
EP-01	Existing Conditions
EP-02	Grading Plan, Subgrade
EP-03	Grading Plan, Final Grade
EP-04	Profiles A-A and B-B
EP-05	Project Details

The drawings and this text describe the proposed design for the purpose of obtaining a Permit to Construct. Prior to construction, detailed construction drawings, technical specifications, and contract documents will be prepared for use by Wilkes County in soliciting construction bids. Phase 3 was designed anticipating the vertical expansion of Phase 4. Certain elements of the design for Phase 4 have been updated from Phase 3 to incorporate actual Phase 3 construction information.

2.0 ANALYSIS OF THE FACILITY DESIGN

2.1 Foundation

The Phase 4 expansion is vertical in nature and will not affect the existing landfill subgrade. The subgrade of the landfill consists of the underlying soils and controlled fill components (subgrade, berms and embankments). The underlying material that will serve as the foundation for the landfill is predominantly partially weathered rock that becomes fine sandy silt when sampled.

Controlled fill will be placed in uniform lifts and compacted to within 95% of the soil's maximum dry density as determined by a Standard Proctor Test (ASTM D698). The range of acceptable moisture levels (% of optimal) will be established based on pre-construction testing of available soil material. Settlement and bearing capacity analyses have been conducted to demonstrate that the subgrade will support the loads of the landfill and maintain the integrity of the landfill's structural components. The anticipated maximum total settlement is estimated to be 0.075 feet (0.90 inches). The base grades of the landfill were designed with a slope of 2.5% over a length of 500 feet, allowing for 2.5 feet of differential settlement. Supporting calculations are included in Appendix III-1.

The bearing capacity of the subgrade was evaluated to determine if the subgrade material could bear the weight of the landfill without enduring shear failure. The results of the bearing capacity

analyses indicate a minimum factor of safety of 15.4 using the Vesic equation. Therefore, we anticipate that the subgrade will support the proposed landfill expansion. Supporting calculations are in Appendix III-2.

Global stability analyses were performed to evaluate the likelihood of a deep seated rotational failure of the landfill, or a sliding block translational failure of the waste mass along the liner. The stability analyses performed for Phase 4 indicate a factor of safety of 1.91 in the static condition, and 1.30 during a seismic event. These estimated factors of safety are conservative since XSTBLE models a worst case two dimensional landfill section. Supporting calculations are in Appendix III-2.

2.2 Base Liner

The base liner system will not be affected by the Phase 4 vertical expansion.

2.3 Leachate Collection and Removal System

General

The leachate collection and removal system will not be modified due to the vertical nature of the expansion. The leachate collection and removal system consists of one main header pipe and four lateral collection pipes embedded in a 24-inch layer of aggregate material on the flatter bottom area of Phase 3. The aggregate serves as both a drainage layer for leachate and a protective cover for the underlying geomembrane during landfill operations. The minimum required hydraulic conductivity of the drainage layer is 3.0×10^{-1} cm/sec. A 16-ounce non-woven geotextile was placed directly on top of the geomembrane to protect the membrane from damage during placement of the aggregate material. The upper 12 inches of the drainage layer was replaced with a 12 inch layer of tire chips. Tire chips have a hydraulic conductivity similar to gravel, are lightweight, and easy to handle during construction, and was proven to be more cost effective than gravel.

Cleanouts in the pipe network provide access for periodic cleaning of all pipes and video inspection. Cleaning the pipes by flushing, mechanical devices or chemical agents will help maintain the hydraulic capacity of the pipes by preventing excessive clogging. Leachate pipe cleaning will be performed once every two years. During the cleaning process sludge residue that is flushed into the sumps will be removed by a vacuum pump truck and disposed of in the active area of the landfill or leachate holding pond.

Calculations were conducted to demonstrate that adequate pipe strength is provided by the leachate collection system for the Phase 4 expansion. These calculations are found in Appendix III-4.

Leachate reaching the perforated collection pipes within the cell will flow by gravity to the leachate header pipe that will discharge to a sump at the downgradient end of the cell. From the sump, leachate will be pumped to an on-site holding pond. Leachate will be removed from the holding pond periodically and transported by tanker truck to the local wastewater treatment plant for disposal.

2.4 Leachate Storage Facility

Leachate will drain to the existing leachate holding pond located west of Phase 1. Accumulated leachate will be removed from the holding pond periodically and transported by tanker truck to the local wastewater treatment plant for disposal.

Holding Pond Design

The leachate holding pond was constructed in 1993 in conjunction with the Phase 1 construction. The capacity of the pond is approximately 1.5 million gallons. The location of the holding pond is shown on EP-01.

Leachate Hauling and Treatment

Leachate will be removed from the storage pond periodically and transported by tanker truck to the Wilkesboro Wastewater Treatment Plant for disposal and treatment. These operations will be conducted in accordance with the agreement between Wilkes County and the Town of Wilkesboro.

Inspections and Record-Keeping

The operator of this facility will conduct weekly inspections of the facility. Records of these inspections, as well as leachate generation rates and analytical results of sampling events, will be maintained at the facility and made available to the Division at its request. See the Operations Plan for a further discussion of these procedures.

Closure Plan

Upon closure of the landfill, leachate will continue to be collected on an as-needed basis throughout the post-closure period. When leachate generation ceases, the following closure activities will be completed within 180 days: leachate collection pipes will be plugged, and liquid and solid waste will be removed from the storage facilities. Material that is removed will be disposed in accordance with applicable requirements.

2.5 Final Cover System

Final grading contours for Phase 4 are shown on Drawing No. EP-03. Final contours have been designed with post-settlement surface slopes of at least five percent on top of the cell. Cross-

sectional details of the proposed closure cap are provided on Drawing No. EP-04. The following components are proposed from bottom to top as shown on the details:

a. Intermediate Cover and Leveling Course - Local soil will be placed over the daily cover soil to provide at least 12 inches of intermediate cover and a uniform base for construction of the cap.

b. Passive Gas Vents – Passive gas vents will be installed at a frequency of approximately one per acre. A typical passive gas vent is detailed on Drawing No. EP-05. Passive venting of landfill gasses will protect the integrity of the cap by preventing excessive pressure buildup beneath the cap.

c. Gas Migration Layer – A geonet composite will be installed between the intermediate cover and the overlying infiltration layer. The geonet composite will provide a pathway for accumulated gas to move laterally to the vents.

d. Composite Cap: Clay Component - The infiltration layer is proposed to consist of a geosynthetic clay liner. This layer will be constructed over the geonet composite that will serve as the gas migration layer. Installation and testing requirements for the cap are provided in the Technical Specifications (Appendix III-6) and the CQA Plan.

e. Composite Cap: Geomembrane Component - The geomembrane component of the infiltration layer will consist of a textured 40 mil flexible geomembrane. The membrane will be in direct contact with the underlying layer. The testing program and quality assurance requirements for the geomembrane are described in the CQA Plan.

f. Drainage Layer - A drainage layer consisting of a geonet and geotextile composite will be placed over the geomembrane to promote drainage.

g. Protective Layer - A layer consisting of at least 18 inches of local soil will be placed above the drainage layer to provide a protective cover for the underlying cap components.

h. Erosion Layer - A layer of topsoil material or organically amended local soil will be placed above the protective layer. This soil layer will be at least 6 inches in thickness. The topsoil material will be lightly compacted so that a good stand of vegetation can be established. Soil tests will be conducted prior to seeding to determine if soil additives are needed to establish and maintain the vegetation.

i. Vegetation - After placement of the erosion layer, the area will be seeded. Seeding will be accomplished in accordance with the "North Carolina Erosion and Sediment Control Planning and Design Manual", and recommendations from the Granville County Agricultural Extension Office may be used. Mulch and erosion

matting will be used as needed to control erosion and promote vegetative growth. The vegetative cover will be inspected regularly during the post-closure period. Areas found during inspections to be sparsely covered will be revegetated.

The stability of the cap system was evaluated under static and seismic conditions by examining potential rotational failure through the exterior slopes and veneer failure. Calculations for these analyses are found in Appendix III-2. The analyses indicate that the proposed cap system will be stable under design static and seismic conditions.

The results of the stability analyses described above indicate that the proposed landfill cap will be stable under the design static loadings and assumed seismic loadings. However, as with the base liner stability analyses, certain minimum physical properties were assumed, including interface friction angles and soil properties (internal friction angles, cohesion). Laboratory testing of actual materials proposed for use in constructing the cap will be completed prior to use to verify that the materials meet the specified parameters for stability.

Additional information on the design, construction, maintenance and probable cost of the final cover system can be found in the Closure and Post-Closure Plan, Section VI of this Application.

2.6 Erosion and Sediment Control Plan

The Erosion and Sediment Control Plan (ESCP) was submitted to the Division of Land Quality under separate cover for Phase 3 Expansion. The ESCP was approved by the Division of Land Quality, Land Resources Section on May 15, 2008. The Letter of Approval with Modifications and Certificate of Plan Approval with Modifications can be found in Appendix III-5.

2.7 Landfill Gas Collection and Control System (GCCS) Design Plan

MSW landfills that have permitted capacities greater than 2.5 million Mg or 2.5 million cubic meters and that have an emission rate for non-methane organic compounds (NMOC) in excess of 50 Mg/year, must install and operate active landfill gas collection and control systems in accordance with the New Source Performance Standards (NSPS) for MSW landfills (40 CFR 60, Subpart WWW). There is approximately 965,273 tons of waste material currently in place within the closed and active phases. This equates to approximately 875,681 Mg. It is projected that the proposed Phase 4 expansion will add an additional capacity of 368,012 tons. Therefore, the projected total capacity for Phase 4 is approximately 1,534,557 tons or 1,392,000 Mg, which is below the 2.5 million Mg threshold required for NSPS Title V permitting.

3.0 TECHNICAL REFERENCES

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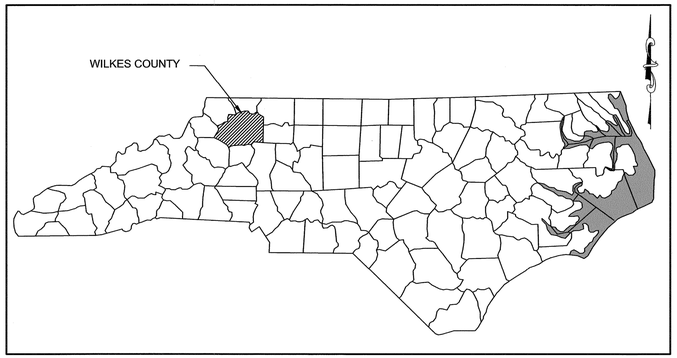
DRAWINGS

ROARING RIVER LANDFILL
PHASE 4 EXPANSION

WILKES COUNTY, NORTH CAROLINA



NORTH CAROLINA
COUNTY LOCATION MAP

OWNER INFORMATION

PREPARED FOR:	WILKES COUNTY DEPARTMENT OF SOLID WASTE
ADDRESS:	9219 ELKIN HIGHWAY ROARING RIVER, NORTH CAROLINA, 28669
CONTACT:	KENT BRANDON (336) 696-5806 (336) 927-4117

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NCDENR PERMIT:	97-04
ACREAGE:	145 ACRES

VICINITY MAP

DRAWING INDEX

SHEET	DESCRIPTION
EP-T	TITLE SHEET
EP-L	LEGEND AND GENERAL NOTES
EP-01	EXISTING CONDITIONS
EP-02	GRADING PLAN: SUBGRADE
EP-03	GRADING PLAN: FINAL GRADE
EP-04	PROFILES A-A AND B-B
EP-05	PROJECT DETAIL
EP-06	EROSION AND SEDIMENT CONTROL DETAILS

ENGINEERING PLAN
JANUARY 2011

NO	BY	CK	APP	DATE	REVISIONS AND RECORD OF ISSUE

NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 035841 STEPHEN J. KOONCE

DESIGNED SJC
DRAWN RWH
CHECKED LBB
APPROVED EEA
DATE 1/27/11

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ROARING RIVER LANDFILL
WILKES COUNTY, NORTH CAROLINA

TITLE SHEET

PROJECT NO.
356.10.02

SCALE
N.T.S.

DRAWING NO.
EP-T

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CONVENTIONAL SYMBOLS AND GENERAL NOTES

ENVIRONMENTAL MONITORING FEATURES

MW-X	EXISTING GROUNDWATER MONITORING WELL
MW-#	PROPOSED GROUNDWATER MONITORING WELL
MW-OW-#	EXISTING OBSERVATION WELL
MW-OW-X	PROPOSED OBSERVATION WELL
NES-OW-X	EXISTING NES WELL
NES-OW-#	PROPOSED NES WELL
MW-PW-X	EXISTING PERFORMANCE WELL
MW-PW-#	PROPOSED PERFORMANCE WELL
MW-X	EXISTING SENTINEL WELL
MW-#	PROPOSED SENTINEL WELL
EW-X	EXISTING EXTRACTION WELL
EW-#	PROPOSED EXTRACTION WELL
PZ-#	WETLANDS PIEZOMETER
PZ-X	PIEZOMETER
GP-X	GAS PROBE
GV-X	EXISTING GAS VENT
GV-#	PROPOSED GAS VENT
GW-X	EXISTING GAS WELL
GW-#	PROPOSED GAS WELL
SMP-X	SURFACE WATER MONITORING POINT
LMP-1	LEACHATE MONITORING POINT
B-X	BORE HOLE LOCATION
C-X	CORING LOCATION
SS-X	SOIL SAMPLING LOCATION
TP-X	TEST PIT LOCATION
Ⓦ	WELL LOCATION
S-X	SPRINGHEAD LOCATION

SURVEY FEATURES

BM	BENCHMARK
CP	CONTROL POINT
	PROPERTY LINE
	EASEMENT
R_W R_W	RIGHT OF WAY
x x x	FENCE LINE
	RAILROAD
	GUARDRAIL
	RESOURCE PROTECTION AREA

UTILITIES

	UTILITY POLE
	HYDRANT
	LIGHT POLE
	TANK (SIZE VARIES)
	TRANSFORMER
M	MANHOLE
	CLEANOUT
	VALVE
OHE	OVERHEAD ELECTRIC
UGE UGE	UNDERGROUND ELECTRIC
OHT	OVERHEAD TELEPHONE
UGT UGT	UNDERGROUND TELEPHONE
FM	LEACHATE FORCE MAIN
DCFM DCFM	DUAL CONTAINED LEACHATE FORCE MAIN
SS	SANITARY SEWER
PS	PROCESS SEWER
G	LANDFILL GAS LINE
UGG	NATURAL GAS LINE
W	POTABLE WATER
	SOLID PIPE (TYPE NOTED)
	PERFORATED PIPE (TYPE NOTED)
	CULVERT (SIZE NOTED)

LANDFILL AND ROAD FEATURES

	PAVED ROAD
	GRAVEL/DIRT ROAD
	EDGE OF PAVEMENT
	LIMIT OF WASTE/EDGE OF LINER
	FACILITY BOUNDARY/CELL LIMITS/PHASE LIMITS

BUILDINGS AND STRUCTURES

	BUILDING
	DAM
	FOUNDATION

HYDROLOGY

	APPROXIMATE 100 YEAR FLOOD PLAIN
	DITCH FLOW
	STREAM OR RIVER

VEGETATION

	SINGLE TREE
	TREE LINE
	SHRUB

EROSION AND SEDIMENT CONTROL FEATURES

SF SF	SILT FENCE
IP	INLET PROTECTION
	OUTLET PROTECTION (SIZE VARIES)
	DIVERSION BERM

TOPOGRAPHICAL FEATURES

100	EXISTING 10' TOPO CONTOUR
	EXISTING 2' TOPO CONTOUR
100	PROPOSED 10' TOPO CONTOUR
	PROPOSED 2' TOPO CONTOUR
100	GROUNDWATER SURFACE CONTOUR (FT ABOVE MEAN SEA LEVEL)
100	BEDROCK SURFACE CONTOUR (FT ABOVE MEAN SEA LEVEL)
100.00	SPOT ELEVATION

HATCHING

	WETLANDS
	RIPRAP
	WASHED STONE
	BUFFER AREA
	PROPOSED ROAD
	COMPACTED BACKFILL

SURVEY NOTES:

1. TOPOGRAPHIC CONTOUR INTERVAL = 2 FEET, UNLESS INDICATED OTHERWISE.
3. ON-SITE TOPOGRAPHY PROVIDED BY SPATIAL DATA CONSULTANTS, INC. , 1008 HUTTON LANE, HIGH POINT, NORTH CAROLINA 27262, DATED MARCH 19, 2010.
4. FEDERAL INSURANCE ADMINISTRATION, FLOOD INSURANCE RATE MAP, WILKES COUNTY, NC, INDICATES NO 100 YEAR FLOOD PLAINS ON SITE.
5. PROPERTY BOUNDARY BEARING AND DISTANCES PROVIDED BY TOM FRAZIER, R.L.S 1286 NC. ON MAY 8, 1989.
6. SITE CONTROL INFORMATION UPDATED BY SPATIAL DATA CONSULTANTS, INC. , 1008 HUTTON LANE, HIGH POINT, NORTH CAROLINA 27262, DATED MARCH 19, 2010.
5. THE SURVEY WAS PERFORMED WITHOUT THE BENEFIT OF A TITLE SEARCH AND ALL EASEMENTS AND ENCUMBRANCES MAY NOT BE SHOWN.

GENERAL NOTES:

1. SITE LIGHTING IS NOT PROPOSED FOR THIS PROJECT.
2. LANDSCAPING IS NOT PROPOSED FOR THIS PROJECT. HOWEVER THE BUFFER AREA SHOWN ON DRAWINGS WILL REMAIN UNDISTURBED EXCEPT FOR THE INSTALLATION OF UTILITIES, STORMWATER DRAINAGE FEATURES AND ACCESS TO THE SITE. WHEN POSSIBLE CLEARING WITHIN THE BUFFER WILL BE ALIGNED TO MINIMIZE VISUAL IMPACTS.
3. SOIL STOCKPILE AREAS WILL BE ESTABLISHED TO FACILITATE PHASED CONSTRUCTION. STOCKPILE LOCATIONS AND SIZE MAY VARY AND MAY NOT BE LIMITED TO THE AREAS SHOWN. SILT FENCE WILL BE INSTALLED AROUND THE BASE OF THE STOCKPILE.

NO	BY	CK	APP	DATE	REVISIONS AND RECORD OF ISSUE

NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 035544 STEPHEN L. JOYCE

DESIGNED SJC
DRAWN RVH
CHECKED LBB
APPROVED EEA
DATE 1/27/11

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ROARING RIVER LANDFILL
WILKES COUNTY, NORTH CAROLINA

LEGEND AND GENERAL NOTES

PROJECT NO.
356.10.02

SCALE
N.T.S.

DRAWING NO.
EP-L

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DATE	REVISIONS AND RECORD OF ISSUE	NO	BY	CK	APP

NORTH CAROLINA PROFESSIONAL SEAL 035644 ENGINEER STEPHEN J. COWIE

DESIGNED SJC
DRAWN RWH
CHECKED LBB
APPROVED EEA
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ROARING RIVER LANDFILL
WILKES COUNTY, NORTH CAROLINA

EXISTING CONDITIONS

PROJECT NO.
356.10.02

SCALE
AS SHOWN

DRAWING NO.
EP-01

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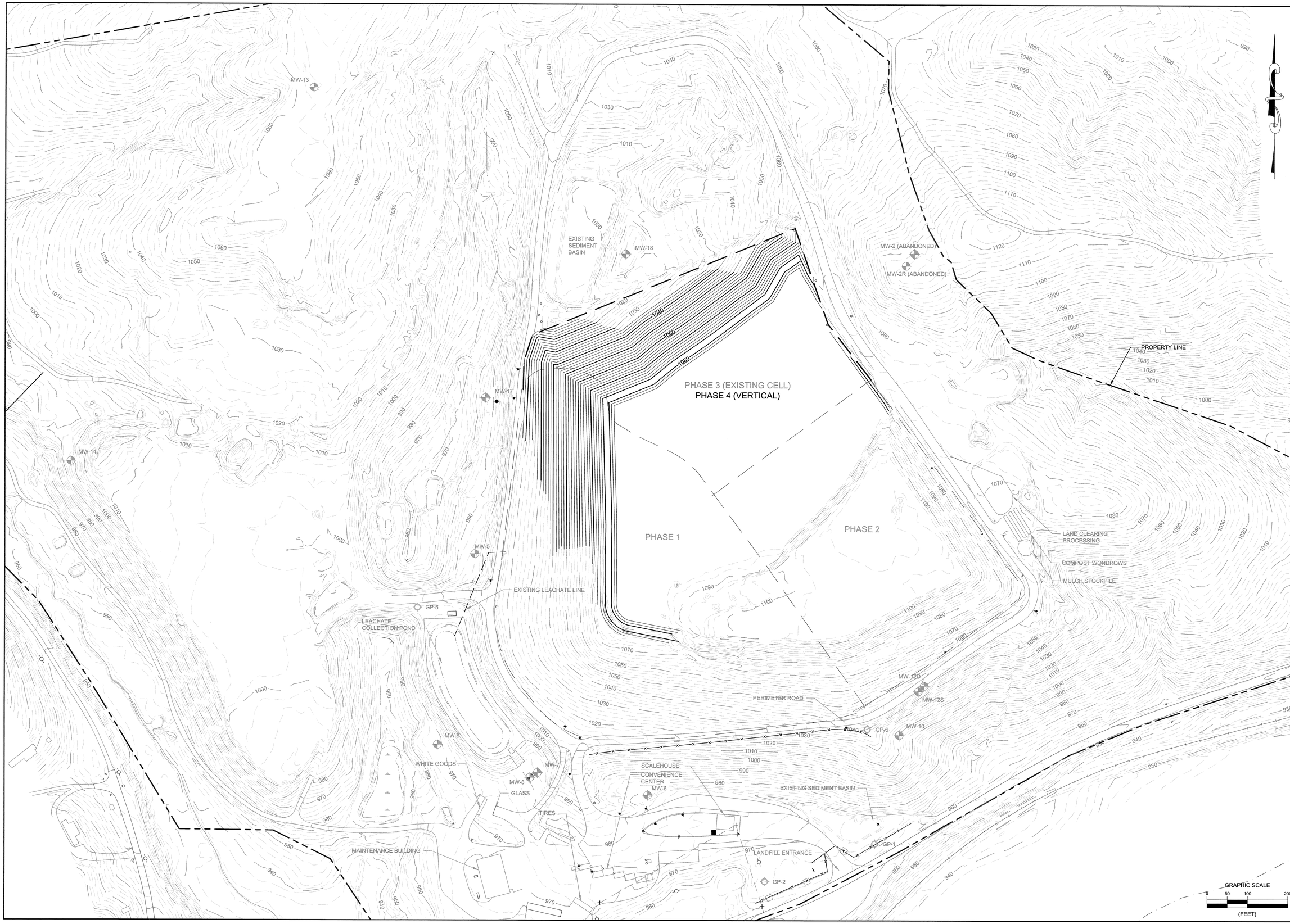

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GREENSBORO, NC 27407
PHONE: (336) 323-0092
NC CORP LIC: C-0782

ROARING RIVER LANDFILL
WILKES COUNTY, NORTH CAROLINA

GRADING PLAN: SUBGRADE

PROJECT NO.
356.10.02

SCALE
AS SHOWN

DRAWING NO.
EP-02

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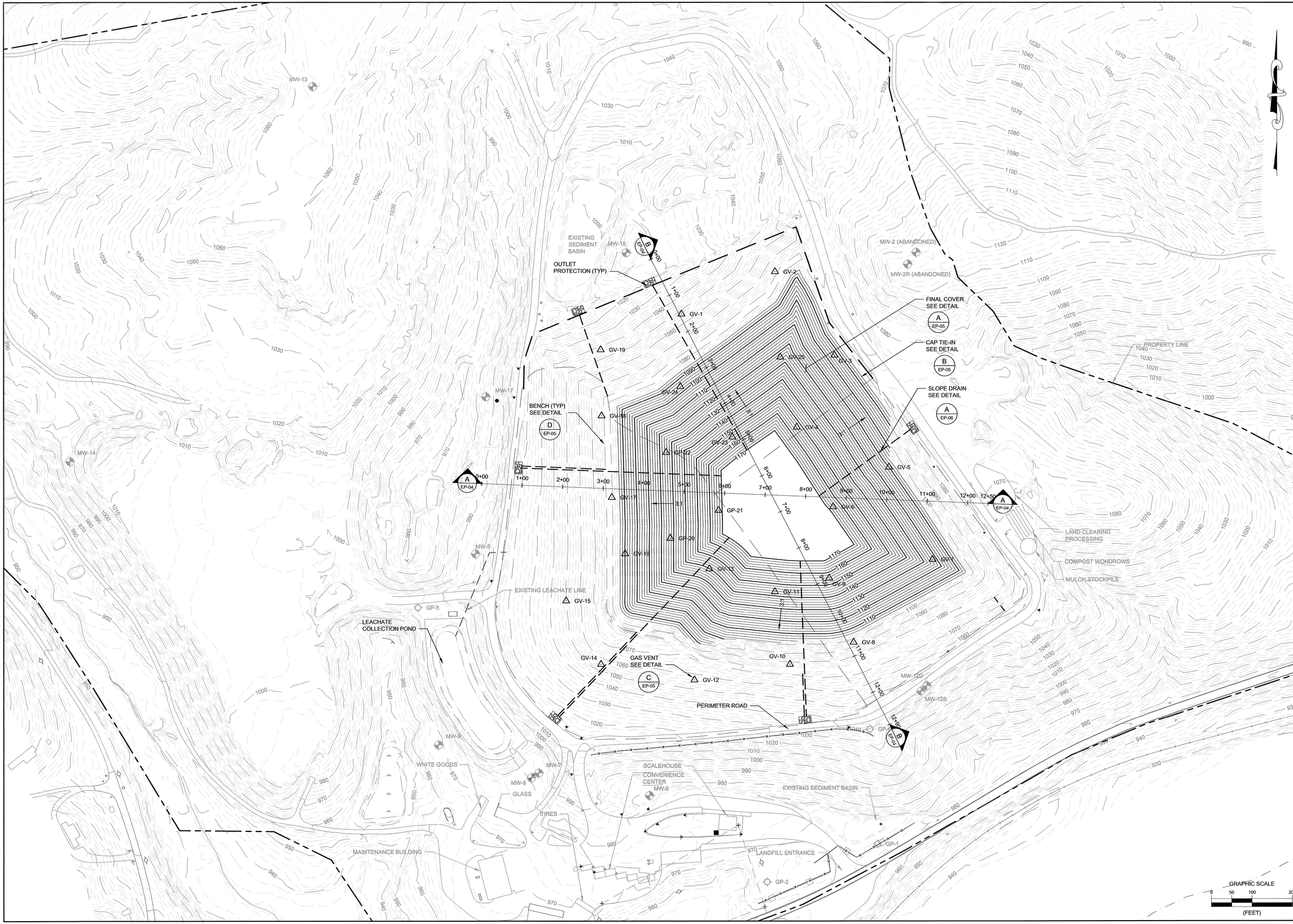

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NORTH CAROLINA PROFESSIONAL SEAL 035644 ENGINEER STEPHEN J. COHEN

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ROARING RIVER LANDFILL
WILKES COUNTY, NORTH CAROLINA

GRADING PLAN: FINAL GRADE

PROJECT NO.
356.10.02

SCALE
AS SHOWN

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EP-03

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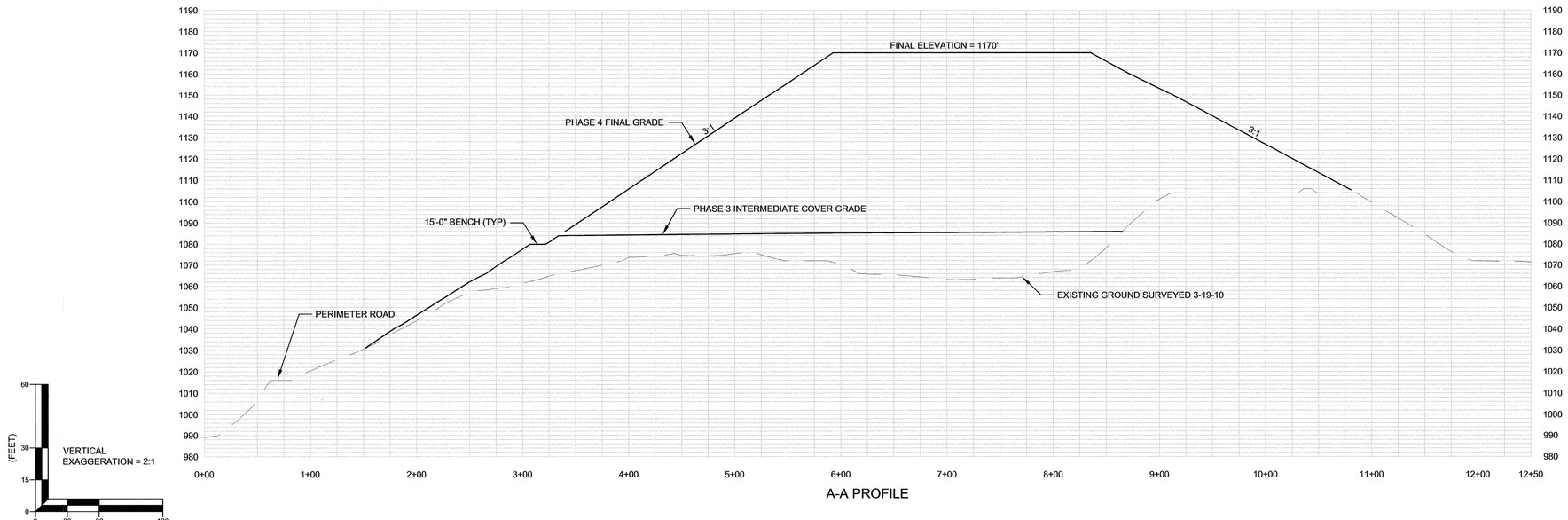
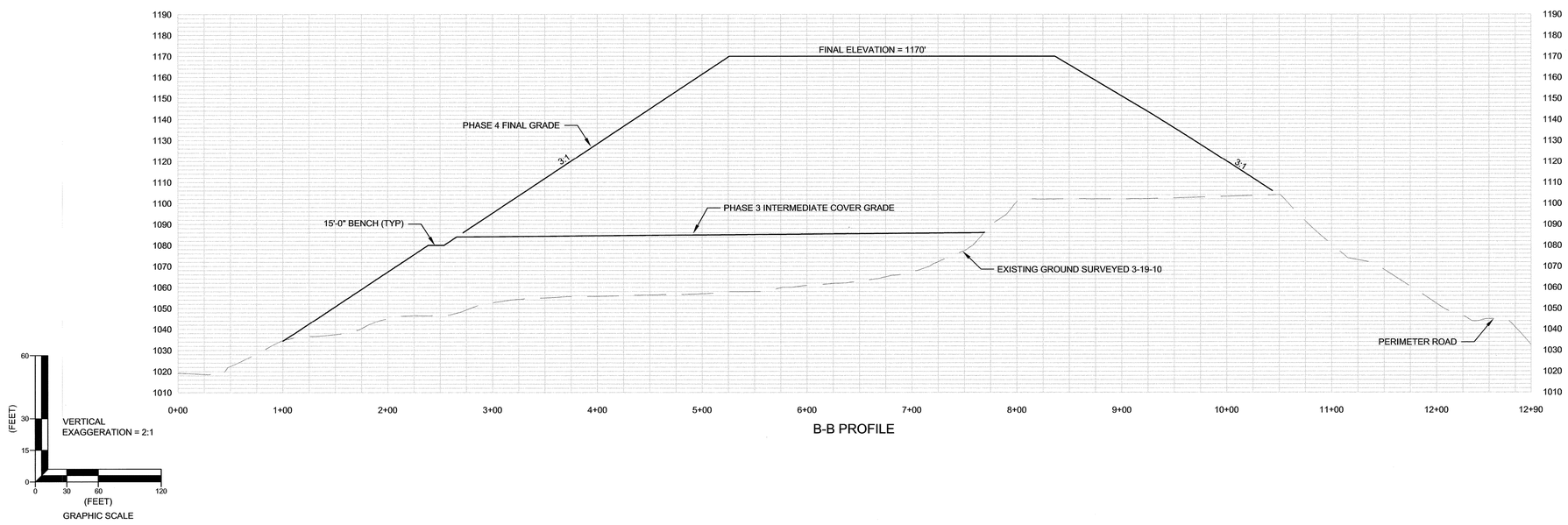


A-A PROFILE



B-B PROFILE

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ROARING RIVER LANDFILL
WILKES COUNTY, NORTH CAROLINA

PROFILES A-A AND B-B

PROJECT NO.
356.10.02

SCALE
AS SHOWN

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EP-04

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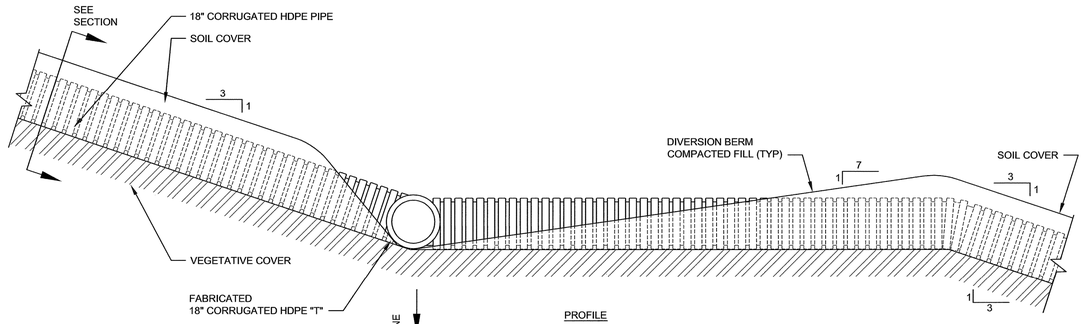

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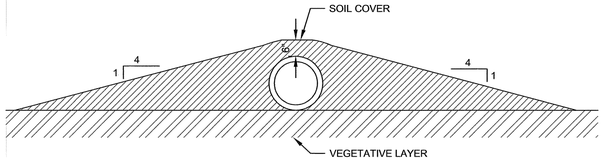

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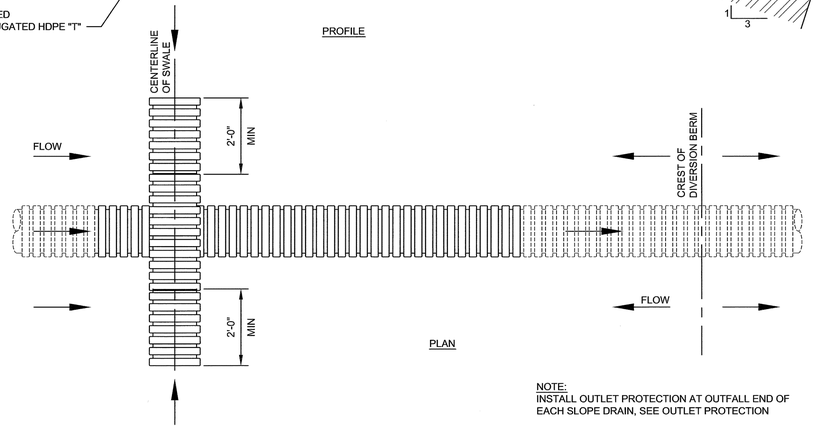
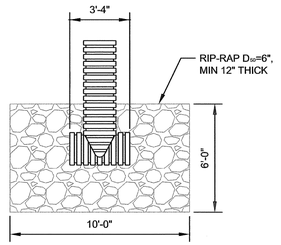


PLAN

NOTE:
INSTALL OUTLET PROTECTION AT OUTFALL END OF EACH SLOPE DRAIN, SEE OUTLET PROTECTION

SLOPE DRAIN DETAIL (A)
N.T.S.



OUTLET PROTECTION DETAIL - (TYP)
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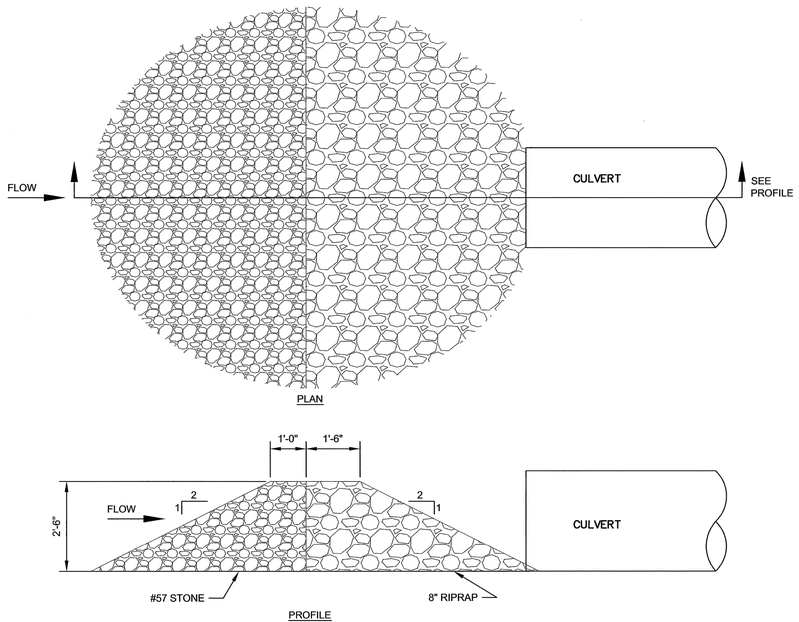

PLAN

PROFILE

INLET PROTECTION DETAIL - (TYP)
N.T.S.

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ROARING RIVER LANDFILL
WILKES COUNTY, NORTH CAROLINA

EROSION AND SEDIMENT CONTROL DETAILS

PROJECT NO.
356.10.02

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AS SHOWN

DRAWING NO.
EP-06

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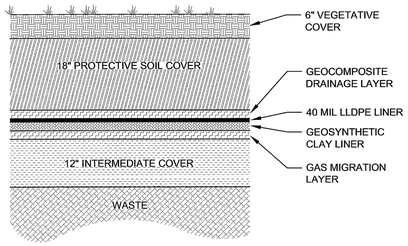

FINAL COVER DETAIL (A)
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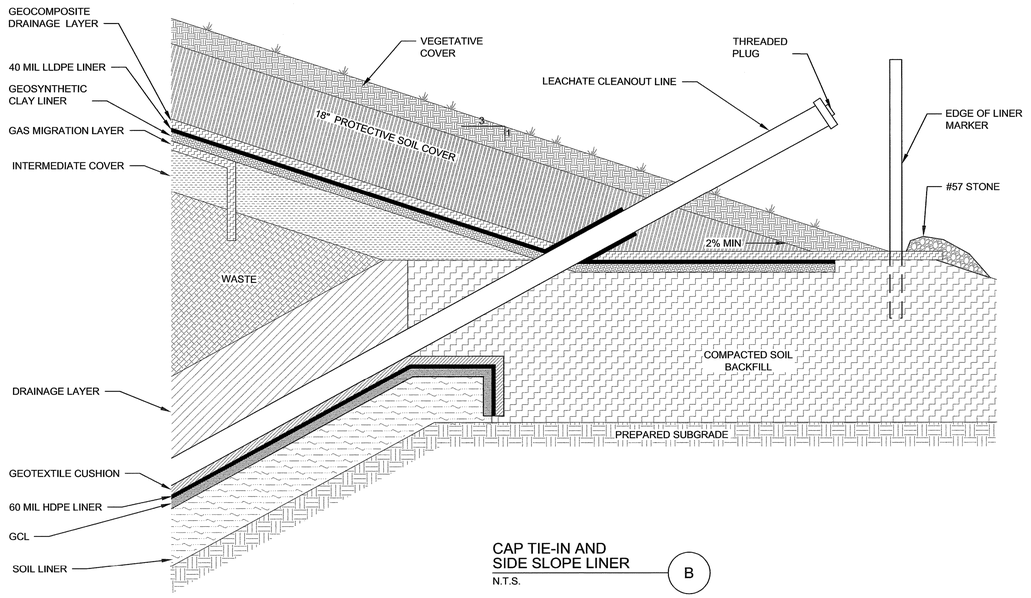
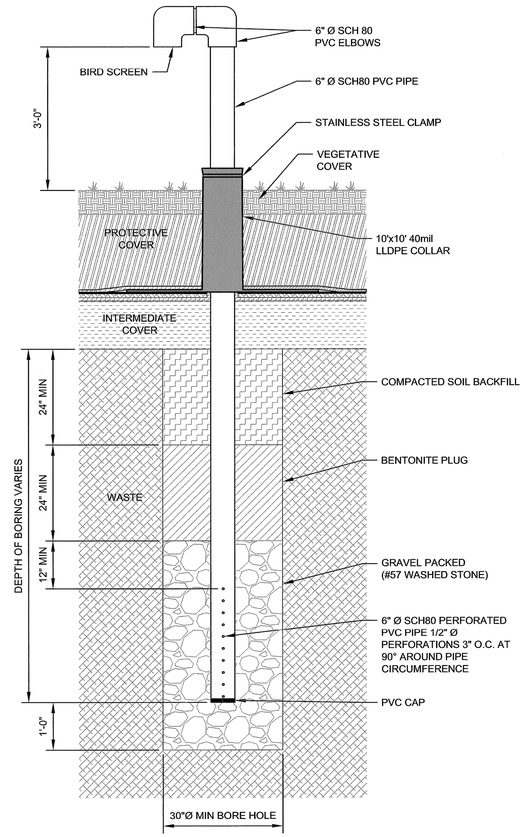


CAP TIE-IN AND SIDE SLOPE LINER (B)
N.T.S.



GAS VENT DETAIL (C)
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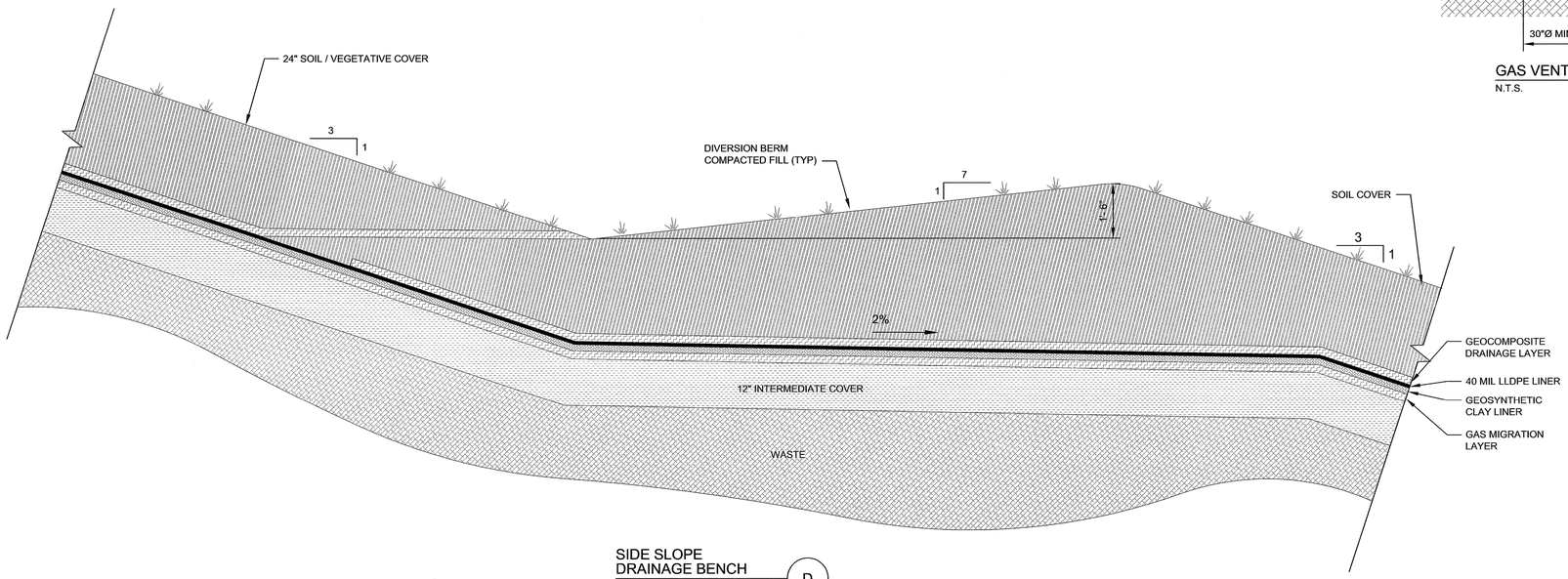

SIDE SLOPE DRAINAGE BENCH (D)
N.T.S.

DATE	REVISIONS AND RECORD OF ISSUE	NO	BY	CK	APP

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ROARING RIVER LANDFILL
WILKES COUNTY, NORTH CAROLINA

PROJECT DETAILS

PROJECT NO.
356.10.02

SCALE
AS SHOWN

DRAWING NO.
EP-05

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APPENDIX III-1

FOUNDATION SETTLEMENT CALCULATIONS

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Project:	Roaring River Landfill Phase 4		
Project Number:	365.1002.11.01		
Calculated By:	CTM	Date:	12/13/10
Revised By:		Date:	
Checked By:	CA	Date:	1/5/11
Subject:	Settlement		
Sheet:	1 of 2		

SETTLEMENT CALCULATIONS

OBJECTIVE

To estimate the amount of differential settlement within the in-situ soil layers lying beneath the landfill and determine what effects it will have upon the landfill baseliner system.

METHODOLOGY

The in-situ soils eventually bear the full weight of the municipal solid waste (MSW) placed within the landfill. Therefore, it is important to estimate the potential magnitude of differential settlement beneath the landfill footprint. Settlement calculations were made for the worst case scenario of differential settlement, calculating the change from the point of maximum settlement, to a point at the edge of the landfill which will conservatively be assumed to experience no settlement. Maximum settlement is a function of the following parameters:

- The waste thickness and density;
- The foundation soil thickness and properties; and
- The distance over which the differential settlement occurs.

Differential settlement of the subgrade bears importance as settlement could induce strain upon the geosynthetic High Density Polyethylene (HDPE) flexible membrane liner (FML) within the landfill baseliner. Therefore, the calculated differential settlement will be used to estimate the magnitude of potential strain within the FML. Differential settlement can also affect the leachate collection system by changing the basegrades and altering the grades of leachate collection pipes placed along the landfill floor to be less than the minimum of 2% for the base grades and 0.5% for the leachate collection pipes.

A total of 2 soil layers were used to evaluate settlement, based on the boring log for PZ-39 which is located in the borrow area.

Depth [ft]		***Description***	***Soil Type***
0		*Base Grade*	
	Layer 1	18' thick	SM
18			
	Layer 2	7' thick	SM
25			
		Bedrock	Assume no settlement below

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Project:	Roaring River Landfill Phase 4		
Project Number:	365.1002.11.01		
Calculated By:	CTM	Date:	12/13/10
Revised By:		Date:	
Checked By:	BJF	Date:	1/5/11
Subject:	Settlement		
Sheet:	2 of 2		

Both of the layers are non-cohesive sand material for which the Schmertmann Method was used. The calculations are attached. In summary, the total maximum settlement expected to occur is **0.075 feet (0.90 inches)**.

EFFECT OF DIFFERENTIAL SETTLEMENT ON THE LEACHATE COLLECTION SYSTEM

The designed slope of the leachate collection pipes and base grades prior to settlement is 2.5%, with a maximum flow length of approximately 500 feet. The flow direction is from the middle of the landfill toward the perimeter, and differential settlement will tend to reduce the slope of flow. Over the 500 feet, there is currently an elevation drop of approximately 12.5 feet (2.5% * 500 feet). The minimum allowable elevation drop to maintain 2% is 10 feet (2.0% * 500 feet) and therefore, 2.5 feet of differential settlement is allowable.

EFFECT OF DIFFERENTIAL SETTLEMENT ON THE GEOSYNTHETIC LINER

The strain on the FML associated with the worst case post settlement floor slope is defined by

Strain = change in length/initial length

The strain at yield for the 60-mil HDPE FML is reported to be 13%.

Maximum settlement will occur at the middle of the landfill, and the landfill is designed with the high point of the base grades in the middle and sumps (low points) along the perimeter. Therefore, settlement will not lengthen the liner but rather would have a flattening affect. No strain on the liner from settlement is expected to occur.

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Maximum settlement (Non-Cohesive Layers)

Project: Wilkes - Roaring River Landfill Phase 4
Project Number: 356.1002.11.01
Calculated By: CTM Date: 11/22/2010
Checked By: [signature] Date: 11/5/11
Subject: Settlement

Conditions encountered at P-39 are used:

Depth [ft]		Description	Soil Type	Blows/ft
0		Base Grade		
	Layer 1	18" thick	structural fill	40
18		Existing Ground		
	Layer 2	7' thick	SM	50
25				
			Assume no settlement below	

Foundation Type

Assume a foundation of approximately 300' x 700'

B = 300
L = 700

Schmertmann Method

Immediate settlement of cohesionless soil will be due to the combined effects of volume distortion and primary compression. The Schmertmann method offers a procedure to calculate settlement resulting from the combined effects of volume distortion and compression in soil deposits that have not been pre-compressed.

$$\Delta S_n = (\varepsilon_{v,avg})(\Delta z_n) = \Delta p(I_v / E_s)(\Delta z_n)$$

where :

ΔS_n = Settlement in layer "n"

$\varepsilon_{v,avg}$ = Average vertical strain in layer "n"

Δz_n = Thickness of layer "n"

Δp = Net foundation bearing pressure imposed onto the soil

I_v = Strain influence factor for the soil beneath th e foundation

E_s = Modulus of elasticity for layer "n"

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	A	B	C	D	E	F	G	H	I	J
60	**Loading**					Project:	Wilkes - Roaring River Landfill Phase 4			
61						Project Number:	356.1002.11.01			
62		Density (pcf)	Depth (ft)			Calculated By:	CTM		Date:	11/22/2010
63	Cover Soil	115	2			Checked By:	[illegible]		Date:	1/5/11
64	Waste	70	135			Subject:	Settlement			
65	Drainage	130	2							
66	Clay Liner	110	1.5							
67										
68										
69	***Layer***	***Layer Thickness Δz (ft)***	***Depth to Center (ft), as mult. of B***		***Blow Count (N)***	***Multiplier*** [1]	***E_s (psf)*** [1]	***Net Load Δp (psf)***	***I_v*** [2]	***ΔS_h (ft)***
70	1	18	9	0.03	**40**	4	320000	10,105	0.1	0.0568
71										
72	2	7	21.5	0.071666667	**50**	4	400000	10,105	0.1	0.0177
73										
74	**assumed value for blow count**								**sum (ft)**	**0.0745**
75		= separately evaluated for settlement in cohesive soils								
76										
77	1) From Figure 1 (below)									
78	2) From Figure 2 (below)									
79										
80	**Figure 1**									

Table 10-2 Values of E_s Related to Soil Type

Soil Type	Approximate Value for E_s (kgf/cm², 0.1 MPa, ton/ft²)	
	In terms of N	In terms of q_c
Sand–silt mixture	$4N$	$1.5q_c$
Fine to medium sands, fine–medium–coarse sands	$7N$–$10N$ (relating to density and compactness)	$2q_c$–$3q_c$ (relating to density and compactness)
Sand–gravel mixtures	$12N$	$4q_c$

93	**Figure 2**	

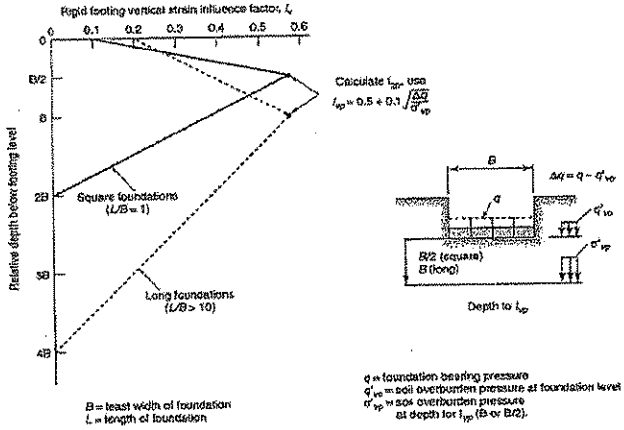

Figure 10-2 Strain influence factors for use with Schmertmann method to estimate settlement of foundations on sand.

119	**References**
120	
121	McCarthy, D.F. Essentials of Soils Mechanics and Foundations: Basic Geotechnics, 1998

APPENDIX III-2

STABILITY ANALYSIS

ENGINEERING, INC.

Project:	Roaring River LF Phase 4		
Project Number:	356.1002.11.01		
Calculated By:	CTM	Date:	12/27/10
Checked By:	BA	Date:	1/24/11
Subject:	Bearing Capacity		
Sheet:	1 of 6		

BEARING CAPACITY

OBJECTIVE

To determine the bearing capacity of the subgrade material beneath the proposed baseliner of the Wilkes County Roaring River Landfill with a modification of closure grades.

METHODOLOGY

The surface beneath the landfill baseliner must be able to bear the weight of the landfill without enduring shear failure or excessive settlement that in turn may cause damage and eventual failure to the landfill baseliner. Vesic's General Bearing Capacity Equation will be used.

The landfill layers and assumed parameters used for the global stability modeling are as follows:

			Modeled Parameters			
Component	Depth	Description	Unit Wt. Moist (pcf)	Unit Wt. Satd. (pcf)	Friction Angle (Ø)	Layer #
Cover	36"	Vegetative Soil	115	120	25	6
		Protective Soil				
		Geocomposite				
		40 mil LLDPE				
		GCL				
		Geocomposite				
		Intermediate Soil				
Waste	145'	approx. max waste depth	70	70	33	5
Bottom Liner	24"	Drainage Layer	130	135	37	4
Geosynthetics	6"		60	60	28	3
Bottom Liner	12"	Compacted Clay Soil	110	115	19	2
Existing Ground	na		115	120	25	1
Bedrock	na		110	110	45	7

A factor of safety (FS) will be calculated comparing the total anticipated applied load to the estimated ultimate load that the foundation soils can support.

BEARING CAPACITY CALCULATION

The overburden pressures developed by the baseliner components are negligible and are not considered in this calculation. The width, B, and the length, L, from the point with the thickest waste mass within the landfill footprint were used for this analysis. A friction angle of 25 degrees and unit weight of 115 pcf were used, based on the weakest foundation soil conditions observed from onsite boring and lab testing (triaxial shear testing from sample from PZ-39).

An additional conservative assumption is that the foundation soil has no cohesion.

An average unit weight of 70 pcf will be used in the analysis for the unit weight of the MSW.

A factor of safety (FS) will be calculated comparing the total anticipated applied load to the estimated ultimate load that the foundation soils can support.

SUMMARY TABLE

Component	Thickness (ft)	Cohesion (psf)	Internal Friction Angle (degrees)	Unit Weight (pcf)
Foundation Soils	-----	0	25	115
Solid Waste	145*	500	33	70
Drainage Aggregate	2	0	37	130
Vesic Bearing Capacity Factors**	___	Nc = 20.72	Nq = 10.66	Nγ = 10.88

* Use a conservative maximum waste vertical height of 145-ft.
**Vesic Bearing Capacity Factors were taken from Table 4 below.

A vertical pressure and a horizontal base are assumed, therefore, the following equation does not include the inclination, ground and base factors.

$$q_{ult} = cN_c S_c d_c + qN_q S_q d_q + 0.5\gamma B N_\gamma S_\gamma d_\gamma \text{ (Vesic Equation)}$$

Where:

q_{ult} = ultimate bearing capacity of the subgrade material, (psf).

c = a cohesion of 0 psf was used in the analysis. This assumption is conservative.

γ = unit weight of the foundation soil = 115 pcf.

B = width of the rectangular foundation = 300-feet.

L = length of the rectangular foundation = 700-feet.

D_f = depth of embedment for a footing in a standard bearing capacity analysis = 10-feet.

$q = \gamma D_f$, soil pressure around footing, not applicable for surface footings.

N_c, N_q, N_γ = bearing capacity factors which are a function of the foundation soil's internal angle of friction, use a ϕ of 25° and see Summary Table to obtain factors:

$N_c = 20.72$, $N_q = 10.66$, $N_\gamma = 10.88$

S_c, S_q, S_γ = Shape Factors for use in the Vesic bearing capacity equation,

$S_c = 1 + (N_q / N_c) \times (B/L) = 1.22$

$S_q = 1 + (B/L)\tan\phi = 0.94$

$S_\gamma = 1 - 0.4(B/L) = 0.83$

d_c, d_q, d_γ = Depth Factors for use in the Vesic bearing capacity equation,

$d_c = 1 + 0.4(D/B)$ for $D/B <= 1$,
$= 1.01$

$d_q = 1 + 2\tan\phi(1-\sin\phi)^2(D/B) = 1.0$

$d_\gamma = 1$

$$q_{ult} = cN_c S_c d_c + qN_q S_q d_q + 0.5\gamma B N_\gamma S_\gamma d_\gamma$$

$q_{ult} = 0 + [(115 * 10) * 10.66 * 0.94 * 1.0] + [0.5 * 115 * 300 * 10.88 * 0.83 * 1]$

q_{ult} = 11,524 psf + 155,774 psf = 167,298 psf or 83.6 tsf

The total applied load from the maximum waste thickness is:

q = (unit weight of waste)(maximum waste thickness) + (unit weight of liner system)(liner system thickness) + (unit weight of Final Cover System)(Final Cover System thickness)

$$q = (70\ pcf\ (\text{Waste}) * 145\ ft) + (130\ pcf\ (\text{Drainage Aggregate}) * 2.0\ ft) + (110\ pcf\ (\text{CSL}) * 1.0\ ft) + (115\ pcf\ (\text{Final Cover}) * 3.0\ ft)$$

q = 10,865 psf or 5.43 tsf

Bearing Capacity Factor of Safety, FS

$$FS = \frac{q\ ultimate}{q} = \frac{83.6\ tsf}{5.43\ tsf} = \mathbf{15.4}$$

CONCLUSION

The bearing capacity of the in-situ soils beneath the landfill was calculated using a conservative maximum waste thickness of **145**-ft. The applied stress was then calculated to be **5.43** tons per square foot (tsf) including liner and final cover system soil components. The bearing capacity of the underlying foundation soils was estimated to be **83.6** tsf.

The resulting FS of **15.4** indicates that the in-situ soil has an adequate safety factor against bearing capacity failure for the conditions analyzed.

REFERENCES

1) Terzaghi & Peck, **"Soil Mechanics in Engineering Practice"**, John Wiley and Sons, 1967.

2) Das, Braja, M., **"Principles of Geotechnical Engineering"**, PWS Publishers, 1985.

3) Vesic, Aleksander S., **"Analysis of Ultimate Loads of Shallow Foundations"**, Journal of the Soil Mechanics and Foundations Division, January 1973.

4) Sowers, **"Settlement of Waste Disposal Fills"**, paper for Law Engineering.

5) Landva, A.O. & Clark, J.I. **"Geotechnics of Waste Fill"**, Geotechnics of Waste Fill - Theory and Practice, ASTM STP 1070, Arvid Landva, G. David Knowles, Editors, American Society for Testing of Materials, Philadelphia, 1990.

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Project:	Roaring River LF Phase 4
Project Number:	356.1002.11.01
Calculated By:	CTM Date: 12/27/10
Checked By:	Date: 1/24/4
Subject:	Bearing Capacity
Sheet:	6 of 6

Bearing Capacity Factors

(Excerpt Taken From Reference 3, Table 4)

Table 4.—Bearing Capacity Factors

Φ (1)	N_c (2)	N_q (3)	N_γ (4)	N_q/N_c (5)	tan Φ (6)
0	5.14	1.00	0.00	0.20	0.00
1	5.38	1.09	0.07	0.20	0.02
2	5.63	1.20	0.15	0.21	0.03
3	5.90	1.31	0.24	0.22	0.05
4	6.19	1.43	0.34	0.23	0.07
5	6.49	1.57	0.45	0.24	0.09
6	6.81	1.72	0.57	0.25	0.11
7	7.16	1.88	0.71	0.26	0.12
8	7.53	2.06	0.86	0.27	0.14
9	7.92	2.25	1.03	0.28	0.16
10	8.35	2.47	1.22	0.30	0.18
11	8.80	2.71	1.44	0.31	0.19
12	9.28	2.97	1.69	0.32	0.21
13	9.81	3.26	1.97	0.33	0.23
14	10.37	3.59	2.29	0.35	0.25
15	10.98	3.94	2.65	0.36	0.27
16	11.63	4.34	3.06	0.37	0.29
17	12.34	4.77	3.53	0.39	0.31
18	13.10	5.26	4.07	0.40	0.32
19	13.93	5.80	4.68	0.42	0.34
20	14.83	6.40	5.39	0.43	0.36
21	15.82	7.07	6.20	0.45	0.38
22	16.88	7.82	7.13	0.46	0.40
23	18.05	8.66	8.20	0.48	0.42
24	19.32	9.60	9.44	0.50	0.45
25	20.72	10.66	10.88	0.51	0.47
26	22.25	11.85	12.54	0.53	0.49
27	23.94	13.20	14.47	0.55	0.51
28	25.80	14.72	16.72	0.57	0.53
29	27.86	16.44	19.34	0.59	0.55
30	30.14	18.40	22.40	0.61	0.58
31	32.67	20.63	25.99	0.63	0.60
32	35.49	23.18	30.22	0.65	0.62
33	38.64	26.09	35.19	0.68	0.65
34	42.16	29.44	41.06	0.70	0.67
35	46.12	33.30	48.03	0.72	0.70
36	50.59	37.75	56.31	0.75	0.73
37	55.63	42.92	66.19	0.77	0.75
38	61.35	48.93	78.03	0.80	0.78
39	67.87	55.96	92.25	0.82	0.81
40	75.31	64.20	109.41	0.85	0.84
41	83.86	73.90	130.22	0.88	0.87
42	93.71	85.38	155.55	0.91	0.90

Table 4.—*Continued*

(1)	(2)	(3)	(4)	(5)	(6)
43	105.11	99.02	186.54	0.94	0.93
44	118.37	115.31	224.64	0.97	0.97
45	133.88	134.88	271.76	1.01	1.00
46	152.10	158.51	330.35	1.04	1.04
47	173.64	187.21	403.67	1.08	1.07
48	199.26	222.31	496.01	1.12	1.11
49	229.93	265.51	613.16	1.15	1.15
50	266.89	319.07	762.89	1.20	1.19

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GLOBAL SLOPE STABILITY

OBJECTIVE

The objective of this calculation is to analyze the stability of the Wilkes County Landfill at final build-out of the Phase 4 vertical expansion. Factors of safety against deep-seated translational and rotational failures of 1.5 for static conditions and 1.0 for seismic conditions should be met to ensure that the landfill will be stable.

METHODOLOGY

Cross Section

The final grade scenario was considered by preparing a cross-section through the proposed landfill Phase 4 final condition configuration that included the maximum crest height and the steepest surrounding land grade.

The cross section alignment and profile view are shown below.

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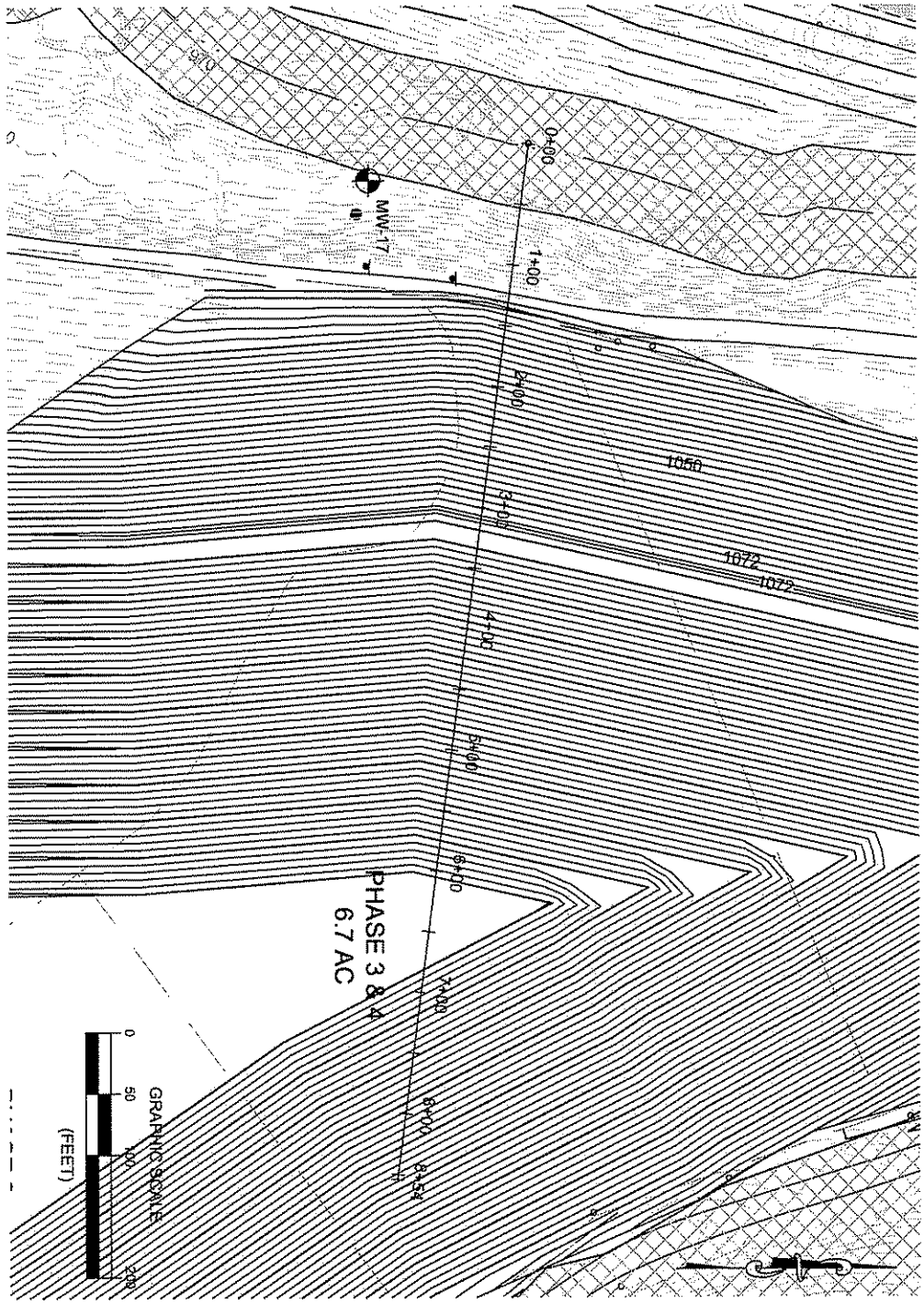
Cross Section Alignment



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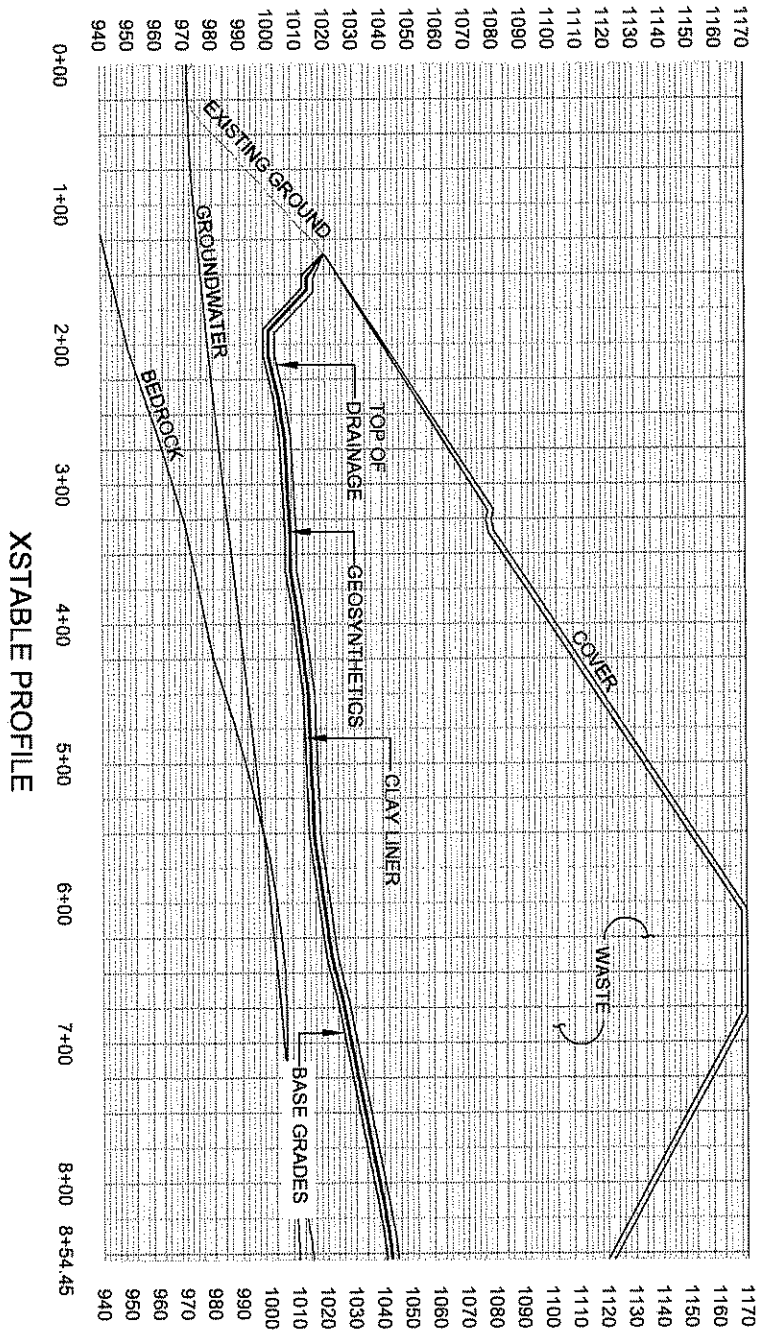
Cross Section Profile View



STATIC STABILITY ANALYSIS

The software program used to calculate slope stability FS within this analysis is entitled, "XSTABL" version 5.206, compiled by Interactive Software Designs, Inc. of Moscow, Idaho. It is a version of "PC STABL 5M" written by Purdue University for the Indiana Department of Highways.

