Permit No.	Date	Document ID No.
54-09	**December 01, 2009**	**8970**

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Solid Waste Section
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PERMIT TO CONSTRUCT

Lenoir County Municipal Solid Waste Landfill Facility

Phase 2

Permit No.: 5409-MSWLF
Site Location: 2949 Hodges Farm Road
Kinston, NC 28551

Applicant: Lenoir County
Applicant's Address: 130 South Queen Street
Kinston, NC 27502

MESCO Project Number
G08095

NORTH CAROLINA PROFESSIONAL SEAL 6182 ENGINEER JIMMY D. WOODIE

11/30/2009

November 2009

Submitted By:

Municipal Engineering Services Company, P.A.

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Corporate License #: C-0281

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SECTION 1.0

FACILITY PLAN

Background

The County currently owns and operates a Subtitle D Sanitary Landfill (Permit No. 5409-MSWLF), a Construction/Demolition and Land Clearing/Inert Debris Landfills and obtaining a permit renewal for the transfer station, located approximately 9 miles northwest of Kinston, North Carolina. All facilities are located on the Owner's property. The new Phase is adjacent to the existing Phase 1. Access to the landfill will be the same as is presently being used. Waste currently received in the existing Phase will be disposed of in the new Phase.

General

The Facility can only accept Municipal Solid Wastes within the County, which includes but is not limited to Household, Industrial, Construction/Demolition and Animal waste. The Facility will not accept any Hazardous or PCB wastes. Tires and White Goods will continue to be processed at the Transfer Station.

The Facility will consist of seven (7) phases of development. The first phase already exists, leaving six (6) phases to be built in the future. Phase 2 is adjacent to existing Phase 1 and is approximately 9.23 acres in size. Phase 3 is adjacent to phases 1 and 2 and is approximately 14.43 acres in size. Phases 4 through 6 will be vertical expansions over Phases 1 through 3. Phase 7 will be the stand alone cell that was originally called Phase 4.

The land use around the proposed facility is mostly agricultural with some rural subdivisions located within two (2) miles of the facility. The landfill will not have any adverse impact on the residents of the County since the proposed landfill is located adjacent to the existing landfill.

1.1 Waste Stream

1.1.1 Waste Types

The Facility will accept Municipal Solid Waste: any solid waste resulting from the operation of residential, commercial, industrial, governmental, or institutional establishments that would normally be collected, processed, and disposed of through a public or private solid waste management service is considered Municipal Solid Waste.

Construction/Demolition waste will continue to be disposed of in the existing Construction/Demolition Landfill. Land Clearing and Inert Debris waste will be disposed at the Land Clearing/Inert Debris Landfill.

Spoiled foods, animal carcasses, abattoir waste, hatchery waste, and other animal waste will be accepted, and covered immediately upon dumping.

Asbestos waste will be accepted and managed in accordance with 40 CFR 61. The waste will be covered immediately with soil in a manner that will not cause airborne conditions and must be disposed of separate and apart from other solid wastes:

i. At the bottom of the working face or;
ii. In an area not contiguous with other disposal areas. Separate areas will be clearly designated so that asbestos is not exposed by future land disturbing activities.

Wastewater treatment sludges must pass the paint filter test and the TCLP test before they may be accepted and co-disposed in the lined area. Hazardous waste as defined within 15A NCAC 13A, to also include hazardous waste from conditional exempt small quantity generators, Polychlorinated biphenyls (PCB) waste as defined in 40 CFR 761 are prohibited.

1.1.2 Disposal Rates

The Facility is open 5.5 days per week. The tonnage per day was approximately 177 tons in the Fiscal year 2007-2008. The life of the Facility will depend on disposal rates and compaction, which can vary throughout the life of the Facility. This variance can either increase or decrease the life of the Facility.

1.1.3 Service Area

The Facility will accept only waste from Lenoir County.

1.1.4 Waste Segregation

The Facility will segregate Municipal Solid Waste, Construction/Demolition Waste, Land Clearing/Inert Debris, Yard Waste, Recyclables, White Goods, and Tires. The Facility will use the current access route from the existing Sanitary Landfill; and the attendant at the existing scale house will direct incoming wastes to their appropriate areas. An attendant is on site to direct segregation of waste during the hours of operation of 8am-5pm, Monday through Friday and 8am-12pm on Saturday. Waste segregation will continue to occur at the existing facility, with MSW being the only type of waste being disposed in the new MSWLF units.

1.1.5 Equipment Requirements

The Facility has and uses the following equipment:

1. Compactor
2. Front-end Loaders
3. Pans
4. Dozers
5. Backhoe

1.2 Landfill Capacity

The Life Expectancy calculations were calculated for Phases 2-7 of development with a vertical expansion being included when a Phase is constructed adjacent to the previous Phase. Each successive phase will vary in size due to being able to expand onto the previously filled areas. The Operation Plan of the Engineering Report will delineate this more clearly. Each individual Phase volume is estimated. The airspace is a net volume excluding the capping requirements.

LIFE EXPECTANCY CALCULATIONS PHASES 2-7

Given:

Life expectancy based on actual air space used in Annual Report Fiscal Year 08-09 is as follows:

Life expectancy based on using the annual average of 110,200 cubic yards/year, for the first year and an annual increase of 0.41% for each year thereafter.

Phases	Airspace Available	Years of Life
Phase 2	= 559,226 cubic yards	= 5.07 years
Phase 3	= 567,029 cubic yards	= 5.04 years
Phase 4	= 584,485 cubic yards	= 5.09 years
Phase 5	= 592,451 cubic yards	= 5.06 years
Phase 6	= 342,959 cubic yards	= 2.87 years
Phase 7	= 148,936 cubic yards	= 1.22 years
	2,795,086 cubic yards	24.35 years

Soil requirements for construction, daily cover and final caps for Phases 2-7
(Assume an 8:1 Trash to soil ratio)

Soil needed for Construction	= 222,479 cubic yards
Soil needed for Daily Cover	= 310,565 cubic yards
Soil needed for Closure	= 307,421 cubic yards
Overall Soil Requirements	= 617,986 cubic yards (soil needed for closure and daily cover)

There is no excess soil available on site. The County also owns property which it will utilize for borrow material as needed. There should be enough borrow material available to complete the landfill. If the need arises the County will purchase additional land to borrow from.

The estimate of the maximum inventory of wastes ever on-site, over the active life to date, of the landfill facility is 511,000 cubic yards.

Estimated schedule of closure will be approximately 24 years.

1.3 Containment and Environmental Control Systems

The County MSWLF Phase 2 will be constructed with a Base Liner System consisting of a cohesive soil liner with a permeability no greater than 1.0×10^{-7} cm/sec. or 1.0×10^{-5} cm/sec. with a reinforced Geosynthetic clay liner, sixty (60) mil High Density Polyethylene (HDPE) liner, 3' of protective cover, 250 mil composite drainage net and leachate collection system consisting of leachate trenches and pipes to collect the leachate. The leachate will be pumped into a leachate lagoon. The waste will be covered daily with either a synthetic cover and/or on-site soils to control disease vectors. The cap system will consist of twelve inches (12") of bridging material (temporary cover), eighteen inches (18") of soil liner with a permeability no greater than 1.0×10^{-5} cm/sec, forty (40) mil Linear Low Density Polyethylene (LLDPE) flexible membrane liner, drainage layer, and twenty four inches (24") of protective/erosive layer. The cap will contain a gas venting system consisting of a series of washed stone trenches below the soil liner that will be vented through pipes that penetrate the cap. The cap system will also include the proper seeding and mulching of the erosive layer and other erosion control devices.

1.4 Leachate Management

1.4.1 Performance and Design Concepts

A HELP model has been created for the design of the leachate collection system, along with performance calculations which are located in Section 2.2.3 of this report.

1.4.2 Normal Operating Conditions

The average monthly values of leachate generation are located in the HELP model Section 2.2.3 of this report, and performance calculations are in Section 2.2.4 of this report.

Surge Volumes created by storm events are calculated in the HELP model and performance calculations in Section 2.2.3 of this report.

1.4.3 Leachate Management System

Leachate pipeline operation capacity is located in the performance calculations in Section 2.2.4 of this report.

Capacity of the lagoon is located in the performance calculations in Section 2.1.7 of this report.

Final Disposal plans and applicable discharge limits, including documented prior approval of the wastewater treatment plant which may be designated in the plan. Appropriate documentation is located in Section 2.1.7 of this report.

1.4.4 Contingency Plan

In the event the Leachate Lagoon or the City of Kinston Wastewater Treatment Plant (WWTP) cannot handle a storm surge, the flow of leachate will be stopped from the MSWLF facility until such a time as the leachate can either be recirculated, held in the lagoon or sent to the Kinston WWTP. In the case of extreme emergency situations the County will apply for acceptance into a private Treatment Plant and they will pump and haul the leachate to the private WWTP. Any abnormal storm events can be handled. If any rain or other event requires storage of leachate or storm water in the cell, the Division of Solid Waste will be notified immediately followed by written communication.

1.5 Special Engineering Features

There are no special engineering features.

1.6 Facility Drawings

1.6.1 Title Sheet
1.6.2 Index and Vicinity Map
1.6.3 Existing Conditions
1.6.4 Proposed Subgrade
1.6.5 Leachate Collection System
1.6.6 Phase 2 Fill
1.6.7 Phase 3 Fill
1.6.8 Phase 4 Fill
1.6.9 Phase 5 Fill
1.6.10 Phase 6 and Phase 7 Fill

LENOIR COUNTY
MUNICIPAL SOLID WASTE
LANDFILL FACILITY

REVISED FACILITY PLAN

Permit Number: 5409-MSWLF

Site Location: 2949 Hodges Farm Road
La Grange, NC 28551

Applicant: Lenoir County

Applicant's Address: 130 South Queen Street
Kinston, NC 28502

BOARD OF COMMISSIONERS

George W. Graham, Jr. - Chairman
Claude Stroud - Vice-Chairman
Jackie Brown
Reuben Davis
Chris Humphrey
Thomas A. Pharo
Linda Rouse Sutton

COUNTY MANAGER

Michael W. Jarman

SOLID WASTE DIRECTOR

Tom Miller

Engineer
Municipal Engineering Services Company, P.A.
Garner, NC - Morehead City, NC - Boone, NC

11/25/2009

by _____
Professional Engineer
(Garner Office)

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SCALE:	1:1
DATE:	10/22/09
DRWN. BY:	L. HAMPTON
CHKD. BY:	J. WOODIE
PROJECT NUMBER	G08095
DRAWING NO. T1	SHEET NO. 1 OF 10

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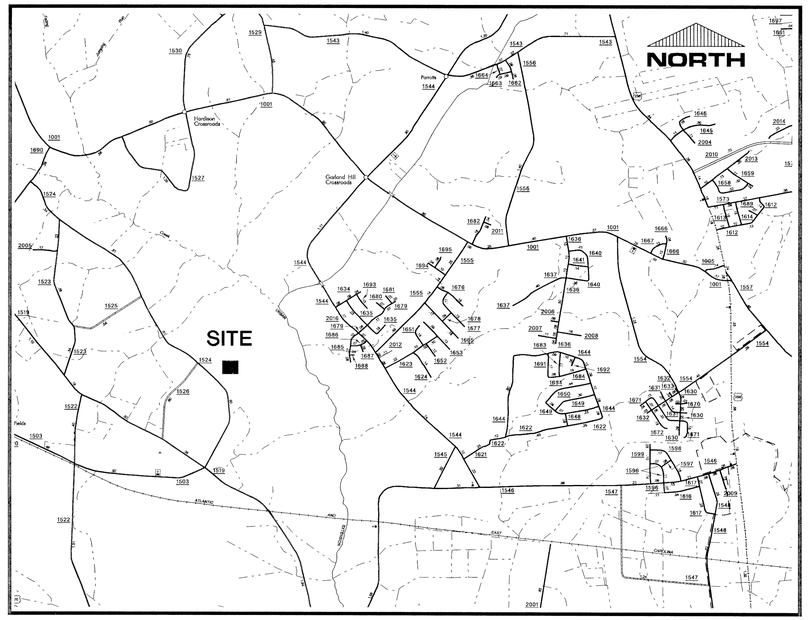
INDEX

SHEET NO.	DRAWING NO.	DESCRIPTION
1	T1	TITLE SHEET
2	T2	INDEX AND VICINITY MAP
3	F1	EXISTING CONDITIONS
4	F2	PROPOSED BASE GRADE
5	F3	LEACHATE COLLECTION SYSTEM
6	F4	PHASE 2
7	F5	PHASE 3
8	F6	PHASE 4
9	F7	PHASE 5
10	F8	PHASE 6 AND 7



VICINITY MAP

Municipal Services
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MUNICIPAL SOLID WASTE LANDFILL FACILITY
LENOIR COUNTY
NORTH CAROLINA

DATE	BY	REV.	DESCRIPTION

INDEX AND VICINITY MAP

NORTH CAROLINA PROFESSIONAL SEAL 6262 ENGINEER JIMMY D. WOODIE
11/25/2009

SCALE:	1:1
DATE:	10/22/09
DRWN. BY:	L. HAMPTON
CHKD. BY:	J. WOODIE
PROJECT NUMBER	G08095
DRAWING NO.	T2
SHEET NO.	2 OF 10

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LEGEND

- EXISTING CONTOURS
- PROPERTY LINE
- EXISITING PATH
- BUFFER ZONE
- EXISTING PIEZOMETER
- REF # — ARCHAEOLOGICAL SITES
- WETLANDS
- P2-12 — EXISTING PIEZOMETERS
- MW-13 — EXISTING MONITORING WELLS

NOTES

1. ARCHAEOLOGICAL SITE 31LR331 (CEMETARY) WILL NOT BE DISTURBED.
2. ARCHAEOLOGICAL SITE 31LR330 WILL BE DISTURBED.

Municipal Services Engineering Company, P.A.
LICENSE NUMBER: C-0281
P.O. BOX 97 GARNER, N.C. 27529 (919) 772-5393
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P.O. BOX 828 MOREHEAD CITY, N.C. 28557 (252) 726-9481

MUNICIPAL SOLID WASTE LANDFILL FACILITY
LENOIR COUNTY NORTH CAROLINA

DATE	BY	REV.	DESCRIPTION

REVISED FACILITY PLAN
EXISTING CONDITIONS

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DRWN. BY:	L. HAMPTON
CHKD. BY:	W. SULLIVAN
PROJECT NUMBER	G08095
DRAWING NO.	F1
SHEET NO.	3 OF 10

NORTH CAROLINA PROFESSIONAL SEAL 022 ENGINEER WILLIAM D. WOODIE 11/25/2009

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- PROPERTY LINE
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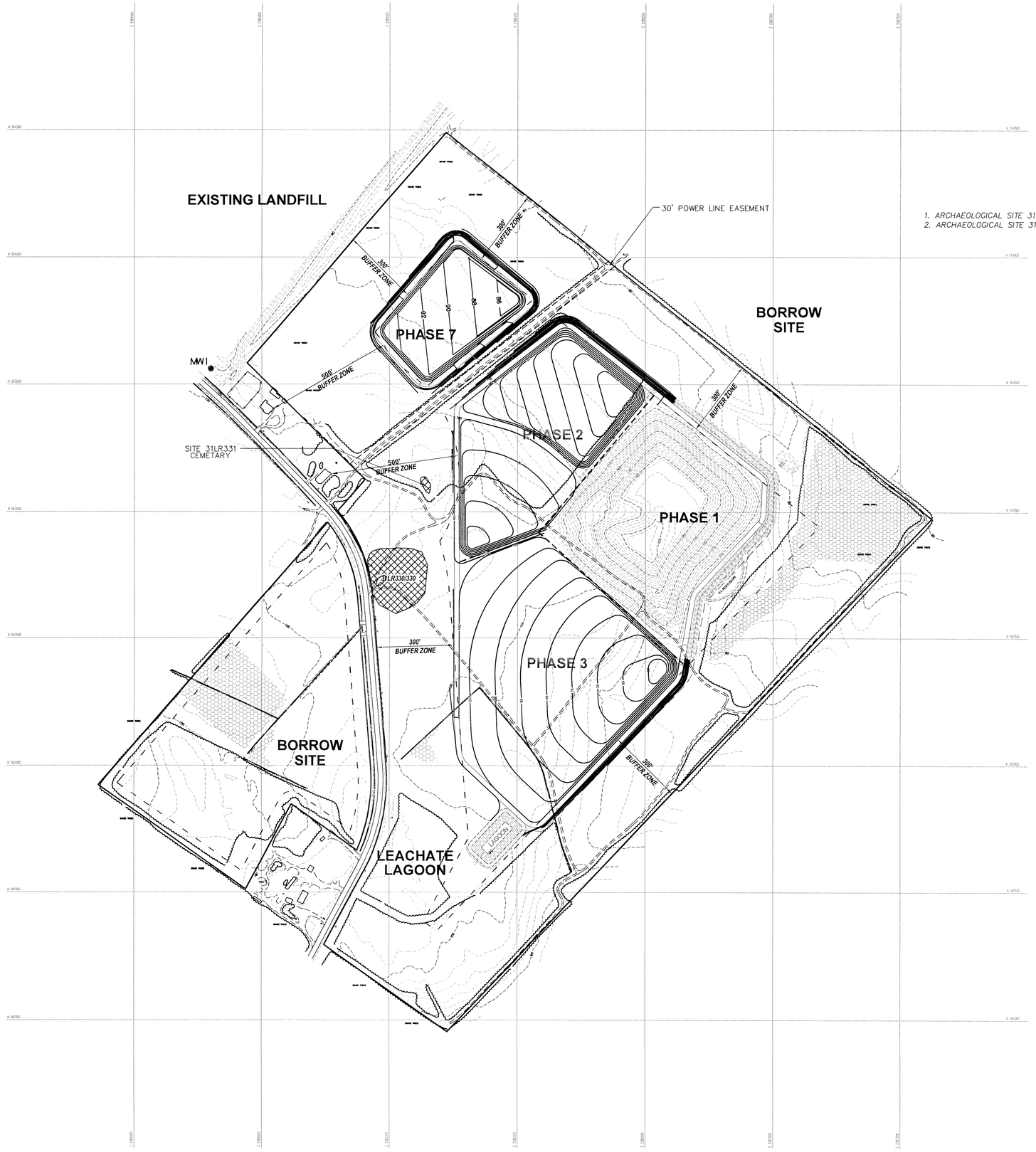
- BUFFER ZONE
- PHASES OF OPERATION
- EXISTING PIEZOMETER
- REF # — ARCHAEOLOGICAL SITES
- WETLANDS



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MUNICIPAL SOLID WASTE LANDFILL FACILITY
LENOIR COUNTY NORTH CAROLINA

DATE	BY	REV.	DESCRIPTION

REVISED FACILITY PLAN
PROPOSED BASE GRADES

NORTH CAROLINA PROFESSIONAL SEAL 6282 ENGINEER JIMMY D. WOODIE 9/25/2009

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DRWN. BY:	L. HAMPTON
CHKD. BY:	W. SULLIVAN
PROJECT NUMBER	G08095
DRAWING NO.	F2
SHEET NO.	4 OF 10

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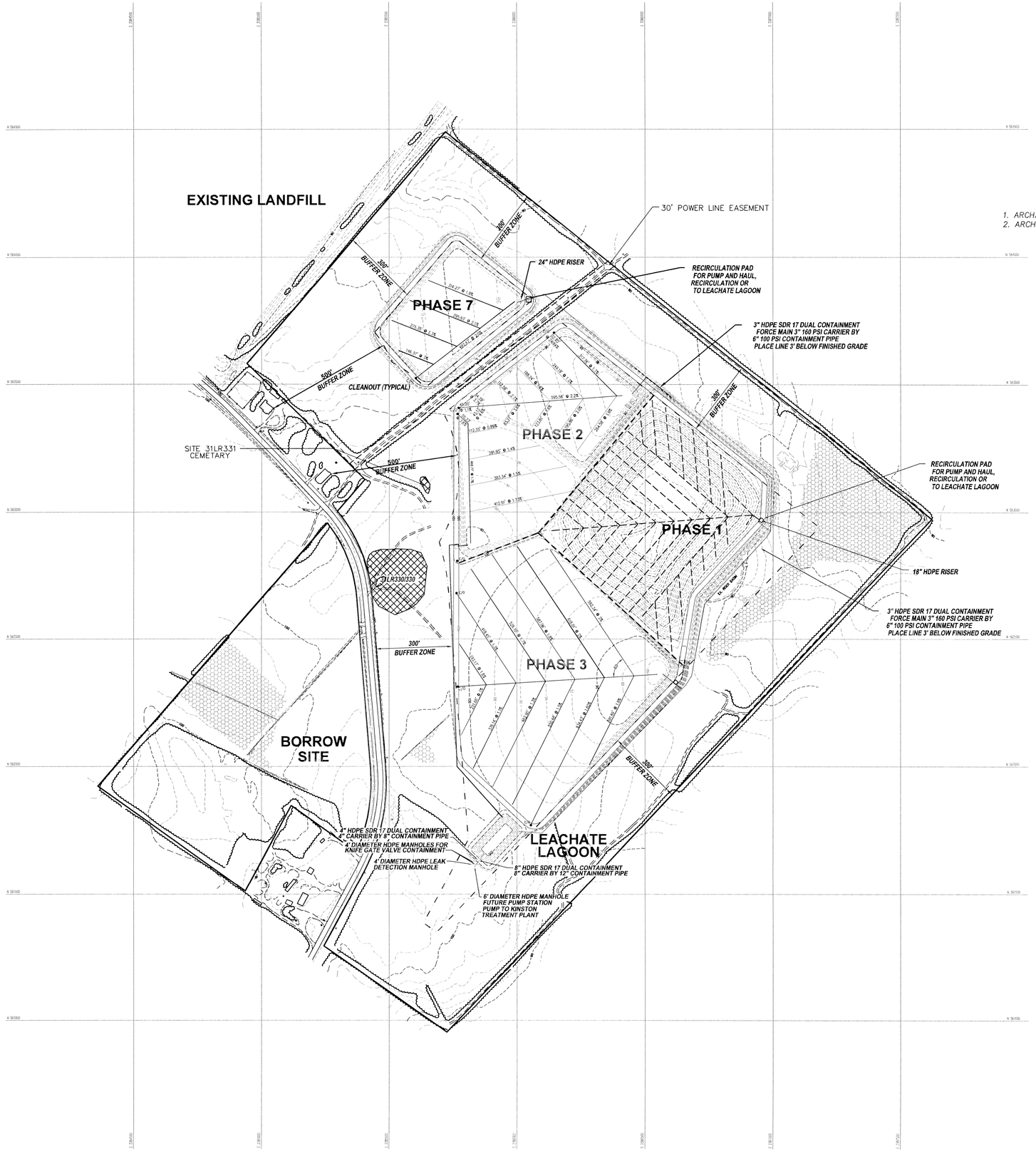
- PHASES OF OPERATION
- REF # — ARCHAEOLOGICAL SITES
- WETLANDS



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LICENSE NUMBER: C-0281

MUNICIPAL SOLID WASTE LANDFILL FACILITY
LENOIR COUNTY NORTH CAROLINA

DATE	BY	REV.	DESCRIPTION

REVISED FACILITY PLAN
LEACHATE COLLECTION SYSTEM

NORTH CAROLINA PROFESSIONAL SEAL 4182 ENGINEER JERRY D. WOODIE
1/25/2009

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CHKD. BY:	W. SULLIVAN
PROJECT NUMBER	G08095
DRAWING NO.	F3
SHEET NO.	5 of 10

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LEGEND

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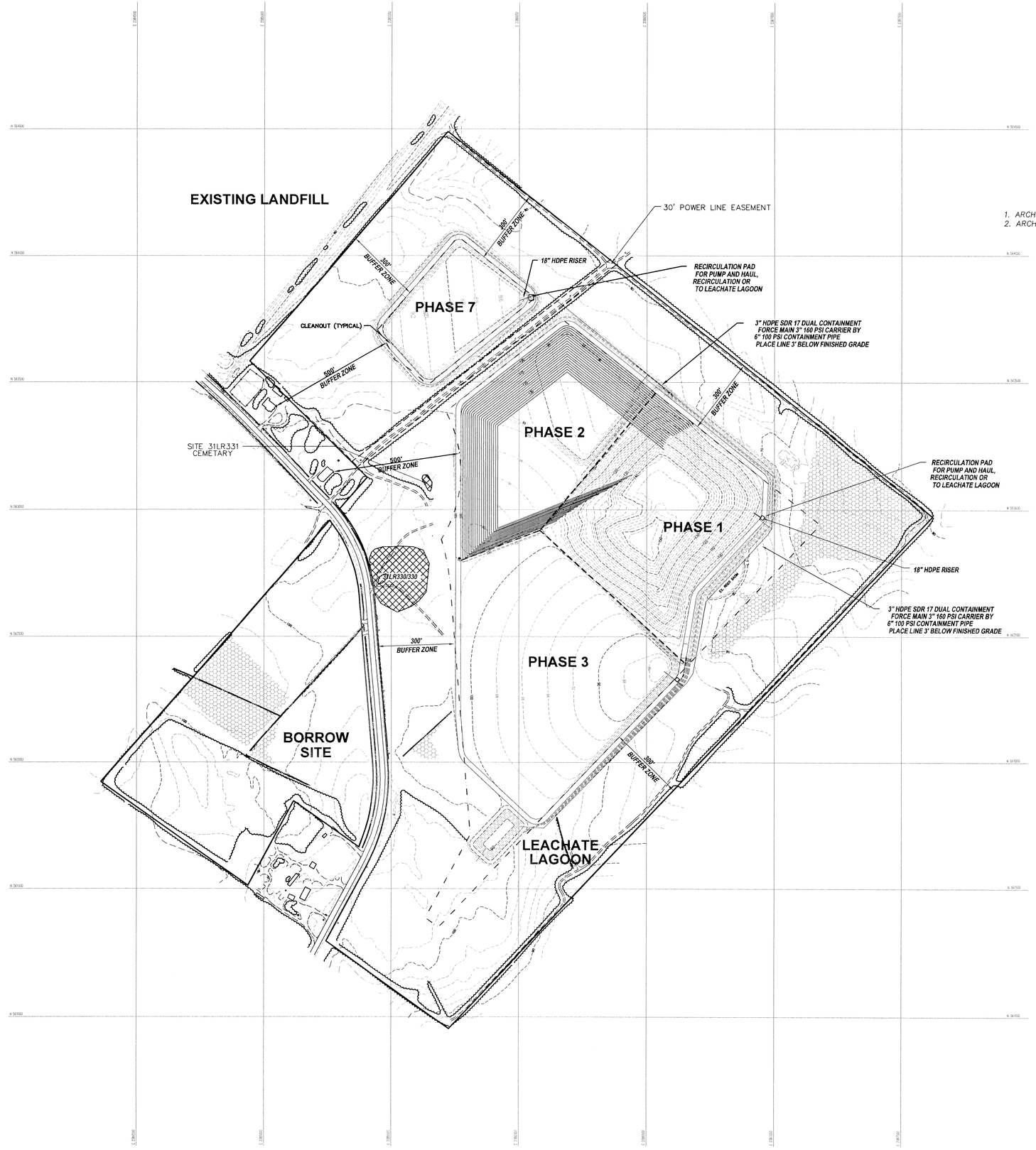
- PHASES OF OPERATION
- ARCHAEOLOGICAL SITES (REF #)
- WETLANDS



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MUNICIPAL SOLID WASTE LANDFILL FACILITY
LENOIR COUNTY NORTH CAROLINA

DATE	BY	REV.	DESCRIPTION

REVISED FACILITY PLAN PHASE 2 FILL

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CHKD. BY:	W. SULLIVAN
PROJECT NUMBER	G08095
DRAWING NO. F4	SHEET NO. 6 of 10

NORTH CAROLINA PROFESSIONAL SEAL 19382 ENGINEER JIMMY D. WOODLI 11/25/2009

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LEGEND

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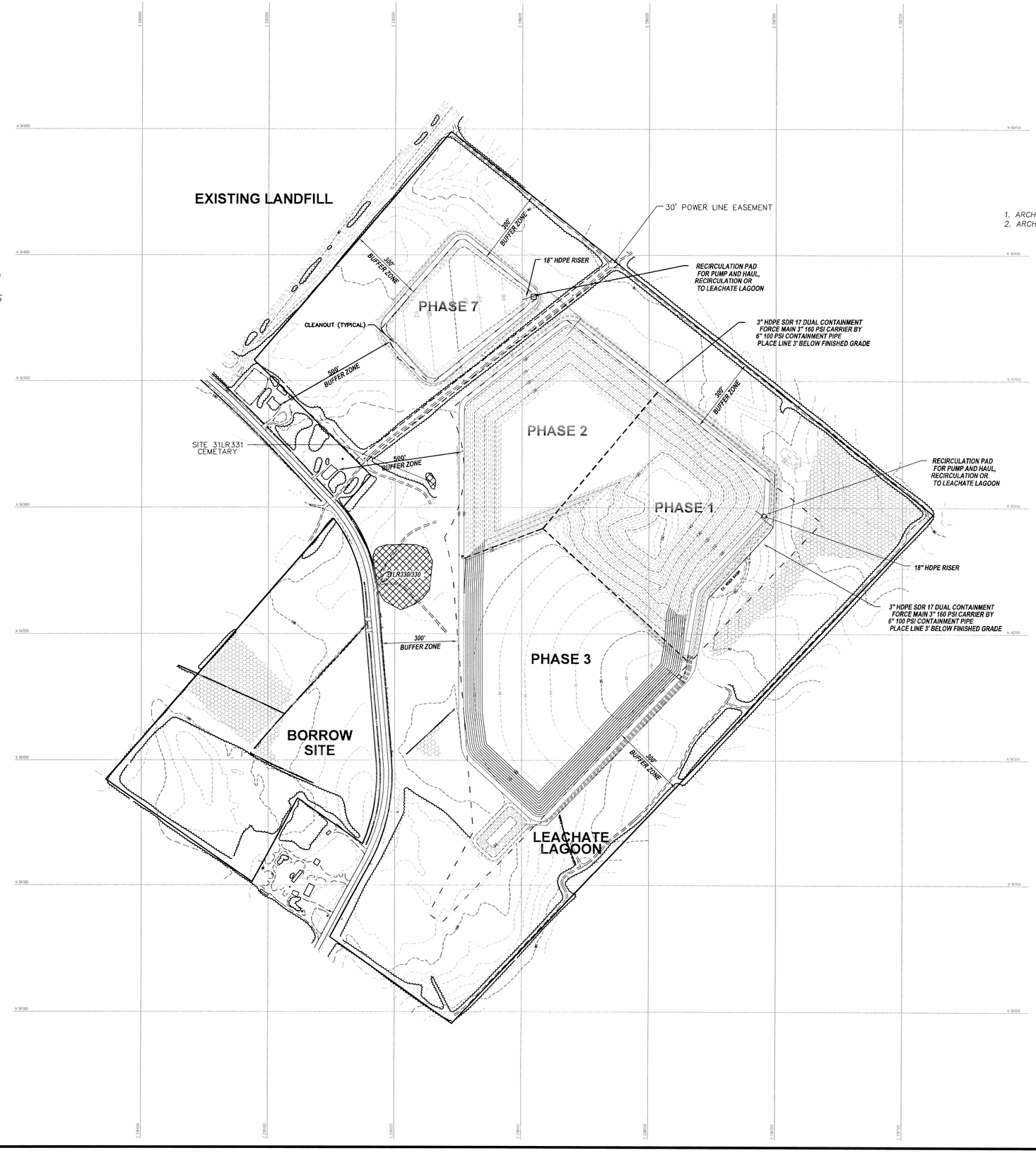
- PHASES OF OPERATION
- REF # — ARCHAEOLOGICAL SITES
- WETLANDS



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MUNICIPAL SOLID WASTE LANDFILL FACILITY
LENOIR COUNTY NORTH CAROLINA

DATE	BY	REV.	DESCRIPTION

REVISED FACILITY PLAN
PHASE 3 FILL

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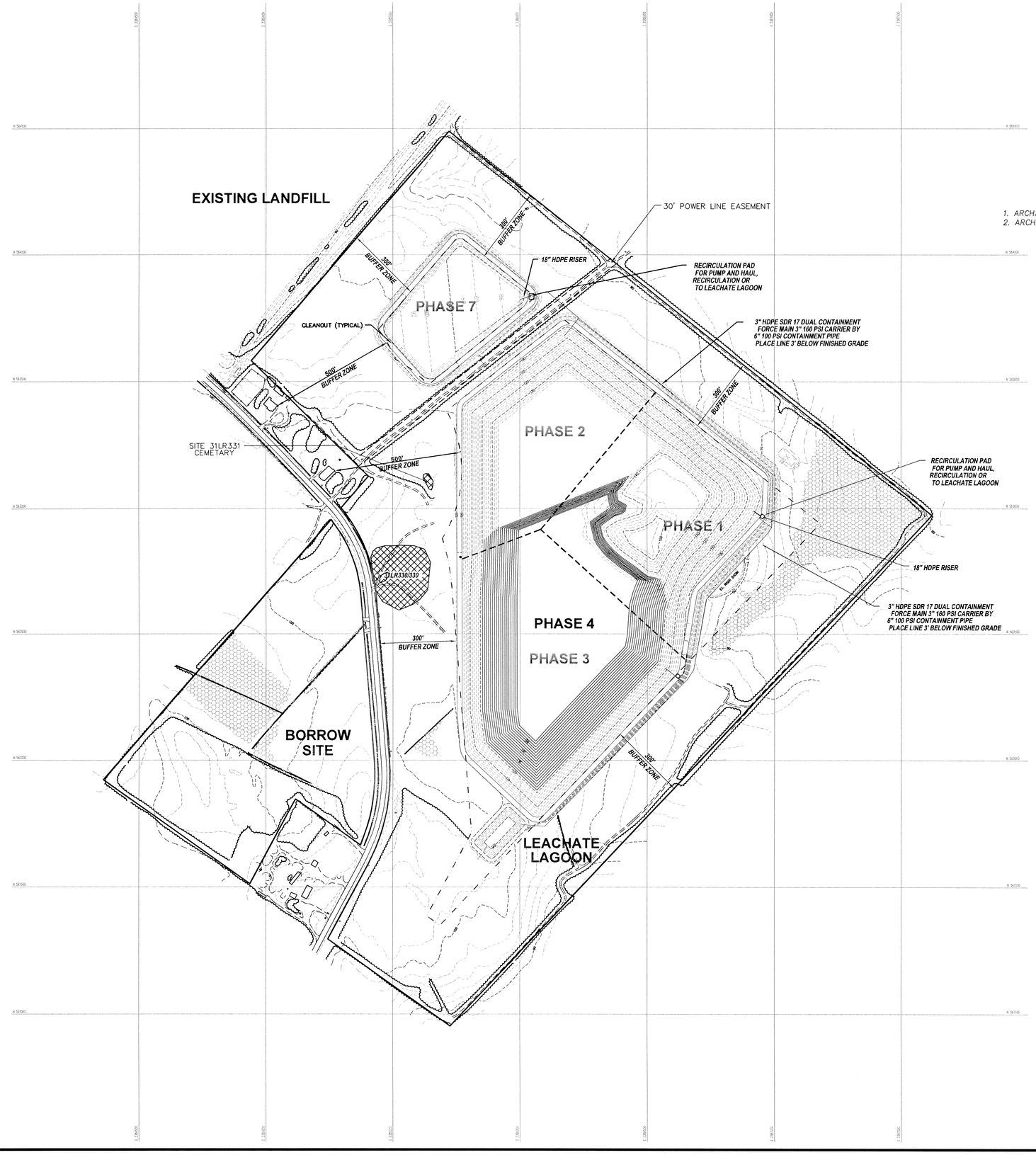
CHKD. BY:	W. SULLIVAN
PROJECT NUMBER	G08095
DRAWING NO.	F5
SHEET NO.	7 of 10