The program uses limit equilibrium techniques to determine a FS for each given input cross-section and corresponding data file. XSTABL will calculate FS for both rotational and translational failure surfaces within each cross-section in terms of both static and seismic conditions based upon slope geometry, phreatic surfaces and the shear strength parameters of MSW, soils and the most critical contact interface within the baseliner system. The software is used to analyze both static and seismic conditions.

Bishop's Simplified Method

Bishop's simplified method is a limit equilibrium technique initially used within this analysis by XSTABL to locate the most critical rotational failure surface within the cross-section.

Characteristics of Bishop's Method include:

- Dividing failure mass into a number of slices;
- Satisfies vertical force equilibrium for each slice and overall moment equilibrium about the center of the rotational failure surface;
- Specifically applicable to rotational failure surfaces;
- Considers all interslice shear forces to be horizontal (no interslice shear forces); and
- Produces a conservative FS.

Rankine Method

The Rankine method is a technique used within XSTABL to locate the most critical translational failure surface within the cross-section.

Characteristics of the Rankine Method include:

- The ability to single out a confined zone that may represent a potentially weak layer.
- Generating passive and active portions of the failure surface at angles dependent on the shear strength of the surrounding soil unit;
- Satisfies both vertical force and moment equilibrium for each slice and overall horizontal force equilibrium for the entire wedge;
- Applicable to any shape of failure surface;
- Considers all interslice shear forces to be horizontal (no interslice shear force); and

- Produces a FS that is considerably lower than methods that satisfies all conditions of equilibrium for each slice.

SEISMIC STABILITY ANALYSIS

According to 15A NCAC 13B.1622(5)(b)(i), stability evaluation under seismic conditions is required if and only if the landfill is located in a seismic impact zone. A seismic impact zone is defined as follows: "Seismic impact zone" means an area with a ten percent or greater probability that the maximum horizontal acceleration in lithified earth material, expressed as a percentage of the earth's gravitational pull (g), will exceed 0.10g in 250 years.

The USGS publishes Seismic Hazard Maps based on a 50 year return period. A probability of exceedance of 2% in 50 years is approximately equal to that of 10% in 250. This equivalency is demonstrated by comparing the return periods for each, as shown below.

Return Period(year)=1/(1-(1-Encounter Probability(%)/100)^(1/Period(year))).

Encounter Probability (%)	10	2
Period (year)	250	50
Return Period (year)	2,373	2,475

For the Wilkes County Landfill location, the maximum horizontal acceleration due to seismic activity expected to occur with a likelihood of 2% in 50 years is 12.37% of gravitational acceleration, or .1237g, as shown below. Since this value is greater than 0.1 g, the site is in a seismic impact zone, and seismic analysis is required.

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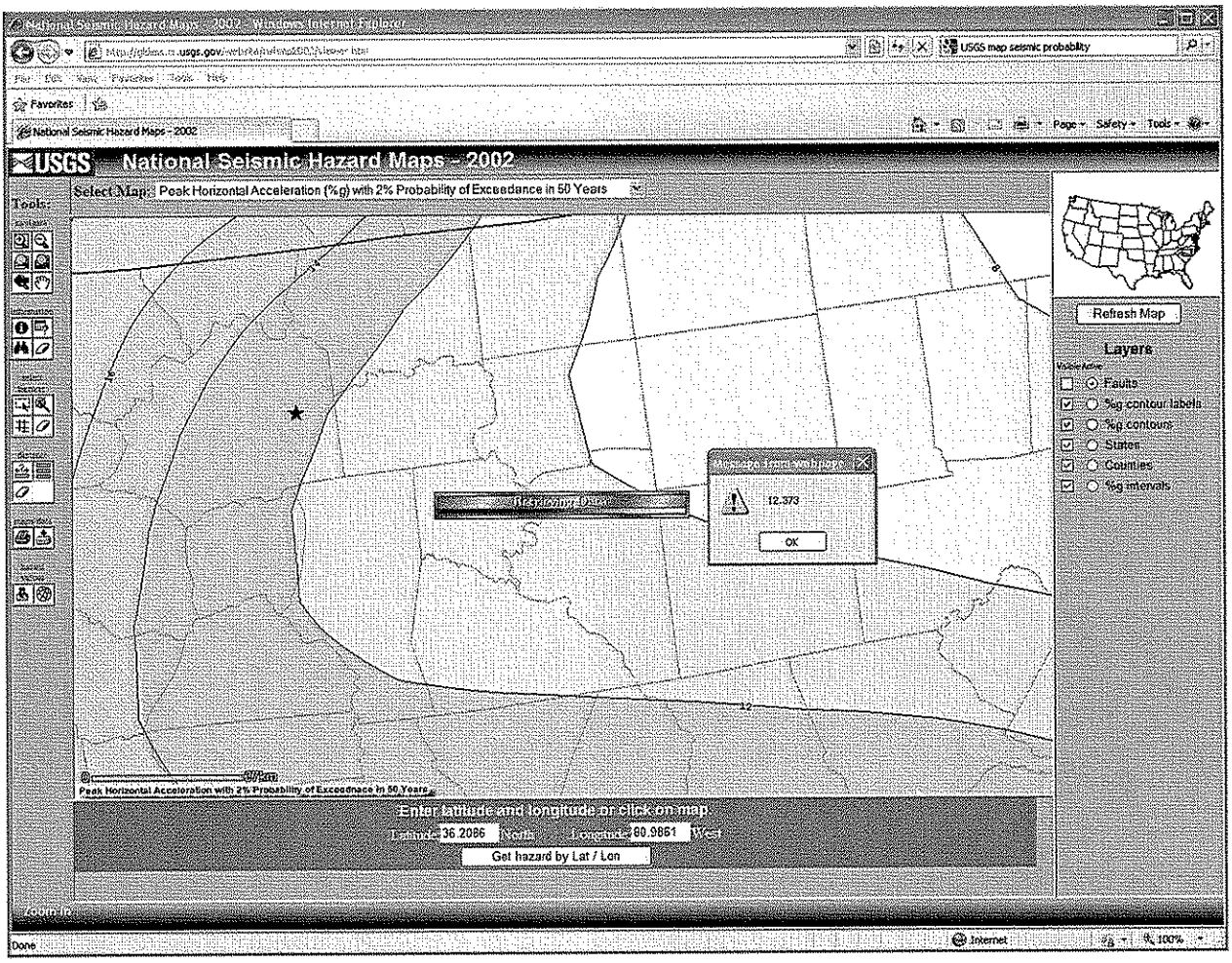

The chart below was used to convert the maximum acceleration at ground level to a maximum acceleration at the crest of waste, for additional conservativeness. The converted value is 0.18 g, and this value is used in the seismic analysis.

Calculation of Max. Acceleration at Waste Crest

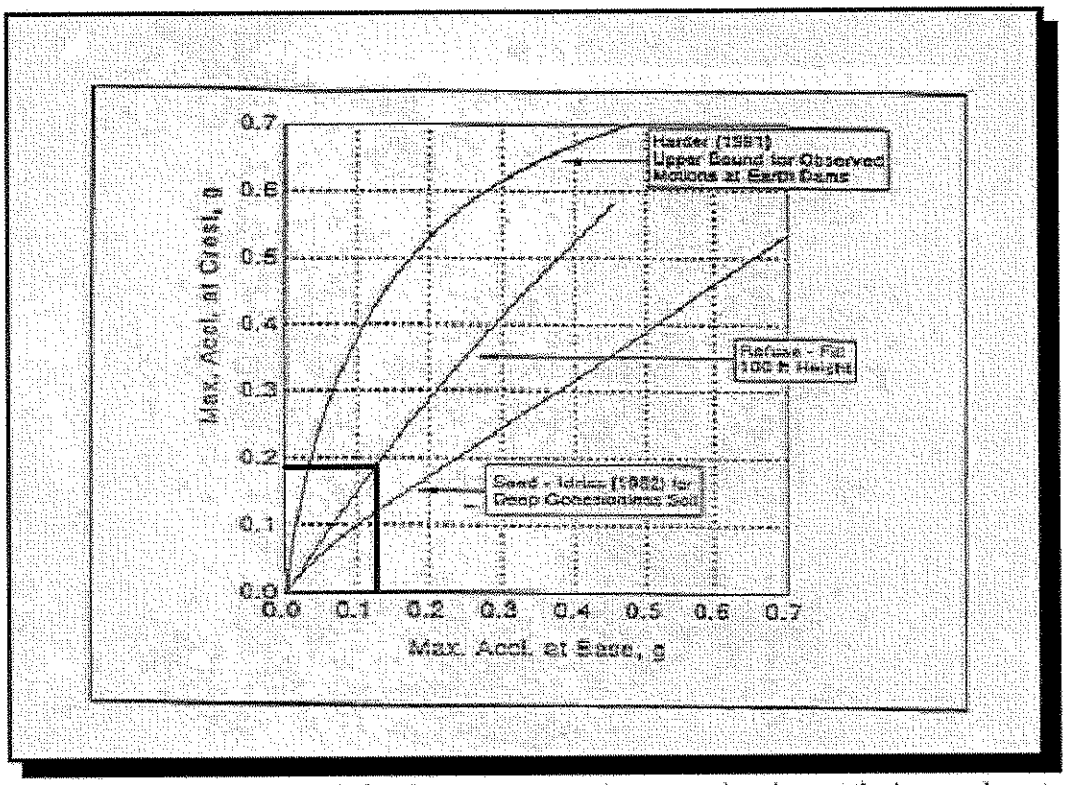

Figure 8-11 Approximate relationship between maximum accelerations at the base and crest for various ground conditions. Singh and Sun.1995. Figure 3.

LANDFILL DESIGN

The landfill layers and assumed parameters used for the global stability modeling are as follows:

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subgrade/structural fill soils described as silty sand (SM), sandy silt (ML), clayey sand (SC) or sandy elastic silt (MH) with in-place moist densities tested approx. 115 pcf.

subgrade/structural fill soils described as silty sand (SM), sandy silt (ML), clayey sand (SC) or sandy elastic silt (MH) with in-place moist densities tested approx. 115 pcf.

soil types include SM, SC, ML, and MH. Although most of the soil does not appear to be MH, that type has the lowest friction angle, ~25, and will be used for conservativeness

		Modeled Parameters				
Component	Depth	Unit Wt. Moist (pcf)	Unit Wt. Satd. (pcf)	Cohesion (psf)	Friction Angle (Ø)	Layer #
Cover	24"	115	120	0	25	6
Waste		70	70	0	33	5
Drainage	24"	130	135	0	37	4
Geosynthetics	6"	60	60	0	28	3
Clay	18"	110	115	0	19	2
Existing Ground /Subgrade	na	115	120	0	25	1
Bedrock	na	110	110	4000	45	7

assume high plasticity clay, CH, for conservativeness

Values based on previous assumptions.

Assumed cohesion is zero to be conservative.

Value based on lab data from construction of W

Value based on typical soil properties

for the geosynthetics this is assumed to be interface friction angle rather than internal friction angle, worst case IFAT was 28 deg for geomembrane/geocomposite

soil types include SM, SC, ML, and MH. Although most of the soil does not appear to be MH, that type has the lowest friction angle, ~25, and will be used for conservativeness

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Typical Soil Parameters

TABLE 1
Typical Properties of Compacted Soils

Group Symbol	Soil Type	Range of Maximum Dry Unit Weight, pcf	Range of Optimum Moisture, Percent	Typical Value of Compression		Typical Strength Characteristics				Typical Coefficient of Permeability ft./min.	Range of CBR Values	Range of Subgrade Modulus k lbs/cu in.
				At 1.4 tsf (20 psi)	At 3.6 tsf (50 psi)	Cohesion (as compacted) psf	Cohesion (saturated) psf	ϕ (Effective Stress Envelope Degrees)	Tan ϕ			
				Percent of Original Height								
GW	Well graded clean gravels, gravel-sand mixtures.	125 - 135	11 - 8	0.3	0.6	0	0	>38	>0.79	5×10^{-2}	40 - 80	300 - 500
GP	Poorly graded clean gravels, gravel-sand mix	115 - 125	14 - 11	0.4	0.9	0	0	>37	>0.74	10^{-1}	30 - 60	250 - 400
GM	Silty gravels, poorly graded gravel-sand-silt.	120 - 135	12 - 8	0.5	1.1	.....	.....	>34	>0.67	$>10^{-3}$	20 - 60	100 - 400
GC	Clayey gravels, poorly graded gravel-sand-clay.	115 - 130	14 - 9	0.7	1.6	.....	.....	>31	>0.60	$>10^{-7}$	20 - 40	100 - 300
SW	Well graded clean sands, gravelly sands.	110 - 130	16 - 9	0.6	1.2	0	0	38	0.79	$>10^{-3}$	20 - 60	200 - 300
SP	Poorly graded clean sands, sand-gravel mix.	100 - 120	21 - 12	0.8	1.6	0	0	37	0.74	$>10^{-3}$	10 - 40	200 - 300
SM	Silty sands, poorly graded sand-silt mix.	110 - 125	16 - 11	0.8	1.6	1050	420	34	0.67	$5 \times >10^{-5}$	10 - 40	100 - 300
SM-SC	Sand-silt clay mix with slightly plastic fines.	110 - 130	15 - 11	0.8	1.4	1050	300	33	0.65	$2 \times >10^{-6}$	5 - 30	100 - 300
SC	Clayey sands, poorly graded sand-clay mix.	105 - 125	19 - 11	1.1	2.2	1550	230	31	0.60	$5 \times >10^{-7}$	5 - 20	100 - 300
ML	Inorganic silts and clayey silts.	95 - 120	24 - 12	0.9	1.7	1400	190	32	0.62	$>10^{-5}$	15 or less	100 - 200
ML-CL	Mixture of inorganic silt and clay.	100 - 120	22 - 12	1.0	2.2	1350	460	32	0.62	$5 \times >10^{-7}$	.....	
CL	Inorganic clays of low to medium plasticity.	95 - 120	24 - 12	1.3	2.5	1600	270	28	0.54	$>10^{-7}$	15 or less	50 - 200
OL	Organic silts and silt-clays, low plasticity.	80 - 100	33 - 21	.....	.....	.....	.....	.....	.....	.....	5 or less	50 - 100
MH	Inorganic clayey silts, elastic silts.	70 - 95	40 - 24	2.0	3.8	1500	420	25	0.47	$5 \times >10^{-2}$	10 or less	50 - 100
CH	Inorganic clays of high plasticity	75 - 105	36 - 19	2.6	3.9	2150	230	19	0.35	$>10^{-7}$	15 or less	50 - 150
OH	Organic clays and silty clays	65 - 100	45 - 21	.....	.....	.....	.....	.....	.....	.....	5 or less	25 - 100

From: Essentials of Soil Mechanics and Foundations (5th Edition), David F. McCarthy

Table 11-2 Approximate Relationship between N and ϕ for Cohesionless Soil

Value of N[a]	Relative Condition of Soil	Approximate Value of ϕ
10	Loose	30° ±
20	Medium-dense	32° ±
30	Medium-dense to dense	35° ±
40	Dense	38° ±
50	Dense to very dense	40° ±
60	Very dense	42° ±

[a]In the so-called standard penetration test, N is the number of blows required to drive a standard 2-in.-outside-diameter (51 mm) split-barrel soil sampler 12 inches (.3 m) into undisturbed soil with a 140-lb weight falling 30 inches (or 63.5 kg with a 0.76 m drop). Values in this table refer to soil sampling procedures where the efficiency of the drop hammer is approximately 60%. For further information on the standard penetration test, refer to Chapter 5.

Table 11-3 Approximate Relationship Between N and Cohesion of Clays

Value of N*	Relative Condition of Soil	Approximate Value of Cohesion, c	
		psf	kN/m² (kPa)
2–4	Soft	250–500	12–24
4–8	Medium	500–1000	24–48
8–15	Stiff	1000–2000	48–96
15–30	Very Stiff	2000–4000	96–190
> 30	Hard	>4000	>190

*Values refer to sampling procedures where the efficiency of the drive hammer is approximately 60 percent; refer Table 11-2.

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Phase 3 Construction Lab Test Results (Soils)

Wilkes County, Phase 3 Expansion, 2005
Laboratory Soil Analyses Summary

Proctor	Soil description	USCS	MDD	OMC	LL	PL	PI	K (cm/sec)
Geotechnics Structiral Fill								
SF-01	Red-brown sandy SILT	ML	102.2	18.8	46	28	18	
SF-02	Red-brown silty SAND	SM	102.0	21.2				
SF-03	Light brown lean clayey sand w/gravel	SC	119.3	13.1	37	20	17	
SF-04	Red-brown sandy elastic SILT	MH	92.1	24.0	64	33	31	
SF-05	Red-brown elastic SILT with sand	MH	79.5	35.1	59	32	27	
SF-06	Red-brown elastic sandy SILT	MH	84.5	27.2	51	31	20	
Geotechnics Low-Perm Soil Liner		USCS	MDD	OMC	LL	PL	PI	K (cm/sec)
TP-03	Red Silt	MH	103.0	20.3	52	32	20	8.2E-06
TP-05	Red elastic Silt	MH	89.5	30.4	67	35	32	4.6E-06
TP-06	Red elastic Silt	MH	91.5	27.5	55	35	20	2.6E-06
TP-07	Red elastic Silt	MH	89.4	28.0	53	31	22	3.5E-06
TP-08	Red brown elastic Silt	MH	92.9	27.5	53	33	20	6.2E-06
CL-01	Red silty Clay (Test Pad)	CH	92.6	27.7	71	33	38	2.1E-06
CL-02	Reddish brown elastic Silt (A2L1)	MH	96.4	24.7	57	32	25	1.0E-05
Unifour		USCS	MDD	OMC	LL	PL	PI	K (cm/sec)
Prelim.	Red-brown silty SAND	SM	107.5	15.5				
Prelim.	Red-brown silty SAND	SM	104.8	18.5				
H1	Red-brown SILT w/fine sand	ML	95.9	25.0				2.6E-05
H2	Red-brown SILT w/fine sand	ML	91.5	26.7				5.2E-06
B1	Yellow-red silty fine SAND	SM	96.9	24.9				6.1E-05
B2	Yellow-red SILT w/sand	ML	91.5	27.2				1.3E-05
B3	Yellow-red SILT w/sand	ML	89.7	28.0				6.3E-06
B4	Yellow-red SILT w/sand	ML	90.7	27.2				7.9-E06
B5	Yellow-red SILT w/sand	ML	91.0	27.1				7.8E-06
B6	Yellow-red SILT w/sand	ML	91.0	27.9	90.2	27.4		5.1E-06
B7	Yellow-red SILT w/sand	ML	91.8	28.0	90.5	28.6		5.2E-06
GeoTesting Express		USCS	MDD	OMC	LL	PL	PI	K (cm/sec)
S-001	Yellow-red CLAY		94.0	27.0				

Phase 3 Construction Lab Test Results (Interface Friction Angle Testing, Worst Case)

GeoTesting express

Client:	Envirocon, Inc.		
Project Name:	Wilkes Landfill		
Project Location:	Roaring River, NC		
GTX #:	6228		
Start Date:	10/05/05	Tested By:	rmt
End Date:	10/06/05	Checked By:	jdt
Geosynthetic ID:	Geomembrane: Black, 60 mil microspike HDPE. Geocomposite: TN-270-2-6		
Geosynthetic Description:	Geomembrane: Black, 60 mil microspike HDPE. Geocomposite: Black, double non-woven.		

Interface Shear Test Series by ASTM D 5321

Test Series #:	1
Test Profile - Top to Bottom:	Textured Gripping Surface / GEOMEMBRANE / GEOCOMPOSITE / Textured Gripping Surface
Soil Preparation:	---
Compaction Characteristics:	Corrected Maximum Dry Density --- pcf Corrected Optimum Moisture Content --- % Compaction Test Method ---
Geosynthetic Preparation:	Saturated for 15 minutes under normal load prior to shear.
Test Equipment:	Top box = 12 in x 12 in; Bottom box = 16 in x 12 in; Load cells and LVDTs connected to data acquisition system for shear force, normal load and horizontal displacement readings; Flat plate clamping device; surface area = 144 in^2
Horizontal Displacement, in/min:	0.2 Test Condition: Inundated

Parameter	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6
Initial Moisture Content, %	---	---	---	---	---	---
Initial Dry Density, pcf	---	---	---	---	---	---
Percent Compaction, %	---	---	---	---	---	---
Normal Compressive Stress, psf	500	2500	5000	---	---	---
Peak Shear Stress, psf	387	1332	2748	---	---	---
Post Peak Shear Stress, psf	218	602	1142	---	---	---
Final Moisture Content, %	---	---	---	---	---	---

NOTES:

Peak Friction Angle:	**28**	**degrees**
Peak Cohesion:	**85**	**psf**
Post Peak Friction Angle:	**12**	**degrees**
Post Peak Cohesion:	**106**	**psf**

Figure a. Shear Force vs. Horizontal Displacement

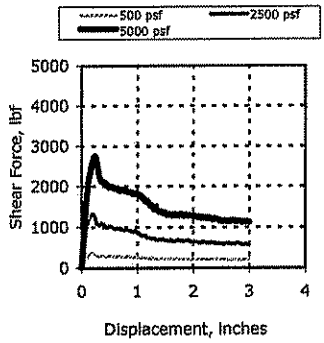
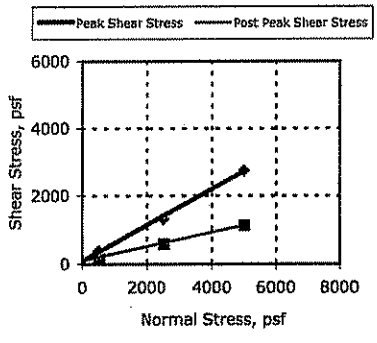


Figure b. Shear Stress vs. Normal Stress



Modeling of Geosynthetic Layers

The flexible membrane liner and geosynthetic clay liner materials were modeled using a single 6" layer with assumed parameters intended to represent the worst case of the internal and interface frictions of the synthetic materials used in the liner.

SLOPE STABILITY RESULTS

Factors of safety (FS) were calculated for the final slope condition for the final build-out of Phase 4. The XSTABL software package calculated FS, expressing the ratio of resisting to driving forces. Calculated factors of safety are provided below, with XSTABL output following.

XSTABL RESULTS

File	Failure Type	Static/Seismic	FS
WILKESCR	Rotational	Static	1.910
WILKESCS	Rotational	Seismic	1.102
WILKESBR	Translational	Static	1.946
WILKESBS	Translational	Seismic	1.103

WILKESCR evaluated the likelihood of a rotational failure through either the waste or underlying soil layers under static conditions.

WILKESCS evaluated the likelihood of a rotational failure through either the waste or underlying soil layers under seismic conditions (peak horizontal acceleration of 0.18 g).

WILKESBR evaluated the likelihood of a translational, sliding block failure along the liner under static conditions.

WILKESBR evaluated the likelihood of a translational, sliding block failure along the liner under seismic conditions.

In conclusion, the factors of safety achieved for the scenarios above indicate a high degree of stability for the worst case cross section of the landfill. From a global stability perspective, construction of the landfill with the grades and materials analyzed is acceptable.

XSTABL FILES

WILKESCR

XSTABL File: WILKESCR 12-15-10 14:13

```
*****************************************
*              X S T A B L              *
*                                       *
*        Slope Stability Analysis       *
*               using the               *
*           Method of Slices            *
*                                       *
*        Copyright (C) 1992 - 2002      *
*   Interactive Software Designs, Inc.  *
*        Moscow, ID 83843, U.S.A.       *
*                                       *
*          All Rights Reserved          *
*                                       *
*  Ver. 5.206                 96 - 1932 *
*****************************************
```

Problem Description : wilkes2010

SEGMENT BOUNDARY COORDINATES
---

8 SURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	.0	973.9	31.0	972.0	1
2	31.0	972.0	40.0	974.0	1
3	40.0	974.0	136.0	1018.0	1
4	136.0	1018.0	324.0	1080.0	6
5	324.0	1080.0	339.0	1081.0	6
6	339.0	1081.0	610.0	1170.0	6
7	610.0	1170.0	686.0	1171.0	6
8	686.0	1171.0	860.0	1122.0	6

62 SUBSURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	136.1	1018.4	323.9	1078.0	5
2	323.9	1078.0	338.9	1078.1	5
3	338.9	1078.1	611.8	1168.0	5
4	611.8	1168.0	685.3	1168.1	5
5	685.3	1168.1	859.5	1120.2	5
6	136.1	1018.3	158.3	1016.0	4
7	158.3	1016.0	168.5	1016.0	4
8	168.5	1016.0	197.7	1002.3	4
9	197.7	1002.3	213.6	1002.4	4
10	213.6	1002.4	282.7	1008.5	4
11	282.7	1008.5	368.3	1010.0	4
12	368.3	1010.0	425.0	1014.0	4

13	425.0	1014.0	450.0	1015.8	4
14	450.0	1015.8	557.2	1018.0	4
15	557.2	1018.0	643.4	1024.0	4
16	643.4	1024.0	775.0	1036.8	4
17	775.0	1036.8	859.6	1045.1	4
18	136.1	1018.2	157.6	1014.0	3
19	157.6	1014.0	166.9	1014.0	3
20	166.9	1014.0	196.2	1000.3	3
21	196.2	1000.3	213.9	1000.4	3
22	213.9	1000.4	283.1	1006.5	3
23	283.1	1006.5	368.7	1008.0	3
24	368.7	1008.0	425.0	1012.0	3
25	425.0	1012.0	450.0	1014.0	3
26	450.0	1014.0	557.5	1016.0	3
27	557.5	1016.0	643.5	1022.0	3
28	643.5	1022.0	775.0	1034.8	3
29	775.0	1034.8	859.6	1043.1	3
30	136.1	1018.1	157.4	1013.5	2
31	157.4	1013.5	166.5	1013.4	2
32	166.5	1013.4	195.8	999.8	2
33	195.8	999.8	214.0	999.9	2
34	214.0	999.9	283.2	1006.0	2
35	283.2	1006.0	368.7	1007.5	2
36	368.7	1007.5	425.0	1011.5	2
37	425.0	1011.5	450.0	1013.3	2
38	450.0	1013.3	557.4	1015.5	2
39	557.4	1015.5	643.7	1021.5	2
40	643.7	1021.5	775.0	1034.3	2
41	775.0	1034.3	859.6	1042.5	2
42	136.1	1018.0	156.5	1012.0	1
43	156.5	1012.0	165.3	1012.0	1
44	165.3	1012.0	194.6	998.3	1
45	194.6	998.3	214.3	998.4	1
46	214.3	998.4	283.5	1004.5	1
47	283.5	1004.5	369.0	1006.0	1
48	369.0	1006.0	425.0	1010.0	1
49	425.0	1010.0	450.0	1011.8	1
50	450.0	1011.8	557.8	1014.0	1
51	557.8	1014.0	644.2	1020.0	1
52	644.2	1020.0	775.0	1032.8	1
53	775.0	1032.8	859.6	1041.0	1
54	100.0	940.0	175.0	946.0	7
55	175.0	946.0	225.2	953.0	7
56	225.2	953.0	274.4	961.2	7
57	274.4	961.2	300.0	964.9	7
58	300.0	964.9	350.0	969.9	7
59	350.0	969.9	425.0	979.7	7
60	425.0	979.7	550.0	997.2	7
61	550.0	997.2	625.0	1003.8	7
62	625.0	1003.8	825.0	1012.5	7

ISOTROPIC Soil Parameters
---

7 Soil unit(s) specified

Soil Unit No.	Unit Weight Moist (pcf)	Unit Weight Sat. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Parameter Ru	Pore Pressure Constant (psf)	Water Surface No.
1	115.0	120.0	.0	25.00	.000	.0	1
2	110.0	115.0	.0	19.00	.000	.0	0
3	60.0	60.0	.0	28.00	.000	.0	0
4	130.0	135.0	.0	37.00	.000	.0	2
5	70.0	70.0	.0	33.00	.000	.0	0
6	115.0	120.0	.0	25.00	.000	.0	0

```
  7   110.0   110.0    4000.0    45.00       .000          .0       0


 2 Water surface(s) have been specified

Unit weight of water =    62.40  (pcf)


Water Surface No.  1 specified by  8 coordinate points

**********************************
         PHREATIC SURFACE,
**********************************

  Point       x-water      y-water
   No.          (ft)         (ft)

    1          125.00       974.60
    2          174.90       977.00
    3          299.90       983.70
    4          350.00       986.80
    5          490.30       994.20
    6          575.10       998.80
    7          674.90      1003.50
    8          848.00      1009.90


Water Surface No.  2 specified by 13 coordinate points

**********************************
         PHREATIC SURFACE,
**********************************

  Point       x-water      y-water
   No.          (ft)         (ft)

    1          136.10      1018.00
    2          158.00      1015.00
    3          168.00      1014.50
    4          198.00      1001.00
    5          213.00      1000.50
    6          283.00      1007.00
    7          368.00      1009.00
    8          425.00      1013.00
    9          450.00      1015.00
   10          557.00      1017.00
   11          643.00      1023.00
   12          775.00      1036.00
   13          859.00      1044.00


A critical failure surface searching method, using a random
technique for generating CIRCULAR surfaces has been specified.


 2500 trial surfaces will be generated and analyzed.


  50 Surfaces initiate from each of  50 points equally spaced
along the ground surface between  x =        .0 ft
                             and  x =       5.0 ft


Each surface terminates between   x =     620.0 ft
                             and   x =     645.0 ft
```

Unless further limitations were imposed, the minimum elevation
at which a surface extends is y = .0 ft

50.0 ft line segments define each trial failure surface.

ANGULAR RESTRICTIONS

The first segment of each failure surface will be inclined within the angular range defined by :

Lower angular limit := -45.0 degrees
Upper angular limit := (slope angle - 5.0) degrees

Factors of safety have been calculated by the :

* * * * * SIMPLIFIED BISHOP METHOD * * * * *

The most critical circular failure surface is specified by 15 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	.31	973.88
2	49.51	965.00
3	99.25	959.91
4	149.24	958.66
5	199.17	961.25
6	248.76	967.66
7	297.71	977.85
8	345.73	991.77
9	392.54	1009.34
10	437.87	1030.44
11	481.44	1054.96
12	523.01	1082.75
13	562.32	1113.65
14	599.14	1147.47
15	620.30	1170.14

**** Simplified BISHOP FOS = 1.910 ****

* * * END OF FILE * * *

WILKESCS

XSTABL File: WILKESCS 12-15-10 14:14

```
*****************************************
*              X S T A B L              *
*                                       *
*        Slope Stability Analysis       *
*               using the               *
*            Method of Slices           *
*                                       *
*        Copyright (C) 1992 - 2002      *
*   Interactive Software Designs, Inc.  *
*        Moscow, ID 83843, U.S.A.       *
*                                       *
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*                                       *
*  Ver. 5.206                 96 - 1932 *
*****************************************
```

Problem Description : wilkes2010

SEGMENT BOUNDARY COORDINATES
---

8 SURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	.0	973.9	31.0	972.0	1
2	31.0	972.0	40.0	974.0	1
3	40.0	974.0	136.0	1018.0	1
4	136.0	1018.0	324.0	1080.0	6
5	324.0	1080.0	339.0	1081.0	6
6	339.0	1081.0	610.0	1170.0	6
7	610.0	1170.0	686.0	1171.0	6
8	686.0	1171.0	860.0	1122.0	6

62 SUBSURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	136.1	1018.4	323.9	1078.0	5
2	323.9	1078.0	338.9	1078.1	5
3	338.9	1078.1	611.8	1168.0	5
4	611.8	1168.0	685.3	1168.1	5
5	685.3	1168.1	859.5	1120.2	5
6	136.1	1018.3	158.3	1016.0	4
7	158.3	1016.0	168.5	1016.0	4
8	168.5	1016.0	197.7	1002.3	4
9	197.7	1002.3	213.6	1002.4	4
10	213.6	1002.4	282.7	1008.5	4
11	282.7	1008.5	368.3	1010.0	4
12	368.3	1010.0	425.0	1014.0	4
13	425.0	1014.0	450.0	1015.8	4
14	450.0	1015.8	557.2	1018.0	4
15	557.2	1018.0	643.4	1024.0	4
16	643.4	1024.0	775.0	1036.8	4
17	775.0	1036.8	859.6	1045.1	4

18	136.1	1018.2	157.6	1014.0	3
19	157.6	1014.0	166.9	1014.0	3
20	166.9	1014.0	196.2	1000.3	3
21	196.2	1000.3	213.9	1000.4	3
22	213.9	1000.4	283.1	1006.5	3
23	283.1	1006.5	368.7	1008.0	3
24	368.7	1008.0	425.0	1012.0	3
25	425.0	1012.0	450.0	1014.0	3
26	450.0	1014.0	557.5	1016.0	3
27	557.5	1016.0	643.5	1022.0	3
28	643.5	1022.0	775.0	1034.8	3
29	775.0	1034.8	859.6	1043.1	3
30	136.1	1018.1	157.4	1013.5	2
31	157.4	1013.5	166.5	1013.4	2
32	166.5	1013.4	195.8	999.8	2
33	195.8	999.8	214.0	999.9	2
34	214.0	999.9	283.2	1006.0	2
35	283.2	1006.0	368.7	1007.5	2
36	368.7	1007.5	425.0	1011.5	2
37	425.0	1011.5	450.0	1013.3	2
38	450.0	1013.3	557.4	1015.5	2
39	557.4	1015.5	643.7	1021.5	2
40	643.7	1021.5	775.0	1034.3	2
41	775.0	1034.3	859.6	1042.5	2
42	136.1	1018.0	156.5	1012.0	1
43	156.5	1012.0	165.3	1012.0	1
44	165.3	1012.0	194.6	998.3	1
45	194.6	998.3	214.3	998.4	1
46	214.3	998.4	283.5	1004.5	1
47	283.5	1004.5	369.0	1006.0	1
48	369.0	1006.0	425.0	1010.0	1
49	425.0	1010.0	450.0	1011.8	1
50	450.0	1011.8	557.8	1014.0	1
51	557.8	1014.0	644.2	1020.0	1
52	644.2	1020.0	775.0	1032.8	1
53	775.0	1032.8	859.6	1041.0	1
54	100.0	940.0	175.0	946.0	7
55	175.0	946.0	225.2	953.0	7
56	225.2	953.0	274.4	961.2	7
57	274.4	961.2	300.0	964.9	7
58	300.0	964.9	350.0	969.9	7
59	350.0	969.9	425.0	979.7	7
60	425.0	979.7	550.0	997.2	7
61	550.0	997.2	625.0	1003.8	7
62	625.0	1003.8	825.0	1012.5	7

ISOTROPIC Soil Parameters
---

7 Soil unit(s) specified

Soil Unit No.	Unit Weight Moist (pcf)	Unit Weight Sat. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Parameter Ru	Pore Pressure Constant (psf)	Water Surface No.
1	115.0	120.0	.0	25.00	.000	.0	1
2	110.0	115.0	.0	19.00	.000	.0	0
3	60.0	60.0	.0	28.00	.000	.0	0
4	130.0	135.0	.0	37.00	.000	.0	2
5	70.0	70.0	.0	33.00	.000	.0	0
6	115.0	120.0	.0	25.00	.000	.0	0
7	110.0	110.0	4000.0	45.00	.000	.0	0

2 Water surface(s) have been specified

Unit weight of water = 62.40 (pcf)

Water Surface No. 1 specified by 8 coordinate points

****
PHREATIC SURFACE,
****

Point No.	x-water (ft)	y-water (ft)
1	125.00	974.60
2	174.90	977.00
3	299.90	983.70
4	350.00	986.80
5	490.30	994.20
6	575.10	998.80
7	674.90	1003.50
8	848.00	1009.90

Water Surface No. 2 specified by 13 coordinate points

****
PHREATIC SURFACE,
****

Point No.	x-water (ft)	y-water (ft)
1	136.10	1018.00
2	158.00	1015.00
3	168.00	1014.50
4	198.00	1001.00
5	213.00	1000.50
6	283.00	1007.00
7	368.00	1009.00
8	425.00	1013.00
9	450.00	1015.00
10	557.00	1017.00
11	643.00	1023.00
12	775.00	1036.00
13	859.00	1044.00

A horizontal earthquake loading coefficient
of .180 has been assigned

A vertical earthquake loading coefficient
of .000 has been assigned

A critical failure surface searching method, using a random
technique for generating CIRCULAR surfaces has been specified.

2500 trial surfaces will be generated and analyzed.

50 Surfaces initiate from each of 50 points equally spaced
along the ground surface between x = .0 ft
and x = 5.0 ft

Each surface terminates between x = 620.0 ft
and x = 645.0 ft

Unless further limitations were imposed, the minimum elevation at which a surface extends is y = .0 ft

50.0 ft line segments define each trial failure surface.

ANGULAR RESTRICTIONS

The first segment of each failure surface will be inclined within the angular range defined by :

Lower angular limit := -45.0 degrees
Upper angular limit := (slope angle - 5.0) degrees

Factors of safety have been calculated by the :

* * * * * SIMPLIFIED BISHOP METHOD * * * * *

The most critical circular failure surface is specified by 15 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	1.84	973.79
2	50.51	962.35
3	99.96	954.98
4	149.86	951.72
5	199.85	952.60
6	249.60	957.62
7	298.76	966.73
8	347.00	979.88
9	393.99	996.97
10	439.40	1017.90
11	482.93	1042.50
12	524.27	1070.63
13	563.14	1102.07
14	599.28	1136.63
15	629.07	1170.25

**** Simplified BISHOP FOS = 1.102 ****

* * * END OF FILE * * *

WILKESBR

XSTABL File: WILKESBR 12-15-10 14:19

```
*****************************************
*              X S T A B L              *
*                                       *
*        Slope Stability Analysis       *
*               using the               *
*           Method of Slices            *
*                                       *
*        Copyright (C) 1992 - 2002      *
*   Interactive Software Designs, Inc.  *
*        Moscow, ID 83843, U.S.A.       *
*                                       *
*          All Rights Reserved          *
*                                       *
*  Ver. 5.206                96 - 1932  *
*****************************************
```

Problem Description : wilkes2010

SEGMENT BOUNDARY COORDINATES

8 SURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	.0	973.9	31.0	972.0	1
2	31.0	972.0	40.0	974.0	1
3	40.0	974.0	136.0	1018.0	1
4	136.0	1018.0	324.0	1080.0	6
5	324.0	1080.0	339.0	1081.0	6
6	339.0	1081.0	610.0	1170.0	6
7	610.0	1170.0	686.0	1171.0	6
8	686.0	1171.0	860.0	1122.0	6

62 SUBSURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	136.1	1018.4	323.9	1078.0	5
2	323.9	1078.0	338.9	1078.1	5
3	338.9	1078.1	611.8	1168.0	5
4	611.8	1168.0	685.3	1168.1	5
5	685.3	1168.1	859.5	1120.2	5
6	136.1	1018.3	158.3	1016.0	4
7	158.3	1016.0	168.5	1016.0	4
8	168.5	1016.0	197.7	1002.3	4
9	197.7	1002.3	213.6	1002.4	4
10	213.6	1002.4	282.7	1008.5	4
11	282.7	1008.5	368.3	1010.0	4
12	368.3	1010.0	425.0	1014.0	4
13	425.0	1014.0	450.0	1015.8	4
14	450.0	1015.8	557.2	1018.0	4
15	557.2	1018.0	643.4	1024.0	4
16	643.4	1024.0	775.0	1036.8	4
17	775.0	1036.8	859.6	1045.1	4

18	136.1	1018.2	157.6	1014.0	3
19	157.6	1014.0	166.9	1014.0	3
20	166.9	1014.0	196.2	1000.3	3
21	196.2	1000.3	213.9	1000.4	3
22	213.9	1000.4	283.1	1006.5	3
23	283.1	1006.5	368.7	1008.0	3
24	368.7	1008.0	425.0	1012.0	3
25	425.0	1012.0	450.0	1014.0	3
26	450.0	1014.0	557.5	1016.0	3
27	557.5	1016.0	643.5	1022.0	3
28	643.5	1022.0	775.0	1034.8	3
29	775.0	1034.8	859.6	1043.1	3
30	136.1	1018.1	157.4	1013.5	2
31	157.4	1013.5	166.5	1013.4	2
32	166.5	1013.4	195.8	999.8	2
33	195.8	999.8	214.0	999.9	2
34	214.0	999.9	283.2	1006.0	2
35	283.2	1006.0	368.7	1007.5	2
36	368.7	1007.5	425.0	1011.5	2
37	425.0	1011.5	450.0	1013.3	2
38	450.0	1013.3	557.4	1015.5	2
39	557.4	1015.5	643.7	1021.5	2
40	643.7	1021.5	775.0	1034.3	2
41	775.0	1034.3	859.6	1042.5	2
42	136.1	1018.0	156.5	1012.0	1
43	156.5	1012.0	165.3	1012.0	1
44	165.3	1012.0	194.6	998.3	1
45	194.6	998.3	214.3	998.4	1
46	214.3	998.4	283.5	1004.5	1
47	283.5	1004.5	369.0	1006.0	1
48	369.0	1006.0	425.0	1010.0	1
49	425.0	1010.0	450.0	1011.8	1
50	450.0	1011.8	557.8	1014.0	1
51	557.8	1014.0	644.2	1020.0	1
52	644.2	1020.0	775.0	1032.8	1
53	775.0	1032.8	859.6	1041.0	1
54	100.0	940.0	175.0	946.0	7
55	175.0	946.0	225.2	953.0	7
56	225.2	953.0	274.4	961.2	7
57	274.4	961.2	300.0	964.9	7
58	300.0	964.9	350.0	969.9	7
59	350.0	969.9	425.0	979.7	7
60	425.0	979.7	550.0	997.2	7
61	550.0	997.2	625.0	1003.8	7
62	625.0	1003.8	825.0	1012.5	7

ISOTROPIC Soil Parameters
---

7 Soil unit(s) specified

Soil Unit No.	Unit Weight Moist (pcf)	Unit Weight Sat. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Parameter Ru	Pore Pressure Constant (psf)	Water Surface No.
1	115.0	120.0	.0	25.00	.000	.0	1
2	110.0	115.0	.0	19.00	.000	.0	0
3	60.0	60.0	.0	28.00	.000	.0	0
4	130.0	135.0	.0	37.00	.000	.0	2
5	70.0	70.0	.0	33.00	.000	.0	0
6	115.0	120.0	.0	25.00	.000	.0	0
7	110.0	110.0	4000.0	45.00	.000	.0	0

2 Water surface(s) have been specified

Unit weight of water = 62.40 (pcf)

Water Surface No. 1 specified by 8 coordinate points

****
PHREATIC SURFACE,
****

Point No.	x-water (ft)	y-water (ft)
1	125.00	974.60
2	174.90	977.00
3	299.90	983.70
4	350.00	986.80
5	490.30	994.20
6	575.10	998.80
7	674.90	1003.50
8	848.00	1009.90

Water Surface No. 2 specified by 13 coordinate points

****
PHREATIC SURFACE,
****

Point No.	x-water (ft)	y-water (ft)
1	136.10	1018.00
2	158.00	1015.00
3	168.00	1014.50
4	198.00	1001.00
5	213.00	1000.50
6	283.00	1007.00
7	368.00	1009.00
8	425.00	1013.00
9	450.00	1015.00
10	557.00	1017.00
11	643.00	1023.00
12	775.00	1036.00
13	859.00	1044.00

A critical failure surface searching method, using a random technique for generating sliding BLOCK surfaces, has been specified.

The active and passive portions of the sliding surfaces are generated according to the Rankine theory.

1600 trial surfaces will be generated and analyzed.

6 boxes specified for generation of central block base

* * * * * DEFAULT SEGMENT LENGTH SELECTED BY XSTABL * * * * *

Length of line segments for active and passive portions of sliding block is 30.0 ft

Box no.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Width (ft)
1	158.0	1013.5	163.0	1013.4	1.0
2	195.0	999.8	200.0	999.9	1.0
3	283.0	1006.0	288.0	1006.1	1.0
4	368.7	1007.5	374.0	1007.7	1.0
5	425.0	1011.5	430.0	1011.7	1.0
6	510.0	1014.5	540.0	1015.1	1.0

Factors of safety have been calculated by the :

* * * * * SIMPLIFIED JANBU METHOD * * * * *

The 10 most critical of all the failure surfaces examined
are displayed below - the most critical first

Failure surface No. 1 specified by 20 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	144.12	1020.95
2	152.04	1016.65
3	157.19	1014.08
4	158.17	1013.49
5	158.52	1013.24
6	197.99	999.40
7	284.60	1005.54
8	371.32	1007.13
9	428.37	1011.47
10	532.50	1014.93
11	532.54	1014.99
12	532.87	1015.54
13	533.86	1017.52
14	548.17	1043.89
15	562.49	1070.25
16	576.80	1096.61
17	591.12	1122.98
18	605.43	1149.34
19	615.57	1168.01
20	616.89	1170.09

** Corrected JANBU FOS = 1.946 ** (Fo factor = 1.050)

* * * END OF FILE * * *

WILKESBS

XSTABL File: WILKESBS 12-15-10 14:19

```
*****************************************
*              X S T A B L              *
*                                       *
*        Slope Stability Analysis       *
*               using the               *
*           Method of Slices            *
*                                       *
*        Copyright (C) 1992 - 2002      *
*   Interactive Software Designs, Inc.  *
*        Moscow, ID 83843, U.S.A.       *
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*          All Rights Reserved          *
*                                       *
*  Ver. 5.206                 96 - 1932 *
*****************************************
```

Problem Description : wilkes2010

SEGMENT BOUNDARY COORDINATES

8 SURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	.0	973.9	31.0	972.0	1
2	31.0	972.0	40.0	974.0	1
3	40.0	974.0	136.0	1018.0	1
4	136.0	1018.0	324.0	1080.0	6
5	324.0	1080.0	339.0	1081.0	6
6	339.0	1081.0	610.0	1170.0	6
7	610.0	1170.0	686.0	1171.0	6
8	686.0	1171.0	860.0	1122.0	6

62 SUBSURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	136.1	1018.4	323.9	1078.0	5
2	323.9	1078.0	338.9	1078.1	5
3	338.9	1078.1	611.8	1168.0	5
4	611.8	1168.0	685.3	1168.1	5
5	685.3	1168.1	859.5	1120.2	5
6	136.1	1018.3	158.3	1016.0	4
7	158.3	1016.0	168.5	1016.0	4
8	168.5	1016.0	197.7	1002.3	4
9	197.7	1002.3	213.6	1002.4	4
10	213.6	1002.4	282.7	1008.5	4
11	282.7	1008.5	368.3	1010.0	4
12	368.3	1010.0	425.0	1014.0	4
13	425.0	1014.0	450.0	1015.8	4
14	450.0	1015.8	557.2	1018.0	4
15	557.2	1018.0	643.4	1024.0	4
16	643.4	1024.0	775.0	1036.8	4
17	775.0	1036.8	859.6	1045.1	4

18	136.1	1018.2	157.6	1014.0	3
19	157.6	1014.0	166.9	1014.0	3
20	166.9	1014.0	196.2	1000.3	3
21	196.2	1000.3	213.9	1000.4	3
22	213.9	1000.4	283.1	1006.5	3
23	283.1	1006.5	368.7	1008.0	3
24	368.7	1008.0	425.0	1012.0	3
25	425.0	1012.0	450.0	1014.0	3
26	450.0	1014.0	557.5	1016.0	3
27	557.5	1016.0	643.5	1022.0	3
28	643.5	1022.0	775.0	1034.8	3
29	775.0	1034.8	859.6	1043.1	3
30	136.1	1018.1	157.4	1013.5	2
31	157.4	1013.5	166.5	1013.4	2
32	166.5	1013.4	195.8	999.8	2
33	195.8	999.8	214.0	999.9	2
34	214.0	999.9	283.2	1006.0	2
35	283.2	1006.0	368.7	1007.5	2
36	368.7	1007.5	425.0	1011.5	2
37	425.0	1011.5	450.0	1013.3	2
38	450.0	1013.3	557.4	1015.5	2
39	557.4	1015.5	643.7	1021.5	2
40	643.7	1021.5	775.0	1034.3	2
41	775.0	1034.3	859.6	1042.5	2
42	136.1	1018.0	156.5	1012.0	1
43	156.5	1012.0	165.3	1012.0	1
44	165.3	1012.0	194.6	998.3	1
45	194.6	998.3	214.3	998.4	1
46	214.3	998.4	283.5	1004.5	1
47	283.5	1004.5	369.0	1006.0	1
48	369.0	1006.0	425.0	1010.0	1
49	425.0	1010.0	450.0	1011.8	1
50	450.0	1011.8	557.8	1014.0	1
51	557.8	1014.0	644.2	1020.0	1
52	644.2	1020.0	775.0	1032.8	1
53	775.0	1032.8	859.6	1041.0	1
54	100.0	940.0	175.0	946.0	7
55	175.0	946.0	225.2	953.0	7
56	225.2	953.0	274.4	961.2	7
57	274.4	961.2	300.0	964.9	7
58	300.0	964.9	350.0	969.9	7
59	350.0	969.9	425.0	979.7	7
60	425.0	979.7	550.0	997.2	7
61	550.0	997.2	625.0	1003.8	7
62	625.0	1003.8	825.0	1012.5	7

ISOTROPIC Soil Parameters
---

7 Soil unit(s) specified

Soil Unit No.	Unit Weight Moist (pcf)	Unit Weight Sat. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Parameter Ru	Pore Pressure Constant (psf)	Water Surface No.
1	115.0	120.0	.0	25.00	.000	.0	1
2	110.0	115.0	.0	19.00	.000	.0	0
3	60.0	60.0	.0	28.00	.000	.0	0
4	130.0	135.0	.0	37.00	.000	.0	2
5	70.0	70.0	.0	33.00	.000	.0	0
6	115.0	120.0	.0	25.00	.000	.0	0
7	110.0	110.0	4000.0	45.00	.000	.0	0

2 Water surface(s) have been specified

Unit weight of water = 62.40 (pcf)

Water Surface No. 1 specified by 8 coordinate points

****
PHREATIC SURFACE,
****

Point No.	x-water (ft)	y-water (ft)
1	125.00	974.60
2	174.90	977.00
3	299.90	983.70
4	350.00	986.80
5	490.30	994.20
6	575.10	998.80
7	674.90	1003.50
8	848.00	1009.90

Water Surface No. 2 specified by 13 coordinate points

****
PHREATIC SURFACE,
****

Point No.	x-water (ft)	y-water (ft)
1	136.10	1018.00
2	158.00	1015.00
3	168.00	1014.50
4	198.00	1001.00
5	213.00	1000.50
6	283.00	1007.00
7	368.00	1009.00
8	425.00	1013.00
9	450.00	1015.00
10	557.00	1017.00
11	643.00	1023.00
12	775.00	1036.00
13	859.00	1044.00

A horizontal earthquake loading coefficient
of .180 has been assigned

A vertical earthquake loading coefficient
of .000 has been assigned

A critical failure surface searching method, using a random technique for generating sliding BLOCK surfaces, has been specified.

The active and passive portions of the sliding surfaces are generated according to the Rankine theory.

1600 trial surfaces will be generated and analyzed.

6 boxes specified for generation of central block base

* * * * * DEFAULT SEGMENT LENGTH SELECTED BY XSTABL * * * * *

Length of line segments for active and passive portions of sliding block is 30.0 ft

Box no.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Width (ft)
1	158.0	1013.5	163.0	1013.4	1.0
2	195.0	999.8	200.0	999.9	1.0
3	283.0	1006.0	288.0	1006.1	1.0
4	368.7	1007.5	374.0	1007.7	1.0
5	425.0	1011.5	430.0	1011.7	1.0
6	510.0	1014.5	540.0	1015.1	1.0

Factors of safety have been calculated by the :

* * * * * SIMPLIFIED JANBU METHOD * * * * *

The 10 most critical of all the failure surfaces examined are displayed below - the most critical first

Failure surface No. 1 specified by 20 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	144.12	1020.95
2	152.04	1016.65
3	157.19	1014.08
4	158.17	1013.49
5	158.52	1013.24
6	197.99	999.40
7	284.60	1005.54
8	371.32	1007.13
9	428.37	1011.47
10	532.50	1014.93
11	532.54	1014.99
12	532.87	1015.54
13	533.86	1017.52
14	548.17	1043.89
15	562.49	1070.25
16	576.80	1096.61
17	591.12	1122.98
18	605.43	1149.34
19	615.57	1168.01
20	616.89	1170.09

** Corrected JANBU FOS = 1.103 ** (Fo factor = 1.050)

* * * END OF FILE * * *

JOYCE ENGINEERING, INC.

Project:	Roaring River Landfill Phase 4		
Project Number:	356.1002.11.01		
Calculated By:	CTM	Date:	12/14/10
Revised By:		Date:	
Checked By:	GA	Date:	4/5/11
Subject:	Cover Veneer Failure Analysis		
Sheet:	1 of 8		

FINAL COVER VENEER FAILURE ANALYSIS

OBJECTIVE

Calculate the shear strength that will provide an unsaturated veneer slope stability FS $\geq$1.5 with respect to the geocomposite drainage layer / soil protective cover layer failing along the final cover 3H:1V sideslopes. The calculation will also consider the presence of moving equipment placing and spreading protective cover material across the sideslope.

METHODOLOGY

The analytical method used to calculate the veneer slope stability FS is taken from a report prepared by the Geosynthetic Research Institute (GRI), Drexel University:

1) "*Cover Soil Slope Stability Involving Geosynthetic Interfaces*", (GRI REPORT #18), by Te-Yang Soong and Robert M. Koerner, December 9, 1996 and

GRI Report #18 is used to consider the presence of equipment on top of the protective cover layer and provides a FS based on the most critical interface shear strength of final cover components. The spreadsheet calculates a FS by dividing the protective cover material along the 3H:1V sideslope into two blocks:

1) an active wedge of protective cover material along the length of the sideslope; and
2) a passive wedge of protective cover material at the toe of the sideslope.

A freebody diagram is then drawn identifying the forces on each wedge and static equilibrium equations are resolved in terms of vertical and horizontal components. Expressions are derived that quantify the magnitude of both the passive and active interwedge forces. Subsequently, the interwedge force equations are set equal to each other and are arranged in the form of a quadratic equation that can be solved to calculate a FS.

This calculation analyzes the longest length of the 3H:1V final cover sideslope between benches. Figure 1 illustrates the proposed geometry of the final cover sideslope and the freebody of the forces acting along the sideslope.

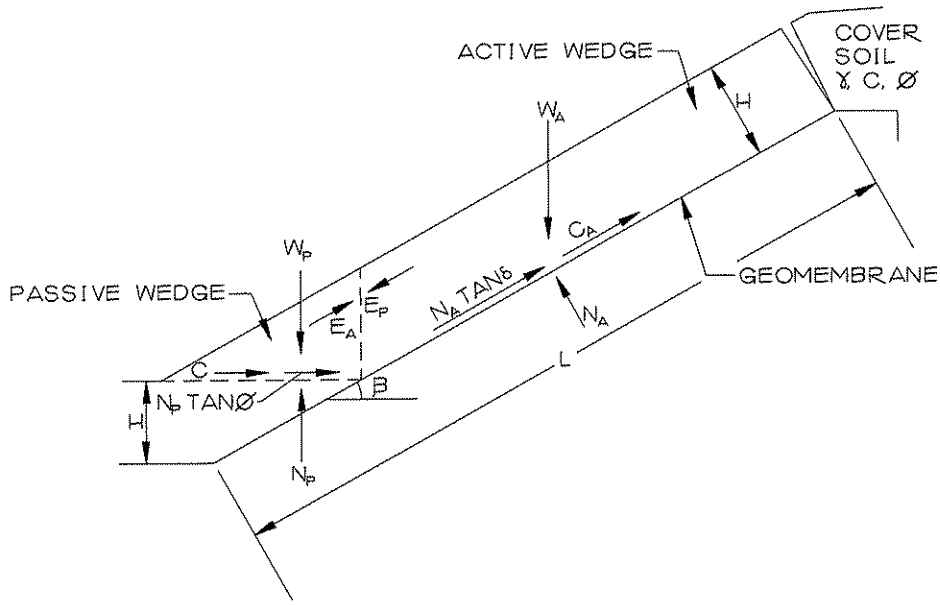

Figure 1, Slope Geometry & Free Body Diagram

Slope Dimensions	
Maximum Length of Sideslope (along the length of the geomembrane)	275 feet
Sideslope Orientation	3H:1V or 18.43 degrees

This veneer slope stability FS calculation is prepared proposing the following assumptions:

- The presence of moving equipment (dynamic loading) along the 3H:1V protective cover sideslope is analyzed within GRI Report #18.
- The shear strength component of adhesion developed between geosynthetic material layers is ignored.
- Tensile strength of the geosynthetic materials contributing to the veneer slope stability FS is ignored.
- The protective cover material provides a buttress at the toe of the slope, i.e. the passive soil wedge.
- For conservatism, the cohesive strength of the proposed protective cover material was ignored.
- Weights of the geosynthetic components are negligible compared to the weight of protective cover material and therefore are not considered in the calculations.
- All calculations will utilize a 1-foot unit width of sideslope.

JOYCE ENGINEERING, INC.

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Checked By:	BJA	Date:	1/5/11
Subject:	Cover Veneer Failure Analysis		
Sheet:	3 of 8		

PROPOSED FINAL COVER

The proposed Final Cover System is outlined below, from top to bottom:

- 6 inches of Vegetative Soil;
- 18 inches of Protective Soil
- Geocomposite Drainage Layer (geotextile heat bonded to both sides of a geonet);
- Textured 40-mil LLDPE Flexible Membrane Liner (FML);
- Geosynthetic clay liner;
- Geotextile/Geonet Gas Migration Layer; and
- 1-foot thick Intermediate Cover Layer.

PROTECTIVE COVER MATERIAL PARAMETERS

Unit weight: γ_{Total} = 115 pcf;

Cohesion: c = 0 psf; and
Internal angle of friction: ϕ_i = 25.0 degrees

REQUIRED SHEAR STRENGTH PARAMETERS

The calculation spreadsheet presented within GRI Report #18 will be used to determine the shear strength parameter (contact interface friction angle, $\delta_{interface\ friction}$) that corresponds to a FS $\geq$1.5 under drained conditions for all geosynthetic interfaces. The input variables of final cover sideslope length, protective cover, and LGP equipment will be held constant within the spreadsheet while the contact interface friction angle, $\delta_{interface\ friction,}$ is varied until a FS of $\geq$1.5 is achieved. Cohesion values of 0 psf will be entered.

The calculated $\delta_{interface\ friction}$ that corresponds to the FS $\geq$1.5 represents laboratory data where a straight line is drawn from the origin through the first data point (i.e. c = 0 psf) that corresponds to the lowest normal load within the given data set. The lowest normal load models the shear strength of protective cover material under relatively light normal loads that are anticipated to be initially encountered in the field during placement of the material. With respect to the protective cover, normal loads representative of 2 feet of protective cover are appropriate. The proposed critical contact interface will undergo ASTM D-5321-92 Direct Shear Testing and will be required to meet the minimum calculated contact interface friction angle corresponding to the first normal load.

The resulting contact interface friction angles will be included with other minimum shear strength parameters specified within the Construction Quality Assurance (CQA) Plan and/or specifications.

VARIABLES DEFINED

W_A = Total weight of the active wedge;
W_P = Total weight of the passive wedge;
N_A = Effective force normal to the failure plane of the active wedge;
N_P = Effective force normal to the failure plane of the passive wedge;
γ = Unit weight of the leachate collection/protective cover material;
h = Thickness of the leachate collection/protective cover material;
L = Length of slope measured along the geomembrane;
β = Soil slope angle beneath the geomembrane;
ϕ = Internal angle of friction within the protective cover soil;
δ = Interface friction angle between the most critical geosynthetic interface;
C_a = Adhesive force between the components lying along the most critical geosynthetic interface of the active wedge;
c_a = The adhesion developed between the components lying along the most critical geosynthetic interface of the active wedge;
C = Cohesive force along the failure plane of the passive wedge;
c = cohesion of the protective cover soil;
E_A = Interwedge force acting on the active wedge from the passive wedge;
E_P = Interwedge force acting on the passive wedge from the active wedge; and
FS = Factor of safety against protective cover soil sliding down the slope.

CALCULATIONS

It is proposed that a Low Ground Pressure (LGP) bulldozer will be used to place protective cover material across the sideslope. The pressure exerted upon the top of the geosynthetic layers by a bulldozer is modeled as illustrated in Figure 2 thus the bulldozer will not operate over the geosynthetic layers until the 24-inch thick protective cover material layer is placed.

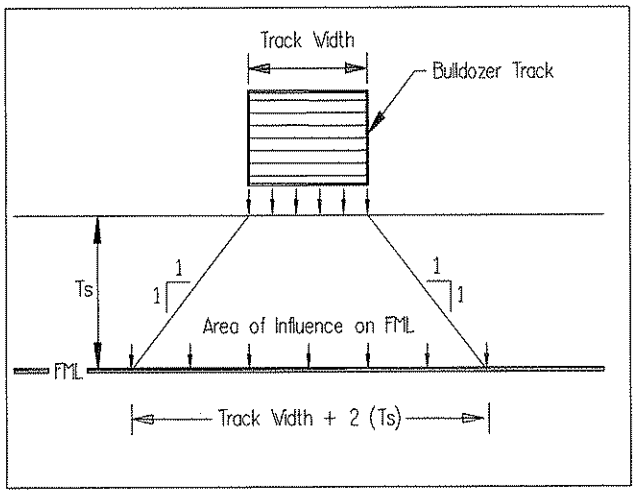

Figure 2, Stress Distribution of the LGP Bulldozer upon the Geosynthetic Layers

The following typical LGP Bulldozer equipment specifications are used within the GRI Report #18.

- 2 tracks
- Track length = 9.4 feet
- Track width = 3.0 feet
- Operating weight = 38,300 lbs
- One Track Contact area = 28.2 ft^2
- One Track Contact pressure = 19,150 lbs / 28.2 ft^2 = 679.1 psf

Subsequently, the forces illustrated in Figure 1 are resolved below to produce a veneer slope stability FS. The equations presented are taken from pages 13 and 14 of GRI Report #18.

$$W_a = \gamma h^2 \left[\frac{L}{h} - \frac{1}{\sin\beta} - \frac{\tan\beta}{2} \right]$$

$$N_a = W_a \cos\beta$$

$$C_a = c_a \left[L - \frac{h}{\sin\beta} \right]$$

Balancing the forces in the vertical direction, the following formulation results:

$$E_A \sin\beta = W_A - N_A \cos\beta - \frac{N_A \tan\delta + C_a}{FS} \sin\beta$$

The interwedge force acting on the active wedge is:

$$E_A = \frac{FS \cdot (W_A - N_A \cos\beta) - (N_A \tan\delta + C_a)\sin\beta}{\sin\beta \, FS}$$

The passive wedge can be considered in a similar manner:

$$W_p = \frac{\gamma h^2}{\sin 2\beta}$$

$$N_p = W_p + E_p \sin\beta$$

$$C = \frac{c\,h}{\sin\beta}$$

Balancing the forces in the horizontal direction produces:

$$E_p \cos\beta = \frac{C + N_p \tan\phi}{FS}$$

The interwedge force acting on the passive wedge is:

$$E_p = \frac{C + W_p \tan\phi}{\cos\beta\,(FS) - \sin\beta\tan\phi}$$

Setting $E_A = E_p$ the equation can be arranged in the form of the quadratic equation:

$$a(FS)^2 + b(FS) + c = 0$$

Where the coefficients a, b and c are equal to the following expressions:

$$a = (W_A - N_A\cos\beta)\cos\beta$$

$$b = -\left[(W_A - N_A\cos\beta)\sin\beta\tan\phi + (N_A\tan\delta + C_a)\sin\beta\cos\beta + \sin\beta(C + W_p\tan\phi)\right]$$

$$c = (N_A\tan\delta + C_a)\sin^2\beta\tan\phi$$

The quadratic equation is then used to calculate the FS:

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

For the ease of calculations the above quadratic equation was input into a spreadsheet format to produce a FS corresponding to a given set of input parameters. A copy of the spreadsheet calculations displaying the results is included in Attachment A.

CONCLUSIONS

Utilizing a contact interface shear strength friction angle of 26.4 degrees resulted in a veneer slope stability FS equal to 1.822 while the equipment is static. While the equipment is placing the protective cover, a veneer slope stability FS equal to 1.727 was calculated. Additional assumptions include:

- The presence of an equipment load along the final cover sideslope, equipment pushes material from toe towards the crest;
- Geosynthetic materials are not in tension;
- Cohesion does not exist within the cover soil.

JOYCE ENGINEERING, INC.

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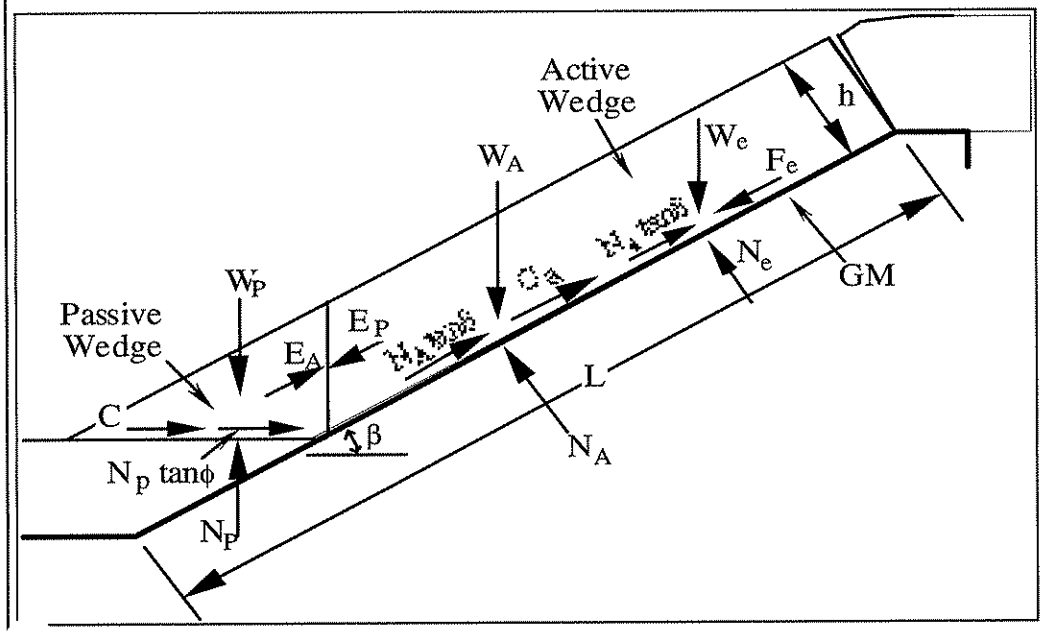
ATTACHMENT A

SPREADSHEET CALCULATION

Roaring River Landfill Phase 3

Placement of the 2 Foot Thick Protective/Vegetative Cover Material Layer

Across the Final Cover Sideslopes with the Incorporation of Static Equipment Loads



Calculation of FS

Active Wedge:

Wa= 61718.3 lb

Na= 58552.8 lb

Passive Wedge:

Wp= 766.8 lb

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

a= 20368.4

b= -40237

c= 5705.0

FS= 1.822

thickness of protective cover soil = h =	2.00	ft			
pro. cov. mat. slope angle beneath the geomembrane = β =	18.43	°	*= 0.32*	*(rad.)*	
finished protective cover material slope angle = ω =	18.43	°	*= 0.32*	*(rad.)*	
length of slope measured along the geomembrane = L =	275.0	ft			
unit weight of the protective cover soil = γ =	115.0	lb/ft^3			
friction angle of the protective cover soil = ϕ =	25.0	°	*= 0.44*	*(rad.)*	
cohesion of the protective cover soil = c =	0.0	lb/ft^2		*C= 0*	*lb*
critical interface friction angle = δ =	26.40	°	*= 0.46*	*(rad.)*	
adhesion = ca =	25.0	lb/ft^2		*Ca= 6716.845*	*lb*

thickness of the protective cover soil = h =	2.00	ft	*b/h= 1.5*
equipment ground pressure (= wt. of equipment/(2wb)) = q =	679.1	lb/ft^2	*We=qwl= 6192.0*
length of each equipment track = w =	9.4	ft	*Ne=Wecosβ= 5874.4*
width of each equipment track = b =	3.0	ft	*Fe=We(a/g)= 0.0*
influence factor* at geomembrane interface = I =	0.97		
acceleration/deceleration of the bulldozer = a =	0.00	g	

*Influence Factor Default Values

Cover Soil Thickness	Equipment Track Width		
	Very Wide	Wide	Standard
[2]300 mm	1.00	0.97	0.94
300-1000 mm	0.97	0.92	0.70
[3] 1000 mm	0.95	0.75	0.30

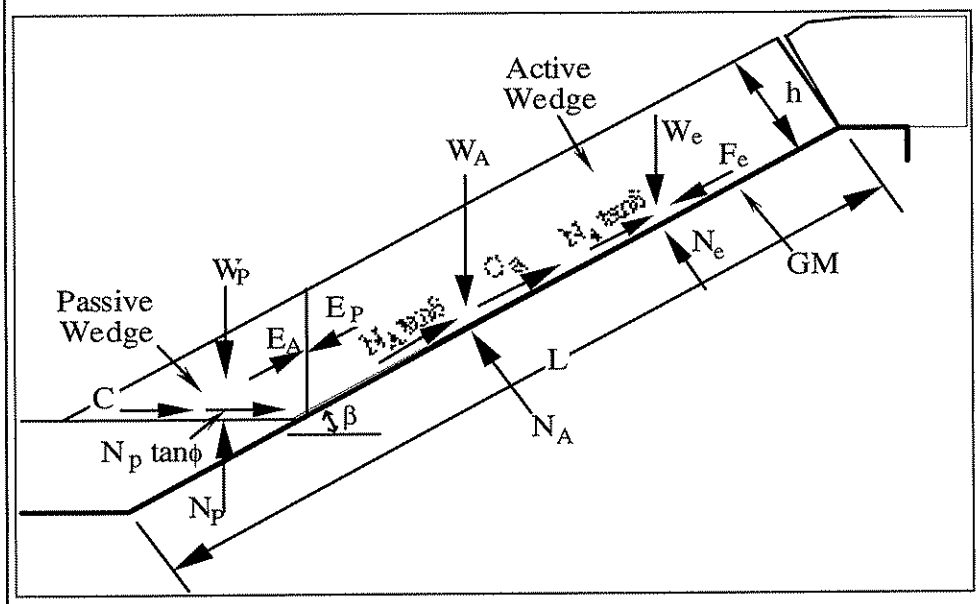
Note: numbers in boxes are input values

numbers in Italics are calculated values

Roaring River Landfill Phase 4

Placement of the 2 Foot Thick Protective/Vegetative Cover Material Layer

across the Final Cover Sideslopes with the Incorporation of Moving Equipment Loads



Calculation of FS

Active Wedge:

Wa= 61718.3 lb

Na= 58552.8 lb

Passive Wedge:

Wp= 766.8 lb

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

a= 21484.5

b= -40410

c= 5705.0

FS= 1.727

thickness of protective cover soil = h =	2.00	ft			
pro. cov. mat. slope angle beneath the geomembrane = β =	18.43	°	*= 0.32*	*(rad.)*	
finished protective cover material slope angle = ω =	18.43	°	*= 0.32*	*(rad.)*	
length of slope measured along the geomembrane = L =	275.0	ft			
unit weight of the protective cover soil = γ =	115.0	lb/ft^3			
friction angle of the protective cover soil = ϕ =	25.0	°	*= 0.44*	*(rad.)*	
cohesion of the protective cover soil = c =	0.0	lb/ft^2		*C= 0*	*lb*
critical interface friction angle = δ =	26.40	°	*= 0.46*	*(rad.)*	
adhesion = ca =	25.0	lb/ft^2		*Ca= 6716.845*	*lb*

thickness of the protective cover soil = h =	2.00	ft		
equipment ground pressure (= wt. of equipment/(2wb)) = q =	679.1	lb/ft^2	*b/h=*	*1.5*
length of each equipment track = w =	9.4	ft	*We=qwl=*	*6192.0*
width of each equipment track = b =	3.0	ft	*Ne=Wecos β=*	*5874.4*
influence factor* at geomembrane interface = I =	0.97		*Fe=We(a/g)=*	*1176.5*
acceleration/deceleration of the bulldozer = a =	0.19	g		

*Influence Factor Default Values

Cover Soil Thickness	Equipment Track Width		
	Very Wide	Wide	Standard
[2] 300 mm	1.00	0.97	0.94
300-1000 mm	0.97	0.92	0.70
[3] 1000 mm	0.95	0.75	0.30

Note: numbers in boxes are input values

numbers in Italics are calculated values

ENGINEERING, INC.

Project:	Roaring River Landfill		
Project Number:	356.1002.12.01		
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Checked By:	EA	Date:	1/5/11
Subject:	Final Cover Veneer Seismic Stability		
Sheet:	1 of 9		

FINAL COVER VENEER SEISMIC SLOPE STABILITY

OBJECTIVE

The objective of this calculation is to perform a seismic slope stability analysis for the final cover system of the landfill.

METHODOLOGY

A spreadsheet taken from a report prepared by the Geosynthetic Research Institute (GRI), Drexel University, entitled "Cover Soil Stability Involving Geosynthetic Interfaces", by Te-Yang Soong and Robert M. Koerner is utilized to perform the calculation. This method analyzes the situation where a uniform layer of cover soil lies along a finite length of landfill side slope.

The seismic coefficient used within the stability analysis was obtained from the "Peak Acceleration (%g) with 2% Probability of Exceedance in 50 Years (site: NEHRP B-C boundary)" published by the U.S.G.S in 2008 and Figure 9-9 of the "Geotechnical and Stability Analyses for Ohio Waste Containment Facilities" September 14, 2002, which are included here. As suggested, the factor of safety for the worst-case slope and most critical interface must be greater than or equal to 1.00.

VARIABLES DEFINED

The shear strength envelope of the most critical interface in the final cover system was defined in the "Final Cover Veneer Slope Stability" calculation included with this Application.

The seismic coefficient, Cs, is defined as follows:

Cs = Seismic Coefficient, or the yield acceleration, Ky, which is expressed as a percentage of g, (acceleration due to gravity)

The seismic coefficient is multiplied by the weight of the active and passive blocks to produce a horizontal force resulting from the seismic acceleration. (F = ma)

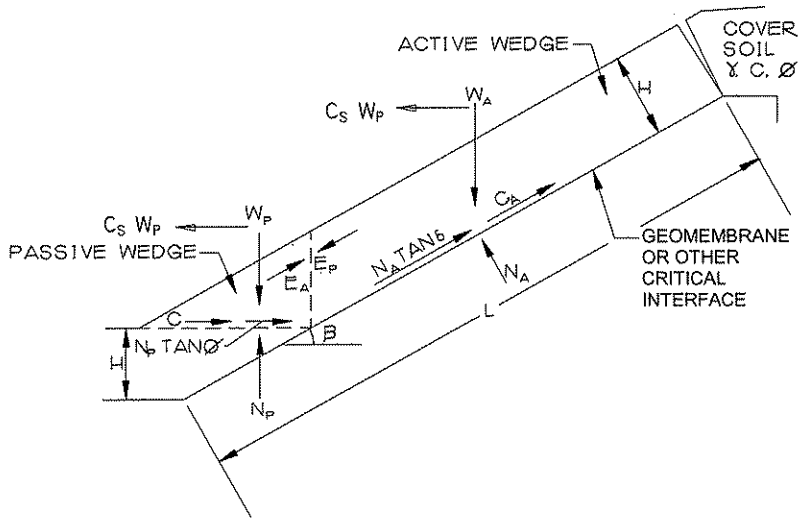

Figure 1, Side Slope Geometry & Free Body Diagram

Slope Dimensions	
Maximum Slope Length	275 feet
Slope Orientation	3H:1V or 18.43 degrees

The proposed final cover system along the landfill sideslope is outlined below, from top to bottom:

- 6-inch thick Vegetative Layer
- 18-inch thick Soil Protection Layer;
- Geocomposite Drainage Layer (geotextile heat bonded to both sides of a geonet);
- 40-mil Textured Flexible Membrane Liner (FML);
- Geosynthetic Clay Liner (GCL);
- Geotextile/Geonet Gas Migration Layer; and
- 12-inch thick Intermediate Cover Layer.

W_A = Total weight of the active wedge;
W_P = Total weight of the passive wedge;
N_A = Effective force normal to the failure plane of the active wedge;
N_P = Effective force normal to the failure plane of the passive wedge;
γ = Unit weight of the cover soil;
h = Thickness of the cover soil;
L = Length of slope measured along the geomembrane;

β = Soil slope angle beneath the geomembrane;
ϕ = Internal angle of friction within the cover soil;
δ = Interface friction angle between the most critical geosynthetic interface;
C_a = Adhesive force between the components lying along the most critical geosynthetic interface of the active wedge;
c_a = The adhesion developed between the components lying along the most critical geosynthetic interface of the active wedge;
C = Cohesive force along the failure plane of the passive wedge;
c = cohesion of the cover soil;
E_A = Interwedge force acting on the active wedge from the passive wedge;
E_P = Interwedge force acting on the passive wedge from the active wedge;
FS = Factor of safety against cover soil sliding down the slope; and
Cs = Seismic coefficient in percent of gravity. The resulting acceleration at the crest of the landfill is based on the design bedrock acceleration.

Relevant Geosynthetic Strength Data

As determined in the "Final Cover Veneer Slope Stability" calculation, the minimum shear strength envelope required in the final cover system was determined to be δ=26.4° with no adhesion.

Additional Material Properties

Assumed unit weight of the cap protection layer material: γ_S = 115 pcf

The final cover soils were modeled as one layer with a thickness of 2.0 feet and assigned the average values for cohesion and friction angle.

Cohesion = 0 psi (0 psf), and
Internal angle of friction = 25°

Equations Used

The forces illustrated in Figure 1 are resolved below to produce a FS:

$$W_a = \gamma h^2 \left[\frac{L}{h} - \frac{1}{\sin\beta} - \frac{\tan\beta}{2} \right]$$

$$N_a = W_a \cos\beta$$

$$C_a = c_a \left[L - \frac{h}{\sin\beta} \right]$$

Balancing the forces in the horizontal direction, the following formulation results:

$$E_A \cos\beta + \frac{N_A \tan\delta + C_a}{FS} \cos\beta = C_S W_A + N_A \sin\beta$$

The interwedge force acting on the active wedge is:

$$E_A = \frac{FS \cdot (C_S W_A + N_A \sin\beta) - (N_A \tan\delta + C_a)\cos\beta}{FS \cos\beta}$$

The passive wedge can be considered in a similar manner:

$$W_p = \frac{\gamma h^2}{\sin 2\beta}$$

$$N_p = W_p + E_p \sin\beta$$

$$C = \frac{c\,h}{\sin\beta}$$

Balancing the forces in the horizontal direction produces:

$$E_p \cos\beta + C_S W_P = \frac{C + N_p \tan\phi}{FS}$$

The interwedge force acting on the passive wedge is:

$$E_p = \frac{C + W_p \tan\phi - C_S W_P (FS)}{\cos\beta\,(FS) - \sin\beta \tan\phi}$$

Setting $E_A = E_p$, the equation can be arranged in the form of the following quadratic equation:

$$a(FS)^2 + b(FS) + c = 0$$

Where the coefficients a, b and c are equal to the following expressions:

$$a = (C_S W_A + N_A \sin\beta)\cos\beta + C_S W_p \cos\beta$$

$$b = -\left[(C_S W_A + N_A \sin\beta)\sin\beta \tan\phi + (N_A \tan\delta + C_a)\cos^2\beta + \cos\beta(C + W_p \tan\phi)\right]$$

$$c = (N_A \tan\delta + C_a)\sin\beta \cos\beta \tan\phi$$

The quadratic equation is then used to calculate the FS:

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

For the ease of calculation the above quadratic equation was input into a spreadsheet format to produce a FS corresponding to a given set of input parameters. A copy of the spreadsheet calculations displaying the results is included in Attachment A.

Seismic Analysis

For the Wilkes County Landfill location, the maximum horizontal acceleration due to seismic activity expected to occur with a likelihood of 2% in 50 years is 12.37% of gravitational acceleration, or .1237g, as shown below. Since this value is greater than 0.1 g, the site is in a seismic impact zone, and seismic analysis is required.

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Calculated By:	CTM	Date:	12/27/10
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Checked By:	BJA	Date:	1/5/11
Subject:	Final Cover Veneer Seismic Stability		
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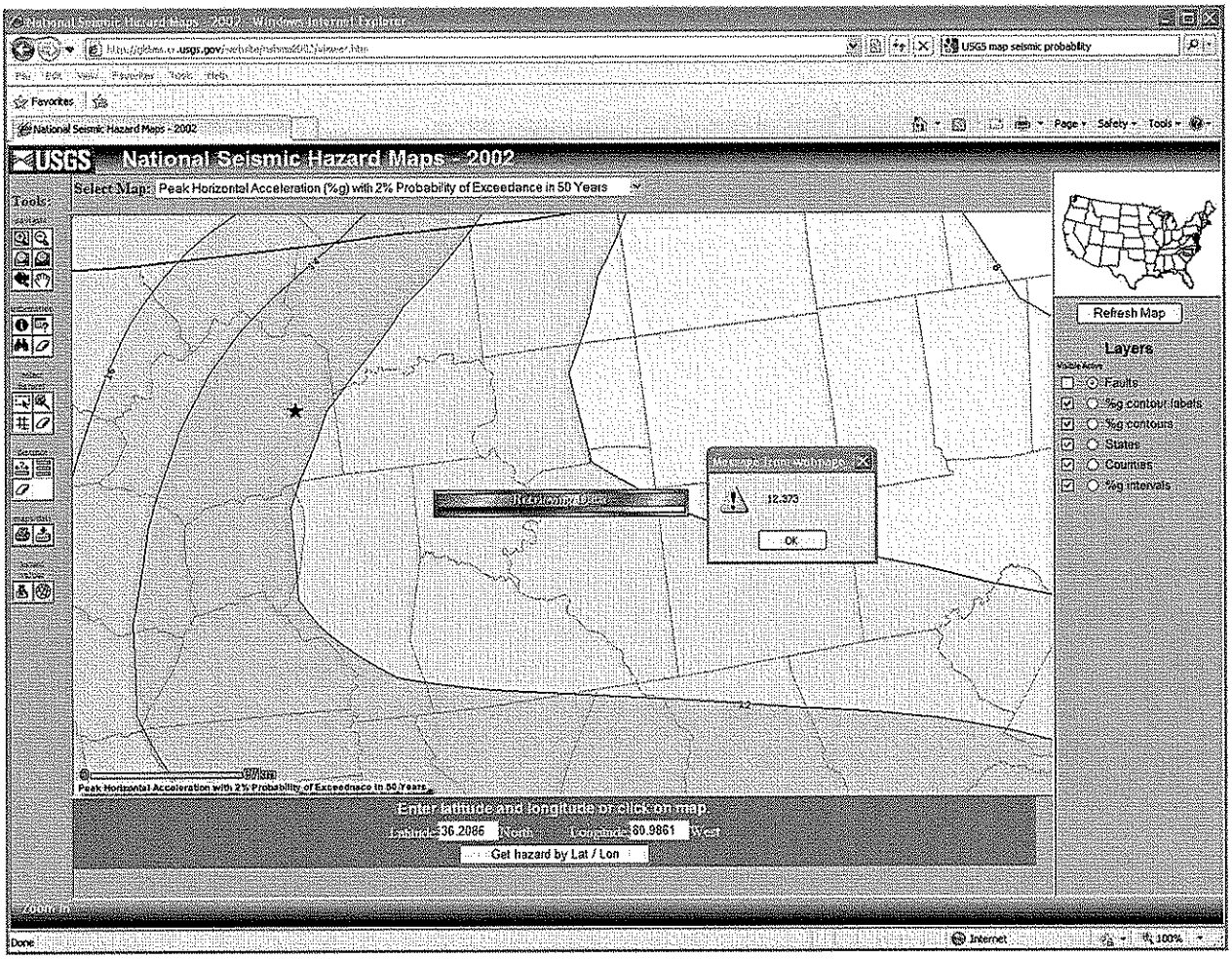

The chart below was used to convert the maximum acceleration at ground level to a maximum acceleration at the crest of waste, for additional conservativeness. The converted value is 0.18 g, and this value is used in the seismic analysis.

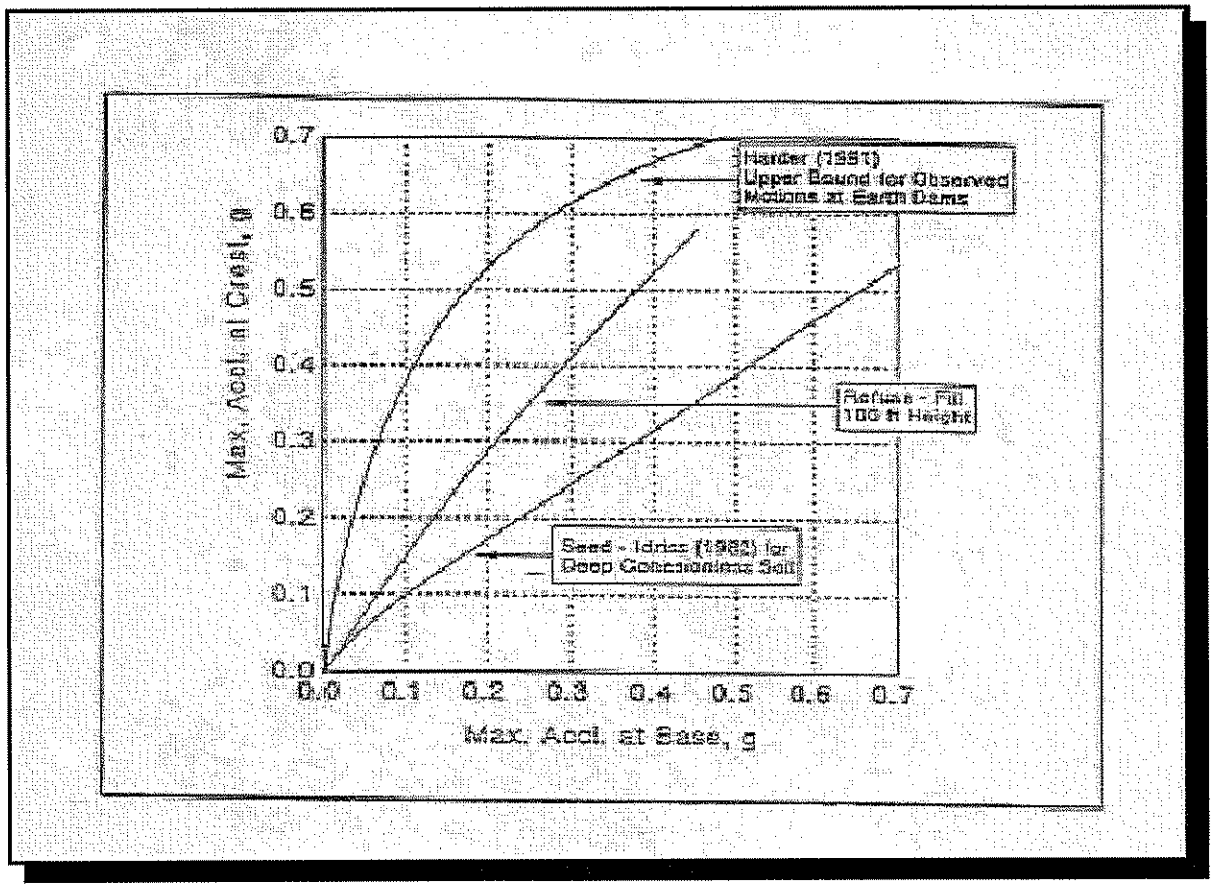

Figure 8-11 Approximate relationship between maximum accelerations at the base and crest for various ground conditions. Singh and Sun,1995, Figure 3.

The parameters used in the seismic analysis are stated below:

h = Thickness of cover soil = 2.0 ft

L = Length of slope measured along the geomembrane = 275 ft

γ = Unit weight of the cover soil = 115.0 lb/ft^3

δ = Critical interface friction angle = 26.4 degrees

ca = The adhesion developed between the components lying along the most critical geosynthetic interface of the active wedge = 25.0 lb/ft^2

D = Thickness of cover soil along the bottom of the slope = 2.0 ft

ϕ = Friction angle of the cover soil layer = 25 degrees

c = Cohesion of cover soil = 0.0 lb/ft^2

CALCULATIONS

The spreadsheet printout of the seismic stability analysis considering yield acceleration is included in Attachment A.

RESULTS

The results of the seismic stability analyses to determine the yield acceleration is presented below:

Cs = 0.18 g, FS = 1.15

Therefore, the final cover system should be stable during seismic activity with a factor of safety of 1.15.

REFERENCES

1. Soong, Te-Yang and Koerner, R.M., (1996) "Cover Soil Slope Stability Involving Geosynthetic Interfaces", Geosynthetic Research Institute, Drexel University, GRI Report #18

2. Ohio EPA, (September 14, 2002), "Geotechnical and Stability Analyses for Ohio Waste Containment Facilities".

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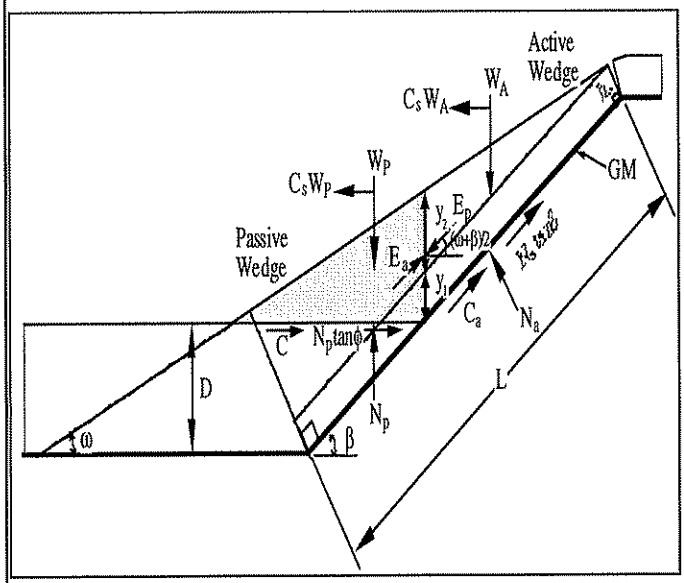
ATTACHMENT A

FINAL COVER SYSTEM
SEISMIC STABILITY ANALYSIS
COMPUTER SPREADSHEET RESULT

Roaring River Landfill Phase 4

Uniform and/or Tapered Cover Soil with Consideration of Seismic Forces



Calculation of FS

Active Wedge:

Wa=	*61718.3*	*lb*
Na=	*58552.8*	*lb*
Ca=	*6716.8*	*lb*

Passive Wedge:

Wp=	*766.8*	*lb*
C=	*0.0*	*lb*

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

a=	*28232.3*
b=	*-36912.2185*
c=	*5004.6*

FS= 1.15

(Note: for uniform cover soil thickness the input value of ω = β)

thickness of cover soil at top (crest) of the slope = hc =	2.00	ft	
thickness of cover soil along the bottom of the site = D =	2.00	ft	
soil slope angle beneath the geomembrane = β =	18.43	°	= 0.32 (rad.)
finished cover soil slope angle = ω =	18.43	°	= 0.32 (rad.)
length of slope measured along the geomembrane = L =	275.0	ft	

y2=	*0.00*	*(ft)*
y1=	*2.11*	*(ft)*
(ω+β)/2=	*0.322*	*(rad.)*
(=	*18.4*	*°)*

unit weight of the cover soil = γ =	115.0	lb/ft^3	
friction angle of the cover soil = ϕ =	25.0	°	= 0.44 (rad.)
cohesion of the cover soil = c =	0.0	lb/ft^2	
critical interface friction angle = δ =	26.4	°	= 0.46 (rad.)
adhesion between cover soil and geocomposite = ca =	25.0	lb/ft^2	

seismic coefficient = Cs = 0.180 g

Note: numbers in boxes are input values

numbers in Italics are calculated values

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Subject:	Required Transmissivity		
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REQUIRED TRANSMISSIVITY OF COVER DRAINAGE LAYER

OBJECTIVE

To determine the required transmissivity of a geocomposite such that an adequate factor of safety with respect to drainage exists for long term conditions.

Additionally, demonstrate that the specified Apparent Opening Size (AOS) of the geocomposite geotextile is acceptable considering the available soil types at the facility.

REFERENCES

"Design of Lateral Drainage Systems for Landfills" by Gregory N. Richardson and Aigen Zhao, 1999.

"*Designing with Geosynthetics*" by Robert Koerner, 1994.

GRI Standard – GC8, Determination of the Allowable Flow Rate of a Drainage Geocomposite

METHODOLOGY

The analytical method used to calculate veneer slope stability FS is taken from a report entitled "Design of Lateral Drainage Systems for Landfills" by Gregory N. Richardson and Aigen Zhao, 1999. The method analyzes the ability of the drainage geocomposite to adequately transmit infiltrating rain flow, and also considers the stability of the final cover soils considering seepage forces. Exceeding the drainage capacity of the geocomposite could potentially cause the final cover soil to become saturated and possibly unstable.

The calculation determines the FS with respect to drainage. A factor of safety less than 1 indicates that the transmissivity of the geocomposite is inadequate and that the final cover soil is completely saturated and subject to seepage forces. For conservatism, the transmissivity of the geocomposite used in the design will be calculated assuming a factor of safety of 1.5 for drainage and also includes reduction factors as suggested within GRI Standard – GC8, and *Designing with Geosynthetics*.

The proposed 3H:1V final cover slope presented in this analysis is typical of Municipal Solid Waste (MSW) Landfills. The final cover slope will be benched providing the longest sideslope length of approximately 275 feet (conservative) between benches. The drainage geocomposite will daylight at the bench.

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An industry accepted design approach for establishing a soil retention design is to use the soil's grain size characteristics and compare them to the 95% opening size (O_{95}) of the geotextile. The term, AOS is equivalent to O_{95}.

PROPOSED FINAL COVER SYSTEM

The proposed Final Cover System is outlined below, from top to bottom:

- 6 inches of Vegetative Soil;
- 18 inches of Protective Soil;
- Geocomposite Drainage Layer (geotextile heat bonded to both sides of a geonet);
- Textured 40-mil LLDPE Flexible Membrane Liner (FML);
- Geosynthetic Clay Liner (GCL);
- Geotextile/Geonet Gas Migration Layer; and
- 1-foot thick Intermediate Cover Layer.

ADDITIONAL MATERIAL PROPERTIES

Assumed unit weight of final cover soil: $\gamma_S = 115$ pcf
Assumed permeability of the final cover soil = 1.0×10^{-4} cm/sec

VARIABLES DEFINED

θ = Transmissivity of the geocomposite;
β = Sideslope angle;
k_{cs} = Permeability of final cover soil;
γ_{sat} = Saturated Unit weight of the final cover soil;
γ_b = Saturated Unit weight of the final cover soil – Unit Weight of water (62.4 pcf)
L = Length of sideslope measured along the FML = 275 feet;
β = Sideslope angle;
i = slope gradient;
δ = Minimum contact interface friction angle of the geosynthetics along the final cover sideslope;
Q_{in} = Flow into the geocomposite; and
Q_{out} = Flow out of the geocomposite.

CALCULATIONS

The FS for drainage is calculated by:

$FS_d = Qout/Qin = (\theta_{req} * i) / (k_{cs} * L) *(\cos \beta)$

As stated above, the Required Transmissivity will be calculated considering a FS = 1.5. This assumes that the geocomposite is capable of handling 1.5 times the design flow, a conservative assumption. A Factor of safety of 1 indicates a steady state condition where the amount of water infiltrating the final cover system is equal to the amount of water draining out of the geocomposite. Having a FS<1 equates to fully saturated conditions where seepage forces can build up.

Rearranging the equation yields:

$\theta_{req} = (\cos \beta) (k_{cs} * L * FS_d) / i$

For long term conditions, this transmissivity will be further reduced using reduction factors based on GRI Standard – GC8 *and Designing with Geosynthetics.*

$\theta_{ult} = \theta_{req} * (RF_{IN} * RF_{CR} * RF_{CC} * RF_{BC})$
Where :

RF_{IN} = Reduction Factor for geotextile intrusion;
RF_{CR} = Reduction Factor for creep deformation;
RF_{CC} = Reduction Factor for chemical clogging; and
RF_{BC} = Reduction Factor for biological clogging.

Since the laboratory testing will be performed using site-specific boundary conditions, the reduction factor for intrusion of the geotextile into the geonet will be ignored. As discussed in GRI Standard – GC8, chemical clogging includes precipitates from soils, and fines from turbid liquids. As determined later in this calculation, the AOS specification for the geotextile component of the geocomposite is adequate for the anticipated soil types at the facility.

The following reduction factors for chemical clogging (RF_{CC} = 1.1), biological clogging (RF_{BC} = 1.5), and creep deformation (RF_{CR} = 1.05) are applied below to result in the specification for final cover geocomposite transmissivity.

The following spreadsheet is utilized for the calculations:

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Project Number:	356.1002.11.01		
Calculated By:	CTM	Date:	12/14/10
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Subject:	Required Transmissivity		
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CALCULATION OF θreq		
$\theta_{req} = (\cos \beta)(k_{cs} * L * FS_d)/i$		
θ_{req} =	Required long term transmisivity	
β =	Slope Angle	
k_{cs} =	Permeability of the final cover soil	
L =	Length of slope	
FS_d =	Factor of Safety for Drainage	
i =	Gradient = sin β	
β =	18.4	
k_{cs} =	1.00E-04 cm/sec	
L =	275 feet (conservative	8382 cm
FS_d =	1.5	
i =	0.315649	
θ_{req} =	**3.78E-04 m^2/sec**	

CALCULATION OF θult	
$\theta_{ULT} = \theta req * (RF_{IN} * RF_{CR} * RF_{CC} * RF_{BC})$	
RF_{IN} =	Reduction Factor for geotextile intrusion
RF_{CR} =	Reduction Factor for creep deformation
RF_{CC} =	Reduction Factor for chemical clogging
RF_{BC} =	Reduction Factor for biological clogging
RF_{IN} =	1
RF_{CR} =	1.05
RF_{CC} =	1.1
RF_{BC} =	1.5
θ_{ult} =	**6.55E-04 m^2/sec**

A minimum value of 6.55 x 10^{-4} m^2/sec for the transmissivity of the geocomposite will be specified in the construction documents. A day light for the geocomposite will have to be installed a minimum of 275 feet of slope.

Verification Of AOS Specification

As suggested in Designing with Geosynthetics, the AOS of a geotextile to be used in a soil retention or separation function can be calculated as a function of the grain size of the soil. This is given by the following equation:

AOS < (2 to 3)*d_{85}

Where d_{85} = the particle size in mm for which 85% of the total soil is finer.

As can be interpreted from the following plot, the d_{85} value for typical site specific soils equals approximately 0.4 mm.

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Checked By:	EA	Date:	1/5/11
Subject:	Required Transmissivity		
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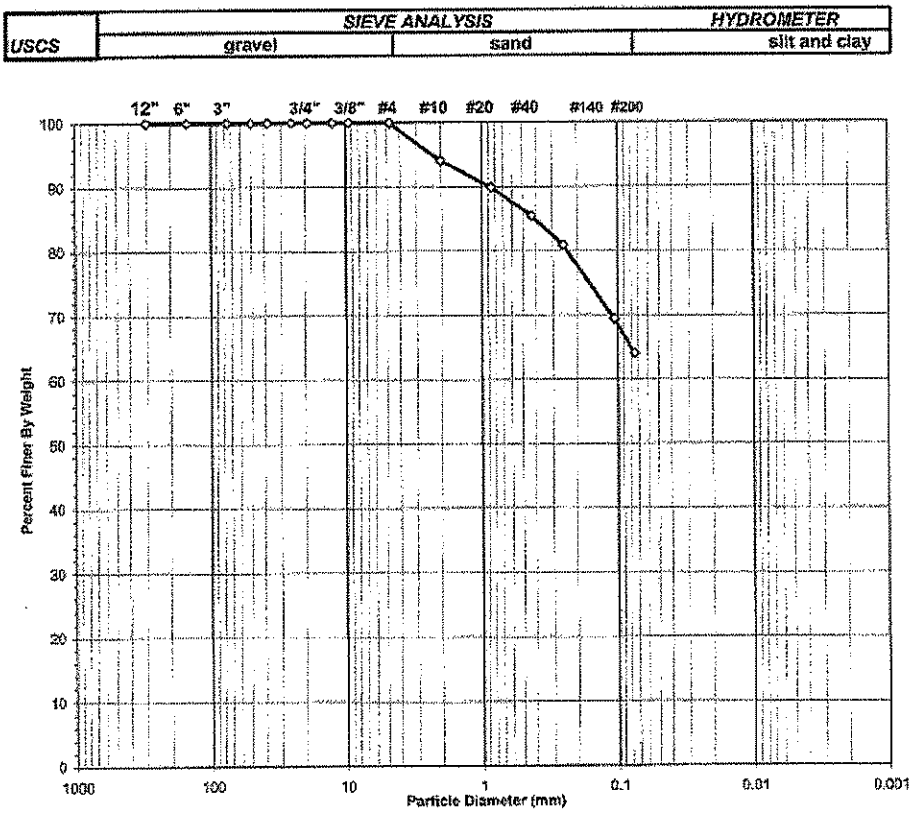
Geotechnics
INTEGRITY IN TESTING

SIEVE ANALYSIS
ASTM D 422-63 (SOP-S3)

Client	JOYCE ENGINEERING, INC.	Boring No.	ACRE 4
Client Reference	ROARING RIVER-PHASE 3 EXP.	Depth (ft)	LIFT 1
Project No.	2005-579-07	Sample No.	5000 YDS.
Lab ID	2005-579-07-06	Soil Color	REDDISH BROWN



The required AOS for a given soil type is calculated using the following equation

AOS < (2 to 3)*d_{85} For this calculation the following equation will be used for conservatism:

AOS < 2 * d_{85}

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Subject:	Required Transmissivity		
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Calculating:

AOS < 2 * 0.4 mm or AOS < 0.8 mm

This means that for soil retention, the AOS of the geotextile should be less than 0.8 mm. The AOS of the geotextile component of the geocomposite specified in the CQA Plan is between the sieve sizes of 70 and 140. A sieve size of 70 = 0.25 mm and a sieve size of 140 = 0.11 mm, therefore the specification for AOS of the geotextile component of the final cover system geocomposite are more conservative and valid for the final cover soil types anticipated at the facility.

APPENDIX III-3

HELP MODEL ANALYSES

Due to the nature of the Phase 4 expansion being vertical, there will be no modifications to the leachate system. The volume of leachate that will be generated was previously determined in the Phase 3 Application to Permit to Construct. The calculations can be found in Volume II, Appendix III-3.

APPENDIX III-4

LEACHATE COLLECTION SYSTEM DESIGN CALCULATIONS

JOYCE ENGINEERING, INC.

Job:	Roaring River Landfill Phase 4
Job Number:	356.1002.11.01
Calculated By:	CTM Date: 12/14/2010
Checked By:	BJA Date: 1/24/11
Subject:	Bearing Strength of Aggregate
Sheet:	1 of 1

Determine the factor of safety for aggregate from crushing.

Given:

The fracture strength for stone is generally above 2,000 psi.

Use a maximum height of waste of 145 feet and unit weight of landfill of 70 pcf.

Find:

Find the factor of safety.

$$P_{allow} = \text{Fracture strength of aggregate}$$

$$P_{allow} = 2{,}000 \text{ psi}$$

$$P_{reqd} = H_w * r_w$$

H_w	=	maximum height of waste	=	145 feet
r_w	=	unit weight of landfill	=	70 pcf

$$P_{reqd} = 10{,}150 \text{ psf}$$

$$70.5 \text{ psi}$$

$$\text{Factor of Safety} = P_{allow}/P_{reqd} = \underline{28.4}$$

The drainage stone will provide more than enough support to the expected loads with out fracturing.

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Job:	Roaring River Landfill Phase 4		
Job Number:	356.1002.11.01		
Calculated By:	CTM	**Date:**	12/15/2010
Checked By:	EA	**Date:**	1/5/11
Subject:	Pipe Strength		
Sheet:	1 of 2		

Given:
Using HDPE SDR 17

Find:
Find the maximum anticipated static load on this pipe and calculate actual compressive stress.

Reference:
Performance Pipe Engineering Manual, Chevron Phillips Chemical Company, 2003

Pt = r x D

Fill Items	Unit Weights, r (pcf)	Depth of Fill, D (ft)	Load, rD (psf)
1.5' Drainage Layer Above Pipe	130	1.5	195
Assumed Maximum Waste Height	70	145	10150
3.0' Closure Cap	115	3	345
Totals		**149.5**	**10690**

Find:
The pipe resistance to ***wall crushing***.

SA = (SDR x Pt)/2 --- Eqn 7-23

Pt	=	maximum vertical stress	=	74.2 psi
SDR	=	std dimension ratio (O.D./thickness)	=	17.0
S_A	=	actual compressive stress	=	631.0 psi
S_{allow}	=	compressive yield strength of material	=	1500.0 psi

Factor of Safety against crushing = S_{allow} / S_A = 2.38

Find:
The pipe resistance to ***wall buckling***.
Pcb = 1.63 x sqrt(B'E'E/(SDR-1)^3)

E	=	modulus of elasticity from Bulliten: PP 814-TN (using 50 yrs life and 100 degrees F)	=	23000 psi
B'	=	elastic support factor (B'=1/(1+4e^(-0.065*H))	=	1.00 psi
H	=	height of fill	=	149.5 ft
E'	=	soils modulus (E'5ft(1+0.15(H-6)^0.5)	=	8391 psi
E'5ft	=	soils modulus at 5' depth	=	3000 psi
Pcb	=	critical buckling pressure at top of pipe	=	354 psi

Factor of Safety against buckling = Pcb / Pt = 4.77

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Job:	Roaring River Landfill		
Job Number:	356.1002.11.01		
Calculated By:	CTM	**Date:**	12/27/2010
Checked By:	GA	**Date:**	1/5/11
Subject:	Pipe Strength		
Sheet:	2 of 2		

Find:
The resistance to pipe ***deflection*** .

% deflection = (X x 100%)/OD
X = (K x D x W)/(0.149 x PS + 0.061 x E')

SDR	=	standard dimension ratio	=	17	
ID	=	inner pipe diameter	=	5.814	inches
K	=	bedding factor	=	0.1	
D	=	deflection lag factor	=	1	
DC	=	depth of fill	=	145	feet
OD	=	outside diameter	=	6.594	inches
r	=	average soil density	=	70	lb/ft3
W	=	weight per lineal inch (W =(DC x OD x r)/144	=	464.8	lb/inch
E	=	flexural modulus of pipe	=	100000	psi
E'	=	soils modulus (E'5ft(1+0.15(H-6)^0.5)	=	8305	psi
E'5ft	=	soils modulus at 5' depth	=	3000	psi
t	=	thickness of pipe	=	0.39	inch
I	=	moment of inertia of pipe (t3/12)	=	0.0049	
R	=	mean radii of the pipe ((OD-t)/2)	=	3.102	inches
PS	=	pipe stiffness ((E x I)/(0.149 x R3))	=	111.15	psi
X	=	calculated deflection	=	0.089	inch
%allow	=	allowable pipe deflection	=	5	%
		% deflection	=	1.35	%

Factor of Safety for deflection = %allow / %deflection = 3.711

References:
Performance Pipe Engineering Manual, Chevron Phillips Chemical Company, 2003
"Deflection: The Pipe/Soil Mechanicsm", Uni-Bell PVC Pipe Association
Technical Note 2.130, ADS, 2003

JOYCE ENGINEERING, INC.

Job:	Roaring River Landfill Phase 4
Job Number:	356.1002.11.01
Calculated By:	CTM Date: 12/15/2010
Checked By:	EA Date: 1/5/11
Subject:	Puncture Resistance - Wheel Load
Sheet:	1 of 3

Determine maximum diameter stone by comparing allowable pressure to pressure exerted by wheel load.

Given:

Use a 16 oz./sy geotextile for a geotextile cushion above the FML.
Use maximum size equipment will be working on stone will be a dump truck with maximum tire pressure of 65 psi.
Assume worst case, truck riding on layer of stone with no dissipation of energy from depth of stone accounted for.
Assume stone is angular and relatively small.

Find:

Find the maximum size that drainage stone can be by trial and error to achieve a minimum factor of safety of 1.5.

$$F_{reqd} = p' \times d_a^{\,2} \times S_1 \times S_2 \times S_3$$

d_a	=	maximum diameter of the puncturing force to be resisted	=	1.50 inches
p'	=	tire pressure (100%)	=	65.00 psi
S_1	=	protrusion factor of the puncturing object	=	0.60
S_2	=	scale factor to adjust to the ASTM D4833 puncture test value	=	0.60
S_3	=	shape factor to adjust to the ASTM D4833 flat puncture probe to actual object shape	=	0.70
F_{reqd}	=	required vertical puncturing force to be resisted	=	36.86 lbs
F_{allow}	=	min. ave. roll value for puncture resistance of 16 oz/sy geotextile	=	240.00 lbs

$$Factor\ of\ Safety = F_{allow}/F_{reqd} = 3.26$$

To be conservative, assume no protective geotextile is placed over the FML:

F_{reqd}	=	required vertical puncturing force to be resisted	=	36.86 lbs
F_{allow}	=	min. ave. roll value for puncture resistance of textured HDPE liner	=	90.00 lbs

$$Factor\ of\ Safety = F_{allow}/F_{reqd} = 1.22$$

Use a drainage stone with a maximum diameter of 1.50 inches or less when using 16 oz/sy geotextile.

Reference:

Koerner, R.M. (2005).Designing with Geosynthetics, 5th Edition, Pearson Education, Inc., Pearson Prentice Hall, Upper Saddle River, NJ.

ENGINEERING, INC.

Job:	Roaring River Landfill Phase 4
Job Number:	356.1002.11.0
Calculated By:	CTM Date: 12/15/2010
Checked By:	Date: 12/29/11
Subject:	Puncture Resistance - Waste
Sheet:	2 of 3

Determine maximum diameter stone by comparing allowable pressure to pressure exerted.

Given:

Use a 16 oz./sq yd geotextile for a geotextile cushion above the FML.
Use maximum height of waste of 145 feet and unit weight of landfill of 75 pcf.

Find:

Find the maximum size that drainage stone can be by trial and error to achieve a minimum factor of safety of 1.5.

$$Pallow = (1/(MF_S \times MF_{PD} \times MF_A \times FS_{CR} \times FS_{CBD})) \times (50 + 0.00045 \times (M/H^2))$$

MF_S	=	mod. factor for protusion shape (angular for worst case)	=	1.0
MF_{PD}	=	mod. factor for packing density (largest stone 2")	=	0.5
MF_A	=	mod. factor for soil arching	=	0.17
FS_{CR}	=	partial factor of safety for creep (worst case)	=	1.5
FS_{CBD}	=	partial factor of safety for chemical/biological degradation	=	1.5
M	=	mass per unit area of geotextile	=	16 oz/yd^2
				542.5 g/m^2
H	=	height of protrusion (maximum diameter stone)	=	1.5 inches
				0.0381 m

$$Pallow = 1140.8 \text{ kPa}$$

$$Preqd = Hw * \rho w$$

Hw	=	maximum height of waste	=	145 feet
				44.196 meters
ρw	=	unit weight of landfil	=	70 pcf
				11.0 kN/m^3

$$Preqd = 486.2 \text{ kPa}$$

$$\textbf{Factor of Safety} = Pallow/Preqd = \underline{2.3}$$

Therefore, use a drainage stone where maximum size is 1.5 inch diameter or less with a 16 oz/sy geotextile.

Reference:

Koerner, R.M. (2005).Designing with Geosynthetics, 5th Edition, Pearson Education, Inc., Pearson Prentice Hall, Upper Saddle River, NJ.

JOYCE ENGINEERING, INC

Job:	Roaring River Landfill Phase 4		
Job Number:	356.1002.11.01		
Calculated By:	CTM	Date:	12/15/2010
Checked By:	BJA	Date:	1/5/11
Subject:	Burst Resistance		
Sheet:	3 of 3		

Determine the factor of safety of the geotextile to provide burst resistance.

Given:

Use a 16 oz/sq yd geotextile for a geotextile cushion above the FML.
Use maximum size equipment will be working on stone will be a dump truck with maximum tire pressure of 65 psi.
Assume worst case, truck riding on layer of stone with no dissipation of energy from depth of stone accounted for.

Find:

Find the required geotextile strength.

$$FS = \frac{T_{allow}}{T_{reqd}} = \frac{(p_{test} d_{test})}{(\prod RF) p' d_v}$$

p_{test}	=	burst pressure of the geotextile at failure (its strength)	=	750	psi
d_{test}	=	diameter of the burst test devise (= 30 mm)	=	1.18	inches
πRF	=	cumulative reduction factors	=	1.50	
p'	=	stress on the geotextile (slightly more than the tire inflation pressure)	=	65.00	
d_a	=	maximum stone diameter	=	1.50	inches
d_v	=	maximum void diameter of the stone = $0.33 d_a$	=	0.50	

Factor of Safety = T_{allow}/T_{reqd} = ***18.34***

Reference:

Koerner, R.M. (2005).Designing with Geosynthetics, 5th Edition, Pearson Education, Inc., Pearson Prentice Hall, Upper Saddle River, NJ.

APPENDIX III-5

EROSION AND SEDIMENT CONTROL PLAN

North Carolina Department of Environment and Natural Resources
Division of Land Resources
Land Quality Section

James D. Simons, PG, PE
Director and State Geologist

Michael F. Easley, Governor
William G. Ross Jr., Secretary

May 15, 2008

LETTER OF APPROVAL WITH MODIFICATIONS

Wilkes County
Attn: Kent Brandon
PO Box 389
Roaring River, NC 28669

RE: Project Name: Wilkes County Landfill (revised)
Project ID: Wilke-2005-021
County: Wilkes
River Basin: Yadkin
Stream Classification: Other
Submitted By: Joyce Engineering, Inc.
Date Received by LQS: 5-14-08
Plan Type: Revised

RECEIVED MAY 16 2008

Dear Mr. Brandon:

This office has reviewed the subject erosion and sedimentation control plan. We find the plan to be acceptable with modifications and hereby issue this letter of Approval With Modifications. The Modifications Required for Approval are listed on the attached page. This plan approval shall expire three (3) years following the date of approval, if no land-disturbing activity has been undertaken, as is required by Title 15A NCAC 4B .0129.

Please be advised that Title 15A NCAC 4B .0118(a) requires that a copy of the approved erosion control plan be on file at the job site. Also, you should consider this letter to give the Notice required by G.S. 113A-61.1(a) of our right of periodic inspection to insure compliance with the approved plan.

North Carolina's Sedimentation Pollution Control Program is performance-oriented, requiring protection of existing natural resources and adjoining properties. If, following the commencement of this project, it is determined that the erosion and sedimentation control plan is inadequate to meet the requirements of the Sedimentation Pollution Control Act of 1973 (North Carolina General Statute 113A-51 through 66), this office may require revisions to the plan and implementation of the revisions to insure compliance with the Act.

Acceptance and approval of this plan is conditioned upon your compliance with Federal and State water quality laws, regulations, and rules. In addition, local city or county ordinances or rules may also apply to this land-disturbing activity. This approval does not supersede any other permit or approval.

Please be aware that your project will be covered by the enclosed NPDES General Stormwater Permit NCGO1000 (Construction Activities). You should first become familiar with all of the requirements for compliance with the enclosed general permit.

Please note that this approval is based in part on the accuracy of the information provided in the Financial Responsibility Form, which you have provided. You are requested to file an amended form if there is any change in the information included on the form. In addition, it would be helpful if you notify this office of the proposed starting date for this project. Please notify us if you plan to have a preconstruction conference.

Your cooperation is appreciated.

Sincerely,

Clif Whitfield, P.G.
Assistant Regional Engineer
Land Quality Section

Enclosures: Certificate of Approval
Modifications Required for Approval
NPDES Permit

cc: Joyce Engineering, Inc.
.....WSRO Files
WSRO DWQ

MODIFICATIONS REQUIRED FOR APPROVAL

Project Name: Wilkes County Landfill (revised)
Project ID: Wilkes-2005-021
County: Wilkes

1. This erosion and sedimentation control plan permit essentially covers the entire Wilkes County Landfill Site and supercedes previous permits. In addition to the plan requirements, Wilkes County is responsible for installing sufficient erosion and sedimentation control measures to prevent sediment from entering any jurisdictional streams/wetlands and to prevent sediment from leaving the boundary of the Wilkes County property. Install any additional measures as needed to accomplish this goal. Also, adequate vegetative groundcover must be provided on all bare areas that have been idle for 15 working days. Application of adequate lime, fertilizer, seed and mulch are sufficient to meet the requirements for groundcover. Please contact this office at 336-771-5000 regarding any requirements of this permit.

CERTIFICATE OF PLAN APPROVAL

with Modifications

The posting of this certificate certifies that an erosion and sedimentation control plan has been approved for this project by the North Carolina Department of Environment and Natural Resources in accordance with North Carolina General Statute 113A - 57 (4) and 113A - 54 (d) (4) and North Carolina Administrative Code, Title 15A, Chapter 4B.0107 (c). This certificate must be posted at the primary entrance of the job site before construction begins and until establishment of permanent groundcover as required by North Carolina Administrative Code, Title 15A, Chapter 4B.0127 (b).

Wilkes County Landfill (revised)

Project Name and Location

Wilke-2005021

5-14-08

Date of Plan Approval

Asst. Regional Engineer

APPENDIX III-6

TECHNICAL SPECIFICATIONS

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SECTION 01410

QUALITY ASSURANCE

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Inspection and Testing Laboratory Services for Quality Assurance.

1.02 INSPECTION AND TESTING LABORATORY SERVICES FOR QUALITY ASSURANCE

A. OWNER will appoint, employ, and pay for services of a CQA firm (CQA Consultant) to conduct inspection and testing for quality assurance purposes.

B. Quality assurance refers to measures taken by the CQA Consultant on behalf of the OWNER to assess whether the Work is in compliance with the Contract Documents.

C. On behalf of the OWNER, the CQA Consultant will conduct inspections, tests, and other services specified in individual specification subsections that address quality assurance requirements. No adjustments to the Contract Time will be granted for any quality assurance activities of the CQA Consultant, including testing.

D. Reports will be submitted by the CQA firm to the ENGINEER, indicating observations and results of tests and indicating compliance or noncompliance with Contract Documents.

E. Re-testing required because of non-conformance to specified requirements shall be conducted by the same CQA firm on instructions by the ENGINEER.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

Not Used

END OF SECTION 01410

SECTION 01500

CONSTRUCTION FACILITIES AND TEMPORARY CONTROLS

PART 1 GENERAL

1.01 PROTECTION AND SAFETY

A. Do not interfere with any transfer station operations if applicable. Protect all on-site monitoring wells, liner systems, and existing leachate collection piping and appurtenances.

B. Do not interfere with the use of, or access to, adjacent buildings. Maintain free and safe passage to and from all facilities.

C. Protect trees, shrubs, lawns, areas to receive planting, rock outcropping, and other features remaining as part of final landscaping.

D. Protect bench marks and existing structures, property corners, roads, sidewalks, paving, and curbs against damage from equipment and vehicular or foot traffic.

E. Cease operations and notify the ENGINEER immediately if safety of adjacent structure(s) appears to be endangered. Do not resume operations until safety is restored.

F. Prevent movement, settlement, or collapse of adjacent services, utilities, structures, trees, and etc. Assume liability for such movement, settlement, or collapse. Promptly repair damage at no cost to the OWNER.

G. Provide, erect, and maintain street barriers, sidewalk sheds, barricades, lighting, and/or guard rails as required to protect general public, workers, and adjoining property.

H. Protect excavations by shoring, bracing, sheet piling, underpinning, or other methods, as required to prevent cave-ins or loose dirt from falling into excavations.

I. Notify ENGINEER of unexpected sub-surface conditions and discontinue work in area until ENGINEER provides notification to resume work.

J. Protect bottom of excavations and soil around and beneath foundations from frost.

K. Make sure that all required environmental protection devices and procedures are in place, properly maintained, and operational.

1.02 TEMPORARY FIELD OFFICE

A. Not required.

B. CONTRACTOR shall maintain plans and specifications on site and be accessible for communications via cell phone, at a minimum.

1.03 SECURITY

A. Coordinate with OWNER'S security program.

1.04 ACCESS ROADS

A. Construct and maintain temporary roads, including haul roads, as needed to serve construction area.

B. Extend and relocate temporary roads as needed as Work progress requires.

C. Provide means of removing mud from vehicle wheels before entering streets.

1.05 PARKING

A. Arrange for surface parking areas to accommodate construction personnel.

1.06 PROGRESS CLEANING

A. Maintain site in a clean and orderly condition.

B. Prior to final completion, thoroughly remove from construction area any debris remaining from construction activities and properly dispose. Leave premises in a clean, neat, orderly and safe condition.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

Not Used

END OF SECTION 01500

SECTION 01720

PROJECT RECORD DOCUMENTS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. The purpose of the record documents is to provide factual information regarding all aspects of the Work, both concealed and visible, to enable future modifications to proceed without lengthy and expensive site investigation.

B. Throughout progress of Work, maintain an accurate record of all revisions to the Work. Upon completion of Work, transfer the recorded changes to a set of record documents. This includes, but is not limited to, all modifications to piping, roads, utilities, grading, structures, limits of liner, and monitoring devices.

C. Submit three (3) complete sets of record drawings, and one set of AutoCAD compatible files acceptable to the ENGINEER upon completion of the project.

1.02 SUBMITTALS

A. Record documents shall be submitted to and deemed complete by the ENGINEER, for the OWNER, prior to the OWNER'S release of retainage and payment of final pay request.

B. Accompany submittal with transmittal letter in duplicate, containing:

1. Date;
2. Project title and number;
3. CONTRACTOR'S name and address;
4. Title and number of each Record Document; and
5. Signature of CONTRACTOR or his authorized representative.

PART 2 - PRODUCTS

Not Used

PART 3 - EXECUTION

3.01 SURVEYOR

A. Employ the services of a surveyor licensed in the State in which the project work is conducted to determine actual locations and elevations of installed items and to prepare the record drawings.

3.02 DOCUMENTS REQUIRED

A. Maintain at the site for the OWNER one record copy of:

1. Contract Drawings;
2. Contract Specifications;
3. Contract Addenda;
4. Change Orders and other Modifications to the Contract;
5. ENGINEER'S Field Orders or written instructions;
6. Approved Shop Drawings, Product Data, and Samples;
7. Field Test Records; and
8. Construction photographs.

3.03 ACCURACY OF RECORDS

A. Thoroughly coordinate all changes within the record documents, making adequate and proper entries on each page of the Specifications and each sheet of the Drawings and other documents where such entry is required to properly show the change. Record accuracy shall be such that future searches for the constructed features may reasonably rely on information obtained from record documents.

3.04 TIMING OF ENTRIES

A. Make all entries within 24 hours after receipt of information.

3.05 SUBMITTAL

A. The ENGINEER'S approval of the current record documents shall be a prerequisite to the ENGINEER'S approval of requests for progress payment and request for final payment under the Contract.

3.06 PROTECTION OF DOCUMENTS

A. Maintain the job set of record documents completely protected from deterioration and from loss and damage until completion of Work and transfer of recorded data to the final record documents.

3.07 MAKING ENTRIES ON DOCUMENTS

A. Use an erasable colored pencil (not ink or indelible pencil), or a digital layer clearly identified as surveyor notes, to clearly describe the change by note and by graphic line as required. Date all entries. Highlight the entry by drawing a "cloud" around the affected area or areas.

3.08 FORMAT OF FINAL RECORD DRAWINGS

A. Prepare Record Drawings in an AutoCAD file format acceptable to the ENGINEER. Provide digital record drawing to ENGINEER only when no exceptions are taken by ENGINEER should paper copies be submitted.

B. At a minimum, provide the following surveys showing spot elevations on a fifty-foot grid and two-foot contours for the layer of interest. The survey points shall include toe and top of slope, and all breaks in the slope. Spot elevations shall be measured to the nearest 0.01 foot. The required surveys shall be completed and stamped by a registered surveyor licensed in the State in which the project work is conducted. Prior to the placement of each layer of the work, the survey drawing shall be submitted to the ENGINEER for approval.

BOTTOM

1. Top of subgrade or bottom of liner
2. Top of low permeability liner (including limits of liner)
3. Geomembrane panels, seams, destructive test locations, and repairs
4. Leachate collection and removal system components
5. Top of drainage layer

COVER

6. Top of intermediate cover layer
7. Geomembrane cap panels, seams, destructive test locations, and repairs
8. Top of protective cover layer
9. Top of vegetative soil layer

C. Submit a spreadsheet, in digital format, which identifies the coordinates of the grid points, the spot elevations of the points, and the differential thicknesses for each successive layer.

D. Provide record drawings of HDPE liner panel layout including panel numbers, destructive sample locations/numbers, and locations/numbers of all repairs. The digital copy of the drawings shall be provided in color with panel numbers labeled in black and in a format of P-##, destructive sample locations/numbers in red with locations marked with a triangle and labels in the format of DS-##, and locations/numbers of all repairs in blue with locations marked with a square and labels in the format of R-##. Paper copies may be provided in grayscale.

E. Provide a final topographic survey, with two-foot contours, of all areas disturbed by all construction activities. Information shall include vertical and horizontal locations of all improvements, including but not limited to, structural fill, access roads, utilities, permanent erosion and sediment control structures, manholes, and location and invert elevations for all risers, piping, underdrains and stormwater channels. The surveyed area shall be merged with the existing topographic survey. These drawings should highlight any changes from design drawings as described in section 3.07 of this specification. Record drawings should also be maintained for construction details. The drawings should be kept up to date during construction and be provided digitally for the ENGINEER to review updates at progress meetings.

END OF SECTION 01720

SECTION 02100

SITE PREPARATION AND RESTORATION

PART 1 - GENERAL

1.01 SCOPE

A. Provide personnel, equipment, materials, and supplies to clear and grub necessary areas of the project site.

B. Provide protection as necessary to prevent damage to existing improvements not indicated to be removed, and improvements on adjoining properties.

C. Restore all improvements damaged by this Work to their original condition, and acceptable to the OWNER or other parties or authorities having jurisdiction.

PART 2 - PRODUCTS

Not Used

PART 3 - EXECUTION

3.01 UTILITIES

A. Locate existing utilities, culverts, and structures above or below ground before any excavation starts. Coordinate Work with Owners of utilities. Protect, maintain service, and prevent damage to utilities not designated to be removed. When utilities are encountered and are not shown on the drawings, or when locations differ from those shown on the drawings, notify ENGINEER for instruction before proceeding.

3.02 SITE PROTECTION

A. Protect benchmarks from damage or displacement.

B. Protect OWNER'S property and adjoining properties from damage due to construction activities. Use barricades, coverings, and warning signs as appropriate.

C. CONTRACTOR is responsible for correcting any damage caused by construction activities. Make repairs to the satisfaction of the OWNER or other parties having jurisdiction. All costs for repairs will be borne by the CONTRACTOR.

D. The Contractor shall protect living trees designated to remain within the construction area and those outside the construction area. Cut or scarred surfaces of trees or shrubs shall be treated with a paint prepared especially for tree surgery.

E. Conduct Work in accordance with the requirements of the project specifications.

3.03 CLEARING

A. Clear and grade areas required for access to site and execution of Work.

B. Remove from the site trees, brush, shrubs, downed timber, undergrowth, deadwood, rubbish, and other vegetation and incidental structures to allow for new construction.

C. Remove all trees, stumps, and roots within 10 feet of any proposed structure or pipeline.

D. Remove all stumps when such stumps will be less than five (5) feet below finished grade. Stumps of trees to be left in place shall be left no more than six 6 inches above original grade.

E. Clearing shall be limited to areas within the limits of construction that need to be cleared in order to execute the Work. Clearing may be required to obtain suitable materials in the borrow area. CONTRACTOR shall keep clearing to the minimum required to complete the Work. Any clearing performed in the borrow area shall be at no additional cost to the OWNER.

F. With the exception of areas that are disturbed in accordance with an erosion and sediment control permit obtained under the provisions of the project specifications; do not disturb other areas outside the limits of construction shown on the Contract Drawings.

3.04 GRUBBING

A. Grub areas within a 10-foot zone bordering all proposed structures and pipelines.

B. In areas to be cleared, remove all stumps, roots ½-inch or larger, organic material, and debris to a depth of approximately one foot below existing grade, or one foot below the proposed subgrade elevation, whichever is lower.

C. Remove grassy vegetation in a manner that maximizes the separation of vegetative cover and topsoil or subsoil. Unless otherwise noted, grassy vegetation shall be removed from the site or disposed on-site as approved by landfill personnel.

D. Use hand methods for grubbing inside the drip lines of trees which are to remain.

E. Clean up debris resulting from site clearing operations continuously with the progress of the Work.

F. Stockpile topsoil material on site in areas designated by the ENGINEER or the OWNER.

G. Keep pavement and areas adjacent to site clean and free from mud, dirt, and debris.

3.05 REMOVAL AND DISPOSAL OF DEBRIS

A. Unless otherwise noted, trees within the construction limits shall become the property of the CONTRACTOR and shall be removed from the site or disposed on-site as approved by landfill personnel.

B. Remove other debris, rock, and extracted plant life from the site or dispose on-site as approved by the OWNER.

C. Removal and disposal of debris, rock and extracted plant life shall be accomplished at no additional cost to the OWNER.

D. Open burning will be permitted if not in violation of local ordinance, or requirements of Rule .1626(5)(b) and after obtaining approvals from the Division of Air Quality and local fire department. No burning will be allowed within 100 feet of waste disposal areas or site access roads.

E. CONTRACTOR shall obtain and comply with all required permits.

3.06 SITE RESTORATION

A. At the end of the construction period, the CONTRACTOR shall restore to existing grade those areas disturbed by construction activities that lie beyond the limits of construction shown on the Drawings. CONTRACTOR is also responsible for restoration of the sections of the borrow area utilized for the construction at no addition cost to the Owner. Areas to be filled shall be nominally compacted as may be achieved with construction equipment, graded to prevent ponding, and permanently seeded in accordance with the requirements of the project specifications.

END OF SECTION 02100

SECTION 02200

EARTHWORK

PART 1 -GENERAL

1.01 SCOPE

A. The Work covered by this specification consists of furnishing all labor, equipment and materials to perform general grading; excavation; and placement and compaction of structural fill for foundations, perimeter berms, embankments and structures, as shown on the Drawings.

B. All excavation shall be unclassified regardless of material encountered, except for Rock as defined in this specification.

C. A layer is defined as a compacted stratum composed of several lifts constructed without joints. A lift is defined as a segment of a layer composed of the maximum thickness of soil permitted to be placed / compacted at one time.

D. All fill materials shall be subject to the approval of the CQA Consultant.

E. The CONTRACTOR is solely responsible for the placement of all fill material and shall not rely on the CQA Consultant for recommendations and directions. It is recommended the CONTRACTOR employs his own geotechnical consultant to provide construction assistance and recommendations.

F. The CQA Consultant will perform field and laboratory testing as required and in accordance with the CQA Plan.

G. The use of explosives is prohibited.

1.02 CONSTRUCTION QUALITY CONTROL (CQC)

A. The CONTRACTOR will provide a testing program to perform the following minimum laboratory tests on soil materials being used for construction. All testing will be performed by an independent qualified geotechnical consultant and testing laboratory and under the direction of a Registered Professional Engineer licensed in the State in which the project work is conducted.