P:\SolidWaste\G08095-Lenoir-Co. PTC Phase 2\dwg\facility\08095-f07.dwg, 11/24/2009 11:18:44 AM, lchlch

LEGEND

- EXISTING CONTOURS
- PROPERTY LINE
- EXISITING PATH
- BUFFER ZONE
- PHASES OF OPERATION
- REF # — ARCHAEOLOGICAL SITES
- WETLANDS



NOTES

1. ARCHAEOLOGICAL SITE 31LR331 (CEMETARY) WILL NOT BE DISTURBED.
2. ARCHAEOLOGICAL SITE 31LR330 WILL BE DISTURBED.

Municipal Engineering Services Company, P.A.
P.O. BOX 97 GARNER, N.C. 27529 (919) 772-5393
P.O. BOX 349 BOONE, N.C. 28607 (828) 262-1767
LICENSE NUMBER: C-0281

MUNICIPAL SOLID WASTE LANDFILL FACILITY
LENOIR COUNTY NORTH CAROLINA

DATE	BY	REV.	DESCRIPTION

REVISED FACILITY PLAN
PHASE 4 FILL

NORTH CAROLINA PROFESSIONAL SEAL 6282 ENGINEER JIMMY D. WOODIE
10/25/2009

SCALE:	1"=200'
DATE:	9/10/09
DRWN. BY:	L. HAMPTON
CHKD. BY:	W. SULLIVAN
PROJECT NUMBER	G08095
DRAWING NO.	F6
SHEET NO.	8 of 10

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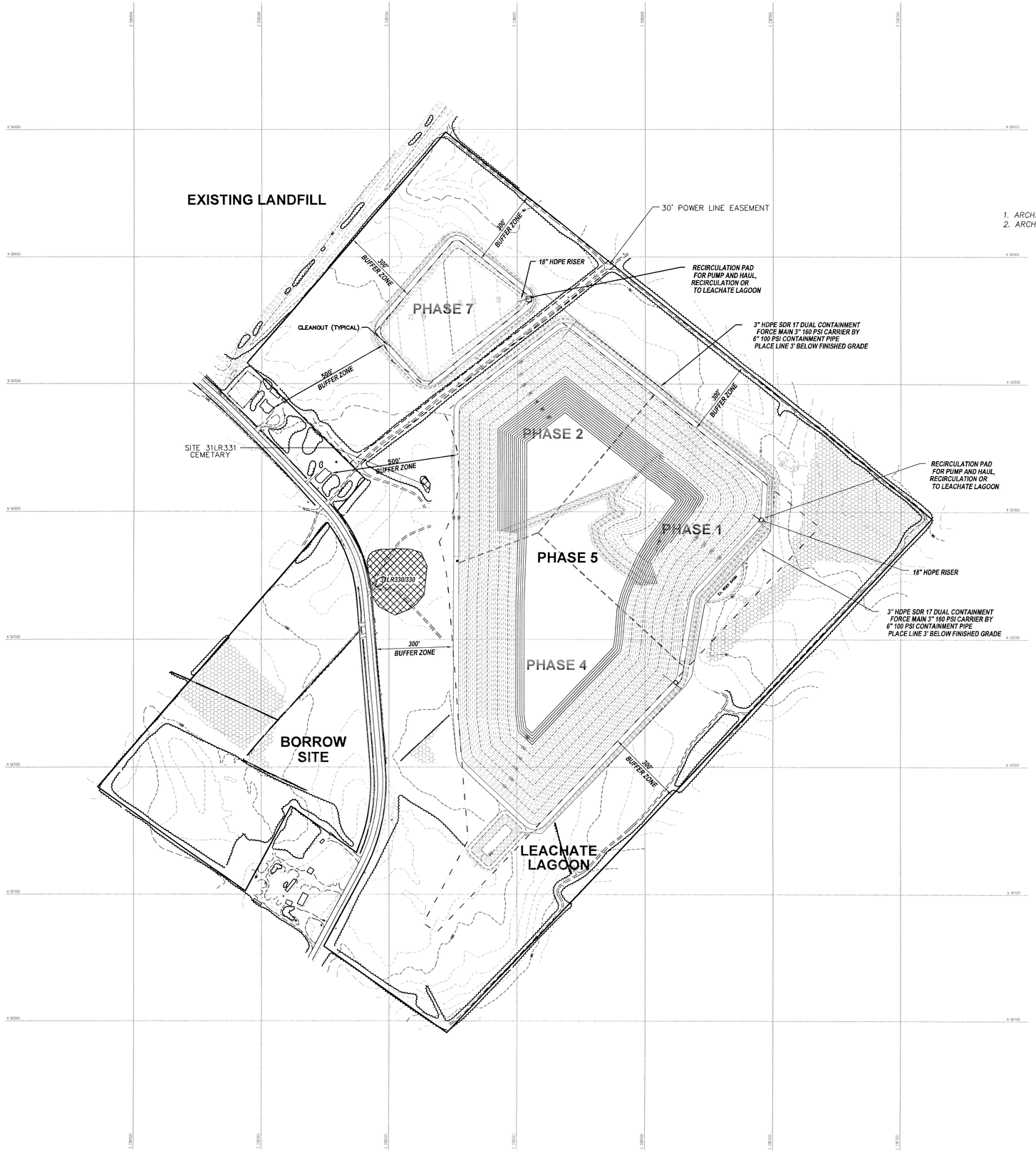
LEGEND

- EXISTING CONTOURS
- PROPERTY LINE
- EXISITING PATH
- BUFFER ZONE
- PHASES OF OPERATION
- REF # — ARCHAEOLOGICAL SITES
- WETLANDS



NOTES

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2. ARCHAEOLOGICAL SITE 31LR330 WILL BE DISTURBED.

Municipal Engineering Services Company, P.A.
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P.O. BOX 97 GARNER, N.C. 27529 (919) 772-5393
LICENSE NUMBER: C-0281

MUNICIPAL SOLID WASTE LANDFILL FACILITY
LENOIR COUNTY NORTH CAROLINA

DATE	BY	REV.	DESCRIPTION

REVISED FACILITY PLAN
PHASE 5 FILL

NORTH CAROLINA PROFESSIONAL SEAL 6782 ENGINEER JIMMY D. WOODIE 10/5/2009

SCALE:	1"=200'
DATE:	9/10/09
DRWN. BY:	L. HAMPTON
CHKD. BY:	W. SULLIVAN
PROJECT NUMBER	G08095
DRAWING NO.	F7
SHEET NO.	9 of 10

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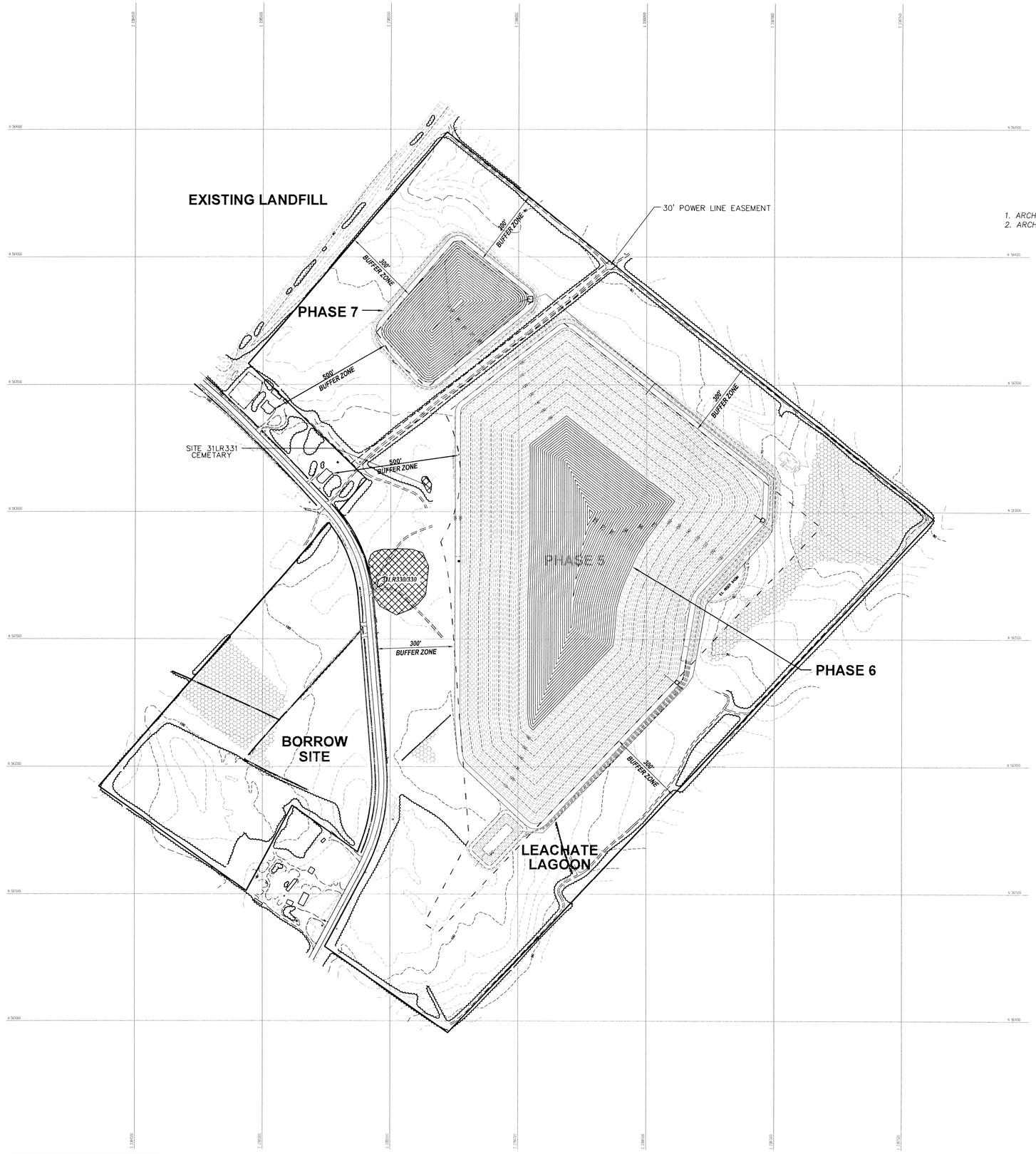
LEGEND

- EXISTING CONTOURS
- PROPERTY LINE
- EXISITING PATH
- BUFFER ZONE
- PHASES OF OPERATION
- REF # — ARCHAEOLOGICAL SITES
- WETLANDS



NOTES

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2. ARCHAEOLOGICAL SITE 31LR330 WILL BE DISTURBED.

Municipal Engineering Services Company, P.A.
P.O. BOX 349 BOONE, N.C. 28607 (828) 262-1767
P.O. BOX 97 GARNER, N.C. 27529 (919) 772-5393
LICENSE NUMBER: C-0281

MUNICIPAL SOLID WASTE LANDFILL FACILITY
LENOIR COUNTY NORTH CAROLINA

DATE	BY	REV.	DESCRIPTION

REVISED FACILITY PLAN
PHASE 6 AND 7 FILL

NORTH CAROLINA PROFESSIONAL SEAL 22282 ENGINEER TIMMY D. WOODIE
11/25/2009

SCALE:	1"=200'
DATE:	9/10/09
DRWN. BY:	L. HAMPTON
CHKD. BY:	W. SULLIVAN
PROJECT NUMBER	G08095
DRAWING NO.	F8
SHEET NO.	10 of 10

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SECTION 2.0

ENGINEERING PLAN

CERTIFICATION

This plan was prepared by the undersigned Professional Engineer. This plan meets all the requirements of Rule 0.1620.

NORTH CAROLINA PROFESSIONAL SEAL 6282 ENGINEER JIMMY D. WOODIE

11/30/2009

Jimmy D. Woodie, PE
License No. 6282

2.1 Analysis of the Facility Design

The MSWLF unit shall be located a minimum of 300' from the property lines, 500' from existing residences/wells, and 50' from any stream, river or lake, and the post settlement subbase elevation shall be prepared a minimum of four feet above the seasonal high groundwater table and bedrock. The landfill subgrade shall be adequately free of organic material and consist of on site soils.

The base liner system consists of a 60 mil HDPE geomembrane liner which is installed above and in direct uniform contact with a compacted clay liner.

The alternate liner system consists of a 60 mil HDPE geomembrane liner which is installed above and in direct contact with a geosynthetic clay liner (GCL) and a compacted clay liner.

The County will cap their landfill within 180 days after the final receipt of solid waste. The cap system will consist of 12 inches bridging material (temporary cover), 18 inches of soil liner with a permeability no greater than 1.0×10^{-5} cm/sec, 40 mil. Linear Low Density Polyethylene (LLDPE), drainage layer, 24 inches of protective/erosive layer. The cap contains gas venting system consisting of a series of washed stone trenches below the soil liner that will be vented through pipes that penetrate the cap. The cap system will also include the proper seeding and mulching of the erosive layer and other erosion control devices.

2.1.1 Base Liner System Standards

The base liner system consists of a geomembrane liner which is installed above and in direct uniform contact with a compacted clay liner.

1. The site shall meet the following design requirements for Landfill subgrade.

   The landfill subgrade shall be adequately free of organic material and consist of on site soils.

2. The site shall meet the following material requirements for the Base Liner System:

   The soil materials used in construction of the compacted clay liner may consist of on-site sources and may possess adequate native properties or may require bentonite conditioning to meet the permeability requirement. However, if on-site soils are not available, the offsite soils will be used. The soil shall be free of particles greater than ¾ inch in dimension.

   The compacted clay liner shall be 24 inches (0.61 m) thick with a permeability not to exceed 1.0×10^{-7} cm/sec.

   The geomembrane liner material shall be high density polyethylene geomembrane with a thickness of 60 mils. which has a demonstrated water vapor transmission rate of not more than 0.03 gm/m^2 day. The liner and seaming materials shall have chemical and physical resistance not adversely affected by environmental exposure, waste placement and leachate generation.

3. The site shall meet the following material requirements for the Alternate Liner System:

   The soil materials used in construction of the compacted clay liner may consist of on-site sources and may possess adequate native properties or may require bentonite conditioning to meet the permeability requirement. However, if on-site soils are not available, the offsite soils will be used. The soil shall be free of particles greater than ¾ inch in dimension.

   The compacted clay liner shall be 18 inches thick with a permeability not to exceed 1.0×10^{-5} cm/sec and a reinforced GCL.

The geomembrane liner material shall be high density polyethylene geomembrane with a thickness of 60 mils. which has a demonstrated water vapor transmission rate of not more than 0.03 gm/m^2-day. The liner and seaming materials shall have chemical and physical resistance not adversely affected by environmental exposure, waste placement and leachate generation.

4. The site shall meet the following design requirements for the Leachate Collection System:

   The Leachate Collection System is designed with stone filled trenches, collection pipes and 250 mil double bonded drainage net that allows less than one foot of head on the liner.

   The impingement rate on the drainage layer is at least equal to the peak monthly precipitation rate.

   The geometry of the landfill shall control and contain the volume of leachate generated by the 24-hour, 25-year storm.

   The collection pipe along with the drainage net flow capacity shall drain the critical volume of leachate generated by the 24-hour, 25-year storm.

   The Leachate Collection System includes a pipe network with clean-outs and geotextile and filter fabrics.

   The Leachate Collection Piping has a minimum nominal diameter of six inches.

   The chemical properties of the pipe and all materials used in installation shall not be adversely affected by waste placement or leachate generated by the landfill.

   The pipe provides adequate structural strength to support the maximum static and dynamic loads and stresses imposed by the overlying materials and any equipment used in construction and operation of the landfill.

   The Geosynthetic filter materials have adequate permeability and soil particle retention, and chemical and physical resistance which is not adversely affected by waste placement, and overlying material or leachate generated by the landfill.

2.1.2 Horizontal Separation Requirements

1. The MSWLF units are located a minimum of 300' from the property lines.
2. The MSWLF units are located a minimum of 500' from existing residences/wells.
3. The MSWLF units are located a minimum of 50' from any stream, river, or lake.

2.1.3 Vertical Separation Requirements

The MSWLF units are designed so that post settlement bottom elevation of the base liner system is a minimum of four feet above the seasonal high ground-water table and bedrock.

2.1.4 Location Coordinates and Survey Control

Survey control coordinates will be furnished upon request.

2.1.5 Sedimentation and Erosion Control Plan

The Sedimentation and Erosion control plan has been completed for the 24-hour, 25-year storm. A copy is submitted under Section 2.2.2 of this application.

2.1.6 Cap System Standards

The County will cap their landfill within 180 days after the final receipt of solid waste. The cap system will consist of 12 inches bridging material (temporary cover), 18 inches of soil liner with a permeability no greater than 1.0×10^{-5} cm/sec, 40 mil. Linear Low Density Polyethylene (LLDPE), drainage layer, 24 inches of protective/erosive layer. The cap contains a gas venting system that consists of a series of washed stone trenches below the soil liner that will be vented through pipes that penetrate the cap. The cap system will also include the proper seeding and mulching of the erosive layer and other erosion control devices.

Prior to beginning closure, the County will notify the Division of Solid Waste that a notice of the intent to close the unit has been placed in the operating record. The County will begin closure activities no later than thirty (30) days after the date on which the landfill receives the final wastes or if the landfill has remaining capacity and there is a reasonable likelihood that the landfill will receive additional wastes, no later than one year after the most recent receipt of wastes. Extensions beyond the one-year deadline for beginning closure may be granted by the Division of Solid Waste if the County demonstrates that the landfill has the capacity to receive additional waste and the County has taken and will continue to take all steps necessary to prevent threats to human health and the environment from the closed landfill.

The County will complete closure activities in accordance with the closure plan within 180 days following the final receipt of waste. Extensions of the closure period may be granted by the Division of Solid Waste if the County demonstrates that closure will, of necessity, take longer than one hundred eighty (180) days and the County has taken and will continue to take all steps to prevent threats of human health and environment from the enclosed landfill.

Following closure of the landfill, the County will record a notation on the deed to the landfill property and notify the Division of Solid Waste that the notation has been recorded and a copy has been placed in the operating record. The notation on the deed will in perpetuity notify any potential purchaser of the property that the land has been used as a landfill and its use is restricted under the closure plan approved by the Division of Solid Waste. The County may request permission from the Division to remove the notation from the deed if all waste is removed from the landfill.

2.1.7 Leachate Storage Requirements

The County's existing leachate lagoon was designed and built with a minimum of two feet of freeboard. Odor and vector controls are practiced when necessary. A groundwater monitoring system has been installed. The lagoon is protected from external damage by an 8' high chain link fence.

The management of leachate is a major daily operational task. The generation of leachate should always be kept to a minimum. The leachate that is generated will be pumped to the Town of Kinston Wastewater Treatment Plant. The leachate is treated according to the pre-treatment agreement with the City of Kinston. The reason for this testing is to assure the City that the leachate will not harm the biological processes in their treatment facility. The County also records rainfall events as they occur and leachate generation to track the effect rainfall amounts have on the amount of leachate that is generated.

The leachate will be collected in the existing double lined lagoon which will hold approximately 624,000 gallons at 8 feet deep. The Lagoon is 10 feet deep which allows for 2 feet of free board. In the event that the lagoon fills up faster than it can be pumped to the City of Kinston WWTP, the valves can be turned off which will allow the lagoon to be drained. Once the leachate levels have been lowered, the valves can be opened. Leachate will be a management problem from the time the garbage is placed in the landfill until long after closure has taken place. Consequently, it is imperative that storm water be diverted away from any solid waste and managed properly.

All storm water falling outside of the existing lined areas will be diverted away from the lined section through the use of diversion berms and ditches. Storm water that falls within the lined area but does not come in contact with solid waste can be diverted to the perimeter areas of the landfill.

The County will close the leachate lagoon within 180 days after liquid collection has ceased.

All solid waste will be removed from the leachate lagoon, connecting sewer lines, and manholes. All solid waste removed will be properly handled and disposed of according to Federal and State requirements. All connecting lines will be disconnected and securely capped or plugged.

All waste residues, contaminated system components (composite liner system), contaminated subsoil, structures and equipment contaminated with waste will be removed and appropriately disposed. If the groundwater surrounding the impoundment is contaminated, other corrective actions to remediate a contaminant plume may be required by the Department. If the groundwater surrounding the lagoon is found not to be contaminated, the liner system may remain in place if drained and cleaned to remove all traces of waste, and both liners punctured so that drainage is allowed. The lagoon is to be backfilled and re-graded to the surrounding topography.

2.2 Summary of the Facility Design

Several factors have been looked at in the design and stability of the landfill. The first is earthwork calculations to see if the facility will need to borrow material from another source. For the construction of Phase 2 the facility will need 30,860 cubic yards of off-site soil. An additional 62,136 cubic yards will be needed for daily cover and an additional 74,455 cubic yards will be needed for closure. An Erosion Control plan has been developed and approved by the Land Quality Section of NCDENR, and the calculations are in section 2.2.2.

HELP Model Summary

A "Hydrologic Evaluation of Landfill Performance" (HELP) Model has been performed to simulate precipitation and leachate generation under certain conditions. The output can be found in Section 2.2.3. The analysis is done through the landfill with 8 ft. of solid waste with no runoff for the 1st year of operation and with 25 ft. of solid waste with no runoff for the 1st through the 5th year of operation. Simulation was also done on a closed landfill. The peak daily head on the liner of 0.312 inches occurs after 1 year of operation with 8 ft. of solid waste and no surface runoff. The peak daily head on the liner for the 1st five years is 0.479 inches. The drainage layer (layer 5) is a double bonded 250 mil thick drainage net.

Leachate Collection System Calculations Summary

The leachate collection system consists of a 250 mil double bonded drainage net that is the drainage layer, stone filled trenches and collection pipes. The adequacy of the drainage layer is demonstrated in the HELP models (see sec.2.2.3).

Calculations have been performed for the Leachate Collection Pipes, and are located in Section 2.2.4. The calculations uses Manning's equation and the orifice equation to determine the adequacy of the leachate piping system to drain the leachate. The system adequately drains the 24hr 25yr storm. See calculations in section 2.2.4.

Strength of the HDPE leachate pipe calculations have been done and are located in section 2.2.5. The SDR 17 HDPE pipe can handle the loads created by at least 250' of waste. See section 2.2.5 for calculations.

Liner System Calculation Summary

Several calculations were done for the stress on the textured flexible geomembrane liner during construction. The thermal stress on the liner created by the temperature changing 100°F is 0.67% which is well within the 13% elongation yield limit. (see sec. 2.2.6) The self-weight stress on the textured flexible geomembrane liner shows that on a 3:1 slope the total length of slope allowed far exceeds the longest slope design (see sec. 2.2.6).

The Anchor trench has also been analyzed and the design depth of the Anchor trench is 4.0 ft. which allows pullout just prior to liner failure. (see sec. 2.2.6). An analysis of the drainage net for anchor trench requirements was analyzed and no anchor trench was required; however, the drainage net will be placed in the same anchor trench as the flexible membrane liner.(see sec.2.2.6).

The factor of safety for the sliding of the protective soil cover was analyzed showing a factor of safety greater than 1 for the interface between the soil and double bonded drainage net. (see sec. 2.2.6). The stresses due to the placement of protective cover were also analyzed (see sec. 2.2.6). Soil placed on the 3:1 embankment 50 ft. high does not affect the drainage net or the liner. The soil is buttressed enough at the base to have a negative effect on the slopes.

The geotechnical evaluation report by ECS, Ltd. states that the proposed plan is suitable and falls within acceptable safety factors. The report is located in Section 2.2.8.

2.2.1 Earthwork Calculations

*Required soil for:

Subbase preparation Phase 2:	18,557 cubic yards
Composite Liner System Phase 2:	30,616 cubic yards
Protective Cover Phase 2:	45,139 cubic yards
Total Soil required for Construction Phase 3:	**94,312 cubic yards**

Required soil for:

Daily Cover Phase 2:	62,136 cubic yards
Closure System Phase 2:	74,455 cubic yards
Total Soil required To build, operate and close Phase 3:	**230,903 cubic yards**

*Determined by AutoCADD computer program.

2.2.2 Erosion Control

REVISION TO APPROVED EROSION CONTROL PLAN

for

Lenoir County Municipal Solid Waste Landfill Facility

Landfill Permit No.: 5409-MSWLF

Site Location: 2949 Hodges Farm Road
Kinston, NC 28551

Applicant: Lenoir County

Applicant's Address: 130 South Queen Street
Kinston, NC 27502

MESCO Project Number
G08095

November 2009

Submitted By:

Municipal Engineering Services Company, P.A.

Garner	Boone	Morehead City
P.O. Box 97	P.O. Box 349	P.O. Box 828
Garner, NC 27529	Boone, NC 28607	Morehead City, NC 28557
(919) 772-5393	(828) 262-1767	(252) 726-9481

DRAINAGE/DISTURBED AREAS

Drainage/ Disturbed Areas

Area Designation	Acres	C factor
D1	11.99	0.50
D2	1.96	0.50
D3	2.81	0.35
D4	3.59	0.35

Total Disturbed
13.95 acres

Runoff Coefficient
NC Erosion Control Manual Table 8.03b
C = varies (see above)

Rainfall Intensity

NC Erosion Control Manual Fig. 8.03c
Rainfall Intensity Chart for Raleigh

I = 6.19

Raleigh, North Carolina 35.8706N, 78.7864W										
ARI* (years)	5 min.	10 min.	15 min.	30 min.	60 min.	120 min.	3 hr.	6 hr.	12 hr.	24 hr.
2	5.58	4.46	3.74	2.58	1.62	0.94	0.66	0.40	0.24	0.14
10	7.08	5.66	4.78	3.46	2.25	1.33	0.95	0.58	0.34	0.021
25	7.78	6.19	5.24	3.88	2.58	1.54	1.11	0.68	0.41	0.24
100	8.64	[illegible]86	5.78	4.43	3.05	1.85	1.36	0.84	0.51	0.30

USE
6.19

Design Sediment Basin 1

Disturbed/Drainage area to Basin 1

Area Designation	Acres	C factor
D1	11.99	0.50
D2	1.96	0.50
D3	2.81	0.35
D4	3.59	0.35

Find Composite C:

13.95 x 0.50 = 6.98
6.40 x 0.35 = 2.24
20.35 9.22

Combined C factor ÷ acreage = Composite C = 9.22 ÷ 20.35 = 0.45 = Composite C

$Q_{(25)}$ = CIA= (.45)(6.19)(20.35) = 56.68 cfs

Surface area needed: : 435 Sq. Ft./Peak cfs

Surface area S = 435(56.68) = 24,656 ft^2
Use 6:1 Length:width ratio = $(24,656I6)^{.5}$ = 64.10'
use 69' x 448' min. surface area dimension

Surface Area required = 24,656 square feet
Surface Area Provided = 26,000 square feet

Depth of basin:

depth = Capacity/disturbed area

Capacity needed is 1800 ft^3/acre.
Capacity = (1800)(20.35) = 36,630 ft^3 of storage needed

Use a storage depth of 2'
Bottom area = 36,630 ft^3 ÷ 2' = 18,315 ft^2

Use 6:1 length:width ratio
$(18315 \div 6)^{.5}$ = 55.25 ft. use 57 ft.

Bottom Area Required = 56' x 336'
Bottom Area Provided= 57' x 392'

Storage volume required = 36,630 cubic feet
Storage Volume Provided = 53,256 cubic feet

The actual storage capacity of the basin is adequate to contain the runoff.

Principal spillway barrel size:

Size for a 25 year storm:

C = 0.45 (composite C)
I = 6.19
A = 20.35 acres (total drainage area)

$Q_{(25)}$ = CIA= (0.45)(6.19)(20.35) = 56.68 cfs

Q = 56.68 cfs n = .024 s = .015

$D = 16\,(Q\,n \div \sqrt{s})^{.375}$ Use corrugated metal pipe

$D = 16[(56.68)(.024)\div\sqrt{.015}]^{.375}$ = 39.46" Use 42" CMP

Outlet Protection: L =20' W = 23.5' d_{50} = 12" 27" min. thickness

Riser pipe for Principal spillway:

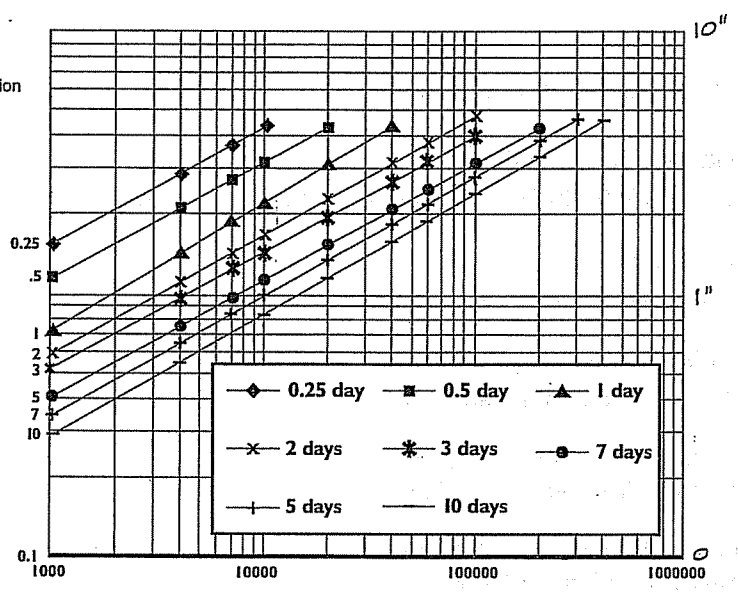
1.5 times the required min. barrel size = 1.5(39.46") = 59.19"
Use 60" pipe diameter

Footing for riser pipe:

Weight of water: $\pi r^2 h(62.4)$ = 2450.44
Concrete: 150 lbs per ft^3
16.33 ft^3 of concrete needed
use 36 ft^3 of concrete
1'x6'x6' footing.

Skimmer: Use skimmer designed with 4" orifice diameter. (Determined by using chart below found in NC Erosion Control Manual) Based on Basin Volume of 53,256 cubic feet and 2 day dewatering time.

Figure 6.64b Skimmer orifice diameter as a function of the basin volume and basin dewatering time.