B. Laboratory Testing - Soils:

1. Visual Classification
   Visual classification (ASTM D2487) shall be conducted at a frequency of one test for each soil type.
2. Gradation Analysis
   Gradation analysis (ASTM D422) shall be conducted at a frequency of one test for each soil type.
3. Atterberg Limits and Moisture Content

Atterberg limits (ASTM D4318) and moisture content test (ASTM 2216) shall be conducted at a frequency of one test for each soil type.

4. Standard Proctor Density Test
   Standard Proctor density test (ASTM D698) shall be conducted at a frequency of one test for each soil type.
5. Specific Gravity
   Specific gravity test (ASTM D854) shall be conducted at a frequency of one test for each soil type.
6. Triaxial Compression Testing
   Consolidated Undrained Triaxial with Pore Pressure Measurements Series (ASTM D4767), Three Point Series, Remolded, shall be conducted at a frequency of one test for each soil type.

PART 2 - PRODUCTS

2.01 FILL MATERIAL

All fill material used to establish necessary grades as shown on the Drawings shall be free of debris, roots, stumps, brush, vegetation, frozen material, organic matter, rock, or gravel larger than two inches in any dimension, or other harmful matter, unless allowed by the CQA Consultant.

All fill materials shall be subject to the approval of the CQA Consultant. CONTRACTOR shall notify the CQA Consultant at least 10 working days in advance of intention to begin filling operations. Notification shall include designation of the proposed borrow source and all necessary laboratory testing data to demonstrate the adequacy of the material to perform its intended use. CONTRACTOR shall provide the CQA Consultant with 120 pounds of the proposed material in three, five-gallon, PVC, sample buckets with lids and handles at the time of notification. CONTRACTOR shall not initiate filling activities without the approval of the CQA Consultant to use the intended material for filling activities.

Fill material shall have a minimum internal friction angle of 32 degrees, unless otherwise approved by engineer.

2.02 ROCK

Rock shall be construed as solid mineral material with a volume in excess of two (2) cubic yards or solid material that cannot be fractured and/or removed with conventional earth moving equipment. Conventional earth moving equipment shall be defined as a Cat D8L or equivalent tractor with a single-shank ripper, or Cat 330 sized or equivalent hydraulic excavator.

2.03 UNSUITABLE MATERIAL

Material such as clay mass, frozen materials, cinders, ashes, refuse, vegetation, organic material and muck shall be construed as unsuitable material for backfill. All unsuitable material under access roads, structural fills and berms shall be removed from the area to be filled.

PART 3 - EXECUTION

3.01 GENERAL

A. Strip topsoil to full depth, and stockpile separate from other excavated materials and pile free of roots, stones, and other undesirable materials. Follow local erosion and sediment control guidelines to prevent erosion. Any depressions caused by removal of stumps of the clearing shall be excavated to firm subgrade.

B. The CONTRACTOR shall perform all excavation described in whatever material encountered to dimensions and elevations shown on the Drawings.

C. Existing utilities, structures, and fencing shall be protected during the construction period, and if damaged or removed by the CONTRACTOR in his operations, shall be repaired or replaced at the CONTRACTOR'S expense.

D. Where unauthorized excavations have been carried below or beyond points required, restore these areas to the elevations and dimensions shown on the Drawings with material approved by CQA Consultant and compact as specified, at no additional cost to the OWNER.

E. Material rendered not suitable for construction due to fault or negligence of the CONTRACTOR, shall be removed and replaced at no additional cost to the OWNER.

3.02 UTILITIES TO BE ABANDONED OR REMOVED

A. When underground utilities are to be abandoned in place, plug, cap, or seal with concrete at the "Construction Limits" or at points designated by the CQA Consultant.

B. Remove underground utilities indicated on the Drawings to be removed and backfill resulting excavation with suitable material, compacted as specified. Plug, cap or seal utilities with concrete at the construction limits or at points designated by the CQA Consultant.

3.03 PROOFROLLING

A. Prior to the placement of any fill material, the subgrade, or bridge lift, shall be proofrolled.

B. Prior to the placement of the liner system, the natural ground or excavated subgrade, shall be proofrolled.

C. Prior to the placement of the liner system, the top of fill shall be proofrolled

D. Proofrolling shall be performed using a rubber-tired device having a static weight of at least 10 tons (such as a loaded tandem axle dump truck). This shall be performed during dry weather conditions and under the direction of the CQA Consultant. Areas that "pump" or otherwise exhibit instability shall be repaired as directed by the CQA Consultant.

3.04 WETLANDS PROTECTION

Prior to the placement of any fill material, the Best Management Practices (BMPs), such as stormwater conveyance channels, sediment basins, outlet protection, and silt fence, shown on the contract documents must be installed. In addition, the CONTRACTOR is responsible for flagging the maximum limits of disturbance prior to the start of on-site construction activities. At no time shall the CONTRACTOR impact any areas beyond the maximum limits of disturbance, without prior approval from the ENGINEER and CQA Consultant.

3.05 EXCAVATION

A. Areas that receive permanent seeding shall be graded below finished grades shown, leaving space for the vegetative support layer.

B. Stockpile excavated soil material satisfactory for backfill or fill until required. Place, grade and shape stockpiles for proper drainage. Proper erosion and sediment control measures shall be installed in conjunction with stockpile development.

C. Remove existing pavement as required.

D. Dispose of materials unsatisfactory for backfill or fill continuously with the progress of work.

E. Dispose of trash and debris, and all excess material continuously with the progress of the work.

F. All excavation shall be dewatered as necessary to provide proper protection. The CQA Consultant may require excavation to be continuously dewatered 24 hours per day byadequate pumping or well-points satisfactory to the CQA Consultant until backfilling has been completed.

G. Where underground streams or springs are found, provide temporary drainage and notify ENGINEER and CQA Consultant.

H. Extreme caution shall be taken when excavating in the vicinity of existing facilities. Any damage to the facilities will be repaired to original condition at no additional cost to the OWNER.

I. Excavate unsuitable soil materials encountered that extend below required elevations. The limits of the unsuitable material and depth of removal shall be determined by the CONTRACTOR, and agreed to by the ENGINEER and/or the CQA Consultant.

J. Remove shoring and all form materials.

K. Grade site to prevent surface water run-on into excavations.

3.06 EXCAVATION FOR STRUCTURES

A. Conform to elevations and dimensions shown on the Drawings. Extend excavation sufficient distance from footings and foundations to permit placing and removal of concrete form work,

installation of services, and for other required construction. Foundation concrete shall not be poured until the bearing stratum has been examined and found satisfactory for the design bearing capacity.

B. Where rock is encountered, notify ENGINEER. When the entire structure will bear on rock, it shall be used to support the foundation. Where only a part of the foundation would bear on rock, excavate 12 inches below the entire structure and backfill with aggregate fill and thoroughly compact.

C. Provide a 12-inch minimum clearance between rock excavation and walls of structure when forming is not used. Provide a two (2) feet clearance when forming is used.

3.07 ROCK REMOVAL

A. Rock removal will be by mechanical method only unless prior approval is received from the OWNER, ENGINEER, and CQA Consultant.

B. If Rock is encountered as defined in this specification, The CONTRACTOR will before proceeding:

1. Demonstrate findings to the CQA Consultant;
2. Determine limits of the rock above the base grade; and
3. Quantify the rock and provide information, including limits, to the CQA Consultant for assessment.

C. Remove rock at bottom of excavations to form level bearings.

D. In utility trenches, excavate to 4 inches below invert elevation of pipe and to width indicated on Standard Details.

E. Remove rock loosened by mechanical method. Over-excavation of six inches to one foot will be allowed.

F. Correct unauthorized rock removal in accordance with backfilling and compaction requirements of the project specifications.

G. Excavated rock will be removed from the site or segregated and stockpiled on-site as directed by the OWNER.

3.08 COMPACTION OF FILL

A. Compaction of each layer shall be continuous over the entire area and the compaction equipment shall make sufficient trips to assure that the density has been obtained. Fill shall be placed and compacted in uniform lifts and shall not exceed 6 inches in compacted thickness. All fill shall be compacted to within 95 percent of maximum density (standard proctor) as determined by ASTM D698. This compaction method shall apply to all fills, berms, embankments, paved areas and for a distance of at least 25 feet beyond structures and at least five feet beyond fills, berms, embankments and paved areas. All other unpaved areas shall be compacted to within 90 percent of maximum density as determined by ASTM D698.

B. Compaction equipment shall be of such design that it will be able to compact the fill to the specified density. Use power-driven hand tampers for compacting materials adjacent to structures.

3.09 COMPACTION TESTS

Field tests of the compaction of fill will be made by the CQA Consultant. If a test fails to meet the required compaction level or moisture content, then the area represented by that test shall be reworked and retested, at no additional cost to the OWNER, until a passing test results. The CONTRACTOR may elect at his own expense to remove the failing material.

3.10 SURFACE WATER

All excavations and fill areas shall be kept free of standing water. Grade surfaces and ditches to drain. Pumping of water shall be required to remove water from areas that cannot drain naturally.

3.11 FILL AND BACKFILL

A. Remove vegetation, debris, unsatisfactory materials prior to placement of fill. Plow, strip or break up sloped surfaces steeper than 4 to 1 so that fill material shall bond with existing surface.

B. Obtain clean earth fill from excavation or other approved sources. The material shall be compacted in accordance with these Specifications. Rock fragments and stones up to 2 feet in its greatest dimension may be placed in an embankment fill to within 10 feet of the top of the earth fill. The remainder of the embankment to within 2 feet of the top of the earth fill shall not contain rock more than 6 inches in its greatest dimension. The top 2 feet of the embankment shall not contain rock more than 2 inches in its greatest dimension. Rock, fines, and earth shall be distributed throughout each lift so that voids are filled. Rock shall not be placed in the embankment where, piling, borings, monitoring wells or boundary probes are to be driven, drilled or constructed. Prevent nesting of large rocks and compact fill to prevent voids. Maximum rock size within 12 inches of footing elevations shall be 2 inch diameter.

C. Provide borrow material when on-site excavation is not sufficient to grade site to contours and finished grade elevations shown on the Drawings. All necessary costs shall be included in Bid Price.

D. Remove and replace, or scarify and air dry, soil material that is too wet to permit compaction to specified percentage of maximum density.

E. Do not backfill with or compact over frozen soil material.

F. Soil material that has been removed as too wet to permit compaction may be stockpiled or spread to dry. When moisture content is reduced to a satisfactory value, soil material may be used as fill or backfill.

G. Place clean earth fill to obtain elevations shown on the Drawings.

H. Excavate depression caused by removed stumps or other clearing operations to firm subgrade, fill with clean earth and compact as specified.

I. When the existing ground surface has been disturbed and has a density of less than that specified for the particular area, scarify the ground surface, adjust moisture content and compact to required depth and percentage of maximum density.

J. Place backfill and fill materials in layers which, when compacted, shall not exceed six inches in lift thickness at depths less than four feet below finished grade and 12 inches in lift thickness at depths greater than four feet below finished grade. Each layer shall be spread evenly and shall be thoroughly bladed and mixed during the spreading to ensure uniformity of material in each layer. If required, the fill material shall be dried by aerating with a scarifier, disc harrow, blade or other equipment or by such other means as may be necessary. If required, the fill material shall be wetted by the use of water trucks. Dried or wetted fill material shall be thoroughly mixed to provide optimum moisture content. Compact each layer to the required density.

K. Place backfill and fill materials evenly adjacent to structures. Prevent wedging of the backfill against structures by carrying the material uniformly around the structure to approximately the same elevation in each lift.

L. Place aggregate fill material under all structures as shown on the Drawings. Compact to density required for fill under buildings and structures.

3.12 GRADING

A. Uniformly grade all areas within the limits designated on the Drawings, including adjacent transition areas. Finish surfaces within specified tolerances with uniform levels or slopes between points where elevations are shown and existing grades.

B. Finish all surfaces free from irregular changes and grade to drain as shown on the Drawings.

C. Finish areas to receive geosynthetic liner to within 0.10 feet of required subgrade elevations, unless approved in writing by ENGINEER.

D. Shape subgrade under unpaved areas to line, grade and cross-section to within 0.25 feet of required subgrade elevation.

E. Shape subgrade under pavement to line, grade, and cross-section to within 0.05 feet of required subgrade elevations.

F. Grade for structures to required elevation within tolerance of 0.05 feet.

G. Protect newly graded areas from traffic, erosion, desiccation or other damage. Repair and re-establish grade in settled, eroded, or rutted areas to the specified tolerances.

H. Where compacted areas are disturbed by subsequent construction or adverse weather, scarify the surface, reshape and compact to the required density. Use hand tamper for recompaction over underground utilities. Portions of the fill damaged due to exposure shall be reworked to meet the project specifications or, at the discretion of the CQA Consultant, removed and replaced with conforming material at no additional cost to the OWNER.

I. Place vegetative support layer to a minimum depth of 6 inches. Where existing on-site supply of topsoil is inadequate to provide the required amount, supply additional topsoil, meeting the specification for Topsoil, from off-site sources. Source and quality of additional material shall be approved by ENGINEER. Cost of off-site material shall be at no additional cost to OWNER. Reference shall be made to the project specifications for requirements of topsoil testing and topsoil amendment options.

3.13 LANDFILL SUBGRADE

The landfill subgrade shall be surveyed in accordance with Section 01720 to demonstrate that proper grades are achieved. The survey of the subgrade will be reviewed and approved by the engineer/CQA consultant prior to construction of the landfill liner. The CQA consultant will provide a visual inspection of the subgrade and will notify DENR if any unexpected conditions or deviations from the Drawings are observed in the field or in review of the survey. Testing will be performed as outlined in Table 1 of the CQA Plan for "Fill"

3.14 SEASONAL LIMITS

No fill material shall be placed, spread, or rolled while the ground is frozen or thawing, or during unfavorable weather conditions. When the work is interrupted by inclement weather, fill operations shall not be resumed until approved by the CQA Consultant. Repairs from inclement weather must be corrected by the CONTRACTOR to the satisfaction of the CQA Consultant at no additional cost to OWNER.

END OF SECTION 02200

SECTION 02210

COMPACTED SOIL LINER/CAP

PART 1 - GENERAL

1.01 SCOPE

A. The CONTRACTOR shall furnish all labor, materials, equipment, tools and appurtenances required to complete the work of furnishing, installing and compacting the low permeability soil layer of the liner/cap system (soil liner/cap) as shown, specified or required.

B. The construction methods and the related material properties including, but not limited to: type of compaction equipment, method of operation, number of passes, operating frequency, moisture content of the material, compacted density, and permeability of the material, shall be determined by the results obtained from the Test Pad.

C. Acceptance by the CQA Consultant of the compacted soil liner/cap shall be dependent on the CONTRACTOR satisfying the requirements imposed by the CQA plan during the course of the work, and test results showing that all requirements of the project specifications and results obtained from the Test Pad have been met. Such acceptance shall be based on the soil liner/cap meeting the required moisture content, density and permeability, in combination with approval of all CONTRACTOR operations, based on visual observation and tests conducted by the CQA Consultant.

D. The cost of all sampling and retesting associated with any reconstruction of the compacted soil liner/cap shall be borne by the CONTRACTOR.

E. Field and laboratory testing conducted by the CQA Consultant under Paragraph 1.03 of this Section will be done at the OWNER'S expense.

F. A separate test pad will be required for each borrow source, change in material or change in construction method.

G. Placement of the compacted soil liner/cap shall not start until the test pad and all associated testing have been completed and approved by the CQA Consultant in writing.

1.02 SUBMITTALS

The following submittals shall be furnished by the CONTRACTOR for the work of this Section as specified herein.

A. All submittals as required by the project specification applicable to the work being performed, or as requested by the CQA Consultant.

1.03 CONSTRUCTION QUALITY ASSURANCE (CQA)

A. The Construction Quality Assurance Plan will be administered by the CQA Consultant. CQA testing by the CQA Consultant shall include, but not necessarily be limited to the following:

1. In-place moisture content and density;
2. Standard proctor density test; and
3. Permeability testing.

B. The CONTRACTOR shall provide time and space for the CQA tests to be conducted. The CONTRACTOR shall inform the CQA Consultant when an area is suitable for testing. The CQA Consultant reserves the right to test any area at any time at the CQA Consultants discretion.

The CONTRACTOR shall prepare level areas on which testing or sampling shall be performed and shall repair any disturbances to the soil liner generated through testing and sampling. If ASTM D1556 (Sand-Cone Method) is used for density/moisture content tests, all sand shall be removed from the test hole prior to backfilling. All test and sample holes shall be backfilled with soil liner/cap material and recompacted by compaction equipment at the proper moisture content to achieve the minimum liner permeability.

C. In all areas where permeability requirements are not achieved, as determined based on moisture content and density tests, and/or visual observations, the representative area, as determined by the CQA Consultant, shall be reconstructed by reworking and recompacting, or removal and replacement, at no additional cost to the OWNER, and retested until the quality requirements set forth in this Section are met. All additional CQA costs associated with any reconstruction, reworking or replacement of the compacted soil liner/cap and associated laboratory testing fees will be included in a Change Order and deducted from the Contract Price.

D. The soil liner/cap construction shall proceed in orderly manner to allow for CQA field and laboratory testing results prior to continuing with subsequent lifts. No lift shall be covered by new material until laboratory test results have been reviewed and found to meet the permeability requirement for the soil liner/cap.

E. The CONTRACTOR is solely responsible for the construction of the compacted soil liner/cap and shall not rely on the CQA Consultant for recommendations and directions. It is recommended the CONTRACTOR employs his own geotechnical consultant to provide construction assistance and recommendations.

PART 2 - PRODUCTS

2.01 MATERIALS

Material supplied for use to construct the soil liner/cap shall be a mineral soil with cohesive characteristics, free of organic matter, shall not contain particles larger than 3/8 inches, and shall have a hydraulic conductivity (permeability) as indicated on the Drawings. The material supplied

for use to construct the soil liner/cap shall be the same material used to construct the approved test pad.

PART 3 - EXECUTION

3.01 SUBGRADE PREPARATION

Areas to receive soil liner/cap shall be cleared, grubbed, and stripped of topsoil in accordance with the requirements set forth in the project specifications. After stripping all topsoil and organic soil, any soft natural soil or soft existing fill shall be removed. Removed soils shall be replaced with compacted layers of fill. Any soil that softens due to precipitation, groundwater, disturbance, exposure, or any other cause shall be removed and replaced at no additional cost to the OWNER. The area shall then be observed and approved by the CQA Consultant before placement of the soil liner/cap.

The surface shall be free from ruts, hummocks, or other uneven features which would tend to prevent uniform compaction.

The CONTRACTOR shall employ a professional land surveyor licensed in the State in which the project work is conducted to obtain surveyed elevations, at 50-foot intervals on a grid pattern across the subgrade/intermediate cover prior to placement of the soil liner/cap. From this survey, a contour plan showing contours at no more than two-foot intervals shall be generated. This survey information and contour plan shall become part of the Record Drawings.

3.02 SITE DRAINAGE

At all times, the CONTRACTOR shall maintain and operate proper and adequate surface and subsurface drainage to keep the construction site dry and in such condition that placement and compaction of the soil liner/cap may proceed unhindered by saturation of the area.

Construction of the soil liner/cap material on a saturated subgrade is prohibited. After a rainfall the subgrade shall be given sufficient time to drain and dry to the design moisture content before placing soil.

3.03 INSTALLATION

A. PLACEMENT OF SOIL LINER/CAP MATERIAL

The soil shall be thoroughly mixed and spread immediately after dumping, by mechanical equipment above the approved subgrade, and shall be built up in even horizontal layers. Prior to compaction, the soil shall be mixed by disc-harrow or an equivalent method to a homogeneous consistency. Lift thickness shall be no greater than six compacted inches. The loose lift thickness shall not exceed the effective depth of compaction for the equipment utilized.

The soil liner/cap shall be constructed in such a manner that bonding between lifts is achieved.

The final grades of the soil liner/cap shall result in a smooth surface through fine finishing with a road grader and a smooth drum roller. The final grades of the soil liner/cap shall be true to grade and shall not allow the ponding of water, with deviations of no more than 0.1 foot for soil liners and 0.2 feet for soil caps, measured across any 10-foot section. The minimum thickness, measured perpendicularly to slope, as shown on the plans, shall be achieved.

The CONTRACTOR shall employ a professional land surveyor licensed in the licensed in the State in which the project work is conducted to obtain surveyed elevations of the top of the compacted soil liner/cap, at the same 50-foot grid locations used to survey the subgrade/intermediate cover. From this survey, a contour plan showing contours at no more than two-foot intervals shall be generated. This survey information and contour plan shall become part of the Record Drawings.

B. MOISTURE CONTROL

Material that is too wet shall be spread and permitted to dry, assisted by discing or harrowing, if necessary, and the work shall be delayed until the moisture is reduced to the required limits.

When the material is too dry, the CONTRACTOR shall add moisture to each layer. Water must be allowed to soak into the soil for a period of time sufficient to permit hydration of the soil. Harrowing, or other approved methods shall be required to work the moisture into the soil and break up any dry clods until a uniform distribution of moisture is obtained. The moisture content after compaction shall be uniform throughout any one layer.

If it is impractical to obtain the required moisture/density by wetting or drying the soil at the site, the CONTRACTOR shall condition the material off the site.

C. COMPACTION

The soil liner/cap shall be compacted to the moisture/density determined from the results of the Test Pad. The CONTRACTOR may be permitted to modify the compaction and moisture content to fit site conditions and material requirements if he can demonstrate that all design parameters can be satisfied as determined and approved by the CQA Consultant. The compaction procedures (e.g., equipment and methods, operating frequency, number of passes, etc.) shall be in accordance with the results determined by the Test Pad.

Successive lifts of soil liner/cap shall not be placed until the previous lift is accepted by the CQA Consultant.

To avoid damage to structures and pipes, hand-operated vibratory type plate compactor, jumping jack, or other suitable equipment shall be used in areas not accessible to larger roller or compactor. The compaction around penetrations shall be as specified and able to achieve the hydraulic conductivity requirements.

3.04 FROST

No soil liner/cap materials shall be placed when either the soil or the previous lift (or subgrade) on which it is to be placed is frozen. In the event that any installed soil liner/cap or subgrade becomes frozen, it shall be scarified, thawed and recompacted, or removed to the approval of the CQA Consultant before the next lift is placed. Any soft spots resulting from frost shall be removed or recompacted to the satisfaction of the CQA Consultant before new soil lift material is placed. No frozen material shall be used as soil liner/cap.

3.05 GEOSYNTHETIC AREA PREPARATION

Surfaces to receive a geosynthetic material shall be kept smooth and free of debris, roots, sticks, bones and angular or sharp rocks larger than 3/8 inch in any dimension. The surface should provide a firm, unyielding foundation with no sudden, sharp, or abrupt changes or break in grade. No standing water or excessive moisture shall be allowed. Final compaction of any area to receive a geosynthetic shall be with smooth steel wheel roller. The CONTRACTOR shall certify in writing that the surface on which the material is to be installed is acceptable before commencing placement of geosynthetic materials.

3.06 PROTECTION OF WORK

It is imperative that the CONTRACTOR schedule his work to prevent the soil liner/cap from drying and/or cracking due to exposure, or from softening due to precipitation. This applies to every layer of soil liner/cap material placed. The CONTRACTOR shall develop a construction contingency plan for responding to construction deficiencies resulting from circumstances including, but not limited to: inclement weather, sediment deposits run-on, defective materials, or construction inconsistent with the project specifications as demonstrated by quality assurance testing and observations by the CQA Consultant. The plan shall provide a methodology for selecting and implementing the corrective action.

Any portion of the soil liner/cap damaged due to exposure shall be reworked, removed or replaced with conforming material to meet the project specifications. Payment for the soil liner/cap will not be made until it has been covered with the overlying material and protected from damage.

3.07 REMEDIAL MAINTENANCE

The CONTRACTOR shall maintain all compacted soil liner/cap fill in an undisturbed and compacted state until covered and protected from damage. All work and materials required for remedial maintenance shall be performed at no additional cost to the OWNER. In the event of slides, sloughing, or erosion in any part of the work, the CONTRACTOR shall remove the disturbed material from the damaged area and shall rebuild such portion as directed by the CQA Consultant. The removal of material and the rebuilding of any slide area shall be performed at no additional cost to the OWNER.

END OF SECTION 02210

SECTION 02212

AMENDED SOIL LINER/CAP

PART 1 SCOPE OF WORK

1.01 WORK INCLUDED

This work shall include the furnishing of all labor, materials, tools, equipment and other items necessary for the manufacturing, fabrication and installation of soil-bentonite barrier consisting of six (6) inch layers of acceptable borrow containing a sealant consisting of a free flowing, chemically treated, high swelling sodium based bentonite, specifically processed as a soil sealant for the containment of municipal wastes as described in the Specifications and shown on the Drawings.

1.02 REFERENCES

A. American Society for Testing and Materials (ASTM)
   1. D698 Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft)

1.03 GENERAL

A. These specifications cover the mixing of chemically and polymerically treated, granular high swelling sodium type bentonite with the borrow soil for the liner/cap.

1.04 SUBMITTALS

A. Provide certification of the materials from the supplier, attesting that the material properties meet the requirements of the specifications.

1.05 STORAGE AND HANDLING

A. Clear and level storage sites for bulk shipments, prior to stockpiling the bentonite material.

B. Protect stockpiled bentonite material from the elements in accordance with the manufacturer's recommendations to preserve the fitness and quality of the material.

1.06 CONSTRUCTION QUALITY CONTROL AND CONSTRUCTION QUALITY ASSURANCE (CQC/CQA)

A. Acceptance by the ENGINEER of the compacted soil liner/cap shall be dependent on the CONTRACTOR determining that all requirements imposed by the CQA plan are met. The Construction Quality Assurance Plan will be administered by the ENGINEER. CQA Testing by the CQA Consultant shall include, but not necessarily be limited to the following:

- Visual classification;

- Gradation analysis;
- Atterberg limits and moisture content;
- In-place moisture content and density;
- Standard proctor density test;
- Permeability testing; and
- Thickness verification.

B. The CONTRACTOR shall provide time and space for the CQC/CQA tests to be conducted. The CONTRACTOR shall inform the CQA Consultant when an area is suitable for testing. The CQA Consultant reserves the right to test any area at any time at the CQA Consultants discretion.

The CONTRACTOR shall prepare level areas on which testing or sampling shall be performed and shall repair any disturbances to the soil liner generated through testing and sampling. If ASTM D1556 (Sand-Cone Method) is used for density/moisture content tests, all sand shall be removed from the test hole prior to backfilling. All test and sample holes shall be backfilled with soil liner/cap material and recompacted by compaction equipment at the proper moisture content to achieve the minimum liner permeability.

C. In all areas where permeability requirements are not achieved, as determined based on direct testing, moisture content and density tests, and/or visual observations, the representative area, as determined by the ENGINEER, shall be reconstructed, such as by reworking and recompacting, or removal and replacement, and retested at no additional cost to the OWNER until the quality requirements set forth in this Section are met. The cost of all sampling and retesting associated with any reconstruction of the soil liner shall be borne by the CONTRACTOR.

1.07 TEST PAD

A separate test pad will be required for each borrow source, change in material or change in construction method.

PART 2 PRODUCTS

2.01 MATERIALS

A. Borrow materials for the compacted soil liner/cap shall be tested and approved in accordance with the procedures as outlined in the CQA Plan.

B. HIGH SWELLING bentonite is defined as the ability of two grams of the untreated base bentonite, when mechanically reduced to -100 mesh, to swell in water to an apparent volume of 16.0 cc, or more, when added a little at a time, to 100 cc of distilled water contained in a graduated cylinder.

1. The COLLOID CONTENT of the base bentonite shall exceed 85% as measured by evaporating the suspended portion of a 2% solution after 24 hours of sedimentation in a glass graduated cylinder or breaker.

2. DRY FINENESS of the soil sealant shall be:
   15% maximum retained on a 20 mesh screen.
   15% maximum passing a 200 mesh screen.

C. The amended soil shall meet the gradation requirements as outlined in specification Section 02210 - Compacted Soil Liner/Cap.

2.02 WARRANTY COVERAGE

A. The bentonite shall be covered by the manufacturer's warranty against defects in material and workmanship and have a useful life of 30 years under normal weathering and use conditions.

PART 3 EXECUTION

3.01 PREPARATION

A. The bentonite application rates shall be determined by a soil-testing laboratory, approved by the ENGINEER and reviewed by the bentonite manufacturer. The bentonite shall be applied at a rate to achieve the required permeability. Prior to application of the bentonite, a soils testing laboratory shall perform a soil analysis on samples submitted by the CONTRACTOR, and recommend an application rate, which will provide the permeability coefficient as specified. This shall be done prior to construction.

B. Grade the surface upon which the amended soil liner/cap is to be constructed as per the Drawings or ENGINEER's instructions. Slopes having a grade steeper than 3:1 shall be approved by the ENGINEER.

C. Remove all vegetation and rocks, which would penetrate or deform the amended soil liner/cap.

3.02 CONSTRUCTION

A. Work on slopes shall be undertaken before work on the flatter areas to permit drainage in the event of rainfall.

B. An agent or representative of the bentonite supplier should provide on site start-up information and instruction to the CONTRACTOR and ENGINEER regarding product application techniques as necessary.

C. Water shall be added to the soil (or dried, if too wet) before applying the bentonite to yield the optimum moisture content of the soil-bentonite mixture as defined by ASTM-D698.

D. Spread the bentonite uniformly across each lift, prior to compaction, at the specified application rate, using an agricultural seed or lime spreader or other equipment as approved by the ENGINEER. Premeasured tarpaulin or drop cloths spread in different locations shall be weighted prior to and after spreading material over them to insure that the proper application rate is being applied. The bentonite may also be applied at the appropriate application rate by distributing 100

lb. bags of the material in marked grid patterns. Each square of the grid shall be of the proper square footage to be covered by any multiple of 100 lb. bags of the material. Break open bags and spread the material evenly within each grid square, using hand rakes. Thoroughly mix the bentonite to the specified depth using an adjustable rotary tiller or similar mixing equipment.

E. An alternative method of mixing is to use a pug mill mixer at the site. Operate the pug mill mixer in accordance with manufacturer's recommendations. The CQA representative(s) will observe the operation on site.

F. Compact the soil-bentonite layer to the density specified by the testing laboratory, which set the bentonite mixture ratio as approved by the ENGINEER. Compaction equipment shall be approved by the ENGINEER after a demonstration of its effectiveness on the test pad.

G. Work only those areas that can be completed in one working day. Completion is defined as the soil moisture adjustment, spreading of bentonite, mixing of the soil-bentonite and required compaction.

H. Apply and compact by hand a dry mixture of 1 part bentonite to 4 parts soil (by volume) around any sumps, penetrations or other appurtenances.

3.03 FIELD QUALITY CONTROL

A. For testing information, refer to the Construction Quality Assurance Plan (CQA).

3.04 GEOSYNTHETIC AREA PREPARATION

Surfaces to receive a geosynthetic material shall be kept smooth and free of debris, roots, sticks, bones and angular or sharp rocks larger than 3/8 inch in any dimension. The surface should provide a firm, unyielding foundation with no sudden, sharp, or abrupt changes or break in grade. No standing water or excessive moisture shall be allowed. Final compaction of any area to receive a geosynthetic shall be with smooth steel wheel roller. The CONTRACTOR shall certify in writing that the surface on which the material is to be installed is acceptable before commencing placement of geosynthetic materials.

3.05 PROTECTION

A. Protect the completed liner/cap from the elements, construction activities, drying, swelling and other situations, which may degrade the quality of the liner/cap.

END OF SECTION 02212

SECTION 02218

TEST PAD

PART 1 - GENERAL

1.01 SCOPE

A. The work covered by this Section shall include all labor, equipment and materials necessary to construct a test pad(s) as specified herein.

B. The test pad shall include construction of a trial section of a compacted soil layer as shown on the Drawings. The test pad shall include, but not be limited to:

1. Preparation of subgrade in accordance with Section 02200 - Earthwork; and
2. Construction of compacted soil test pad or amended soil test pad.

C. The purpose of the test pad is to develop and demonstrate construction methods to produce a compacted low permeability soil layer of the liner/cap system (soil liner/cap) satisfying the requirements of the project specification in all respects. Of particular concern are the construction methods to be adopted to construct a compacted soil liner/cap to achieve the required permeability.

The construction methods and the related material properties to be noted shall include, but are not limited to: type of compaction equipment, method of construction, number of passes, moisture content of the material, compacted density, and the resulting permeability of the material.

D. A separate test pad will be required for each borrow source, change in material or change in construction method.

E. Acceptance by the CQA Consultant of the test pad shall be dependent on the CONTRACTOR satisfying the requirements imposed by the CQA plan during the course of the work, and test results showing that all requirements of the project specifications have been met. Such acceptance shall be based on the test pad meeting the required permeability, in combination with approval of all CONTRACTOR operations, based on visual observation and tests conducted by the CQA Consultant.

F. Testing of soil samples as required under Paragraph 1.03 of this Specification shall be paid for by CONTRACTOR. The cost of all sampling and retesting associated with additional or separate test pads or any reconstruction of the test pad shall be borne by the CONTRACTOR.

G. Field and laboratory testing conducted by the CQA Consultant under Paragraph 1.04 of this Specification will be performed at the OWNER'S expense.

1.02 SUBMITTALS

A. CONTRACTOR shall notify the CQA Consultant at least 10 working days in advance of intention to begin filling operations. Notification shall include designation of the proposed borrow source and all necessary laboratory testing data to demonstrate the adequacy of the material to perform its

intended use. CONTRACTOR shall provide the CQA Consultant with 120 pounds of the proposed material in three, five-gallon, PVC, sample buckets with lids and handles at the time of notification. CONTRACTOR shall not initiate filling activities without the approval of the CQA Consultant to use the intended material for filling activities.

B. The results of analyses required under Paragraph 1.03 of this Specification shall be submitted to the CQA Consultant at least two weeks prior to beginning construction of the test pad.

The equipment used for compacting the soil liner/cap material shall be a sheepsfoot roller that can effectively compact the loose lift thickness to meet the specifications.

1.03 CONSTRUCTION QUALITY CONTROL (CQC)

A. The CONTRACTOR shall perform a borrow evaluation to determine the moisture content / dry density / permeability relationship for the material. These tests shall be run to develop an acceptable window of density and moisture to obtain the permeability criteria.

B. If an alternate borrow material is proposed or required, the CONTRACTOR shall perform a borrow evaluation to determine the moisture content / dry density / permeability relationship of the material. These tests shall be run to develop an acceptable window of density and moisture to obtain the permeability criteria.

C. Final criteria for construction of the compacted soil liner/cap (including moisture content, compactive effort, and density) shall be determined based on the results of the Test Pad demonstration.

D. For all soils to be used to construct the test pad, the CONTRACTOR shall perform:

1. Sieve analyses in accordance with ASTM D 422. Frequency: A minimum of one test per test pad.
2. Testing for Atterberg Limits accordance with ASTM D 4318. Frequency: A minimum of one test per test pad.
3. Testing for PROCTOR in accordance with ASTM D 698. Frequency: A minimum of one test per test pad.
4. Remolded permeability testing in accordance with ASTM D 5084. Frequency: One test per test pad (composite sample). Conduct tests using a confining pressure of 5 psi, and a hydraulic gradient of 10.
5. Triaxial Compression Testing
Consolidated Undrained Triaxial with Pore Pressure Measurements Series (ASTM D4767), Three Point Series, Remolded, shall be conducted at a frequency of one test for each soil type.

1.04 CONSTRUCTION QUALITY ASSURANCE (CQA)

A. The Construction Quality Assurance Plan will be administered by the CQA Consultant. CQA testing by the CQA Consultant shall include, but not necessarily be limited to the following:

1. In-place moisture content and density; and
2. Permeability testing.

B. The CONTRACTOR shall provide time and space for the CQA tests to be conducted. The CONTRACTOR shall inform the CQA Consultant when an area is suitable for testing. The CQA Consultant reserves the right to test any area at any time at the CQA Consultants discretion.

The CONTRACTOR shall prepare level pads on which tests or sampling shall be performed and shall repair disturbances to the test pad generated through testing and sampling. If ASTM D1556 (Sand-Cone Method) is used for density/moisture content tests, the CONTRACTOR shall remove all sand from the test hole prior to backfilling. All test and sample holes shall be backfilled with soil liner/cap material and recompacted to achieve the minimum specified permeability.

C. The test pad construction shall proceed in orderly manner to allow for CQA field and laboratory testing. In all areas where permeability requirements are not achieved, as determined based on direct testing, moisture content and density tests, and/or visual observations, the representative area, as determined by the CQA Consultant, shall be reconstructed, such as by reworking and recompacting, or removal and replacement, at no additional cost to the OWNER, and retested until the quality requirements set forth in this Section are met. All additional CQA costs associated with any reconstruction, reworking or replacement of the test pad and associated laboratory testing fees will be included in a Change Order and deducted from the Contract Price.

D. The CONTRACTOR is solely responsible for the construction of the compacted soil layer test pad and shall not rely on the CQA Consultant for recommendations and directions. The CONTRACTOR shall employ his own geotechnical consultant to provide construction assistance and recommendations.

PART 2 - PRODUCTS

2.01 MATERIALS

Borrow materials for the test pad shall be tested and approved in accordance with procedures as outlined in this specification and the CQA Plan.

The material shall have an internal friction angle of 20 degrees or greater unless otherwise approved by engineer.

PART 3 – EXECUTION

3.01 GENERAL

A. The plan area for the test pad shall be a minimum of 50 by 150 feet. It shall be constructed and tested prior to the placement of the compacted soil liner/cap. The location of the test pad shall be selected by the CONTRACTOR and approved by the CQA Consultant. The test pad shall be located on a slope equal to the steepest slope proposed to receive the compacted soil liner/cap.

B. The test pad shall be constructed with the equipment and methods proposed for the compacted soil liner/cap. The compacted lift thickness shall not exceed six inches, unless otherwise approved in writing by the CQA Consultant.

C. The test pad may be part of the landfill compacted soil liner/cap. If the CONTRACTOR chooses to construct the test pad as part of the landfill liner/cap, all component materials of the test pad and the associated testing must be in accordance with the Specifications. Unsuccessful trial or defective sections shall be replaced at no additional cost to the OWNER.

D. Should the CONTRACTOR change the borrow source for the compacted soil liner/cap material, or the properties of material at borrow source have significantly changed as determined by the CQA Consultant, a new test pad 50 feet by 150 feet shall be constructed from this material.

E. The Contractor shall keep equipment used for the test pad construction on the test pad at all times to avoid contamination of the low-permeability soil with the adjacent soils.

F. If in the opinion of the CQA Consultant, the construction methods, equipment or materials result in unsatisfactory placement, the CONTRACTOR shall make necessary modifications and reconstruct the appropriate sections or layer of the test pad. This will be done at no additional cost to the OWNER.

G. Placement of the compacted soil liner/cap shall not start until the test pad and all associated testing have been completed and approved by the CQA Consultant in writing.

PART 4 - PAYMENT

4.01 The test pad shall be considered incidental to the soil liner/cap and will not be measured for separate payment.

END OF SECTION 02218

SECTION 02220

TRENCHING, BACKFILLING, AND COMPACTING

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Excavating, backfilling, and compacting for installation of underground pipelines and related structures.

B. Compacted Bedding

1.02 REFERENCES

A. ASTM D 698 - Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3))

B. ANSI/ASTM D 1556 - Test Method for Density of Soil in Place by the Sand-Cone Method.

C. ASTM D 2937 - Test Method for Density of Soil in Place by the Drive Cylinder Method

D. ASTM D 2487 - Test Method for Clarification of Soils for Engineering Purposes

E. ASTM D 2488 - Practice for Description and Identification of Soils (Visual-Manual Procedure)

F. ASTM D 2922 - Test Method for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)

PART 2 PRODUCTS

2.01 BEDDING MATERIAL

A. Sediment basin outlet barrels: Material shall be NCDOT #57 stone.

B. Leachate force main (bedding and haunching material): If the subgrade is unsuitable for compaction as determined by the CQA Consultant, excavate and remove the unsuitable material and replace with NCDOT #57 stone (minimum 4" thick).

C. Provide NCDOT approved material test report.

2.02 BACKFILL MATERIAL

A. Use clean earth fill, substantially free of lumps, debris, organic matter or other perishable matter, rock or gravel larger than one inch in any dimension, pavement material, frozen soil, snow, and topsoil.

B. Soil excavated from the trench that meets the above criteria will be considered suitable for use as trench backfill only after approval by the CQA Consultant.

PART 3 EXECUTION

3.01 GENERAL

A. Conduct all construction operations in accordance with the U.S. "Occupational Safety and Health Act of 1970", the Standards of the U.S. Department of Labor, Occupational Safety and Health Administration and the latest amendments thereto.

B. Protect structures, utilities, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by trenching operations.

3.02 PREPARATION

A. Identify required lines and levels.

B. Maintain benchmarks, other control points, existing structures, and paving. If disturbed or destroyed, re-establish at no additional cost to Owner.

C. Locate existing utilities and structures above or below ground before excavation starts.

D. Maintain and protect existing utilities not designated for removal. When utilities are encountered but are not shown on the Drawings, or when locations differ from those shown on the Drawings, notify Engineer for instructions before proceeding.

3.03 TRENCH EXCAVATION

A. Remove topsoil or stone paving from trench lines and stockpile for later use over compacted backfill.

B. Excavate trenches to the depth shown on the Drawings.

C. Accurately grade the trench bottom to provide uniform bearing for the utility.

D. Trim and shape trench bottom and leave free of irregularities, lumps, and projections.

E. The trench walls above the top of the pipe may be sloped or the trench above the top of the pipe may be widened as necessary for bracing, sheeting, and shoring. Conduct all trenching, bracing, shoring, and sheeting in accordance with OSHA requirements.

F. Excavate trenches to elevations shown on the Contract Drawings.

G. The width of the trench at and below the top of the pipe shall not exceed the outside diameter of the pipe plus 18 inches except that for pipe 12 inches or less in diameter, the trench width shall

not exceed 33 inches. Where this width is exceeded, provide for increased pipe loading as directed by the Engineer.

H. If the subgrade is unsuitable for compaction as determined by the CQA Consultant, excavate and remove the unsuitable material and replace with pipe bedding material meeting the requirements of Paragraph 2.01 of this Section.

I. Removal of materials beyond the indicated subgrade elevation without authorization by the Engineer shall be classified as unauthorized excavation and shall be backfilled and compacted at no additional cost to the Owner.

J. Where rock is encountered at the bottom of the trench, excavate to approximately 6 inches below the depth shown on the Drawings. Place and compact pipe bedding material as specified in paragraphs 2.01 and 3.05 B.

K. Remove water from the excavation continuously throughout the progress of the Work and keep the excavation dry until the pipe installation and backfilling are completed.

L. Provide trench depth to maintain the minimum cover below finished grade as shown on the Drawings.

M. Where rock is encountered so that a manhole, vault, or other structure will bear on rock, it shall be used to support the foundation. Where only a part of the foundation will be on rock, at least 8 inches of compacted granular material shall be provided below bottom of footings.

N. Blasting for the excavation of trenches requires prior written approval by the Engineer.

O. Provide a minimum of 8 inches between rock excavation and sides of structures.

P. Where underground streams or springs are found, provide temporary drainage and notify Engineer.

Q. Remove and dispose of excess material and material unsatisfactory for backfill as Work progresses.

R. Remove shoring and all form materials prior to backfilling.

3.04 SHEETING

A. Maintain trench walls in a safe condition at all times. Provide sheeting, shoring, and bracing as necessary to prevent cave-in of excavation or damage to existing structures on or adjoining the site.

B. Comply with local codes and authorities having jurisdiction.

C. All costs of providing sheeting and shoring shall be borne by the CONTRACTOR.

3.05 BEDDING

A. Provide bedding (if required) in accordance with this Specification.

B. Place bedding material in continuous layers not exceeding 6 inches compacted depth. Compact bedding material to prevent settlement.

C. Compact bedding and haunching material (if required) for the leachate force main to achieve 100 percent maximum density at optimum moisture plus or minus 2 percent as determined by ASTM D 698.

3.06 BACKFILLING AND COMPACTING (SEDIMENT BASIN OUTLET BARRELS)

A. Support pipe during placement and compaction of fill material.

B. Do not backfill over porous, wet, frozen, or spongy subgrade surfaces.

C. Backfill trench up to a compacted depth of one foot above the pipe with select backfill in accordance with the details shown on the Drawings. Place backfill material by hand, uniformly on each side of pipe and compact in layers not exceeding 6 inches compacted thickness.

D. Backfill trench from one foot above the pipe to grade with clean earth fill free of stones not larger than 5 inches or one-half the layer thickness, whichever is smaller. Layers shall not exceed 12 inches compacted thickness, except that under road shoulders and under existing or future paved areas, layers shall not exceed 8 inches compacted thickness.

E. Excavate depressions caused by the removal of stumps or other cleaning operations to firm subgrade. Backfill with clean earth fill and compact as specified.

F. Place backfill material on both sides of the pipe at the same time and to approximately the same elevation. Each layer shall be thoroughly compacted by hand-tamping or mechanical means being careful not to damage the pipe. Any pipe that is damaged shall be replaced at the CONTRACTOR'S expense.

G. Maintain optimum moisture content of backfill materials to attain required compaction density.

H. Compact soil materials using equipment suitable for materials to be compacted and work area locations. Use power-driven hand tampers for compacting materials adjacent to structures.

I. Backfill material shall be compacted to the minimum density of 95 % and as determined by pre-construction soil testing (ASTM D 698).

J. Spread stockpiled topsoil material over disturbed areas and lightly compact.

3.07 BACKFILLING AND COMPACTING (LEACHATE FORCE MAIN)

A. Support pipe during placement and compaction of fill material.

B. Backfill trench with local backfill material free from stones, frozen lumps, chunks of highly plastic clay, or other objectionable material as approved by the ENGINEER. Place backfill material by hand, and compact in layers not exceeding 6 inches compacted thickness.

C. Maintain optimum moisture content of backfill materials to attain required compaction density.

D. Compact soil materials using equipment suitable for materials to be compacted and work area locations. Any pipe that is damaged shall be replaced at the Contractor's expense.

E. Backfill material shall be compacted to 95% maximum density at optimum moisture ± 2% content as determined by pre-construction soil testing (ASTM D 698).

F. Replace stone paving in disturbed areas and compact.

3.08 TOLERANCES

A. Top surface of backfilling: ± 1 inch from required elevations.

3.09 FIELD QUALITY CONTROL

A. Testing of Trench Backfill Material

1. Compaction/Density tests: minimum of one test for every 100 feet of trench.

B. Materials not meeting density specification requirement shall be scarified, recompacted, and retested at Contractor's expense.

C. The Engineer may require additional tests to establish gradation, maximum density, and in-place density as working conditions dictate, at the Contractor's expense.

3.10 DISPOSAL OF MATERIAL

A. Dispose excess and unsuitable materials on site at a location designated by the Engineer.

END OF SECTION 02220

SECTION 02222

EXCAVATION

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Removal of topsoil material.

B. Soil excavation for landfill cells and other project features.

C. Undercutting and backfilling.

D. Soil excavation for structures.

E. Grading.

F. Stockpiles.

1.02 BASIS OF PAYMENT

A. Payment for excavation of anchor trenches shall be included in the contract price (lump sum) for Anchor Trench Excavation and Backfilling.

B. Undercutting and backfilling shall be paid for at the contract unit price per cubic yard for Undercutting and Backfilling. The quantity shall be based on the volume of in-place backfilled material, calculated by the Method of Average End Areas between the excavated surface and the finished earthwork lines with no shrinkage or other factors applied. The contract price shall include the excavation and disposal of material removed, and furnishing and placing suitable backfill material to meet specified requirements.

C. Excavation for the remaining work performed under this Section shall be paid for at the contract unit price per cubic yard for Unclassified Soil Excavation. The quantity shall be the volume of excavation in cubic yards, calculated by the Method of Average End Areas with no shrinkage or other factors applied.

D. Payment will constitute full compensation for all labor, materials, equipment, and all other items necessary to the performance of the work, including hauling and stockpiling.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.01 GENERAL

A. Identify required lines, levels, contours and datum.

B. Locate existing utilities, culverts and structures, above or below ground, before excavation activities begin. Coordinate Work with Owners of utilities. Protect, maintain in service, and prevent damage to utilities not designated to be removed. When utilities are encountered and are not shown on the Contract Drawings, or when locations differ from those shown on the Contract Drawings, notify Engineer for instructions before proceeding.

C. Unauthorized excavation consists of the removal of material below or beyond indicated subgrade elevations or sides without approval of the Engineer. Unauthorized excavation shall be replaced at Contractor's expense.

D. All fill materials used to restore unauthorized excavations shall be subject to the approval of the CQA Consultant.

E. Depressions caused by the removal of stumps shall be excavated to firm subgrade.

F. Existing utilities, structures, and fencing shall be protected during the construction period, and if damaged or removed by the Contractor, shall be repaired or replaced to the satisfaction of the Owner at the Contractor's expense.

G. Where excavations have been carried below or beyond points required, restore these areas to the elevations and dimensions shown on the Contract Drawings with material approved by the Engineer and compacted as specified.

H. Where the removal of unsatisfactory material is due to the fault or negligence of the Contractor, by inadequate shoring or bracing, or other failure to meet specified requirements, work shall be conducted at no additional cost to the Owner.

3.02 REMOVAL OF TOPSOIL MATERIAL

A. Excavate topsoil material from areas to be further excavated or regraded.

B. Strip topsoil material to full depth, and stockpile separate from other excavated materials. Stockpile free of roots, stones, and other undesirable materials. Follow guidelines in the North Carolina Erosion and Sediment Control Planning and Design Manual to prevent erosion.

C. Stockpile in area designated on-site.

D. Stockpile topsoil material to depth not exceeding 8 feet.

3.03 EXCAVATION FOR LANDFILL CELLS AND OTHER PROJECT FEATURES

A. Excavate to the lines and grades shown on the Drawings.

B. Areas that receive permanent seeding shall be graded below finished grades shown, leaving space for topsoil material.

C. Excavated soil not needed immediately for construction shall be stockpiled in an area designated by the Owner. Implement erosion control practices as shown on the Contract Drawings and as required by the North Carolina Erosion and Sediment Control Planning and Design Manual.

D. Stockpile or dispose at the active landfill facility continuously with the progress of the work and as directed by facility personnel all excess material, trash and debris, and materials that are unsatisfactory for backfill or fill.

E. All excavations shall be dewatered as necessary to provide proper protection. The Engineer may require excavation to be continuously dewatered 24 hours per day until backfilling has been completed.

F. Where underground streams or springs are found, provide temporary drainage and notify the Engineer immediately.

G. Excavate so that banks of excavation will not be undercut and stratum for foundations will not be disturbed.

H. Excavate unsatisfactory soil materials encountered to the additional depth as directed by the Engineer.

I. Grade site to prevent introduction of surface water into excavations.

3.04 ANCHOR TRENCH EXCAVATION AND BACKFILLING

A. Excavate trenches to the depth and dimension shown on the Drawings, and trim and shape trench bottom and leave free of irregularities, lumps, and projections.

B. Remove water from the excavation throughout the progress of the Work and keep the excavation dry until the geosynthetic materials installation and backfilling are completed.

C. Place excavated soil as backfill evenly maintaining approximately the same elevation. Each layer shall be compacted by mechanical means being careful not to damage the geomembrane. Any damaged liner shall be replaced at the CONTRACTOR'S expense.

D. Maintain optimum moisture content of backfill materials to attain required compaction density.

E. Compact backfill using equipment suitable for materials to be compacted and work area locations.

F. Backfill material shall be compacted to achieve at least 95 percent within $\pm$ 2 percent of optimum moisture content as determined by ASTM D 698.

G. Anchor trench backfill material Compaction/Density test frequency minimum of one test for every 100 feet of trench.

H. Materials not meeting density specification requirement shall be scarified, recompacted, and retested at Contractor's expense.

I. The Engineer may require additional tests to establish gradation, maximum density, and in-place density as working conditions dictate, at the Contractor's expense.

3.05 UNDERCUTTING AND BACKFILLING

A. Excavate muck or other unsuitable soils to a depth below grade as directed by CQA Consultant.

B. Limit cut slopes to 1 vertical to 3 horizontal.

C. Dispose excavated materials in the designated daily cover stockpile area.

D. Backfill excavation with materials meeting the requirements of 02200.

E. Prepare subgrade and backfill excavation in accordance with Section 02200.

3.06 EXCAVATION FOR STRUCTURES

A. Conform to elevations and dimensions shown on the Contract Drawings. Extend the excavation a sufficient distance from footings and foundations to permit placement and removal of concrete forms and other construction required. Foundation concrete shall not be placed until the bearing stratum has been examined by Engineer and found satisfactory for the design bearing capacity.

B. Where rock is encountered, notify the Engineer. When the entire structure will bear on rock, it shall be used to support the foundation. Where only a part of the foundation would bear on rock, excavate 8 inches below the entire structure and backfill with aggregate fill and thoroughly compact.

C. Provide an 8-inch minimum clearance between rock excavation and walls of pipes and structures.

3.07 GRADING

A. Uniformly grade all areas within the limits designated on the Drawings, including adjacent transition areas. Finish surfaces within specified tolerances with uniform slopes between points where elevations are shown and existing grades.

B. Finish all surfaces free from irregular changes, and grade to drain as shown on the Drawings.

C. Shape the subgrade under unpaved areas to the proposed line and grade so that the finished surface is within 0.20 feet of the required subgrade elevation.

D. Protect newly graded areas from traffic and erosion. Repair and re-establish grade in settled, eroded, or rutted areas to the specified tolerances.

E. Where compacted areas are disturbed by subsequent construction or adverse weather, scarify the surface, reshape and compact to the required density. Use hand tamper for recompaction over underground utilities.

F. Grade borrow area and conduct borrow activities in accordance with the approved Erosion and Sediment Control Plan for the borrow area.

3.08 STOCKPILES

A. Construct stockpile slopes no steeper than 2:1 (Horizontal:Vertical).

B. Soil in stockpiles shall be compacted to a sufficient degree to minimize infiltration of rainfall. Compaction shall be to the satisfaction of the Engineer. Cover stockpile with plastic sheeting if necessary.

C. Slopes of the stockpile shall be "tracked" by movement of a cleated dozer up and down the slope.

D. Grass finished stockpile surfaces that will be exposed for more than 30 days.

E. Maintain adequate temporary erosion control until grass is well established.

END OF SECTION 02222

SECTION 02225

DRAINAGE LAYER (AGGREGATE)

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Construction of the drainage layer for the landfill cell.

1.02 REFERENCES

A. North Carolina Department of Transportation Standard Specifications for Roads and Structures, latest edition.

1.03 SUBMITTALS

A. Submit quarry certificates showing material compliance with specifications.

B. Submit results of laboratory analyses.

1.04 BASIS OF PAYMENT

A. The Work performed under this Section shall be paid for at the contract price (lump sum) for Drainage Layer (Aggregate).

PART 2 CONSTRUCTION QUALITY CONTROL (CQC)

A. The CONTRACTOR will provide a testing program to perform the following minimum laboratory tests on drainage material. All testing will be performed by an independent qualified geotechnical consultant and testing laboratory and under the direction of a Registered Professional Engineer licensed in the State in which the project work is conducted.

B. Laboratory Testing :

1. Gradation Analysis
   Gradation analysis (ASTM D422) shall be conducted at a frequency of one test for each material type.
2. Specific Gravity
   Specific gravity test (ASTM D854) shall be conducted at a frequency of one test for each material type.
3. Triaxial Compression Testing
   Consolidated Undrained Triaxial with Pore Pressure Measurements Series (ASTM D4767), Three Point Series, Remolded, shall be conducted at a frequency of one test for each material type.

4. Hydraulic Conductivity
   Laboratory Compacted Hydraulic Conductivity (ASTM D5084) , shall be conducted at a frequency of one test for each material type.

PART 3 PRODUCTS

A. Material shall be a washed non-calcium carbonate granular material. A quarry certificate is required to demonstrate that the material is non-calcium carbonate.

B. The gradation of the material shall conform to North Carolina Department of Transportation Specifications for No. 57 coarse aggregate.

C. The density of the material shall be 135 pcf or greater unless otherwise approved by engineer.

D. The hydraulic conductivity of the material shall be 0.3 cm/sec or greater unless otherwise approved by engineer.

E. The material shall contain no more than 5% by weight passing the #200 sieve and no particles larger than 3" in any direction.

F. The material shall have an internal friction angle of 30 degrees or greater unless otherwise approved by engineer.

PART 4 EXECUTION

A. Construct drainage layer as shown on the Drawings.

B. Place and spread drainage layer material in such a manner as to avoid operation of the equipment directly on the synthetic membrane or geotextile.

C. Low ground pressure dozers (less than 15 psi), or other equipment approved by the Engineer, shall be used for spreading and grading the drainage layer material.

D. Construct a 4-foot thick traffic surface to support haul trucks delivering material to the Phase.

E. Do not damage the synthetic membrane.

F. Place drainage layer in one lift. Do not compact.

G. Expansion of the geomembrane can result in slack material or wrinkles developing. Geomembrane expands when heated and contracts when cooled. Stone must be placed such that the geomembrane underneath is flat. Folding over of wrinkles is not allowed. The placement of stone can be planned with knowledge of the weather and expected temperature changes in mind in order to minimize buildup of slack material. Once cover is placed over the geomembrane, the material will be shielded from the sun and will not expand/contract as much. As a last resort, slack material may need to be cut out and repaired in accordance with Section 13320.

H. When placing the drainage layer material on slopes, begin placement of the material at the bottom of the slope and work up.

I. Do not push material down the slopes.

J. Field inspection will be performed under provisions of Section 01410.

END OF SECTION 02225

SECTION 02274

RIPRAP

PART 1 GENERAL

1.01 WORK INCLUDED

A. Providing and placing riprap.

1.02 BASIS OF PAYMENT

A. Payment for Work under this Section is included in the Contract unit price per cubic yard of Riprap. Such payment shall constitute full compensation for providing all materials, and furnishing all labor, equipment and other items necessary to construct the riprap features shown on the Drawings.

PART 2 PRODUCTS

2.01 MATERIALS

A. Subgrade lining: Non-woven geotextile mat equivalent to Mirafi 1100N or crusher run stone produced by secondary crushing of durable rock.

B. Riprap

1. Provide stone that is sound, tough, dense, angular, resistant to the action of air and water, and suitable in all other respects for the purpose intended.

2. Provide stone meeting the criteria as shown on Erosion and Sediment Control drawings.

3. Grade stone so that the smaller stones are uniformly distributed throughout the mass.

PART 3 EXECUTION

3.01 PROCEDURE

A. Line prepared subgrade with 6 inches of crusher-run stone or geotextile mat.

B. Reject mat material having defects, rips, holes, flaws, deterioration or damage during manufacture, transportation or storage.

C. Lay mat material smooth and free from tension, stress, folds, wrinkles or creases. Overlaps shall be a minimum of 12 inches with the upper fabric overlapping the lower fabric.

D. Remove fabric that is displaced during riprap placement and reposition at no additional cost to the

Owner.

E. Remove fabric that is damaged during riprap placement and replace at no additional cost to the Owner.

F. Protect fabric from damage due to placement of riprap by limiting the height of drop of the material.

G. No more than 72 hours shall elapse from the time the fabric is unwrapped to the time the fabric is covered with riprap.

H. Place riprap stone to the dimensions indicated on the Drawings.

I. Stone may be placed by mechanical methods, augmented by hand placing where necessary.

J. The minimum thickness of the riprap shall be as indicated on the Drawings. The completed riprap layer shall be properly graded, dense and neat.

END OF SECTION 02274

SECTION 02500

STONE SURFACING

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Providing aggregate base course for roadways..

1.02 REFERENCES

A. ASTM D422 – Standard Test Method for Particle-Size Analysis of Soils.

B. ASTM D698 – Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3))

C. ASTM D3017 – Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).

D. North Carolina Department of Transportation Standard Specifications for Roads and Structures, latest edition.

1.03 SUBMITTALS

A. Submit job mix formula of proposed material at least 40 days prior to placement of aggregate base course.

B. Proposed job mix formula shall be approved by the ENGINEER prior to use.

C. Testing of aggregate samples shall be paid for by CONTRACTOR.

D. Identify proposed supplier with the job mix formula submission.

1.04 CONSTRUCTION QUALITY CONTROL AND CONSTRUCTION QUALITY ASSURANCE CQC/CQA)

A. Acceptance by the ENGINEER of aggregate base course shall be dependent on the Soils CQA Consultant satisfying all requirements of the CQA Plan during the course of the work and the test results showing that all requirements of this Section have been met.

B. Supporting data for CQA purposes shall be obtained by field and laboratory testing to be conducted by the soils CQA Consultant.

C. Field and laboratory testing conducted by the CQA Consultant will be done at the OWNER'S expense.

PART 2 PRODUCTS

2.01 AGGREGATE BASE COURSE

A. Aggregate shall be NCDOT Type ABC aggregate furnished in accordance with the latest edition of the NCDOT Standard Specifications for Roads and Structures.

2.02 GEOTEXTILE FABRIC

A. Geotextile fabric shall be Mirafi 600X or approved equal.

PART 3 EXECUTION

3.01 SUBGRADE PREPARATION

A. Prepare areas to receive aggregate base course in accordance with Section 02100, Site Preparation.

B. Where subgrade requires undercutting, limit cut slopes to 1 vertical to 3 horizontal.

C. Grade areas to receive aggregate base course to a uniform surface. Scarify surface if directed by the ENGINEER.

D. Eliminate ruts, hummocks, or other uneven features.

E. Proofroll the subgrade with a loaded tandem-axle dump truck having a minimum weight of 20 tons or other similar rubber-tired equipment.

F. Make at least two passes in each direction with the proofrolling equipment.

G. Remove and replace any soft, saturated or yielding areas indicated by pumping or rutting.

H. Replace soil that has been removed with structural fill material in accordance with the requirements of Section 02200.

I. Where unsuitable soil was removed, compact the structural fill material to at least 95% of the maximum dry density as determined by ASTM D698 to a depth of at least 12 inches.

J. Dry or wet the subgrade at the discretion of the ENGINEER to establish a subgrade with acceptable moisture content.

K. Place geotextile fabric as shown on the drawings. Place in strict accordance with manufacturer's recommendations.

L. Do not construct structural fill layer until the subgrade has been approved by the ENGINEER.

3.02 CONSTRUCTION

A. Construct project features to the lines and grades shown on the Drawings.

B. Place aggregate in lifts no greater than 6 inches compacted depth.

C. Compact aggregate to a minimum dry density of 100% of the maximum dry density determined from the Standard Proctor Test (ASTM D698).

D. In-place aggregate which does not meet the density requirements shall be recompacted or removed and reworked to meet density objectives.

E. Do not place aggregate during sustained period of temperatures below 32° F.

3.03 PROTECTION OF WORK

A. Protect the finished surface from erosion, desiccation, or other damage.

B. Portions of the aggregate base course damaged due to exposure shall be reworked to meet the Specifications or, at the discretion of the ENGINEER, removed and replaced with conforming material at no additional cost to the OWNER.

3.04 QUALITY ASSURANCE

A. Field inspection and testing will be performed under provisions of Section 01410.

B. Prior to material placement, testing for moisture-density relationship will be performed on proposed aggregate base course material in accordance with ASTM D698. Frequency: A minimum of one test per 5000 cubic yards of aggregate base course.

C. Testing of the in-place aggregate base course will include density/moisture content tests in accordance with ASTM D2922/D3017. Frequency: One test per 100 linear feet of roadbed per lift.

D. If tests indicate Work does not meet specified requirements, remove Work, replace and retest at no cost to OWNER.

E. The horizontal and vertical location of all test locations will be recorded. A drawing will be prepared showing all test locations.

END OF SECTION 02500

SECTION 02618

HIGH-DENSITY POLYETHYLENE (HDPE) PIPE AND FITTINGS

PART 1 GENERAL

1.01 WORK INCLUDED

A. Installation of HDPE piping and fittings

1.02 REFERENCES

A. ASTM D1248 - High-density polyethylene (HDPE) weight resin for pipes and fittings.

B. ASTM D2513 - Industrial molded fittings for high-density polyethylene (HDPE) pipes.

C. ASTM D3261 - Butt fittings for high-density polyethylene (HDPE) pipes.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Protect pipe from sun, elements, and weather changes.

B. Store pipe in areas that are safe from normal daily plant operations and from construction activities.

1.04 SUBMITTALS

A. Include data on pipe materials, pipe fittings, and accessories.

B. Inspect material a minimum of 7 days prior to installation, and indicate in writing any deficiencies to the OWNER.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Acceptable manufacturers of pipe include, but are not limited to:

1. Spirolite Corporation
   4094 Blue Ridge Industrial Parkway
   Norcross, GA 30071

2. Plexco
   3240 N. Mannheim Road
   Franklin Park, IL 60131

3. CRS PolyPipe
   Drawer HH
   Gainesville, TX 76240

4. Phillips Driscopipe, Inc.
2929 North Central Expressway
Richardson, TX 75083

2.02 MATERIALS

A. HDPE Pipe - SDR 17, PE3408, minimum 2% carbon black, cell classification 345444C (or other classification approved by the ENGINEER).

B. Joints: Butt, heat fusion process as per manufacturer instruction. Joints at connections between phases may be electrofusion type couplings. Saddle connections by sidewall heat plate machine (not by extrusion).

C. Fittings: Fittings may be molded or prefabricated by the manufacturer.

PART 3 EXECUTION

3.01 INSPECTION

A. Inspect pipe, fittings, and other appurtenances before installation to verify quality of material.

3.02 PREPARATION

A. Ream pipe and tube ends. Remove burrs.

B. Remove dirt and other contaminants, inside and outside, from pipe and fitting materials before assembly.

C. Make straight field cuts without chipping or cracking pipe.

3.03 INSTALLATION

A. Make heat fusion joints in accordance with manufacturer's recommended procedures.

B. Install pipe and fittings to the line and grade specified on the drawings.

C. The maximum allowable tolerance for grade is 0.10 foot.

D. Construct bedding material and general soils over pipe with care to avoid damage to pipe. Minimize traffic and turning of traffic over pipe.

E. Compact pipe trenches by hand or mechanical tamping in 6 in. layers.

3.04 FIELD QUALITY CONTROL

A. ENGINEER to observe all pipe, joints and fittings prior to backfilling.

B. Flush pipe with sewer cleaning equipment when construction is completed. Submit details of flushing program to ENGINEER for approval. Provide detail of temporary flushing method that will allow free flow discharge of flush water from low end of pipe so that flush water may be observed by the ENGINEER. Flush until water runs clear. Flushing program is to remove all debris including HDPE cuttings, soil, gravel, and all contaminants from pipelines. CONTRACTOR to provide all water and equipment required to complete the flushing.

C. Air testing: Air test the system in accordance with the pipe manufacturer's instructions and as follows, and submit all test results to ENGINEER.

1. Landfill gas pipes: Pressure-test all pipe, fittings, and appurtenances except piping below landfill gas well heads. Mechanically plug the ends of pipelines to be tested and close gate valves at all wells. Pressurize the line to 3.0 pounds per square inch (gauge pressure). Close the valve on the pressurizing unit, and monitor the pressure for a minimum of 30 minutes.