Emergency Spillway:

n =	0.032	9" stone
B =	20.00	
S =	0.015	
Y =	1	
M =	3	
Depth =	1	

W =	26	
R =	0.873709	R value
Q =	119.5511	Flow
A =	23	Adjusted Area of flow
P =	26.32456	Adjusted Wetted Perimeter

V = 5.197873 Va =8

Shear Stress	0.936	0-.45	jute netting
		.46-1.45	straw with net
		1.45-2.00	synthetic mat
		2.00max.	6" stone
		3.00max.	9" stone

Elevations:

Top of Dam	68.0'
Emergency Spillway	67.0'
Riser Crest	66.0'
Conduit Inlet	64.0'
Conduit Outlet	63.5.0'
Bottom Elevation	64.0'

Design Diversion Ditch #1 :

Areas Draining Into Diversion Ditch #1

Area Designation	Acres	C factor	Intensity
D1	11.99	0.50	6.19

$$Q_{(25)} = CIA = (.50)(6.19)(11.99) = 37.11 \text{ cfs}$$

Ditch Calculation:

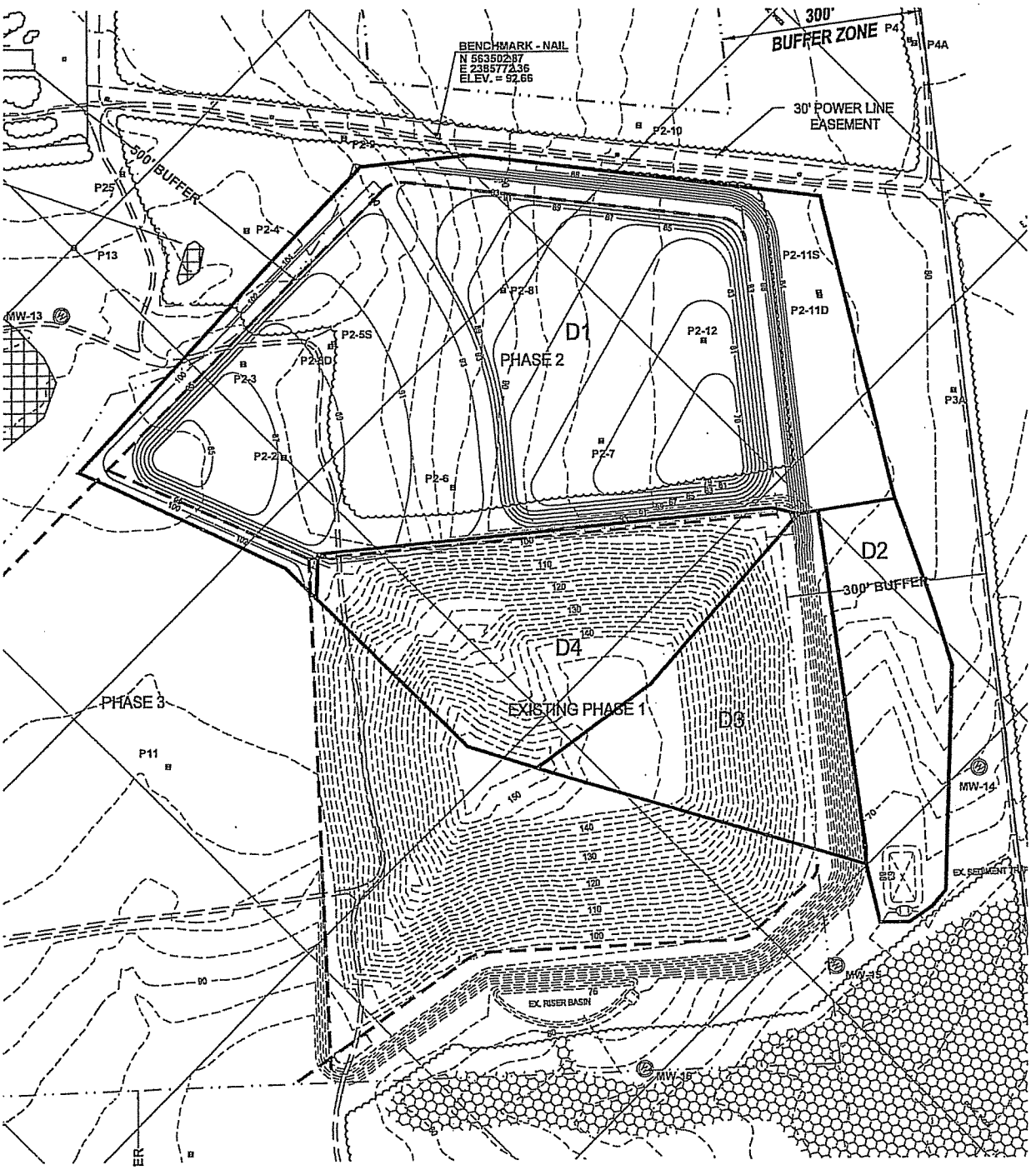
n =	0.03	grass lined
B =	7.00	
S =	0.01	
Y =	1	
M =	3	
Depth =	1	

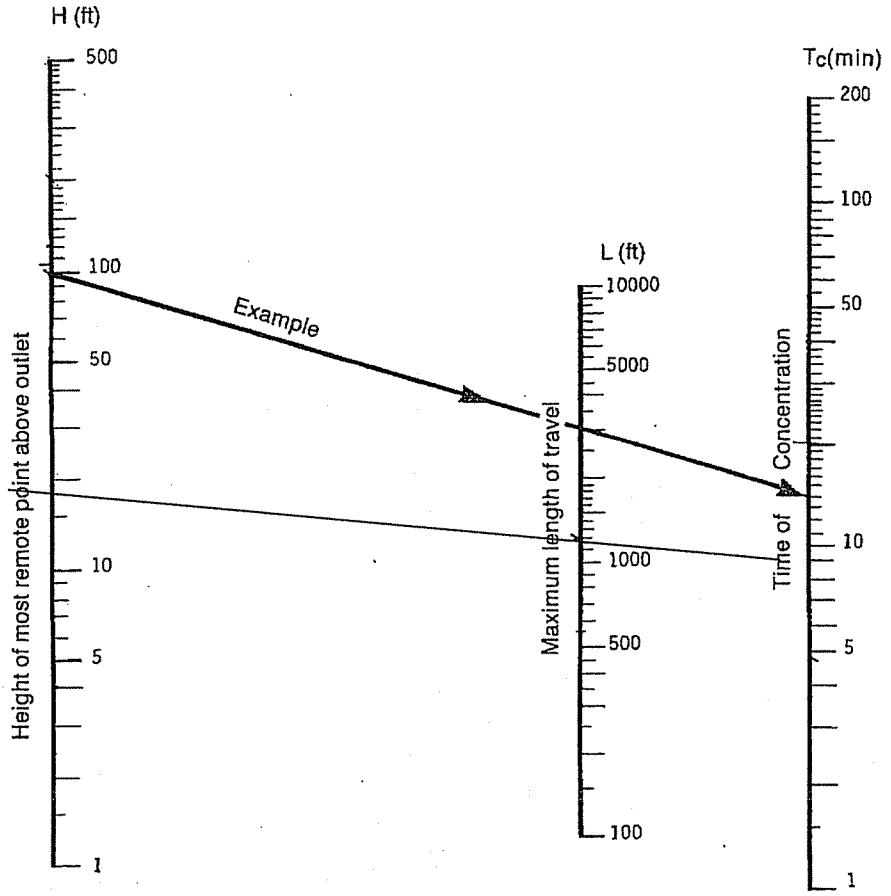
W =	13	
R =	0.750494	R value
Q =	40.90682	Flow
A =	10	Adjusted Area of flow
P =	13.32456	Adjusted Wetted Perimeter

V = 4.090682 Va =5.0

Shear Stress	0.624	0-.45	jute netting
		.46-1.45	straw with net
		1.45-2.00	synthetic mat
		2.00max.	6" stone

Reference Materials


BENCHMARK - NAIL
N 563502.87
E 2385777.36
ELEV. = 92.66
300' BUFFER ZONE
P4
P4A
30' POWER LINE EASEMENT
P2-10
P2-9
500' BUFFER
P25
P2-4
P13
MW-13
P2-11S
P2-11D
P2-8I
D1
PHASE 2
P2-12
P2-5S
P2-5D
P2-3
P3A
P2-7
P2-2
P2-6
D2
300' BUFFER
D4
PHASE 3
EXISTING PHASE 1
D3
P11
MW-14
EX. SETTLEMENT TRAP
MW-15
EX. RISER BASIN
MW-16
ER



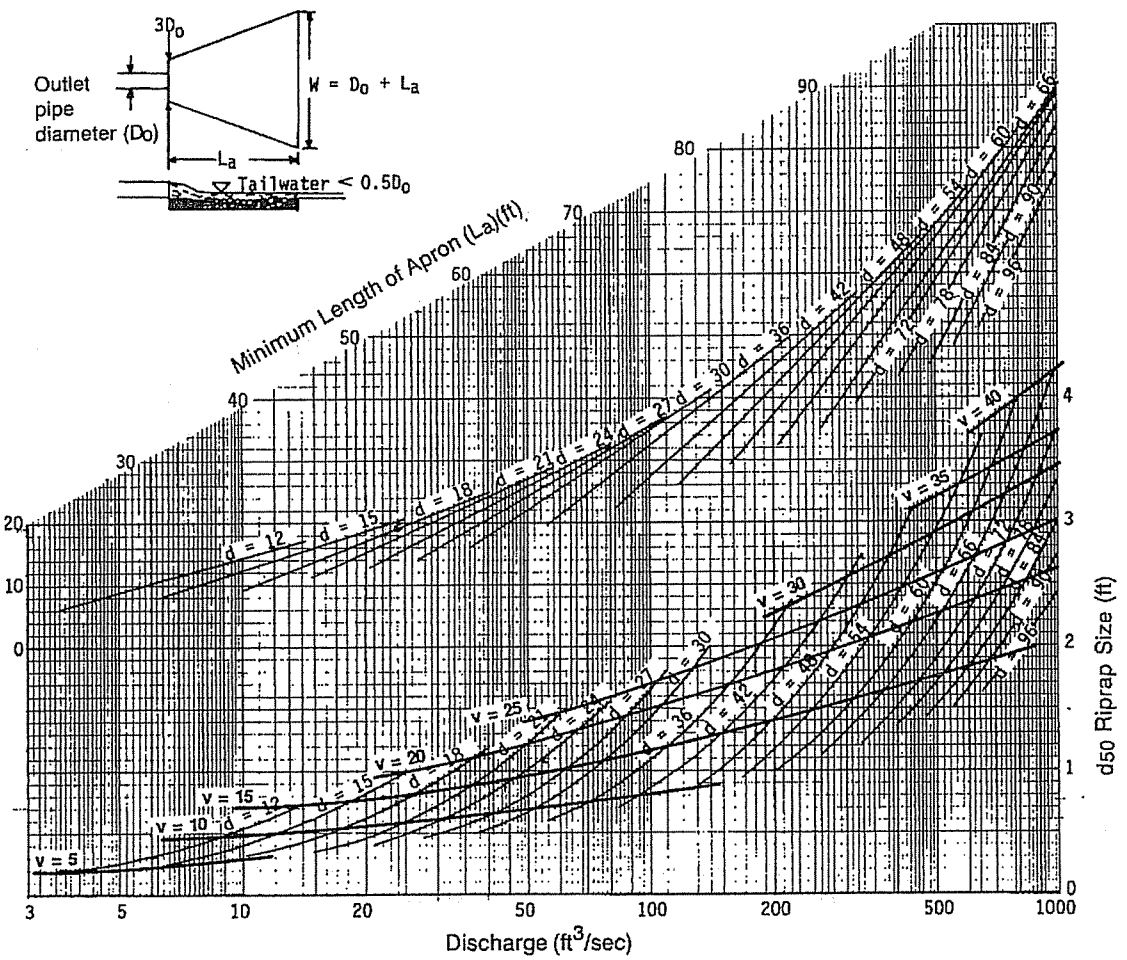
Note:
Use nomograph Tc for natural basins with well-defined channels, for overland flow on bare earth, and for mowed-grass roadside channels.

For overland flow, grassed surfaces, multiply Tc by 2.

For overland flow, concrete or asphalt surfaces, multiply Tc by 0.4.

For concrete channels, multiply Tc by 0.2.

Figure 8.03a Time of concentration of small drainage basins.



Curves may not be extrapolated.

Figure 8.06a Design of outlet protection protection from a round pipe flowing full, minimum tailwater condition (T_w < 0.5 diameter).

2.2.3 HELP Model

INSERT FIRST HELP MODEL
STANDARD LINER SYSTEM (Alt. 1)
PHASE 2 OPEN 1st YEAR

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******************************************************************************
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**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.04    (13 MARCH 1995)                **
**                 DEVELOPED BY ENVIRONMENTAL LABORATORY                    **
**                   USAE WATERWAYS EXPERIMENT STATION                      **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:      C:\HELP3\LENOIR.D4
TEMPERATURE DATA FILE:        C:\HELP3\Lenoir.D7
SOLAR RADIATION DATA FILE:    C:\HELP3\Lenoir.D13
EVAPOTRANSPIRATION DATA:      C:\HELP3\Lenoir.D11
SOIL AND DESIGN DATA FILE:    C:\HELP3\Lenoir.D10
OUTPUT DATA FILE:             C:\HELP3\Lenoir1.OUT
```

Time: 11:33 Date: 10/10/2009

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******************************************************************************
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Title: Lenoir County Phase 2 Open 1st Year (Alt. 1)

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


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


                                  LAYER  1
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  12
          THICKNESS                    =      12.00   INCHES
          POROSITY                     =       0.4710 VOL/VOL
          FIELD CAPACITY               =       0.3420 VOL/VOL
          WILTING POINT                =       0.2100 VOL/VOL
          INITIAL SOIL WATER CONTENT   =       0.3106 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.419999997000E-04 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  4.63
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

```
                    LAYER  2
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  19
THICKNESS                      =      96.00   INCHES
POROSITY                       =       0.1680 VOL/VOL
FIELD CAPACITY                 =       0.0730 VOL/VOL
WILTING POINT                  =       0.0190 VOL/VOL
INITIAL SOIL WATER CONTENT     =       0.0726 VOL/VOL
EFFECTIVE SAT. HYD. COND.      =  0.100000005000E-02 CM/SEC


                    LAYER  3
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  14
THICKNESS                      =      36.00   INCHES
POROSITY                       =       0.4790 VOL/VOL
FIELD CAPACITY                 =       0.3710 VOL/VOL
WILTING POINT                  =       0.2510 VOL/VOL
INITIAL SOIL WATER CONTENT     =       0.4313 VOL/VOL
EFFECTIVE SAT. HYD. COND.      =  0.249999994000E-04 CM/SEC


                    LAYER  4
                    --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER  34
THICKNESS                      =       0.25   INCHES
POROSITY                       =       0.8500 VOL/VOL
FIELD CAPACITY                 =       0.0100 VOL/VOL
WILTING POINT                  =       0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT     =       0.0574 VOL/VOL
EFFECTIVE SAT. HYD. COND.      =   33.0000000000      CM/SEC
SLOPE                          =       2.00   PERCENT
DRAINAGE LENGTH                =     100.0    FEET


                    LAYER  5
                    --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  35
THICKNESS                      =       0.06   INCHES
```

POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	4.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	4.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 6

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #12 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 200. FEET.

SCS RUNOFF CURVE NUMBER	=	91.70	
FRACTION OF AREA ALLOWING RUNOFF	=	0.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	4.421	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	7.332	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.710	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	36.488	INCHES
TOTAL INITIAL WATER	=	36.488	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
RALEIGH NORTH CAROLINA

STATION LATITUDE	=	35.87 DEGREES
MAXIMUM LEAF AREA INDEX	=	3.50
START OF GROWING SEASON (JULIAN DATE)	=	86
END OF GROWING SEASON (JULIAN DATE)	=	310
EVAPORATIVE ZONE DEPTH	=	22.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	7.70 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	66.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	70.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	78.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	72.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.11	3.66	3.96	3.39	4.42	5.39
6.20	5.76	5.30	3.06	2.92	3.42

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
41.80	43.60	51.40	61.00	68.40	74.90
78.70	78.10	72.80	61.80	52.50	44.00

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA
AND STATION LATITUDE = 35.13 DEGREES

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MONTHLY TOTALS (IN INCHES) FOR YEAR 1

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	1.69	4.39	3.13	1.63	2.14	8.50
	7.20	7.75	2.85	3.84	0.72	5.12

RUNOFF	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION	1.383	1.891	2.948	2.478	3.036	5.925
	6.447	4.289	2.814	3.416	0.420	0.810
LATERAL DRAINAGE COLLECTED FROM LAYER 4	1.6587	0.4137	2.0998	0.6726	0.2942	0.0073
	0.2401	2.2378	1.6912	1.8216	0.6605	1.3076
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 5	0.002	0.001	0.002	0.001	0.000	0.000
	0.000	0.002	0.002	0.002	0.001	0.001
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 5	0.001	0.000	0.002	0.000	0.000	0.000
	0.000	0.002	0.001	0.002	0.000	0.003

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ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	48.96	177724.844	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	35.855	130152.031	73.23
DRAINAGE COLLECTED FROM LAYER 4	13.1053	47572.070	26.77
PERC./LEAKAGE THROUGH LAYER 6	0.000003	0.011	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0012		
CHANGE IN WATER STORAGE	0.000	0.692	0.00
SOIL WATER AT START OF YEAR	36.488	132451.344	
SOIL WATER AT END OF YEAR	36.488	132452.031	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.037	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 1

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.69	4.39	3.13	1.63	2.14	8.50
	7.20	7.75	2.85	3.84	0.72	5.12
STD. DEVIATIONS	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	1.383	1.891	2.948	2.478	3.036	5.925
	6.447	4.289	2.814	3.416	0.420	0.810
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
LATERAL DRAINAGE COLLECTED FROM LAYER 4						
TOTALS	1.6587	0.4137	2.0998	0.6726	0.2942	0.0073
	0.2401	2.2378	1.6912	1.8216	0.6605	1.3076
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 6						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 5

AVERAGES	0.0018	0.0005	0.0022	0.0007	0.0003	0.0000
	0.0003	0.0024	0.0019	0.0019	0.0007	0.0014
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

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

	INCHES		CU. FEET	PERCENT
PRECIPITATION	48.96	(0.000)	177724.8	100.00
RUNOFF	0.000	(0.0000)	0.00	0.000
EVAPOTRANSPIRATION	35.855	(0.0000)	130152.03	73.232
LATERAL DRAINAGE COLLECTED FROM LAYER 4	13.10525	(0.00000)	47572.070	26.76726
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000	(0.00000)	0.011	0.00001
AVERAGE HEAD ON TOP OF LAYER 5	0.001	(0.000)		
CHANGE IN WATER STORAGE	0.000	(0.0000)	0.69	0.000

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              PEAK DAILY VALUES FOR YEARS    1 THROUGH    1
  ---------------------------------------------------------------------------
                                              (INCHES)      (CU. FT.)
                                              ----------    -------------
     PRECIPITATION                              2.85         10345.500

     RUNOFF                                     0.000            0.0000

     DRAINAGE COLLECTED FROM LAYER  4           0.30297       1099.77881

     PERCOLATION/LEAKAGE THROUGH LAYER  6       0.000000         0.00017

     AVERAGE HEAD ON TOP OF LAYER  5            0.010

     MAXIMUM HEAD ON TOP OF LAYER  5            0.312

     SNOW WATER                                 1.63          5916.4204

     MAXIMUM VEG. SOIL WATER (VOL/VOL)                 0.2670

     MINIMUM VEG. SOIL WATER (VOL/VOL)                 0.1232

       ***  MAXIMUM HEADS ARE COMPUTED USING THE MOUND EQUATION.  ***

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FINAL WATER STORAGE AT END OF YEAR 1

LAYER	(INCHES)	(VOL/VOL)
1	3.7289	0.3107
2	6.9729	0.0726
3	15.5240	0.4312
4	0.0143	0.0573
5	0.0000	0.0000
6	10.2480	0.4270
SNOW WATER	0.000	

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INSERT SECOND HELP MODEL
STANDARD LINER SYSTEM (Alt. 1)
PHASE 2 OPEN 5 YEARS w/25 FT. OF SOLID WASTE

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**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.04    (13 MARCH 1995)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
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PRECIPITATION DATA FILE:      C:\HELP3\LENOIR.D4
TEMPERATURE DATA FILE:        C:\HELP3\Lenoir.D7
SOLAR RADIATION DATA FILE:    C:\HELP3\Lenoir.D13
EVAPOTRANSPIRATION DATA:      C:\HELP3\Lenoir.D11
SOIL AND DESIGN DATA FILE:    C:\HELP3\LENOIR2.D10
OUTPUT DATA FILE:             C:\HELP3\Lenoir2.OUT
```

Time: 12:31 Date: 10/10/2009

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Title: Lenoir County Phase 2 Open 5 Years w/ 25 ft. Waste (Alt. 1)

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


                                  LAYER  1
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  12
          THICKNESS                  =      12.00   INCHES
          POROSITY                   =       0.4710 VOL/VOL
          FIELD CAPACITY             =       0.3420 VOL/VOL
          WILTING POINT              =       0.2100 VOL/VOL
          INITIAL SOIL WATER CONTENT =       0.3107 VOL/VOL
          EFFECTIVE SAT. HYD. COND.  =  0.419999997000E-04 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  4.63
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 19

THICKNESS	=	300.00	INCHES
POROSITY	=	0.1680	VOL/VOL
FIELD CAPACITY	=	0.0730	VOL/VOL
WILTING POINT	=	0.0190	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0729	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC

LAYER 3

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 14

THICKNESS	=	36.00	INCHES
POROSITY	=	0.4790	VOL/VOL
FIELD CAPACITY	=	0.3710	VOL/VOL
WILTING POINT	=	0.2510	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4467	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.249999994000E-04	CM/SEC

LAYER 4

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 34

THICKNESS	=	0.25	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0100	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	33.0000000000	CM/SEC
SLOPE	=	2.00	PERCENT
DRAINAGE LENGTH	=	100.0	FEET

LAYER 5

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES

POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	4.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	4.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 6

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #12 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 200. FEET.

SCS RUNOFF CURVE NUMBER	=	91.70	
FRACTION OF AREA ALLOWING RUNOFF	=	50.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	4.425	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	7.332	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.710	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	51.927	INCHES
TOTAL INITIAL WATER	=	51.927	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
RALEIGH NORTH CAROLINA

STATION LATITUDE	=	35.87 DEGREES
MAXIMUM LEAF AREA INDEX	=	3.50
START OF GROWING SEASON (JULIAN DATE)	=	86
END OF GROWING SEASON (JULIAN DATE)	=	310
EVAPORATIVE ZONE DEPTH	=	22.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	7.70 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	66.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	70.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	78.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	72.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.11	3.66	3.96	3.39	4.42	5.39
6.20	5.76	5.30	3.06	2.92	3.42

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
41.80	43.60	51.40	61.00	68.40	74.90
78.70	78.10	72.80	61.80	52.50	44.00

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA
AND STATION LATITUDE = 35.13 DEGREES

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MONTHLY TOTALS (IN INCHES) FOR YEAR 1

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	1.69	4.39	3.13	1.63	2.14	8.50
	7.20	7.75	2.85	3.84	0.72	5.12

RUNOFF	0.024	0.201	0.094	0.000	0.067	0.513
	0.658	0.795	0.103	0.277	0.013	0.455
EVAPOTRANSPIRATION	1.387	1.893	2.950	2.554	2.869	5.896
	6.419	4.291	2.817	3.420	0.368	0.814
LATERAL DRAINAGE COLLECTED FROM LAYER 4	2.1708	0.4291	1.8354	0.6745	0.2714	0.0190
	0.0748	0.9028	1.2214	1.4691	0.7060	0.3114
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 5	0.002	0.001	0.002	0.001	0.000	0.000
	0.000	0.001	0.001	0.002	0.001	0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 5	0.002	0.000	0.002	0.000	0.000	0.000
	0.000	0.001	0.001	0.001	0.000	0.001

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ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	48.96	177724.844	100.00
RUNOFF	3.200	11616.245	6.54
EVAPOTRANSPIRATION	35.679	129513.109	72.87
DRAINAGE COLLECTED FROM LAYER 4	10.0857	36611.102	20.60
PERC./LEAKAGE THROUGH LAYER 6	0.000003	0.009	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0009		
CHANGE IN WATER STORAGE	-0.004	-15.620	-0.01
SOIL WATER AT START OF YEAR	51.927	188496.016	
SOIL WATER AT END OF YEAR	51.923	188480.391	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.009	0.00

****

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MONTHLY TOTALS (IN INCHES) FOR YEAR 2

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	2.83 5.47	2.30 1.76	5.14 1.45	3.78 8.97	9.70 1.43	10.52 1.63
RUNOFF	0.453 0.465	0.093 0.173	0.220 0.042	0.069 1.255	1.463 0.002	1.315 0.035
EVAPOTRANSPIRATION	1.105 4.813	1.698 3.013	2.782 1.054	4.163 3.008	5.817 1.499	4.146 0.982
LATERAL DRAINAGE COLLECTED FROM LAYER 4	2.6468 3.1049	1.1639 0.7303	1.1808 0.5017	0.9334 0.8673	0.8064 2.2869	2.8500 0.4220
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 5	0.003 0.003	0.001 0.001	0.001 0.001	0.001 0.001	0.001 0.003	0.003 0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 5	0.002 0.003	0.001 0.000	0.001 0.000	0.000 0.002	0.001 0.002	0.003 0.000

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ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	54.98	199577.391	100.00
RUNOFF	5.585	20273.453	10.16

EVAPOTRANSPIRATION	34.080	123709.836	61.99
DRAINAGE COLLECTED FROM LAYER 4	17.4943	63504.293	31.82
PERC./LEAKAGE THROUGH LAYER 6	0.000004	0.014	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0016		
CHANGE IN WATER STORAGE	-2.179	-7910.161	-3.96
SOIL WATER AT START OF YEAR	51.923	188480.391	
SOIL WATER AT END OF YEAR	49.744	180570.234	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.039	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 3

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	9.81	3.17	6.82	1.16	2.13	5.54
	10.76	21.29	8.25	4.81	2.02	2.19
RUNOFF	1.289	0.174	0.652	0.035	0.034	0.753
	1.513	4.949	2.057	0.406	0.108	0.170
EVAPOTRANSPIRATION	1.711	2.118	2.858	2.497	2.207	2.944
	7.181	5.396	2.334	3.056	1.453	0.942
LATERAL DRAINAGE COLLECTED FROM LAYER 4	0.9719	6.1603	2.0721	1.3133	0.5571	0.1675
	0.9356	6.1825	8.9298	1.1095	1.1543	1.2025
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.001	0.007	0.002	0.001	0.001	0.000

TOP OF LAYER 5	0.001	0.007	0.010	0.001	0.001	0.001
STD. DEVIATION OF DAILY	0.001	0.004	0.002	0.001	0.000	0.000
HEAD ON TOP OF LAYER 5	0.002	0.007	0.007	0.000	0.001	0.001

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ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	77.95	282958.469	100.00
RUNOFF	12.140	44067.172	15.57
EVAPOTRANSPIRATION	34.697	125948.898	44.51
DRAINAGE COLLECTED FROM LAYER 4	30.7564	111645.586	39.46
PERC./LEAKAGE THROUGH LAYER 6	0.000006	0.021	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0028		
CHANGE IN WATER STORAGE	0.357	1296.804	0.46
SOIL WATER AT START OF YEAR	49.744	180570.234	
SOIL WATER AT END OF YEAR	50.101	181867.031	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.021	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 4

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	2.94	3.35	4.50	2.16	4.28	4.38
	7.06	4.14	6.25	1.06	4.01	3.99

RUNOFF	0.047	0.242	0.245	0.033	0.012	0.310
	0.662	0.051	1.037	0.000	0.275	0.417
EVAPOTRANSPIRATION	1.623	2.011	2.927	3.738	4.578	4.055
	4.713	3.932	2.667	2.412	1.298	0.995
LATERAL DRAINAGE COLLECTED FROM LAYER 4	0.9159	1.2525	1.3016	0.6137	0.2793	0.0220
	0.0223	0.2065	0.6208	1.4680	0.3667	0.6123
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 5	0.001	0.002	0.001	0.001	0.000	0.000
	0.000	0.000	0.001	0.002	0.000	0.001
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 5	0.000	0.001	0.001	0.000	0.000	0.000
	0.000	0.000	0.002	0.001	0.000	0.001

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ANNUAL TOTALS FOR YEAR 4

	INCHES	CU. FEET	PERCENT
PRECIPITATION	48.12	174675.578	100.00
RUNOFF	3.331	12092.490	6.92
EVAPOTRANSPIRATION	34.949	126864.789	72.63
DRAINAGE COLLECTED FROM LAYER 4	7.6816	27884.281	15.96
PERC./LEAKAGE THROUGH LAYER 6	0.000002	0.008	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0007		
CHANGE IN WATER STORAGE	2.149	7799.133	4.46
SOIL WATER AT START OF YEAR	50.101	181867.031	
SOIL WATER AT END OF YEAR	52.250	189666.172	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0096	34.879	0.02

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MONTHLY TOTALS (IN INCHES) FOR YEAR 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	1.63 1.82	1.80 5.68	3.90 3.68	6.60 2.40	3.00 4.65	10.89 2.89
RUNOFF	0.000 0.034	0.000 0.389	0.278 0.452	0.476 0.079	0.032 0.357	1.573 0.328
EVAPOTRANSPIRATION	1.418 2.724	1.708 2.275	2.834 2.717	4.082 2.772	4.199 1.609	6.328 1.329
LATERAL DRAINAGE COLLECTED FROM LAYER 4	2.5870 2.1321	0.4808 0.4903	0.2447 0.9118	0.7331 1.0259	1.4471 0.4852	0.4435 1.1496
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 5	0.003 0.002	0.001 0.001	0.000 0.001	0.001 0.001	0.002 0.001	0.001 0.001
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 5	0.002 0.002	0.000 0.000	0.000 0.001	0.001 0.000	0.001 0.000	0.000 0.000

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ANNUAL TOTALS FOR YEAR 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	48.94	177652.187	100.00
RUNOFF	3.998	14514.175	8.17

EVAPOTRANSPIRATION	33.994	123398.742	69.46
DRAINAGE COLLECTED FROM LAYER 4	12.1309	44035.285	24.79
PERC./LEAKAGE THROUGH LAYER 6	0.000003	0.011	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0011		
CHANGE IN WATER STORAGE	-1.183	-4296.002	-2.42
SOIL WATER AT START OF YEAR	52.250	189666.172	
SOIL WATER AT END OF YEAR	51.066	185370.172	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.033	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.78	3.00	4.70	3.07	4.25	7.97
	6.46	8.12	4.50	4.22	2.57	3.16
STD. DEVIATIONS	3.43	1.00	1.40	2.21	3.17	2.92
	3.24	7.68	2.73	3.01	1.69	1.40
RUNOFF						
TOTALS	0.363	0.142	0.298	0.123	0.321	0.893
	0.666	1.271	0.738	0.403	0.151	0.281
STD. DEVIATIONS	0.550	0.096	0.210	0.199	0.638	0.535
	0.538	2.075	0.837	0.502	0.159	0.176
EVAPOTRANSPIRATION						
TOTALS	1.449	1.885	2.870	3.407	3.934	4.674
	5.170	3.781	2.318	2.934	1.245	1.012
STD. DEVIATIONS	0.236	0.185	0.069	0.821	1.427	1.404
	1.726	1.199	0.729	0.373	0.503	0.191

LATERAL DRAINAGE COLLECTED FROM LAYER 4

TOTALS	1.8585	1.8973	1.3269	0.8536	0.6723	0.7004
	1.2539	1.7025	2.4371	1.1879	0.9998	0.7395
STD. DEVIATIONS	0.8550	2.4129	0.7084	0.2836	0.4865	1.2140
	1.3422	2.5181	3.6402	0.2705	0.7798	0.4132

PERCOLATION/LEAKAGE THROUGH LAYER 6

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

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 5

AVERAGES	0.0020	0.0023	0.0014	0.0009	0.0007	0.0008
	0.0013	0.0018	0.0027	0.0013	0.0011	0.0008
STD. DEVIATIONS	0.0009	0.0028	0.0008	0.0003	0.0005	0.0013
	0.0014	0.0027	0.0040	0.0003	0.0009	0.0004

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 5

	INCHES		CU. FEET	PERCENT
PRECIPITATION	55.79	(12.690)	202517.7	100.00
RUNOFF	5.651	(3.7492)	20512.71	10.129
EVAPOTRANSPIRATION	34.680	(0.6893)	125887.07	62.161
LATERAL DRAINAGE COLLECTED FROM LAYER 4	15.62978	(9.19839)	56736.109	28.01538
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000	(0.00000)	0.013	0.00001
AVERAGE HEAD ON TOP OF LAYER 5	0.001	(0.001)		
CHANGE IN WATER STORAGE	-0.172	(1.6389)	-625.17	-0.309

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 5

	(INCHES)	(CU. FT.)
PRECIPITATION	6.77	24575.100
RUNOFF	2.586	9387.6406
DRAINAGE COLLECTED FROM LAYER 4	0.71604	2599.20947
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00036
AVERAGE HEAD ON TOP OF LAYER 5	0.024	
MAXIMUM HEAD ON TOP OF LAYER 5	0.479	
SNOW WATER	1.63	5916.4204

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.2703
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1232

*** MAXIMUM HEADS ARE COMPUTED USING THE MOUND EQUATION. ***

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FINAL WATER STORAGE AT END OF YEAR 5

LAYER	(INCHES)	(VOL/VOL)
1	3.8049	0.3171
2	22.8243	0.0761
3	14.1864	0.3941
4	0.0025	0.0100
5	0.0000	0.0000
6	10.2480	0.4270
SNOW WATER	0.000	

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INSERT FINAL HELP MODEL
STANDARD LINER SYSTEM (Alt. 1)
PHASE 2 CLOSED