2. Leachate forcemains: Pressure test in accordance with Specification 02714.

3. Pressure tests shall be performed in the presence of the ENGINEER. Give 48-hour notice to ENGINEER prior to testing. A written report shall be prepared by the CONTRACTOR for each test and submitted to the ENGINEER. Provide all gauges, pumps, pipe, connections, and all other necessary apparatus to conduct tests.

4. If results of tests performed do not conform to requirements as stated herein, CONTRACTOR shall make the necessary repairs and repeat tests, as required until satisfactory results are obtained.

END OF SECTION 02618

SECTION 02712

LEACHATE COLLECTION SYSTEM

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Furnishing and installing leachate collector and header pipes, fittings and accessories.

B. Furnishing and installing collector pipe cleanouts.

1.02 PROJECT RECORD DOCUMENTS

A. Submit documents under provisions of Section 01720.

B. Accurately record location of pipe runs, connections, and invert elevations.

1.03 BASIS OF PAYMENT

A. Furnishing and installing the leachate collection system shall be paid for at the contract price (lump sum) for Leachate Collection System. This pay item includes trenching for installation of the pipes, furnishing and installation of all header pipes with stone backfill and geotextile fabric, furnishing and installation of all header pipes and cleanouts, repair of any damage to underlying liner components due to trenching, and soil backfill as required. Such payment shall constitute full compensation for providing all materials, fittings, and accessories, including valves and boxes, and furnishing all labor, equipment, and other items necessary to install the system as shown on the Drawings.

PART 2 PRODUCTS

2.01 PIPE

A. HDPE pipe shall meet requirements of Section 02618 – HDPE Pipe & Fittings.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that the base is ready to receive work and excavations, and dimensions and elevations are as indicated on the Drawings.

3.02 INSTALLATION

A. Install pipe to the lines and grades shown on the Drawings.

B. Install pipe and pipe fittings in accordance with manufacturer's instructions.

3.03 FIELD QUALITY ASSURANCE

A. Field inspection will be performed under provisions of Section 01410.

3.04 PROTECTION

A. Protect finished installation under provisions of Section 01500.

END OF SECTION 02712

SECTION 02714

LEACHATE FORCE MAIN

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Furnishing and installing the leachate force main, and required fittings and accessories for a complete and operable system as shown on the Drawings.

1.02 PROJECT RECORD DOCUMENTS

A. Accurately record location of pipe runs and connections and provide a surveyed Record Drawing of the leachate forcemain under provisions of Section 01720.

1.03 BASIS OF PAYMENT

A. Furnishing and installing the leachate force main shall be paid for at the contract price (lump sum) for leachate force main. Such payment shall constitute full compensation for providing all materials, fittings, and accessories, and furnishing all labor, equipment, and other items necessary to complete all required connections and to construct a complete, working system as shown on the Drawings. Labor and materials for excavating and backfilling the trench and for constructing the thrust blocks are included in the contract price for leachate force main.

PART 2 PRODUCTS

2.01 PIPE

A. Use HDPE pipe according to Specification 02618 with a nominal inside diameter of four inches.

B. Leachate foremain pipe shall be dual contained.

2.02 DISCHARGE VALVES

A. Check Valve: Ball type, constructed of solid PVC thermoplastic. Valves shall be single ball design with Viton seal. Valves shall have a minimum pressure rating of 150 psi at 70 degrees F. Fittings shall be as required to allow connection with mating pipe and allow access to the valve for removal and service.

B. Ball Valve: Full port ball true union type constructed of PVC thermoplastic with Viton seals. Valves shall have a minimum working pressure of 225 psi at 70 degrees F. Fittings shall be as required to allow connection with mating pipe and allow access to the valve for removal or service.

C. Air Release Valve: The air release valve shall be selected for the size of the piping system and application, and be constructed of PVC with seals compatible with the application.

D. Valves shall be provided with required suitable companion flanges/fittings and stainless steel bolt kits with gaskets where required for installation in the system.

2.03 THRUST BLOCKS

A. Thrust blocks shall be constructed of concrete meeting the requirements of ASTM C94 and having a compressive strength of 3,000 psi at 28 days.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install pipe and pipe fittings in accordance with manufacturer's instructions.

3.02 HYDROSTATIC TESTS

A. Conduct hydrostatic tests on the leachate force main in the presence of the CQA Consultant.

C. Furnish all labor, materials and equipment required for conducting tests as specified, including pumps, gauges, temporary bulkheads and other miscellaneous items required. No piping shall be concealed until the hydrostatic tests are satisfactorily completed.

D. Conduct tests in such a manner as to avoid injury to personnel, and damage to equipment, Work, and existing facilities.

E. After the force main is in place and joints completed, partially backfill the trench, leaving the joints exposed for examination. Conduct a hydrostatic pressure test on the in-place pipe as described below.

1. The pipe shall be tested in place at 150% of the maximum anticipated operating pressure of the system. Test the pipe at 40 psi.

2. Devices that could be damaged by the test pressure shall be isolated or removed from the system during the testing periods. If the device cannot be removed or isolated, then the limiting section test pressure shall be the maximum allowable test pressure for that device.

3. Tests shall be conducted for a minimum of two hours after stabilization at the test pressure. No loss of pressure shall be permitted for the duration of the test.

4. Carefully examine exposed pipe, joints and fittings during the pressure testing.

5. Replace any leaking or defective piping and fittings disclosed by the testing. Replace or repair defective components of the pipe system in a manner acceptable to the CQA Consultant, and at no additional cost to the Owner. The CQA Consultant may reject any repaired component if he feels that the repair is unsatisfactory. Do not complete backfilling until all tests have been conducted, and all defects corrected to meet the requirements of the specified test, and all piping proves to be tight. No caulking of defective piping or joints will be permitted.

3.03 FIELD QUALITY ASSURANCE

A. Field inspection will be performed under provisions of Section 01410.

3.04 PROTECTION

A. Protect finished installation under provisions of Section 01500.

END OF SECTION 02714

SECTION 02720

STORMWATER PIPE SYSTEMS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Construction of the stormwater conveyance piping.

1.02 REFERENCES

A. North Carolina Department of Transportation Standard Specifications for Roads and Structures, latest edition.

1.03 SUBMITTALS

A. Submit shop drawings of prefabricated drainage structures.

1.04 PROJECT RECORD DOCUMENTS

A. Submit documents under provisions of Section 01720.

B. Accurately record location of pipe runs, connections, and invert elevations.

PART 2 PRODUCTS

2.01 REINFORCED CONCRETE PIPE: All concrete pipe for the project shall be round reinforced concrete pipe conforming to AASHTO M 170, Class III. Joints shall be tongue and groove compression gasket joints complying with AASHTO M 198, type B flexible gaskets.

2.02 CORRUGATED METAL PIPE:

A. Use asphalt-coated corrugated steel culvert pipe conforming to the requirements of North Carolina Department of Transportation Road and Bridge Specifications. The pipe shall be of galvanized steel, minimum 16 gauge, and may be of riveted or non-riveted type.

B. Corrugations shall have a pitch of 2-2/3 inches and a depth of ½ inch.

C. Special sections shall be of the same gauge as the conduit to which they are joined and shall conform to the applicable standards of AASHTO M36.

D. All fittings, connecting bands, and special sections shall be from the same manufacturer as the pipe to which they are joined.

E. If helically formed pipe is used, the ends shall be rerolled a minimum of two angular corrugations where connecting bands or flared end sections are required.

F. All joints are to be constructed watertight.

G. Coupling bands need not be coated unless required for water tightness.

2.03 BACKFILL MATERIAL FOR STORMWATER CONVEYANCE PIPE

A. Use on-site or off-site borrow area natural soils.

B. Use material free of topsoil, roots, stumps, brush, vegetation, and other deleterious material.

C. Backfill material shall be in accordance with Section 02220.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that the excavation base is ready to receive work and excavations, dimensions and elevations are as indicated on the Drawings.

3.02 PREPARATION

A. Hand trim excavations to required elevations. Correct over-excavation with fill material of course aggregate.

B. Remove stones or other hard matter that could impede consistent backfilling or compaction.

3.03 PIPE INSTALLATION

A. Lay pipe true to line and grade as shown on the Drawings, and in such a manner as to form a close concentric joint with adjoining pipe and to prevent sudden offsets to flow line.

B. Provide a continuous and uniform bedding for all buried pipe.

C. Install pipe and pipe fittings in accordance with manufacturer's instructions. All stormwater pipe systems are to be constructed watertight.

D. Do not lay pipe when trench conditions or weather are unsuitable for such work.

E. As work progresses, clear pipe of dirt and other superfluous materials.

F. Backfilling of soil in pipe trenches shall be in accordance with 02220, Trenching and Backfilling.

3.04 FIELD QUALITY ASSURANCE

A. Field inspection will be performed under provisions of Section 01410.

3.05 PROTECTION

A. Protect finished installation under provisions of Section 01500.

END OF SECTION 02720

SECTION 02936

SEEDING

PART 1 GENERAL

1.01 WORK INCLUDED

A. Preparation of subsoil.

B. Placing topsoil material.

C. Fertilizing.

D. Temporary seeding.

E. Permanent seeding.

F. Mulching.

1.02 RELATED SECTIONS

A. 02200 - Earthwork

1.03 QUALITY ASSURANCE

A. Provide seed mixture in containers showing percentage of seed mix, year of production, net weight, date of packaging, and location of packaging.

1.04 MAINTENANCE DATA

A. Submit maintenance data for continuing Owner maintenance.

B. Include maintenance instructions, cutting method and maximum grass height; types, application frequency, and recommended coverage of fertilizer.

1.05 DELIVERY, STORAGE AND HANDLING

A. Transport and handle products in accordance with manufacturer's instructions.

B. Deliver grass seed mixture in sealed containers. Seed in damaged packaging will not be acceptable.

C. Deliver fertilizer in waterproof bags showing weight, chemical analysis, and name of manufacturer.

D. Promptly inspect shipments to assure that products comply with requirements, quantities are correct, and products are undamaged.

E. Store and protect products in accordance with manufacturer's instructions, with seals and labels intact and legible.

PART 2 PRODUCTS

2.01 SOIL MATERIALS

A. Topsoil Material: Excavated from site and free of weeds.

2.02 ACCESSORIES

A. Mulching material: Oat or wheat straw, dry, free from weeds and other foreign matter detrimental to plant life.

B. Lime: Lime shall comply with applicable North Carolina state laws and shall be delivered in unopened bags or other convenient standard containers, each fully labeled with the manufacturer's guaranteed analysis. Lime shall be ground limestone containing not less than 85 percent total carbonates, and shall be ground to such fineness that 90 percent by weight will pass through a No. 20 mesh sieve and 50 percent by weight will pass through a No. 100 mesh sieve.

C. Fertilizer: Fertilizer shall comply with applicable North Carolina state laws and shall be delivered in unopened bags or other convenient standard container, each fully labeled with the manufacturer's guaranteed analysis. Fertilizer shall contain not less than 10 percent nitrogen, 10 percent available phosphoric acid and 10 percent water soluble potash (N-P-K, 10-10-10). Any fertilizer which becomes caked or otherwise damaged, making it unsuitable for use, will not be acceptable and shall be immediately removed from the job site.

PART 3 EXECUTION

3.01 GENERAL

A. Areas where topsoil material is to be placed and areas to be seeded include all areas disturbed during construction beyond the limits of the proposed cell which are not to be paved.

B. Verify that prepared soil base is ready to receive the work of this Section, and seed all areas disturbed as a result of construction activities.

3.02 PREPARATION OF SUBSOIL

A. Prepare subsoil to eliminate uneven areas and low spots. Maintain lines, levels, profiles and contours. Make changes in grade gradual. Blend slopes into level areas.

B. Remove deleterious materials, such as weeds, and undesirable plants and their roots. Remove contaminated subsoil.

C. Scarify subsoil to a depth of 3 inches where topsoil material is to be placed. Repeat cultivation in areas where equipment used for hauling and spreading topsoil has compacted subsoil.

3.03 PLACING TOPSOIL MATERIAL

A. Place topsoil material during dry weather and on dry unfrozen subgrade 2 to 3 weeks prior to sowing seed.

B. Spread topsoil material over area to be seeded. Finished thickness of topsoil material shall be 3 inches minimum after settling and nominal compaction caused by spreading equipment.

C. Grade to eliminate rough, low, or soft areas, and to ensure positive drainage.

D. Rake topsoil material and remove roots, vegetable matter, rocks, clods, and other non-organic material.

3.04 FERTILIZER AND LIME

A. Apply lime and fertilizer according to soil tests, or apply lime at the rate of 90 lbs./1000 sq.ft. and fertilizer at the rate of 20 lbs./1000 sq.ft.

B. Mix thoroughly into upper 4 inches of topsoil.

C. Lightly water to aid the dissipation of fertilizer and lime.

3.05 SEEDBED PREPARATION

A. Prepare seedbed to a depth of 4 to 6 inches.

B. Remove loose rocks, roots and other obstructions so that they will not interfere with the establishment and maintenance of vegetation.

3.06 TEMPORARY SEEDING

A. Provide temporary seeding on any cleared, unvegetated, or sparsely vegetated soil surface where vegetative cover is needed for less than one year or when seeding dates will prevent the establishment of vegetative cover if permanent seeding is attempted.

B. Seed in accordance with the following schedule and application rates:

Description	**Seeding Dates**	**Seeding Mixture**	**Rate (lbs/acre)**
Steep Slopes (3:1)	April 15 – August 20	German Millet	40
	October 25 – February 1	Rye Grain	120
Low Maintenance Areas	October 25 – February 1	Rye Grain	120
Areas requiring cover less than 1 year	February 1 – April 15	Rye Grain Kobe Lespedeza	120 50
	April 15 – August 20	German Millet	40
	August 20 – February 1	Rye Grain Kobe Lespedeza	120 50

C. To amend soil, follow recommendations of soil tests or apply 2000 lbs./acre ground agricultural limestone and 750 lbs./acre 10-10-10 fertilizer.

D. Mulch in accordance with the following schedule and application rates
   1. Steep Slopes (3:1): In mid-summer, late fall, or winter, apply 100 lb/1000 ft^2 grain straw, cover with V netting and staple to the slope. In the spring or early fall, use 45 lb/1000 ft^2 wood fiber in a hydroseeder slurry.
   2. Low Maintenance areas and areas requiring cover less than 1 year: Apply 90 lb/1000 ft^2 grain straw and tack with 11 gal/1000 ft^2.

E. Refertilize if growth is not fully adequate.

F. Reseed, refertilize and mulch immediately following erosion or other damage.

3.08 PERMANENT SEEDING

A. Seed in accordance with the following schedule and application rates:

Description	**Seeding Dates**	**Seeding Mixture**	**Rate (lbs/acre)**
Steep Slopes (3:1)	February 1 – April 15, August 20 – October 25	Tall Fescue Kobe Lespedeza Bahiagrass Rye Grain	100 10 25 40
Grassed Channels	February 1 – April 15, August 20 – October 25	Tall Fescue Rye Grain	200 40
	April 15 – August 20	Tall Fescue German Millet	200 10
Low Maintenance Areas	February 1 – April 15, August 20 – October 25	Tall Fescue Kobe Lespedeza Bahiagrass Rye Grain	100 10 25 40
	April 15 – August 20	Tall Fescue Kobe Lespedeza Bermuda Grass German Millet	100 10 15 10

B. Compact seeded areas by means of a roller or other approved equipment immediately after sowing.

C. Mulch in accordance with the following schedule and application rates

   1. Steep Slopes (3:1): In mid-summer, late fall, or winter, apply 100 lb/1000 ft^2 grain straw, cover with V netting and staple to the slope. In the spring or early fall, use 45 lb/1000 ft^2

wood fiber in a hydro seeder slurry.

2. Grassed Channels: Install excelsior mat in the channel to the top of the channel, and secure according to manufacturer's specifications.
3. Low Maintenance areas: Apply 90 lb/1000 ft^2 grain straw and tack with synthetic mulch binder. Apply binder at rate recommended by manufacturer.

D. Refertilize in the second year unless growth is fully adequate. Reseed, refertilize, and mulch damaged areas immediately.

END OF SECTION 02936

SECTION 03300

CAST-IN-PLACE CONCRETE

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Construction of cast-in-place concrete

1.02 REFERENCES

A. AC 301 – Structural Concrete for Buildings.

B. ACI 304 – Recommended Practice for Measuring, Mixing, Transporting, and Placing Concrete.

C. ACI 305R – Hot Weather Concreting.

D. ACI 306R – Cold Weather Concreting.

E. ACI 308 – Standard Practice for Curing Concrete.

F. ACI 318 – Building Code Requirements for Reinforced Concrete.

G. ASTM C33 – Concrete Aggregates.

H. ASTM C94 – Ready-Mixed Concrete.

I. ASTM C150 – Portland Cement.

J. ASTM C260 – Air Entraining Admixtures for Concrete

K. ASTM C494 – Chemicals Admixtures for Concrete.

1.03 PROJECT RECORD DOCUMENTS

A. Submit under provisions of Section 01720

B. Accurately record locations of embedded utilities and components concealed from view.

1.04 QUALITY ASSURANCE

A. Perform work in accordance with ACI 304.

B. Maintain on-site one copy of each document referenced in subpart 1.02.

C. Acquire cement and aggregate from same source for all work.

D. Conform to ACI 305R when concreting during hot weather.

E. Conform to ACI 306R when concreting during cold weather.

PART 2 PRODUCTS

2.01 CONCRETE MATERIALS

A. Cement: ASTM C150, Type I-Normal.

B. Fine and Coarse Aggregates: ASTM C33.

C. Water: Clean and not detrimental to concrete.

2.02 CONCRETE MIX

A. Mix and deliver concrete in accordance with ASTM C94, Alternative no. 2.

B. Select proportions for normal weight concrete in accordance with ACI 301.

C. Provide concrete to the following criteria:

Compressive Strength in 7 days 2100 psi and in 28 days 3000 psi.

D. Use accelerating admixtures in cold weather only when approved by Engineer. Use of admixtures will not relax cold weather placement requirements.

E. Use calcium chloride only when approved by Engineer.

F. Use set retarding admixtures during hot weather only when approved by ENGINEER.

G. Add air entraining agent to normal weight concrete mix for all concrete work.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify requirements for concrete cover over reinforcement.

B. Verify that anchors, seats, plates, reinforcement, and other items to be cast into concrete are placed and positioned securely, and will not cause hardship in placing concrete.

3.02 PLACING CONCRETE

A. Place concrete in accordance with ACI 304.

B. Ensure reinforcement, inserts, and embedded parts are not disturbed during concrete placement.

C. Maintain records of concrete placement. Record date, location, quantity, air temperature, and test samples taken.

3.03 CURING AND PROTECTION

A. Immediately after placement, protect concrete from premature drying, excessively hot or cold temperatures, and mechanical injury.

B. Maintain concrete with minimal moisture loss at relatively constant temperature for period necessary for hydration of cement and hardening of concrete.

C. Curing time for concrete will be a minimum of 3 days unless otherwise approved by engineer.

3.04 FIELD QUALITY ASSURANCE

A. Field inspection and testing will be performed in accordance with ACI 301 and under provisions of Section 01410.

B. Provide free access to Work and cooperate with appointed firm.

C. Submit proposed mix design to Engineer for review prior to commencement of Work.

D. Tests of cement and aggregates may be performed to ensure conformance with specified requirements.

3.05 DEFECTIVE CONCRETE

A. Defective Concrete: Concrete not conforming to required lines, details, dimensions, tolerances or specified requirements.

B. Repair or replacement of defective concrete will be determined by the Engineer.

C. Do not patch, fill, touch-up, repair, or replace exposed concrete except upon express direction of the Engineer for each individual area.

END OF SECTION 03300

SECTION 13910

LANDFILL GAS EXTRACTION WELLS

PART 1 GENERAL

1.01 SCOPE OF APPLICATION

A. Supply all equipment, materials and labor needed to install the landfill gas (LFG) extraction wells as specified herein and as indicated on the Drawings.

1.02 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM C136 - Standard Method for Sieve Analysis of Fine and Coarse Aggregates.

2. ASTM C702 - Standard Practice for Reducing Field Samples of Aggregate to Testing Size.

3. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3)).

4. ASTM D2487 - Standard Test Method for Classification of Soils for Engineering Purposes.

5. ASTM D2488 - Standard Practice for Description of Soils (Visual-Manual Procedure).

6. ASTM D2922 - Standard Test Methods for Density of Soil and Soil-Aggregate In-Place by Nuclear Methods (Shallow Depth).

7. ASTM D4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

8. ASTM D4373 – Standard Test Method for Calcium Carbonate Content of Soils.

1.03 SUBMITTALS

A. Submit to the ENGINEER Certificates of Compliance on materials furnished, and manufacturer's brochures containing complete information and instructions pertaining to the storage, handling, installation, and inspection of pipe and appurtenances furnished.

B. The CONTRACTOR shall submit to the ENGINEER samples of all well backfill materials furnished.

C. The CONTRACTOR shall keep detailed well logs and construction diagrams for all wells drilled, including the total depth of the well, the static water level, depth, thickness, and description of soil or waste strata, (including dates from any readable material), and the occurrence of any water bearing zones. Well logs shall be submitted to the ENGINEER.

1.04 SITE CONDITIONS

A. Obstructions and saturated conditions are sometimes encountered when drilling in a landfill, many of which can be drilled through. The CONTRACTOR is expected to make reasonable effort to drill through obstructions and saturated conditions and will be paid for offset re-drilling and boring abandonment only if prior approval is granted in writing by OWNER. CONTRACTOR will be paid for abandonment of abandoned hole and for well installation at new location.

1.05 BASIS OF PAYMENT

A. All work performed under this Section shall be paid for at the contract price (linear foot) for gas well installation and shall include any required boots and surface completions.

PART 2 PRODUCTS

2.01 AGGREGATE

A. Gravel pack shall be No. 57 stone, (non-calcareous rock, quarry certificate required).

2.02 BENTONITE

A. Bentonite shall be pelletized sodium bentonite.

2.03 SOLID WALL PIPE

A. All pipe and fittings shall be rigid PVC (Schedule 80) pipe.

2.04 PERFORATED/SLOTTED PIPE

A. Perforations in vent piping shall be 1/2-inch diameter spaced 90 degrees around the circumference of the pipe, and 3-inches on center along the pipe.

PART 3 EXECUTION

3.01 DRILLING

A. LFG vents must be installed prior deployment of any geosynthetic materials or construction of a low-permeable soil layer. LFG wells are to be 30-inch diameter. CONTRACTOR must use dry drilling equipment; wet rotary drilling equipment may not be used. All borings shall be made with bucket type augers.

B. The locations and depths of borings will be provided by the ENGINEER. The ENGINEER will use available record drawings to establish the appropriate depths of boring. The ENGINEER will be onsite during well drilling to ensure the proper depth of drilling. The boring depths may be adjusted in the field by the ENGINEER. Two reasons limiting depth might be as follows:

1. If water is encountered in a boring, the CONTRACTOR may be directed to drill beyond the point at which it was encountered. If wet conditions remain, the boring may be terminated and the length of perforated pipe adjusted by the ENGINEER, or the well may be relocated. If wet conditions cease (e.g. due to trapped water layer), then drilling will continue to the design depth.

2. Unsuitable Drilling is defined as drilling that must be abandoned (as approved by onsite ENGINEER) due to physical limitations before 75% of the specified depth is reached.

3. Each extraction well location and elevation shall be established and staked based on pre-construction survey of the closure area. Final well locations should be surveyed by a licensed surveyor with a record drawing provided under the provisions of Specification 01720.

C. As soon as drilling is completed, a safety screen shall be placed over the top of the bore. This screen shall stay in place until backfilling is within 4 feet of the surface. Safety screen size should be large enough to accommodate all backfill materials and any tools used during backfill yet not large enough for any human to accidentally fall through.

D. The bore for the well shall be straight and the well pipe shall be installed in the center of the bore hole. The CONTRACTOR will take all tension off of the pipe by mechanical means and center the pipe in the middle of the borehole before starting to backfill.

E. PVC well pipe shall be solvent cemented and lag bolted.

3.02 BACKFILLING

A. Backfilling of the well shall commence immediately after well drilling is completed and the well piping has been installed in the borehole. Backfill materials shall be installed as indicated on the Drawings and as approved by the ENGINEER.

B. Gravel pack shall be poured or scooped through the screen at a rate that will not endanger the integrity of the well casing.

C. The bentonite seal shall be hydrated with 5 gallons of potable water.

D. Soil backfill shall be rodded in the boring to provide even distribution and compaction.

3.03 DISPOSAL

A. Refuse from well drilling operations shall be the CONTRACTOR'S responsibility to dispose of at the on-site landfill working face. No tipping fee will apply.

3.04 HEALTH AND SAFETY

A. The Contractor shall be responsible of job site safety, and have a Health and Safety Plan for the proposed work to comply with State and Federal regulations.

END OF SECTION 13910

SECTION 13302

GEOCOMPOSITE

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. This specification covers the technical requirements for the furnishing and installation of the geocomposite described herein. All materials used and work performed shall meet the requirements of this specification and the Contract Drawings, or the manufacturer's manufacturing and installation procedures, whichever are more stringent.

B. The Geosynthetics Installer shall be prepared to install the geocomposite in conjunction with earthwork and other components of the cover system.

1.02 REFERENCES

A. Geosynthetic Research Institute (GRI) standard specifications and guides, latest versions.

B. The most recent versions of the following American Society for Testing and Materials (ASTM) standards:

1. ASTM D 792 Standard Test Methods for Specific Gravity and Density of Plastics Displacement;
2. ASTM D 1505 Standard Test Method for Density of Plastics by the Density-Gradient Technique;
3. ASTM D 1603 Standard Test Method for Carbon Black in Olefin Plastics;
4. ASTM D 4218 Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds by Muffle-Furnace Technique;
5. ASTM D 4491 Standard Test Method for Water Permeability of Geocomposites by Permeability;
6. ASTM D 4632 Standard Test Method for Breaking Load and Elongation of Geocomposites (Grab Method);
7. ASTM D 4716 Standard Test Method for Constant Head Hydraulic Transmissivity (In-Place Flow) of Geocomposites and Geocomposite Related Products;
8. ASTM D 4751 Standard Test Method for Determining Apparent Opening Size of Geocomposite;
9. ASTM D 4833 Standard Test Method for Index Puncture Resistance of Geocomposites, Geomembranes, and Related Products;
10. ASTM D 5199 Standard Test Method for Measuring Nominal Thickness of Unit Area of Geocomposites;
11. ASTM D 5321 Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method;

12. ASTM D7005 Standard Test Method for Determining the Bond Strength (Ply Adhesion) of Geocomposites;
13. Geosynthetic Research Institute (GRI) Test GC-7: Determination of Adhesion and Bond Strength of Geocomposites; and
14. Geosynthetic Research Institute (GRI) Test GC-8: Determination of the Allowable Flow rate of a Drainage Geocomposite.

1.03 SUBMITTALS

A. The following submittals shall be furnished by the CONTRACTOR for the work of this Section within 30 days prior to material delivery to the site and as specified herein:

1. A representative sample of all materials to be used on this Project.
2. A list of similar completed projects in which the proposed materials have been successfully used.
3. Manufacturer's instructions for installation and handling, and material data sheets giving full details of the material physical properties and test methods.
4. Draft warranties and guarantees as described hereinafter.

B. At least seven days prior to the loading and shipment of any geocomposite material the CONTRACTOR shall provide the CQA Consultant with the following information:

1. The origin (resin supplier's name and resin production plant), identification (brand name, number) and production date of the resin.
2. A copy of the quality control certificates issued by the resin supplier.
3. Reports on the tests conducted by the Manufacturer to verify the quality of the resin used to manufacture the geocomposite rolls assigned to the project. At a minimum, these tests should include density [ASTM D1505 or ASTM 792 method B], and melt index [ASTM D1238].
4. A statement that no reclaimed polymer is added to the resin (however, the use of polymer recycled during the manufacturing process may be permitted if done with appropriate cleanliness and if recycled polymer does not exceed 2 percent by weight).
5. The manufacturer's data and samples of the geocomposite to be used, giving full details of the minimum physical properties and test methods, as specified herein, certified test reports indicating the physical properties of the materials to be used, and roll numbers and identification.
6. The manufacturer's certificate shall state that the finished geocomposite meets MARV requirements of this specification as evaluated under the manufacturer's quality control program. A person having legal authority to bind the manufacturer shall attest the certificate.

1.04 CONSTRUCTION QUALITY CONTROL

The CONTRACTOR shall have an individual experienced in the installation of geocomposites on-site at all times during the installation. The designated individual shall be responsible for ensuring that the geocomposite is installed according to this

specification and the Contract Drawings.

1.05 CONSTRUCTION QUALITY ASSURANCE

A. The installation of the geocomposite shall be monitored by the CQA Consultant as outlined in the CQA Plan.

B. CONTRACTOR shall be aware of the activities outlined in the CQA Plan and shall account for these CQA activities in the installation schedule.

1.06 WARRANTY

A. The CONTRACTOR shall provide a written warranty for a minimum 10 years pro-rated relative to materials and one year on installation certifying the geocomposite materials provided and work performed under this project shall be free from any defects. Said warranty shall apply to normal use and service by the OWNER. Such written warranty shall provide for the repair or replacement of the defect or defective area of lining materials upon written notification and demonstration by the OWNER of the specific non-conformance of the lining material with the project specifications. Such defects or non-conformance shall be repaired or replaced within a reasonable period of time at no cost to the OWNER.

PART 2 - PRODUCTS

2.01 GEOCOMPOSITE MATERIAL

A. The geocomposite shall be composed of a high density polyethylene drainage net with a U.V. stabilized, nonwoven, needle punched geocomposite bonded to each side of the drainage net. The geocomposite shall not be glued or bonded to the geonet in any manner other than heat bonding. Along edges, approximately six inches of the geocomposite shall not be heat bonded to the geonet to allow connection in the field.

B. The net strands shall be so produced as to be free of holes, blisters, undispersed raw materials, or any sign of contamination by foreign matter. Any defects discovered in the field shall be repaired by cutting out the defect and joining a new piece of net material in its place. The joint shall be placed in accordance with the requirements for field joints.

2.02 GEOCOMPOSITE MATERIAL PROPERTIES

A. The geocomposite properties shall meet the minimum average roll requirements stated in Table 1.

B. In addition to the property values listed in Table 1, the geocomposite shall be chemically inert when immersed in a leachate representative of that from a typical landfill. The geonet shall contain a maximum of one percent by weight of additives, fillers, or extenders (not including carbon black) and shall not contain foaming agents or voids within the ribs of the geonet. The resin used to manufacture the HDPE must be of first quality, the same resin must be used throughout the project.

2.03 MANUFACTURING QUALITY CONTROL

A. Manufacturer's Quality Control (MQC) testing (test methods and frequencies) shall be conducted in accordance with Table 1, or the manufacturer quality control guide, whichever is more stringent.

2.04 ACCEPTANCE AND CONFORMANCE TESTING

A. Conformance testing must be performed, prior to shipment to the site, at the manufacturer's facility. The CONTRACTOR shall notify the ENGINEER at least three weeks prior to shipping in order to arrange for conformance testing. No material shall be shipped to the site until conformance sampling has been performed. When completed, the particular approved lot should be marked for the particular site under investigation. The expressed purpose of in-plant Material Conformance Test Sampling is to verify that geocomposite material designated for the project is confirmed as meeting the project specifications prior to shipment to the site. The Manufacturer shall make available all necessary personnel and equipment to assist the CQA Consultant in retrieving conformance samples of the geocomposite material.

B. Procedures in the Event of a Conformance Test Failure

The following procedure shall apply whenever a sample fails a conformance test that is conducted by the CQA Laboratory:

1. The Manufacturer shall replace the roll of geocomposite that is not in conformance with these Specifications with a roll that meets Specifications.
2. The CONTRACTOR shall remove conformance samples for testing by the CQA Laboratory from the closest numerical roll on both sides of the failed roll. These two samples must conform to these Specifications. If either of these samples fail, the two numerically closest untested rolls on both sides of the failed sample shall be tested by the CQA Laboratory. These four samples must conform to the Specifications. If any of these samples fail, every roll of geocomposite on site and every subsequently delivered roll that is from the same supplier must be tested by the CQA Laboratory for conformance to the Specifications. This additional conformance testing shall be at the expense of the CONTRACTOR.

2.05 HANDLING OF MATERIALS

A. Protective Wrapping - All rolls of geocomposite, irrespective of their type, must be enclosed in a protective wrapping that is opaque and waterproof. The objective is to prevent any degradation from atmospheric exposure (ultraviolet light, ozone, etc.), moisture uptake (rain, snow), and, to a limited extent, accidental damage. The following important issues shall be considered:

1. The protective wrapping shall be wrapped around (or placed around) the geocomposite in the manufacturing facility and shall be included as the final step in the manufacturing process.
2. The packaging shall not interfere with the handling of the rolls either by slings or by the utilization of the central core upon which the geocomposite is wound.
3. The protective wrapping shall prevent exposure of the geocomposite to ultraviolet light, prevent it from moisture uptake and limit minor damage to the roll.

4. Every roll must be labeled with the manufacturers name, geocomposite style and type, lot and roll numbers, and roll dimensions (length, width and gross weight).

B. Shipment

1. Each shipping document shall include a notation certifying that the material is in accordance with the manufacturer's quality control certificates.
2. The method of loading the geocomposite rolls, transporting them, and off-loading them at the job site should not cause any damage to the geocomposite, its core, nor its protective wrapping.
3. The protective wrapping shall be maintained during periods of shipping and storage.
4. All rolls, where the protective wrapping is damaged or stripped from the rolls, shall be moved to an enclosed facility until its repair can be made to the approval of the CQA Consultant.

C. Storage at the Site

1. Handling of geocomposite rolls shall be done in a competent manner such that damage does not occur to the geocomposite or to its protective wrapping.
2. The CONTRACTOR shall be responsible for the storage of the geocomposite on site in an area that is well drained and remains dry during material storage, and is protected from theft, vandalism, passage of vehicles, etc.
3. The rolls shall be stacked in such a way that cores are not crushed nor is the geocomposite damaged.
4. Outdoor storage of rolls should not exceed manufacturer's recommendations, or longer than six months, whichever is less. For storage periods longer than six months a temporary enclosure should be placed over the rolls, or they should be moved within an enclosed facility.
5. Additionally, if any special handling of the geocomposite is required, it shall be so marked on the top surface of the geocomposite.

PART 3 - EXECUTION

The work shall be executed according to manufacturer's specifications which shall be provided to engineer under provisions of Part 1.03 of this Section.

3.01 INSTALLATION

A. Install geocomposite as shown on the Contract Drawings.

3.02 PLACEMENT

A. The CONTRACTOR shall remove the protective wrappings from the geocomposite rolls to be deployed only after the substrate layer, soil, or other geosynthetic have been documented and approved by the CQA Consultant. Items to be considered are the following:

1. The installer shall take the necessary precautions to protect the underlying layers upon which the geocomposite shall be placed. If the substrate is soil, construction equipment can be used, provided that rutting is not created. If the substrate is a geosynthetic material, deployment must be by hand, or by use of low ground contact pressure all-terrain vehicles (ATVs).
2. During placement, care must be taken not to entrap sandbags, stones, moisture, or other materials that could damage a geocomposite, cause clogging of drains or filters, or hamper subsequent seaming.
3. On side slopes, the geocomposite shall be anchored at the top and then unrolled to keep the geocomposite free of wrinkles and folds.
4. The geocomposite shall be positioned by hand after being unrolled, to be free of wrinkles.
5. When the geocomposite is placed on another geosynthetic, trimming should be performed using only an upward-cutting hook blade.
6. The geocomposite shall be weighted with sandbags, to provide resistance against wind uplift.
7. A visual examination of the deployed geocomposite shall be carried out to ensure that no potentially harmful objects are present, e.g., stones, sharp objects, small tools, sandbags, etc.
8. After un-wrapping the geocomposite material from its protective cover, soil backfilling or covering by another geosynthetic shall be done within the period stipulated for the particular type of geotextile. Typical time frames for geotextile are within 14 days for polypropylene and 28 days for polyester geotextile.

3.03 SEAMS AND OVERLAPS

A. The components of the geocomposite (i.e., geocomposite-geonet-geocomposite) will be secured or seamed to the like component at overlaps.

B. Geonet Components

1. The geonet components shall be overlapped by at least 4 inches along the roll length.
2. Adjoining geocomposite rolls (end to end) across the roll width should be shingled down in the direction of the slope, with the geonet portion of the top overlapping the geonet portion of the bottom geocomposite a minimum of 12 inches across the roll width.
3. Overlaps shall be secured by tying. Tying shall be achieved by plastic fasteners, or polymer braid. Tying devices shall be white or yellow for easy inspection. Metallic devices shall not be used.
4. Tying shall be every 5 feet along the roll length, and every 12 inches along the roll width.

C. Geotextile Components

1. Seaming of geotextile layers shall be performed by either sewing or heat bonding. The overlap shall be a minimum of four inches for each method.
2. Polymeric thread, with chemical resistance properties equal to or exceeding those of the

geocomposite component, shall be used for all sewing.

3.04 REPAIR

A. If the geonet is undamaged but the geocomposite is damaged, then the Geosynthetic Installer shall repair the damaged area as follows:

1. Remove damaged geocomposite. Cut patch of new geocomposite to provide minimum 12-inch overlap in all directions.

2. Thermally bond geocomposite patch to existing geocomposite.

B. All seams that have no geocomposite flaps available for sewing shall be thermally bonded with patch that extends 12 inches beyond the edges of the panel.

C. Any holes or tears in the geocomposite material shall be repaired by first removing the damaged portion of the geonet and placing a patch under the panel that extends six inches beyond the edges of the hole or tear. The patch shall be secured by tying fasteners through the patch, and through the panel. The patch shall then be secured every six inches with approved tying devices. A geocomposite patch shall be heat-sealed to the top of the geocomposite needing repair. If the hole or tear width across the roll exceeds 50 percent of the width of the roll, then the entire damaged geocomposite panel shall be removed and replaced.

3.05 PLACEMENT OF COVER MATERIALS

A. CONTRACTOR shall place all soil materials over geocomposite such that:

1. The geocomposite and underlying materials are not damaged;

2. Prevent slippage between the geocomposite layer and underlying layers; and

3. Tensile stresses are not produced in the geocomposite.

B. Equipment shall not be driven directly atop the geocomposite. Placement of the cover material shall occur as soon as practical and shall proceed from the base of the slope upwards. Unless otherwise specified by ENGINEER, all equipment operating on soil material overlying the geocomposite shall be a D-5 class low Ground Pressure Dozer or smaller. No traffic by rubber-tired vehicles shall occur on the geocomposite without a combined thickness of four feet above the geocomposite layer. Turning of all vehicles will be kept to a minimum and the speed of all vehicles will be limited to less than 10 miles per hour.

C. Anchor trenches must be allowed to drain to prevent ponding and softening of the soils while the trench is open. Anchor trenches shall be backfilled and compacted by the CONTRACTOR. Care shall be taken when backfilling the trenches to prevent damage to the geocomposite.

3.06 PRODUCTION PROTECTION

A. CONTRACTOR shall use all means necessary to protect all prior work and all materials and completed work of other Sections.

B. In the event of damage, CONTRACTOR shall immediately make all repairs and replacements necessary, to the approval of the CQA Consultant and at no additional cost to

OWNER.

3.07 ACCEPTANCE

A. The CONTRACTOR shall retain all responsibility for the geocomposite in the landfill cell or cap until acceptance by the OWNER.

B. The geocomposite shall be accepted by the OWNER when:

1. The installation is finished.

2. The OWNER and CONTRACTOR have signed a certificate of Substantial Completion, and all conditions identified on the certificate have been met for the OWNER to assume responsibility for the geocomposite. The signed certificate of Substantial Completion and acceptance of the geocomposite will be part of the CQA Report.

Table 1 – Geocomposite
MANUFACTURING QUALITY CONTROL TEST FREQUENCY

CHARACTERISTICS	TEST METHOD	UNITS	FREQUENCY	MARV
Resin				
POLYMER DENSITY	ASTM D1505	g/cm^3	Once per Lot	> 0.94
MELT FLOW INDEX	ASTM D1238	g/10 min	Once per Lot	$\leq$1.0
Geonet Tests				
DENSITY	ASTM D1505	g/cm^3	1 per 50,000 ft^2	0.94
CARBON BLACK	ASTM D1603	%	1 per 50,000 ft^2	2 to 3
TENSILE STRENGTH, MD	ASTM D5035	lbs/in^2	1 per 50,000 ft^2	50
Geotextile Tests				
AOS	ASTM D4751	US sieve (mm)	1 per 540,000 ft^2	70 0.212
MASS PER UNIT AREA	ASTM D5261	oz/yd^2	1 per 90,000 ft^2	6.0
FLOW RATE	ASTM D4491	gpm/ft^2	1 per 540,000 ft^2	110
GRAB TENSILE STRENGTH	ASTM D4632	lb	1 per 90,000 ft^2	170
PUNTURE STRENGTH	ASTM D4833	lb	1 per 90,000 ft^2	90
Geocomposite Tests				
PLY ADHESION	ASTM D7005	lbs/in	1 per 50,000 ft^2	1.0
TRANSMISSIVITY	ASTM D4716	m^2/sec	1 per 540,000 ft^2	$1.0x10^{-3}$(a)

(a) Minimum value @ hydraulic gradient of 0.33 ft/ft for the cap (vertical loading of 300 psf)

END OF SECTION 13302

SECTION 13310

GEOTEXTILES

PART 1 - GENERAL

1.01 REQUIREMENTS INCLUDED

This specification covers the technical requirements for the furnishing and installation of the geotextile described herein. All materials used and work performed shall meet the requirements of this specification and the Contract Drawings, or the manufacturer's manufacturing and installation procedures, whichever are more stringent.

1.02 REFERENCES

A. Geosynthetic Research Institute (GRI) standard specifications and guides, latest versions.

B. The most recent versions of the following American Society for Testing and Materials (ASTM) standards.

1. D3786 Mullen Burst
2. D4354 Standard Practice for Sampling of Geosynthetics for Testing
3. D4355 Standard Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus)
4. D4491 Standard Test Methods for Water Permeability of Geotextiles by Permittivity
5. D4533 Standard Test Method for Trapezoid Tearing Strength of Geotextiles
6. D4632 Standard Test Method for Grab Breaking Load and Elongation of Geotextiles
7. D4751 Standard Test Method for Determining Apparent Opening Size of a Geotextile
8. D4759 Standard Practice for Determining the Specification Conformance of Geosynthetics
9. D4833 Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products
10. D4873 Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls
11. D4884 Standard Test Method for Strength of Sewn or Thermally Bonded Seams of Geotextiles

12. D5199 Standard Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes

13. D5261 Standard Test Method for Measuring Mass per Unit Area of Geotextiles

1.03 SUBMITTALS

A. The following submittals shall be furnished by the CONTRACTOR for the work of this Section within 30 days prior to material delivery to the site, and as specified herein:

1. A representative sample of all materials to be used on this Project.

2. A list of similar completed projects in which the proposed materials have been successfully used.

3. Manufacturer's instructions for installation and handling, and material data sheets giving full details of the material physical properties and test methods.

4. Draft warranties and guarantees as described hereinafter.

B. The following submittals shall be furnished by the CONTRACTOR for the work of this Section within 7 days prior to material delivery to the site, and as specified herein:

1. The manufacturer's data and samples of the geotextile to be used, giving full details of the minimum physical properties and test methods, as specified herein, certified test reports indicating the physical properties of the materials to be used, and roll numbers and identification.

2. The manufacturer's certificate shall state that the finished geotextile meets MARV requirements of this specification as evaluated under the manufacturer's quality control program. A person having legal authority to bind the manufacturer shall attest the certificate.

3. "Needle-Free" statement for non-woven geotextile.

C. The following submittals shall be furnished by the CONTRACTOR for the work of this Section prior to the issuance of a certificate of substantial completion for the Project:

1. Signed subgrade Acceptance forms, if applicable.

2. Final warranties and guarantees as described hereinafter.

1.04 WARRANTY AND GUARANTEE

The CONTRACTOR shall provide a written warranty for a minimum 10 years pro-rated relative to materials and 1 year on installation certifying the geotextile materials provided and work performed under this project shall be free from any defects. Said warranty shall apply to normal use and service by the OWNER. Such written warranty shall provide for the repair or replacement

of the defect or defective area of lining materials upon written notification and demonstration by the OWNER of the specific non-conformance of the lining material with the project specifications. Such defects or non-conformance shall be repaired or replaced within a reasonable period of time at no cost to the OWNER.

1.05 CONSTRUCTION QUALITY CONTROL

The CONTRACTOR shall have an individual experienced in the installation of geotextile on-site at all times during the installation. The designated individual shall be responsible for ensuring that the geotextile is installed according to this specification and the Contract Drawings. The designated individual shall be subject to approval by the OWNER or CQA Consultant.

1.06 CONSTRUCTION QUALITY ASSURANCE

A. The installation of the geotextile shall be monitored by the CQA Consultant as outlined in the CQA Plan.

B. CONTRACTOR shall be aware of the activities outlined in the CQA Plan and shall account for these CQA activities in the installation schedule.

PART 2 - PRODUCTS

2.01 MATERIALS

A. All geotextile shall be manufactured of 100 percent polyester or polypropylene. The fabric shall be a continuous filament, non-woven, needle punched geotextile that is UV stabilized and is mildew, rot, insect, and rodent resistant. The fabric shall be guaranteed free of any treatment, coating, or deleterious elements, which might significantly alter its physical properties, or its proper functioning.

B. All geotextile shall have a minimum mass per unit area of 16 oz/yd^2 as indicated on the Contract Drawings.

C. The geotextile properties shall meet the minimum average roll requirements stated in the most recent versions of GRI Test Method GT12(a) for geotextile cushions and GRI Test Method GT13(a) (moderate survivability) for geotextile separators.

D. Manufacturer's Quality Control (MQC) testing (test methods and frequencies) shall be conducted in accordance with the most recent versions of GRI Test Method GT12(a) for geotextile cushions and GRI Test Method GT13(a) (moderate survivability) for geotextile separators, or the manufacturer quality control guide, whichever is more stringent.

E. Other types of geotextile may be considered that differ from the requirements of Section 2.01.A. These must be approved by the ENGINEER in writing prior to any bidding or construction. Any geotextile used must meet the requirements of Section 2.01.C.

2.02 ACCEPTANCE AND CONFORMANCE TESTING

A. Conformance testing must be performed, prior to shipment to the site, at the manufacturer's facility. The CONTRACTOR shall notify the ENGINEER at least three (3) weeks prior to shipping in order to arrange for conformance testing. No material shall be shipped to the site until conformance sampling has been performed. When completed, the particular approved lot should be marked for the particular site under investigation. The expressed purpose of in-plant Material Conformance Test Sampling is to verify that geotextile material designated for the project is confirmed as meeting the project specifications prior to shipment to the site. The Manufacturer shall make available all necessary personnel and equipment to assist the CQA Consultant in retrieving conformance samples of the geotextile material.

B. Procedures in the Event of a Conformance Test Failure

The following procedure shall apply whenever a sample fails a conformance test that is conducted by the CQA Laboratory:

1. The Manufacturer shall replace the roll of geotextile that is not in conformance with these Specifications with a roll that meets Specifications.

2. The CONTRACTOR shall remove conformance samples for testing by the CQA Laboratory from the closest numerical roll on both sides of the failed roll. These two samples must conform to these Specifications. If either of these samples fail, the two (2) numerically closest untested rolls on both sides of the failed sample shall be tested by the CQA Laboratory. These four samples must conform to the Specifications. If any of these samples fail, every roll of geotextile on site and every subsequently delivered roll that is from the same supplier must be tested by the CQA Laboratory for conformance to the Specifications. This additional conformance testing shall be at the expense of the CONTRACTOR.

2.03 HANDLING OF MATERIALS

A. Protective Wrapping - All rolls of geotextile, irrespective of their type, must be enclosed in a protective wrapping that is opaque and waterproof. The objective is to prevent any degradation from atmospheric exposure (ultraviolet light, ozone, etc.), moisture uptake (rain, snow), and, to a limited extent, accidental damage. The following important issues shall be considered:

1. The protective wrapping shall be wrapped around (or placed around) the geotextile in the manufacturing facility and shall be included as the final step in the manufacturing process.

2. The packaging shall not interfere with the handling of the rolls either by slings or by the utilization of the central core upon which the geotextile is wound.

3. The protective wrapping shall prevent exposure of the geotextile to ultraviolet light, prevent it from moisture uptake and limit minor damage to the roll.

4. Every roll must be labeled with the manufacturers name, geotextile style and type, lot and roll numbers, and roll dimensions (length, width and gross weight).

B. Shipment

1. Each shipping document shall include a notation certifying that the material is in accordance with the manufacturer's quality control certificates.

2. The method of loading the geotextile rolls, transporting them, and off-loading them at the job site should not cause any damage to the geotextile, its core, nor its protective wrapping.

3. The protective wrapping shall be maintained during periods of shipping and storage.

4. All rolls, where the protective wrapping is damaged or stripped from the rolls, shall be moved to an enclosed facility until its repair can be made to the approval of the CQA Consultant.

C. Storage at the Site

1. Handling of geotextile rolls shall be done in a competent manner such that damage does not occur to the geotextile or to its protective wrapping.

2. The CONTRACTOR shall be responsible for the storage of the geotextile on site in an area that is well drained and remains dry during material storage, and is protected from theft, vandalism, passage of vehicles, etc.

3. The rolls shall be stacked in such a way that cores are not crushed nor is the geotextile damaged.

4. Outdoor storage of rolls should not exceed manufacturer's recommendations, or longer than six months, whichever is less. For storage periods longer than six months a temporary enclosure should be placed over the rolls, or they should be moved within an enclosed facility.

5. Additionally, if any special handling of the geotextile is required, it shall be so marked on the top surface of the geotextile.

PART 3 - EXECUTION

The work shall be executed according to manufacturer's specifications which shall be provided to engineer under provisions of Part 1.03 of this Section.

3.01 INSTALLATION

A. Install geotextile as shown on the Contract Drawings.

3.02 PLACEMENT

A. The CONTRACTOR shall remove the protective wrappings from the geotextile rolls to be deployed only after the substrate layer, soil, or other geosynthetic have been documented and approved by the CQA Consultant. Items to be considered are the following:

1. The installer shall take the necessary precautions to protect the underlying layers upon which the geotextile shall be placed. If the substrate is soil, construction equipment can be used, provided that rutting is not created. If the substrate is a geosynthetic material, deployment must be by hand, or by use of low ground contact pressure all-terrain vehicles (ATVs).
2. During placement, care must be taken not to entrap sandbags, stones, moisture, or other materials that could damage a geomembrane, cause clogging of drains or filters, or hamper subsequent seaming.

3. On side slopes, the geotextile shall be anchored at the top and then unrolled to keep the geotextile free of wrinkles and folds.

4. The geotextile shall be positioned by hand after being unrolled, to be free of wrinkles.

5. When the geotextile is placed on another geosynthetic, trimming should be performed using only an upward-cutting hook blade.

6. The geotextile shall be weighted with sandbags, to provide resistance against wind uplift.

7. A visual examination of the deployed geotextile shall be carried out to ensure that no potentially harmful objects are present, e.g., stones, sharp objects, small tools, sandbags, etc.

3.03 SEAMING/JOINING REQUIREMENTS

Seaming of geotextile may be performed by either sewing or heat bonding. The overlap shall be a minimum of six (6) inches for each method.

Polymeric thread, with chemical resistance properties equal to or exceeding those of the geotextile, shall be used for all sewing.

3.04 REPAIR PROCEDURES

Holes, or tears, in geotextile made during placement or anytime before backfilling shall be repaired by patching. The following shall be observed:

1. The patch material used for repair of a hole or tear shall be the same type of polymeric material as the damaged geotextile, or as approved by the CQA Consultant.

2. The patch shall extend at least 12 inches beyond any portion of the damaged geotextile.

3. The patch shall be sewn in place by hand or machine, or possibly heat bonded, so as not to accidentally shift out of position or be moved during backfilling or covering operations.

3.05 PROTECTION AND BACKFILLING OR COVERING

A. If soil is to cover the geotextile, it shall be done such that the geotextile is not shifted from its intended position and underlying materials are not exposed or damaged.

B. If a geosynthetic is to cover the geotextile, both the underlying geotextile and the newly deployed material shall not be damaged during the process.

C. The overlying material shall not be deployed such that tensile stress is exerted in the geotextile. On side slopes, this requires soil backfill to proceed from the bottom of the slope upward.

D. Equipment shall not be driven directly atop the geotextile layer. Placement of the cover material shall occur as soon as practical and shall proceed from the base of the slope upwards. Unless otherwise specified by ENGINEER, all equipment operating on soil material overlying the geotextile layer shall be a D-5 class low Ground Pressure Dozer or smaller. No traffic by rubber-tired vehicles shall occur on the geotextile without a combined thickness of four (4) feet above the geotextile layer. Turning of all vehicles will be kept to a minimum and the speed of all vehicles will be limited to less than 10 miles per hour.

E. Soil backfilling or covering by another geosynthetic shall be done within the period stipulated for the particular type of geotextile. Typical time frames for geotextile are within 14 days for polypropylene and 28 days for polyester geotextile.

F. Anchor trenches must be allowed to drain to prevent ponding and softening of the soils while the trench is open. Anchor trenches shall be backfilled and compacted by the CONTRACTOR. Care shall be taken when backfilling the trenches to prevent damage to the geotextile.

3.06 ACCEPTANCE

A. The CONTRACTOR shall retain all responsibility for the geotextile in the landfill cell or cap until acceptance by the OWNER.

B. The geotextile shall be accepted by the OWNER when:

1. The installation is finished;

2. The OWNER and CONTRACTOR have signed a certificate of Substantial Completion, and all conditions identified on the certificate have been met for the OWNER to assume responsibility for the geotextile. The signed certificate of Substantial Completion and acceptance of the geotextile will be part of the CQA Report.

END OF SECTION 13310

SECTION 13315

GEOSYNTHETIC CLAY LINER (GCL)

PART 1 GENERAL

1.01 WORK INCLUDED

A. Furnishing and installing the geosynthetic clay liner for the composite liner.

1.02 SUBMITTALS

A. The CONTRACTOR shall furnish prior to placement of the GCL:

1. Conceptual description of the proposed plan for placement of the GCL panels over the area of installation.

2. GCL manufacturer's MQC Plan for documenting compliance to Paragraph 2.01 and 2.02 of this Section.

3. Manufacturer's recommended installation procedures.

B. At the ENGINEER'S request the CONTRACTOR shall furnish:

1. A representative sample of the GCL proposed for use on this project.

2. A project reference list for the GCL(s) consisting of the principal details of at least 10 projects totaling at least 10 million square feet in size.

C. Upon shipment, the CONTRACTOR shall furnish the GCL manufacturer's Quality Assurance/Quality Control (QA/QC) certifications that the materials supplied for the project are in accordance with the requirements of this specification.

D. As installation proceeds, the CONTRACTOR shall submit certificates of subgrade acceptance signed by the CONTRACTOR and CQA Consultant for each area covered by the GCL.

1.03 QUALIFICATIONS

A. GCL Manufacturer must have produced at least 10 million square feet of GCL, with at least 8 million square feet installed.

B. The GCL Installer must either have installed at least 1 million square feet of GCL, or must provide to the ENGINEER satisfactory evidence through similar experience in the installation of other types of geosynthetics that the GCL will be installed in a competent, professional manner.

1.04 CONSTRUCTION QUALITY ASSURANCE (CQA)

A. Acceptance by the ENGINEER of the installed GCL shall be dependent on the Geosynthetic CQA Consultant determining that all requirements of this Section (Section 13315) have been met.

B. Field observations conducted by the CQA Consultant will be done at the OWNER'S expense.

C. ENGINEER will administer the CQA Program.

PART 2 PRODUCTS

2.01 MATERIALS

A. The GCLs shall consist of a layer of natural sodium bentonite clay encapsulated between two geotextiles and shall comply with all of the criteria listed in this Section. 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 section. The CONTRACTOR must obtain prior approval of the alternative GCL by the ENGINEER.

B. Reinforced GCL must be used on slopes greater than 10H:1V. Unreinforced GCL may be used on areas of the site not exceeding 10H:1V in steepness, or as approved by the ENGINEER.

C. Acceptable GCL products are Bentomat ST, Claymax 200R, as manufactured by CETCO, 1350 West Shure Drive, Arlington Heights, Illinois 60004 USA (847-392-5800); Bentofix NS, Bentofix NW as manufactured by Fluid Sysytems, Inc., 1245 Corporate Boulevard, Aurora, Illinois 60504 USA (864-467-1495) or an Engineer approved equal.

D. The GCL(s) and their components shall have properties that meet or exceed CETCO's certified properties for Bentomat "ST" (reinforced GCL) and Claymax "200R" (unreinforced GCL):

Bentomat "ST"

Material Property	Test Method	Test Frequency (ft^2)	Required Values
Bentonite Swell Index	ASTM D 5890	1 per 50 tonnes	24 mL/2g min.
Bentonite Fluid Loss	ASTM D 5891	1 per 50 tonnes	18 mL max.
Bentonite Mass/Area	ASTM D 5993	40,000 ft^2	0.75 lb/ft^2 min.
GCL Grab Strength	ASTM D 4632	200,000 ft^2	90 lbs MARV
GCL Peel Strength	ASTM D 4632	40,000 ft^2	15 lbs min.
GCL Index Flux	ASTM D 5887	Weekly	$1x10^{-8}$ m^3/m^2/sec max.
GCL Permeability	ASTM D 5887	Weekly	$5x10^{-9}$ cm/sec max.
GCL Hydrated Internal Shear Strength	ASTM D 5321	Periodic	500 psf (24 kPa) typical

Index Flux and Permeability testing should be done utilizing a hydraulic gradient of .33 ft/ft and confining pressure of 300 psf.

Claymax "200R"

Material Property	Test Method	Test Frequency (ft^2)	Required Values
Bentonite Swell Index	ASTM D 5890	1 per 50 tonnes	24 mL/2g min.
Bentonite Fluid Loss	ASTM D 5891	1 per 50 tonnes	18 mL max.

Bentonite Mass/Area	ASTM D 5993	40,000 ft^2	0.75 lb/ft^2 min.
GCL Grab Strength	ASTM D 4632	200,000 ft^2	100 lbs MARV
GCL Peel Strength	ASTM D 4632	N/A	N/A
GCL Index Flux	ASTM D 5887	Weekly	$1x10^{-8}$ m^3/m^2/sec max.
GCL Permeability	ASTM D 5887	Weekly	$5x10^{-9}$ cm/sec max.
GCL Hydrated Internal Shear Strength	ASTM D 5321	Periodic	50 psf (24 kPa) typical

Index Flux and Permeability testing should be done utilizing a hydraulic gradient of .33 ft/ft and confining pressure of 300 psf.

E. The acceptable dimensions of full-size GCL panels shall be 150 feet in length and 15 feet in width.

F. A 6-inch (150 mm) overlap guideline shall be imprinted on both edges of the upper geotextile component of the GCL as a means for providing quality assurance of the overlap dimension. Lines shall be printed in easily visible, permanent ink.

2.02 PRODUCT QUALITY DOCUMENTATION

A. The GCL manufacturer shall provide the CONTRACTOR or other designated party with manufacturing QA/QC certifications for each shipment of GCL. The certifications shall be signed by a responsible party employed by the GCL manufacturer and shall include:

1. Manufacturer's certification for the bentonite clay used in GCL production, demonstrating compliance with the parameters swell index, fluid loss and bentonite mass/area shown in CETCO's current Technical Data Sheets TR404bm and/or TR404cm.

Property	Test	Standard	Unit	Value
Swell index	ASTM D5890	Minimum	M1	24
Fluid loss	ASTM D5891	Minimum	Ml	18
Bentonite mass/ Area	ASTM D5993	Minimum	Lb/ft^2	0.75

2. GCL lot and roll numbers supplied for the project (with corresponding shipping information).

2.03 PRODUCT LABELING

A. Prior to shipment, the GCL manufacturer shall label each roll, identifying:

1. Product identification information (manufacturer's name and address, brand name, product code).
2. Lot number and roll number.
3. Roll length, width, and weight.

2.04 PACKAGING

A. The GCL shall be wound around a rigid core having a diameter sufficient to facilitate handling. The core should be sufficiently strong to prevent collapse during transit.

B. All rolls shall be labeled and bagged in packaging that is resistant to photodegradation by ultraviolet (UV) light.

2.05 ACCESSORY BENTONITE

A. The granular bentonite or bentonite sealing compound used for 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.

PART 3 EXECUTION

The work shall be executed according to manufacturer's specifications which shall be provided to engineer under provisions of Part 1 of this Section.

3.01 SHIPPING AND HANDLING

A. Handling and storage of the GCL are the responsibility of the CONTRACTOR.

B. A visual inspection of each roll shall be made during unloading to identify if any packaging has been damaged. Rolls with damaged packaging should be marked and set aside for further inspection. The packaging should be repaired prior to being placed in storage.

C. The party responsible for unloading the GCL should contact the manufacturer prior to shipment to ascertain the appropriateness of proposed unloading methods and equipment.

3.02 STORAGE

A. Storage of the GCL rolls is the responsibility of the CONTRACTOR. Select a storage area at the job site that is away from high traffic areas and is level, dry, and well-drained.

B. Store rolls in a manner that prevents sliding or rolling from the stacks. Stack rolls at a height no higher than the lifting apparatus can be safely operated (typically no higher than four).

C. Cover all stored GCL materials and the accessory bentonite with a plastic sheet or tarpaulin until their installation.

D. Preserve the integrity and legibility of the labels during storage.

3.03 EARTHWORK

Earthwork shall comply with Section 02200.

A. Earthen surface upon which the GCL is to be installed shall be prepared and compacted in

accordance with the project specifications and drawings. The surface shall be smooth, firm, unyielding, and free of vegetation, construction debris, wood, rocks, void spaces, ice, abrupt elevation changes, standing water, cracks larger than one-quarter inch in width, and any other matter that could damage the GCL.

B. Subgrade surfaces consisting of granular soils or gravel may not be acceptable due to their large void fraction and puncture potential. Subgrade soils should possess a particle size distribution such that at least 80 percent of the soil is finer than a #60 sieve (0.2 mm), or as approved by the ENGINEER.

C. Immediately prior to GCL deployment, grade the subgrade to fill in all voids and cracks, and then smooth-roll to provide the best practical surface for the GCL. At the completion of this activity, no wheel ruts, footprints or other surface irregularities shall exist in the subgrade. All protrusions extending more than one-half inch from the surface shall either be removed, crushed or pushed into the surface with a smooth-drum compactor.

D. The Installer shall certify acceptance of the subgrade before GCL placement.

E. It shall be the Installer's responsibility thereafter to indicate to the ENGINEER any change in condition of the subgrade to be out of compliance with any of the requirements of this Section.

F. At the top of sloped areas of the job site, an anchor trench for the GCL shall be excavated in accordance with the project Drawings. The trench shall be excavated and approved by the CQA Consultant prior to GCL placement. No loose soil shall be allowed at the bottom of the trench, and no sharp corners or protrusions shall exist anywhere within the trench.

3.04 GCL PLACEMENT

A. Deliver GCL rolls to the working area of the site in their original packaging. Prior to deployment, carefully remove the packaging without damaging the GCL. The orientation of the GCL shall be in accordance with the manufacturer's recommendations.

B. Equipment that could damage the GCL shall not be allowed to travel directly on the GCL. If the installation equipment causes rutting of the subgrade, the subgrade must be restored to its originally accepted condition before GCL placement continues.

C. Care shall be taken to minimize the extent to which the GCL is dragged across the subgrade in order to avoid damage to the bottom surface of the GCL. A temporary slip sheet or rub sheet may be used to reduce friction damage during placement.

D. The GCL shall be placed so that seams are parallel to the direction of the slope. Seams should be located at least 3 feet from the toe of slopes steeper than 4H:1V.

E. All GCL panels should lie flat on the underlying surface, with no wrinkles or folds.

F. Only as much GCL shall be deployed as can be covered at the end of the working day with soil, a geomembrane, 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. The project ENGINEER, CQA Consultant, or GCL

supplier should be consulted for specific guidance if premature hydration occurs.

G. GCL should be placed such that non-woven side will be on top.

3.05 ANCHORAGE

A. In accordance with the Drawings, the end of the GCL roll shall be placed in an anchor trench at the top of the slope. The front edge of the trench should be rounded so as to eliminate sharp corners. Remove loose soil from the bottom of the trench.

3.06 SEAMING

A. 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. Supplemental bentonite is required in accordance with paragraph 3.06.D if the GCL has one or more non-woven needlepunched geotextiles.

B. The minimum dimension of the longitudinal overlap shall be 6 inches. End-of-roll overlapped seams should be similarly constructed, but the minimum overlap shall measure 24 inches.

C. Seams at the ends of the panels should be constructed such that they are shingled in the direction of the grade to prevent runoff from entering the overlap zone.

D. For all GCL products other than Bentomat ST, bentonite-enhanced seams shall be constructed between the overlapping adjacent panels described above (Bentomat ST does not require supplemental bentonite). The underlying edge of the longitudinal overlap shall be exposed and a continuous bead of granular sodium bentonite applied along a zone defined by the edge of the underlying panel and the 6-inch line. For all GCL products, including Bentomat ST, a similar bead of granular sodium bentonite shall be applied at the end-of-roll overlap. The bentonite shall be applied at a minimum application rate of one quarter pound per linear foot.

3.07 DETAIL WORK

A. The GCL shall be sealed around penetrations and embedded structures in accordance with the project drawings.

B. Cut GCL using a sharp utility knife.

3.08 DAMAGE REPAIR

A. Repair GCL damaged during installation. Cut a patch to fit over the damaged area. The patch shall be cut to overlap 12 inches around all of the damaged area. Dry bentonite or bentonite mastic should be applied around the damaged area at a rate of .25 pounds per linear foot, or as specified by manufacturer, prior to placement of the patch. It may be desirable to use an adhesive to affix the patch in place to prevent displaced during cover placement.

3.09 COVER PLACEMENT

A. Cover soils shall be free of stones or other matter that could damage the GCL. Cover soils shall be

approved by the project ENGINEER with respect to particle size, uniformity, and chemical compatibility. Cover soils with high concentrations of calcium (e.g., limestone, dolomite) are not acceptable.

B. Soil cover shall be placed over the GCL using construction equipment that minimizes stresses on the GCL. A minimum thickness of 1 foot of cover shall be maintained between the equipment tires/tracks and the GCL at all times during the covering process. For frequently traveled areas, a minimum thickness of 2 feet is required.

C. Soil cover shall be placed in a manner that prevents the soil from entering the GCL overlap zones. Cover soil shall be pushed up slopes, not down slopes, to minimize tensile forces on the GCL.

D. Although direct vehicular contact with the GCL is to be avoided, lightweight, low ground pressure vehicles (such as 4-wheel all-terrain vehicles) may be used to facilitate the installation of geosynthetic material to be placed over the GCL. The GCL Supplier or CQA Engineer should be contacted for specific recommendations on appropriate procedures in this situation.

E. When a textured geomembrane is to be installed over the GCL, a temporary slip sheet or rub sheet should be used to minimize friction during placement, and to enable the textured geomembrane to be more easily moved into final position.