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**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.04    (13 MARCH 1995)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:      C:\HELP3\LENOIR.D4
TEMPERATURE DATA FILE:        C:\HELP3\Lenoir.D7
SOLAR RADIATION DATA FILE:    C:\HELP3\Lenoir.D13
EVAPOTRANSPIRATION DATA:      C:\HELP3\Lenoir.D11
SOIL AND DESIGN DATA FILE:    C:\HELP3\LENOIRC.D10
OUTPUT DATA FILE:             C:\HELP3\LenoirC.OUT
```

Time: 13:15 Date: 10/10/2009

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Title: Lenoir County Phase 2 Closed (Alt. 1)

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


                                  LAYER  1
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  12
          THICKNESS                  =      24.00   INCHES
          POROSITY                   =       0.4710 VOL/VOL
          FIELD CAPACITY             =       0.3420 VOL/VOL
          WILTING POINT              =       0.2100 VOL/VOL
          INITIAL SOIL WATER CONTENT =       0.3496 VOL/VOL
          EFFECTIVE SAT. HYD. COND.  =  0.419999997000E-04 CM/SEC
     NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  4.63
              FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
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                    LAYER  2
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          TYPE 2 - LATERAL DRAINAGE LAYER
            MATERIAL TEXTURE NUMBER  20
THICKNESS                    =      0.20    INCHES
POROSITY                     =      0.8500 VOL/VOL
FIELD CAPACITY               =      0.0100 VOL/VOL
WILTING POINT                =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.0279 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =   10.0000000000      CM/SEC
SLOPE                        =      5.00    PERCENT
DRAINAGE LENGTH              =    300.0     FEET


                    LAYER  3
                    --------

          TYPE 4 - FLEXIBLE MEMBRANE LINER
            MATERIAL TEXTURE NUMBER  35
THICKNESS                    =      0.04    INCHES
POROSITY                     =      0.0000 VOL/VOL
FIELD CAPACITY               =      0.0000 VOL/VOL
WILTING POINT                =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY          =      4.00    HOLES/ACRE
FML INSTALLATION DEFECTS     =      4.00    HOLES/ACRE
FML PLACEMENT QUALITY        =  3 - GOOD


                    LAYER  4
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          TYPE 3 - BARRIER SOIL LINER
            MATERIAL TEXTURE NUMBER  23
THICKNESS                    =     18.00    INCHES
POROSITY                     =      0.4610 VOL/VOL
FIELD CAPACITY               =      0.3600 VOL/VOL
WILTING POINT                =      0.2030 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.4610 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.900000032000E-05 CM/SEC


                    LAYER  5
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          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  12
THICKNESS                     =     12.00   INCHES
POROSITY                      =      0.4710 VOL/VOL
FIELD CAPACITY                =      0.3420 VOL/VOL
WILTING POINT                 =      0.2100 VOL/VOL
INITIAL SOIL WATER CONTENT    =      0.3420 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.419999997000E-04 CM/SEC


                        LAYER  6
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  19
THICKNESS                     =    360.00   INCHES
POROSITY                      =      0.1680 VOL/VOL
FIELD CAPACITY                =      0.0730 VOL/VOL
WILTING POINT                 =      0.0190 VOL/VOL
INITIAL SOIL WATER CONTENT    =      0.0730 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.100000005000E-02 CM/SEC


                        LAYER  7
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  14
THICKNESS                     =     36.00   INCHES
POROSITY                      =      0.4790 VOL/VOL
FIELD CAPACITY                =      0.3710 VOL/VOL
WILTING POINT                 =      0.2510 VOL/VOL
INITIAL SOIL WATER CONTENT    =      0.3710 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.249999994000E-04 CM/SEC


                        LAYER  8
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           TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER  34
THICKNESS                     =      0.25   INCHES
POROSITY                      =      0.8500 VOL/VOL
FIELD CAPACITY                =      0.0100 VOL/VOL
WILTING POINT                 =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT    =      0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =   33.0000000000     CM/SEC
SLOPE                         =      2.00   PERCENT
DRAINAGE LENGTH               =    100.0    FEET
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LAYER 9

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	4.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	4.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 10

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #12 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 200. FEET.

SCS RUNOFF CURVE NUMBER	=	91.70	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	7.627	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	10.362	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	4.620	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	70.685	INCHES
TOTAL INITIAL WATER	=	70.685	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
RALEIGH NORTH CAROLINA

STATION LATITUDE	=	35.87	DEGREES
MAXIMUM LEAF AREA INDEX	=	3.50	
START OF GROWING SEASON (JULIAN DATE)	=	86	
END OF GROWING SEASON (JULIAN DATE)	=	310	
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	7.70	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	66.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	70.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	78.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	72.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.11	3.66	3.96	3.39	4.42	5.39
6.20	5.76	5.30	3.06	2.92	3.42

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
41.80	43.60	51.40	61.00	68.40	74.90
78.70	78.10	72.80	61.80	52.50	44.00

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA
AND STATION LATITUDE = 35.13 DEGREES

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MONTHLY TOTALS (IN INCHES) FOR YEAR 1

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	1.69 7.20	4.39 7.75	3.13 2.85	1.63 3.84	2.14 0.72	8.50 5.12
RUNOFF	0.060 1.301	0.502 1.626	0.225 0.224	0.000 0.640	0.131 0.026	0.987 0.969
EVAPOTRANSPIRATION	1.458 6.251	1.931 4.148	2.997 2.746	2.705 3.423	3.665 1.451	5.741 0.922
LATERAL DRAINAGE COLLECTED FROM LAYER 2	0.3419 0.0030	0.5529 0.0033	1.4962 0.3970	0.0051 1.2745	0.0012 0.0000	0.0015 0.7550
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000
LATERAL DRAINAGE COLLECTED FROM LAYER 8	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 10	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 3	0.001 0.000	0.002 0.000	0.005 0.001	0.000 0.004	0.000 0.000	0.000 0.003
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 3	0.001 0.000	0.006 0.000	0.006 0.002	0.000 0.007	0.000 0.000	0.000 0.005
AVERAGE DAILY HEAD ON TOP OF LAYER 9	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 9	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000

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ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	48.96	177724.844	100.00
RUNOFF	6.691	24286.932	13.67

EVAPOTRANSPIRATION	37.438	135898.812	76.47
DRAINAGE COLLECTED FROM LAYER 2	4.8315	17538.311	9.87
PERC./LEAKAGE THROUGH LAYER 4	0.000086	0.311	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0014		
DRAINAGE COLLECTED FROM LAYER 8	0.0001	0.310	0.00
PERC./LEAKAGE THROUGH LAYER 10	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
CHANGE IN WATER STORAGE	0.000	0.415	0.00
SOIL WATER AT START OF YEAR	70.685	256587.672	
SOIL WATER AT END OF YEAR	70.685	256588.094	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.053	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 2

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	2.83	2.30	5.14	3.78	9.70	10.52
	5.47	1.76	1.45	8.97	1.43	1.63
RUNOFF	0.983	0.210	0.510	0.160	3.007	2.662
	0.910	0.346	0.083	2.480	0.007	0.092
EVAPOTRANSPIRATION	1.160	1.739	2.824	4.198	5.871	5.111
	5.915	3.135	1.062	3.076	1.435	0.941
LATERAL DRAINAGE COLLECTED FROM LAYER 2	1.2869	0.1341	1.1743	0.4855	1.4163	0.7637
	0.5029	0.0000	0.0001	0.8757	0.3173	0.5609
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

LATERAL DRAINAGE COLLECTED FROM LAYER 8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 3	0.004	0.001	0.004	0.002	0.005	0.003
	0.002	0.000	0.000	0.003	0.001	0.002
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 3	0.005	0.001	0.003	0.002	0.008	0.005
	0.003	0.000	0.000	0.005	0.002	0.002
AVERAGE DAILY HEAD ON TOP OF LAYER 9	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 9	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000

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ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	54.98	199577.391	100.00
RUNOFF	11.452	41571.547	20.83
EVAPOTRANSPIRATION	36.468	132379.062	66.33
DRAINAGE COLLECTED FROM LAYER 2	7.5178	27289.729	13.67
PERC./LEAKAGE THROUGH LAYER 4	0.000135	0.492	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0022		
DRAINAGE COLLECTED FROM LAYER 8	0.0001	0.491	0.00
PERC./LEAKAGE THROUGH LAYER 10	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
CHANGE IN WATER STORAGE	-0.458	-1663.399	-0.83
SOIL WATER AT START OF YEAR	70.685	256588.094	
SOIL WATER AT END OF YEAR	70.227	254924.687	

SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.026	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 3

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	9.81 10.76	3.17 21.29	6.82 8.25	1.16 4.81	2.13 2.02	5.54 2.19
RUNOFF	2.912 2.958	0.402 10.325	1.425 4.343	0.075 0.881	0.064 0.264	1.499 0.378
EVAPOTRANSPIRATION	1.680 7.036	2.089 5.366	2.834 2.285	2.847 3.037	3.187 1.416	2.553 0.922
LATERAL DRAINAGE COLLECTED FROM LAYER 2	3.6591 0.0010	2.2787 3.9575	1.5415 2.8780	0.4575 0.2120	0.0132 1.3199	0.0003 0.8198
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.0001 0.0000	0.0000 0.0001	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000
LATERAL DRAINAGE COLLECTED FROM LAYER 8	0.0001 0.0000	0.0000 0.0001	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 10	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 3	0.013 0.000	0.009 0.014	0.005 0.010	0.002 0.001	0.000 0.005	0.000 0.003
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 3	0.016 0.000	0.008 0.013	0.007 0.017	0.002 0.001	0.000 0.002	0.000 0.003
AVERAGE DAILY HEAD ON TOP OF LAYER 9	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000

STD. DEVIATION OF DAILY	0.000	0.000	0.000	0.000	0.000	0.000
HEAD ON TOP OF LAYER 9	0.000	0.000	0.000	0.000	0.000	0.000

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ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	77.95	282958.469	100.00
RUNOFF	25.525	92657.109	32.75
EVAPOTRANSPIRATION	35.251	127962.703	45.22
DRAINAGE COLLECTED FROM LAYER 2	17.1384	62212.418	21.99
PERC./LEAKAGE THROUGH LAYER 4	0.000284	1.031	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0050		
DRAINAGE COLLECTED FROM LAYER 8	0.0003	1.031	0.00
PERC./LEAKAGE THROUGH LAYER 10	0.000000	0.001	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
CHANGE IN WATER STORAGE	0.035	125.235	0.04
SOIL WATER AT START OF YEAR	70.227	254924.687	
SOIL WATER AT END OF YEAR	70.262	255049.922	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.034	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 4

JAN/JUL FEB/AUG MAR/SEP APR/OCT MAY/NOV JUN/DEC

PRECIPITATION	2.94	3.35	4.50	2.16	4.28	4.38
	7.06	4.14	6.25	1.06	4.01	3.99
RUNOFF	0.127	0.556	0.538	0.074	0.024	0.615
	1.279	0.099	2.153	0.000	0.549	0.940
EVAPOTRANSPIRATION	1.608	1.995	2.913	3.690	5.578	3.788
	4.638	3.632	2.566	3.418	1.316	0.806
LATERAL DRAINAGE COLLECTED FROM LAYER 2	0.6796	1.4127	0.6597	0.0042	0.0140	0.0020
	0.0005	0.0004	0.2960	0.0850	0.0004	1.6669
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LATERAL DRAINAGE COLLECTED FROM LAYER 8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 3	0.002	0.005	0.002	0.000	0.000	0.000
	0.000	0.000	0.001	0.000	0.000	0.006
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 3	0.003	0.005	0.002	0.000	0.000	0.000
	0.000	0.000	0.002	0.001	0.000	0.011
AVERAGE DAILY HEAD ON TOP OF LAYER 9	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 9	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000

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ANNUAL TOTALS FOR YEAR 4

	INCHES	CU. FEET	PERCENT
PRECIPITATION	48.12	174675.578	100.00
RUNOFF	6.955	25245.174	14.45
EVAPOTRANSPIRATION	35.947	130489.352	74.70

DRAINAGE COLLECTED FROM LAYER 2	4.8214	17501.805	10.02
PERC./LEAKAGE THROUGH LAYER 4	0.000086	0.311	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0014		
DRAINAGE COLLECTED FROM LAYER 8	0.0001	0.310	0.00
PERC./LEAKAGE THROUGH LAYER 10	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
CHANGE IN WATER STORAGE	0.387	1404.121	0.80
SOIL WATER AT START OF YEAR	70.262	255049.922	
SOIL WATER AT END OF YEAR	70.648	256454.047	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0096	34.822	0.02

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MONTHLY TOTALS (IN INCHES) FOR YEAR 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	1.63	1.80	3.90	6.60	3.00	10.89
	1.82	5.68	3.68	2.40	4.65	2.89
RUNOFF	0.000	0.003	0.575	1.080	0.079	3.038
	0.068	0.755	0.984	0.180	0.754	0.730
EVAPOTRANSPIRATION	1.256	1.617	2.787	3.970	5.248	6.035
	3.738	2.149	2.460	3.111	1.636	1.290
LATERAL DRAINAGE COLLECTED FROM LAYER 2	0.3165	0.2689	0.2563	1.5714	0.4318	0.0693
	0.2865	0.0000	0.3256	0.2499	0.4835	0.5591
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LATERAL DRAINAGE COLLECTED FROM LAYER 8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 3	0.001	0.001	0.001	0.006	0.001	0.000
	0.001	0.000	0.001	0.001	0.002	0.002
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 3	0.001	0.001	0.001	0.005	0.002	0.001
	0.002	0.000	0.001	0.001	0.002	0.001
AVERAGE DAILY HEAD ON TOP OF LAYER 9	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 9	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000

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ANNUAL TOTALS FOR YEAR 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	48.94	177652.187	100.00
RUNOFF	8.246	29932.645	16.85
EVAPOTRANSPIRATION	35.298	128131.203	72.12
DRAINAGE COLLECTED FROM LAYER 2	4.8188	17492.143	9.85
PERC./LEAKAGE THROUGH LAYER 4	0.000092	0.333	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0014		
DRAINAGE COLLECTED FROM LAYER 8	0.0001	0.333	0.00
PERC./LEAKAGE THROUGH LAYER 10	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
CHANGE IN WATER STORAGE	0.577	2095.880	1.18
SOIL WATER AT START OF YEAR	70.648	256454.047	
SOIL WATER AT END OF YEAR	71.226	258549.922	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00

SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.020	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.78	3.00	4.70	3.07	4.25	7.97
	6.46	8.12	4.50	4.22	2.57	3.16
STD. DEVIATIONS	3.43	1.00	1.40	2.21	3.17	2.92
	3.24	7.68	2.73	3.01	1.69	1.40
RUNOFF						
TOTALS	0.816	0.334	0.655	0.278	0.661	1.760
	1.303	2.630	1.557	0.836	0.320	0.622
STD. DEVIATIONS	1.238	0.227	0.453	0.452	1.312	1.052
	1.051	4.340	1.760	0.984	0.327	0.379
EVAPOTRANSPIRATION						
TOTALS	1.432	1.874	2.871	3.482	4.710	4.645
	5.515	3.686	2.224	3.213	1.451	0.976
STD. DEVIATIONS	0.223	0.193	0.084	0.671	1.205	1.454
	1.317	1.194	0.671	0.191	0.116	0.183
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	1.2568	0.9295	1.0256	0.5048	0.3753	0.1674
	0.1588	0.7922	0.7793	0.5394	0.4242	0.8723
STD. DEVIATIONS	1.3988	0.9034	0.5558	0.6404	0.6100	0.3347
	0.2286	1.7694	1.1829	0.5126	0.5424	0.4591
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

LATERAL DRAINAGE COLLECTED FROM LAYER 8

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

PERCOLATION/LEAKAGE THROUGH LAYER 10

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

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	0.0043	0.0035	0.0035	0.0018	0.0013	0.0006
	0.0005	0.0027	0.0028	0.0018	0.0015	0.0030
STD. DEVIATIONS	0.0048	0.0034	0.0019	0.0023	0.0021	0.0012
	0.0008	0.0061	0.0042	0.0018	0.0019	0.0016

DAILY AVERAGE HEAD ON TOP OF LAYER 9

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

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 5

	INCHES		CU. FEET	PERCENT
PRECIPITATION	55.79	(12.690)	202517.7	100.00
RUNOFF	11.774	(7.9171)	42738.68	21.104
EVAPOTRANSPIRATION	36.081	(0.9097)	130972.22	64.672
LATERAL DRAINAGE COLLECTED FROM LAYER 2	7.82559	(5.33511)	28406.881	14.02686

PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00014 (	0.00009)	0.496	0.00024
AVERAGE HEAD ON TOP OF LAYER 3	0.002 (	0.002)		
LATERAL DRAINAGE COLLECTED FROM LAYER 8	0.00014 (	0.00009)	0.495	0.00024
PERCOLATION/LEAKAGE THROUGH LAYER 10	0.00000 (	0.00000)	0.000	0.00000
AVERAGE HEAD ON TOP OF LAYER 9	0.000 (	0.000)		
CHANGE IN WATER STORAGE	0.108 (	0.3987)	392.45	0.194

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 5

	(INCHES)	(CU. FT.)
PRECIPITATION	6.77	24575.100
RUNOFF	5.236	19006.6582
DRAINAGE COLLECTED FROM LAYER 2	0.68827	2498.41602
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000010	0.03471
AVERAGE HEAD ON TOP OF LAYER 3	0.073	
MAXIMUM HEAD ON TOP OF LAYER 3	2.561	
DRAINAGE COLLECTED FROM LAYER 8	0.00001	0.03471
PERCOLATION/LEAKAGE THROUGH LAYER 10	0.000000	0.00000
AVERAGE HEAD ON TOP OF LAYER 9	0.000	
MAXIMUM HEAD ON TOP OF LAYER 9	0.014	
SNOW WATER	1.63	5916.4204

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4269

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.2100

*** MAXIMUM HEADS ARE COMPUTED USING THE MOUND EQUATION. ***

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FINAL WATER STORAGE AT END OF YEAR 5

LAYER	(INCHES)	(VOL/VOL)
1	8.9217	0.3717
2	0.0157	0.0783
3	0.0000	0.0000
4	8.2980	0.4610
5	4.1040	0.3420
6	26.2800	0.0730
7	13.3560	0.3710
8	0.0025	0.0100
9	0.0000	0.0000
10	10.2480	0.4270
SNOW WATER	0.000	

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INSERT FIRST HELP MODEL
ALTERNATE LINER SYSTEM (Alt. 2)
PHASE 2 OPEN 1st YEAR

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**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.04    (13 MARCH 1995)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:      C:\HELP3\LENOIR.D4
TEMPERATURE DATA FILE:        C:\HELP3\Lenoir.D7
SOLAR RADIATION DATA FILE:    C:\HELP3\Lenoir.D13
EVAPOTRANSPIRATION DATA:      C:\HELP3\Lenoir.D11
SOIL AND DESIGN DATA FILE:    C:\HELP3\LENOIRA.D10
OUTPUT DATA FILE:             C:\HELP3\LenoirA.OUT
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Time: 13:25 Date: 10/10/2009

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Title: Lenoir County Phase 2 Open 1st Year (Alt. 2)

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


                                  LAYER  1
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                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  12
          THICKNESS                  =     12.00   INCHES
          POROSITY                   =      0.4710 VOL/VOL
          FIELD CAPACITY             =      0.3420 VOL/VOL
          WILTING POINT              =      0.2100 VOL/VOL
          INITIAL SOIL WATER CONTENT =      0.3106 VOL/VOL
          EFFECTIVE SAT. HYD. COND.  =  0.419999997000E-04 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  4.63
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
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                    LAYER  2
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          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  19
THICKNESS                    =      96.00   INCHES
POROSITY                     =       0.1680 VOL/VOL
FIELD CAPACITY               =       0.0730 VOL/VOL
WILTING POINT                =       0.0190 VOL/VOL
INITIAL SOIL WATER CONTENT   =       0.0726 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC


                    LAYER  3
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  14
THICKNESS                    =      36.00   INCHES
POROSITY                     =       0.4790 VOL/VOL
FIELD CAPACITY               =       0.3710 VOL/VOL
WILTING POINT                =       0.2510 VOL/VOL
INITIAL SOIL WATER CONTENT   =       0.4313 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.249999994000E-04 CM/SEC


                    LAYER  4
                    --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER  34
THICKNESS                    =       0.25   INCHES
POROSITY                     =       0.8500 VOL/VOL
FIELD CAPACITY               =       0.0100 VOL/VOL
WILTING POINT                =       0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT   =       0.0574 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =   33.0000000000      CM/SEC
SLOPE                        =       2.00   PERCENT
DRAINAGE LENGTH              =     100.0    FEET


                    LAYER  5
                    --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  35
THICKNESS                    =       0.06   INCHES
```

```
POROSITY                        =      0.0000 VOL/VOL
FIELD CAPACITY                  =      0.0000 VOL/VOL
WILTING POINT                   =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT      =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.       =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY             =      4.00   HOLES/ACRE
FML INSTALLATION DEFECTS        =      4.00   HOLES/ACRE
FML PLACEMENT QUALITY           =  3 - GOOD
```

LAYER 6

```
TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER  17
THICKNESS                       =      0.24   INCHES
POROSITY                        =      0.7500 VOL/VOL
FIELD CAPACITY                  =      0.7470 VOL/VOL
WILTING POINT                   =      0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT      =      0.7470 VOL/VOL
EFFECTIVE SAT. HYD. COND.       =  0.300000003000E-08 CM/SEC
```

LAYER 7

```
TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER  23
THICKNESS                       =     18.00   INCHES
POROSITY                        =      0.4610 VOL/VOL
FIELD CAPACITY                  =      0.3600 VOL/VOL
WILTING POINT                   =      0.2030 VOL/VOL
INITIAL SOIL WATER CONTENT      =      0.4610 VOL/VOL
EFFECTIVE SAT. HYD. COND.       =  0.900000032000E-05 CM/SEC
```

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

```
NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
         SOIL DATA BASE USING SOIL TEXTURE #12 WITH A
         POOR STAND OF GRASS, A SURFACE SLOPE OF  2.%
         AND A SLOPE LENGTH OF  200. FEET.

SCS RUNOFF CURVE NUMBER                =     91.70
FRACTION OF AREA ALLOWING RUNOFF       =      0.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE     =      1.000  ACRES
EVAPORATIVE ZONE DEPTH                 =     22.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE      =      4.421  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE     =      7.332  INCHES
```

LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.710	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	34.717	INCHES
TOTAL INITIAL WATER	=	34.717	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
RALEIGH NORTH CAROLINA

STATION LATITUDE	=	35.87	DEGREES
MAXIMUM LEAF AREA INDEX	=	3.50	
START OF GROWING SEASON (JULIAN DATE)	=	86	
END OF GROWING SEASON (JULIAN DATE)	=	310	
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	7.70	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	66.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	70.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	78.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	72.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.11	3.66	3.96	3.39	4.42	5.39
6.20	5.76	5.30	3.06	2.92	3.42

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
41.80	43.60	51.40	61.00	68.40	74.90
78.70	78.10	72.80	61.80	52.50	44.00

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA
AND STATION LATITUDE = 35.13 DEGREES

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MONTHLY TOTALS (IN INCHES) FOR YEAR 1

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	1.69	4.39	3.13	1.63	2.14	8.50
	7.20	7.75	2.85	3.84	0.72	5.12
RUNOFF	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION	1.383	1.891	2.948	2.478	3.036	5.925
	6.447	4.289	2.814	3.416	0.420	0.810
LATERAL DRAINAGE COLLECTED FROM LAYER 4	1.6588	0.4137	2.0998	0.6726	0.2942	0.0073
	0.2401	2.2378	1.6912	1.8216	0.6605	1.3076
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 5	0.002	0.001	0.002	0.001	0.000	0.000
	0.000	0.002	0.002	0.002	0.001	0.001
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 5	0.001	0.000	0.002	0.000	0.000	0.000
	0.000	0.002	0.001	0.002	0.000	0.003
AVERAGE DAILY HEAD ON TOP OF LAYER 7	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 7	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000

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ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT

PRECIPITATION	48.96	177724.844	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	35.855	130152.031	73.23
DRAINAGE COLLECTED FROM LAYER 4	13.1053	47572.082	26.77
PERC./LEAKAGE THROUGH LAYER 5	0.000001	0.004	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0012		
PERC./LEAKAGE THROUGH LAYER 7	0.000001	0.004	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
CHANGE IN WATER STORAGE	0.000	0.692	0.00
SOIL WATER AT START OF YEAR	34.897	126674.406	
SOIL WATER AT END OF YEAR	34.897	126675.094	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.031	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 1

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.69	4.39	3.13	1.63	2.14	8.50
	7.20	7.75	2.85	3.84	0.72	5.12
STD. DEVIATIONS	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000

	0.000	0.000	0.000	0.000	0.000	0.000

EVAPOTRANSPIRATION

TOTALS	1.383	1.891	2.948	2.478	3.036	5.925
	6.447	4.289	2.814	3.416	0.420	0.810
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000

LATERAL DRAINAGE COLLECTED FROM LAYER 4

TOTALS	1.6588	0.4137	2.0998	0.6726	0.2942	0.0073
	0.2401	2.2378	1.6912	1.8216	0.6605	1.3076
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 5

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

PERCOLATION/LEAKAGE THROUGH LAYER 7

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

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 5

AVERAGES	0.0018	0.0005	0.0022	0.0007	0.0003	0.0000
	0.0003	0.0024	0.0019	0.0019	0.0007	0.0014
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

DAILY AVERAGE HEAD ON TOP OF LAYER 7

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

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     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS     1 THROUGH     1
-------------------------------------------------------------------------------
                                       INCHES            CU. FEET       PERCENT
                                  -------------------  -------------   ---------
 PRECIPITATION                     48.96    (   0.000)    177724.8     100.00

 RUNOFF                             0.000   (  0.0000)        0.00       0.000

 EVAPOTRANSPIRATION                35.855   (  0.0000)    130152.03     73.232

 LATERAL DRAINAGE COLLECTED        13.10526 (  0.00000)    47572.082   26.76727
   FROM LAYER  4

 PERCOLATION/LEAKAGE THROUGH        0.00000 (  0.00000)       0.004     0.00000
   LAYER  5

 AVERAGE HEAD ON TOP                0.001 (     0.000)
   OF LAYER  5

 PERCOLATION/LEAKAGE THROUGH        0.00000 (  0.00000)       0.004     0.00000
   LAYER  7

 AVERAGE HEAD ON TOP                0.000 (     0.000)
   OF LAYER  7

 CHANGE IN WATER STORAGE            0.000   (  0.0000)        0.69      0.000

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*******************************************************************************
                PEAK DAILY VALUES FOR YEARS    1 THROUGH    1
  ---------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------    -------------
     PRECIPITATION                               2.85         10345.500

     RUNOFF                                      0.000            0.0000

     DRAINAGE COLLECTED FROM LAYER  4            0.30297       1099.77893

     PERCOLATION/LEAKAGE THROUGH LAYER  5        0.000000         0.00003

     AVERAGE HEAD ON TOP OF LAYER  5             0.010

     MAXIMUM HEAD ON TOP OF LAYER  5             0.312

     PERCOLATION/LEAKAGE THROUGH LAYER  7        0.000000         0.00003

     AVERAGE HEAD ON TOP OF LAYER  7             0.000

     SNOW WATER                                  1.63          5916.4204

     MAXIMUM VEG. SOIL WATER (VOL/VOL)                  0.2670

     MINIMUM VEG. SOIL WATER (VOL/VOL)                  0.1232

       ***  MAXIMUM HEADS ARE COMPUTED USING THE MOUND EQUATION.  ***

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FINAL WATER STORAGE AT END OF YEAR 1

LAYER	(INCHES)	(VOL/VOL)
1	3.7289	0.3107
2	6.9729	0.0726
3	15.5240	0.4312
4	0.0143	0.0573
5	0.0000	0.0000
6	0.1793	0.7470
7	8.2980	0.4610
SNOW WATER	0.000	

****
****

INSERT SECOND HELP MODEL
ALTERNATE LINER SYSTEM (Alt.2)
PHASE 2 OPEN 5 YEARS w/25 FT. OF SOLID WASTE

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.04    (13 MARCH 1995)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:      C:\HELP3\LENOIR.D4
TEMPERATURE DATA FILE:        C:\HELP3\Lenoir.D7
SOLAR RADIATION DATA FILE:    C:\HELP3\Lenoir.D13
EVAPOTRANSPIRATION DATA:      C:\HELP3\Lenoir.D11
SOIL AND DESIGN DATA FILE:    C:\HELP3\LENOIR2A.D10
OUTPUT DATA FILE:             C:\HELP3\Lenoir2A.OUT
```

Time: 13:40 Date: 10/10/2009

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******************************************************************************
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Title: Lenoir County Phase 2 Open 5 Years w/ 25 ft. Waste (Alt. 2)

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


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


                                  LAYER  1
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  12
          THICKNESS                    =     12.00   INCHES
          POROSITY                     =      0.4710 VOL/VOL
          FIELD CAPACITY               =      0.3420 VOL/VOL
          WILTING POINT                =      0.2100 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.3107 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.419999997000E-04 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  4.63
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
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                    LAYER  2
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  19
THICKNESS                    =    300.00   INCHES
POROSITY                     =      0.1680 VOL/VOL
FIELD CAPACITY               =      0.0730 VOL/VOL
WILTING POINT                =      0.0190 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.0729 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC


                    LAYER  3
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  14
THICKNESS                    =     36.00   INCHES
POROSITY                     =      0.4790 VOL/VOL
FIELD CAPACITY               =      0.3710 VOL/VOL
WILTING POINT                =      0.2510 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.4467 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.249999994000E-04 CM/SEC


                    LAYER  4
                    --------

           TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER  34
THICKNESS                    =      0.25   INCHES
POROSITY                     =      0.8500 VOL/VOL
FIELD CAPACITY               =      0.0100 VOL/VOL
WILTING POINT                =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =   33.0000000000     CM/SEC
SLOPE                        =      2.00   PERCENT
DRAINAGE LENGTH              =    100.0    FEET


                    LAYER  5
                    --------

           TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  35
THICKNESS                    =      0.06   INCHES
```

```
POROSITY                      =      0.0000 VOL/VOL
FIELD CAPACITY                =      0.0000 VOL/VOL
WILTING POINT                 =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT    =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY           =      4.00   HOLES/ACRE
FML INSTALLATION DEFECTS      =      4.00   HOLES/ACRE
FML PLACEMENT QUALITY         =  3 - GOOD
```

LAYER 6

```
TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER  17
THICKNESS                     =      0.24   INCHES
POROSITY                      =      0.7500 VOL/VOL
FIELD CAPACITY                =      0.7470 VOL/VOL
WILTING POINT                 =      0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT    =      0.7470 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.300000003000E-08 CM/SEC
```

LAYER 7

```
TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER  23
THICKNESS                     =     18.00   INCHES
POROSITY                      =      0.4610 VOL/VOL
FIELD CAPACITY                =      0.3600 VOL/VOL
WILTING POINT                 =      0.2030 VOL/VOL
INITIAL SOIL WATER CONTENT    =      0.4610 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.900000032000E-05 CM/SEC
```

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

```
NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
         SOIL DATA BASE USING SOIL TEXTURE #12 WITH A
         POOR STAND OF GRASS, A SURFACE SLOPE OF  2.%
         AND A SLOPE LENGTH OF  200. FEET.

SCS RUNOFF CURVE NUMBER                =     91.70
FRACTION OF AREA ALLOWING RUNOFF       =     50.0     PERCENT
AREA PROJECTED ON HORIZONTAL PLANE     =      1.000   ACRES
EVAPORATIVE ZONE DEPTH                 =     22.0     INCHES
INITIAL WATER IN EVAPORATIVE ZONE      =      4.425   INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE     =      7.332   INCHES
```

LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.710	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	50.157	INCHES
TOTAL INITIAL WATER	=	50.157	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
RALEIGH NORTH CAROLINA

STATION LATITUDE	=	35.87	DEGREES
MAXIMUM LEAF AREA INDEX	=	3.50	
START OF GROWING SEASON (JULIAN DATE)	=	86	
END OF GROWING SEASON (JULIAN DATE)	=	310	
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	7.70	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	66.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	70.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	78.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	72.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.11	3.66	3.96	3.39	4.42	5.39
6.20	5.76	5.30	3.06	2.92	3.42

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
41.80	43.60	51.40	61.00	68.40	74.90
78.70	78.10	72.80	61.80	52.50	44.00

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA
AND STATION LATITUDE = 35.13 DEGREES

****

MONTHLY TOTALS (IN INCHES) FOR YEAR 1

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	1.69	4.39	3.13	1.63	2.14	8.50
	7.20	7.75	2.85	3.84	0.72	5.12
RUNOFF	0.024	0.201	0.094	0.000	0.067	0.513
	0.658	0.795	0.103	0.277	0.013	0.455
EVAPOTRANSPIRATION	1.387	1.893	2.950	2.554	2.869	5.896
	6.419	4.291	2.817	3.420	0.368	0.814
LATERAL DRAINAGE COLLECTED FROM LAYER 4	2.1708	0.4291	1.8354	0.6745	0.2714	0.0190
	0.0748	0.9028	1.2214	1.4691	0.7060	0.3114
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 5	0.002	0.001	0.002	0.001	0.000	0.000
	0.000	0.001	0.001	0.002	0.001	0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 5	0.002	0.000	0.002	0.000	0.000	0.000
	0.000	0.001	0.001	0.001	0.000	0.001
AVERAGE DAILY HEAD ON TOP OF LAYER 7	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 7	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000

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ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT

PRECIPITATION	48.96	177724.844	100.00
RUNOFF	3.200	11616.245	6.54
EVAPOTRANSPIRATION	35.679	129513.109	72.87
DRAINAGE COLLECTED FROM LAYER 4	10.0857	36611.109	20.60
PERC./LEAKAGE THROUGH LAYER 5	0.000001	0.004	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0009		
PERC./LEAKAGE THROUGH LAYER 7	0.000001	0.004	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
CHANGE IN WATER STORAGE	-0.004	-15.620	-0.01
SOIL WATER AT START OF YEAR	50.336	182719.078	
SOIL WATER AT END OF YEAR	50.332	182703.453	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.011	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 2

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	2.83	2.30	5.14	3.78	9.70	10.52
	5.47	1.76	1.45	8.97	1.43	1.63
RUNOFF	0.453	0.093	0.220	0.069	1.463	1.315
	0.465	0.173	0.042	1.255	0.002	0.035
EVAPOTRANSPIRATION	1.105	1.698	2.782	4.163	5.817	4.146
	4.813	3.013	1.054	3.008	1.499	0.982
LATERAL DRAINAGE COLLECTED FROM LAYER 4	2.6468	1.1639	1.1808	0.9334	0.8064	2.8500
	3.1049	0.7303	0.5017	0.8673	2.2869	0.4220
PERCOLATION/LEAKAGE THROUGH	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

LAYER 5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 5	0.003 0.003	0.001 0.001	0.001 0.001	0.001 0.001	0.001 0.003	0.003 0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 5	0.002 0.003	0.001 0.000	0.001 0.000	0.000 0.002	0.001 0.002	0.003 0.000
AVERAGE DAILY HEAD ON TOP OF LAYER 7	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 7	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000

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ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	54.98	199577.391	100.00
RUNOFF	5.585	20273.453	10.16
EVAPOTRANSPIRATION	34.080	123709.836	61.99
DRAINAGE COLLECTED FROM LAYER 4	17.4943	63504.297	31.82
PERC./LEAKAGE THROUGH LAYER 5	0.000001	0.004	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0016		
PERC./LEAKAGE THROUGH LAYER 7	0.000001	0.004	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
CHANGE IN WATER STORAGE	-2.179	-7910.147	-3.96
SOIL WATER AT START OF YEAR	50.332	182703.453	
SOIL WATER AT END OF YEAR	48.152	174793.312	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00

SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.049	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 3

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	9.81 10.76	3.17 21.29	6.82 8.25	1.16 4.81	2.13 2.02	5.54 2.19
RUNOFF	1.289 1.513	0.174 4.949	0.652 2.057	0.035 0.406	0.034 0.108	0.753 0.170
EVAPOTRANSPIRATION	1.711 7.181	2.118 5.396	2.858 2.334	2.497 3.056	2.207 1.453	2.944 0.942
LATERAL DRAINAGE COLLECTED FROM LAYER 4	0.9719 0.9356	6.1603 6.1825	2.0721 8.9298	1.3133 1.1095	0.5571 1.1543	0.1675 1.2025
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 5	0.001 0.001	0.007 0.007	0.002 0.010	0.001 0.001	0.001 0.001	0.000 0.001
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 5	0.001 0.002	0.004 0.007	0.002 0.007	0.001 0.000	0.000 0.001	0.000 0.001
AVERAGE DAILY HEAD ON TOP OF LAYER 7	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 7	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000

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ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	77.95	282958.469	100.00
RUNOFF	12.140	44067.172	15.57
EVAPOTRANSPIRATION	34.697	125948.898	44.51
DRAINAGE COLLECTED FROM LAYER 4	30.7564	111645.594	39.46
PERC./LEAKAGE THROUGH LAYER 5	0.000001	0.005	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0028		
PERC./LEAKAGE THROUGH LAYER 7	0.000001	0.005	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
CHANGE IN WATER STORAGE	0.357	1296.804	0.46
SOIL WATER AT START OF YEAR	48.152	174793.312	
SOIL WATER AT END OF YEAR	48.510	176090.109	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.019	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 4

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	2.94	3.35	4.50	2.16	4.28	4.38
	7.06	4.14	6.25	1.06	4.01	3.99
RUNOFF	0.047	0.242	0.245	0.033	0.012	0.310
	0.662	0.051	1.037	0.000	0.275	0.417

EVAPOTRANSPIRATION	1.623	2.011	2.927	3.738	4.578	4.055
	4.713	3.932	2.667	2.412	1.298	0.995
LATERAL DRAINAGE COLLECTED FROM LAYER 4	0.9159	1.2525	1.3016	0.6137	0.2793	0.0220
	0.0223	0.2065	0.6208	1.4680	0.3667	0.6123
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 5	0.001	0.002	0.001	0.001	0.000	0.000
	0.000	0.000	0.001	0.002	0.000	0.001
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 5	0.000	0.001	0.001	0.000	0.000	0.000
	0.000	0.000	0.002	0.001	0.000	0.001
AVERAGE DAILY HEAD ON TOP OF LAYER 7	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 7	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000

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ANNUAL TOTALS FOR YEAR 4

	INCHES	CU. FEET	PERCENT
PRECIPITATION	48.12	174675.578	100.00
RUNOFF	3.331	12092.490	6.92
EVAPOTRANSPIRATION	34.949	126864.789	72.63
DRAINAGE COLLECTED FROM LAYER 4	7.6816	27884.285	15.96
PERC./LEAKAGE THROUGH LAYER 5	0.000001	0.003	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0007		
PERC./LEAKAGE THROUGH LAYER 7	0.000001	0.003	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
CHANGE IN WATER STORAGE	2.149	7799.133	4.46

SOIL WATER AT START OF YEAR	48.510	176090.109	
SOIL WATER AT END OF YEAR	50.658	183889.250	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0096	34.880	0.02

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MONTHLY TOTALS (IN INCHES) FOR YEAR 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	1.63 1.82	1.80 5.68	3.90 3.68	6.60 2.40	3.00 4.65	10.89 2.89
RUNOFF	0.000 0.034	0.000 0.389	0.278 0.452	0.476 0.079	0.032 0.357	1.573 0.328
EVAPOTRANSPIRATION	1.418 2.724	1.708 2.275	2.834 2.717	4.082 2.772	4.199 1.609	6.328 1.329
LATERAL DRAINAGE COLLECTED FROM LAYER 4	2.5870 2.1321	0.4808 0.4903	0.2447 0.9118	0.7331 1.0259	1.4471 0.4852	0.4435 1.1496
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 5	0.003 0.002	0.001 0.001	0.000 0.001	0.001 0.001	0.002 0.001	0.001 0.001
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 5	0.002 0.002	0.000 0.000	0.000 0.001	0.001 0.000	0.001 0.000	0.000 0.000
AVERAGE DAILY HEAD ON	0.000	0.000	0.000	0.000	0.000	0.000

TOP OF LAYER 7	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY	0.000	0.000	0.000	0.000	0.000	0.000
HEAD ON TOP OF LAYER 7	0.000	0.000	0.000	0.000	0.000	0.000

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ANNUAL TOTALS FOR YEAR 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	48.94	177652.187	100.00
RUNOFF	3.998	14514.175	8.17
EVAPOTRANSPIRATION	33.994	123398.742	69.46
DRAINAGE COLLECTED FROM LAYER 4	12.1309	44035.289	24.79
PERC./LEAKAGE THROUGH LAYER 5	0.000001	0.004	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0011		
PERC./LEAKAGE THROUGH LAYER 7	0.000001	0.004	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
CHANGE IN WATER STORAGE	-1.183	-4296.016	-2.42
SOIL WATER AT START OF YEAR	50.658	183889.250	
SOIL WATER AT END OF YEAR	49.475	179593.234	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.016	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC

PRECIPITATION						
TOTALS	3.78	3.00	4.70	3.07	4.25	7.97
	6.46	8.12	4.50	4.22	2.57	3.16
STD. DEVIATIONS	3.43	1.00	1.40	2.21	3.17	2.92
	3.24	7.68	2.73	3.01	1.69	1.40
RUNOFF						
TOTALS	0.363	0.142	0.298	0.123	0.321	0.893
	0.666	1.271	0.738	0.403	0.151	0.281
STD. DEVIATIONS	0.550	0.096	0.210	0.199	0.638	0.535
	0.538	2.075	0.837	0.502	0.159	0.176
EVAPOTRANSPIRATION						
TOTALS	1.449	1.885	2.870	3.407	3.934	4.674
	5.170	3.781	2.318	2.934	1.245	1.012
STD. DEVIATIONS	0.236	0.185	0.069	0.821	1.427	1.404
	1.726	1.199	0.729	0.373	0.503	0.191
LATERAL DRAINAGE COLLECTED FROM LAYER 4						
TOTALS	1.8585	1.8973	1.3269	0.8536	0.6723	0.7004
	1.2539	1.7025	2.4371	1.1879	0.9998	0.7395
STD. DEVIATIONS	0.8550	2.4129	0.7084	0.2836	0.4865	1.2140
	1.3422	2.5181	3.6402	0.2705	0.7798	0.4132
PERCOLATION/LEAKAGE THROUGH LAYER 5						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 7						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 5						
AVERAGES	0.0020	0.0023	0.0014	0.0009	0.0007	0.0008

	0.0013	0.0018	0.0027	0.0013	0.0011	0.0008
STD. DEVIATIONS	0.0009	0.0028	0.0008	0.0003	0.0005	0.0013
	0.0014	0.0027	0.0040	0.0003	0.0009	0.0004

DAILY AVERAGE HEAD ON TOP OF LAYER 7

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

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 5

	INCHES		CU. FEET	PERCENT
PRECIPITATION	55.79	(12.690)	202517.7	100.00
RUNOFF	5.651	(3.7492)	20512.71	10.129
EVAPOTRANSPIRATION	34.680	(0.6893)	125887.07	62.161
LATERAL DRAINAGE COLLECTED FROM LAYER 4	15.62978	(9.19839)	56736.113	28.01539
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.00000	(0.00000)	0.004	0.00000
AVERAGE HEAD ON TOP OF LAYER 5	0.001	(0.001)		
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00000	(0.00000)	0.004	0.00000
AVERAGE HEAD ON TOP OF LAYER 7	0.000	(0.000)		
CHANGE IN WATER STORAGE	-0.172	(1.6389)	-625.17	-0.309

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              PEAK DAILY VALUES FOR YEARS     1 THROUGH     5
  ------------------------------------------------------------------------------
                                                (INCHES)       (CU. FT.)
                                               ----------     -------------
     PRECIPITATION                               6.77          24575.100

     RUNOFF                                      2.586          9387.6406

     DRAINAGE COLLECTED FROM LAYER  4            0.71604        2599.20996

     PERCOLATION/LEAKAGE THROUGH LAYER  5        0.000000          0.00004

     AVERAGE HEAD ON TOP OF LAYER  5             0.024

     MAXIMUM HEAD ON TOP OF LAYER  5             0.479

     PERCOLATION/LEAKAGE THROUGH LAYER  7        0.000000          0.00004

     AVERAGE HEAD ON TOP OF LAYER  7             0.000

     SNOW WATER                                  1.63           5916.4204

     MAXIMUM VEG. SOIL WATER (VOL/VOL)                   0.2703

     MINIMUM VEG. SOIL WATER (VOL/VOL)                   0.1232

       ***  MAXIMUM HEADS ARE COMPUTED USING THE MOUND EQUATION.  ***

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FINAL WATER STORAGE AT END OF YEAR 5

LAYER	(INCHES)	(VOL/VOL)
1	3.8049	0.3171
2	22.8243	0.0761
3	14.1864	0.3941
4	0.0025	0.0100
5	0.0000	0.0000
6	0.1793	0.7470
7	8.2980	0.4610
SNOW WATER	0.000	

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INSERT FINAL HELP MODEL
ALTERNATE LINER SYSTEM (Alt. 2)
PHASE 2 CLOSED

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**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.04    (13 MARCH 1995)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:      C:\HELP3\LENOIR.D4
TEMPERATURE DATA FILE:        C:\HELP3\Lenoir.D7
SOLAR RADIATION DATA FILE:    C:\HELP3\Lenoir.D13
EVAPOTRANSPIRATION DATA:      C:\HELP3\Lenoir.D11
SOIL AND DESIGN DATA FILE:    C:\HELP3\LENOIRCA.D10
OUTPUT DATA FILE:             C:\HELP3\LenoirCA.OUT
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Time: 13:56 Date: 10/10/2009

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Title: Lenoir County Phase 2 Closed (Alt. 2)

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


                                  LAYER  1
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  12
          THICKNESS                    =     24.00   INCHES
          POROSITY                     =      0.4710 VOL/VOL
          FIELD CAPACITY               =      0.3420 VOL/VOL
          WILTING POINT                =      0.2100 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.3496 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.419999997000E-04 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  4.63
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
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LAYER 2

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20

THICKNESS	=	0.20	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0279	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000	CM/SEC
SLOPE	=	5.00	PERCENT
DRAINAGE LENGTH	=	300.0	FEET

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.04	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	4.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	4.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 23

THICKNESS	=	18.00	INCHES
POROSITY	=	0.4610	VOL/VOL
FIELD CAPACITY	=	0.3600	VOL/VOL
WILTING POINT	=	0.2030	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4610	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.900000032000E-05	CM/SEC

LAYER 5

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          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  12
THICKNESS                      =      12.00    INCHES
POROSITY                       =       0.4710 VOL/VOL
FIELD CAPACITY                 =       0.3420 VOL/VOL
WILTING POINT                  =       0.2100 VOL/VOL
INITIAL SOIL WATER CONTENT     =       0.3420 VOL/VOL
EFFECTIVE SAT. HYD. COND.      =  0.419999997000E-04 CM/SEC


                    LAYER  6
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  19
THICKNESS                      =     360.00    INCHES
POROSITY                       =       0.1680 VOL/VOL
FIELD CAPACITY                 =       0.0730 VOL/VOL
WILTING POINT                  =       0.0190 VOL/VOL
INITIAL SOIL WATER CONTENT     =       0.0730 VOL/VOL
EFFECTIVE SAT. HYD. COND.      =  0.100000005000E-02 CM/SEC


                    LAYER  7
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          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  14
THICKNESS                      =      36.00    INCHES
POROSITY                       =       0.4790 VOL/VOL
FIELD CAPACITY                 =       0.3710 VOL/VOL
WILTING POINT                  =       0.2510 VOL/VOL
INITIAL SOIL WATER CONTENT     =       0.3710 VOL/VOL
EFFECTIVE SAT. HYD. COND.      =  0.249999994000E-04 CM/SEC


                    LAYER  8
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            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER  34
THICKNESS                      =       0.25    INCHES
POROSITY                       =       0.8500 VOL/VOL
FIELD CAPACITY                 =       0.0100 VOL/VOL
WILTING POINT                  =       0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT     =       0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.      =   33.0000000000      CM/SEC
SLOPE                          =       2.00    PERCENT
DRAINAGE LENGTH                =     100.0     FEET
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LAYER 9

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	4.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	4.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 10

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.24	INCHES
POROSITY	=	0.7500	VOL/VOL
FIELD CAPACITY	=	0.7470	VOL/VOL
WILTING POINT	=	0.4000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7470	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000003000E-08	CM/SEC

LAYER 11

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 23

THICKNESS	=	18.00	INCHES
POROSITY	=	0.4610	VOL/VOL
FIELD CAPACITY	=	0.3600	VOL/VOL
WILTING POINT	=	0.2030	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4610	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.900000032000E-05	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #12 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 2.%

AND A SLOPE LENGTH OF 200. FEET.

SCS RUNOFF CURVE NUMBER	=	91.70	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	7.627	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	10.362	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	4.620	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	68.915	INCHES
TOTAL INITIAL WATER	=	68.915	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
RALEIGH NORTH CAROLINA

STATION LATITUDE	=	35.87	DEGREES
MAXIMUM LEAF AREA INDEX	=	3.50	
START OF GROWING SEASON (JULIAN DATE)	=	86	
END OF GROWING SEASON (JULIAN DATE)	=	310	
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	7.70	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	66.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	70.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	78.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	72.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.11	3.66	3.96	3.39	4.42	5.39
6.20	5.76	5.30	3.06	2.92	3.42

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
41.80	43.60	51.40	61.00	68.40	74.90
78.70	78.10	72.80	61.80	52.50	44.00

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA
AND STATION LATITUDE = 35.13 DEGREES

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MONTHLY TOTALS (IN INCHES) FOR YEAR 1

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	1.69 7.20	4.39 7.75	3.13 2.85	1.63 3.84	2.14 0.72	8.50 5.12
RUNOFF	0.060 1.301	0.502 1.626	0.225 0.224	0.000 0.640	0.131 0.026	0.987 0.969
EVAPOTRANSPIRATION	1.458 6.251	1.931 4.148	2.997 2.746	2.705 3.423	3.665 1.451	5.741 0.922
LATERAL DRAINAGE COLLECTED FROM LAYER 2	0.3419 0.0030	0.5529 0.0033	1.4962 0.3970	0.0051 1.2745	0.0012 0.0000	0.0015 0.7550
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000
LATERAL DRAINAGE COLLECTED FROM LAYER 8	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 9	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 3	0.001 0.000	0.002 0.000	0.005 0.001	0.000 0.004	0.000 0.000	0.000 0.003
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 3	0.001 0.000	0.006 0.000	0.006 0.002	0.000 0.007	0.000 0.000	0.000 0.005
AVERAGE DAILY HEAD ON	0.000	0.000	0.000	0.000	0.000	0.000

TOP OF LAYER 9	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 9	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
AVERAGE DAILY HEAD ON TOP OF LAYER 11	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 11	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000

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ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	48.96	177724.844	100.00
RUNOFF	6.691	24286.932	13.67
EVAPOTRANSPIRATION	37.438	135898.812	76.47
DRAINAGE COLLECTED FROM LAYER 2	4.8315	17538.311	9.87
PERC./LEAKAGE THROUGH LAYER 4	0.000086	0.311	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0014		
DRAINAGE COLLECTED FROM LAYER 8	0.0001	0.310	0.00
PERC./LEAKAGE THROUGH LAYER 9	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
PERC./LEAKAGE THROUGH LAYER 11	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 11	0.0000		
CHANGE IN WATER STORAGE	0.000	0.388	0.00
SOIL WATER AT START OF YEAR	69.094	250810.750	
SOIL WATER AT END OF YEAR	69.094	250811.141	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.080	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 2

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	2.83 5.47	2.30 1.76	5.14 1.45	3.78 8.97	9.70 1.43	10.52 1.63
RUNOFF	0.983 0.910	0.210 0.346	0.510 0.083	0.160 2.480	3.007 0.007	2.662 0.092
EVAPOTRANSPIRATION	1.160 5.915	1.739 3.135	2.824 1.062	4.198 3.076	5.871 1.435	5.111 0.941
LATERAL DRAINAGE COLLECTED FROM LAYER 2	1.2869 0.5029	0.1341 0.0000	1.1743 0.0001	0.4855 0.8757	1.4163 0.3173	0.7637 0.5609
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000
LATERAL DRAINAGE COLLECTED FROM LAYER 8	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 9	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 3	0.004 0.002	0.001 0.000	0.004 0.000	0.002 0.003	0.005 0.001	0.003 0.002
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 3	0.005 0.003	0.001 0.000	0.003 0.000	0.002 0.005	0.008 0.002	0.005 0.002
AVERAGE DAILY HEAD ON TOP OF LAYER 9	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 9	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
AVERAGE DAILY HEAD ON TOP OF LAYER 11	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000

STD. DEVIATION OF DAILY	0.000	0.000	0.000	0.000	0.000	0.000
HEAD ON TOP OF LAYER 11	0.000	0.000	0.000	0.000	0.000	0.000

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ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	54.98	199577.391	100.00
RUNOFF	11.452	41571.547	20.83
EVAPOTRANSPIRATION	36.468	132379.062	66.33
DRAINAGE COLLECTED FROM LAYER 2	7.5178	27289.729	13.67
PERC./LEAKAGE THROUGH LAYER 4	0.000135	0.492	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0022		
DRAINAGE COLLECTED FROM LAYER 8	0.0001	0.491	0.00
PERC./LEAKAGE THROUGH LAYER 9	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
PERC./LEAKAGE THROUGH LAYER 11	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 11	0.0000		
CHANGE IN WATER STORAGE	-0.458	-1663.399	-0.83
SOIL WATER AT START OF YEAR	69.094	250811.141	
SOIL WATER AT END OF YEAR	68.636	249147.750	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.026	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 3

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	9.81	3.17	6.82	1.16	2.13	5.54
	10.76	21.29	8.25	4.81	2.02	2.19
RUNOFF	2.912	0.402	1.425	0.075	0.064	1.499
	2.958	10.325	4.343	0.881	0.264	0.378
EVAPOTRANSPIRATION	1.680	2.089	2.834	2.847	3.187	2.553
	7.036	5.366	2.285	3.037	1.416	0.922
LATERAL DRAINAGE COLLECTED FROM LAYER 2	3.6591	2.2787	1.5415	0.4575	0.0132	0.0003
	0.0010	3.9575	2.8780	0.2120	1.3199	0.8198
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000
LATERAL DRAINAGE COLLECTED FROM LAYER 8	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 3	0.013	0.009	0.005	0.002	0.000	0.000
	0.000	0.014	0.010	0.001	0.005	0.003
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 3	0.016	0.008	0.007	0.002	0.000	0.000
	0.000	0.013	0.017	0.001	0.002	0.003
AVERAGE DAILY HEAD ON TOP OF LAYER 9	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 9	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
AVERAGE DAILY HEAD ON TOP OF LAYER 11	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 11	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000

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ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	77.95	282958.469	100.00
RUNOFF	25.525	92657.109	32.75
EVAPOTRANSPIRATION	35.251	127962.703	45.22
DRAINAGE COLLECTED FROM LAYER 2	17.1384	62212.418	21.99
PERC./LEAKAGE THROUGH LAYER 4	0.000284	1.031	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0050		
DRAINAGE COLLECTED FROM LAYER 8	0.0003	1.031	0.00
PERC./LEAKAGE THROUGH LAYER 9	0.000000	0.001	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
PERC./LEAKAGE THROUGH LAYER 11	0.000000	0.001	0.00
AVG. HEAD ON TOP OF LAYER 11	0.0000		
CHANGE IN WATER STORAGE	0.035	125.235	0.04
SOIL WATER AT START OF YEAR	68.636	249147.750	
SOIL WATER AT END OF YEAR	68.670	249272.984	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.034	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 4

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	2.94	3.35	4.50	2.16	4.28	4.38

	7.06	4.14	6.25	1.06	4.01	3.99
RUNOFF	0.127 1.279	0.556 0.099	0.538 2.153	0.074 0.000	0.024 0.549	0.615 0.940
EVAPOTRANSPIRATION	1.608 4.638	1.995 3.632	2.913 2.566	3.690 3.418	5.578 1.316	3.788 0.806
LATERAL DRAINAGE COLLECTED FROM LAYER 2	0.6796 0.0005	1.4127 0.0004	0.6597 0.2960	0.0042 0.0850	0.0140 0.0004	0.0020 1.6669
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000
LATERAL DRAINAGE COLLECTED FROM LAYER 8	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 9	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 3	0.002 0.000	0.005 0.000	0.002 0.001	0.000 0.000	0.000 0.000	0.000 0.006
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 3	0.003 0.000	0.005 0.000	0.002 0.002	0.000 0.001	0.000 0.000	0.000 0.011
AVERAGE DAILY HEAD ON TOP OF LAYER 9	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 9	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
AVERAGE DAILY HEAD ON TOP OF LAYER 11	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 11	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000

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ANNUAL TOTALS FOR YEAR 4

	INCHES	CU. FEET	PERCENT

PRECIPITATION	48.12	174675.578	100.00
RUNOFF	6.955	25245.174	14.45
EVAPOTRANSPIRATION	35.947	130489.352	74.70
DRAINAGE COLLECTED FROM LAYER 2	4.8214	17501.805	10.02
PERC./LEAKAGE THROUGH LAYER 4	0.000086	0.311	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0014		
DRAINAGE COLLECTED FROM LAYER 8	0.0001	0.310	0.00
PERC./LEAKAGE THROUGH LAYER 9	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
PERC./LEAKAGE THROUGH LAYER 11	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 11	0.0000		
CHANGE IN WATER STORAGE	0.387	1404.121	0.80
SOIL WATER AT START OF YEAR	68.670	249272.984	
SOIL WATER AT END OF YEAR	69.057	250677.094	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0096	34.822	0.02

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MONTHLY TOTALS (IN INCHES) FOR YEAR 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	1.63	1.80	3.90	6.60	3.00	10.89
	1.82	5.68	3.68	2.40	4.65	2.89
RUNOFF	0.000	0.003	0.575	1.080	0.079	3.038
	0.068	0.755	0.984	0.180	0.754	0.730
EVAPOTRANSPIRATION	1.256	1.617	2.787	3.970	5.248	6.035
	3.738	2.149	2.460	3.111	1.636	1.290

LATERAL DRAINAGE COLLECTED FROM LAYER 2	0.3165	0.2689	0.2563	1.5714	0.4318	0.0693
	0.2865	0.0000	0.3256	0.2499	0.4835	0.5591
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LATERAL DRAINAGE COLLECTED FROM LAYER 8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON TOP OF LAYER 3	0.001	0.001	0.001	0.006	0.001	0.000
	0.001	0.000	0.001	0.001	0.002	0.002
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 3	0.001	0.001	0.001	0.005	0.002	0.001
	0.002	0.000	0.001	0.001	0.002	0.001
AVERAGE DAILY HEAD ON TOP OF LAYER 9	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 9	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
AVERAGE DAILY HEAD ON TOP OF LAYER 11	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY HEAD ON TOP OF LAYER 11	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000

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ANNUAL TOTALS FOR YEAR 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	48.94	177652.187	100.00
RUNOFF	8.246	29932.645	16.85
EVAPOTRANSPIRATION	35.298	128131.203	72.12
DRAINAGE COLLECTED FROM LAYER 2	4.8188	17492.143	9.85

PERC./LEAKAGE THROUGH LAYER 4	0.000092	0.333	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0014		
DRAINAGE COLLECTED FROM LAYER 8	0.0001	0.333	0.00
PERC./LEAKAGE THROUGH LAYER 9	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
PERC./LEAKAGE THROUGH LAYER 11	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 11	0.0000		
CHANGE IN WATER STORAGE	0.577	2095.880	1.18
SOIL WATER AT START OF YEAR	69.057	250677.094	
SOIL WATER AT END OF YEAR	69.634	252772.984	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.020	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.78	3.00	4.70	3.07	4.25	7.97
	6.46	8.12	4.50	4.22	2.57	3.16
STD. DEVIATIONS	3.43	1.00	1.40	2.21	3.17	2.92
	3.24	7.68	2.73	3.01	1.69	1.40
RUNOFF						
TOTALS	0.816	0.334	0.655	0.278	0.661	1.760
	1.303	2.630	1.557	0.836	0.320	0.622
STD. DEVIATIONS	1.238	0.227	0.453	0.452	1.312	1.052
	1.051	4.340	1.760	0.984	0.327	0.379

EVAPOTRANSPIRATION

TOTALS	1.432	1.874	2.871	3.482	4.710	4.645
	5.515	3.686	2.224	3.213	1.451	0.976
STD. DEVIATIONS	0.223	0.193	0.084	0.671	1.205	1.454
	1.317	1.194	0.671	0.191	0.116	0.183

LATERAL DRAINAGE COLLECTED FROM LAYER 2

TOTALS	1.2568	0.9295	1.0256	0.5048	0.3753	0.1674
	0.1588	0.7922	0.7793	0.5394	0.4242	0.8723
STD. DEVIATIONS	1.3988	0.9034	0.5558	0.6404	0.6100	0.3347
	0.2286	1.7694	1.1829	0.5126	0.5424	0.4591

PERCOLATION/LEAKAGE THROUGH LAYER 4

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

LATERAL DRAINAGE COLLECTED FROM LAYER 8

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

PERCOLATION/LEAKAGE THROUGH LAYER 9

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

PERCOLATION/LEAKAGE THROUGH LAYER 11

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

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	0.0043	0.0035	0.0035	0.0018	0.0013	0.0006

	0.0005	0.0027	0.0028	0.0018	0.0015	0.0030
STD. DEVIATIONS	0.0048	0.0034	0.0019	0.0023	0.0021	0.0012
	0.0008	0.0061	0.0042	0.0018	0.0019	0.0016

DAILY AVERAGE HEAD ON TOP OF LAYER 9

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

DAILY AVERAGE HEAD ON TOP OF LAYER 11

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

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 5

	INCHES		CU. FEET	PERCENT
PRECIPITATION	55.79	(12.690)	202517.7	100.00
RUNOFF	11.774	(7.9171)	42738.68	21.104
EVAPOTRANSPIRATION	36.081	(0.9097)	130972.22	64.672
LATERAL DRAINAGE COLLECTED FROM LAYER 2	7.82559	(5.33511)	28406.881	14.02686
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00014	(0.00009)	0.496	0.00024
AVERAGE HEAD ON TOP OF LAYER 3	0.002	(0.002)		
LATERAL DRAINAGE COLLECTED FROM LAYER 8	0.00014	(0.00009)	0.495	0.00024
PERCOLATION/LEAKAGE THROUGH LAYER 9	0.00000	(0.00000)	0.000	0.00000
AVERAGE HEAD ON TOP OF LAYER 9	0.000	(0.000)		
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.00000	(0.00000)	0.000	0.00000

AVERAGE HEAD ON TOP OF LAYER 11	0.000 (	0.000)		
CHANGE IN WATER STORAGE	0.108	(0.3987)	392.45	0.194

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 5

	(INCHES)	(CU. FT.)
PRECIPITATION	6.77	24575.100
RUNOFF	5.236	19006.6582
DRAINAGE COLLECTED FROM LAYER 2	0.68827	2498.41602
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000010	0.03471
AVERAGE HEAD ON TOP OF LAYER 3	0.073	
MAXIMUM HEAD ON TOP OF LAYER 3	2.561	
DRAINAGE COLLECTED FROM LAYER 8	0.00001	0.03471
PERCOLATION/LEAKAGE THROUGH LAYER 9	0.000000	0.00000
AVERAGE HEAD ON TOP OF LAYER 9	0.000	
MAXIMUM HEAD ON TOP OF LAYER 9	0.001	
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.000000	0.00000
AVERAGE HEAD ON TOP OF LAYER 11	0.000	
SNOW WATER	1.63	5916.4204

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4269

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.2100

*** MAXIMUM HEADS ARE COMPUTED USING THE MOUND EQUATION. ***

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FINAL WATER STORAGE AT END OF YEAR 5

LAYER	(INCHES)	(VOL/VOL)
1	8.9217	0.3717
2	0.0157	0.0783
3	0.0000	0.0000
4	8.2980	0.4610
5	4.1040	0.3420
6	26.2800	0.0730
7	13.3560	0.3710
8	0.0025	0.0100
9	0.0000	0.0000
10	0.1793	0.7470
11	8.2980	0.4610
SNOW WATER	0.000	

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2.2.4 Leachate Collection System Design Calculations

Initial Calculations

25 yr. 24 hr. Storm = 7.2"

Lagoon storage capacity = 624,000 gallons

Discharge pipe (Liner Penetration)= 8" HDPE SDR-17 Pipe ≥ 2% slope

Based on the HELP Model, the average monthly flows for a 5 year period on a per acre basis are as follows:

1.	January	=	50,503 gallons/acre
2.	February	=	51,590 gallons/acre
3.	March	=	36,112 gallons/acre
4.	April	=	23,079 gallons/acre
5.	May	=	18,192 gallons/acre
6.	June	=	19,007 gallons/acre
7.	July	=	33,941 gallons/acre
8.	August	=	46,159 gallons/acre
9.	September	=	66,252 gallons/acre
10.	October	=	32,311 gallons/acre
11.	November	=	27,152 gallons/acre
12.	December	=	20,093 gallons/acre
	Total	=	424,391 gallons/acre

Annual Flow based on 9.23 acres = 3,917,129 gallons

The leachate lagoon holds 624,000 gallons of leachate. The HELP Model predicts 3,917,129 gallons of leachate per year.

Based on 3,917,129 gal./yr., the leachate lagoon has to be emptied 6.3 times a year or once every 1.9 months.

Maximum Flow Through 8" pipe @2% (Manning's Equation)

n = 0.009 s = 0.02 ft/ft A= 0.311026 ft^2 P= 1.977381 ft R = A/P

$Q = 1.486/n\ (AR^{2/3}s^{1/2})$
$Q = 1.486/.009(0.311026)(0.157292)^{2/3}(.02)^{1/2}$
Q = 2.1162 cfs = 949.75 gpm

Leachate Collection System Components

Flow into perforation of pipe	= 662,300 ft^3/yr. = 9.42 gpm/ft.
Vertical Flow through Rock Fill	= 441,500 ft^3/ft/yr. = 6.28 gpm/ft.
Horizontal Flow through Rock Fill w/1.0' of Head	= 346,500 ft^3/yr. = 4.94 gpm

System Performance

The largest area with no garbage will be approximately 5.0 acres.

Q_{25} = (5 ac)(43,560 sq.ft./ac)(7.2"/12")(7.48 gal/cu.ft.) = 977,486 gal./day
Q_{25} = 40,729 gal./hr.

Lagoon size without the 2 feet of freeboard = 624,000 gallons

∴ Lagoon will hold 25 yr. 24 hr. storm w/ no garbage and an exposed cell w/ no evaporation, for 15.3 hours at which time the landfill will have to hold the remaining runoff until the lagoon can be emptied.

Flow Through 8" HDPE SDR-17 pipe @ the penetration

Q_{pipe}	=	949.75 gpm
	=	1,367,640 gpd
$Q_{25/5\ acres}$	=	977,486 gal./day

∴ Penetration pipe will adequately carry the 25 yr. 24 hr. storm out of the landfill if 5 acres are exposed with no garbage in 17.15 hours. The pipe at penetration will more than adequately handle the daily peak flow as shown by the HELP Model for a five year period, which is 40,953 gallons.

Factor of Safety = 1,367,640 ÷ 40,953 = 3.3

Flow Through most restrictive component of the leachate collection system (Horizontal Flow Through Rock)

Q_{rock} = 4.94 gpm

Q_{25} = 1,357.62 gpm

∴ The rock will act as a restrictive factor in the horizontal flow of leachate; consequently, the flow will be passed to the pipe through the perforations. There would only need to be 144 ft. of perforated pipe to carry the flow. There are 4,156 total feet of perforated pipe in Phase 2.

Leachate Trench Capacity for flow into trench.

25 yr. 24 hr. storm = 7.2"

Assume no evaporation or soil retained water:
- everything is runoff
- assume 7.2" rainfall in first hour of day.

∴ 5.0 acres lined x 43560 ft^2/acres x 7.2"/12"
= 130,680 ft^3 first hour x 7.48 gal/ft^3 ÷ 60 min.
= 16,291 gpm

Vertical flow through Rock Fill = 441,500 ft^3/ft/yr.
= 6.28 gpm/ft.

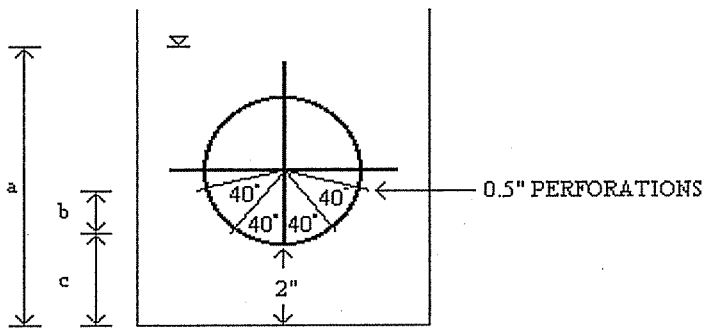
What length of trench is required to allow the 25 yr. storm to flow through the rock at the surface of the protective cover in 24 hours?

16,291 gpm. ÷ 6.28 gpm/ft = 2,594 ft
The length of design leachate trench = 4,156 ft.