3.10 RECORDS AND QUALITY ASSURANCE

A. The installation of the GCL will be monitored by a CQA Consultant provided by the OWNER. The purpose of CQA activities is to document the installation of the GCL. Refer to the CQA Plan. The following records shall be kept:

Roll Placement Checklist

Repair Checklist

General Photographic Record of installation

Record Drawing indicating work progress each day of installation

B. Do not cover GCL until all repairs have been properly logged.

END OF SECTION 13315

SECTION 13320

GEOMEMBRANE

PART 1 – GENERAL

1.01 SCOPE OF APPLICATION

This specification covers the technical requirements for the furnishing and installation of the geomembrane described herein. All materials used and work performed shall meet the requirements of this specification and the Contract Drawings, or the manufacturer's manufacturing and installation procedures, whichever are more stringent.

1.02 REFERENCES

A. Geosynthetic Research Institute (GRI) standard specifications and guides, latest versions.

B. The most recent versions of the following American Society for Testing and Materials (ASTM) standards:

1. D4218 Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique.

2. D5596 Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics.

3. D1505 Standard Test Method for Density of Plastics by the Density-Gradient Technique.

4. D1238 Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer.

5. D638 Standard Test Method for Tensile Properties of Plastics.

6. D5199 Standard Test Method for Measuring Nominal Thickness of Geosynthetics.

7. D5994 Standard Test Method for Measuring Core Thickness of Textured Geomembrane.

8. D4833 Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.

9. D1004 Standard Test Method for Initial Tear Resistance of Plastic Film and Sheeting.

10. D1603 Standard Test Method for Carbon Black in Olefin Plastics.

11. D3895 Standard Test Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Calorimetry.

12. D5885 Standard Test Method for Oxidative-Induction Time of Polyolefin Geosynthetics by High-Pressure Differential Scanning Calorimetry.

1.03 SUBMITTALS

A. The following submittals shall be furnished by the CONTRACTOR for the work of this Section within 30 days prior to material delivery to the site, and as specified herein.

1. A representative sample of the geomembrane material.

2. Manufacturer's instructions for installation and handling, and material data sheets giving full details of the material physical properties and test methods.

3. A project reference list totaling at least 1 million square feet in size;

4. Draft warranties and guarantees as described herein.

5. Proposed panel layout drawing showing anchor trenches, seams, and panel numbering.

6. List of proposed seaming personnel and their experience records.

7. Current (within 12 months of the geomembrane installation) calibration certificates for all tensiometers to be used for field shear and peel strength testing.

B. The following submittals shall be furnished by the CONTRACTOR prior to the issuance of the certificate of substantial completion for the Project:

1. Warranties and guarantees as described herein.

2. QC Daily field reports.

3. Subgrade Acceptance.

4. Panel Placement records.

5. Panel seaming records.

6. Destructive test records.

7. Non-destructive test records.

8. Trial seam records.

9. Repair records.

10. Inventory sheets/Bills of Lading.

11. Record drawing showing and identifying all panels, seams, seam types, destructive test locations, and all repairs to the geomembrane.

1.04 CONSTRUCTION QUALITY CONTROL

The CONTRACTOR shall have an individual experienced in the installation of geomembrane on-site at all times during the installation. The designated individual shall be responsible for ensuring that the geomembrane is installed according to this specification and the Contract Drawings. The designated individual shall be subject to approval by the OWNER or CQA Consultant.

1.05 WARRANTY AND GUARANTEE

The CONTRACTOR shall provide a written warranty for a minimum 20 years pro-rated relative to materials and 1 year on installation certifying the geomembrane materials provided and work performed under this project shall be free from any defects. Said warranty shall apply to normal use and service by the OWNER. Such written warranty shall provide for the repair or replacement of the defect or defective area of lining materials upon written notification and demonstration by the OWNER of the specific non-conformance of the lining material with the project specifications. Such defects or non-conformance shall be repaired or replaced within a reasonable period of time at no cost to the OWNER.

1.06 CONSTRUCTION QUALITY ASSURANCE

A. The installation of the geomembrane shall be monitored by the CQA Consultant as outlined in the CQA Plan.

B. CONTRACTOR shall be aware of the activities outlined in the CQA Plan and shall account for these CQA activities in the installation schedule.

PART 2 – PRODUCTS

2.01 RAW MATERIALS

A. The raw material from which the HDPE geomembrane will be made shall be first quality polyethylene resin containing no more than 2 percent clean recycled polymer by weight, and meeting the following specifications:

1. Density [ASTM D1505 or ASTM 792 Method B]: 0.932 g/ml or higher (without carbon black); and

2. Melt Index [ASTM D1238]: <1.0 g/10 minutes

B. The raw material from which the LLDPE geomembrane will be made shall be first quality polyethylene resin containing no more than 2 percent clean recycled polymer by weight, and meeting the following specifications:

1. Density [ASTM D1505 or ASTM 792 Method B]: 0.926 g/ml or lower (without carbon black); and

2. Melt Index [ASTM D1238]: <1.0 g/10 minutes

2.02 GEOMEMBRANE

A. The materials supplied under these Specifications shall be first quality industrial grade products designed and manufactured specifically for the purposes of this work, and which have been satisfactorily demonstrated by prior use to be suitable and durable for use in sanitary landfills accepting municipal waste.

B. The geomembrane shall be uniform in thickness and surface texture, and free of undispersed raw materials, streaks, gels, blisters, cracks, tears, or pinholes. Material shall be chemically and temperature stable under the intended conditions, and shall contain no additives or filler that can leach out and cause deterioration over time.

C. The geomembrane properties shall meet the minimum average roll requirements stated in Tables 1 and 2 of GRI Test Method GM13 (latest version) for HDPE geomembrane and Tables 1 and 2 of GRI Test Method GM17 (latest version) for LLDPE geomembrane.

D. Manufacturer's Quality Control (MQC) testing (test methods and frequencies) shall be conducted in accordance with the most recent versions of Tables 1 and 2 of GRI Test Method GM13 for HDPE geomembrane and Tables 1 and 2 of GRI Test Method GM17 for LLDPE geomembrane, or the manufacturer quality control guide, whichever is more stringent.

E. At least seven (7) days prior to the loading and shipment of any geomembrane material, the CONTRACTOR shall provide the CQA Consultant with the following information:

1. The origin (resin supplier's name and resin production plant), identification (brand name, number) and production date of the resin;

2. A copy of the quality control certificates issued by the resin supplier;

3. Reports on the tests conducted by the Manufacturer to verify the quality of the resin used to manufacture the geomembrane rolls assigned to the project. At a minimum, these tests should include density [ASTM D1505 or ASTM 792 method B], and melt index [ASTM D1238]; and

4. A statement that no reclaimed polymer is added to the resin (however, the use of polymer recycled during the manufacturing process may be permitted if done with appropriate cleanliness and if recycled polymer does not exceed 2 percent by weight).

5. The manufacturer's data and samples of the material to be used, giving full details of the minimum physical properties and test methods, as specified herein, certified test reports indicating the physical properties of the materials to be used, and roll numbers and identification.

6. The manufacturer's certificate shall state that the finished material meets MARV requirements of the specification as evaluated under the manufacturer's quality control program. A person having legal authority to bind the manufacturer shall attest the certificate.

2.03 CONFORMANCE TESTING

A. Conformance testing sampling must be performed, prior to shipment to the site, at the manufacturer's facility. The CONTRACTOR shall notify the CQA Consultant at least three

(3) weeks prior to shipment in order to arrange for conformance sampling. No material shall be shipped to the site until conformance sampling has been performed and reports reviewed by the CQA Consultant. When completed, the particular approved lot should be marked for the particular site under investigation. The expressed purpose of in-plant Material Conformance Test Sampling is to verify that geomembrane material designated for the project is confirmed as meeting the project specifications prior to shipment to the site. The Manufacturer shall make available all necessary personnel and equipment to assist the CQA Consultant in retrieving conformance samples of the geomembrane material.

B. Procedures in the Event of a Conformance Test Failure

The following procedure shall apply whenever a sample fails a conformance test conducted by the CQA Laboratory:

1. The Manufacturer shall replace the roll of geomembrane that is in nonconformance with the Specifications with a roll that meets Specifications.

2. The CONTRACTOR shall remove conformance samples for testing by the CQA Laboratory from the next numbered rolls on each side of the failed roll. These two samples must both conform to Specifications. If either of these samples fails, every roll of geomembrane on site and every roll delivered subsequently must be tested by the CQA Laboratory for conformance to the Specifications. This additional conformance testing shall be at the expense of the CONTRACTOR.

2.04 DELIVERY

Transportation and unloading of the geomembrane is the responsibility of the CONTRACTOR. The CONTRACTOR is responsible for the shipping manifests and all other relevant documents. Shipping manifests and all other relevant documents shall be submitted to the CQA Consultant, as the rolls are unloaded from the truck.

2.05 STORAGE

The CONTRACTOR shall be responsible for the storage of the geomembrane on site in an area that is well drained and remains dry during material storage, and is protected from theft, vandalism, passage of vehicles, etc.

PART 3 – EXECUTION

3.01 SUBGRADE PREPARATION

A. The subgrade shall be unyielding, smoothly graded, with no abrupt changes or break in grade, and constructed to elevations indicated on the Contract Drawings. No standing water or excessive moisture shall be allowed. The surface shall be free of loose soil, rocks, roots, sticks, vegetation, sharp objects, debris, frost or other materials. Final compaction shall be with a smooth steel wheel roller.

B. The CONTRACTOR shall inspect the entire subgrade and certify in writing that the subgrade on which the geomembrane shall be installed is acceptable before commencing placement. This inspection shall be performed in the presence of the CQA Consultant. The CONTRACTOR shall repair any defects noted in the underlying material prior to the installation of the geomembrane.

C. Placement of the geomembrane on a saturated subgrade is prohibited. After a rain event, the subgrade shall be given sufficient time to dry or drain to the design moisture content before placing the geomembrane.

3.02 INSTALLATION

The CONTRACTOR shall certify in writing that the surface on which the geomembrane shall be installed is acceptable. The CONTRACTOR shall give the certificate of acceptance to the CQA Consultant prior to commencement of geomembrane installation in the area under consideration.

A. Geomembrane Placement

1. A field panel is the unit area of geomembrane, which is to be seamed in the field, i.e., a field panel is a roll or a portion of roll installed in the field.

2. The CONTRACTOR shall submit to the CQA Consultant a panel layout plan at least 30 days prior to installation.

3. It shall be the responsibility of the CONTRACTOR to ensure that each field panel is marked with the original roll number. The roll number shall be marked at a location agreed upon by the CQA Consultant.

B. Field Panel Placement

1. The CQA Consultant shall verify that field panels installation follows the proposed CONTRACTOR's layout plan, or as approved or modified.

2. The CONTRACTOR shall be responsible for providing calculations verifying the required amount of compensation, which must be installed. .

3. Field panels shall be placed one at a time, and each field panel shall be seamed immediately after its placement (in order to minimize the number of unseamed field panels exposed to wind).

4. It is usually beneficial to "shingle" overlaps in the down slope direction to facilitate drainage in the event of precipitation. It is also beneficial to proceed in the direction of prevailing winds. Scheduling decisions must be made during installation, in accordance with varying conditions. In any event, the CONTRACTOR shall be fully responsible for the decisions made regarding placement procedures.

5. Geomembrane placement shall not proceed at ambient temperatures below 40 degrees Fahrenheit or above 104 degrees Fahrenheit unless otherwise authorized by the CQA Consultant. Geomembrane placement shall not be done during any precipitation, in an area of ponded water, or during excessive winds.

6. The CONTRACTOR shall assure that:
   a. Any equipment used does not damage the geomembrane by handling, trafficking, heat, leakage of hydrocarbons or other means;

   b. The prepared surface underlying the geomembrane has not deteriorated since previous acceptance, and is still acceptable immediately prior to geomembrane placement; any geosynthetic elements immediately underlying the geomembrane are of acceptable cleanliness and are free of debris;

   c. Personnel working on the geomembrane do not smoke, wear shoes which may damage the geomembrane, or engage in other activities which could damage the geomembrane;

   d. The method used to unroll the panels does not cause scratches or crimps in the geomembrane and does not damage the supporting soil;

   e. The method used to place the panels minimizes wrinkles (especially differential wrinkles between adjacent panels);

   f. Adequate temporary loading and/or anchoring using sand bags or other means not damaging the geomembrane, has been placed to prevent uplift by wind. The loading should be continuous along the edges of panels to minimize the risk of wind flow under the panels;

   g. All field seaming and installation of appurtenances (sumps, etc.) are done in accordance with Section 3.02.C; and

   h. Direct contact of equipment with the geomembrane is minimized; i.e., the geomembrane is protected by geotextile, additional geomembrane, or other suitable material, in areas where traffic may be expected.

C. Field Seaming

1. The CONTRACTOR and CQA Consultant shall review the proposed panel layout and reach an agreement on any changes to accommodate field conditions.

2. In general:
   a. Seams should be oriented parallel to the line of maximum slope, i.e., oriented with, not across, the slope.

   b. In corners and other geometrically complex locations, the number of seams should be minimized.

   c. No base seam or tee seam shall be less than 5 feet from the toe of slopes, or areas of potential stress concentrations, unless otherwise authorized by the CQA Consultant.

   d. Panels of geomembrane have a finished overlap, sufficient to allow peel tests to be performed on the seam;

e. No solvent or adhesive is used unless the product is approved in writing by the CQA Consultant (samples shall be submitted to the CQA Consultant for testing and evaluation); and

f. The procedure used to temporarily bond adjacent panels together does not damage the geomembrane (in particular, the temperature of hot air at the nozzle of any spot seaming apparatus is controlled such that the geomembrane is not damaged. "Damage" includes a loss in durability).

3. The finished overlap of the seam shall be sufficient to allow peel tests to be performed. No solvent or adhesive shall be used for temporary bonding unless the CQA Consultant approves the product in writing. The procedure used to temporarily bond adjacent panels together shall not damage the geomembrane. In particular, the temperature of hot air at the nozzle of a spot seaming apparatus shall be controlled such that the geomembrane is not damaged. "Damage" includes a loss in durability.

4. Requirements of Personnel

   a. All personnel performing seaming operations shall be qualified by experience.

   b. Seaming personnel must have seamed at least 2,000 feet of geomembrane seams using the same type of seaming apparatus to be used on this project.

   c. At least one seamer shall have experience seaming a minimum of 20,000 feet of geomembrane seams using the same type of seaming apparatus to be used on this site-specific geomembrane.

   d. The most experienced seamer, the "master seamer," shall provide direct supervision over less experienced seamers.

5. Seaming Equipment and Products

   Approved methods for field seaming are extrusion seaming and fusion seaming. Proposed alternate methods shall be documented and submitted to the CQA Consultant for approval. Only apparatus that has been specifically approved by make and model shall be used. The CONTRACTOR shall use appropriate measuring equipment to ensure that accurate temperatures are being achieved.

6. Extrusion Process

   a. The extrusion-seaming apparatus shall be equipped with gauges giving the relevant temperatures of the apparatus such as the preheat and operating temperature.

   b. The CONTRACTOR shall provide documentation regarding the extrudate to the CQA Consultant, and shall verify that the extrudate is compatible with the Specifications, and is comprised of the same resin as the geomembrane sheeting.

   c. The CONTRACTOR shall perform his work so that:

- Apparatus temperatures, extrudate temperatures, ambient temperatures, and geomembrane temperatures are verified at appropriate intervals;

- Abrading is performed perpendicular to the seam and is completed no more than one hour prior to seaming;

- Abrading of the seam area must not extend beyond either side of the extrusion weld;

- The depth of the abrasion must not exceed 10 percent of the nominal material thickness;

- The extruder is purged prior to beginning a seam until all heat-degraded extrudate has been removed from the barrel;

- The electric generator is placed on a smooth base such that no damage occurs to the geomembrane;

- A smooth insulating plate or fabric is placed beneath the hot seaming apparatus after usage; and

- The geomembrane is protected from damage in heavily trafficked areas.

7. Fusion Process

   a. The fusion-seaming equipment must be an automated roller-mounted device, and equipped with gauges giving the applicable temperatures. The CONTRACTOR shall establish the appropriate machine operating temperature and speed settings by trial seam testing prior to each seaming period.

   b. The CONTRACTOR shall perform his work so that:

      - For tee seam intersections, any flap on the cross seam is cut back to the edge of the outer track of the seam prior to seaming;

      - The electric generator is placed on a smooth base such that no damage occurs to the geomembrane;

      - A smooth insulating plate or fabric is placed beneath the hot seaming apparatus after usage;

      - The geomembrane is protected from damage in heavily-trafficked areas; and

      - Build-up of moisture between the sheets shall be prevented; any moisture shall be wiped dry prior to welding.

8. Weather Conditions for Seaming

   a. The following protocols shall be observed during seaming:

- Unless authorized in writing by the CQA Consultant, no seaming shall be attempted at ambient temperatures below 40°F or above 104°F.

- If geomembrane temperature is below 50°F, pre-heating may be required.

- The geomembrane seaming area shall be dry and protected from wind.

- Ambient temperatures shall be measured 2 inches above the geomembrane surface.

b. If the CONTRACTOR wishes to use methods which may allow seaming at ambient temperatures below 40°F or above 104°F, the CONTRACTOR shall demonstrate and certify that such methods produce seams that are equivalent to seams produced at geomembrane temperatures above 40°F and below 104°F, and that the overall quality and durability of the geomembrane is not adversely affected.

c. In addition, an addendum to the contract between the OWNER and the CONTRACTOR is required to specifically state that the seaming procedure does not cause any physical or chemical modification to the geomembrane that shall generate any short or long-term damage to the geomembrane. Then, the temperatures in the above quality assurance procedure shall be modified.

9. Trial Seams

a. Trial seams shall be made on same geomembrane material that will be used on the project installation to verify that seaming conditions are adequate.

b. At a minimum, test seams shall be made upon each start of work for each seaming crew and upon every four hours of continuous seaming, every time seaming equipment is changed or if significant changes in geomembrane temperature and weather conditions are observed.

c. A trial seam shall also be made in the event that the ambient temperature varies more than 20°F since the last passing trial seam. Trial seams shall be made under the same conditions as actual seams. If any seaming apparatus is turned off for any reason, regardless of the length of time, a new passing trial seam must be completed for that specific seaming apparatus.

d. The trial seam sample shall be at least 2 feet long by 1 foot wide with the sample centered lengthwise.

e. The CONTRACTOR shall cut six (6) specimens, each one (1) inch wide and a minimum of six (6) inches long from the trial seam sample. Three specimens shall be tested in shear and three in peel using a calibrated field tensiometer, and the test results shall meet or exceed the values given in Tables 1 and 2 of GRI Test Method GM19 (latest version). If any specimen fails, the entire operation should be repeated. If the additional seam sample fails, the seaming apparatus and seamer shall not be accepted and shall not be used for seaming until the deficiencies are corrected and two consecutive successful full trial seams are achieved.

10. General Seaming Procedure

Unless otherwise specified, the general seaming procedure used by the CONTRACTOR shall be as follows:

a. Fishmouths or wrinkles at the seam overlaps shall be cut along the ridge of the wrinkle in order to achieve a flat overlap. The cut fishmouths or wrinkles shall be seamed and any portion where the overlap is inadequate shall then be patched with an oval or round patch of the same geomembrane extending a minimum of 6 inches beyond the cut in all directions. If approved by the CQA Consultant, fishmouths or wrinkles may be repaired in the field by the CONTRACTOR.

b. Seaming shall be performed during hours of adequate natural light. If approved by the CQA Consultant, seaming operations may be carried out at night; provided adequate illumination is supplied.

c. Seaming shall extend entire length of panels including the portion placed in the anchor trench.

D. Nondestructive Seam Continuity Testing

1. The CONTRACTOR shall nondestructively test all field seams over their full-length using air pressure test (for double fusion seams only), or other approved method. Vacuum testing and air pressure testing are described in Sections 3.02.D.5 and 3.02.D.6, respectively. The purpose of nondestructive test is to verify the continuity of seams. It does not provide any information on seam strength. Continuity testing shall be carried out as the seaming work progresses, not at the completion of all field seaming. Nondestructive testing shall not be permitted before sunrise or after sunset unless there is, in the opinion of the CQA Consultant, adequate illumination.

2. The CONTRACTOR shall complete any required repairs in accordance with Section 3.02.F.

3. The following procedures applies to segments of seams that cannot be nondestructively tested:

a. All such seam segments shall be capped with the same geomembrane.

c. If the seam is accessible to testing equipment prior to final installation, the seam shall be nondestructively tested prior to final installation.

d. The CQA Consultant and CONTRACTOR shall observe the seaming and cap-stripping operations for uniformity and completeness.

4. Vacuum Testing

a. The equipment shall be comprised of the following:

b. A vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, port hole, valve assembly, and a vacuum gauge;

c. A vacuum tank and pump assembly equipped with a pressure controller and pipe connections; and

d. A pressure/vacuum hose with fittings and connections.

The following procedure shall be followed:

- If vacuum testing a fusion seam, the seam flap must be cut off prior to exposing the seam for testing;
- Energize the vacuum pump and reduce the tank pressure to approximately 5 psi gauge;
- With a soapy solution, wet geomembrane few inches wider and longer than the vacuum box;
- Place the box over the wetted area;
- Close the bleed valve and open the vacuum valve;
- Ensure that a leak-tight seal is created;
- Examine the geomembrane seam through the viewing window for the presence of soap bubbles for a period of not less than 10 seconds;
- If no bubbles or foam appears after 10 seconds, close the vacuum valve and open the bleed valve. Before moving the box over the next adjoining area, place a mark on the geomembrane at the leading edge of the viewing window, then move the box over the next adjoining area so that the last mark on the geomembrane is within the viewing window, and repeat the process; and
- All areas where soap bubbles appear shall be marked and repaired in accordance with Section 3.02.F.

5. Air Pressure Testing (For Double Fusion Seam Only)

a. The equipment shall be comprised of the following:

- An air pump equipped with a pressure gauge capable of generating and sustaining a pressure between 25 and 30 psi;
- A pressure gauge display with one psi increments;
- A hose with fittings and connections; and
- A sharp hollow needle or other approved pressure-feed device.

b. The following procedures shall be followed:

- Seal both ends of the seam to be tested;
- Insert the needle or other approved pressure-feed device into the channel created by the fusion seam;
- Energize the air pump to a pressure between 25 and 30 psi and maintain the pressure for approximately 2 minutes to allow the temperature of the air in the channel to stabilize;
- Close the valve and verify that the pressure is between 25 and 30 psi and observe the pressure for a minimum of 5 minutes;
- If loss of pressure exceeds 3 psi or if the pressure does not stabilize, locate the faulty area and repair it in accordance with Section 3.02.F.
- To verify that there is airflow through the entire channel, the air pressure gauge shall be observed for a decrease in pressure when the technician removes the seal at the end of the channel away from the air pump. If it is found that there is a blockage in the channel, the entire seam must be capped and nondestructively tested; and
- Remove the needle or other approved pressure-feed device and seal the hole.

E. Destructive Testing

1. Destructive seam tests shall be performed at selected locations. The purpose of these tests is to evaluate field seam strength as the seaming work progresses not at the completion of all field seaming.

2. The CQA Consultant shall select locations where seam samples shall be cut out for laboratory testing. These locations shall be established as follows:

   a. A minimum frequency of one sample for every 500 feet of seam.

   b. Test locations shall be determined during seaming at the CQA Consultant's discretion. Selection of such locations may be prompted by suspicion of excess crystallinity, contamination, offset seams, or any other potential cause of imperfect seaming.

   c. The CONTRACTOR shall not be informed in advance of the locations where the seam samples shall be taken.

3. Samples shall be cut by the CONTRACTOR as the seaming progresses in order to have laboratory test results before the geomembrane is covered by other material.

4. All holes in the geomembrane resulting from destructive seam sampling shall be immediately repaired in accordance with repair procedures described in Section 3.02.F. The continuity of

the resulting extruded seams in the repaired area shall be non-destructively tested according to Section 3.02.D.

5. The destructive sample shall be 12 inches wide by 48 inches long with the seam centered lengthwise. The sample shall be cut into three parts and distributed as follows:
   a. One portion, measuring 12 inches x 18 inches, to the CONTRACTOR for field testing;

   b. One portion, measuring 12 inches x 12 inches, to the CQA Consultant for archive storage; and

   c. One portion, measuring 12 inches x 18 inches, for CQA Laboratory testing.

6. Ten 1-inch wide specimens shall be tested in the field, by calibrated gauged tensiometer, five in peel for adhesion and five in shear for shear strength. If any field test sample fails to pass the criteria stated in GRI Test Method GM19 (latest version), then the procedures outlined in Section 3.02.E. shall be followed.

7. The following procedures shall apply whenever a sample fails a destructive test, whether that test is conducted by the CQA Laboratory, the CONTRACTOR's laboratory, or by field tensiometer. The CONTRACTOR has two options:

   a. Reconstruct the seam between any two passed destructive seam test locations.

   b. Trace the seaming path to an intermediate location (at 10 feet - maximum from the point of the failed test in each direction) and take a small sample for an additional field test at each location. If these additional samples pass tensiometer testing, then full destructive laboratory samples should be taken. If these destructive laboratory samples pass the tests, then the seam should be reconstructed between these locations by capping. If either sample fails, then the process is repeated to establish the zone in which the seam should be reconstructed.

8. If a fusion-type seam fails destructive testing and the CONTRACTOR chooses to cap the seam, the only acceptable capping method is as described in Section 3.02.F.4. Applying topping (bead of extrudate) is not an approved method of capping seams.

9. All acceptable reconstructed seams must be bounded by two locations from which destructive samples passing laboratory tests have been taken. In cases exceeding 150 feet of reconstructed seam, a sample shall be taken from the zone in which the seam has been reconstructed. This sample must pass destructive testing or the procedure outlined in this section must be repeated.

F. Defects and Repairs

1. All seams and the geomembrane shall be examined by the CONTRACTOR and the CQA Consultant for identification of defects, penetrating stones, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter. Because light reflected by the geomembrane helps to detect defects, the surface of the geomembrane shall be clean at the time of examination. The geomembrane surface shall be swept or washed by the CONTRACTOR if the amount of dust or mud inhibits examination.

2. Each suspect location shall be nondestructively tested using the methods described in Section 3.02.D. Each location that fails the nondestructive testing shall be marked by the CQA Consultant and repaired by the CONTRACTOR. Work shall not proceed that would cover locations that have been repaired until laboratory results with passing values are available.
3. Any portion of the geomembrane exhibiting a flaw, or failing a destructive or nondestructive test, shall be repaired. Several procedures exist for the repair of these areas. The final decision as to the appropriate repair procedure shall be agreed upon between the CONTRACTOR, and CQA Consultant. The procedures available include:

    a. Patching, used to repair all penetration holes, tears, undispersed raw materials, and contamination by other matter;

    c. Spot seaming, used to repair small scratches, or other minor, localized flaws; and

    d. Capping, used to repair large lengths of failed seams.

4. In addition, the following provisions shall be satisfied:

    c. Surfaces of the geomembrane which are to be repaired shall be abraded no more than one hour prior to the repair;

    d. All surfaces must be clean and dry at the time of the repair;

    d. All seaming equipment used in repairing procedures must be approved;

    e. The repair procedures, materials, and techniques shall be approved in advance of the specific repair by the CQA Consultant, and CONTRACTOR; and

    e. Patches or caps shall extend at least 6 inches beyond the edge of the defect, and all corners of patches shall be rounded with a radius of at least 3 inches.

5. Each repair shall be logged. Each repair shall be nondestructively tested using the methods described in this specification. Repairs that pass the nondestructive test shall be considered acceptable. Failed tests shall require the repair to be redone and retested until a passing test is achieved.

6. When seaming of the geomembrane is completed (or when seaming of a large area of the geomembrane is completed) and prior to placing overlying materials, the CQA Consultant shall observe the geomembrane for wrinkles.

    a. Bridging of the geomembrane shall be considered unacceptable. Compensating materials shall be installed at these locations.

G. Backfilling of Anchor Trench

Anchor trenches must be allowed to drain to prevent ponding and softening of the soils while the trench is open. Anchor trenches shall be backfilled and compacted by the CONTRACTOR. Care shall be taken when backfilling the trenches to prevent damage to the membrane liner system.

H. Acceptance

1. The CONTRACTOR shall retain all responsibility for the geomembrane in the landfill cell or cap until acceptance by the OWNER.
2. The geomembrane shall be accepted by the OWNER when:

   a. The installation is finished.

   b. Verification of all seams and repairs, including testing, is complete.

   c. CONTRACTOR furnishes the CQA Consultant with written warranty in accordance with Section 1.05 of this specification.

   c. All documentation of installation required by the Contract Documents has been received by the CQA Consultant.

   e. The OWNER and CONTRACTOR have signed a certificate of Substantial Completion, and all conditions identified on the certificate have been met for the OWNER to assume responsibility for the geomembrane.

END OF SECTION 13320

SECTION 13400

INTERFACE FRICTION AND SOIL STRENGTH TESTING

PART 1 GENERAL

1.01 REQUIREMENTS INCLUDE

A. Provide personnel, equipment and materials to test materials proposed for use in constructing the facility to ensure the proposed materials are in accordance with applicable design parameters. The cost of all tests required under this Section shall be the responsibility of the CONTRACTOR.

1.02 REFERENCES

A. American Society for Testing and Materials (ASTM)

1. D5321-92 (1998) Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method.
2. D3080-98 Standard Test Method Direct Shear Test of Soils Under Consolidated Drained Conditions.

1.03 TESTING LABORARTORY

A. The testing laboratory shall be accredited to conduct ASTM D5321 in accordance with the Geosynthetic Accreditation Institute Laboratory Accreditation Program (GAI – LAP) at the time of testing. Verification of the accreditation shall be provided to the ENGINEER prior to testing.

PART 2 PRODUCTS

2.01 TEST SAMPLES

A. Soil Materials - Soils used for interface friction and/or soil strength testing shall be representative of those that will be used for construction. If a variation is anticipated in soil characteristics that cannot be appropriately modeled as a composite sample, individual samples of each specific soil material shall be obtained. Obtain a minimum of 75 lbs of each soil for each test.

B. Geosynthetic Materials - Geosynthetics used for interface friction testing shall be representative of those that will be used for construction. Samples shall be obtained from same manufacturer and preferably off of the same rolls anticipated for use in the construction. Obtain a minimum of four samples of each geosynthetic for each test. Take the longest dimension of the samples in the machine direction of the geosynthetic roll.

PART 3 EXECUTION

3.01 SAMPLE PREPARATION

A. Samples to be used for interface friction and soil strength testing shall be collected, transported, stored, and prepared in accordance with all applicable ASTM standards.

B. Prior to shear testing, all soil samples shall undergo index testing in accordance with the following:

TEST NAME	TEST METHOD
Moisture/density relationship	ASTM D698
Atterberg Limits	ASTM D4318
Gradation	ASTM D422 and D1140
USCS Classification	ASTM D2487

C. Prepare samples to appropriately model anticipated field conditions of moisture content and density at which the samples are to be tested.

3.02 LOADING

A. Testing for each interface shall include a minimum of three (3) points corresponding to three (3) compressive loadings. The loadings shall be as specified for each in paragraph 3.03.A below.

3.03 REQUIRED TESTING

A. The following tests are required for this project. Additional testing may be required by the ENGINEER based on material variability and unanticipated conditions.

1. FINAL COVER SYSTEM (ASTM D5321)

a. 40-mil dual textured LLDPE membrane vs. Geosynthetic clay liner (GCL). Normal loads: 250 psf, 1000 psf, and 2000 psf. And a shear rate of 0.2 in/min.

b. 40-mil dual textured LLDPE membrane vs. Geocomposite nonwoven geotextile layer under wet conditions. Normal loads: 250 psf, 1000 psf, and 2000 psf. And a shear rate of 0.2 in/min.

c. Intermediate Cover soil vs. Geocomposite nonwoven geotextile with high end of moisture range and proper compaction. Normal loads: 250 psf, 1000 psf, and 2000 psf. And a shear rate of 0.04 in/min.

d. Protective Cover soil vs. Geocomposite nonwoven geotextile with high end of moisture range and proper compaction. Normal loads: 250 psf, 1000 psf, and 2000 psf. And a shear rate of 0.04 in/min.

e. Geosynthetic clay liner (GCL) vs. Geocomposite nonwoven geotextile. Normal loads: 250 psf, 1000 psf, and 2000 psf. And a shear rate of 0.2 in/min.

2. LINER SYSTEM (ASTM D5321)

a. 60-mil dual textured HDPE membrane vs. clay liner with clay at high end of moisture range and proper compaction. Normal loads: 500 psf, 2500 psf, and 5000 psf. And a shear rate of 0.04 in/min.

b. 60-mil dual textured HDPE membrane vs. Top of GCL-FML liner (bentonite side). Normal loads: 500 psf, 2500 psf, and 5000 psf. And a shear rate of 0.2 in/min.

c. Geotextile cushion vs. FML. Normal loads: Normal loads: 500 psf, 2500 psf, and 5000 psf. And a shear rate of 0.2 in/min.

d. Geotextile cushion vs. Drainage Layer: Normal loads: 500 psf, 2500 psf, and 5000 psf. And a shear rate of 0.04 in/min.

3.04 MATERIAL REQUIREMENTS

A. The peak interface friction angle shall be greater than 25.3 degrees for each interface of the soils and geosynthetics for the bottom liner components and 26.2 degrees for the cover materials to be considered as having acceptable friction characteristics unless otherwise allowed by the ENGINEER.

3.05 TEST RESULTS

A. All test results shall be submitted to the ENGINEER prior to the delivery of the materials to the project.

B. Test reports shall conform to all reporting requirements of ASTM D5321, including, but not limited to: data and results for peak and large-displacement friction angles, a plot of the failure envelopes showing friction angles and adhesion values, and notification of any departure from the test procedures of ASTM D5321.

C. The ENGINEER shall review the test data for conformance with the specifications.

D. The ENGINEER will either accept the test results or require additional testing. The ENGINEER may request up to 5 points per test to define a material property.

E. Acceptance by the ENGINEER shall not relieve the CONTRACTOR from the responsibility of providing material and constructing it in such a way that the required frictional characteristics are obtained.

END OF SECTION 13400

SECTION 15160

LEACHATE PUMPING SYSTEM (SIDE SLOPE PUMP)

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Furnishing and installing the leachate pumping system at the side slope risers as shown on the Drawings.

1.02 SCOPE OF WORK

A. The leachate pumping system outlined in this section shall perform to the design operating requirements within the conditions and dimensions as described and shall be complete and minimally consist of a pump and motor assembly with power cable, system controller and level sensor and cable with gages and meters as required; deployment and retrieval assembly to include pump carriage/sled (with shroud, if necessary); discharge hose/pipe assembly; appropriate exit fittings for gas-tight transition through the sump or riser wall and all appropriate fasteners, fittings and accessories necessary for operation in the service intended.

B. System shall be designed for primary, secondary and or leakage detection service. Multiple systems shall ideally be identical and interchangeable, and if not identical, will share as many identical, similar and interchangeable components and characteristics as practical.

C. The CONTRACTOR is responsible for installing the complete leaching pumping system under the supervision of the manufacturer, and for furnishing, installing and testing all wiring, conduit, fittings, etc. necessary to provide a fully integrated workable system. This includes providing the electrical connections between the existing on-site power service facilities and the pump control panel.

D. All equipment within the leachate extraction pumping system shall be provided by a single manufacturer who shall have sole and complete responsibility for the system without recourse to others. The manufacturer shall be a duly incorporated, licensed and insured entity with a minimum of five (5) years of experience in providing complete leachate extraction pumping systems for landfills and other wastewater applications.

E. The supplier of the leachate removal system shall provide all warranty and warranty services without regard for or dependence on pass through warranties, which may or may not be provided by the original equipment manufacturer (OEM) of various components of the system for a period of sixty (60) months from date of start-up by the manufacturer or authorized representative or eighteen (18) months, if start-up services are performed by others.

F. Any system manufacturer or supplier not specifically named as an approved manufacturer must provide a complete submittal package to the ENGINEER prior to the bid date for pre-approval as an equal system provider. To simplify comparison, the manufacturer seeking approval will provide references and documentation of experience and a thorough technical brief addressing each specifying paragraph as either "no exception taken" (acceptance of both

the fact and spirit of the designer's intent) or "exception taken " with arguments for equality to the specification.

G. It is the designer's purpose to insure that the system is suitable, reliable, and maintainable for the end-user and OWNER in all short and long term respects.

1.03 WARRANTIES

A. The complete pumping system as a whole, inclusive of all provided components, parts, equipment, controllers, instrumentation, assemblies and accessories shall be warranted to be free of defects in material and workmanship for a period of sixty (60) months from date of start-up by the manufacturer or authorized representative or eighteen (18) months, if start-up services are performed by others.

B. If any portion of the system fails due to either materials or workmanship during the applicable period, the manufacturer shall repair, substitute or replace the item at no-charge based on the item's being returned freight pre-paid with a returned materials authorization (RMA) to the system manufacturer for evaluation. The repaired, substituted or replaced item shall be promptly returned to the OWNER freight prepaid by the manufacturer. The system manufacturer will not be liable for a fair wear and tear through service in application or damage to any item caused by abnormal operating conditions, accident, misuse, power surges, ungrounded equipment, acts of God, unauthorized alteration, modification or repair.

C. The manufacturer shall provide reasonable assistance and troubleshooting by telephone at no cost to the OWNER. On-site technical assistance by an engineer or service technician shall be available with compensation to the manufacturer based on time, materials and expenses with pro-rated credit to be issued if a warranty consideration is determined to be merited.

1.04 ANNUAL PUMP MAINTENANCE SERVICES

A. Each submittal will have a proposed Annual Scheduled Maintenance Inspection Agreement for consideration as an optional purchase by the end-user or OWNER.

B. The Agreement will include services to provide an annual inspection, adjustment, calibration and evaluation of the pumping systems for operability, performance, and serviceability, and to conduct routine maintenance as necessary for the pumps, motors and controllers by a complete and thorough electrical and mechanical inspection of the station(s), pump(s), motor(s), accessories and associated first tier (immediate) pump controllers, as well as first hand operator training on first echelon pump inspection and operation techniques.

1.05 SUBMITTALS

A. The submittal package shall include a complete list of components provided; pump curves, motor data, layout drawing, control panel drawings consisting of wiring schematic, bill of materials and component layout drawing, and warranty statement.

PART 2 PRODUCTS

2.01 PUMPS

A. The CONTRACTOR shall furnish and install one complete simplex leachate extraction pumping systems as manufactured by GunnCo Pump and Control Inc of Cumming, Georgia (770-889-7114) or engineer approved equal.

B. Pumps shall be of centrifugal, submersible design suitable for primary landfill leachate. The pump shall be coupled to a submersible motor that is non-overloading throughout the operating curve of the pump.

C. Pumps shall be GunnCo ™ Model Sidesloper P2K-60 or approved equal rated for a minimum duty performance of 60 gallons per minute (GPM) at 95 feet total dynamic head (TDH).

D. Motor horsepower shall be a minimum of one horsepower, and shall operate on 120/240 volt, single phase, 60 hertz supply power. Verify cyclic frequency (hertz) and voltage available at site prior to ordering pump.

E. Pump design shall include the following features:

1. Semi-open, multi-vane hardened 316 stainless steel impeller.
2. Pre-lubricated ball type bearings.
3. All wetted parts to be constructed of 316 stainless steel.
4. All elastomers shall be Viton.
5. A dual mechanical seal of silicon carbide/ceramic working in a separate oil chamber shall be provided with an additional lip seal installed under the oil chamber to inhibit silt, sand and other material intrusion.

2.02 MOTOR DESIGN

A. The motor stator housing shall be air-filled.

B. The motor shall not require the use of oil or grease for lubrication.

C. The motor, located on top of the oil chamber, shall be cooled by use of the pump media around the stator chamber.

D. The motor shall be rated for a minimum of 10 evenly spaced starts per hour and shall be provided with internal thermal protection.

E. A properly sized jacketed power cable suitable for leachate service shall be provided in a length commensurate with the dimensional requirements of the application by field fit by installing contractor. No cable splices will be permitted within the sump or riser for any reason.

2.03 CARRIAGE

A. The pump shall be mounted in a patented 300 series stainless steel carriage/sled shroud for use in a 17 SDR /18-inch diameter HDPE riser pipe with a constant inside diameter set at a 3H to 1V slope.

B. The carriage/sled shall provide a low center of gravity and all wheels shall remain in contact with the inner contour of the riser pipe. The wheels shall be constructed of non-corrosive material with self-lubricating qualities and must be minimum diameter of 6 inches to able to travel over welding beads typically found in riser pipe fabrications.

C. The level sensor shall be carriage/sled mounted and be removable or replaceable without disassembly of the pump assembly or removal of the pump from the carriage/sled.

D. A properly sized sensor cable suitable for leachate service shall be provided in a length commensurate with the dimensional requirements of the application by field fit by installing contractor. No cable splices will be permitted within the sump or riser for any reason.

E. A safety/retrieval assembly with properly sized cable suitable for leachate service shall be provided in a length commensurate with the dimensional requirements of the application by field fit by installing contractor with appropriate dips, snap hooks, and anchor eyebolt constructed of 300 series stainless steel.

2.04 DISCHARGE HOSE

A. Discharge hose shall be 2-inch thermoplastic vinyl nitrile (VNBR) flexible hose having a rated working pressure of 200 to 300 PSI and a temperature range of -20 to +180 degrees Fahrenheit.

B. Hose shall be suitable for leachate service and shall be provided in a length commensurate with the dimensional requirements of the application by field fit by installing contractor.

2.05 DISCHARGE HOSE FITTINGS

A. All hose fittings, bands and accessories shall be 300 series stainless steel and shall be suitable for the application. A stainless steel pump discharge cam and groove connector and companion stainless steel hose shank fitting shall be provided to connect the pump and hose. Fitting shall have a positive locking mechanism.

2.06 EXIT FITTINGS

A. A riser side exit discharge disconnect fitting of 300 series stainless steel shall be provided and positioned within 6 inches to 18 inches of the mouth of the riser to allow quick connection/disconnection of the pump discharge hose within the riser exit, allowing the pump to be removed without the interference of the stationary fittings. The exit arrangement shall thread through the riser pipe with a male threaded nipple as to provide a gas-tight transition to piping outside the riser.

B. Fittings for the power and sensor cables shall be nylon construction non-corrosive and sized for the power and sensor cables provided for the pump.

C. A two-inch stainless steel flow meter tee fitting shall be provided for the installation of the flow meter. Flow tee shall be installed so that the fitting remains full at all times.

2.07 CONTROL PANEL

A. The system controller shall be manufactured and registered by a UL certified UL508, UL913 and UL698 panel shop permitted to make industrial control panels relating to hazardous locations and intrinsically safe apparatus and associated apparatus for use in Class I, II, and III, Division 1, Hazardous Locations. The system controller shall comply with all other necessary requirements dictated and noted by the designer for relevant panel location and service.

B. The unit shall include a primary power TVSS lightning arrestor (UL 1449 listed/40,000 amps/phase and phase indicating LED's), control circuit suppressor (UL 1449 listed) with operational indicating LED, and an instrument signal surge suppressor. The level system shall be intrinsically safe using a dual barrier fused ISB. A plug in type adjustable voltage monitor with operational LED shall be provided to protect against voltage fault conditions. A properly sized circuit breaker for voltage/phase monitor shall be provided on the back plate.

C. The system controller shall provide the means to control and adjust pump operation, provide status information on pump conditions, faults, alarms, level indication and optionally flow indication, and appropriate electrical and motor protection.

D. Control panel shall consist of a NEMA 4X, 14 gauge, 304 stainless steel enclosure (24x30 inch) with lockable outer cover door with an operator viewing window (11x17 inch) and the capability to open a minimum of 180 degrees.

E. The inner door shall be a brushed aluminum dead front mounted on a continuous aircraft type hinge. The dead front door shall contain appropriate mounting of operator accessible controls and status information without exposing the operator to the live internal wiring of the system controller.

F. Operator accessible components mounted on the dead front door shall minimally include following:

1. H-O-A Switch
2. Pump Run Indicating Light (Green)
3. Motor Overload Indicating Light (Red)
4. Digital Level Indicator
5. Elapsed Time Meter
6. Main Disconnect Breaker Switch
7. Pump Breaker Switch
8. Control Circuit Breaker Switch
9. High Level Light
10. Electronic Overload Relay
11. High Level Transfer Station Lockout

G. The back plate shall consist of 12-gauge sheet steel finished with a primer coat and two coats of baked on enamel. All hardware mounted to the sub-panel shall be accomplished with machine thread tapped holes. Sheet metal screws are not acceptable. All devices shall be permanently identified with phenolic engraved nameplates.

H. The panel power distribution shall include all necessary components and shall be completely wired with standard copper conductors. Control wiring shall be property sized and installed in Panduit type wiring trays.

I. An individual circuit breaker shall be provided from main power, each pump, and control circuit. All circuit breakers shall meet or exceed the North America and International Standards: UL, CSA, File No. E19224 Category NLDX and NLDX2; CSA File No. LR353, Class 3211-07, and UL File No. E19223, Category NKCR and NKCR2; GSA File No. LR353, Class 3211-03, plus IEC, VDE, CE and other International Standards as does Cutler Hammer HQP Series thru QCFH Series or equal.

J. Thermal magnetic breakers shall be quick-make and quick-break on manual or automatic operation. Breakers shall have inverse time characteristics secured through the use of bimetallic tripping elements supplemented by a magnetic trip.

K. Breakers shall be designed so that an overload on one pole automatically trips and opens all legs. Field installed handle ties shall not be acceptable.

L. Motor starters shall be open frame, across the line, shall comply with the same above mentioned standards as the breakers and shall be derated by 20%, as does Cutler Hammer CE12 Series thru ECE26 Series with interchangeable bimetallic overload units on each phase. Motor starter contacts and coil shall be replaceable from the front of the starter without removing it from the panel.

M. Individual surge arrestors shall be provided in the control panel for incoming supply power, control circuit and the 4 to 20 mA instrument circuit.

N. A fused type control transformer shall be used to provide the 120 VAC control circuit.

O. Individual surge arrestors shall be provided in the control panel for the primary incoming supply power circuit, secondary control circuit and the tertiary 4 to 20 mA instrument circuit.

P. A top mounted, 40 watt, weatherproof/shatterproof red visual high-level alarm beacon shall be provided.

2.08 LEVEL CONTROL

A. A panel mounted digital readout display controller with 3-1/2-inch digits shall be provided to indicate level in the sump. The pump 'ON', 'OFF" and 'HIGH LEVEL` selections shall be user friendly and capable of being set/adjusted on the front of the unit by means of a screwdriver. The controller shall be capable of accepting a 4 to 20 mA signal from a submersible transducer to provide a level indication range of 0 to 138.6 inches of liquid. When a high level condition occurs, the display will flash until the condition is corrected.

B. A submersible transducer with adequate sized cable shall be provided. The transducer shall be constructed of 300 series stainless steel and shall be mounted to the pump carriage. Transducer shall provide a 4 to 20 mA output signal and come equipped with built-in surge protection. Static accuracy shall be no less than 1.0%.

C. A permanent aneroid bellows type breather device shall be mounted in the control panel to prevent moisture in the vent tube.

D. A panel mounted intrinsically safe barrier shall be provided for the transducer signal.

2.09 ELECTRONIC OVERLOAD RELAY

A. A single phase electronic overload relay shall be provided. Device shall be programmable without requiring auxiliary electronic equipment. The device, in addition to field programming, must be programmable in shop by using 115/120V single phase power. Device must have LED digital readout for programming diagnostics and fault enunciation. The relay, at minimum, must detect high and low voltage and over or under current. The relay, at minimum, must include rapid cycle prevention timer, 45:1 current adjustment range on trip settings, last four faults in memory, programmable tamper guard and five year warranty.

2.10 REMOTE TRANSFER STATION LOCKOUT

A. A transfer station high level lockout shall be provided to inhibit the leachate extraction pump from pumping from the landfill during conditions of high level within the transfer station. The lockout will automatically reset once the liquid level drops and adequate storage capacity is available. Signal from the pump system controller to the tank shall be intrinsically safe.

2.11 ULTRASONIC FLOWMETER

A. An enhanced ultrasonic doppler flow meter capable of measuring clean liquid to liquid with entrained-solids shall be provided. The solid state measurement shall minimize re-calibration requirements and be virtually maintenance free. Mounting shall not require long straight runs of pipe and will be immune to build-ups commonly found in leachate applications.

B. The transducer shall be capable of being clamped on the outside of metal or plastic pipe varying in size from ¼-inch to 10-inches in size. The clamp on, non-intrusive transducers shall be constructed of aluminum, Ultem™ with epoxy encapsulation construction, operating temperature range of -40° to 250°F, and come standard with 20 feet of interconnecting cable enclosed in a flexible armored conduit. Longer lengths shall be provided up to 300 feet.

C. The transmitter shall be mounted in the control panel or mounted in a separate NEMA 4X Enclosure, capable of operating in ambient conditions (-22 to 160°F, 0 to 95% relative humidity, non-condensing). Power requirements shall be 110 VAC. A 4-20 mA isolated output shall be provided as standard for chart trending or data logging capabilities. Transmitter shall be non-linearity ±2%, sensitivity 0.4%, repeatability ±0.4% of full scale and have a standard response time of 5 to 50 seconds or be user configured up to 90% of value step change in flow. Display shall be a backlit LCD providing 2 line by 20 character alphanumeric, eight-digit rate and eight digit totalizer (resetable). Indicators provided shall include power, signal strength, flow analyzer, fault, over-range and read. Units for flow rate (FPS, GPM or MGD) and Totalizer (Gallons) shall be standard or user configured.

2.12 CABLE FITTINGS

A. Non-metallic, compression type threaded cable fittings, properly sized for either the pump power cable or level sensor cable shall be provided for Installation in the riser to provide a gas-tight transition to outside the riser for conduits.

PART 3 EXECUTION

3.01 START-UP

A. The manufacturer or authorized representative of the system manufacturer shall provide field installation assistance, start-up and operator training on the system. The scheduling of this service shall be coordinated by the CONTRACTOR to insure the sideslope riser and sump is completed, the piping and electrical service are in place, the control panel is set and connected to power prior to the manufacturer's on-site start-up visit.

B. A complete operations and maintenance manual with index for the system shall be provided with manufacturer's contact list, equipment list, equipment cut sheets, parts breakdowns, control panel information and a troubleshooting guide.

C. Electric power will be provided to the valve vault area by the Owner. Contractor shall coordinate the power installation with his work and shall be responsible for all connections, disconnects, wiring, conduits and all materials, labor, permits and construction necessary to complete the work.

D. Locate the control enclosure approximately 5-feet above ground and adjacent to the concrete valve vault on aluminum or pressure treated wood supports.

E. Provide smooth surfaces at joints in the HDPE riser pipes to insure that pumps can easily be removed and lowered.

F. A start-up report shall be provided to include all component settings and motor operating characteristics and certification that the system has been properly installed or notes on any deficiencies that need correction or related recommendations.

PART 4 TESTING

Contractor shall test pumps in the presence of the Engineer. Tests shall include demonstrating that the pumps will automatically alternate starts, start, and stop at the water levels indicated on the plans, activate the alarm level indicator, and run simultaneously at the high level. There shall be no visible leaks in the piping during the tests.

END OF SECTION 15160

Section IV
CQA Plan

PREPARED FOR:
WILKES COUNTY DEPARTMENT OF SOLID WASTE
9219 ELKIN HIGHWAY
ROARING RIVER, NORTH CAROLINA 28669

ROARING RIVER LANDFILL
WILKES COUNTY, NORTH CAROLINA
PERMIT NO. 97-04

PHASE 4 EXPANSION

CONSTRUCTION QUALITY ASSURANCE PLAN

JANUARY 2011

PREPARED BY:

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VOLUME 2, SECTION IV
CONSTRUCTION QUALITY ASSURANCE PLAN (CQA)

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TABLES

Table 1 - Soil Testing Methods and Frequencies

1.0 INTRODUCTION

1.1 PURPOSE

This plan addresses the construction quality assurance (CQA) procedures and requirements to be employed during construction of the project. The plan is intended to supplement, but not supersede, the Contract Drawings and Specifications; where a conflict arises, the Contract Documents or approved Contract Drawings and Specifications shall govern.

All parties involved in the project should obtain a copy of this plan from the OWNER or ENGINEER. They should also obtain copies of any supplemental CQA documents prepared specifically for the project.

The overall goals of the CQA program are to ensure that proper construction techniques and procedures are employed, and to verify that the materials used meet the approved Contract Specifications. Additionally, the program shall identify and define problems that may occur during construction, allowing corrective activities to be implemented in a timely manner. At the completion of the work, the program requires the certifying CQA Consultant(s) to prepare certification reports indicating that the facility has been constructed in accordance with the approved design standards and Contract Specifications.

1.2 DEFINITIONS

The following definitions are applicable to this plan:

1.2.1 Quality Control

Definition (ASTM D3740): - a planned system of activities, or the use of such a system, whose purpose is to provide a level of quality that meets the needs of users. The objective of quality control is to provide quality that is safe, adequate, dependable, and economical. The overall system involves integrating the quality factors of several related steps including: the proper specification of what is wanted, production to meet the full intent of the specification, inspection to determine whether the resulting material, product, service, etc… is in accordance with the Specifications, and review of usage to determine necessary revisions of Specifications.

In practice, Quality Control refers to those procedures, criteria, and tests employed and paid for by the CONTRACTOR(s) to confirm that the work satisfies the CONTRACTOR's standards, and is in compliance with the Contract Drawings and Specifications. This plan does not address Quality Control procedures, criteria, and/or tests employed by the CONTRACTOR.

1.2.2 Quality Assurance

Definition (ASTM D3740): - a planned system of activities whose purpose is to provide assurance that the overall quality control program is in fact being effectively implemented. The system involves a continuing evaluation of the adequacy and effectiveness of the overall quality control program with the ability to have corrective measures initiated where necessary. For a specific material, product, service, etc…, this involves verifications, audits, and the evaluation of the quality factors that affect the specification, production, inspection, and use of the product, service, system, or environment.

In practice, Quality Assurance refers to those procedures, criteria, and tests required and paid for by the OWNER to confirm that the work performed by the CONTRACTOR(s) is in compliance with the approved Contract Drawings and Specifications and any additional requirements of this plan.

1.2.3 Layer

A layer is defined as a compacted stratum composed of several lifts constructed without joints.

1.2.4 Lift

A lift is defined as a segment of a layer composed of the maximum thickness of soil permitted to be placed / compacted at one time.

1.3 PARTIES

1.3.1 OWNER

The OWNER is the owner of the solid waste permit, and bears the ultimate responsibility for the facility; the OWNER may or may not also be the Operator of the facility. The OWNER shall contract and manage the CONTRACTOR(s), and the CQA consultant(s) and laboratories. For this project, the Coastal Regional Solid Waste Management Authority is the OWNER.

1.3.2 ENGINEER

The ENGINEER is the official representative of the OWNER, and is responsible for the preparation of the Contract Drawings, Technical Specifications, and CQA Plan. The ENGINEER is also responsible for the interpretation of those documents and for the resolution of technical matters that may arise during construction. For this project, the ENGINEER is Joyce Engineering, Inc.

1.3.3 CQA Consultant

The CQA Consultant is independent from the CONTRACTOR(s), Manufacturer, and Installer, that is responsible for observing, testing, and documenting activities related to the Quality Assurance of the earthwork and geosynthetic components at the site. The CQA Consultant corresponds with the ENGINEER throughout the project and shall report deviations from the Work and items of non-compliance. The CQA Consultant is also responsible for issuing a certification report, sealed by a registered Professional Engineer, licensed in the State in which the project work is conducted.

1.3.4 Soils CQA Laboratory

The Soils CQA Laboratory is independent from the CONTRACTOR(s), and Supplier, responsible for performing the required laboratory testing of the project earthwork components.

1.3.5 Geosynthetic CQA Laboratory

The Geosynthetic CQA Laboratory is independent from the CONTRACTOR(s), Manufacturer, and Installer, responsible for performing the required laboratory testing of the project geosynthetic materials.

1.3.6 CONTRACTOR

The CONTRACTOR has the primary responsibility for ensuring that the work is performed in accordance with the Contract Drawings and Specifications developed by the ENGINEER and approved by the permitting agency. Other responsibilities include the performance of all construction activities at the site including site facilities, administration, material purchasing, procurement, supervision, Construction Quality Control, installation, and subcontracting. The CONTRACTOR is responsible for the protection of completed work until it is accepted by the OWNER. The CONTRACTOR is also responsible for informing the OWNER and CQA Consultants of the scheduling and occurrence of all construction activities.

1.3.7 Geomembrane Manufacturer(s)

The geomembrane manufacturer is responsible for the production of geomembrane rolls from resin.

1.3.8 Geomembrane Installer(s)

The Geomembrane Installer is responsible for the handling, sorting, placing, seaming, loading and other construction-related aspects of the project geosynthetics. The Installer is also responsible for transportation of the materials to the site, and the protection of the materials once they arrive on site, until the work is accepted by the CONTRACTOR.

1.3.9 Surveyor

The Surveyor is responsible for establishing and maintaining lines and grades and temporary benchmarks throughout all relevant areas of the construction site. The Surveyor shall issue a complete set of Record Drawings certified by a Professional Land Surveyor, licensed in the State in which the project work is conducted.

1.4 COMMUNICATIONS AND MEETINGS

Frequent and open communications are a necessary and essential component of this plan in order to achieve a high degree of coordination, cooperation, and quality in the finished product, and to minimize or avoid delays. It is one goal of this plan to resolve problems at the lowest possible level of authority while maintaining thorough documentation, informing all responsible parties, and obtaining approvals as necessary or appropriate. The documentation requirements of CQA activities are addressed in various sections of this plan. A series of meetings shall be held before, during, and after construction to facilitate planning, progress reports and problem resolution. Minutes are to be kept of all meetings as directed by the ENGINEER. The meetings shall be as follows unless otherwise directed by the OWNER:

- Preconstruction Meeting to be held as directed by the ENGINEER and to be attended by the OWNER or Owner's Representative, CQA Consultant, CONTRACTOR, significant subcontractors and suppliers as designated by the ENGINEER.
- Progress Meetings to be held as directed by the ENGINEER and to be attended by the OWNER or Owner's Representative, CQA Consultant, CONTRACTOR, and representatives of parties actively involved in the construction as designated by the ENGINEER.
- Post-Construction Resolution Meeting to be attended by the OWNER or Owner's Representative, CQA Consultant, CONTRACTOR, significant subcontractors and suppliers as directed by the ENGINEER.

2.0 EARTH MATERIALS

2.1 INTRODUCTION

This section of the plan describes Construction Quality Assurance (CQA) procedures for the installation of the earth material components of the project.

2.2 SCOPE

2.2.1 General

The work addressed under this section shall facilitate proper construction of all earth material components of the project. All work shall be constructed to the lines, grades, and dimensions indicated on the approved Contract Drawings, in accordance with the Contract Specifications, or as required by the OWNER or OWNER's Representative.

2.3 EARTH MATERIALS CQA TESTING

2.3.1 General

Assurance that construction of the earth material components of the project has been performed in accordance with the approved Contract Drawings and Specifications shall be accomplished by use of CQA testing and visual observations.

CQA testing shall consist of the following:

- Construction Quality Evaluation; and
- Special Testing.

2.3.2 Construction Quality Evaluation Testing

Construction quality evaluation shall be performed on all components of earthwork construction at the frequencies shown in Table 1. Criteria to be used for determination of acceptability of the work shall be as identified in the Contract Specifications and as detailed in this plan. Construction evaluation testing shall consist of visual observations of the work, in-place density/moisture content verification, investigations into the adequacy of layer bonding and clod destruction, elevation and thickness monitoring, and special testing. Evaluation of the construction work shall include the following:

- Observations and documentation of the water content, clod size and other physical properties of the soil during processing, placement and compaction;
- Observation and documentation of each compacted lift's ability to accept and bond to subsequent lifts;
- Observation and documentation of the thickness of compacted and loosely placed lifts;
- Observation and documentation of the performance of the compaction and heavy hauling equipment on the construction surface (sheepsfoot penetration, pumping, cracking, etc…); and
- Observation and documentation of the effectiveness of the procedures used to prevent desiccation and/or freezing of completed lifts and layers.

The in-place density test methods shall cause minimal delay to the placement of subsequent lifts; therefore, the nuclear method is preferred unless construction sequencing is such that fill placement is not interrupted by sand cone or drive cylinder testing. An acceptable test for soils

used in structural or "controlled fill" applications (i.e. embankments, berms, backfill, soil liner, subgrade, etc.) shall be defined as one, which meets or exceeds the specified minimum density within the specified moisture range.

If there is any question as to the classification of the tested soil, and hence the appropriateness of a given moisture-density plot, a "one-point" Standard Proctor compaction test shall be performed for comparison with the available plots. The optimum moisture content and maximum dry density extrapolated from the one-point test result must fall on or near the plotted line of optimums for the classification of a soil to be confirmed. For controlled fill, the reference maximum dry density can be adjusted to accommodate the one-point data.

Questions concerning the accuracy of any single test shall be addressed by retesting in that or another representative location. Periodic sand cone or drive cylinder testing shall be performed to verify the adequacy of the nuclear gauge testing at the frequencies designated in Table 1. If a conflict exists between the sand cone or drive cylinder testing and the corresponding nuclear density test results, then the sand cone and/or drive cylinder results shall control.

It is important to bond lifts together to the greatest extent possible. Bonding of lifts is enhanced by:

- Ensuring that the surface of the previously compacted lift (or subgrade) is rough before placing the new lift of soil;
- Adding moisture to the previously compacted lift (or subgrade); and
- Using a fully penetrating footed roller.

Evaluation of lift bonding in soil liner and similar applications shall be done by using test pits or auger holes to visually observe the lift interfaces. Alternatively, Shelby tubes pushed through the lift interfaces can be visually inspected for proper lift bonding.

2.3.3 Test Pad

A test pad shall be constructed as outlined in the project specifications to develop and demonstrate construction methods that shall be used to produce a compacted soil liner/cap satisfying the requirements of the specifications.

2.4 DOCUMENTATION/CERTIFICATION

2.4.1 General

The CQA Consultant shall document the activities associated with the construction of the earth material components of the project. Such documentation shall include, as a minimum, daily reports of construction activities and a summary technical report on the construction project.

Documentation and reporting shall meet all requirements of the Contract Specifications and this CQA Plan.

2.4.2 Construction Monitoring

Construction of earth material components of the project shall be monitored and documented by a CQA Consultant. Soils laboratory testing shall be performed and documented by an independent testing laboratory working under the direction of the CQA Consultant.

Written daily documents shall include a record of observations, test data sheets, identification of problems encountered during construction, corrective measures taken, weather conditions, and personnel and equipment on site.

2.4.3 Certification

The CQA Consultant(s) shall prepare a certification report addressing each major item identified above for each phase of construction under their areas of responsibility. Certification reports required by regulatory agencies shall also be prepared and submitted as required.

Certification shall include assessments of compliance with the Contract Drawings and Specifications and the results of the physical sampling and testing. At a minimum, the certification report shall include:

- Copies of all daily CQA field reports;
- Results of all field testing including drawings depicting the locations of construction testing when appropriate;
- Results of all laboratory testing;
- Photographic record of the project including representative photographs of each major construction activity; and
- Certification statement assessing compliance with the Contract Drawings and Specifications, sealed by a professional engineer, licensed in the State in which the project work is conducted.

3.0 GEOSYNTHETICS

3.1 INTRODUCTION

This section of the plan describes Construction Quality Assurance (CQA) procedures for the installation of all geosynthetic components of the project. This section is devoted to Quality Assurance, not to Quality Control. A separate geosynthetic Quality Control manual shall be submitted by the CONTRACTOR in accordance with the Shop Drawings Submittals of the project.

3.2 SCOPE

3.2.1 General

The work addressed under this section shall facilitate proper construction of all geosynthetic components for the project. All work shall be constructed to the lines, grades, and dimensions indicated on the Contract Drawings, in accordance with the Contract Specifications, and as required by the ENGINEER, OWNER, or the CQA Consultant.

The CQA Consultant shall issue a written daily report of activities. These reports shall include observations and test results as well as problems encountered and solutions achieved. Construction reports summarizing significant events, as well as addressing problems and their solutions, shall be submitted to the CQA Consultant.

3.2.2 Installation

The CQA Consultant shall verify that the geosynthetics are installed in accordance with the Contract Drawings and Specifications.

3.3 GEOMEMBRANE MANUFACTURE, FABRICATION, AND DELIVERY

3.3.1 Geomembrane Manufacturing

The geomembrane shall be manufactured from a first quality resin. Only one type of resin (one manufacturer, one resin classification) shall be used to manufacture the geomembrane for this project. In addition, all geomembrane used for this project shall be from the same batch unless otherwise approved in writing by the CQA Consultant and the installer or manufacturer agree to pay for any additional conformance testing required.

3.3.2 Manufacturing

3.3.2.1 Submittals

The CQA Consultant shall verify that:

- The property values certified by the Manufacturer meet all of the Specifications; and
- The measurements of properties by the Manufacturer are properly documented, the test methods used are acceptable, and the geomembrane meets the Manufacturer's and project specifications

3.3.2.2 Rolls

The CQA Consultant shall verify that the manufacturer's quality control certificates have been provided at the specified frequency for all rolls, and that each certificate identifies the rolls related to it, and review the manufacturer's quality control certificates and verify that the certified roll properties meet the Specifications.

3.3.2.3 Conformance Testing

3.3.2.3.1 In-Plant Material Conformance Test Sampling

The CQA Consultant shall arrange for the CQA Laboratory to sample the geomembrane material in-plant and ship these samples to their laboratory for conformance testing as outlined in the project specifications.

The CQA Consultant shall report any nonconformance of sampling procedures as outlined in the project specifications to the ENGINEER.

The expressed purpose of in-plant Material Conformance Test Sampling is to verify that geomembrane material designated for the OWNER'S project is confirmed as meeting the project Specifications prior to shipment to the site. The Manufacturer shall make available all necessary personnel and equipment to assist the CQA Consultant in retrieving conformance samples of the geomembrane material.

Sampling Procedures

The samples will be taken from selected rolls and cutting full-width, 3 feet long, samples from the outer wrap of the selected roll(s). The outer revolution of geomembrane shall be discarded before the test sample is taken. The sample rolls must be relabeled for future identification. The CQA Consultant shall mark the roll direction on the samples with an arrow.

Unless otherwise specified, samples shall be taken at a rate of one per batch or one per 100,000 ft^2, whichever is the most frequent.

Test Procedures

Conformance testing shall be conducted in accordance with the test methods stated in Tables 1 and 2 of GRI Test Method GM13 (latest version) for HDPE geomembranes and Tables 1 and 2 of GRI Test Method GM17 (latest version) for LLDPE geomembranes and include the following properties:

- Density;

- Carbon black content;
- Carbon black dispersion;
- Melt index;
- Thickness;
- Tensile strength;
- Tear resistance; and
- Asperity height.

3.3.2.4 Test Results

The CQA Consultant shall examine all results from laboratory conformance testing and shall report any nonconformance to the ENGINEER.

3.3.2.4.1 Procedures in Event of a Conformance Test Failure

The procedures described in the project specifications shall be followed. The CQA Consultant shall document actions taken in conjunction with conformance test failures.

3.3.3 Delivery

3.3.3.1 Transportation and Handling

The CQA Consultant shall verify that:

- Handling equipment used on the site does not damage the geomembrane; and
- The Installer's personnel handle the geomembrane with care.

Upon delivery at the site, the Installer and the CQA Consultant shall conduct a surface observation of all rolls for defects and for damage. This examination shall be conducted without unrolling rolls unless defects or damages are found or suspected.

- Rolls, or portions thereof, which should be rejected and removed from the site because they have severe flaws; and
- Rolls which include minor repairable flaws.

3.3.3.2 Storage

The CQA Consultant shall verify that the geosynthetic materials staging area is well draining, that the materials are covered, protected and stay dry during storage.

3.4 GEOMEMBRANE INSTALLATION

3.4.1 Earthwork

3.4.1.1 Surface Preparation

The CONTRACTOR shall be responsible for preparing the supporting soil according to the Specifications.

The CQA Consultant shall verify that:

- A qualified land surveyor, licensed in the State in which the project work is conducted, has verified all lines and grades;
- That the supporting soils meet the density specification and provide a firm foundation;
- Surface of the subgrade has been prepared and has been certified as acceptable to the Installer; and
- The surface is generally free of irregularities, rocks, sticks, roots, loose soil, and abrupt changes in grade which may cause damage to the geomembrane and require its repair after deployment;

In general, at any time before and during the geomembrane installation, the CQA Consultant shall indicate to the CONTRACTOR locations, which may not provide adequate support to the geomembrane.

3.4.2 Geomembrane Placement

3.4.2.1 Field Panel Identification

It shall be the responsibility of the CQA Consultant to ensure that each field panel shall be given an "identification code" (number or letter-number) consistent with the layout plan. This field panel identification code should be as simple and logical (manufacturing roll numbers are usually cumbersome and are not related to location in the field).

3.4.2.2 Field Panel Placement

3.4.2.2.1 Location

The CQA Consultant shall verify that field panel installation follows the Installer's layout plan, as approved or modified.

3.4.2.2.2 Installation Schedule

The CQA Consultant shall:

- Evaluate every change in the schedule proposed by the Installer.
- Verify that the condition of the supporting soil has not changed detrimentally during installation.
- Record the identification code, location, and date of installation of each field panel.

3.4.2.2.3 Weather Conditions

Geomembrane placement shall not proceed:

- At ambient temperatures below 40°F or above 104 °F unless authorized by the CQA Consultant.
- During any precipitation, in an area of ponded water, or during excessive winds.

The CQA Consultant shall verify that the above conditions are fulfilled. Additionally, the CQA Consultant shall verify that the supporting soil has not been damaged by weather conditions.

3.4.2.2.4 Method of Placement

The CQA Consultant shall verify that:

- Any equipment used does not damage the geomembrane by handling, trafficking, heat, leakage of hydrocarbons or other means;
- The prepared surface underlying the geomembrane has not deteriorated since previous acceptance, and is still acceptable immediately prior to geomembrane placement; any geosynthetic elements immediately underlying the geomembrane are of acceptable cleanliness and are free of debris;
- All personnel working on the geomembrane do not smoke, wear shoes which may damage the geomembrane, or engage in other activities which could damage the geomembrane;

- The method used to unroll the panels does not cause scratches or crimps in the geomembrane and does not damage the supporting soil;
- The method used to place the panels minimizes wrinkles (especially differential wrinkles between adjacent panels);
- Adequate temporary loading and/or anchoring using sand bags has been placed to prevent uplift by wind. The loading should be continuous along the edges of panels to minimize the risk of wind flow under the panels;
- All field seaming and installation of appurtenances (sumps, etc.) are done in accordance with the plans and Specifications; and
- Direct contact of equipment with the geomembrane is minimized; i.e., the geomembrane is protected by geotextile, extra geomembrane, or other suitable materials, in areas where heavy traffic may be expected.

3.4.2.2.5 Damage

The CQA Consultant shall visually examine each panel, after placement and prior to seaming, for damage. Damaged panels or portions of damaged panels, which have been rejected, shall be marked, and their removal from the work area recorded by the CQA Consultant. Repairs shall be made according to procedures described in the project specifications.

As a minimum, The CQA Consultant shall ensure that each panel is placed in such a manner that it is unlikely to be damaged, and any tears, punctures, holes, thin spots, etc., are marked for repair or the panel is rejected.

3.4.3 Field Seaming

3.4.3.1 General Seaming Procedure

The CQA Consultant shall verify that the seaming procedures listed in the project specifications are followed.

- The CQA Consultant shall log all appropriate temperatures and conditions, and shall log and report any non-compliance.
- The CQA Consultant shall observe all trial seam procedures and log the date, hour, ambient temperature, number of seaming unit, name of seamer, and pass or fail description. Additional samples may be cut from the remainder of the trial seam to be archived by the OWNER, and/or tested by the CQA Laboratory or CQA Consultant.

3.4.3.2 Seam Preparation

The CQA Consultant shall verify that:

- Prior to seaming, the seam area is clean and free of moisture, dust, dirt, debris of any kind, and foreign material;
- If seam overlap grinding is required, the process is completed according to the Manufacturer's Specification, and in a way that does not damage the geomembrane; the depth of the abrasion must not exceed 10 percent of the nominal material thickness;
- Seams are aligned without wrinkles and "fishmouths".

3.4.3.3 Weather Conditions for Seaming

The CQA Consultant shall verify that the weather conditions are suitable for seaming or determine if the installation should be stopped or postponed.

3.4.3.4 Overlapping and Temporary Bonding

The CQA Consultant shall verify that:

- The panels of geomembrane have a finished overlap, sufficient to allow peel tests to be performed on the seam;
- No solvent or adhesive is used unless the product is approved in writing by the ENGINEER (samples shall be submitted to the ENGINEER for testing and evaluation); and
- The procedure used to temporarily bond adjacent panels together does not damage the geomembrane (in particular, the temperature of hot air at the nozzle of any spot seaming apparatus is controlled such that the geomembrane is not damaged. "Damage" includes a loss in durability).

3.4.4 Nondestructive Seam Continuity Testing

The CQA Consultant shall:

- Observe continuity testing;
- Record location, date, time, name of tester, and outcome of all testing; and
- Inform the Installer of any required repairs.

The Installer shall complete any required repairs in accordance with the project specifications.

The CQA Consultant shall:

- Observe the repair and re-testing of the repair;
- Mark on the geomembrane that the repair has been made; and
- Record location, date, time, name of tester, and outcome of all testing.

3.4.5 Destructive Testing

3.4.5.1 Sampling Procedure

The CQA Consultant shall:

- Observe sample cutting;
- Assign a number to each sample, and mark it accordingly; record the reason for taking the sample at this location (e.g., statistical routine, suspicious feature of the geomembrane).

3.4.5.2 Field Testing

The CQA Consultant shall witness field tests and mark samples and portions with their number. The CQA Consultant shall also log the date and time, number of seaming unit, name of technician, seaming apparatus temperatures and speeds, pass or fail description.

3.4.5.3 Construction Quality Assurance Laboratory Testing

Destructive test samples shall be packaged and shipped by the CQA Consultant to the CQA Laboratory. The CQA Consultant shall be responsible for storing the archive samples. Test samples shall be tested by CQA Laboratory.

Testing shall follow GRI Test Method GM19. The minimum acceptable values to be obtained in these tests are those indicated in GRI Test Method GM19.

The CQA Laboratory shall provide test results within 24 hours after they receive the samples. The CQA Consultant shall review laboratory test results as they become available.

3.4.5.4 Destructive Sample Pass/Fail Criteria

The CQA Consultant shall document all laboratory results for destructive samples to assure that they meet the requirements set forth in the project specifications and GRI Test

Method GM19.

3.4.5.5 Procedures for Destructive Test Failure

The CQA Consultant shall document all actions taken in conjunction with destructive test failures to verify that they meet the requirements set forth in the project specifications.

3.4.6 Defects and Repairs

3.4.6.1 Verification of Repairs

The CQA Consultant should observe nondestructive testing of repairs and record the date of the repair and test outcome.

3.4.6.2 Large Wrinkles

The CQA Consultant shall indicate which wrinkles should be cut and repaired by the Installer. The repair thus produced shall be tested like any other repair.

3.4.7 Backfilling of Anchor Trench

The CQA Consultant shall observe the backfilling operation.

3.4.8 Lining System Acceptance

The CQA Consultant shall verify that installation has proceeded in accordance with the CQA Plan for the project.

3.4.9 Materials in Contact with the HDPE Geomembrane

3.4.9.1 Soils

The CQA Consultant shall verify that the Specifications are consistent with the state of practice such as:

- Placement of soils on the geomembrane shall not proceed at an ambient temperature below 40°F nor above 104°F unless otherwise specified;
- A geotextile or other cushion approved by the ENGINEER may be installed between a drainage layer and the geomembrane;
- Equipment used for placing soil shall not be driven directly on the geomembrane;

- A minimum thickness of 1 foot of drainage material is specified between a light dozer (such as a wide pad Caterpillar D-5 or lighter) and the geomembrane;
- A minimum thickness of 4 feet of soil/stone is specified between rubber-tired vehicles and the geomembrane; and
- In heavily trafficked areas such as access ramps, soil/stone thickness should be at least 4 feet.
- Verify the required soil thickness; and that placement of soil is done in such a manner that geomembrane damage is unlikely.

3.4.10 Sumps and Appurtenances

The CQA Consultant shall review the Specifications and verify the use of geosynthetic layers between structures and geomembrane.

The CQA Consultant shall verify that:

- Installation of the geomembrane in sump and appurtenance areas, and connection of geomembrane to sumps and appurtenances have been made according to Drawings and Specifications;
- Welding around appurtenances is complete since neither non-destructive nor destructive testing may be feasible in these areas; and
- The geomembrane has not been visibly damaged while making connections to sumps and appurtenances.

3.5 GEOTEXTILES

3.5.1 Manufacturing

The CQA Consultant shall examine all manufacturer certifications to ensure that the property values listed on the certifications meet or exceed those specified for the particular type of geotextile.

3.5.2 Labeling

The CQA Consultant shall examine rolls upon delivery and note any deviation from the requirements listed in the project specifications.

3.5.3 Shipment and Storage

The CQA Consultant shall observe rolls upon delivery at the site and note any deviation from the requirements listed in the project specifications. Any damaged rolls shall be rejected and replaced at no additional cost to the OWNER.

3.5.4 Conformance Testing

3.5.4.1 Tests

In-Plant Material Conformance Test Sampling

The CQA Consultant shall arrange for the CQA Laboratory to sample the geotextile material in-plant and ship these samples to their laboratory for conformance testing as outlined in the project specifications.

The CQA Consultant shall report any nonconformance of sampling procedures as outlined in the project specifications.

NOTE: All geotextiles used for this project shall be from the same lot unless otherwise approved by the CQA Consultant. The manufacturer or supplier shall perform additional conformance testing, at no additional cost to the OWNER.

3.5.4.2 Sampling Procedures

The samples will be taken from selected rolls by removing the protective wrapping and cutting full-width, 1-m-long (3-ft-long) samples from the outer wrap of the selected roll(s). The outer revolution of geotextile is to be discarded before the test sample is taken. The sample rolls must be relabeled for future identification. Items to be considered are the following:

- The conformance test samples shall be identified by type, style, or lot and roll numbers. The machine direction should be noted on the sample(s) with a waterproof marker.
- A lot is defined as a unit of production, a group of other units, rolls having one or more common properties, and being readily separable from other similar units.
- Unless otherwise stated, sampling should be based on one per lot or one per 100,000 sq ft, whichever is greater.

3.5.4.3 Test Procedures

Conformance testing shall be shall be conducted in accordance with the most recent versions of GRI Test Method GT12(a) for geotextile cushions and GRI Test Method

GT13(a) (moderate survivability) for geotextile separators, and include the following properties:

Mass per unit area
Grab tensile strength
Trapezoidal tear strength
Puncture strength
Permittivity*
Apparent opening size*

*Only if geotextile is to be used as a filter/separator

3.5.4.4 Test Results

The CQA Consultant shall examine all results from laboratory conformance testing.

3.5.4.5 Conformance Test Failure

The CQA Consultant shall document actions taken in conjunction with conformance test failures as outlined in the project specifications.

3.5.5 Handling and Placement

The CQA Consultant shall note any noncompliance to the project specifications.

3.5.6 Seams and Overlaps

The CQA Consultant shall note any noncompliance to the project specifications.

3.5.7 Repair

The CQA Consultant shall observe any repair, note any noncompliance with the requirements listed in the project specifications.

3.5.8 Placement of Soil Materials

The Installer shall place cover soil materials on top of a geotextile in such a manner as to ensure no damage to the geotextile such as slippage on underlying layers, and tensile stresses in the geotextile.

3.6 GEOCOMPOSITE

3.6.1 Manufacturing

The CQA Consultant shall examine all manufacturer's certifications to ensure that the property values listed on the certifications meet or exceed those specified.

3.6.2 Labeling

The CQA Consultant shall examine rolls upon delivery and note any deviation from the requirements listed in the project specifications.

3.6.3 Shipment and Storage

The CQA Consultant shall verify that geocomposite materials are free of soil and dust before installation and shall record the observation of this verification. Washing operations shall be observed by the CQA Consultant.

3.6.4 Conformance Testing

3.6.4.1 Tests

In-Plant Material Conformance Test Sampling

The CQA Consultant shall arrange for the CQA Laboratory to sample the geocomposite material in-plant and ship these samples to their laboratory for conformance testing as outlined in the project specifications.

The CQA Consultant shall report any nonconformance of sampling procedures as outlined in the project specifications.

NOTE: All geocomposite used for this project shall be from the same lot unless otherwise approved by the ENGINEER. The manufacturer or supplier shall perform additional conformance testing, at no additional cost to the OWNER.

As a minimum, the following tests shall be performed on geocomposite:

Geotextile apparent opening size
Geotextile puncture strength
Geocomposite transmissivity

3.6.4.2 Sampling Procedures

The samples will be taken from selected rolls by removing the protective wrapping and cutting full-width, 1-m-long (3-ft-long) samples from the outer wrap of the selected roll(s). The outer revolution of geocomposite is to be discarded before the test sample is taken. The sample rolls must be relabeled for future identification. Items to be considered are the following:

- The conformance test samples shall be identified by type, style, or lot and roll numbers. The machine direction should be noted on the sample(s) with a waterproof marker.
- A lot is defined as a unit of production, a group of other units, rolls having one or more common properties, and being readily separable from other similar units.
- Unless otherwise stated, sampling should be based on one per lot or one per 100,000 sq ft, whichever is greater.

3.6.4.3 Test Results

The CQA Consultant shall examine all results from laboratory conformance testing.

3.6.4.4 Conformance Test Failure

The CQA Consultant shall document actions taken in conjunction with conformance test failures as outlined in the project specifications.

3.6.5 Handling and Placement

The CQA Consultant shall note any noncompliance to the project specifications.

3.6.6 Repair

The CQA Consultant shall observe repairs, note any noncompliance to the project specifications.

3.6.7 Placement of Soil Materials

Any noncompliance to the project specifications shall be noted by the CQA Consultant.

If portions of the geocomposite are exposed, the CQA Consultant shall periodically place marks on the geocomposite and the underlying geomembrane and measure the elongation of the geocomposite during the placement of soil.

3.7 GEOSYNTHETIC CLAY LINER (GCL)

3.7.1 Storage

Geosynthetic clay liner rolls must always be stored in a location where they shall not be exposed to moisture.

3.7.2 Handling & Placement

On slopes, geosynthetic clay liners should be placed with overlap oriented parallel to the maximum slope (i.e. down the slope).

Adjoining panels of geosynthetic clay liners should be overlapped a minimum of six inches (6").

Geosynthetic clay liners should never be installed in standing water or during rain.

Geosynthetic clay liners should always be installed with appropriate side up.

Rolls should be pulled tight to smooth out any creases or folding.

Precautions should be taken to avoid damage to any underlying geosynthetic materials while placing the geosynthetic clay liners.

Cover geosynthetic clay liners with geomembrane or other cover materials after placement to avoid damage from precipitation.

3.7.3 Repairs

Repairs to cuts or tears in installed material should extend a minimum of six inches (6") beyond the area in need of repair. Repair pieces should be held in place until cover material has been placed.

4.0 LEACHATE COLLECTION PIPING

4.1 INTRODUCTION

This section of the plan addresses the quality assurance of the installation of all pipes and manholes used on the project in the leachate collection and removal system (LCRS) including, leachate collection pipes and leachate transmission pipes.

4.2 SCOPE

4.2.1 General

The work addressed under this section shall facilitate proper construction of all LCRS piping installed in or outside the disposal cells on the project. All work shall be constructed to the lines, grades, and dimensions indicated on the project plans, in accordance with the project specifications, or as required by the OWNER and ENGINEER. The CQA Consultant shall issue a written daily report of activities. These reports shall include, as a minimum, observations and test results as well as problems encountered and solutions achieved. Construction reports summarizing significant events, as well as addressing all problems encountered and their solutions, shall be issued weekly to the OWNER and ENGINEER. The format of these reports shall be established at the pre-construction meeting.

4.3 MANUFACTURING AND DELIVERY OF MATERIALS

4.3.1 Pipe, Fittings, and Manholes

It is a requirement of the contract that prior to delivery of materials, the CONTRACTOR shall submit detailed or shop drawings and manufacturer's specifications of all materials to be furnished for the project. These drawings and specifications shall be reviewed by the ENGINEER to determine if the materials meet the requirements of the contract specifications. The submittals shall be either approved or rejected. Rejection shall require a resubmission of the information.

4.3.2 Delivery

Upon delivery, the CQA Consultant shall inspect all pipes, fittings, and other appurtenances for conformity with the specifications and proper storage. The CQA Consultant may prescribe corrective repairs or may reject the material as deemed necessary.

4.4 INSTALLATION OF PIPES AND MANHOLES

4.4.1 Testing

Testing shall be done on sections of pipeline as determined ready for testing by the CQA Consultant.

4.4.1.1 Examination of Materials

All pipes, fittings, manholes, and other appurtenances shall be examined carefully for damage and other defects immediately before installation. Defective materials shall be marked and the deficiency shall be corrected or the material shall be rejected and replaced as deemed necessary by the CQA Consultant.

4.4.1.2 Alignment and Gradient

The alignment of the pipe shall be surveyed by a surveyor licensed in the State in which the project work is conducted.

Alignment and gradient of gravity leachate pipes between manholes shall also be checked by the CQA Consultant by sighting from one manhole to a bright light held at the next manhole. Should alignment vary horizontally more than 1/4 the diameter of the pipe, that is, sags and rises be found in the grade, the CONTRACTOR shall locate and correct the defective joints to the satisfaction of the CQA Consultant.

4.4.1.3 Leak Testing of Leachate Transmission Lines

4.4.1.3.1 Infiltration Test

Infiltration test shall be performed only when the line is below the water table to provide a minimum of four feet of head above the top of the pipe at the highest elevation being tested. A weir shall be installed in the lower end of the section being tested and measurement of the depth of flow over the weir recorded at 15-minute intervals for one hour.

4.4.1.3.2 Exfiltration Test

Exfiltration test shall be performed after replacement of broken or cracked pipe, repair of defective joints, and verification of the pipe installation for line and grade, and after cleaning and conditioning the pipe free from deposits, joint drippings, extrusions, or from foreign matter of any kind. Each section of line between manholes, or for longer distances if allowed before backfilling, shall be maintained completely full of water for a period of not less than 30 minutes to allow for absorption of water by the sewer. By use of pre-installed riser sections of pipes at manholes if necessary, or by plumbers plugs and riser, a column of water shall then be maintained at least four feet above the uppermost top section of pipe under test for lines with grades of one percent or less, and to one inch above the crown of the upper end of the pipe, for grade between one to five percent, and as the CQA Consultant directs, for greater grades. In case the water table in the trench at the time of the test is above the highest invert of the sewer section under test, the column of water above specified shall be accordingly increased.

4.4.1.3.3 Air Test

Air test shall be performed on all leachate transmission lines with grade greater than five percent as outlined below.

Conduct air test when pipe is clean. Plug line at each manhole with pneumatic balls. Introduce low pressure air into plugged line until internal air pressure reaches 4.0 psig greater than average back pressure of any groundwater pressure that may submerge the pipe. Allow at least two minutes for air temperature to stabilize before readings are taken and timing started.

Portion being tested shall pass if it does not lose air at a rate to cause pressure to drop from 3.6 to 3.0 psig (greater than average back pressure of any groundwater that may submerge the pipe) in less time than listed below:

Pipe Diameter in Inches	Minimum Allowable Minutes 3.6 - 3.0 psig Pressure
8 or less	4.0

In lieu of standard exfiltration test, CONTRACTOR may make air tests on lines.

4.4.1.3.4 Infiltration - Exfiltration Test

Infiltration - exfiltration test shall be made by the CONTRACTOR immediately upon completion of the first run of pipe between two manholes, under the direction of the CQA Representative. The remainder of the sewer installation may be tested as the work progresses or upon completion of the project at the option of the CONTRACTOR.

4.4.1.3.5 Leakage

Acceptance of line shall not be made until test requirements have been met. If leakage is detected, CONTRACTOR shall locate and repair defects until leakage is eliminated.

4.4.1.4 Pipe Bedding and Backfill

The gradation and compaction of pipe bedding shall be tested by the contractor to verify compliance with contract specifications.

4.5 INSTALLATION OF DRAINAGE LAYER

4.5.1 Testing

Hydraulic conductivity and grain size will be tested according to Table 1. Additionally the Contractor shall provide test results, as indicated in the Specifications to ensure density, particle size,

hydraulic conductivity and shear strength meat the required parameters. The CQA consultant will review test result and approve of material prior to placement.

4.5.2 Placement

The Contractor is required to provide surveys in accordance with Specification 01720 to demonstrate that the drainage stone was installed to the specified thickness.

5.0 DOCUMENTATION

5.1 Daily Reports

The CQA Consultant shall complete a daily report and logs on prescribed forms, outlining all of the monitoring activities for that day. The area, panel numbers, and seams completed, and measures taken to protect unfinished areas overnight should be identified. Failed seams or other panel areas requiring remedial action must be identified with regard to nature of action, required repair, and location. Repairs completed must also be identified. Any problems or concerns with regard to operations on site should also be noted.

5.2 Record Drawings

Contractor(s) shall provide Record Drawings of installed components including, as applicable:

- Scaled drawing of the completed installation of geomembrane;
- Panels shown and labeled in their relative locations;
- Location of all destructive test samples;
- Location of all geomembrane repairs;
- Leachate piping;
- Landfill gas wells;
- Landfill gas piping.

The Project Record Drawings shall address each layer of soil liner, geomembrane and drainage layer for landfill liner expansion, or intermediate cover, geomembrane, and final cover soil for landfill closure; and if necessary, another drawing that identifies problems or unusual conditions of the geotextile or geocomposite layers. In addition, applicable cross-sections shall show layouts of geocomposite and geotextile that are unusual or different from the design drawings.

5.3 Final Certification Report

A Final Certification Report shall be prepared by the CQA Consultant and submitted upon completion of the work. This report shall include all reports prepared by the CQA Consultant personnel, summarize the activities of the project, and document all aspects of the quality assurance program performed. The Final Certification Report shall include as a minimum the following information:

- Personnel involved with the project;
- Scope of work and outline of project;
- Quality assurance methods;
- All test results, including failed ones (destructive and non-destructive, including laboratory tests);
- Descriptions of deviations from the approved plans and of corrections to remediate the deviation;
- Series of color photographs of major project features;
- Certification sealed and signed by a registered Professional Engineer licensed in the State in which the project work is conducted.
- Record Drawings, sealed and signed by a registered Surveyor or Professional Engineer, licensed in the State in which the project work is conducted.

END OF CONSTRUCTION QUALITY ASSURANCE PLAN

TABLES

TABLE 1 - SOIL TESTING METHODS AND FREQUENCIES

Test Method	Fill		Test Pad		Soil Liner/Cap	Drainage Layer	
	Pre-Construction	Construction	Pre-Construction	Construction	Construction	Pre-Construction	Construction
Particle Size Analysis of Soils ASTM D422	One/Material	One/Material[1]	One/Material	NA	NA	NA	1/10,000 CY[2]
Unified Soil Classification System ASTM D2487	One/Material	One/Material[1]	One/Material	NA	NA	NA	NA
Moisture Content of Soil Lab Method ASTM D2216	One/Material	One/Material[1]	One/Material	NA	NA	NA	NA
Atterberg Limits ASTM D4318	One/Material	One/Material[1]	One/Material	NA	NA	NA	NA
Specific Gravity ASTM D854	One/Material	One/Material[1]	One/Material	NA	NA	NA	NA
Standard Proctor ASTM D698	One/Material	One/Material[1]	One/Material	NA	NA	NA	NA
In-place Density by Sand Cone ASTM D1556 or Drive Cylinder ASTM D2937	NA	1/Acre	NA	1/Lift	1/Lift/Acre	NA	NA
In-place Density and Water Content by Nuclear Method ASTM D6938	NA	5/Acre	NA	5/Lift	5/Lift/Acre	NA	NA
Soil Moisture By Direct Heating ASTM D4959	NA	1/Acre	NA	1/Lift	1/Lift/Acre	NA	NA
Undisturbed Hydraulic Conductivity ASTM D5084	NA	NA	NA	1/Lift	1/Lift/Acre	NA	NA
Laboratory Compacted Hydraulic Conductivity ASTM D5084	NA	NA	One/Material	NA	One/Material	NA	One/Material
Two-Stage Field Permeameter ASTM D6391 (VA liner only)	NA	NA	NA	One/TP	NA	NA	NA

NA – Not Applicable
(1) required only if material changes
(2) for each material provided

Section V
Operations Plan

PREPARED FOR:
WILKES COUNTY DEPARTMENT OF SOLID WASTE
9219 ELKIN HIGHWAY
ROARING RIVER, NORTH CAROLINA 28669

ROARING RIVER LANDFILL
WILKES COUNTY, NORTH CAROLINA
PERMIT NO. 97-04

PHASE 4 EXPANSION

OPERATIONS PLAN

JANUARY 2011

PREPARED BY:

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VOLUME 2, SECTION V
OPERATION PLAN

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Appendix V-4 Compost End User Brochure

DRAWINGS

Drawing No. OP-T Title Sheet
Drawing No. OP-L Legend and General Notes
Drawing No. OP-01 Existing Conditions
Drawing No. OP-02 Phasing Plan: Years 1-5

1.0 GENERAL

This operation plan describes how the design and construction plans will be implemented during the life of the facility. The plan consists of drawings and accompanying text which illustrate existing conditions, cell progression, waste placement and daily operations, leachate management, special waste management, buffer zones and soil borrow procedures.

The Wilkes County Landfill is owned and operated by Wilkes County. Approximately 200 tons of municipal solid waste is managed daily at the site which is located off Highway 268 in Roaring River. The facility began accepting waste in October 1993 when lined Phase 1 began operating. Wastes are currently placed in the approximate 6.5 acre Phase 3 cell. Leachate collected from Phases 1, 2, and 3 is stored in a lined surface impoundment, and then transported to the Wilkesboro Wastewater Treatment Plant for disposal.

Other on-site development consists of a scale house and office, maintenance building, recycling area, wood disposal area, and a soil borrow area. Much of the remainder of the site is wooded. See Drawing OP-1 for an illustration of the existing conditions at the site.

2.0 OPERATIONS DRAWINGS

2.1 Existing Conditions

The site existing conditions is presented on Drawing No. OP-01 and currently includes the following components:

- Active MSW landfill
- Convenience center (drop-off area for recyclables and waste)
- Office and maintenance building
- Weighing scales
- Tire collection area
- White goods collection area
- Land clearing debris collection area
- Yard trash collection and compost area

The drawing also shows the limits of the existing waste disposal area, the environmental monitoring system, the landfill entrance road, landfill access and perimeter roads, scale house, and office. Current topography for the property is shown, as well as the neighboring residence and wells, the 300-foot buffer from the property line, and other site features.

2.2 Proposed Site Development

Development of Phase 4 is presented on Drawing No. OP-02. The construction of the Phase 4 disposal area described in the Engineering Plan consists of 6.7 acres.

The components listed in the existing conditions section above are included in this drawing in addition to the leachate holding pond, force main line, and overhead electrical.

The on-site soil resources, usage, and balances are shown in Table 3 of the Facility Plan. The deficit of soil during the operation of Phase 3 can be satisfied by excavating from the large stockpile on the southern end of Phase 6.

2.3 Operations

The progression of operations for Phase 4 is presented on Drawing No. OP-02. This drawing includes the progression of initial waste placement, transition contours, and final contours.

3.0 GENERAL OPERATING CONDITIONS

3.1 Hours of Operation

The landfill is open to private waste haulers and the public from 7:00 a.m. to 5:00 p.m. and the convenience center hours are 7:00 a.m. to 6:00 p.m. Monday through Saturday. The following holidays are observed: New Year's Day, Martin Luther King Day, Easter, Memorial Day, July 4, Labor Day, Veterans Day, Thanksgiving, Christmas Eve and Christmas Day.

3.2 Site Access and Safety

Access to the landfill is controlled through a single access road with a secure gate to prevent access when the landfill is not open. A sign containing information required in Rule .1626(6)(e), (i.e., dumping procedures, hours, permit number, etc.) is posted at the landfill entrance. During the hours of operation, traffic is routed from the entrance gate and scale house to a gravel road leading to the disposal area. Directional signs and speed limit signs are posted to provide traffic control. The road is maintained so that it is passable during all weather conditions. An attendant is on duty at the scale house at all times during operating hours.

3.3 Waste Acceptance

The landfill will accept only those solid wastes included in the current permit, including household, commercial and industrial solid wastes. These are defined in Rule .1602 as follows:

- Household waste means any solid waste derived from households including single and multiple residences, hotels and motels, bunkhouses, ranger stations, crew quarters, campgrounds, picnic grounds, and day-use recreation areas.

- Commercial solid waste means all types of solid waste generated by stores, offices, restaurants, warehouses, and other nonmanufacturing activities, excluding residential and industrial wastes.

- Industrial solid waste means solid waste generated by manufacturing or industrial processes that is not a hazardous waste regulated under Subtitle C of RCRA. Such waste may include, but is not limited to, waste resulting from the following manufacturing processes: electric power generation; fertilizer/agricultural chemicals; food and related products/by-products; inorganic chemicals; iron and steel manufacturing; leather and leather products; nonferrous metals manufacturing/ foundries; organic chemicals; plastics and resins manufacturing; pulp and paper industry; rubber and miscellaneous plastic products; stone, glass, clay, and

concrete products; textile manufacturing; transportation equipment; and water treatment. This term does not include mining waste or oil and gas waste.

Neither spoiled food, hatchery waste, nor other animal waste has been received historically in quantities large enough to be problematic for operations. In the event that such wastes are received, they will be immediately buried and covered with a thick layer of soil followed by nonputrescible municipal solid waste. If asbestos waste is received, it shall be managed in accordance with 40 CFR 61. The waste will be disposed of at the bottom of the working face and covered immediately with soil in a manner that will not cause asbestos particles to become airborne.

On or before August 1 of each year, Wilkes County will report to the Solid Waste Section the amount of waste received in tons at this facility and disposed of in the landfill units. Data will be transmitted on forms prescribed by the Section. The report will include the following:

- The reporting period shall be for the previous year beginning July 1 and ending on June 30.
- The amount of waste received and landfilled in tons, compiled on a monthly basis by county or transfer station of origin and by specific waste type if diverted to a specific unit within the permitted facility; and
- The completed report shall be forwarded to the Regional Waste Management Specialist for the facility. A copy of the completed report shall be forwarded to the County Manager of each county from which waste was received.

3.4 Prohibited Waste

A sign is posted at the landfill gate (see Section 2.B above) that reads "No hazardous or liquid waste accepted without written permission from the Division of Solid Waste Management". The landfill will not accept:

- hazardous waste as defined within 15A NCAC 13A, including hazardous waste from conditionally exempt small quantity generators;

- Polychlorinated biphenyl (PCB) wastes as defined in 40 CFR 761;liquid wastes (i.e., any waste material that is determined to contain "free liquids" as defined by SW-846 Method 9095 (Paint Filter Liquids Test), unless the waste is household waste other than septic waste or waste oil, or leachate or gas condensate derived from the landfill (however, leachate and gas condensate may only be recirculated in cells with liner constructed as described in Rule .1624(b)(1)(A)(i).); and

- barrels and drums unless they are empty and sufficiently perforated, except fiber drums containing asbestos;

- other wastes specifically banned from landfill disposal by rule or statute, such as lead acid batteries, whole tires, used oil, aluminum cans, wooden pallets, oil filters, plastic bottles, discarded computer equipment and televisions, or oyster shells.

Wilkes County will notify the Division within 24 hours of attempted disposal of any waste the landfill is not permitted to receive, including waste from outside the area the landfill is permitted to serve. The waste screening program is described later in this Operation Plan.

3.5 Special Wastes

The landfill accepts "special waste" such as tires, white goods, and wood waste. These special waste are separated from the general disposal area.

The tire collection shall be managed in accordance with Solid Waste Management Regulations Section .1100. Section .1107 provides detailed scrap tire collection site operational requirements.

1) Scrap tires stored indoors shall meet conditions for the Standard for Storage of Rubber Tires, NFPA 231-D1986 by the National Fire Protection Association.
2) All scrap tire collection sites processing tires outdoors must comply with technical and operational standards (2)(a) through (2)(l) of the Section .1107.
3) Processed tires shall be stored in accordance with the requirements of indoor/outdoor storage rules (a) temperature rules, and (b) residuals from the scrap tire disposal.
4) The Division may approve exceptions to the technical and operational standards (a) at least once during 30-day period all scrap tires are removed from the site for disposal; and (b) the site owner has sufficient fire suppression equipment or materials on-site to extinguish potential fire.

Tires are collected at the designated tire collection area and placed in a trailer for transportation to disposal. The County contracts with a private hauler to transport the tires to an approved facility for recycling and/or disposal.

White goods are separated from the general waste and stored for salvage by a private recycler. The landfill's recycling area handles cardboard, mixed paper, old newsprint, aluminum, steel cans, used motor oil and plastic.

Clean, untreated wood waste (largely pallets) is separated and stored on-site until it can be recycled or ground for mulch. C&D waste that is not appropriate for recycling or mulching is currently disposed in the lined landfill.

3.6 Litter Control

The public judges a landfill site by the things that they see. While there is no way to catch every piece of paper, scattered and blowing litter can be minimized by keeping the size of the working face small and by covering parts of the cell as it is constructed. Some measures that may be taken to minimize litter are:

a. Unload vehicles at the base of the working slopes to use the working face itself as a wind screen.

b. Unloading against the wind can help to keep the load compacted until the loader can push the waste onto the working face.

c. Add a thin layer of cover material to the compacted working face periodically throughout windy days to help

d. Heavier waste materials can be used on the surface to help keep lighter waste materials from dislodging or becoming airborne.

e. Temporary litter fences strategically located on the working face help intercept and trap blowing litter. Any litter recovered from such fences, as well as litter blown into adjacent areas shall be collected and landfilled at the conclusion of each day of operation. Multiple defenses of temporary fences and/or berms help to contain windblown material during operations. In addition, landfill personnel will pick up windblown litter along the access road and in locations around the active disposal area.

3.7 Equipment

The following list of equipment is currently in use at the landfill for current operations averaging approximately 200 tons of waste disposed per day (TPD_6):

Type	Model	Quantity
Trucks	Rolloff Truck	1
	Road Tractor with Dump Trailer	1
	Articulated Truck	1
Compactors	CAT 826G or Equivalent	1
	Back-up	1
Bulldozer	Cat D6 or Equivalent	1
Excavator	Cat 320BL or Equivalent	1
Loader	Cat 963C Trackloader or Equivalent	1
	Bobcat Skidsteer Loader	1
Other	Motorgrader	1
	General Purpose Tractor	1
	Hydroseeder	1

As the waste stream changes during the operational life of the facility, equipment needs will be periodically reviewed and additional equipment purchased or leased as needed. New equipment will be phased in as older equipment is retired.

3.8 Air Quality

Open burning of solid waste including yard waste and brush is prohibited at the landfill. Burning of brush and/or stumps would only be requested on an infrequent basis in conjunction with construction events and approved by the Section in accordance with Rule .1626(5)(b) prior to burning activities taking place.

3.9 Dust, Odor, Fire and Vector Control

Dusty road surfaces will be sprayed with water from a water truck during windy, dry weather. Odors and disease vectors will be controlled by promptly covering the waste at the working face, and by the use of daily cover. Daily cover is described in more detail in a subsequent section.

Incoming waste loads shall be observed by site operators for evidence of fire such as flames, smoke, or the odor of burning material. Burning loads will be extinguished before dumping if possible. If there is evidence of fire in the landfill itself, the Wilkes County Solid Waste Director will be notified immediately. If possible, the waste will be removed or segregated from other waste in the disposal area. The landfill operator will evaluate the situation to determine whether the fire can be extinguished using fire extinguishers or equipment present at the site, or if off-site equipment will be needed. If necessary, the local fire department (Roaring River Volunteer Fire Department) will be called to render assistance in extinguishing the fire. Fires that occur at the landfill will be reported verbally to the Division within 24 hours and in writing within 15 days.

Fire extinguishers shall be located on each piece of equipment on site. Equipment operators shall be trained in the use of these extinguishers. Fire extinguishers will be used for small, localized fires. A stockpile of soil shall be maintained near the working face to be used for extinguishing small surface fires that may be too large to control with the fire extinguishers carried on the landfill equipment.

Emergency equipment will be called in the case of fires too large to be extinguished with fire extinguishers or soil as described above. Water contained in sedimentation ponds and the Yadkin River can serve as emergency reservoirs to aid local firefighters in the extinguishing of larger fires.

3.10 Scavenging/Salvaging

The unauthorized removal of waste and scavenging at the landfill is prohibited. Removal of recyclable or reusable items is sometimes authorized when recovery of such items can be accomplished with no risk to landfill staff or the general public, for instance, prior to disposal on the working face. Landfill personnel may remove salvageable materials and place them at the recycling center for removal by others. The general public is not allowed to scavenge items from the working face, and landfill staff attempts to prevent them from coming in contact with waste. The placement of additional roll-off containers near the scalehouse should help keep residential users from coming in contact with the waste.

3.11 Type 1 Composting Facility

3.11.1 Waste Quantities

Wilkes County receives yard waste from Wilkes County this waste consists of yard and garden waste, silvicultural waste, untreated and unpainted wood waste. The facility may receive up to 175 tons of this type of waste per month.

Accurate records of incoming waste should be kept at the scale house. These records should differentiate between loads of brush (including all land clearing debris), clean wood, and loads of leaves or grass clippings.

3.11.2 Design Considerations

Design Capacities and Product Quality

The facility currently receives an average of 100 tons per month of compostable waste. This waste is stockpiled until sufficient material is available to produce a windrow.

The following table summarizes the design criteria used to verify adequate space at the facility for the composting operation. As a factor of safety, it was assumed that the density of the product remains the same as the incoming waste stream.

Total waste stream (by weight)	1,000 tons (annual)
Total waste stream for composting (95%)	950 tons
Density (assumed average)	500 lb/cubic yard
Composting waste stream (by volume)	3,800 cubic yards (102,600 ft^3)
Cross-section windrow 2' (top) x 15' (base) x 5' (ht)	42 square feet
Total length windrow required	2,500 feet
At 100' length	25 windrows needed annually
With 15' base and 10' aisle, total acreage required	0.25 acres maximum (running 3 windrows at a time)

The site is designed with a working area for the Type 1 facility of approximately 0.25 acres as illustrated on Drawing No. OP-01. Sufficient room is available for the operations.

Site Plan

The composting facility is located northeast of the active cell. The location is shown on Drawing No. OP-01.

The grinding and composting area shown on Drawing No. OP-01 has an approved Erosion and Sediment Control Plan that diverts stormwater. The area will continue to operate under the guidelines of the approved plan.

3.11.3 Operations

General Description

Incoming yard waste is weighed and directed to the mulching operational area. The yard waste is stockpiled until a sufficient quantity is accumulated to form a windrow. On average approximately one windrow can be formed weekly. The material is run through a tub grinder which can process all incoming waste. Once ground, the material is formed into windrows using a front end loader. The windrows are spaced approximately 10 feet apart and each has a

north/south orientation and the following geometry: 5 feet high x 15 feet wide at base x 2 feet wide at top.

Once the windrow is formed, it will be turned several times using a front end loader to mix the materials. If necessary, water will be added as the windrow is constructed and then periodically during the stabilization process. The pile will be sprayed as it is turned on an as needed basis. For optimum composting the moisture should be maintained between 45% and 60%. Dryer than 45% and the microbial action is slowed; higher than 60% and the material becomes difficult to handle and difficult to aerate.

The temperatures are taken at a minimum of each third (3 separate places) of the windrow. It is suggested that the temperature be controlled by turning (aerating) to assure that the compostable material is maintained at an optimum range for decomposition (between 104°F and 113°F) and then allowed to elevate to 131°F where it must be maintained for a period of 3 consecutive days as required by Rule .1406(10). When the temperature within the windrow falls below 120 °F – 130°F during the final stages of composting, the windrow is turned. Windrow construction and turning frequency will be sufficient to maintain aerobic conditions to produce a compost product in the desired time frame. Separate records are kept for each windrow. Once a windrow is constructed, it is assigned an I.D. number and folder which are used over the lifespan of the windrow. Every time windrow data is taken, it is documented and logged in the folder.

A nitrogen source may be added to the yard waste as needed to promote the compost process. The County uses calcium nitrate when necessary. The calcium nitrate is spread by hand and mechanically mixed.

The process from grinding though stabilization is expected to take 4 weeks. The final time frame is a function of material density, material type, moisture and operational controls.

Once the windrow begins to cool indicating stabilization, the County removes the larger particles are reuses them in the process or used as woodchips or mulch. By keeping the coarser materials in the compost, it enables more oxygen to get into the windrows and produces more compost in the finished product. The compost is now stockpiled. Depending on the end use requirements, the compost may be screened again prior to stockpiling if a finer screen is available. The larger particles would be either reused in the process or used as a coarser product.

If the material is free of sharp particles, has no offensive odor, and has minimal pathogens, it may be used in an unrestricted way.

Once the compost meets the regulatory requirements for distribution to the public, it can be released for use. As the public obtains the material they must be given the information indicated in Section 3.11.8.

3.11.4 Waste Acceptance Rule .1406 (6)

The Type 1 compost facility shall accept only yard and garden waste, silvicultural waste, untreated and unpainted wood waste. No municipal solid waste (MSW), hazardous waste,

asbestos containing waste, or medical waste shall be accepted at the facility. The County accepts yard waste in a non-bagged state or in approved biodegradable bags. Deliveries are monitored at the site. The County anticipates little contamination of the material.

3.11.5 Monitoring Requirements Rule .1406 (9)

The windrows are monitored for temperature daily. A log will be kept of all temperature readings, which includes the location of the probes. A copy of the temperature log is contained in Appendix V-4.

Moisture should be kept in the range of 45% - 60%. Water should be added as required to stay within this range. Temperature will be monitored daily until readings of 131°F are achieved for three (3) consecutive days. To monitor temperature, the probe should be inserted 12"- 24" every 50' along the windrow at a 45° - 90° angle.

3.11.6 Temperature Parameters Rule .1406 (10)

For Type I facilities, the compost process must be maintained at or above 55°C (131°F) for 3 consecutive days and aerated to maintain elevated temperatures.

3.11.7 Addition of Nitrogen Bearing Materials Rule .1406 (13)

Nitrogen compounds may be added as necessary to adjust the nutrient balance for optimum product development. Only approved waste materials (i.e. grass clippings, leaves) or chemical compounds may be added. Nitrogen rich materials can decompose rapidly and cause odor problems. Materials such as grass clippings must be incorporated into the process as soon as possible.

To determine if nitrogen is necessary, the carbon to nitrogen ratio should be calculated. For proper composting, this ratio should be greater than 25:1, but less than 40:1 at the start of composting. Incoming materials have the following estimated ratios:

- Grass clippings 12 - 15:1
- Dry leaves 40:1
- Paper and wood 200:1
- Sawdust 200 - 500:1

Thus, adjustment may be necessary after grinding, screening and blending the feedstock materials.

3.11.8 Classification/Distribution of MSW Compost Products Rule .1407

Requirements

For unrestricted use, the finished Type I compost must meet the following criteria:

- Minimal pathogenic organisms
- Free from offensive odors
- Containing no sharp particles
- Man made inerts do not exceed 1 inch in size

If these criteria are met then the finished compost material will be marketed to residents of the County and surrounding areas with directions provided.

Labeling

When the Type 1 compost material is to be marketed to the public, sufficient information should be provided to the public to:

- Inform users of the benefits of using compost
- Advise users on suggested uses of product
- Inform users of cautions in using product
- Inform users of composition of the material including nutrients and contaminants
- Inform users of source of feedstock

Appendix VI-5 includes samples of informative brochures that may be provided to the end user.

4.0 RANDOM WASTE SCREENING PROGRAM

4.1 Authority

The Wilkes County Solid Waste Department has developed this "Random Waste Screening Program" in accordance with North Carolina's Solid Waste Management Regulations, Rule .1626(1)(f). Key elements of Rule .1626(1)(f) addressing waste screening are as follows:

No hazardous or liquid wastes as defined in 15A NCAC 13A or materials shall be accepted at the landfill except as specifically authorized by the facility permit or by the Division. The owner or operator shall implement an inspection program to detect and prevent disposal of hazardous and liquid wastes and polychlorinated biphenyls (PCB). This program shall include, at a minimum:

- Random inspections of incoming loads unless the owner or operator takes other steps to ensure that incoming loads do not contain regulated hazardous or liquid wastes or PCB wastes;
- Records of any inspections;
- Training of facility personnel to recognize regulated hazardous waste, liquid waste, and PCB wastes; and
- Development of a contingency plan to properly manage any identified hazardous and/or liquid wastes.

4.2 Random Selection

Random selection of vehicles to be inspected will be conducted on a regular basis, depending on personnel available. At least one vehicle per week, but not less than one percent by weight of the waste stream (based on the previous week's total), will be randomly selected at the working face by the personnel conducting the inspection. A random truck number and time will be selected (e.g., the tenth load after 10:00 a.m.) on the day of inspections.

4.3 Record Keeping

Report forms for record-keeping purposes are included in Appendix V-1. These forms are completed at each inspection. All reports and resulting correspondence are maintained at the Wilkes County Landfill office for the life of the landfill and during the post-closure period.

4.4 Training

Inspections will be carried out and supervised by landfill staff trained to identify and manage hazardous and liquid waste. Landfill operators responsible for screening waste are trained by attending the Waste Screening training course offered by the Solid Waste Association of North America.

4.5 Inspection Site Location

Inspections will be conducted in a designated area near the working face of the landfill.

4.6 Action Plan

The following action plan details the procedure for conducting random waste inspections.

1) Dump single load in prepared area. Detain truck and driver until inspection is completed.

2) Spread waste with compactor and/or hand tools as appropriate. Hand rake loads that include items such as large closed containers to avoid possible rupturing of the containers. Have appropriate safety equipment present. Minimum safety equipment will include:

- Rubber gloves;
- Rubber boots;
- Safety glasses; and
- Long handled hoe.

3) Examine waste for excluded waste and/or safety hazards:

- Containers labeled hazardous;
- Excessive or unusual moisture;
- Regulated biomedical (red bag) waste;
- Powders, dusts, smoke, vapors, or chemical odors;
- Sludges, pastes, slurries, or bright colors (such as dyes); and
- Unauthorized out-of-County waste.

4) Take appropriate action(s) as follows:

- Incorporate acceptable waste into working face.

- Hold suspect waste for identification by on-site personnel and, if necessary, confirmation by others such as a contract laboratory, hazardous waste management firm, or state and/or federal regulator.
- Interview driver and hauler to identify the source of suspect waste in the load.
- Hold rejected hazardous or liquid waste for generator.
- Arrange for hazardous or liquid waste collection by licensed collector.

5) Document Actions:
- Record Inspection.
- Retain Reports.
- Report hazardous, liquid or PCB wastes to Solid Waste Section - DENR.

5.0. SUBCELL PROGRESSION AND WASTE PLACEMENT

5.1. Subcell Progression

Phase 4, as well as successive phases, will be constructed with multiple subcells and stormwater segregation features to limit the amount of stormwater runoff that becomes leachate. Inactive subcells will be separated from the active area by the use of temporary berms to segregate the uncontaminated runoff. As subsequent subcells are opened in the planned sequence, uncontaminated stormwater can be diverted around the active subcells for collection and removal at the northwest corner of the cell. Stormwater will be drained from the collection area into the existing drainage channel leading to the sediment basin north of Phase 3.

Drawing OP-2 shows annual phases of development for Phase 4 of the landfill. The grades are projected based on the waste stream increasing at a rate of 1% as discussed in the Facility Plan.

5.2. Waste Placement and Compaction

The waste will be tipped in the active subcell as closely as possible to the working face, then pushed, if necessary, to the desired area. The length of the daily working face will be maintained at approximately 100 feet in order to provide adequate space for several trucks to dump at the same time. The width of the working face will vary somewhat depending on the rate of waste acceptance on a given day, weather conditions and other factors, but will be maintained as small as possible. The waste will be compacted as described below with one of two steel-wheeled compactors the County owns (see equipment list earlier in this section).

To minimize the chance of damage to the liner in any new subcell, the initial lift of waste will be at least 5 feet thick, and will consist of only residential, non-bulky waste. Compaction will be minimal because later lifts will surcharge the initial lift so that there is no net loss of density. Typical compaction procedures on lifts above the initial one will involve placement of waste in thin layers (1-2 feet thick) as flat as is practical. The compactor will roll across and slightly past the waste (to prevent wind-blown material leaving from the edge of the lift) a minimum of three times. Previous calculations have determined that the approximate in-place density of waste and soil combined is around 1200 pounds per cubic yard. This waste density calculation will be reviewed periodically and operational procedures may be revised to improve the efficiency of the site.

5.3. Filling Operations

The method of filling shall be in accordance with the filling sequence shown on Drawing No. OP-02. The waste will be compacted according to the procedures described above. Each lift of waste shall be approximately 10 feet thick, including an allowance for weekly cover. The proposed waste to total soil volume ratio is approximately 7:1. The size of the working face will be maintained as small as possible. The width of the working face will vary, depending on the rate of waste acceptance on a given day and weather conditions.

5.4. Daily Cover

At the end of each day's operation, compacted waste in the subcell shall be covered with either a minimum six inches of soil, or an approved alternative cover material approved by the Solid Waste Section (SWS). When soil is used for daily cover, at least two passes of heavy equipment will be made over the area to provide adequate soil compaction. Waste may be covered more frequently than once per day if necessary to control fires, odors, or blowing litter.

5.5. Intermediate Cover

In areas where another lift of waste will not be placed for at least 12 months, an additional 6 inches of soil shall be placed over the daily cover for a total of 12 inches of intermediate cover. Organic soil amendment in ratio 50/50 is allowed with the cover soil to promote healthy vegetative growth. Provisions for a vegetative ground cover sufficient to restrain erosion shall be accomplished within 120 calendar days following completion of each phase of development.

5.6 Alternate Cover Material

One alternate cover material (ACM) method is described in this section; tarps. The ACM shall provide control for disease vectors, fires, odor, blowing litter, and scavenging. An ACM in addition to soil may be used daily. Through a NCDENR Solid Waste Section demonstration period October 29, 2008 through February 20, 2009, the ACM has been determined to provide an equal or better element control as soil.

For precautionary measures regarding fire in the waste, ACM shall not be used more than 5 consecutive days. Soil will be used on the 6th day of covering.

5.6.1 Tarps

Tarps are proposed as an ACM. The tarps will be placed either manually or by using equipment. Tarps will not be used on any waste area that will not receive additional waste over a 24 hour period.

5.6.1.1 Properties of Tarps

Tarps shall be Fabrene TGPN3N3M or equal (manufacturer data sheet is included in Appendix V-2) and have properties as follows:

Unit Weight	$9oz/yd^2$

Warp Construction	23.9 Tapes/in (Warp) 16.0 Tapes/in (Weft)
Tensile Grab Strength	495 lbf (Warp) 326 lbf (Weft)
Tear Strength (tongue)	135 lbf (Warp) 152 lbf (Weft)
Tear Strength (trapezoid)	162 lbf (Warp) 107 lbf (Weft)
Coating Thickness	1.5 mil
Mullen Burst Strength	609 psi
Nominal Thickness	20 mil
Dimensions	48'-0" x 50'-0" (approximate)

Tarps shall be coated on two sides with low density polyethylene and will contain ultraviolet inhibitors.

5.6.1.2 Tarp Cover System Application Procedures

Procedure for Inspecting Tarps
The tarps are inspected for tears each morning and afternoon. Should a tear be found in the tarp, an attempt will be made to repair the area by stitching the material. If repair is inadequate or cannot be made, the tarp will not be used on the working face.

Application Procedure for Placement of Tarps
Application of the tarp will employ the following minimum procedures:

- Visually inspect working face to ensure that no sharp objects are protruding from the compacted waste which may tear the tarp;
- If necessary, run compacter or tracked machine over any protruding objections;
- Deploy tarp onto the landfill face by attaching the tarp to the spreader bar via integrated D-rings. Final placement is completed by hand to ensure proper coverage;
- Place additional tarps as needed to adequately cover working face;
- Tarps are self anchored with perimeter chains;
- The tarps will be visually inspected following placement to ensure that uplift will not occur; and,
- Soil will be placed over any areas of exposed waste and/or inadequate coverage.

Maximum Daily Area Coverage
Based on the 2010 Airspace Analysis Report:

- Annual waste disposal rate (MSW only) = approximately 51,000 tons
- Operating days per year = 305 days;
- Approximate daily waste disposal rate = 187 tons In-place density = 1,061 lbs/cy of MSW per cubic yard;
- Daily cubic yards disposed = daily waste disposal rate / in-place density = 352 cy or 9,504 cf

- The working face will be restricted to the smallest area feasible; and
- The working lift is typically 2-3 feet high. Based on a working lift thickness of 2 feet, the working face area averages 5,000 square feet (daily cubic yards disposed / working lift thickness), which is equal to the daily coverage area.

Any additional areas of uncovered waste will be covered each day with 6 inches of soil.

Daily Depth and Quantity to be Applied
N/A

Average Monthly Volume of Daily Cover
N/A

List of Equipment
Equipment utilized for Tarps consists of:

Dozer, Loader, or other equipment available on-site will be the equipment used for the tarp installation.

Material and Equipment Storage
Tarps will be stored adjacent to the working face in a County designated area that will not conflict with daily haul and disposal operations.
The equipment will be stored in a County designated area that will not conflict with daily haul and disposal operations.

Wet Weather Operation
The tarping wet weather operation will be similar to operations the County currently follows when using soil as daily cover during wet weather.

Contingency Plans
If, for any reason the County cannot use tarps as ACM material; soil will be used.

Screening Criteria
N/A

6.0. ENVIRONMENTAL MONITORING PROGRAMS

6.1 Water Quality

The water quality monitoring program for groundwater and surface water is described in the Water Quality Monitoring Plan. Refer to that plan in Section VII of this Application for a detailed discussion of the program.

6.2 Landfill Gas

Landfill gas is a by-product from the decomposition of organic waste in a sanitary landfill. The major components of landfill gas are methane and carbon dioxide. Other gases, such as volatile organic compounds, are present in trace quantities. To protect public health and safety in the vicinity of the landfill, landfill gas produced by the decomposition of refuse will be controlled

and monitored during the operational, closure, and post- closure periods. A gas management plan and gas monitoring program will be implemented for the purpose of maintaining the concentration of methane gas below the following regulatory levels:

- The concentration of methane gas generated is not to exceed 25 percent of the lower explosive limit (LEL) for methane in on-site structures (excluding gas control or recovery system components); and

- The concentration of methane gas is not to exceed the LEL for methane at the facility property boundary.

The landfill gas management plan is currently proposed to include monitoring, and passive gas collection in the landfill. The gas may be actively recovered in the future if generation rates are sufficient to justify the additional costs of an active system. Other remedial measures will be implemented as needed to mitigate a potential gas migration problem.

Regarding compliance with air quality (New Source Performance Standards), based on NCDENR Administrative Code .1703 Emission Standards, the Roaring River landfill does not exceed the permitting threshold requirements for design capacity or NMOC emission rates. There is approximately 965,273 tons of waste material currently in place within the closed and active phases. This equates to approximately 875,681 Mg. It is projected that the proposed Phase 4 expansion will add an additional capacity of 368,012 tons (693,709 cy). Therefore, the projected total capacity for Phase 4 is approximately 1,534,557 tons or 1,392,000 Mg, which is below the 2.5 million Mg threshold required for NSPS Title V permitting.

6.2.1 General

Gas monitoring at the Wilkes County Landfill will be performed during the active life of the landfill and throughout the post-closure care period. At a minimum, quarterly monitoring will be conducted at all subsurface gas detection probes and in all structures located on the landfill property. Currently these structures include the scalehouse, a maintenance building, and a small trailer.

Additional gas detection probes will be installed on the site as additional phases are constructed. They will be designed to extend to a depth at least equal to the maximum depth of waste within 1,000 feet of the monitoring point or to either bedrock or the water table, whichever is encountered first. Proposed probe locations will likely be field engineered due to rough topography adjacent to expansion areas which may limit access with a drill rig. Sufficient numbers of gas wells will be installed to adequately monitor the unit. At least three probes will be installed within each borehole to monitor shallow, intermediate, and deep zones within the subsurface profile. The actual spacing of the probes within the borehole will be established after review of the drilling log to identify potential preferential pathways. Construction records for the gas probes will be submitted to the Division upon completion.

Passive landfill gas vents will be installed along with the final cover system to allow release of gas to the atmosphere. These vents will be installed at a density of approximately one per acre of cap surface area.

6.2.2 Monitoring Procedure

Record Keeping: The operator will record the date, time, location, sampling personnel, atmospheric temperature, reported barometric pressure, equipment calibration information, and general weather conditions at the time of sampling, in addition to the concentration of combustible gases. The records will be maintained in the landfill operating record.

On-site Structures: Gas monitoring in on-site structures will attempt to identify the "worst case" concentrations. Monitoring will be conducted at the earliest possible time after the structure has been unused (e.g., a morning after a weekend or holiday). The monitoring locations will be in corners along floors and ceilings, at cracks in the floor, and at other areas likely to accumulate gas. Gas monitoring will also be conducted in any confined space requiring the entry of personnel for maintenance or inspection. The monitoring will take place prior to entry by personnel in accordance with OSHA regulations.

Gas Detection Probes: Gas monitoring in detection probes will consist of attaching the monitor to each tubing within the probes, and recording both the initial concentration and steady state concentration of combustible gases. SWANA guidelines for purging wells and other monitoring procedures will be followed.

Equipment: A portable combustible gas monitor, measuring the concentration of combustible gases in units of percent of lower explosive limit, shall be used to conduct gas monitoring. Lower explosive limit (LEL) means the lowest percent by volume of a mixture of combustible gas in air that will propagate a flame at 25 degrees Celsius and atmospheric pressure. The gas monitor shall be calibrated to methane using the manufacturer's calibration kit and procedure before the monitoring activities begin. Calibration information must be recorded on the Landfill Gas Monitoring Data Form.

6.2.3 Response to Detected Combustible Gases

The regulatory action levels for combustible gas monitoring in gas detection probes are 100% LEL at the facility boundary and 25% LEL in on-site structures. Readings exceeding the regulatory action levels shall be reported to Wilkes County immediately. The County will notify the North Carolina Department of Environment, Health, and Natural Resources, Solid Waste Section in writing and will take immediate steps to ensure safety and protection of human health.

At a minimum, the following actions will be taken if the methane concentration exceeds 25% in any structure:

- Put out all smoking materials and turn off all ignition sources;
- Evacuate all personnel;
- Vent the structure;

- Do not allow personnel to reenter the building except to perform gas monitoring until the results of additional monitoring indicate that methane concentrations are sustained or stabilized below 25% LEL;
- Begin continuous monitoring within the structure; and
- Undertake an assessment to determine the origin and pathways of the gas migration.

Within seven days of detection, the monitoring results will be placed in the Operating Record and the County will indicate actions taken and actions proposed to resolve the problem. Within 60 days of detection, the County will develop and implement a landfill gas remediation plan for the combustible gas releases and notify the Division that the plan has been implemented. The plan will describe the nature and extent of the problem and the proposed remedy.

The County will also use monitoring action levels of 75% LEL in the gas detection probes at the property boundary, if installed in the future, and 15% LEL in structures. If gas readings exceed the monitoring action levels, the monitoring frequency will be increased to monthly until three consecutive readings below those levels are recorded. If the monitoring action level is exceeded in structures, options will be evaluated to permanently reduce the current levels and to prevent a further increase in gas levels in the structures.

7.0 EROSION AND SEDIMENT CONTROL REQUIREMENTS

The operator 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, but not limited to, the National Pollutant Discharge Elimination System (NPDES) requirements, pursuant to Section 402, or 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. Surface water shall be diverted from the operational area and shall not be impounded over or in waste.

All vegetative and structural erosion and sediment control practices have been designed and shall be constructed and maintained according to the North Carolina Erosion and Sediment Control Planning and Design Manual (NCESCPDM). An *Erosion and Sediment Control Plan for the Wilkes County Landfill* was prepared and previously approved by the Land Quality Section. A copy of The Letter of Approval with Modifications and Certificate of Plan Approval with Modifications can be found in Appendix III-5 of the Engineering Plan.

8.0 RECORD KEEPING REQUIREMENTS

The following records will be maintained in the Operating Record at the landfill office:

- The operating permit and pertinent correspondence;
- Operation Plan;
- Emergency Response Plan;

- Inspection records, waste determination records, and training procedures for waste screening programs;
- Amounts by weight of solid waste received at the facility, including the source of generation;
- Gas monitoring plan, monitoring results and any remediation plans developed in accordance with Division requirements if required as a response to elevated gas concentrations;
- Water Quality Monitoring Plan and any demonstration, certification, finding, monitoring, testing, or analytical data required by the water quality monitoring program at the site;
- Closure and Post-Closure Plans and any required monitoring, testing or analytical data performed during the closure and post-closure periods;
- Required cost estimates and financial assurance documentation;
- Leachate management records; and
- Safety training records.

9.0 LEACHATE MANAGEMENT PLAN

9.1 Maintenance of the Leachate Collection System

Leachate control and migration begins with proper operational safeguards. Proper facility operation by maintaining design grades, placement of daily cover, intermediate and final covers, maintaining good vegetative cover, and applying run-on and run-off controls will help to reduce leachate production. The operator will conduct weekly inspections of the leachate collection and storage system. Leachate levels in the storage lagoon will be monitored at least weekly and after storm events to assess the need for leachate removal and hauling. Cleanouts are provided to allow access to the leachate collection system. Water under pressure has been and will continue to be introduced through these cleanouts periodically as preventive maintenance of the piping system. Mechanical equipment or chemical cleaning agents may also be used to mitigate clogging. Maintenance needs will be re-evaluated if there is an unexpected decrease or increase in leachate production rates.

9.2 Leachate Generation Records

Wilkes County maintains records of leachate hauled from the leachate pond at the landfill to the wastewater treatment plant. The County is currently considering the installation of a flowmeter in the manhole upgradient of the pond so that accurate quanitites of leachate flowing from the landfill can be measured. The volume of leachate in the lagoon is checked on a regular basis and after every significant storm event. Records will be maintained at the landfill throughout the operating life and during the post-closure care period. In addition to leachate generation quantities, Wilkes County will maintain analytical data from leachate sampling events. See Appendix III-4 of the Engineering Plan for additional information on leachate generation rates.

9.3 Leachate Monitoring

The chemical composition of untreated leachate generated will be analyzed at least semi-annually, concurrent with water quality sampling. The leachate will be analyzed for the Detection Monitoring constituents (EPA Appendix I list from Subtitle D) required by Rule.1633, as well as pH, specific conductance, BOD, COD, phosphate, nitrate and sulfate. Test results will be submitted to the Solid Waste Section. Monitoring parameters include the following:

PARAMETER	Sample Type	FREQUENCY
PH	Grab	Semi-annually
Oil and Grease	Grab	Semi-annually
BOD	Grab	Semi-annually
TSS	Grab	Semi-annually
Cd-Cadmium	Grab	Semi-annually
Cr-Chromiun (Total)	Grab	Semi-annually
Cu-Copper	Grab	Semi-annually
Ni-Nickel	Grab	Semi-annually
Cyanide	Grab	Semi-annually
Zn-Zinc	Grab	Semi-annually
Pb-Lead	Grab	Semi-annually
Mercury	Grab	Semi-annually
Temperature	Grab	Semi-annually

9.4 Leachate Disposal and Recirculation

Leachate will continue to be collected on site and stored in the existing on-site leachate storage pond. The leachate is periodically removed by pumping the leachate into a tanker truck for transport to the Wilkesboro Wastewater Treatment Plant for treatment and disposal. This practice is expected to continue with the opening of subsequent phases at the landfill. An agreement with the Town of Wilkesboro is in place for the discharge of wastewater from the landfill to the plant. Leachate will be tested in accordance with pretreatment conditions as described above. Although no pretreatment has been required to date, aerators are being installed in the pond to reduce BOD levels in the wastewater.

As previously approved in the Wilkes County Transition Plan and other correspondence, Wilkes County intends to continue leachate recirculation in the existing Phase 1 area. The current practice consists of the introduction of minimal amounts of leachate back into the lined cell by applying it with a water truck or by using a pump and sprinkler system to control dust.

9.5 Contingency Plan for Extreme Conditions

Wilkes County Landfill staff hauls leachate from the pond to the wastewater treatment plant using a leased vehicle. If required due to extreme conditions, additional hauling capacity will be obtained from subcontract haulers or by the rental of additional tanker trucks. If for some reason the receiving facility no longer accepts the leachate, it will be pre-treated to facilitate acceptance, or hauled to another POTW or commercial pretreatment facility.