Total length of leachate trench w/ a flow rate of 6.28 gpm/ft = 4,156 x 6.28
= 26,100 gpm

For total system to collect the 25 yr. 24 hr. storm that fell in 1 hour:

130,680 ft^3 x 7.48 ft^3/gal ÷ 26,100 gpm = 37.45 min.



r = Radius, a = 1.0' Head

C = r - rCos40° + 2"

BC = r -rCos80° + 2"

C_6 = 2.70" BC_6 = 4.48"
C_8 = 2.94" BC_8 = 5.31"

∴ Head on the 40° perforation @ 1.0 overall head on liner:
(6") = 12"- 2.70" = 9.30"
(8") = 12" - 2.94" = 9.06"

∴ Head on the 80° perforation @ 1.0 overall head on liner:
(6") = 12"- 4.48" = 7.52"
(8") = 12" - 5.31" = 6.69"

Use the orifice equation to determine the flow into the holes w/ 1.0' of head on the liner.

$Q = CA\sqrt{(2gh)}$ where: $C = 0.95$ $A = 0.0014 ft^2$ $g = 32.2$ ft/sec. H = head (ft.)
Q = cfs

$Q_{40°}$

$Q_6 = 0.95(0.0014)\sqrt{(2(32.2)((12-2.70)\div 12)} = 0.0094$ cfs

$Q_8 = 0.95(0.0014)\sqrt{(2(32.2)((12-2.94)\div 12)} = 0.0093$ cfs

$Q_{80°}$

$Q_6 = 0.95(0.0014)\sqrt{(2(32.2)((12-4.48)\div 12)} = 0.0084$ cfs

$Q_8 = 0.95(0.0014)\sqrt{(2(32.2)((12-5.31)\div 12)} = 0.0080$ cfs

Flow per foot of 6" leachate line:
4(0.0094) + 4(0.0084) = .0712 cfs

Flow per foot of 8" leachate line:
4(0.0093) + 4(0.0080) = .0692 cfs

Total leachate trench capacity in Cell 1 (smallest):
2,773 L.F. of 6" Leachate Line @ 0.0712 cfs/ft.

Total flow capability of 6" line:
2,773 x .0712 = 197.44 cfs = 88,610 gpm

Required 6" Line: 16,291 ÷ (.0712x7.48x60) = 510 L.F.
Provided 2,773 L.F. O.K.

Factor of Safety = 2,336 ÷ 510 = 4.6
(6 inch line will handle the flow)

∴ Perforations more than adequate to handle the total flow w/ 1.0' of Head.

Leachate pipe separations are 50 ft. Assume the 25 yr. 24 hr. storm falls on a strip 50 ft. by 1 ft.

∴ Total rainfall on strip = 50' x 1' x 7.2/12 = 30 ft^3

Assume this total falls in 1 hr.
∴ 30 ft^3 ÷ 60 min./hr = .50 ft^3/min. = 3.74 gpm

1 ft. of 6" perforated line will drain 0.0712 cfs @ 1.0 ft. of head.

∴ 0.0712 cfs = 31.95 gpm Most extreme case 3.74 gpm.

Factor of safety = 31.95 gpm ÷ 3.74 gpm = 8.54

Assume worst conditions:

7.2" rain on 5.0 acres in one hour and nothing is discharged from the landfill until rain has stopped.

$\therefore$ Volume of water retained = 7.2/12 x 5.0 x 43,560
= 130,680 ft^3
= 977,486 gallons

The most restrictive component in the system is the 8" leachate line at the lowest point which is designed w/ a slope of 2%. Consequently, the maximum water that can be discharged through this pipe is:

Maximum Flow Through 8" pipe @2% (Manning's Equation)

n = 0.009 s = 0.02 ft/ft A= 0.3110 ft^2 P= 1.9774 ft R = A/P

$$Q = \frac{1.486\ (AR^{2/3}s^{1/2})}{n}$$

$$Q = \frac{1.486\ (.3110)(.1573)^{2/3}(.02)^{1/2}}{0.009}$$

Q = 2.12 cfs = 950 gpm

Volume to Discharge = 977,486 gals.

977,486 gals ÷ 950 gpm = 2,058 min. = 17.1 hours

This is an extreme condition that cannot happen because the storm event would be discharged as it was occurring and not after it happened.

2.2.5 Strength of Pipe

Rinker Materials PolyPipe Division Design and Engineering Guide for Polyethylene Piping

PolyPipe®

C Earthloading Critical Buckling

$$P_t = P_b + P_L + P_s$$

$$P_{CB} = \frac{1}{SF}\sqrt{\frac{2.67 \times B \times RW \times \Sigma_s \times \Sigma}{SDR^3}}$$

$$P_{CB} \geq P_t$$

See Page C-5 Thru C-8

09/17/2009

Rho	60	lbs/ft³
H	200	ft
PL	21	psi
PS	0	psi
HW	5	ft
SF	2	
DR	17	
E	30000	psi
Es	3000	psi
Pt	104.33	psi
Pcb	110.12	

Variable descriptions

Note: If Pcb is less than Pt, critical buckling of the pipe may occur.
DR = standard dimension ratio
Pcb = critical buckling stress
SF = safety factor (recommend SF = 2)
Rw = water buoyancy factor
' Rw = (1-(0.33*hw/h))
' Note: hw must be less than h
H = height of soil cover above pipe
Hw = height of water table above pipe
B = empirical coefficient of elastic support
e = 2.718
Es = soil modulus (see table C-4)
E = pipe modulus of elasticity
Ps = surface load exerted by a permanent structure in close proximity to buried pipe. See page C-6 for value calculation
PL = live load exerted by heavy equipment on surface above the pipe. See page C-7 for table of values. If depth of bury is greater than 4ft. then H20 load is 3psi and E80 load is 21psi. For depth of bury greater than 10ft. E80 load is 9psi.
Rho = Density of backfill meterial

Using this CD for Design Purposes

Due to wide variations in service conditions, quality of installation, etc., no warranty or guarantee, expressed or implied, is given in conjunction with the use of the calculations and analytical solutions

Select the appropriate soil modulus Es (psi). For crushed rock bedding use 3000 psi.

PolyPipe®

C Earthloading % Deflection

$$\% \text{ Deflection} = \frac{\Delta x}{D} \times 100$$

$$\text{where } \Delta x = \frac{DI \times K \times W}{\frac{2E}{3 \times 6DR^3} + 0.61 \times E_s}$$

$$\text{where } W = \frac{C_d \times \rho \times B_d \times D}{144}$$

See Page C-4

09/17/2009

CD	3.0	
Rho	60	lbs/ft³
Bd	2	ft
D	6.625	in
DR	17	
H	200	ft
DI	1.50	
K	0.1	
E	30000	psi
Es	3000	psi
W	16.563	psi
delta X	0.013546	
% deflection	0.20446	

Variable descriptions

W = earthload
Cd = trench coefficient (See figure 15)
Rho = soil density
D = outside diameter of pipe
DR = Standard Dimension Ratio
Bd = trench width at top of pipe
H = height of backfill above top of pipe
delta x = vertical defection of pipe
DI = deflection lag factor (1.50)
K = bending constant (0.10)
E = modulus of pipe elasticity
Es = soil modulus

Using this CD for Design Purposes

Due to wide variations in service conditions, quality of installation, etc., no warranty or guarantee, expressed or implied, is given in conjunction with the use of the calculations and analytical solutions. PolyPipe® has checked the calculations in this CD and to the best of our knowledge these calculations are accurate. However, users of this CD assume all responsibility for the accuracy of the analytical solutions. In all cases, third party verification or a licensed professional engineer should be consulted prior to any actual selection of product or material specification or use.

Contact our Technical Services Group at (800) 433-5632 for further assistance.

Maximum allowable safe deflection for flexible polyethylene pipe w/DR 17 is 5%.

PolyPipe®

C Earthloading % Deflection

$$\% \text{ Deflection} = \frac{\Delta x}{D} \times 100$$

$$\text{where } \Delta x = \frac{DI \times K \times W}{\frac{2E}{3 \times SDR^3} + 0.61 \times E_s}$$

$$\text{where } W = \frac{C_d \times \rho \times B_d \times D}{144}$$

See Page C-4

09/17/2009

CD	3.0	
Rho	60	lbs/ft³
Bd	2	ft
D	8.625	in
DR	17	
H	200	ft
DI	1.50	
K	0.1	
E	30000	psi
Es	3000	psi
W	21.563	psi
delta X	0.017635	
% deflection	0.20446	

Variable descriptions

W = earthload
Cd = trench coefficient (See figure 15)
Rho = soil density
D = outside diameter of pipe
DR = Standard Dimension Ratio
Bd = trench width at top of pipe
H = height of backfill above top of pipe
delta x = vertical defection of pipe
DI = deflection lag factor (1.50)
K = bending constant (0.10)
E = modulus of pipe elasticity
Es = soil modulus

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Maximum allowable safe deflection for flexible polyethylene pipe w/DR 17 is 5%.

PolyPipe®

C Earthloading % Deflection

$$\% \text{ Deflection} = \frac{\Delta x}{D} \times 100$$

$$\text{where } \Delta x = \frac{DI \times K \times W}{\frac{2E}{3 \times 8DR^3} + 0.61 \times E_s}$$

$$\text{where } W = \frac{C_d \times \rho \times B_d \times D}{144}$$

See Page C-4

09/17/2009

CD	3.0	
Rho	60	lbs/ft³
Bd	2	ft
D	10.75	in
DR	17	
H	200	ft
DI	1.50	
K	0.1	
E	30000	psi
Es	3000	psi
W	26.875	psi
delta X	0.02198	
% deflection	0.20446	

Variable descriptions

W = earthload
Cd = trench coefficient (See figure 15)
Rho = soil density
D = outside diameter of pipe
DR = Standard Dimension Ratio
Bd = trench width at top of pipe
H = height of backfill above top of pipe
delta x = vertical defection of pipe
DI = deflection lag factor (1.50)
K = bending constant (0.10)
E = modulus of pipe elasticity
Es = soil modulus

Using this CD for Design Purposes

Due to wide variations in service conditions, quality of installation, etc., no warranty or guarantee, expressed or implied, is given in conjunction with the use of the calculations and analytical solutions. PolyPipe® has checked the calculations in this CD and to the best of our knowledge these calculations are accurate. However, users of this CD assume all responsibility for the accuracy of the analytical solutions. In all cases, third party verification or a licensed professional engineer should be consulted prior to any actual selection of product or material specification or use.

Contact our Technical Services Group at (800) 433-5632 for further assistance.

Maximum allowable safe deflection for flexible polyethylene pipe w/DR 17 is 5%.

2.2.6 Base Liner Calculations

Reference: Designing w/ Geosynthetics Robert M. Koerner

T_{allow} = $F_u + F_L + 2F_{at}$
T_{allow} = $\sigma_{allow}\, t$
σ_{allow} = the mobilized allowable geomembrane stress = $\sigma_{ult} \div FS$
FS = Factor of Safety
t = Geomembrane Thickness
F_u = the friction force above geomembrane(assumed to be negligible, since the cover soil probably moves along with the liner as it deforms)
q = the surcharge pressure = $d_{cs}\gamma_{cs}$
d_{cs} = the depth of cover soil
γ_{cs} = the unit weight of cover soil
δ = the friction angle between geomembrane and soil or geomembrane and drainage net
L_{RO} = length of run out
F_{AT} = $(\sigma_h)_{ave} \tan \delta (d_{at})$
σ_h = the average horizontal stress in anchor trench = $K_0\sigma_v$
σ_v = γH_{ave}
γ = the unit weight of backfill soil
H_{ave} = the average depth of anchor trench (requires an estimate)
K_0 = $1\text{-}\sin\phi$
ϕ = the angle of shearing resistance of backfill soil
d_{at} = the (unknown) depth of anchor trench

Allowable Stress in Liner

T_{allow} = $\sigma_{allow} t$
σ_{allow} = σ_{ult}/FS
σ_{ult} = 2,100 psi (from N.S.F. 54)

σ_{allow} = $\sigma_{ult} \div FS$ = 2,100 psi ÷ 1.0
$\therefore T_{allow}$ = 2,100 psi x 0.06 in.
= 126 lbs/in.
= 1,512 lbs/ft.

Compute Forces below Liner (F_L)

F_L = $q\tan\delta(L_{ro})$
L_{ro} = 3.0 ft.
d_{cs} = 3.0 ft.
γ_{cs} = 110 pcf
δ = 25° textured liner

q = $d_{cs}\gamma_{cs}$
= (3.0)(110)
= 330 lbs/ft^2

$\therefore F_L$ = (330)tan 25° (3.0)
= 461.64 lbs/ft.

Compute Forces Due to Anchor Trench (F_{at})

F_{at} = $(\sigma_h)_{ave}$ tan δ (d_{at})
= $(1-\sin\phi)(\gamma)(H_{ave})\tan\delta\ (d_{at})$
ϕ = 30°
γ = 110 lbs/ft^3
H_{ave} = 5 ft.
δ = 25°

$\therefore F_{at}$ = $(1-\sin 30°)(110\ \text{lbs/ft}^3)(5\text{ft})(\tan 25°)(d_{at})$
= 128.23d_{at}

Compute Required Anchor Trench Depth for FML

T_{allow} = $F_u + F_c + 2F_{at}$

1512 lbs/ft = 0 + 461.64 lbs/ft. + 2(128.23 d_{at})
$\therefore$ d_{at} = (1512.00-461.64)÷256.46
= 4.10ft provide anchor 4.0 ft. deep no factor of safety applied.

Check Anchor Trench for Drainage Net

T_{allow} = 168psi ÷ 1.3 x 0.25in F.S. = 1.3
= 32.31 lbs/in
= 387.72 lbs/ft.

Compute Forces Below Drainage Net (F_L)

F_L = q tan $\delta(L_{ro})$
δ = 24° Friction angle between textured liner and double bonded geonet.
q = $d\gamma$ = 3'(110lbs/ft^3)
= (3.0)(110)(tan24°)(3.0)
= 440.78 lbs/ft.

Compute Forces Due to Anchor Trench

F_{at} = (1-sin30°)(110)(5)(tan24°)(d_{at})
= 122.44 d_{at}

Compute Required Anchor Trench

387.72 lbs./ft. = 0 + 440.78 lbs./ft. +122.24d_{at}
$\therefore$ d_{at} = -0.43 ft.

Note: No anchor trench is required for geonet, however, it will be anchored in F.M.L. anchor trench @4.00 ft.

Check Sliding Forces of Soil Cover

F.S. = (tanδ)÷(tanβ)
δ = Friction Angle = 26° for soil to double bonded geonet
β = Slope Angle = 3:1 slope = 18.418°

F.S. = (tanδ)÷(tanβ)
= (tan 26°)÷(tan18.418°)
= 1.46 > 1 $\therefore$ O.K.

Check Stress Due to Placement of Protective Cover

Ref: Giroud and Beech (1989)

$$T = (\gamma_p Z^2_p \div \sin 2\beta)[((2H_p\cos\beta \div Z_p)-1)((\sin(\beta-\phi_{cm})\div\cos\phi_{cm})-(\sin\phi_{pm}\div\cos(\beta+\phi_{pm}))]$$

T	= Tension generated by placement of Cover (lbs/in width)
γ_p	= unit weight of protective cover (lbs/in^3)
Z_p	= thickness of protective cover (in.)
β	= Slope angle of the liner (degrees)
H_p	= Vertical height of protective cover (in.)
ϕ_{cm}	= Critical mobilized interface friction angle of liner (degrees) = 26°
ϕ_{pm}	= mobilized internal friction angle of protective cover (degs.) = 30°

Assume worst case of 50 ft deep on a 3:1 slope with a factor of safety of 1.3

ϕ_{cm}	= $\phi_c \div$F.S. = 26°÷1.3 = 20°
ϕ_{pm}	= $\phi_p \div$F.S. = 30°÷1.3 = 23.1°
γ_p	= 0.0637 lbs/in^3.
Z_p	= 36 in.
β	= 18.418° (for 3:1 slope)
H_p	= 600 in.

$$T = (0.0637\text{x}36^2) \div \sin (2)18.418°)[((2\text{x}600\cos 18.418° \div 36)-1)((\sin(18.418°-20.0°)\div\cos 20.0°)-(\sin 23.1° \div \cos(18.418°+23.1°))]$$

$$T = 137.70[(30.63)(-0.03)-0.52]$$
$$= 137.70(-092) - 0.52$$
= -127.20 lb/in. < T_{allow} 50 ft. 3:1 Embankment O.K.

Conclusion: Highest and steepest slope can have protective cover installed during the construction of the cell. Therefore, any of the other slopes will be o.k.

Self-Weight Stress during Construction

Tensile stress due to self-weight of the Smooth 60mil HDPE liner

$T = \gamma \times H \times L \times (\sin\beta - \cos\beta\tan\delta)$

T = Tension due to self-weight (lbs/in.)
H = thickness of liner system component (in.)
L = length of liner system component (in.)
β = Slope angle of the liner (degrees)
δ = critical interface friction angle of liner system
γ = unit weight of liner system component (lbs/in^3)
W = weight per square area of membrane (lbs/in^2)

Assume worst condition:
The length of the liner on a 3:1 slope that would induce failure in the liner.

$T = F_p = 126$ lbs/in

Solve for L (Length)

$L = T \div (\gamma \times H \times (\sin\beta - \cos\beta\tan\delta))$

$\gamma = W \times .06$ in $= 0.00012$ lbs/in^3
$H = 0.06$ in. (60mil Smooth HDPE)
$\beta = 18.418°$ (for 3:1 slope)
$\delta = 17°$

$L = 126 \div ((0.00012 \times 0.06(\sin 18.418° - \cos 18.418° \tan 17°))$

$= 67{,}628$ in.

= 5,636ft. far exceeds any requirement

∴ Self Weight stress is O.K.

Thermal Stress during Construction

$\varepsilon = \Delta L \div L$ = Strain

ε = Strain in the liner system (percent)
ΔL = Change in length of liner due to change in temperature
L = Length of liner before temperature change

$\Delta L = (\alpha)L(\Delta T)$

α = Coefficient of liner thermal expansion (°F^{-1})
ΔL = Change in length of liner due to change in temperature
ΔT = Change in Temperature (°F°)

Assume:

α	=	Coefficient of liner thermal expansion ($°F^{-1}$) = 6.7×10^{-5} $°F^{-1}$
ΔT	=	100°F Conservative assumption
L	=	1 ft.

$$\varepsilon = \alpha L \Delta T \div L$$
$$= \alpha \Delta T$$
$$= \mathbf{0.0067\ ft.\ or\ 0.67\%}$$

Allowable elongation @ yield = 13%
∴allowable > design thermal stress o.k.

2.2.7 Alternate Base Liner Calculations

Geosynthetic Clay Liner (GCL) Calculations
Ref: CETCO Design Manual

FS = factor of safety
T = the allowable long-term tensile strength in the layer above the critical surface being analyzed.
L = the slope length.
S = the shear strength along the surface being analyzed.
β = slope angle (degrees).
γ = the unit weight of cover soil
z = the thickness of the cover soil layer.
ϕ = the internal or interface friction angle along the surface being analyzed.
C = the apparent cohesion along the surface being analyzed.

$$FS = \frac{[(T \div L) + S]}{[(z)(\gamma)(\sin \beta)]} \qquad S = (\gamma)(z)(\cos \beta)(\tan \phi) + C$$

Check interface between cohesive soil liner and Bentomat (Reinforced GCL):

$\phi = 13.5°$
$\gamma = 110$ lbs./ft^3
z = 3 ft.
$\beta = 18.4°$ (3:1 slopes)

C = 500 lbs./ft^2
T = 90 lbs./ft.
L = 150 ft.

$$\therefore S = (110)(3)(0.9489)(0.2401) + 500$$
$$S = 575.18 \text{ lbs/ft}^2$$

$$\therefore FS = \frac{(90 \div 150) + 575.18}{(3)(110)(\sin 18.4°)}$$

FS = 5.53 OK

Check interface between Bentomat (Reinforced GCL) and 60 mil Textured HDPE Liner:

$$FS = \frac{[(T \div L) + S]}{[(z)(\gamma)(\sin \beta)]} \qquad S = (\gamma)(z)(\cos \beta)(\tan \phi) + C$$

$\phi = 13°$
$\gamma = 110$ lbs./ft^3
z = 3 ft.
$\beta = 18.4°$ (3:1 slopes)

C = 200 lbs./ft^2
T = 1,512 lbs./ft.
L = 150 ft.

$$\therefore S = (110)(3)(0.9489)(0.2309) + 200$$
$$S = 272.29 \text{ lbs/ft}^2$$

$$\therefore FS = \frac{(1{,}512 \div 150) + 272.29}{(3)(110)(\sin 18.4°)}$$

FS = 2.71 OK

2.2.8 Foundation, Settlement, and Slope Stability Analysis

ECS CAROLINAS, LLP
"Setting the Standard for Service"
Geotechnical • Construction Materials • Environmental • Facilities NC Registered Engineering Firm F-1078

20 November 2009

Mr. Wayne Sullivan
Municipal Engineering Services Co. PA
PO Box 97
Garner, NC 27529

Reference: Report of Geotechnical Services
Lenoir County Landfill, Phase 2
2949 Hodges Farm Road
Kinston, North Carolina
ECS Project No. 06:16717

Dear Mr. Sullivan:

ECS Carolinas, LLP (ECS) has completed the geotechnical analysis for the proposed Phase 2 of the Lenoir County Landfill as requested by Municipal Engineering Services Company, PA (MESCO).

Project Information

The Lenoir County Landfill is located at 2949 Hodges Farm Road in Kinston, North Carolina. Based on information and the Engineering Plan dated October 5, 2009 for the landfill prepared and provided by MESCO, the proposed approximately 9-acre Phase 2 of the landfill will be located north-northwest of and adjacent to the existing Phases 1. In our experience, it is typical for the actual waste placement to be approximately 5 feet above the subgrade due to placement of a 2-foot thick conventional clay liner overlain by a 60-mil thick HDPE flexible membrane liner (FML) and a 3-foot thick layer of protective cover soil over the FML, and a 2-foot thick cap of protective soil compacted over the top of the waste.

Based on the proposed finished cap grades for Phase 2 from the facility plan, we understand that the maximum waste height will be approximately 115 feet. The permanent side slopes for the cap will have an inclination of 4H: 1V (horizontal to vertical).

Soil borings in the Phase 2 area were conducted by Derry's Well Drilling under subcontract to MESCO. ECS has been provided with the boring logs (the Boring Logs and the Slope Stability Location Diagram are presented in Appendix A). The Lenoir County Landfill lies in the Coastal Plains Providence, and consists of sands overlaying Black Creek Formations Clay. The soils encountered on the site generally consist of medium dense to very dense Clayey to Silty SANDS. Groundwater was encountered within most of the borings ranging from approximately 12 to 26 feet below the prevailing ground surface.

Engineering Analyses

Analyses were performed on Phase 2 to determine settlement of the subgrade soils and local slope stability of the proposed embankment and global slope stability of the landfill. These analyses were based on the design drawings provided by MESCO. Shear strength and compressibility of the soil were estimated based on the soil descriptions on the provided boring logs and our previous experience. The analyses were performed by engineers specializing in geotechnical engineering and copies of the slope stability analyses are attached in Appendix B.

The approximately 115-foot maximum height of proposed waste, including the 5 feet of combined clay liner and protective soil mentioned previously as well as the 2 feet of cap of protective soil compacted over top of the waste, will apply a foundation load of approximately 8,435 psf or 4.2 tsf. The maximum fill height was determined to be in the vicinity of boring P2-6 where the proposed final fill elevations are approximately 115 feet higher than proposed subgrade elevations. An average in-place moist density of the compacted waste and daily cover of 70 pounds per cubic foot was assumed based on the typical values published by National Solid Wasted Management Association and several studies consulted by this office. Based on our experience with similar soil conditions, the silty sands at the proposed subgrade elevations are suitable for support of the applied loads.

The total and differential settlement of the foundation soils from the applied solid waste loads were estimated using an elastic analysis and estimated compressibility based on the Standard Penetration Test N-values obtained form the Boring Logs provided to us. The borings performed within the proposed landfill area were advanced to depths ranging from approximately 25 to 51 feet below the prevailing ground surface.

Based on available boring information provided by MESCO, settlements were estimated for locations along section B-B' shown on Figure 1 included in the Appendix to this report. The maximum waste fill height occurred in the vicinity of boring P2-6 along section B-B'. The thickness of the soil profile underlying the waste and clay liner is approximately 8 feet of fill material, assumed to be onsite clayey to silty sand borrow material, and 30 feet of natural clayey to silty sands in the vicinity of P2-6. The applied load is approximately 8,435 psf, resulting in estimated settlements on the order of 7 inches.

Based on the provided boring results, the soil conditions across the site are reasonably uniform. Settlement will typically be proportional to the waste and embankment height, with little abrupt differential movements.

The waste fill and perimeter embankment were evaluated for slope stability analysis using circular potential failure mechanism. Two sections were selected for the stability analysis, which is considered representative of the most unfavorable conditions. The locations of the analyzed sections are shown on the Slope Stability Location Diagram in Appendix A. The slope stability analysis was performed using the proprietary Slide 5.0 computer program. The modeled slope configuration was based on the topographic information and site grading plan provided to us by the client, while the soil strata information, index properties and engineering properties used in these analyses were estimated based on the soil descriptions on the provided boring logs and our previous experience.

The factors of safety were determined for both static and seismic loading, using the pseudo-static method. For the pseudostatic analysis of the slope, we used an earthquake ground motion having a 2-percent probability of exceedance within a 50-year period (2,475 year return period). According to the USGS Map, October 2002, the seismic acceleration at the bed rock level based on the probabilistic earthquake (2,475 year return period) for this site is 0.08g.

The resulting factors of safety were computed to exceed 2.0 for permanent slopes under static loading conditions and more than 1.4 for seismic conditions. The results of the slope stability analysis are presented in Appendix B.

In conclusion, the results of the geotechnical analysis indicate that the 4H: 1V (permanent) slope configuration and the perimeter embankment fill slopes will be stable and provide an appropriate factor of safety.

Construction Considerations

Based on the provided boring logs and the design drawings, we expect that dewatering will not be necessary during any excavation into natural site soils. If groundwater is encountered during construction, it probably can be controlled through the use of ditches, sumps, and pumps. If water is encountered that cannot be controlled by such procedures, ECS should be further consulted. Earthwork and trench excavation in saturated materials may require sheeting and shoring, slope flattening, or benching to control sloughing of soils. Seasonal variations in groundwater levels should be anticipated due to precipitation changes, evaporation, surface water runoff, and other factors.

The soils encountered within the test borings should generally be able to be excavated with conventional earth moving equipment such as pans/scrapers, loaders, bulldozers, rubber tired backhoes, etc. On-site soils used as earth fill should have a well-graded grain size distribution with rock and soil particles ranging from clay or silt size particles to a maximum size of 6 inches in diameter. Particles larger than this should be broken by mechanical compaction equipment to achieve the desired grain size distribution, and the samples shall have a minimum of 20 percent passing the No. 200 sieve and 50 percent passing the No. 40 sieve. Variations from these requirements shall be approved by the geotechnical engineer in the field at the time the samples are prepared.

This report has been prepared in order to aid in the evaluation of this property and to assist the architect and/or engineer in the design of this project. The scope is limited to the specific project and locations described herein and our description of the project represents our understanding of the significant aspects relative to soil and foundation characteristics. In the event that any changes in the nature or location of the proposed construction outlined in this report are planned, we should be informed so that the changes can be reviewed and the conclusions of this report modified or approved in writing by the geotechnical engineer. It is recommended that all construction operations dealing with earthwork and foundations be reviewed by an experienced geotechnical engineer to provide information as to whether the design requirements are fulfilled in the actual construction. If you wish, we would welcome the opportunity to provide field construction services for you during construction.

The data submitted in this report are based upon the information obtained from the soil borings and tests performed by others at the locations as indicated on the information referenced in this report. This report does not reflect any variations which may occur between the borings. In the performance of the subsurface exploration, specific information is obtained at specific locations at specific times. However, it is a well known fact that variations in soil conditions exist on most sites between boring locations and also such situations as groundwater levels vary from time to time. The nature and extent of variations may not become evident until the course of construction. If site conditions vary from those identified during the explorations, the recommendations contained in this report may require revision.

Thank you for the opportunity to work with you on this project. Should you have any questions or if we could be of further assistance, please do not hesitate to contact us.

Respectfully,
ECS CAROLINAS, LLP represented by;
Firm License Number: F-1078

Heather A. Hickerson, PE
Geotechnical Project Engineer
NC PE License No. 035100

NORTH CAROLINA PROFESSIONAL SEAL 035138 ENGINEER ARIC V. GEDA
11/20/09

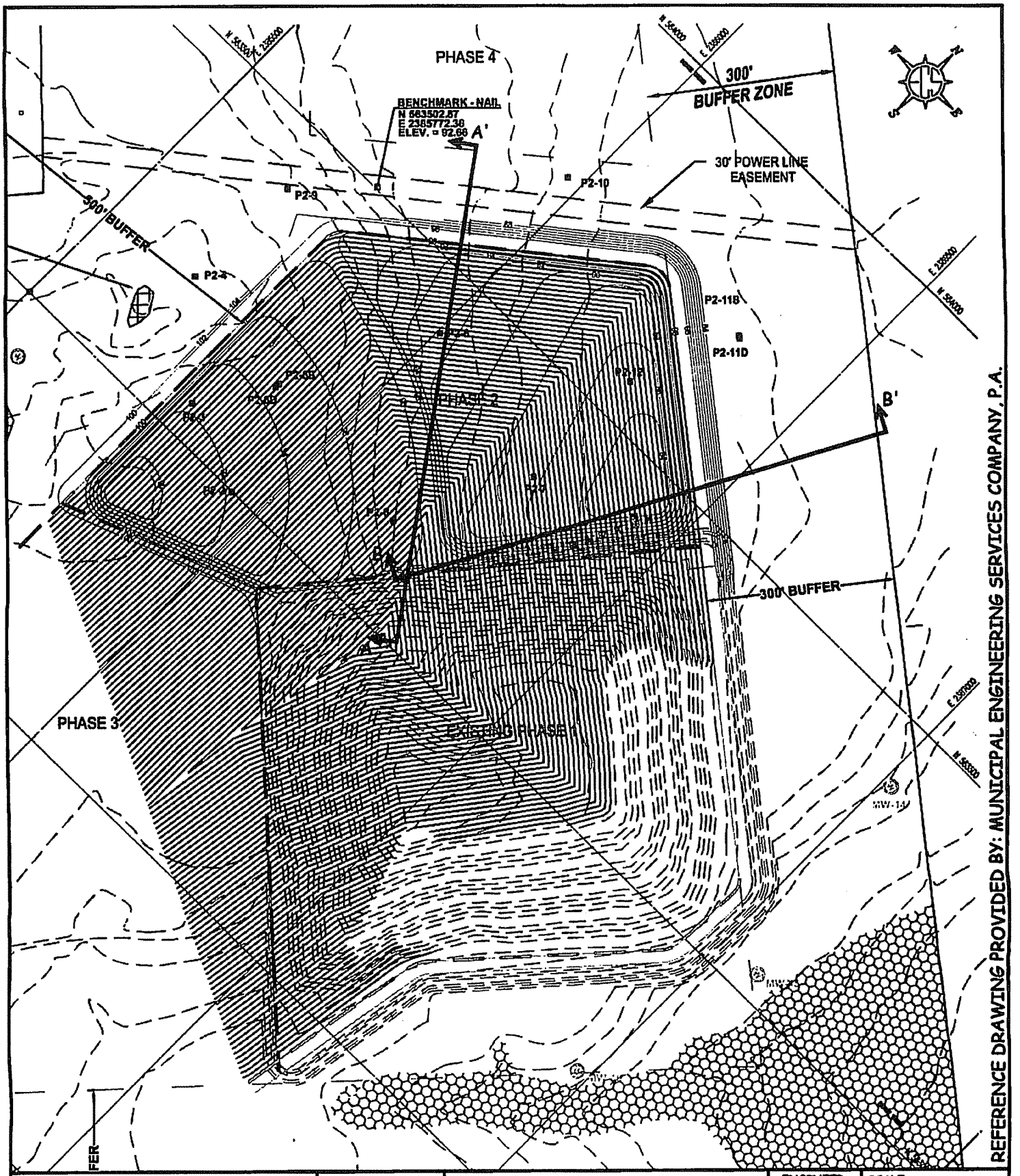
Aric V. Geda, PE
Vice President / Branch Manager
NC PE License No. 035138

APPENDICES

APPENDIX A

EXPLORATION LOCATION DIAGRAM

SELECTED BORING LOGS



SLOPE STABILITY LOCATION DIAGRAM	ECS LLP CAROLINAS SETTING THE STANDARD FOR SERVICE	**LENOIR COUNTY LANDFILL - PHASE 2**	ENGINEER HAH	SCALE 1"=200'
			DRAFTSMAN DAH	PROJECT NO. 06:16717
			REVISIONS	SHEET FIGURE 1
MUNICIPAL ENGINEERING SERVICES CO., P.A.		**LENOIR COUNTY, NORTH CAROLINA**		DATE 11-19-09

LOG OF BORING: P2-1

Lenoir County MSWLF Phase 2 — **Project No. G08095.6**

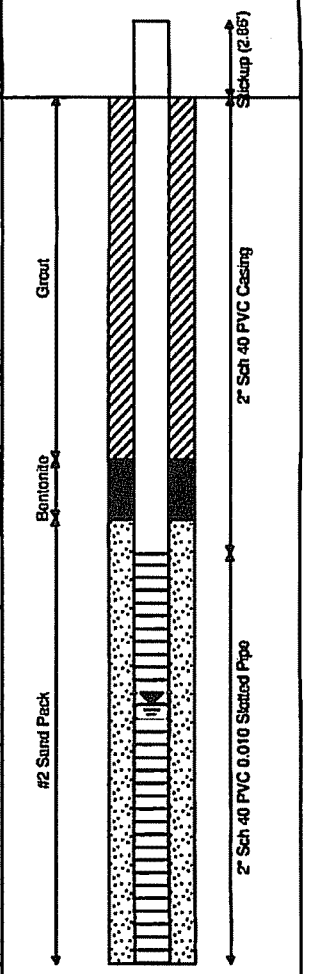
Drilling contractor: Derry's Well Drilling
Drill rig & method: 7.75" OD HSA, SPT
Logged by: J. Pfohl