[End]

APPENDIX V-1

RANDOM WASTE SCREENING PROGRAM FORMS

- FORM A – WASTE INSPECTION FORMS
- USEPA HAZARDOUS WASTE INSPECTION DECISION TREE

WASTE INSPECTION FORM **FORM A**

FACILITY: _____ PERMIT NO. _____

LOCATION: _____ DATE: _____

INSPECTOR: _____ COMPANY: _____

Waste Name(s) & Address (es)

1. _____
2. _____
3. _____
4. _____
5. _____

Waste Hauler _____

Address _____

Driver's Name _____

Waste Accepted [ ] Rejected [ ] Held [ ]

NOTIFIED: Waste Source [ ] Hauling Management [ ] Site Management [ ]

State [ ] Federal [ ]

Loader Operator: _____

Personnel Conducting the Inspection: _____

_____

1. Supervisor Conducting the Inspection: _____

SIGNATURE: _____

2. Witness: _____

SIGNATURE: _____

3. Driver: _____

SIGNATURE: _____

4. Other: _____

Company: _____ Title: _____

SIGNATURE: _____

DATE: _____ TIME _____ AM [ ] PM [ ]

ADDITIONAL COMMENTS: on the back

CONTAINER INVENTORY **FORM A**

FACILITY: _____ PERMIT NO. _____

LOCATION: _____ DATE: _____

INSPECTOR: _____ COMPANY: _____

Container:

Drum [ ] Metal [ ] Cardboard [ ] Plastic [ ] Other [ ]

Other: _____

Contents:

1. Full [ ] Partially Full [ ] Empty [ ]
2. Crushed [ ] Punctured [ ]
3. Labeled [ ] Hazardous [ ]

Identified: _____

Additional Information:

Container:

Drum [ ] Metal [ ] Cardboard [ ] Plastic [ ] Other [ ]

Other: _____

Contents:

1. Full [ ] Partially Full [ ] Empty [ ]
2. Crushed [ ] Punctured [ ]
3. Labeled [ ] Hazardous [ ]

Identified: _____

Additional Information:

INSPECTION CHECK LIST: (Check all that apply) **FORM A**

(If "YES" Please explain in the space provided below)

FACILITY: _____ PERMIT NO. _____

LOCATION: _____ DATE: _____

INSPECTOR: _____ COMPANY: _____

	YES	NO
1. Powders/Dusts	____	____
Identified: _____		
Unknown	____	____
2. Unacceptable Saturation	____	____
3. Odor/Fumes	____	____
Strong	____	____
Faint	____	____
Describe: _____		
4. Heat	____	____
Item: _____		
5. Battery	____	____
6. Oil	____	____
7. Biomedical	____	____
8. Radioactivity	____	____
9. Ashes/Residue	____	____
10. Sod/Soil	____	____
11. Asbestos (not properly contained)	____	____
12. PCB	____	____
13. Out of County Waste	____	____

Explanation:

REFUSE/UNIDENTIFIED WASTE INSPECTION **FORM - B**

FACILITY: _____ PERMIT NO. _____

LOCATION: _____ DATE: _____

INSPECTOR: _____ COMPANY: _____

REJECTABLE WASTE DESCRIPTION: _____

_____

_____

_____

WASTE: Rejected [ ] Accepted [ ]

NOTIFIED: [ ] Waste Source [ ] Hauling Management [ ] Federal
[ ] Site Management [ ] State

REFUSED WASTE TRANSPORTED BY:

Hauler Address: _____

_____

Destination: _____

_____

ACCEPTED WASTE:

Contained area: _____

Secured by: _____

Lab to complete testing: _____

ADDITIONAL COMMENTS: _____

_____

_____

ROARING RIVER LANDFILL
WASTE INSPECTION FORM

FORM A

DATE: _____ TIME WEIGHED IN. _____
TRUCK OWNER: _____ DRIVER NAME: _____
TRUCK TYPE: _____ VEHICLE ID/TAG: _____
WEIGHT: _____ TARE: _____
WASTE SOURCE: _____

Reason Load Inspected: Random Inspection _____ Staff Initials _____
Detained at Scales _____ Staff Initials _____
Detained by Operating Staff _____ Staff Initials _____

Inspection Location: _____

Description of Load: _____

Waste: Accepted [ ] Rejected [ ] Held [ ]

Notified: Supervisor [ ] County EMS [ ] Generator [ ]
Hauler [ ] NCDENR [ ] Federal [ ]

Loader Operator: _____

Personnel Conducting the Inspection: _____

Load Accepted (signature) _____ Date _____

Load Not Accepted (signature) _____ Date _____

REASON LOAD NOT ACCEPTED (Complete the following section if load not accepted)

Description of Suspicious Contents:

Color _____ Texture _____ Smell _____

Drums Present _____ Haz Waste Markings _____

Estimated CY present in load: _____ Estimated tons present in load: _____

Emergency Management Contacted? _____

Hazardous Materials Present: _____

_____

Hauler notified (if waste not accepted) Phone: _____ Time Contacted: _____

Other Observations: _____

_____

Final Disposition Signature: _____ Date: _____ Time: _____

Waste Screening Inspector or Landfill Manager

ADDITIONAL COMMENTS: on the back

Attach related correspondence to this form
File completed form in Operating Record

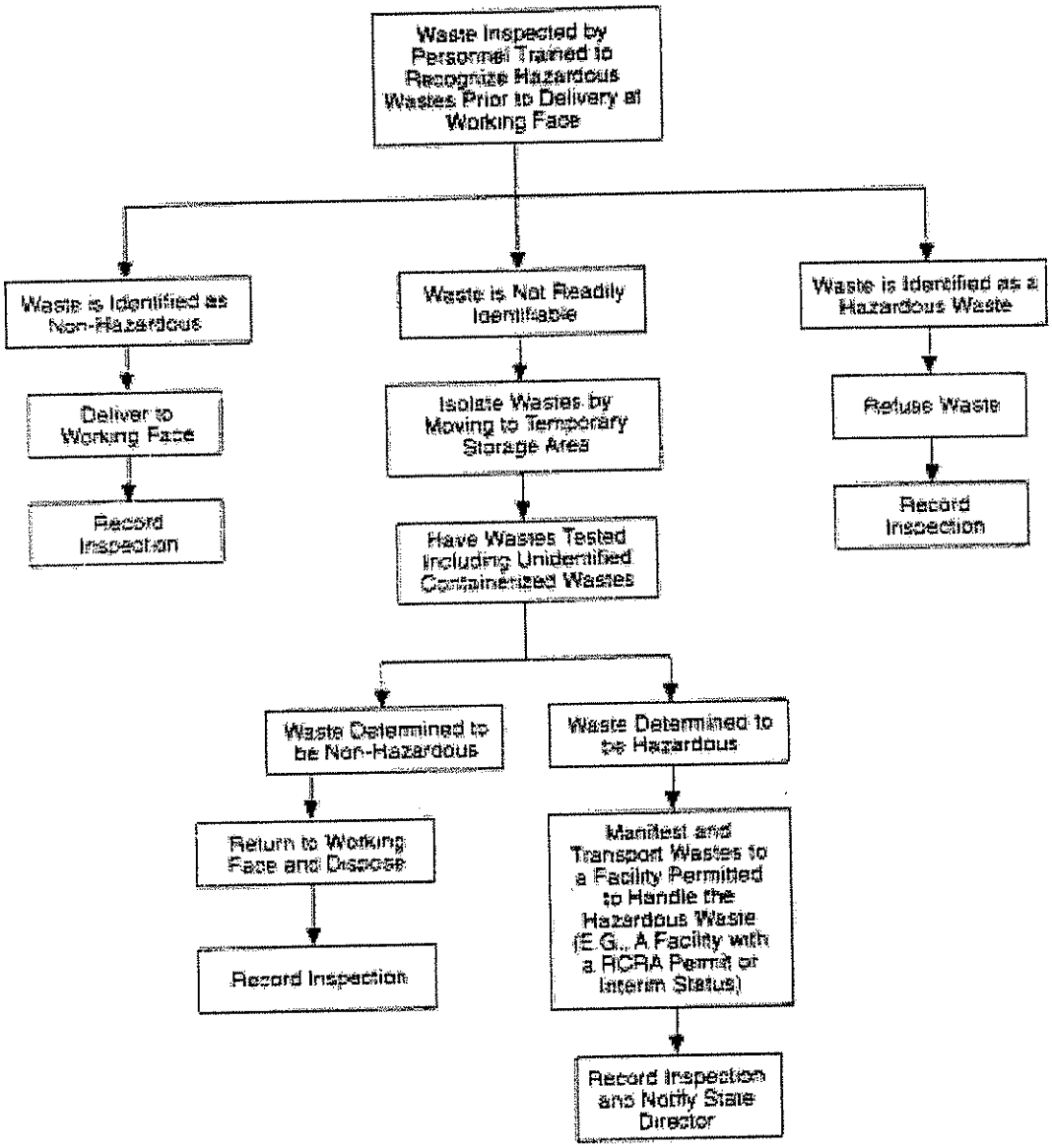

Figure 3-1
Hazardous Waste Inspection Decision Tree
Inspection Prior to Working Face

EPA Landfill Criteria Technical Manual, Subpart C, November 1993

APPENDIX V-2

TARP DATA SHEET

FABRENE®

INDUSTRIAL SYNTHETIC FABRICS

TYPE TGPN3N3M

Made from high density polyethylene tapes, coated on two sides with low density polyethylene.

PROPERTY	UNIT		VALUES	TEST METHOD
Unit Weight	g/m2		305	ASTM D3776
Warp Construction	Tapes/10cm	Warp	94	ASTM D3775
		Weft	63	
Tensile Grab Strength	Newtons	Warp	2200	ASTM D751
		Weft	1450	
Tear Strength * (tongue)	Newtons	Warp	600	ASTM D2261
		Weft	675	
Tear Strength (trapezoid)	Newtons	Warp	720	ASTM D4533
		Weft	475	
Coating	µm		38	ASTM D1777 MOD
Mullen Burst Strength	kPa		4200	ASTM D751
Nominal Thickness	µm		513	ASTM D1777 MOD

* Includes force to shift tapes - Tear may be crosswise to direction of force.

Fabrene® TGPN3N3M contains ultraviolet inhibitors and is suitable for outdoor applications.
For further information, contact your FABRENE Inc. representative.

Suggested Applications: Heavy tarpaulins, Geomembranes

SALES INQUIRIES

abrene Inc.
l: (888) 322-7363 ext 234
el: (705) 476-7057 ext 234
Fax: (705) 476-7787

ORDER DESK

North Bay, ON, Canada
Tel: (888) FABRENE
(888) 322-7363
ext. 222 or 226
Fax: (705) 476-0665

MAILING ADDRESS

Fabrene Inc.
240 Dupont Rd.
P.O. Box 4040
North Bay, ON, Canada
P1B 9B4

Date: 00/10/23

ISO 9001:2000
CSA Registered
Certificate: 92540

APPENDIX V-3

TEMPERATURE LOG DATA SHEET

WILKES COUNTY
LANDFILL
TEMPERATURE LOG

(Complete one (1) per windrow)

Windrow ID Number: _____

Date Windrow Started: _____

General windrow location and length: _____

Date & Initials	(x) if turned and number of times turned	Temp. at Location #1	Temp. at Location #2	Temp. at Location #3	Temp. at Location #4	Weather: Temp/ Condition

APPENDIX V-4

COMPOST END USER BROCHURE

US Composting Council

USCC Factsheet: Compost and Its Benefits[1]

What is Compost?

Compost is the product resulting from the controlled biological decomposition of organic material that has been sanitized through the generation of heat and stabilized to the point that it is beneficial to plant growth. Compost bears little physical resemblance to the raw material from which it originated.

Photo: Larry Strong

Compost is an organic matter resource that has the unique ability to improve the chemical, physical, and biological characteristics of soils or growing media. It contains plant nutrients but is typically not characterized as a fertilizer.

How is Compost Produced?

Compost is produced through the activity of aerobic (oxygen-requiring) microorganisms. These microbes require oxygen, moisture, and food in order to grow and multiply. When these factors are maintained at optimal levels, the natural decomposition process is greatly accelerated. The microbes generate heat, water vapor, and carbon dioxide as they transform raw materials into a stable soil conditioner. Active composting is typically characterized by a high-temperature phase that sanitizes the product and allows a high rate of decomposition, followed by a lower-temperature phase that allows the product to stabilize while still decomposing at a lower rate. Compost can be produced from many "feedstocks" (the raw organic materials, such as leaves, manures or food scraps). State and federal regulations exist to ensure that only safe and environmentally beneficial composts are marketed.

Benefits of Compost and its Effects on Soils and Plants

Thanks to its many attributes, compost is extremely versatile and beneficial in many applications. Compost has the unique ability to improve the properties of soils and growing media physically (structurally), chemically (nutritionally), and biologically. Although some equate the benefit of compost use to lush green growth, caused by plant-available nitrogen, the real benefits of using compost are long-term and related to its organic matter content.

Benefits of Using Compost

- Improves the soil structure, porosity, and density, thus creating a better plant root environment.
- Increases infiltration and permeability of heavy soils, thus reducing erosion and runoff.
- Improves water holding capacity, thus reducing water loss and leaching in sandy soils.
- Supplies a variety of macro and micronutrients.
- May control or suppress certain soil-borne plant pathogens.
- Supplies significant quantities of organic matter.
- Improves cation exchange capacity (CEC) of soils and growing media, thus improving their ability to hold nutrients for plant use.
- Supplies beneficial microorganisms to soils and growing media.
- Improves and stabilizes soil pH.
- Can bind and degrade specific pollutants.

Physical Benefits

Improved Structure

Compost can greatly enhance the physical structure of soil. In fine-textured (clay, clay loam) soils, the addition of compost will reduce bulk density, improve friability (workability) and porosity, and increase its gas and water permeability, thus reducing erosion. When used in sufficient quantities, the addition of compost has both an immediate and long-term positive impact on soil structure. It resists compaction in fine-textured soils and increases water holding capacity and improves soil aggregation in coarse-textured (sandy) soils. The soil-binding properties of compost are due to its humus content. Humus is a stable residue resulting from a high degree of organic matter decomposition. The constituents of the humus act as a soil 'glue,' holding soil particles together, making them more resistant to erosion and improving the soil's ability to hold moisture.

Moisture Management

The addition of compost may provide greater drought resistance and more efficient water utilization. Therefore, the frequency and intensity of irrigation may be reduced. Recent research also suggests that the addition of compost in sandy soils can facilitate moisture dispersion by allowing water to more readily move laterally from its point of application.

Chemical Benefits

Modifies and Stabilizes pH

The addition of compost to soil may modify the pH of the final mix. Depending on the pH of the compost and of the native soil, compost addition may raise or lower the soil/compost blend's pH. Therefore, the addition of a neutral to slightly alkaline compost to an acidic soil will increase soil pH if added in appropriate quantities. In specific conditions, compost has been found to affect soil pH even when applied at quantities as low as 10-20 tons per acre. The incorporation of compost also has the ability to buffer or stabilize soil pH, whereby it will more effectively resist pH change.

[1] Excerpted from the Field Guide to Compost Use, ©2001 The United States Composting Council

Increases Cation Exchange Capacity

Compost will also improve the cation exchange capacity of soils, enabling them to retain nutrients longer. It will also allow crops to more effectively utilize nutrients, while reducing nutrient loss by leaching. For this reason, the fertility of soils is often tied to their organic matter content. Improving the cation exchange capacity of sandy soils by adding compost can greatly improve the retention of plant nutrients in the root zone.

Provides Nutrients

Compost products contain a considerable variety of macro and micronutrients. Although often seen as a good source of nitrogen, phosphorous, and potassium, compost also contains micronutrients essential for plant growth. Since compost contains relatively stable sources of organic matter, these nutrients are supplied in a slow-release form. On a pound-by-pound basis, large quantities of nutrients are not typically found in compost in comparison to most commercial fertilizers. However, compost is usually applied at much greater rates; therefore, it can have a significant cumulative effect on nutrient availability. The addition of compost can affect both fertilizer and pH adjustment (lime/sulfur addition). Compost not only provides some nutrition, but often makes current fertilizer programs more effective.

Biological Benefits

Provides Soil Biota

The activity of soil organisms is essential in productive soils and for healthy plants. Their activity is largely based on the presence of organic matter. Soil microorganisms include bacteria, protozoa, actinomycetes, and fungi. They are not only found within compost, but proliferate within soil media. Microorganisms play an important role in organic matter decomposition which, in turn, leads to humus formation and nutrient availability. Microorganisms can also promote root activity as specific fungi work symbiotically with plant roots, assisting them in the extraction of nutrients from soils. Sufficient levels of organic matter also encourage the growth of earthworms, which through tunneling, increase water infiltration and aeration.

Suppresses Plant Diseases

Disease incidence on many plants may be influenced by the level and type of organic matter and microorganisms present in soils. Research has shown that increased population of certain microorganisms may suppress specific plant diseases such as pythium and fusarium as well as nematodes. Efforts are being made to optimize the composting process in order to increase the population of these beneficial microbes.

Additional Benefits of Compost

Some additional benefits of compost have been identified, and has led to new uses for it. These benefits and uses are described below.

Binds Contaminants

Compost has the ability to bind heavy metals and other contaminants, reducing both their leachability and absorption by plants. Therefore, sites contaminated with various pollutants may often be improved by amending the native soil with compost. The same binding affect allows compost to be used as a filter media for storm water treatment and has been shown to minimize leaching of pesticides in soil systems.

Degrades Compounds

The microbes found in compost are also able to degrade some toxic organic compounds, including petroleum (hydrocarbons). This is one of the reasons why compost is being used in bioremediation of petroleum contaminated soils.

Wetland Restoration

Compost has also been used for the restoration of native wetlands. Rich in organic matter and microbial population, compost and soil/compost blends can closely simulate the characteristics of wetland soils, thereby encouraging the re-establishment of native plant species.

Erosion Control

Coarser composts have been used with great success as a mulch for erosion control and have been successfully used on sites where conventional erosion control methods have not performed well. In Europe, fine compost has been mixed with water and sprayed onto slopes to control erosion.

Weed Control

Immature composts or ones which possess substances detrimental to plant growth (phytotoxins), are also being tested as an alternative to plastic mulches for vegetable and fruit production. While aiding in moisture conservation and moderating soil temperatures, immature composts also can act as mild herbicides.

A Bright Future

With these many benefits and its myriad of applications, from the traditional growing of plants to novel uses in stormwater management and climate change mitigation, the production and use of compost has a bright future indeed!

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About the USCC: The United States Composting Council (USCC) is a national not-for-profit organization dedicated to the development, expansion and promotion of the composting industry. For more information visit www.compostingcouncil.org

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*How much compost to use when planting?**

- **Trees and Shrubs** – Backfill plantings with a 50:50 mix of compost and native soil. Mulch a 2 to 3 inch layer of compost around plants extending 6 inches beyond the drip line. Do not mound compost or mulch around stems and tree trunks because this invites insects and diseases.
- **Flowers and Vegetable Gardens** – Work 2 to 3 inches of compost into the top 6 inches of soil before planting.
- **Turf Grass** – Work 2 to 3 inches of compost into the top 6 inches of soil prior to sod placement or seeding.
- **Containers and Raised Beds:** Add transplants to containers and beds filled with a 30 percent blend of compost and potting soil.
- **Foundations** – Replace compacted and contaminated fill along building foundations with a blend of compost, sand and topsoil.
- **Mulch** – Spread a 2 to 3 inch layer around plants to prevent erosion, act as a weed barrier and conserve water.

MIX CALCULATOR: Creating a landscape bed? Use this formula: **square feet to be covered X depth to be filled (in inches) X 0.0031 = cubic yards of mix needed.** Use compost instead of peat moss.

Depth of Compost Layer	Cubic Yards Needed Per 1,000 Square Feet
1/2 inch	1.5
1 inch	3.0
2 inches	6.0
3 inches	9.0

* Provided by Gardening and Recycling Organics Wisely (GROW), a program sponsored by S.C. DHEC's Office of Solid Waste Reduction and Recycling.

Artwork provided by the Seattle, Washington Saving Water Partnership's "The Natural Lawn & Garden" series. Reprinted with permission.

Layout and design provided by the S.C. Department of Health and Environmental Control's (S.C. DHEC) Office of Solid Waste Reduction and Recycling.

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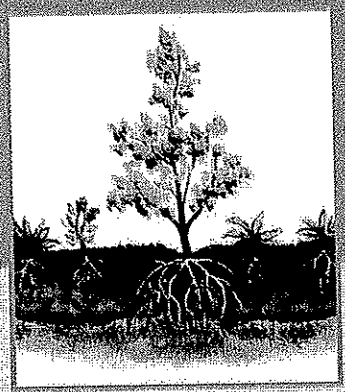
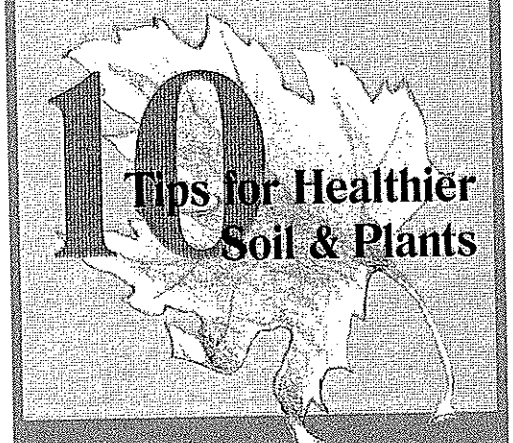


Landscape with Compost



10 Tips for Healthier Soil & Plants

Carolinas
COMPOSTING COUNCIL
www.carolinascompostingcouncil.org
(919) 545-9050

Landscape with compost!

1. **It's alive! It's alive!** Like every other living organism, soil needs food, water and oxygen. Feed your soil to grow healthier plants. Keep it aerated. Don't let it dry out or become water logged.

2. **Break it up.** Soil preparation is an important first step. Don't skip it. Break up large areas of high compaction by tilling and amending with compost before planting. Dig planting beds to a depth of 6 to 12 inches and add compost.

3. **Boost resistance.** Compost is microbiologically active like yogurt and yeast. This helps plants with nutrient uptake as well as builds resistance to pests and diseases. Do not use fumigants and harsh chemicals that will kill hard-working microbes and cancel one of compost's most desirable benefits.

4. **Control run-off.** Compost is one of the best products you can use to encourage rainwater to stay on your property. It will reduce erosion and minimize run-off of soils and nutrients to rivers and streams. Sediment and excess nutrients negatively impact water quality and aquatic life.

5. **Waterhogs unite!** Consider water resources when placing plants in the landscape. Plants that need more water should be located where water naturally collects – near downspouts, roof drip lines and similar locations. Use compost to improve both moisture retention and drainage.

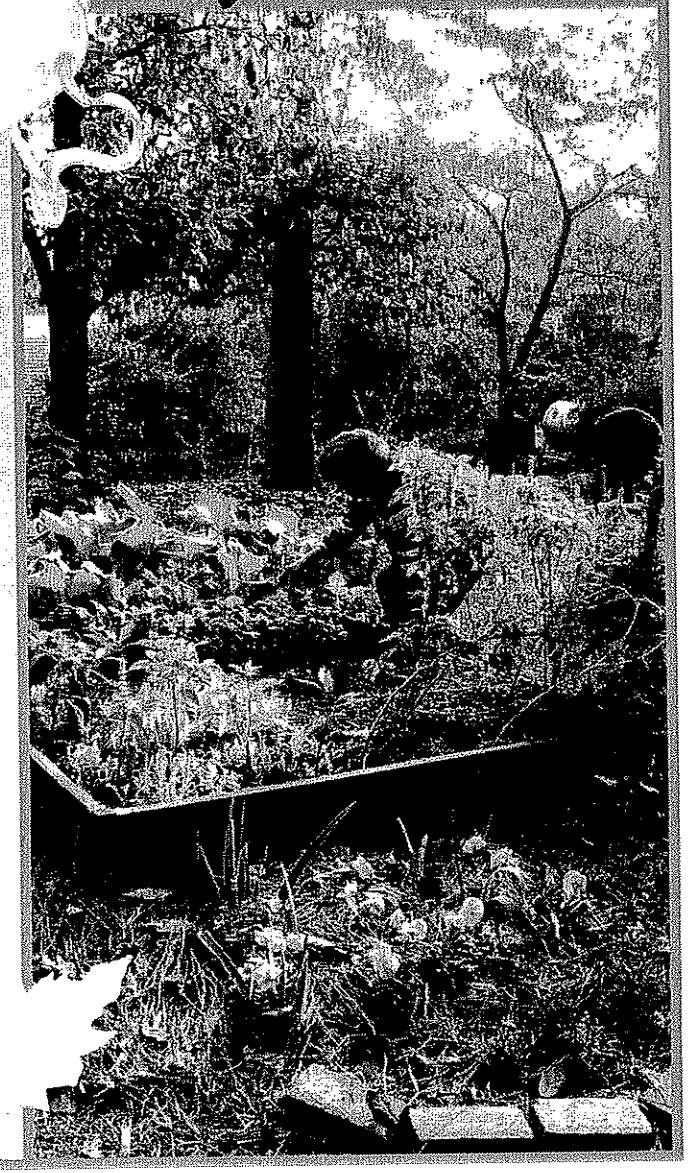
6. **It looks like soil.** Look for compost that is dark in color and smells like soil. Immature compost is light in color and/or smells like ammonia. Immature compost may burn sensitive plants and compete for nutrients.

7. **A little bit does a lot.** As little as 1/4 inch of compost as a top dressing can give lawns a boost. Bare spot? Add a layer of compost and rake into the soil before seeding.

8. **Quality counts.** The U.S. Composting Council has developed a marketing label to identify tested compost. Look for the Seal of Testing Assurance when comparing products.

9. **Don't concentrate!** Add no more than 30 percent compost in a blend with bark, topsoil, sand, clay and other ingredients. Use in raised beds or in potting and planting mixes for trees, shrubs and garden plants. As mulch, add 2 to 3 inches to the surface.

10. **Dress it up.** Top dress with 1/4 to 1/2 inch of compost to replenish nutrients and keep root zones cool and moist. Surface applications should always be well incorporated with a rake or tilling equipment.

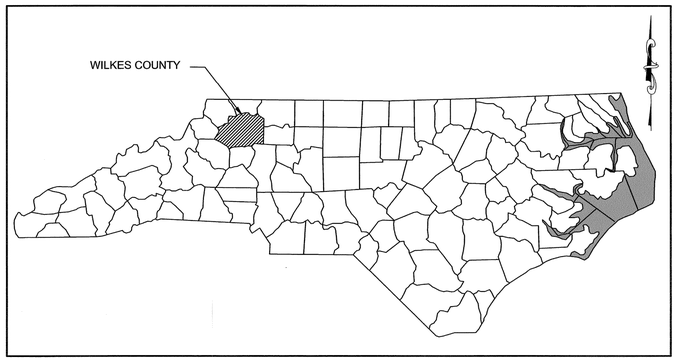


Pictured (right): This garden shows many places to use compost – around trees as mulch, in flower and vegetable beds, in raised beds and containers as well as around shrubs.

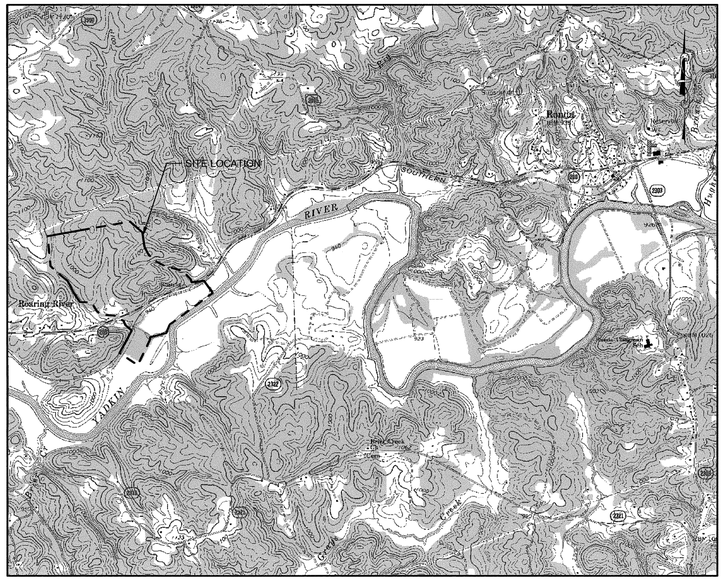
DRAWINGS

ROARING RIVER LANDFILL
PHASE 4 EXPANSION

WILKES COUNTY, NORTH CAROLINA



NORTH CAROLINA
COUNTY LOCATION MAP



VICINITY MAP

OWNER INFORMATION

PREPARED FOR:	WILKES COUNTY DEPARTMENT OF SOLID WASTE
ADDRESS:	9219 ELKIN HIGHWAY ROARING RIVER, NORTH CAROLINA, 28669
CONTACT:	KENT BRANDON (336) 696-5806 (336) 927-4117

PROPERTY INFORMATION

ADDRESS:	9219 ELKIN HIGHWAY ROARING RIVER, NORTH CAROLINA, 28669
NCDENR PERMIT:	97-04
ACREAGE:	145 ACRES

DRAWING INDEX

SHEET	DESCRIPTION
OP-T	TITLE SHEET
OP-L	LEGEND AND GENERAL NOTES
OP-01	EXISTING CONDITIONS
OP-02	PHASING PLAN: PHASE 4 YEARS 1-5

OPERATIONS PLAN
JANUARY 2011

DATE	REVISIONS AND RECORD OF ISSUE	NO	BY	CK	APP

NORTH CAROLINA PROFESSIONAL SEAL 035644 ENGINEER STEPHEN J. COMIE

DESIGNED SJC
DRAWN RWH
CHECKED LBB
APPROVED EEA
DATE 1/27/11

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JOYCE ENGINEERING, INC.
2211 W. MEADOWVIEW ROAD
GREENSBORO, NC 27407
PHONE: (336) 323-0092
NC CORP LIC: C-0782

ROARING RIVER LANDFILL
WILKES COUNTY, NORTH CAROLINA

TITLE SHEET

PROJECT NO.
356.10.02

SCALE
N.T.S.

DRAWING NO.
OP-T

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CONVENTIONAL SYMBOLS AND GENERAL NOTES

ENVIRONMENTAL MONITORING FEATURES

MW-X	EXISTING GROUNDWATER MONITORING WELL
MW-#	PROPOSED GROUNDWATER MONITORING WELL
MW-OW-#	EXISTING OBSERVATION WELL
MW-OW-X	PROPOSED OBSERVATION WELL
NES-OW-X	EXISTING NES WELL
NES-OW-#	PROPOSED NES WELL
MW-PW-X	EXISTING PERFORMANCE WELL
MW-PW-#	PROPOSED PERFORMANCE WELL
MW-X	EXISTING SENTINEL WELL
MW-#	PROPOSED SENTINEL WELL
EW-X	EXISTING EXTRACTION WELL
EW-#	PROPOSED EXTRACTION WELL
PZ-#	WETLANDS PIEZOMETER
PZ-X	PIEZOMETER
GP-X	GAS PROBE
GV-X	EXISTING GAS VENT
GV-#	PROPOSED GAS VENT
GW-X	EXISTING GAS WELL
GW-#	PROPOSED GAS WELL
SMP-X	SURFACE WATER MONITORING POINT
LMP-1	LEACHATE MONITORING POINT
B-X	BORE HOLE LOCATION
C-X	CORING LOCATION
SS-X	SOIL SAMPLING LOCATION
TP-X	TEST PIT LOCATION
W	WELL LOCATION
S-X	SPRINGHEAD LOCATION

SURVEY FEATURES

BM	BENCHMARK
CP	CONTROL POINT
	PROPERTY LINE
	EASEMENT
R_W R_W	RIGHT OF WAY
X X X	FENCE LINE
	RAILROAD
	GUARDRAIL
	RESOURCE PROTECTION AREA

UTILITIES

	UTILITY POLE
	HYDRANT
	LIGHT POLE
	TANK (SIZE VARIES)
	TRANSFORMER
M	MANHOLE
	CLEANOUT
	VALVE
OHE	OVERHEAD ELECTRIC
UGE	UNDERGROUND ELECTRIC
OHT	OVERHEAD TELEPHONE
UGT	UNDERGROUND TELEPHONE
FM	LEACHATE FORCE MAIN
DCFM DCFM	DUAL CONTAINED LEACHATE FORCE MAIN
SS	SANITARY SEWER
PS	PROCESS SEWER
G	LANDFILL GAS LINE
UGG	NATURAL GAS LINE
W	POTABLE WATER
	SOLID PIPE (TYPE NOTED)
	PERFORATED PIPE (TYPE NOTED)
	CULVERT (SIZE NOTED)

LANDFILL AND ROAD FEATURES

	PAVED ROAD
	GRAVEL/DIRT ROAD
	EDGE OF PAVEMENT
	LIMIT OF WASTE/EDGE OF LINER
	FACILITY BOUNDARY/CELL LIMITS/PHASE LIMITS

BUILDINGS AND STRUCTURES

	BUILDING
	DAM
	FOUNDATION

HYDROLOGY

	APPROXIMATE 100 YEAR FLOOD PLAIN
	DITCH FLOW
	STREAM OR RIVER

VEGETATION

	SINGLE TREE
	TREE LINE
	SHRUB

EROSION AND SEDIMENT CONTROL FEATURES

SF SF	SILT FENCE
IP	INLET PROTECTION
	OUTLET PROTECTION (SIZE VARIES)
	DIVERSION BERM

TOPOGRAPHICAL FEATURES

100	EXISTING 10' TOPO CONTOUR
	EXISTING 2' TOPO CONTOUR
100	PROPOSED 10' TOPO CONTOUR
	PROPOSED 2' TOPO CONTOUR
100	GROUNDWATER SURFACE CONTOUR (FT ABOVE MEAN SEA LEVEL)
100	BEDROCK SURFACE CONTOUR (FT ABOVE MEAN SEA LEVEL)
100.00	SPOT ELEVATION

HATCHING

	WETLANDS
	RIPRAP
	WASHED STONE
	BUFFER AREA
	PROPOSED ROAD
	COMPACTED BACKFILL

SURVEY NOTES:

1. TOPOGRAPHIC CONTOUR INTERVAL = 2 FEET, UNLESS INDICATED OTHERWISE.
3. ON-SITE TOPOGRAPHY PROVIDED BY SPATIAL DATA CONSULTANTS, INC. , 1008 HUTTON LANE, HIGH POINT, NORTH CAROLINA 27262, DATED MARCH 19, 2010.
4. FEDERAL INSURANCE ADMINISTRATION, FLOOD INSURANCE RATE MAP, WILKES COUNTY, NC, INDICATES NO 100 YEAR FLOOD PLAINS ON SITE.
5. PROPERTY BOUNDARY BEARING AND DISTANCES PROVIDED BY TOM FRAZIER, R.L.S 1286 NC. ON MAY 8, 1989.
6. SITE CONTROL INFORMATION UPDATED BY SPATIAL DATA CONSULTANTS, INC. , 1008 HUTTON LANE, HIGH POINT, NORTH CAROLINA 27262, DATED MARCH 19, 2010.
5. THE SURVEY WAS PERFORMED WITHOUT THE BENEFIT OF A TITLE SEARCH AND ALL EASEMENTS AND ENCUMBRANCES MAY NOT BE SHOWN.

GENERAL NOTES:

1. SITE LIGHTING IS NOT PROPOSED FOR THIS PROJECT.
2. LANDSCAPING IS NOT PROPOSED FOR THIS PROJECT. HOWEVER THE BUFFER AREA SHOWN ON DRAWINGS WILL REMAIN UNDISTURBED EXCEPT FOR THE INSTALLATION OF UTILITIES, STORMWATER DRAINAGE FEATURES AND ACCESS TO THE SITE. WHEN POSSIBLE CLEARING WITHIN THE BUFFER WILL BE ALIGNED TO MINIMIZE VISUAL IMPACTS.
3. SOIL STOCKPILE AREAS WILL BE ESTABLISHED TO FACILITATE PHASED CONSTRUCTION. STOCKPILE LOCATIONS AND SIZE MAY VARY AND MAY NOT BE LIMITED TO THE AREAS SHOWN. SILT FENCE WILL BE INSTALLED AROUND THE BASE OF THE STOCKPILE.

NO	BY	CK	APP	DATE	REVISIONS AND RECORD OF ISSUE

NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 035814 RAYMOND W. HAMM, JR. 1/27/11

DESIGNED SJC
DRAWN RWH
CHECKED LBB
APPROVED EEA
DATE 1/27/11

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NC CORP LIC: C-0782

ROARING RIVER LANDFILL
WILKES COUNTY, NORTH CAROLINA

LEGEND AND GENERAL NOTES

PROJECT NO.
356.10.02

SCALE
N.T.S.

DRAWING NO.
OP-L

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DATE	REVISIONS AND RECORD OF ISSUE	NO	BY	CK	APP

NORTH CAROLINA PROFESSIONAL SEAL 035644 ENGINEER STEPHEN J. COME

DESIGNED SJC
DRAWN RWH
CHECKED SJC
APPROVED EEA
DATE 1/27/11

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ROARING RIVER LANDFILL
WILKES COUNTY, NORTH CAROLINA

EXISTING CONDITIONS

PROJECT NO.
356.10.02

SCALE
AS SHOWN

DRAWING NO.
OP-01

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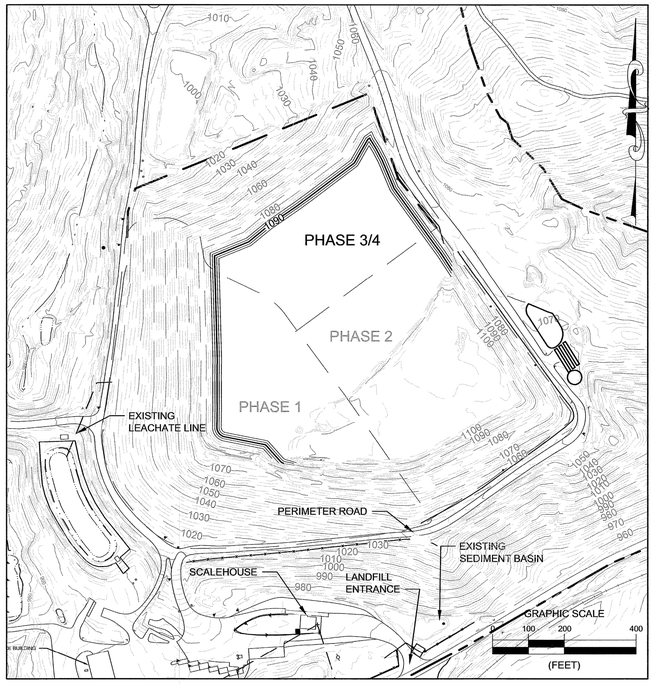
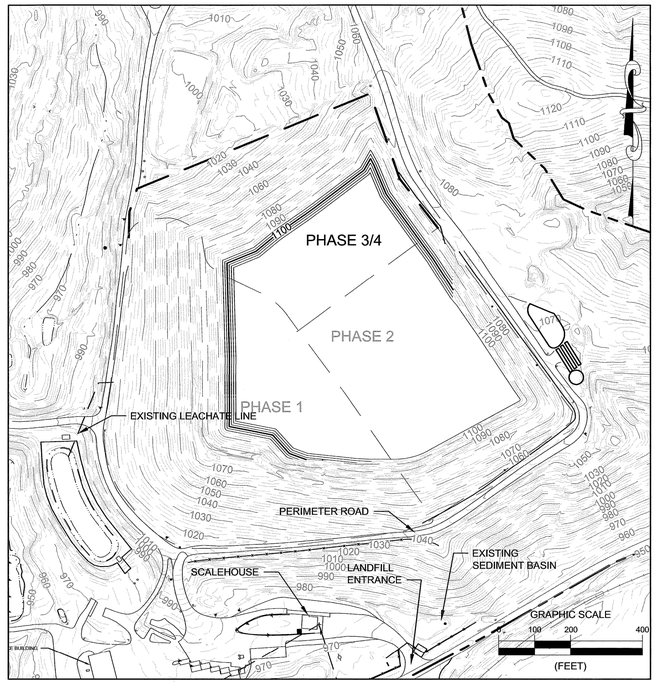
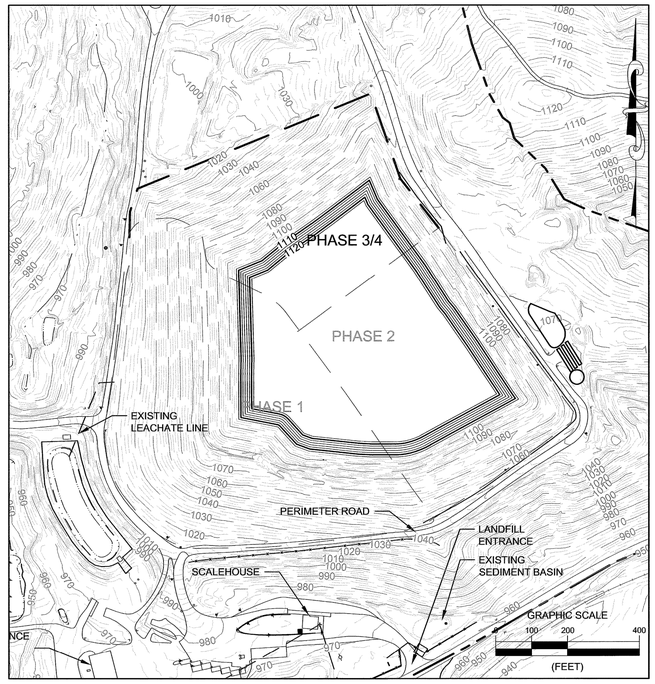


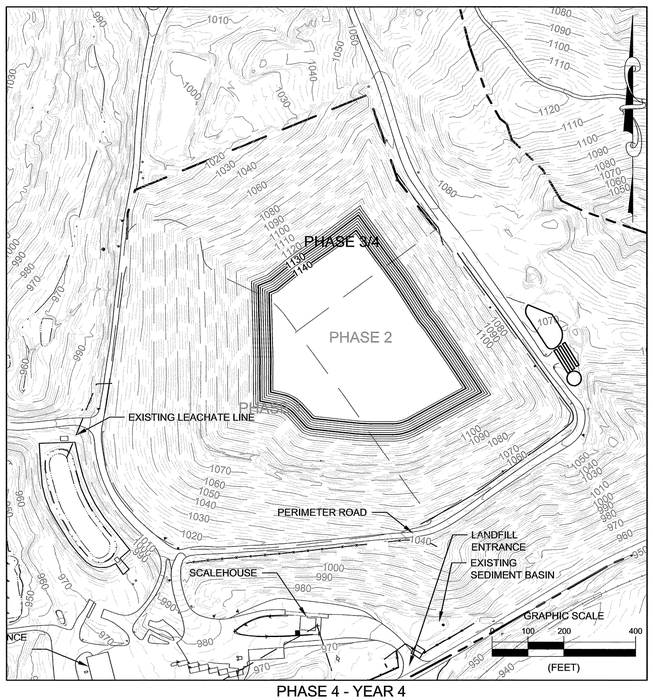
PHASE 4 - YEAR 1
130,210 CY CONSUMED AIRSPACE



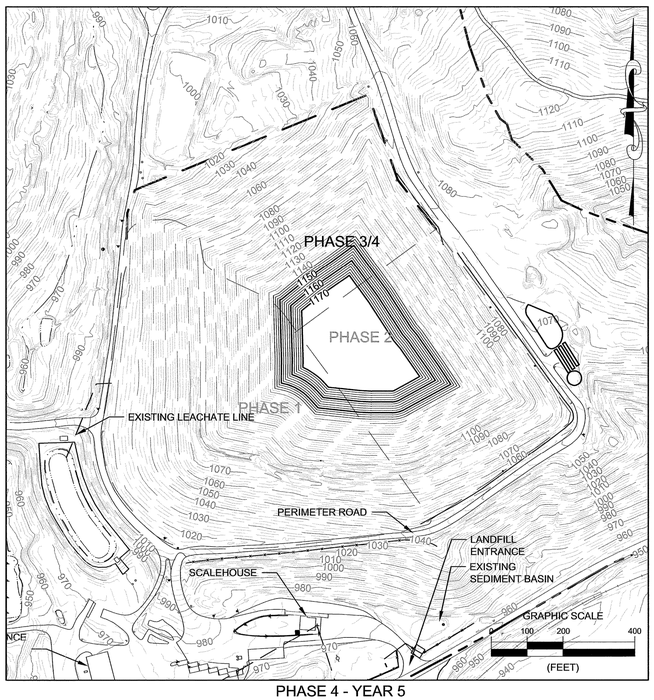
PHASE 4 - YEAR 2
134,050 CY CONSUMED AIRSPACE



PHASE 4 - YEAR 3
140,110 CY CONSUMED AIRSPACE



PHASE 4 - YEAR 4
145,215 CY CONSUMED AIRSPACE



PHASE 4 - YEAR 5
148,124 CY CONSUMED AIRSPACE

NO	BY	CK	APP	DATE	REVISIONS AND RECORD OF ISSUE

NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 035644 STEPHEN J. CRAMER 7/27/11

DESIGNED	SJC
DRAWN	RMH
CHECKED	SJC
APPROVED	EEA
DATE	1/27/11

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ROARING RIVER LANDFILL
WILKES COUNTY, NORTH CAROLINA

PHASING PLAN: PHASE 4/ YEARS 1-5

PROJECT NO.
356.10.02

SCALE
AS SHOWN

DRAWING NO.
OP-2

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Section VI
Closure/Post Closure

PREPARED FOR:
WILKES COUNTY DEPARTMENT OF SOLID WASTE
9219 ELKIN HIGHWAY
ROARING RIVER, NORTH CAROLINA 28669

ROARING RIVER LANDFILL
WILKES COUNTY, NORTH CAROLINA
PERMIT NO. 97-04

PHASE 4 EXPANSION

CLOSURE & POST CLOSURE

JANUARY 2011

PREPARED BY:

JOYCE ENGINEERING, INC.

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PHONE: (336) 323-0092
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JEI PROJECT NO. 356.1002.11.01
NORTH CAROLINA CORPORATE LIC: C-0782

VOLUME 2, SECTION VI
CLOSURE AND POST CLOSURE PLAN

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Appendix VI – 2	Post-Closure Inspection Record
Appendix VI – 3	Groundwater Monitoring Well Maintenance Record
Appendix VI – 4	Landfill Gas Monitoring Data Form
Appendix VI – 5	Post-Closure Cost Estimate

1.0 CLOSURE ACTIVITIES

Pursuant to the North Carolina Solid Waste Management Rules (15A NCAC 13B .1627), this Closure and Post-Closure Plan is submitted as part of the permit application to construct Phase 4, of the Roaring River Landfill. Phase 1 was constructed in 1993, and began accepting waste the same year. Phase 2 was subsequently constructed and Phase 3 is currently accepting waste. This plan describes proposed closure and post-closure activities for Phase 1-4, site modifications, and site characteristics. Within this Closure and Post-Closure Plan, references are made to information and drawings found in the Facility, Operations, and Engineering Plans to reduce redundancy in this report.

Grading plans, cap sections, and other aspects related to closure, including phased development, stormwater management, and erosion and sediment control, are discussed in the Engineering and Operation Plans of this report, and are illustrated on the drawings. The Construction Quality Assurance (CQA) Plan provided in this application describes methods and procedures to be used in monitoring construction of the closure cap. Detailed drawings, specifications, and other documents will be prepared prior to closure for bidding and construction purposes.

The facility will be closed in accordance with the requirements of EPA's Subtitle D regulations (40 CFR 258.60) and Rule .1627 of the North Carolina Solid Waste Management Rules (15A NCAC 13 B). Given the proposed development plan for the facility, the waste disposal areas will be capped and closed in phases as described in the following paragraphs.

1.1 Closure of Disposal Units

1.1.1 Cap Design

Proposed final grading contours for the facility are provided on Drawing No. FP-04 of the Facility Plan. Final contours have been designed with post-settlement surface slopes of at least five percent on top of the cell. The following components (bottom to top) are proposed as shown on the details:

a. Intermediate Cover and Leveling Course - Local soil will be placed over the daily cover soil to provide at least 12 inches of intermediate cover and a uniform base for construction of the cap.

b. Passive Gas Vents – Passive gas vents will be installed at a frequency of one per acre. A typical passive gas vent is detailed on Drawing No. EP-05. Passive venting of landfill gasses will protect the integrity of the cap by preventing excessive pressure buildup beneath the cap.

c. Gas Collection/Migration Layer – A geonet composite will be installed between the intermediate cover and the overlying infiltration layer. The geonet composite will provide a pathway for accumulated gas to move laterally to the gas vents.

d. Infiltration Layer: Clay component: - The infiltration layer is proposed to consist of a geosynthetic clay liner. This layer will be constructed over the geonet composite that will serve as the gas migration layer. Installation and testing requirements for the cap are provided in the Specifications appendix of the Engineering Plan and the CQA Plan.

e. Infiltration Layer: Geomembrane Component - The geomembrane component of the infiltration layer will consist of a textured 40 mil flexible membrane cap (FMC). The membrane will be in direct contact with the underlying layer. The testing program and quality assurance requirements for the geomembrane are described in the CQA Plan.

f. Geocomposite Drainage Layer - A drainage layer consisting of a geonet and geotextile composite will be placed directly over the geomembrane to promote drainage.

g. Protective Layer - A layer consisting of at least 18 inches of local soil will be placed above the drainage layer to provide a protective cover for the underlying cap components. Compaction of the layer will be limited to about 90 percent (plus or minus three percent) of the Standard Proctor maximum dry density so that the vegetation can develop a strong root system, and to avoid damage to the underlying synthetic components.

h. Erosion Layer - A layer of topsoil material or organically amended local soil will be placed above the protective layer. This soil layer will be at least 6 inches in thickness. The topsoil material will be lightly compacted so that a good stand of vegetation can be established. Soil tests will be conducted prior to seeding to determine if soil additives are needed to establish vegetation.

i. Vegetation - After placement of the erosion layer, the area will be seeded. Seeding will be accomplished in accordance with the "North Carolina Erosion and Sediment Control Planning and Design Manual", and recommendations from local agricultural specialists. Mulch and erosion matting will be used as needed to control erosion and promote vegetative growth. The vegetative cover will be inspected regularly. Areas found to be sparsely covered will be revegetated.

1.1.2 Area to Be Capped

The landfill is designed so that closure can occur in stages. Partial closure can occur when final contours are reached, and the waste appears reasonably stabilized, in a given area. Once an area of sufficient size to make construction cost-effective has reached final elevations, closure activities will be carried out according to the schedule presented later in this section.

1.1.3 Cap Settlement and Stability

Non-uniform settlement can be expected over the entire area that will receive a closure cap. The primary mechanism of settlement is waste consolidation due to decomposition of the landfilled material. According to Daniel, et al, long-term settlement is typically 5 to 15 percent over 20 to 30 years; however, settlement of about 5 percent can be expected in the first few months following waste placement. A significant amount of waste consolidation will likely have occurred by the time each portion of the landfill is closed.

The stability of the proposed cap design under static and seismic conditions has been evaluated and is included in the Engineering Plan. The proposed design was found to be stable at a slope of 3H:1V with a 15' wide stability bench.

After capped portions are completed, monthly inspections of the final cover will be conducted to look for areas of the cap that might have experienced displacement. Should these inspections indicate problem areas, (ponding, exposure of the geomembrane, deep cracks, etc.), repairs will be initiated as soon as practical.

1.1.4 Drainage and Erosion

A combination of drainage ditches, diversion berms, vegetative cover, and sediment traps and basins will control drainage and erosion. Construction and design of sediment and erosion control features will be in accordance with applicable sections of the "North Carolina Erosion and Sediment Control Planning and Design Manual." Drainage will be directed to proposed ditches along the perimeter. These ditches will receive runoff from the cap, conveying the flow to on-site sediment basins. For a detailed discussion regarding stormwater management and erosion and sediment control, please refer to the Erosion and Sediment Control Plan submitted to the Division of Land Quality under separate cover for Phase 3 Expansion.

1.1.5 Freeze/Thaw Effects

Based on a published map of frost depths throughout the United States (EPA, November 1993: A530-R-93-017), the anticipated maximum depth of freeze/thaw effects on the site is less than or equal to 10 inches. Since the upper 18 inches of final cover soil is not the low-permeability component of the cap, the effects of freeze/thaw cycles on the closure cap should not be detrimental to its function.

1.2 Waste Volume

A summary of the total airspace available by phase is provided in Table 2 of the Facility Plan. The available airspace was calculated based on a comparison of the base grade and final grade surfaces.

1.3 Closure Plan Schedule

As discussed in the Facility Plan, Phase 4-6 have a projected operating life of approximately 20 years. Thus, closure of the entire landfill is not anticipated until 2033, assuming waste disposal in Phase 4 begins in 2013. Prior to beginning final closure, Wilkes County will notify the Division that a notice of intent to close the facility has been placed in the operating record. An itemized list of closure milestones and a proposed schedule follow. Closure activities are proposed to begin within 30 days of final receipt of waste. Construction of the closure cap is to be completed within 180 days following the initiation of closure activities. The total length of the proposed closure period is 210 days following the final receipt of waste.

The approximate closure milestones shown in Table 1 below are proposed for use in tracking the progress of closure activities. A detailed schedule will be established prior to construction.

Table 1
Proposed Closure Milestones and Schedule

Milestone	Proposed Schedule from the Date of Final Receipt of Waste
Testing of borrow sources	Within 6 months prior to closure
Grading of intermediate cover	Within 30 to 60 days
Placement of soil cap	30 to 150 days
Final inspection of cap by P.E.	150 to 180 days
Construction of stormwater controls	90 to 180 days
Seeding and mulching	150 to 180 days
Preparation of survey plat	180 to 210 days
Submittal of closure certification	180 to 210 days

1.4 Posting and Baiting

At least one sign will remain posted at the entrance to the facility notifying persons of the facility closing. Also, a notice prohibiting further receipt of waste materials will remain posted at the entrance. The site will be secured through the use of gates equipped with locks, fencing, and/or natural barriers. The site will be baited for rodent and vector control before final closure is initiated.

1.5 Notification

Once closure is complete, a survey plat will be prepared by a registered land surveyor showing the locations and dimensions of the landfill disposal areas, the locations of groundwater

monitoring wells and gas probes, and the restrictions on future disturbance of the site. A notation will be recorded on the property deed stating that the land has been used to dispose solid waste and that its use is restricted under the Closure Plan as required by Rule .1627(c)(8). Copies of the deed notations as recorded will be placed in the Operating Record and forwarded to the Division.

1.6 Certification

Upon completion of closure, a licensed professional engineer acting on behalf of the owner will submit a Certification of Closure to the Division. This Certification will state that the site was closed in accordance with the Closure Plan and applicable solid waste regulations and laws as required by Rule .1627(c)(7).

The owner must record a notation on the deed to the landfill facility property at the local county Registrar 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 shall in perpetuity notify any potential purchaser of the property that the land has been used as a MSW facility and its use is restricted under the closure plan approved by the Division.

1.7 Closure Cost Estimate

An estimate of closure costs is provided in Appendix VI-1. All costs are given in 2010 dollars.

2.0 POST-CLOSURE ACTIVITIES

Post-closure activities will be conducted at the landfill in accordance with Rule .1627 for a period of 30 years following closure of the landfill. The length of the period can be increased or decreased in accordance with Division directives.

2.1 Contact

All correspondence and questions concerning the post-closure care of the unit should be directed to:

Mr. Kent Brandon
Solid Waste Director
Wilkes County Department of Solid Waste
PO Box 389
Roaring River, North Carolina, 28669
336-696-5806

2.2 Security

Access to the site will be controlled by the use of barriers and gates at roadway entrances. These control devices will be maintained throughout the post-closure care period, and inspected as part of the monthly inspection program. All barriers and gates will be clearly marked with signs

stating the name and nature of the facility and the person to contact in case of emergency or breach of security.

2.3 Post-Closure Maintenance

Post-closure maintenance and monitoring will be conducted at the Roaring River Landfill for a period of 30 years after final closure. The Division may decrease the length of the post-closure period if the owner or operator demonstrates that the reduced period is sufficient to protect human health and the environment, and the Division approves this demonstration. The period might be increased by the Division if the Division determines that the lengthened period is necessary to protect human health and the environment. Monitoring will include semi-annual sampling of groundwater and surface water, quarterly gas monitoring, and monthly inspection of the final cover and monitoring and control systems. Maintenance needs identified through the monitoring program will be initiated no later than 60 days after the discovery, and within 24 hours if a danger or eminent threat to human health or the environment is indicated. Minor cap maintenance may be deferred until there is a sufficient amount of work to justify the mobilization of equipment and personnel. Unusual or extreme maintenance needs due to calamities or vandalism might require the implementation of emergency contract service procedures established by Wilkes County.

2.4 Inspection Plan

Routine inspections will be conducted throughout the post-closure care period. These inspections will be carried out monthly unless problems are detected which indicate more frequent visits. Potential impacts to the public and environment will be considered in determining the inspection frequency. Items to be included in the monthly inspection will be as follows:

- Access and security control
- Leachate management and storage systems
- Stormwater management
- Erosion and sediment control
- Gas management
- Groundwater and landfill gas monitoring systems
- Integrity of site benchmarks
- Integrity of the final cover system
- Vector control

Inspection forms have been prepared for use during each inspection (see Appendix VI-2). Completed copies of the inspection forms will be kept by the owner, and copies will be forwarded to the Division for its records.

2.5 Monitoring Plan

2.5.1 Groundwater Monitoring

Groundwater monitoring will occur semi-annually throughout the post-closure care period. The monitoring schedule will continue as established during the active life of the facility. The applicable procedures outlined in Rules .1633 through .1637 will be followed through post-closure as required by site findings. Refer to the Water Quality Monitoring Plan in Section VII – Water Quality Monitoring Plan of this submittal.

The post-closure care period for the site is 30 years unless modified by the Division. If the statistical analysis of the groundwater monitoring data does not indicate degradation to the quality of the groundwater after the 30-year post-closure care period, a request will be made to terminate the groundwater monitoring program. All groundwater-monitoring wells will be maintained so that future monitoring can be resumed if desired. A blank groundwater monitoring well maintenance record form is provided in Appendix VI-3.

2.5.2 Surface Water Monitoring

Surface water will be monitored according to the Water Quality Monitoring Plan.

2.5.3 Landfill Gas Monitoring

Landfill gas will be monitored quarterly at permanent gas probes and in all on-site structures. A typical landfill gas monitoring probe is shown on Drawing No. EP-05. The monitoring schedule will continue as established during the active life of the facility. Refer to the Operation Plan for details regarding the landfill gas monitoring program. A blank landfill gas monitoring data form is provided in Appendix VI-4.

2.5.4 Stormwater, Erosion, and Sedimentation Control Facilities

Stormwater management features proposed in the Erosion and Sediment Control Plan are designed to function throughout the post-closure care period. Drainage ditches and sediment ponds will be inspected and maintained as needed to control surface water runoff and erosion.

2.5.5 Leachate Management and Closure Plan

Leachate management will continue according to the approved practices at the facility during the post-closure period as long as leachate continues to be generated. The leachate collection system will be checked periodically and maintained to prevent clogging. Tanker trucks will be used as needed to haul leachate to the wastewater treatment plant for disposal.

When leachate collection ceases, the following closure activities will be completed within 180 days: Leachate removal pipes will be securely plugged, and liquid and solid waste will be removed from the storage facilities and associated piping. Contaminated subsoils, structures,

and equipment will also be removed. Material that is removed will be disposed in accordance with applicable requirements.

2.5.6 Record Keeping

The following records will be maintained in the Operating Record at the landfill office or an alternative location near the facility approved by the Division throughout Post Closure Care of the facility and made available to the Division upon request:

- The facility permit and pertinent correspondence;
- Emergency Response Plan;
- Inspection records, repair and maintenance records;
- Historical amounts by weight of solid waste received at the facility, including the source of generation;
- Gas monitoring plan, monitoring results and any remediation plans developed in accordance with Division requirements if required as a response to elevated gas concentrations;
- Water Quality Monitoring Plan and any demonstration, certification, finding, monitoring, testing, or analytical data required by the water quality monitoring program at the site;
- Required cost estimates and financial assurance documentation;
- Closure and Post-Closure Plans; and
- Leachate generation and disposal quantities (including the amount used as dust suppressant)

2.6 Training

Personnel responsible for conducting monitoring activities, site inspections and maintenance will be competent individuals trained in the skills needed for their job. Personnel will continue to receive training as new programs become available.

Groundwater and surface water monitoring will be performed by a qualified firm, and laboratory analysis will be conducted by a certified environmental laboratory.

2.7 Post-Closure Land Use

The primary land use for the site after closure of the landfill will be open dormant green space. Limited passive recreational uses may be proposed at a later time.

2.8 Post-Closure Cost Estimate

An estimate of post-closure care costs is provided in Appendix VI-5. All costs are given in 2010 dollars.

(End)

APPENDIX VI-1

CLOSURE COST ESTIMATES

Table 1
Estimate of Closure Cost:
Roaring River Landfill
Phase 1-4

ITEM	UNIT	QUANTITY	UNIT COST	COST $
FINAL CAP SYSTEM- 25.4 ACRES (PHASE 1-4)				
Intermediate Cover (12" non-specified)	cy	40,979	$4.00	$163,916
Geonet Composite (Gas Migration Layer)	sf	1,106,424	$0.50	$553,212
GCL	sf	1,106,424	$0.55	$608,533
Geomembrane (40 mil)	sf	1,106,424	$0.50	$553,212
Geonet Composite (Drainage Layer)	sf	1,106,424	$0.50	$553,212
Protective cover (18")	cy	61,469	$5.10	$313,489
Erosion Layer (6")	cy	20,490	$4.00	$81,958
			Subtotal	$2,827,533
SEDIMENTATION AND EROSION CONTROLS				
Diversion Berms				
Construction and lining	lf	5,770	$13.00	$75,010
Slope Drains				
HDPE Pipe and Installation	lf	1,625	$43.12	$70,070
Drainage Bench Inlet	each	14	$300.0	$4,200
Conveyance Channels				
Riprap Channels	lf	0	$57.50	$0
Grass-lined Channels	lf	385	$5.75	$2,214
Drainage Pipe (RCP)	lf	0	$40.00	$0
Miscellaneous				
Outlet Protection (RipRap)	each	3	$440.00	$1,320
Silt Fence	lf	1,000	$3.60	$3,600
			Subtotal	$156,414
GAS CONTROLS (Vents)	each	25	$5,000.00	$127,000
VEGETATIVE COVER	acre	25	$1,750.00	$44,450
TOTAL OF ABOVE ITEMS				$3,155,396
MOBILIZATION / DEMOBILIZATION	(construction only)		5%	$157,770
ENGINEERING FEE	-	-	2%	$63,108
CQA	(cap only)	-	6%	$169,652
CONTINGENCY	-	-	10%	$315,540
ADMINISTRATION	lump sum	-	-	$2,500
CLOSURE CERTIFICATION	lump sum	-	-	$2,500
SURVEY AND DEED	lump sum	-	-	$8,000
TOTAL CLOSURE COST (IN 2010 DOLLARS)				$3,874,466

Notes:
1. Costs are based on conceptual design and should be considered approximate.

APPENDIX VI-2

POST-CLOSURE INSPECTION RECORD

POST-CLOSURE INSPECTION RECORD

FACILITY: _____ PERMIT NO. _____

LOCATION: _____ DATE: _____

INSPECTOR: _____ COMPANY: _____

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1. Access and Security Control

- ☐ Is a notice prohibiting the further disposal of waste materials clearly visible at the entrance to the facility?
- ☐ Is the site adequately secured by means of gates, chains, berms, fences or other security measures to prevent unauthorized entry?
- ☐ Are the access roads to and within the site maintained to provide access to the closed disposal area and to all monitoring points?

2. Erosion and Sediment Control

- ☐ Is the vegetation adequate to stabilize the site and prevent erosion?
- ☐ Are the erosion control measures adequate to prevent silt from leaving the site and to prevent excessive on-site erosion?
- ☐ Do the sediment basins require cleaning out, as indicted by the level of sediment buildup?

3. Drainage Control Requirements

- ☐ Are all areas adequately sloped to promote surface water runoff in a controlled manner?
- ☐ Are there areas of observed settlement, subsidence, and/or displacement of the closure cap?
- ☐ Are all drainage channels free of accumulated sediment?

4. Uncontrolled Escape of Leachate or Landfill Gas

- ☐ Are there any leachate seeps observed?
- ☐ Are there any signs of uncontrolled releases of landfill gas?

5. Environmental Monitoring Systems

- ☐ Are all monitoring wells (gas and groundwater) properly maintained? (Note: Complete the Groundwater Monitoring Well Maintenance Record during semi-annual sampling events.)

6. Miscellaneous

- ☐ Are all site benchmarks marked and evident?
- ☐ Do vector control measures appear adequate?

7. Final Cover System Inspection

- ☐ Are there areas of settlement and/or subsidence on the cap system?
- ☐ Are there areas of erosion or animal burrows on the cap system?

APPENDIX VI-3

GROUNDWATER MONITORING WELL MAINTENANCE

GROUNDWATER MONITORING WELL MAINTENANCE RECORD

FACILITY: _____ WELL #:

LOCATION: _____ DATE:

INSPECTOR: _____ COMPANY:

1. Is surface water diverted away from the wellhead?
2. Is the concrete pad still intact and free of cracks?
3. Has surface water runoff undercut the concrete pad
4. Is the outer casing still secure and locked?
5. Is the well identification tag present and is it legible?

   5a. Does the well identification tag provide the following information:

   - The well identification number?
   - Drilling contractor name and registration number?
   - Total depth of well?
   - Depth to screen?
   - A warning that the well is not for water supply and that the ground water may contain hazardous materials.

6. Is the grout between the inner and outer well casings all the way to the ground surface?
7. Is the inner casing firmly grouted in place?
8. Are the inner and outer casings upright and unobstructed?
9. Is water collecting in the outer casing? Does a weep hole need to be bored in the outer casing to provide drainage?
10. Is the monitoring well accessible by a four-wheel drive vehicle?
11. Have brush and weeds been trimmed so that the well is easy to locate and access?
12. Does the inner well casing have a vented cap?
13. Is the monitoring well visible and adequately protected from moving equipment?

APPENDIX VI-4

LANDFILL GAS MONITORING DATA FORM

Landfill Gas Monitoring Data Form

Facility Name:
Date of Sampling:
Gas Monitor Type & Serial Number:
Field Calibration Date & Time:
General Weather Conditions:

Permit Number:
Personnel:
Calibration Date:
Calibration Gas Type:
Barometer :

Location or LFG Well ID	Instr. purged	Time	Probe Pressure (InWg)	Time Pumped (sec.)	CH_4 (%LEL)	CH_4 (%Vol)	Notes

Abbreviations: BP= Barhole Probe
LEL= Lower Explosive Limit

APPENDIX VI-5

POST-CLOSURE COST ESTIMATE

Table 2
Estimate of Post-Closure Care Costs:
Roaring River Landfill
Phase 1-4

ITEM	UNIT	QUANTITY	UNIT COST	ANNUAL COST
INSPECTIONS/ RECORD KEEPING	per trip	4	$500	$2,000
MONITORING				
Explosive gases (quarterly)	per trip	4	$1,000	$4,000
Groundwater/Surfacewater (semi-annually)				
Sampling	per trip	2	$4,000	$8,000
Analysis	per trip	2	$2,500	$5,000
Reporting	per trip	2	$2,500	$5,000
Surface Water (semi-annually)	per trip	2	$2,100	$4,200
Leachate sampling and analysis	per trip	2	$500	$1,000
Subtotal				$27,200
ROUTINE MAINTENANCE				
Mowing	acre	25.4	$150	$3,810
Fertilizing (once every 3 years)	acre	8.5	$255	$2,159
Reseeding (once every 3 years)	acre	8.5	$1,600	$13,547
Vector and Rodent Control	acre	25.4	$30	$762
Subtotal				$20,278
WELL MAINTENANCE				
Groundwater Wells	lump sum	1	$1,000	$1,000
Gas Detection Probes	lump sum	1	$500	$500
Subtotal				$1,500
CAP REPAIR	lump sum	1	$6,000	$6,000
TOTAL OF ABOVE ITEMS				$56,978
ENGINEERING	-	-	3%	$1,709
CONTINGENCY	-	-	5%	$2,849
TOTAL ANNUAL POST-CLOSURE COST (IN 2010 DOLLARS)				$61,536
TOTAL 30 YEAR POST-CLOSURE COST (IN 2010 DOLLARS)				$1,531,963

Notes:
1. All costs include labor by a third party.
2. Water quality monitoring and leachate management costs are estimated.
3. Cost for groundwater wells assumes maintenance of each well during the period.
4. Cost for the gas probes assumes maintenance of each probe during the period.