Date started: 9/2/2008
Date ended: 9/2/2008
Completion depth: 31.52 ft
Stickup height: 2.86 ft

Surface elevation: 102.12 ft (MSL)
Top of pipe elevation: 104.98 ft (MSL)
Depth to water (TOB): 22.00 ft
Depth to water (24hrs): 22.07 ft

Depth (ft)	SPT (bpf)	Soil Type Symbol	Sample	Description of Material & Remarks
	14		X	Top Soil; light grey organic silty sand, root debris, dry
	12		X	Clayey Sand; red brown, cohesive, homogeneous, moist
5				
	52		X	Clayey Sand; red brown, fine to medium grained cemented sand, dense, cohesive, moist
10				
	52		X	Clayey Sand; same as above
15				
	73		X	Silty Sand; light brown, poorly graded cemented sand, few smooth translucent quartz fragments, dense, dry
20				
	15		X	Clayey Sand; medium to dark grey fine grained sand with cohesive grey clay, wet
25				
	17		X	Clayey Sand; medium to dark grey, fine to medium grained sand with cohesive clay, saturated
30				
				Boring terminated at 31.5 feet
35				
40				
45				

Well Diagram



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Operation/Construction Managers Civil/Sanitary Engineers Environmental Studies
PO Box 97, Garner, North Carolina 27529 (919) 772-5393 PO Box 349, Boone, North Carolina 28607 (828) 262-1767

LOG OF BORING: P2-2

Lenoir County MSWLF Phase 2 — **Project No. G08095.6**

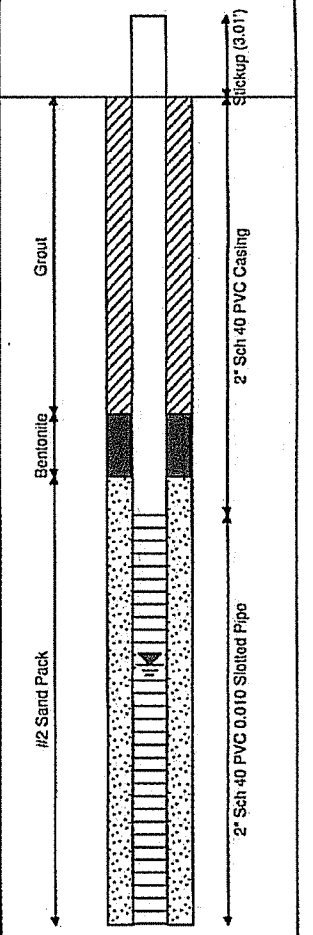
Drilling contractor: Derry's Well Drilling
Drill rig & method: 7.75" OD HSA w/ SPT
Logged by: J. Pfohl

Date started: 9/3/2008
Date ended: 9/3/2008
Completion depth: 30.11 ft
Stickup height: 3.01 ft

Surface elevation: 97.47 ft (MSL)
Top of pipe elevation: 100.48 ft (MSL)
Depth to water (TOB): 20.00 ft
Depth to water (24hrs): 20.76 ft

Depth (ft)	SPT (bpf)	Soil Type Symbol	Sample	Description of Material & Remarks
	13			Clayey Sand; red brown, fine grained,moist
	19			Clayey Sand; red brown to orange, cohesive, mosit
5				Clayey Sand (CL) orange, Gravel=0.02%, Sand=73.85%, Silt & Clay=26.13%, LL=27%, PL=18%, PI=9%
	29			Clayey Sand; red brown, fine to medium grained, homogeneous, cohesive, dry
10				
	22			Clayey Sand; same as above
15				
	18			Silty Sand; light brown, poorly graded fine to gravel size sand, damp
20				
	18			Silty Sand; same as above
25				
	19			Silty Sand; light brown, fine grained, trace clay nodules, wet
30				Boring terminated at 30.1 feet
35				
40				
45				

Well Diagram



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LOG OF BORING: P2-3

Lenoir County MSWLF Phase 2 — **Project No. G08095.6**

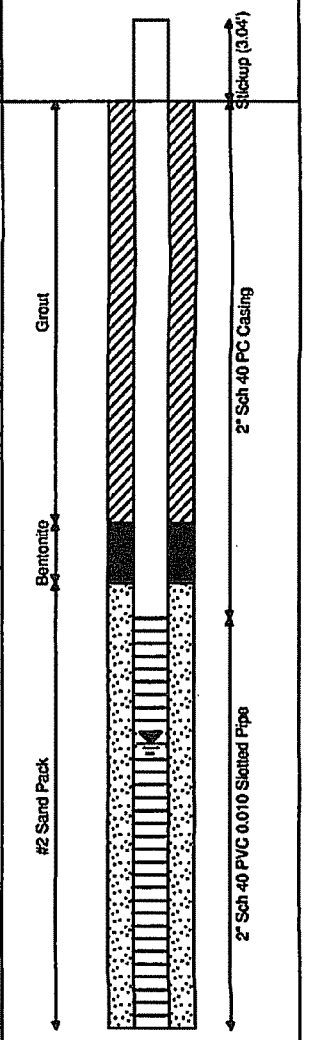
Drilling contractor: Derry's Well Drilling
Drill rig & method: 7.75" OD HSA w/ SPT
Logged by: J.Pfohl

Date started: 9/2/2008
Date ended: 9/2/2008
Completion depth: 33.84 ft
Stickup height: 3.04 ft

Surface elevation: 101.24 ft (MSL)
Top of pipe elevation: 104.28 ft (MSL)
Depth to water (TOB): 24.00 ft
Depth to water (24hrs): 23.40 ft

Depth (ft)	SPT (bpf)	Soil Type Symbol	Sample	Description of Material & Remarks
	14		X	Clayey Sand; reddish brown, fine graind, highly cohesive, moist
	56		X	Clayey Sand; red brown, fine grained cemented sand laminated with cohesive clay, very dense, moist
5				
	61		X	Clayey Sand; same as above
10				
	34		X	Clayey Sand; red brown, poorly graded sand, trace silt, dry
15				
	19		X	Sand with Silt; poorly graded, red brown to orange, coarse grained, homogeneous, dry
20				
	30		X	Silty Sand; light brown, poorly graded sand fine to gravel sand size, moist
25				
	24		X	Silty Sand; same as above
30				
35				Boring terminated at 33.8 feet
40				
45				

Well Diagram



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LOG OF BORING: P2-4

Lenoir County MSWLF Phase 2 | **Project No. G08095.6**

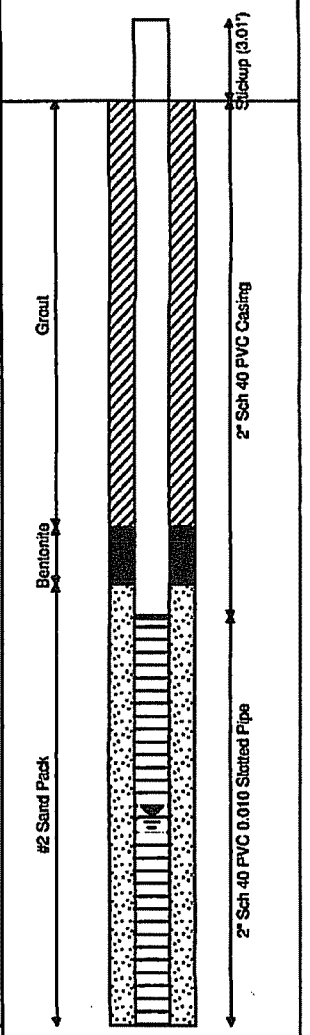
Drilling contractor: Derry's Well Drilling
Drill rig & method: 7.75" OD HSA w/SPT
Logged by: J. Pfohl

Date started: 9/3/2008
Date ended: 9/3/2008
Completion depth: 33.72 ft
Stickup height: 3.01 ft

Surface elevation: 104.61 ft (MSL)
Top of pipe elevation: 107.62 ft (MSL)
Depth to water (TOB): 24.00 ft
Depth to water (24hrs): 26.10 ft

Depth (ft)	SPT (bpf)	Soil Type Symbol	Sample	Description of Material & Remarks
	14			Clayey Sand; red brown, few grey clay nodules, dry
	18			Clayey Sand; red brown, cohesive clay nodules, dry
5				
	52			Silty Sand; red brown, homogeneous, dense cemented sand, trace clay nodules, dry
10				
				Silty Sand (SM) light brown, Gravel=0%, Sand=64.41%, Silt & Clay=35.59%
	59			Silty Sand; light brown, poorly graded, coarse to fine grained, cohesive clay nodules, dry
15				
	53			Silty Sand; light brown, poorly graded, trace silt and clay, dry
20				
	24			Sand with Silt; poorly graded, red brown to orange, coarse grained, homogeneous, dry
25				
	16			Silty Sand; light brown, poorly graded with trace silt, moist
30				
35				Boring terminated at 33.7 feet
40				
45				

Well Diagram



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LOG OF BORING: P2-5S

Lenoir County MSWLF Phase 2 — **Project No. G08095.6**

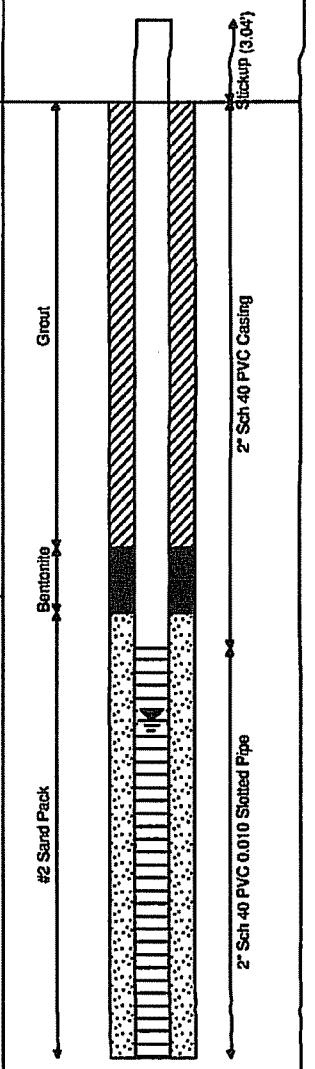
Drilling contractor: Derry's Well Drilling
Drill rig & method: 7.75" OD HSA
Logged by: J. Pfohl

Date started: 8/29/2008
Date ended: 8/29/2008
Completion depth: 34.85 ft
Stickup height: 3.04 ft

Surface elevation: 98.42 ft (MSL)
Top of pipe elevation: 101.46 ft (MSL)
Depth to water (TOB): 25.00 ft
Depth to water (24hrs): 22.52 ft

Depth (ft)	SPT (bpf)	Soil Type Symbol	Sample	Description of Material & Remarks
	18		X	Clayey Sand; brown, fine to medium grained sand laminated with red brown clay, moist
	13		X	Clayey Sand; red brown, fine to medium grained, cohesive, moist
5				
	20		X	Clayey Sand; same as above
10				
	21		X	Clayey Sand; red brown, fine to medium grained, dry
15				
	28		X	Silty Sand; dark brown, medium to coarse grained, trace cohesive clay nodules, dry
20				
	30		X	Silty Sand; dark brown, medium to coarse grained, trace cohesive clay nodules, damp
25				
	31		X	Silty Sand; same as above
30				
	17		X	Silty Sand; brown, poorly graded sand, trace clay nodules, homogeneous, moist
35				
				Boring terminated at 34.9 feet
40				
45				

Well Diagram



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LOG OF BORING: P2-5D

Lenoir County MSWLF Phase 2 — **Project No. G08095.6**

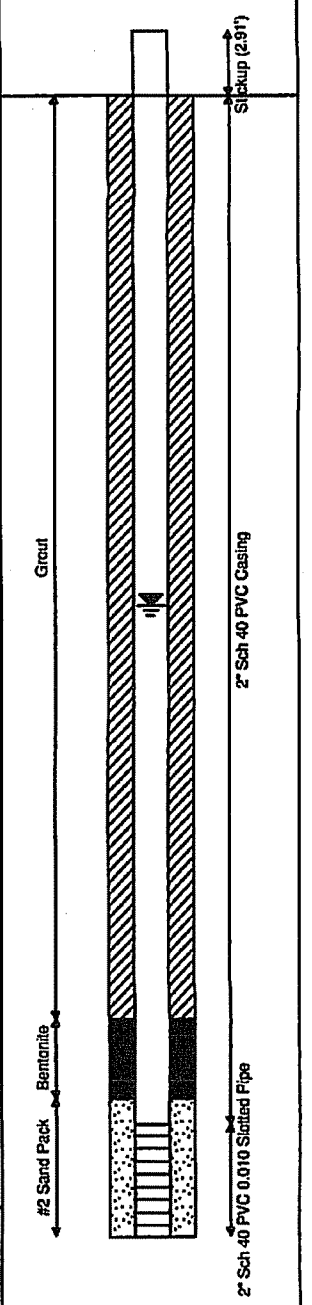
Drilling contractor: Derry's Well Drilling
Drill rig & method: 7.75" OD HSA w/ SPT
Logged by: J. Pfohl

Date started: 8/30/2008
Date ended: 8/30/2008
Completion depth: 50.81 ft
Stickup height: 2.91 ft

Surface elevation: 98.34 ft (MSL)
Top of pipe elevation: 101.25 ft (MSL)
Depth to water (TOB): 25.00 ft
Depth to water (24hrs): 22.69 ft

Depth (ft)	SPT (bpf)	Soil Type Symbol	Sample	Description of Material & Remarks
	18			Clayey Sand; brown, fine to medium grained sand laminated with red brown clay, moist
5	13			Clayey Sand; red brown, fine to medium grained, cohesive, moist
10	20			Clayey Sand; same as above
15	21			Clayey Sand; red brown, fine to medium grained, dry
20	28			Silty Sand; dark brown, medium to coarse grained, trace cohesive clay nodules, dry
25	30			Silty Sand; dark brown, medium to coarse grained, trace cohesive clay nodules, damp
30	31			Silty Sand; same as above
35	17			Silty Sand; brown, poorly graded sand, trace clay nodules, homogeneous, moist
40	18			Silty Sand; brown, poorly graded sand, trace clay nodules, homogeneous, wet
45	21			Silty Sand; same as above
50				Clayey Sand; black, cohesive, thinly laminated black clay with grey, fine to medium grained sand, some lignitic wood, moist
55				Boring terminated at 50.8 feet

Well Diagram



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LOG OF BORING: P2-6

Lenoir County MSWLF Phase 2 — **Project No. G08095.6**

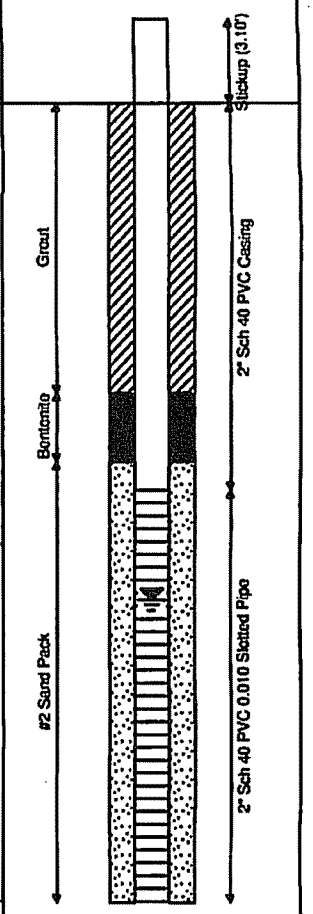
Drilling contractor: Derry's Well Drilling
Drill rig & method: 7.75" OD HSA w/ SPT
Logged by: J. Pfohl

Date started: 9/2/2008
Date ended: 9/2/2008
Completion depth: 29.05 ft
Stickup height: 3.10 ft

Surface elevation: 92.20 ft (MSL)
Top of pipe elevation: 95.29 ft (MSL)
Depth to water (TOB): 18.00 ft
Depth to water (24hrs): 18.05 ft

Depth (ft)	SPT (bpf)	Soil Type Symbol	Sample	Description of Material & Remarks
	17			Clayey Sand; brown yellow, fine to medium grained sand laminated with cohesive light grey clay, moist
5	17			Clayey Sand; brown to brown yellow, fine to medium grained, cohesive, moist
10	22			Clay Sand; brown to brown yellow, fine grained, few black silt partings, dry
15	20			Clayey Sand; same as above
20	37			Silty Sand; brown yellow, poorly graded, trace silt, moist
25	19			Silty Sand; brown yellow, poorly graded, less dense, wet
30				Boring terminated at 29.1 feet
35				
40				
45				

Well Diagram



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LOG OF BORING: P2-7

Lenoir County MSWLF Phase 2 — **Project No. G08095.6**

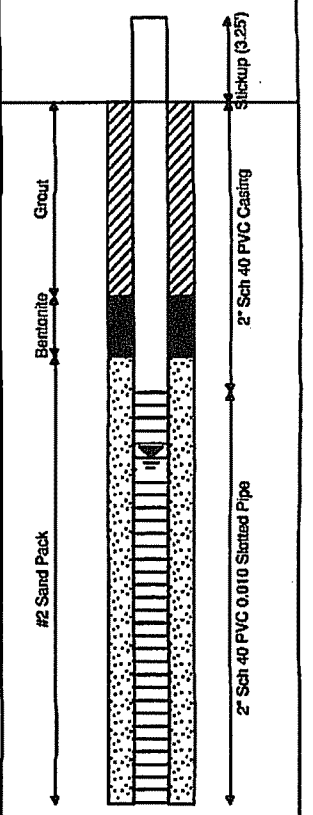
Drilling contractor: Derry's Well Drilling
Drill rig & method: 7.75" HSA w/ SPT
Logged by: J. Pfohl

Date started: 9/3/2008
Date ended: 9/3/2008
Completion depth: 25.56 ft
Stickup height: 3.25 ft

Surface elevation: 84.95 ft (MSL)
Top of pipe elevation: 88.20 ft (MSL)
Depth to water (TOB): 13.00 ft
Depth to water (24hrs): 12.95 ft

Depth (ft)	SPT (bpf)	Soil Type Symbol	Sample	Description of Material & Remarks
	21			Clayey Sand; brown to brown yellow, fine grained, trace organic top soil with root debris, dry
	14			Clayey Sand; brown to brown yellow, fine grained, dry
5				
	21			Clayey Sand; same as above
10				
	38			Silty Sand; light brown, poorly graded, trace silt, moist
15				Silty Sand (ML) tan, Gravel=0.0%, Sand=59.48%, Silt & Clay=40.52%, LL=45%, PL=29%, PI=16%
	19			Silty Sand; light brown, fine grained, wet
20				
	20			Silty Sand; brown yellow, poorly graded, wet
25				Boring terminated at 25.6 feet
30				
35				
40				
45				

Well Diagram



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LOG OF BORING: P2-8

Lenoir County MSWLF Phase 2 — **Project No. G08095.6**

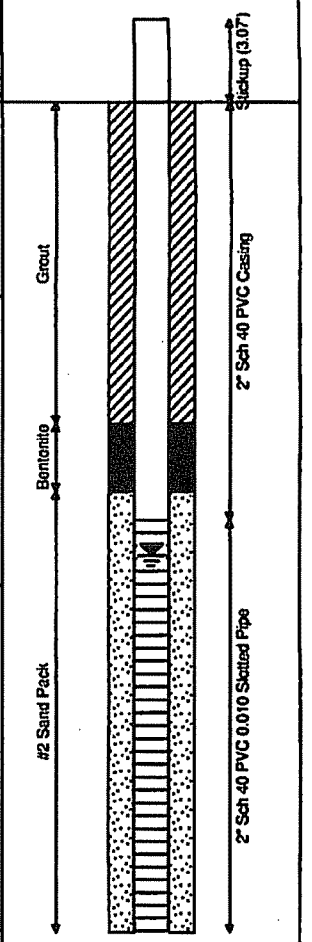
Drilling contractor: Derry's Well Drilling
Drill rig & method: 7.75" HSA w/ SPT
Logged by: J. Pfohl

Date started: 8/30/2008
Date ended: 8/30/2008
Completion depth: 30.15 ft
Stickup height: 3.07 ft

Surface elevation: 89.51 ft (MSL)
Top of pipe elevation: 92.58 ft (MSL)
Depth to water (TOB): 16.50 ft
Depth to water (24hrs): 16.45 ft

Depth (ft)	SPT (bpf)	Soil Type Symbol	Sample	Description of Material & Remarks
				Silty Sand; tan grey, wet, medium dense, coarse grained
5	11			
				Clayey Sand; tan and grey layers, moist, medium dense
10	46			
15	15			Clayey Sand; wet, medium dense, less clay
				Silty Sand; grey brown, wet, medium dense, fine grained
20	10			
25				Soil description (0'-27.5') taken from log for overdrilled well P-7
30	13			Silty Sand; grey brown, fine grained, saturated
				Boring terminated at 30.1 feet
35				
40				
45				

Well Diagram



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LOG OF BORING: P2-9

Lenoir County MSWLF Phase 2 — **Project No. G08095.6**

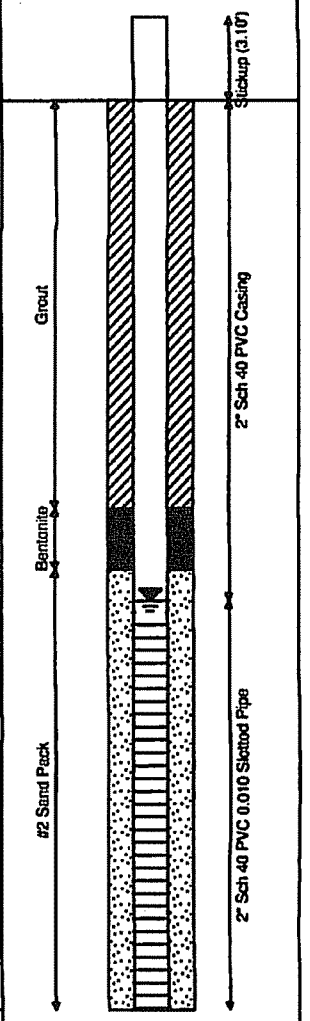
Drilling contractor: Derry's Well Drilling
Drill rig & method: 7.75" OD HSA w/SPT
Logged by: J. Pfohl

Date started: 8/30/2008
Date ended: 8/30/2008
Completion depth: 33.19 ft
Stickup height: 3.10 ft

Surface elevation: 98.84 ft (MSL)
Top of pipe elevation: 101.95 ft (MSL)
Depth to water (TOB): 23.00 ft
Depth to water (24hrs): 18.21 ft

Depth (ft)	SPT (bpf)	Soil Type Symbol	Sample	Description of Material & Remarks
	17		X	Clayey Sand; red brown, few grey clay nodules, dry
5	18		X	Clayey Sand; red brown, fine grained sand laminated with cohesive clay, moist
10	62		X	Silty Sand; red brown, homogeneous, dense cemented sand, dry
15	39		X	Sand with Silt; poorly graded, red brown to orange, coarse grained, dry
20	36		X	Silty Sand; light brown, poorly graded dry
25	23		X	Silty Sand; light brown to orange, few cobble size smooth translucent quartz fragments, damp
30	21		X	Silty Sand; light brown, poorly graded with trace silt, wet
35				Boring terminated at 33.2 feet
40				
45				

Well Diagram



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LOG OF BORING: P2-10

Lenoir County MSWLF Phase 2 | **Project No. G08095.6**

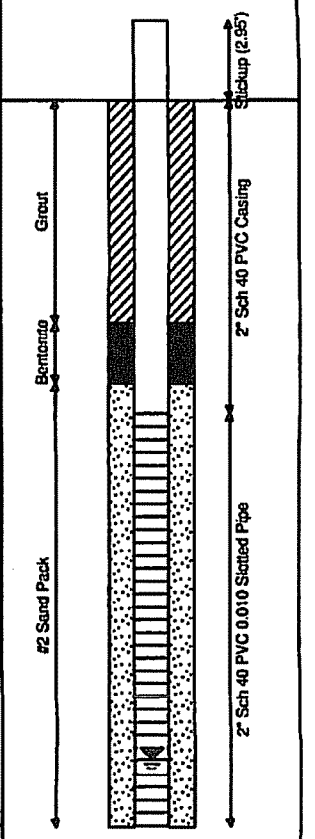
Drilling contractor: Derry's Well Drilling
Drill rig & method: 7.75" OD HSA w/ SPT
Logged by: J. Pfohl

Date started: 8/30/2008
Date ended: 8/30/2008
Completion depth: 26.36 ft
Stickup height: 2.95 ft

Surface elevation: 85.18 ft (MSL)
Top of pipe elevation: 88.14 ft (MSL)
Depth to water (TOB): 14.00 ft
Depth to water (24hrs): 23.91 ft

Depth (ft)	SPT (bpf)	Soil Type Symbol	Sample	Description of Material & Remarks
	9			Clayey Sand; orange, medium grained, loose, dry
	18			Clayey Sand; red brown, medium grained, moderately dense, slight relict structure, dry
5				Clayey Sand (CL) orange brown, Gravel=0.0%, Sand=73.55%, Silt & Clay=26.45%, LL=29%, PL=15%, PI=14%
	80			Clayey Sand; red brown, medium to fine grained, very dense, dry
10				
	37			Silty Sand; tan, medium grained, damp
15				
	28			Silty Sand; tan, medium grained, moderately dense, moist
20				
	26			Silty Sand; tan, medium grained, moderately dense, few black silt partings, wet
25				
				Boring terminated at 26.4 feet
30				
35				
40				
45				

Well Diagram



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LOG OF BORING: P2-11S

Lenoir County MSWLF Phase 2 — **Project No. G08095.6**

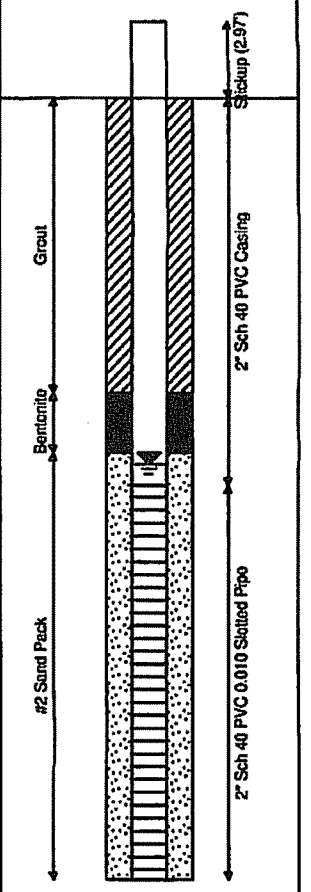
Drilling contractor: Derry's Well Drilling
Drill rig & method: 7.75" OD HSA
Logged by: J. Pfohl

Date started: 8/30/2008
Date ended: 8/30/2008
Completion depth: 29.66 ft
Stickup height: 2.97 ft

Surface elevation: 82.80 ft (MSL)
Top of pipe elevation: 85.76 ft (MSL)
Depth to water (TOB): 14.00 ft
Depth to water (24hrs): 13.85 ft

Depth (ft)	SPT (bpf)	Soil Type Symbol	Sample	Description of Material & Remarks
	13			Clayey Sand; light brown, fine grained sand laminated with grey cohesive clay, moist
5	18			Clayey Sand; light brown, medium grained sand laminated with brown to grey cohesive clay, moist
10	49			Clayey Sand; red brown, poorly graded sand with cohesive clay, dry
15	32			Clayey Sand; brown, medium grained sand with cohesive grey clay, moist
20	17			Silty Sand with Clay, light brown, fine to medium grained sand with cohesive clay, moist
25	31			Silty Sand with Clay; light brown, clay lense, cohesive, wet
30	26			Silty Sand with Clay; same as above
				Boring terminated at 29.7 feet
35				
40				
45				

Well Diagram



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LOG OF BORING: P2-11D

Lenoir County MSWLF Phase 2 — **Project No. G08095.6**

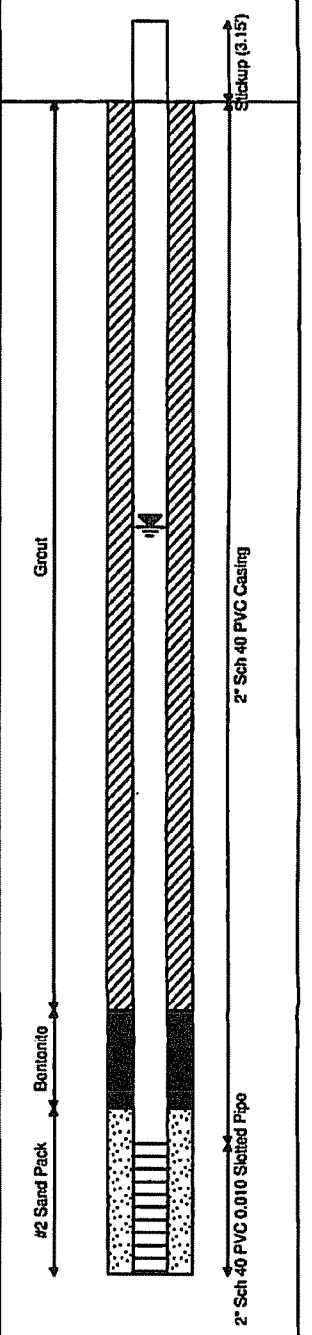
Drilling contractor: Derry's Well Drilling
Drill rig & method: 7.75" OD HSA w/ SPT
Logged by: J. Pfohl

Date started: 8/30/2008
Date ended: 8/30/2008
Completion depth: 44.62 ft
Stickup height: 3.15 ft

Surface elevation: 82.72 ft (MSL)
Top of pipe elevation: 85.87 ft (MSL)
Depth to water (TOB): 14.00 ft
Depth to water (24hrs): 16.05 ft

Depth (ft)	SPT (bpf)	Soil Type Symbol	Sample	Description of Material & Remarks
	13			Clayey Sand; light brown, fine grained sand laminated with grey cohesive clay, moist
5	18			Clayey Sand; light brown, medium grained sand laminated with brown to grey cohesive clay, moist
10	49			Clayey Sand; red brown, poorly graded sand with cohesive clay, dry
				Clayey Sand (CL) brown, Gravel=0.0%, Sand=72.06%, Silt & Clay=27.94%, LL=36%, PL=19%, PI=17%
15	32			Clayey Sand; brown, medium grained sand with cohesive grey clay, moist
20	17			Silty Sand with Clay, light brown, fine to medium grained sand with cohesive clay, moist
25	31			Silty Sand with Clay; light brown, clay lense, cohesive, wet
30	26			Silty Sand with Clay; same as above
35	24			Silty Sand with Clay; same as above
40	23			Clayey Sand; black, thinly laminated black clay interbedded with grey fine to medium grained sand, some lignitic wood, moist
45				Boring terminated at 44.6 feet

Well Diagram



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LOG OF BORING: P2-12

Lenoir County MSWLF Phase 2 — **Project No. G08095.6**

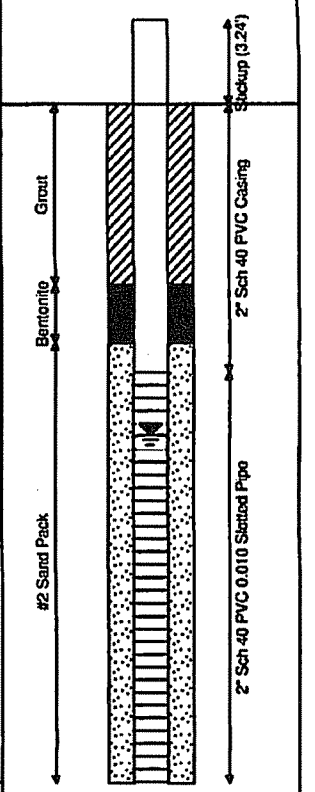
Drilling contractor: Derry's Well Drilling
Drill rig & method: 7.75" OD HSA w/ SPT
Logged by: J. Pfohl

Date started: 8/30/2008
Date ended: 8/30/2008
Completion depth: 24.75 ft
Stickup height: 3.24 ft

Surface elevation: 82.52 ft (MSL)
Top of pipe elevation: 85.77 ft (MSL)
Depth to water (TOB): 12.00 ft
Depth to water (24hrs): 12.01 ft

Depth (ft)	SPT (bpf)	Soil Type Symbol	Sample	Description of Material & Remarks
	8			Clayey Sand; light brown, fine grained sand laminated with grey cohesvie clay, moist
5	14			Clayey Sand; light brown, medium grained sand laminated with gray cohesive clay, moist
10	62			Clayey Sand; red brown, poorly graded sand, few smooth cobble size translucent quartz fragments, dry
15	22			Silty Sand; light brown, poorly graded sand, few grey clay nodules, moist
20	16			Silty Sand; light brown, fine grained, homogeneous, wet
25				Boring terminated at 24.8 feet
30				
35				
40				
45				

Well Diagram



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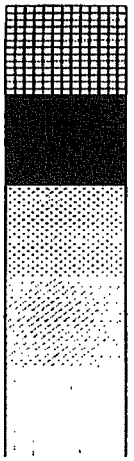
APPENDIX B

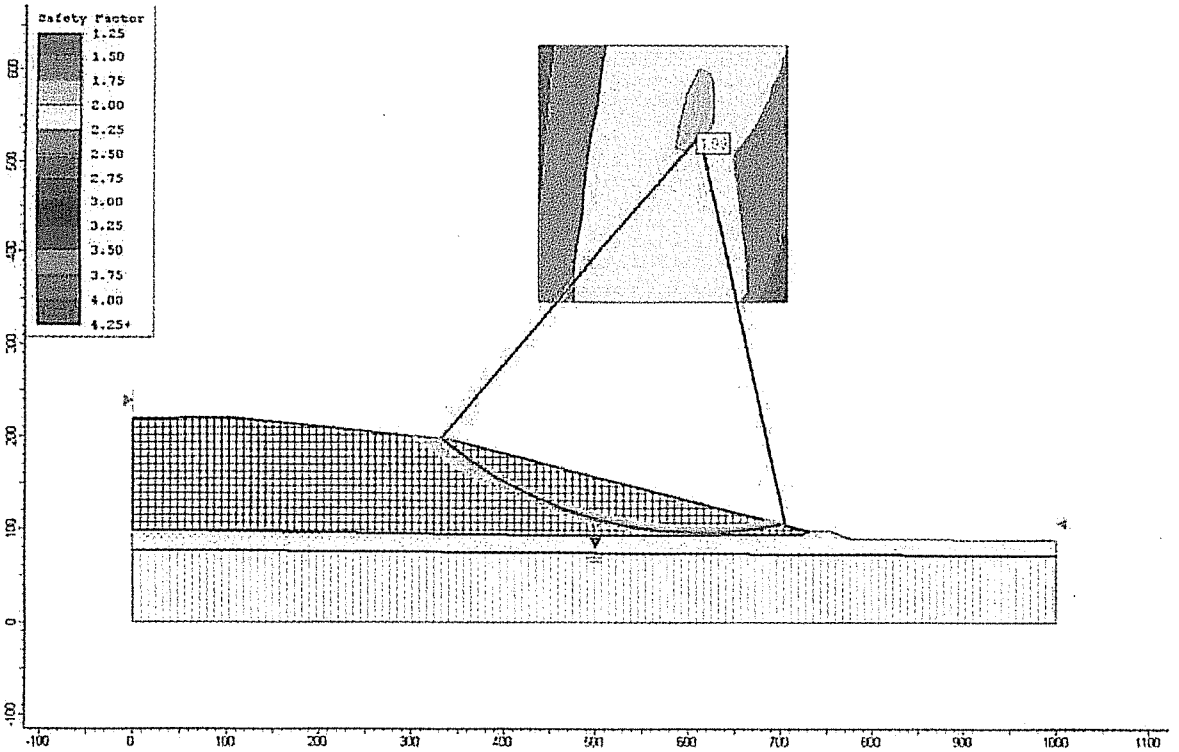
SLOPE STABILITY ANALYSES RESULTS

Material Property Legend

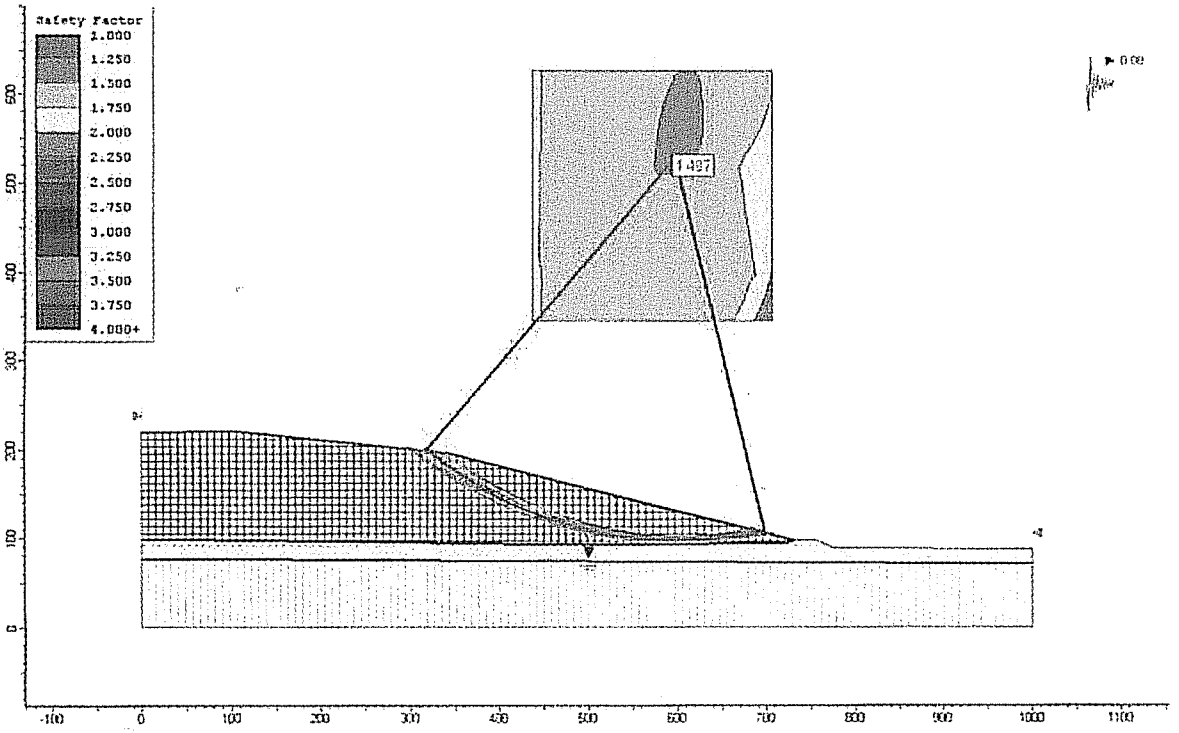


Soil Layer	Unit Weight (PCF)	Friction Angle	Cohesion (psf)
Waste	70	20	200
Clay Liner/Cap	125	20	400
Fill: Silty to Clayey SAND	125	32	150
Clayey SAND	125	32	150
Silty SAND	125	32	100

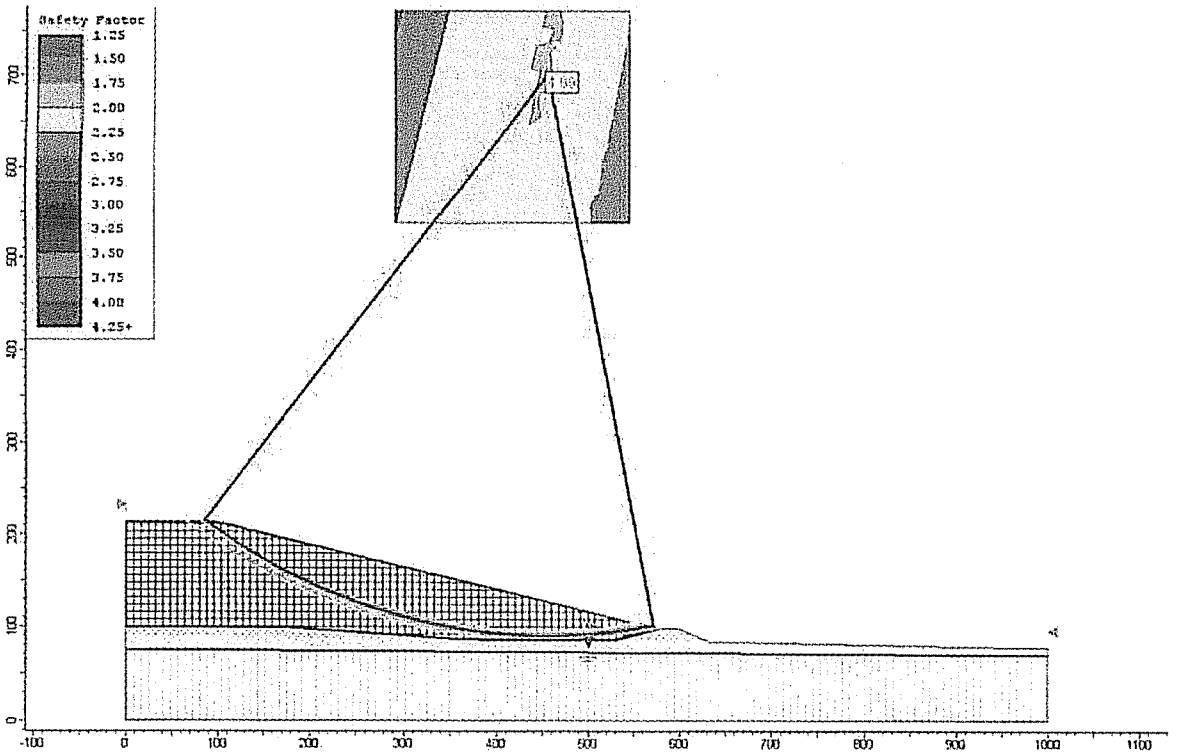
Section A-A' – Global Analysis



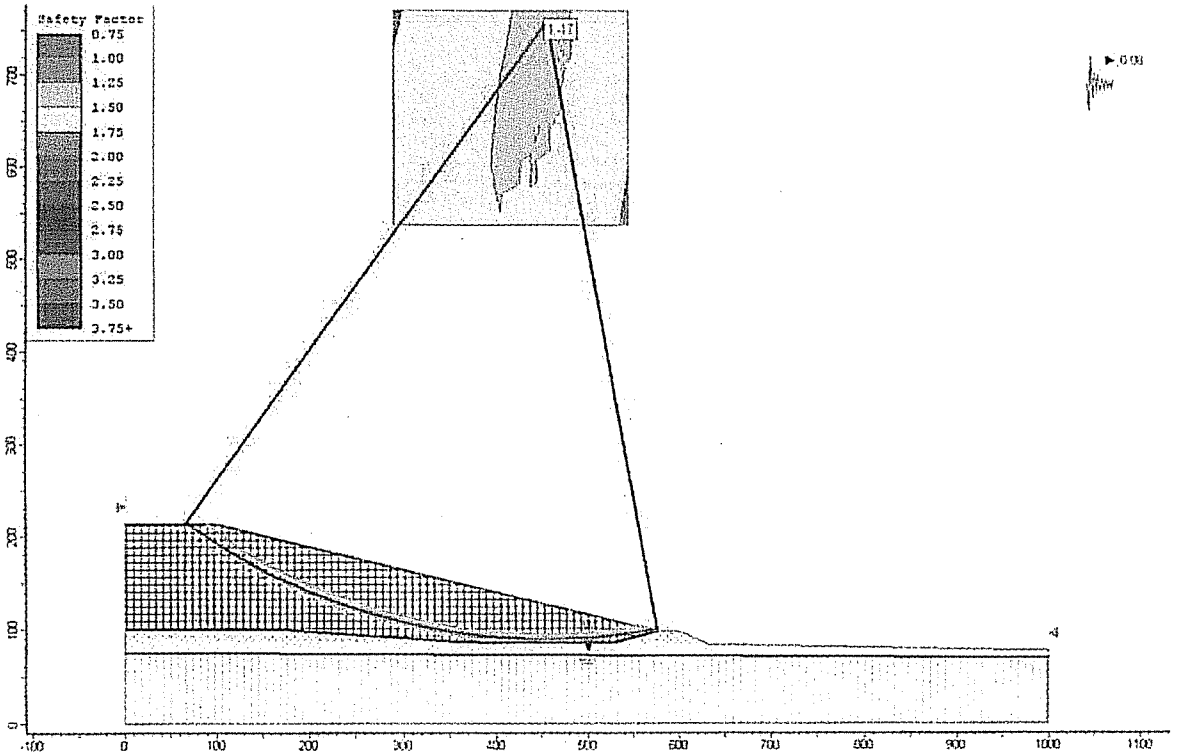
Section A-A' – Seismic Global Analysis



Section B-B' – Global Analysis



Section B-B' – Seismic Global Analysis



2.2.9 Technical References

1. "Lining of Waste Impoundment and Disposal Facilities", (U.S.) Environmental Protection Agency, March 1983.

2. "NSF International (NSF) Standard 54 Flexible Membrane Liner", The NSF Joint Committee on Flexible Membrane Liners, 1991.

3. "Geosynthetic Design Guidance for Hazardous Waste Landfill Cells and Surface Impoundments", S & M E Inc. for the USEPA, December 1987, pgs EPA III-21 to EPA III-49.

4. James K. Mitchell, Raymond B. Seed, and H. Bolton Seed, "Kettleman Hill Waste Landfill Slope Failure I: Liner-System Properties" in Journal of Geotechnical Engineering, April 1 1990, pgs 647-668.

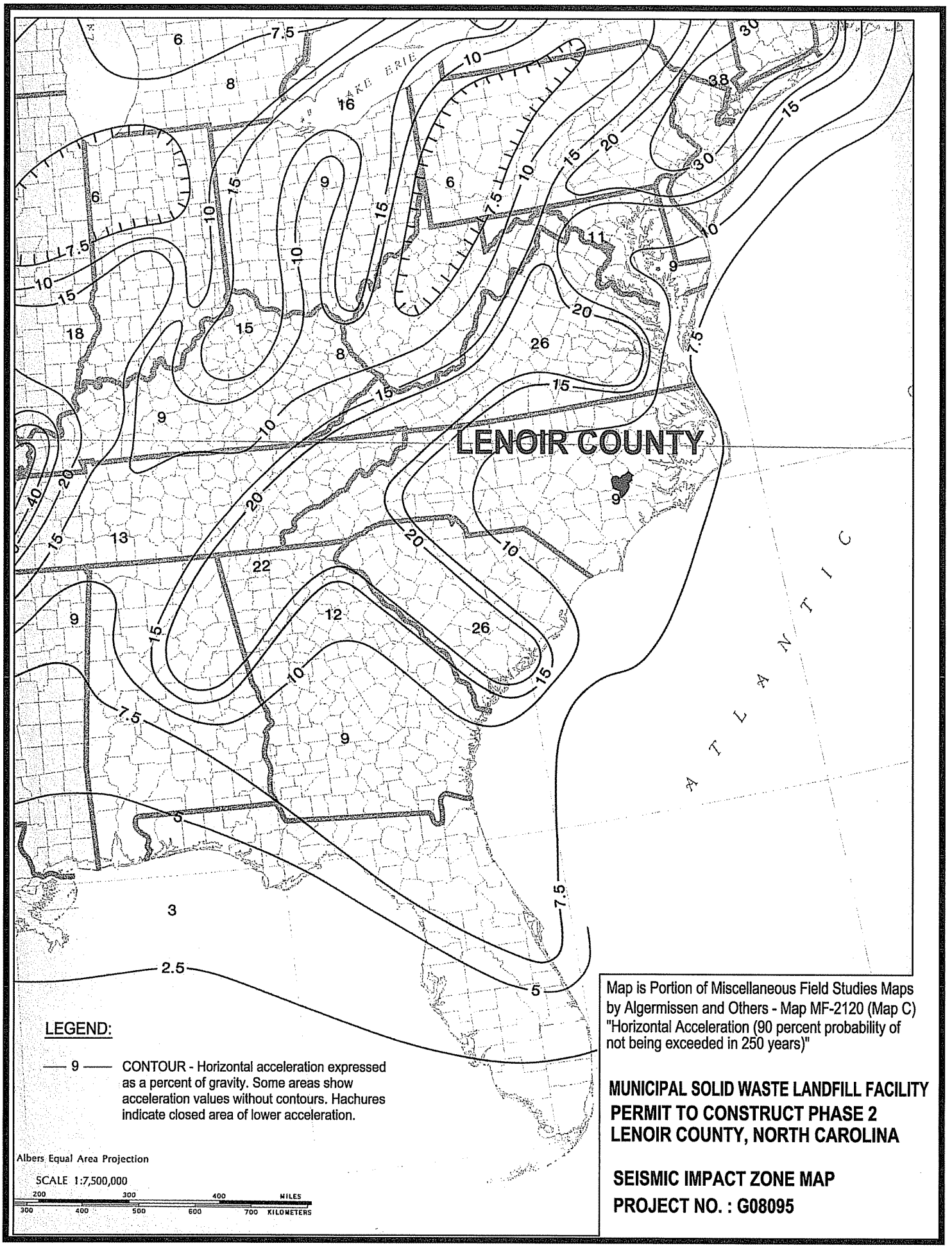
5. Design, Construction and Monitoring of Landfills, Second Edition, Amalendu Bagchi, Wisconsin Department of Natural Resources, Pages 178- 238.

2.2.10 Applicable Location Restriction Demonstrations

All location restrictions, if any, were handled in the site study with the exception of the seismic impact zone. See map in this section.

The County Landfill is located in a seismic impact zone, all safety factors have been applied to insure site stability.

There are no other features that impact the site.



Map is Portion of Miscellaneous Field Studies Maps by Algermissen and Others - Map MF-2120 (Map C) "Horizontal Acceleration (90 percent probability of not being exceeded in 250 years)"

MUNICIPAL SOLID WASTE LANDFILL FACILITY
PERMIT TO CONSTRUCT PHASE 2
LENOIR COUNTY, NORTH CAROLINA

SEISMIC IMPACT ZONE MAP
PROJECT NO. : G08095

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2.3 Engineering Drawings

2.3.1 Title Sheet
2.3.2 Index and Vicinity Map
2.3.3 Existing Conditions
2.3.4 Erosion Control Plan
2.3.5 Erosion Control Details
2.3.6 Proposed Subgrade
2.3.7 Top of Cohesive Soil Liner
2.3.8 Top of Protective Cover
2.3.9 Leachate Collection System
2.3.10 Construction Details
2.3.11 Sump, Riser, Pad and Details
2.3.12 Initial Placement of Waste
2.3.13 Final Fill and Methane Venting
2.3.14 Operation Details
2.3.15 Baseline Profile and Cross Sections

LENOIR COUNTY
MUNICIPAL SOLID WASTE
LANDFILL FACILITY

ENGINEERING PLAN - PHASE 2

Permit Number: 5409-MSWLF
Site Location: 2949 Hodges Farm Road
La Grange, NC 28551

Applicant: Lenoir County
Applicant's Address: 130 South Queen Street
Kinston, NC 28502

BOARD OF COMMISSIONERS

George W. Graham, Jr. - Chairman
Claude Stroud - Vice-Chairman
Jackie Brown
Reuben Davis
Chris Humphrey
Thomas A. Pharo
Linda Rouse Sutton

COUNTY MANAGER

Michael W. Jarman

SOLID WASTE DIRECTOR

Tom Miller

Engineer
Municipal Engineering Services Company, P.A.
Garner, NC - Morehead City, NC - Boone, NC

NORTH CAROLINA PROFESSIONAL SEAL 17287 ENGINEER TAMY D. WOODIE
11/25/2009

by _____
Professional Engineer
(Garner Office)

Municipal Engineering Company, P.A.
LICENSE NUMBER: C-0281
P.O. BOX 97 GARNER, N.C. 27529 (919) 772-5393
P.O. BOX 349 BOONE, N.C. 28607 (828) 262-1767
P.O. BOX 828 MOREHEAD CITY, N.C. 28557 (252) 726-9481

SCALE:	1:1
DATE:	10/20/09
DRWN. BY:	L. HAMPTON
CHKD. BY:	J. WOODIE
PROJECT NUMBER	G08095
DRAWING NO.	T1
SHEET NO.	1 OF 15

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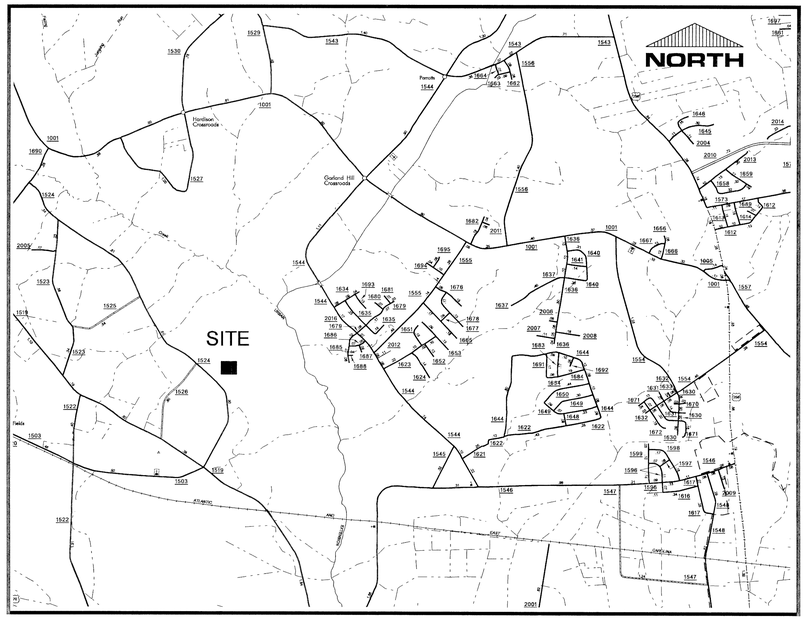
INDEX

SHEET NO.	DRAWING NO.	DESCRIPTION
1	T1	TITLE SHEET
2	T2	INDEX AND VICINITY MAP
3	E1	EXISTING CONDITIONS
4	E2	EROSION CONTROL PLAN
5	E3	EROSION CONTROL DETAILS
6	E4	SUBGRADE
7	E5	TOP OF COHESIVE SOIL LINER
8	E6	TOP OF PROTECTIVE COVER
9	E7	LEACHATE COLLECTION SYSTEM
10	E8	CONSTRUCTION DETAILS
11	E9	SUMP, PUMP, RISER, PAD AND DETAILS
12	E10	INITIAL PLACEMENT OF WASTE AND STORM WATER DIVERSION
13	E11	FINAL FILL WITH METHANE VENTING
14	E12	OPERATION DETAILS
15	E13	BASELINE PROFILE AND CROSS SECTIONS



VICINITY MAP

LICENSE NUMBER: C-0281

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MUNICIPAL SOLID WASTE
LANDFILL FACILITY
LENOIR COUNTY
NORTH CAROLINA

DATE	BY	REV.	DESCRIPTION

INDEX AND VICINITY MAP

NORTH CAROLINA PROFESSIONAL SEAL 6782 ENGINEER JIMMY D. WOODIE
J. Woodie 10/25/2009

SCALE:	1:1
DATE:	10/22/09
DRWN. BY:	L. HAMPTON
CHKD. BY:	J. WOODIE
PROJECT NUMBER	G08095
DRAWING NO.	T2
SHEET NO.	2 OF 15

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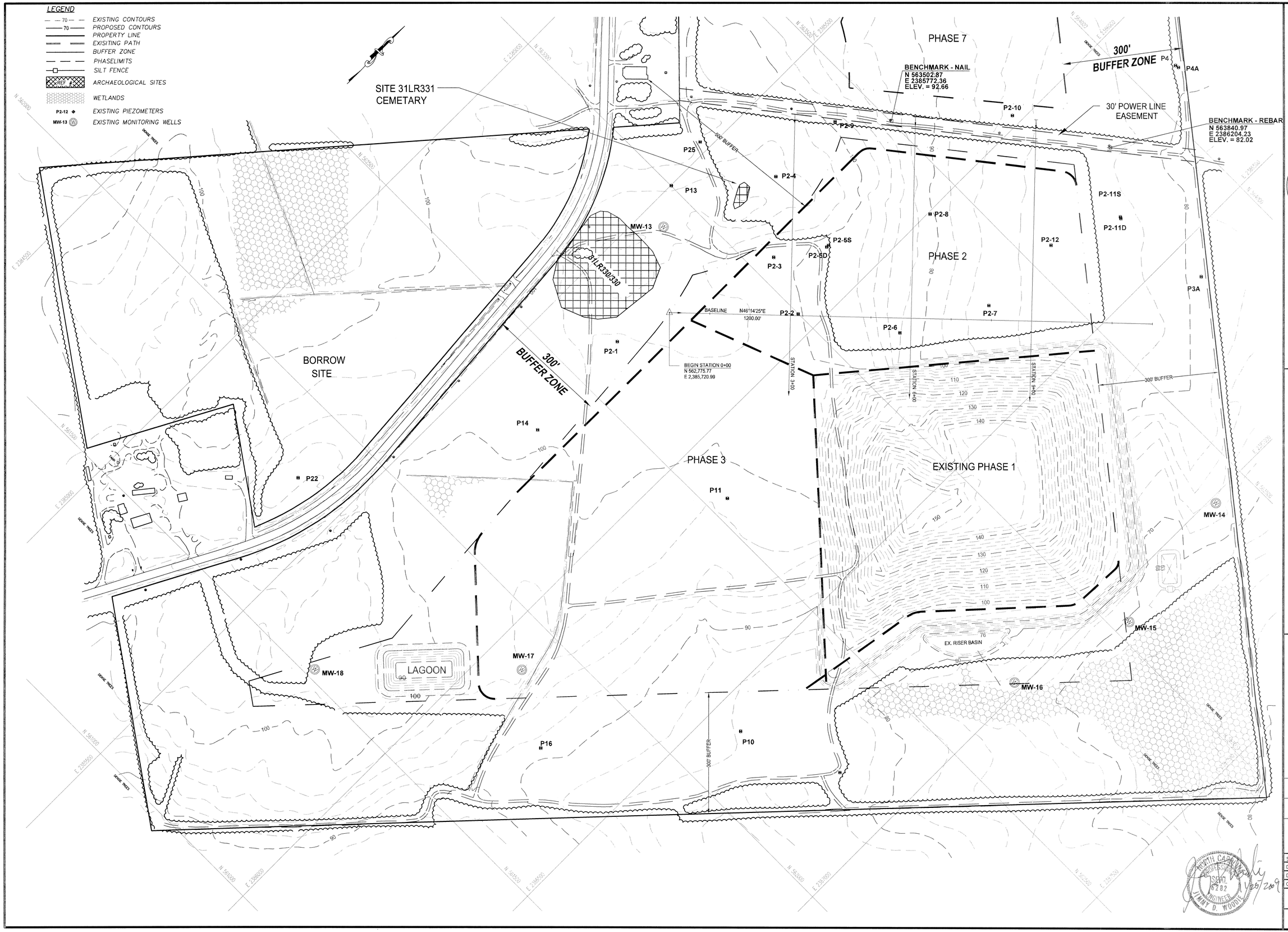
LEGEND

- EXISTING CONTOURS
- PROPOSED CONTOURS
- PROPERTY LINE
- EXISITING PATH
- BUFFER ZONE
- PHASELIMITS
- SILT FENCE
- ARCHAEOLOGICAL SITES
- WETLANDS
- P2-12 EXISTING PIEZOMETERS
- MW-13 EXISTING MONITORING WELLS



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(919) 772-5393

Engineering Company, P.A.
P.O. BOX 349 BOONE, N.C. 28607
(828) 262-1767
P.O. BOX 828 MOREHEAD CITY, N.C. 28557
(252) 726-9481

MUNICIPAL SOLID WASTE LANDFILL FACILITY
LENOIR COUNTY
NORTH CAROLINA

DATE	BY	REV.	DESCRIPTION

ENGINEERING PLAN – PHASE 2
EXISTING CONDITIONS

SCALE:	1" = 100'
DATE:	10/5/09
DRWN. BY:	L. HAMPTON
CHKD. BY:	J. WOODIE
PROJECT NUMBER	G08095
DRAWING NO.	E1
SHEET NO.	3 OF 15

NORTH CAROLINA PROFESSIONAL SEAL 6282 ENGINEER JIMMY D. WOODIE 11/25/2009

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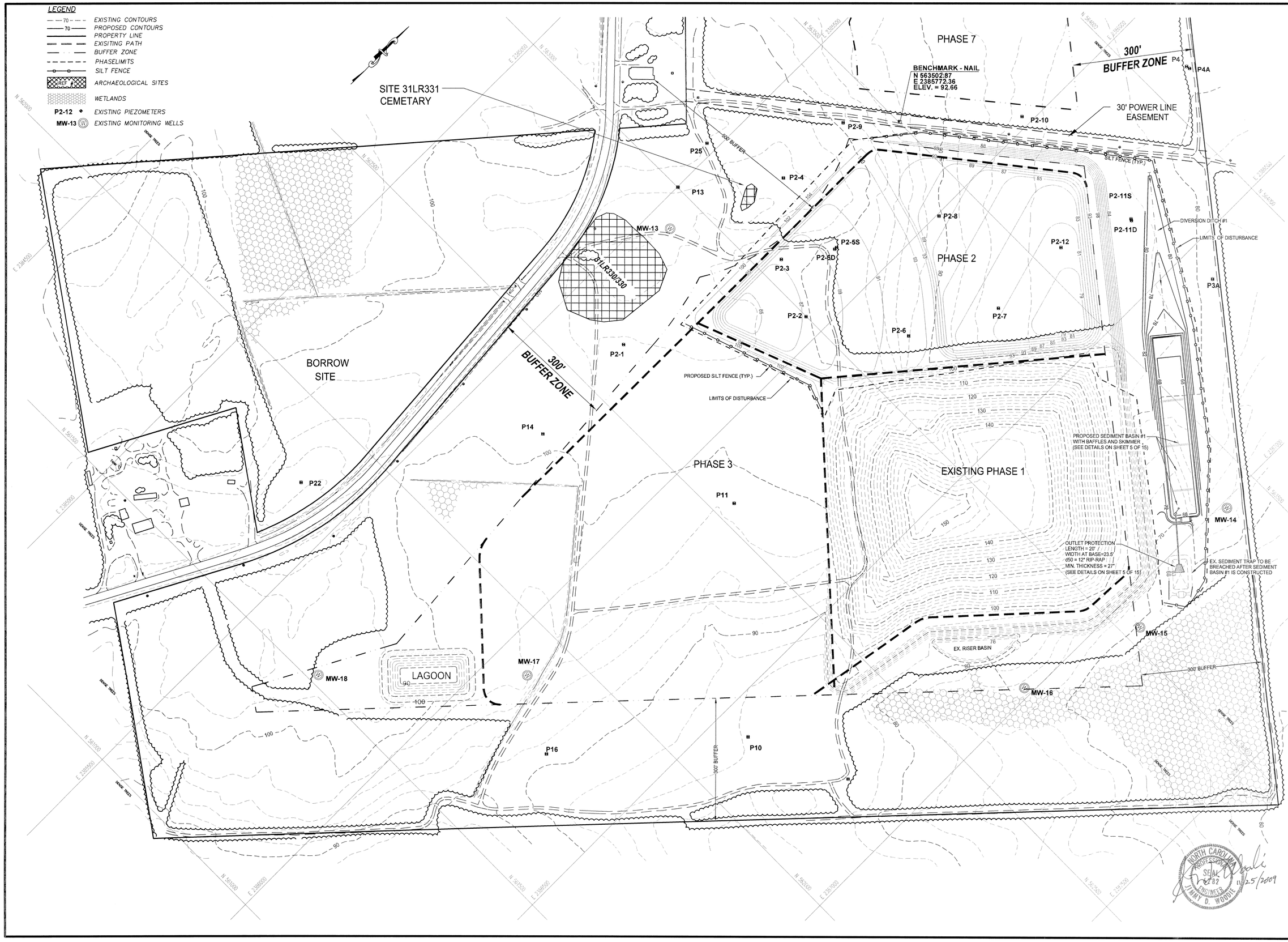

Municipal Engineering Services Company, P.A.
LICENSE NUMBER: C-0281
P.O. BOX 97 GARNER, N.C. 27529 (919) 772-5393
P.O. BOX 349 BOONE, N.C. 28607 (828) 262-1767
P.O. BOX 828 MOREHEAD CITY, N.C. 28557 (252) 726-9481

MUNICIPAL SOLID WASTE LANDFILL FACILITY
LENOIR COUNTY NORTH CAROLINA

DATE	BY	REV.	DESCRIPTION

ENGINEERING PLAN – PHASE 2
EROSION CONTROL PLAN

SCALE:	1" = 100'
DATE:	10/20/09
DRWN. BY:	L. HAMPTON
CHKD. BY:	J. WOODIE
PROJECT NUMBER	G08095
DRAWING NO.	E2
SHEET NO.	4 OF 15

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SEEDBED PREPARATION (SP)

SP-1 FILL SLOPES 3:1 OR STEEPER TO BE SEEDE BY A HYDRAULIC SEEDER (PERMANENT SEEDING)

1) Leave the last 4-6 inches of fill loose and uncompacted, allowing rocks, roots, large clods and other debris to remain on the slope.
2) Roughen slope faces by making grooves 2-3 inches deep, perpendicular to the slope.
3) Spread lime evenly over slopes at rates recommended by soil tests.

SP-2 Fill slopes 3:1 or steeper (temporary seedings)

1) Leave a loose, uncompacted surface. Remove large clods, rocks, and debris which might hold netting above the surface.
2) Spread lime and fertilizer evenly at rates recommended by soil tests.
3) Break up large clods and rake into a loose, uniform seedbed.
4) Rake to loosen surface just prior to applying seed.

SP-4 Gentle or flat slopes where topsoil is not used.

1) Remove rocks and debris.
2) Apply lime and fertilizer at rates recommended by soil tests; spread evenly and incorporate into the top 6" with a disk, chisel plow, or rotary tiller.
3) Break up large clods and rake into a loose, uniform seedbed.
4) Rake to loosen surface just prior to applying seed.

SEEDING METHODS (SM)

SM-1 Fill slopes steeper than 3:1 (permanent seeding)

Use hydraulic seeding equipment to apply seed and fertilizer, a wood fiber mulch at 45 lb./1,000 s.f., and mulch tackifier.

SM-2 Gentle to flat slopes or temporary seedings

1) Broadcast seed at the recommended rate with a cyclone seeder, drop spreader, or cultipacker seeder.
2) Rake seed into the soil and lightly pack to establish good contact.

MULCH (MU)

MU-1 Steep slopes (3:1 or greater)

In mid-summer, late fall or winter, apply 100 lb./1,000 s.f. grain straw, cover with netting and staple to the slope. In spring or early fall use 45lb. / 1,000 s.f. wood fiber in a hydroseeder slurry.

MU-2 High-maintenance vegetation and temporary seedings

Apply 90 lb./1,000 s.f. (4000 lb./acre) grain straw and tack with 0.1 gal./s.y. asphalt (11 gal./1,000 s.f.).

MU-3 Grass-lined channels

Install excelsior mat in the channel, extend up the channel banks to the highest calculated depth of flow, and secure according to manufactur's specifications.
On channel shoulders, apply 100 lb./1,000 s.f. grain straw and anchor with 0.1 gal./s.y. (11 gal./1,000 s.f.) asphalt.

MAINTENANCE (MA)

MA-1 Refertilize in late winter or early spring the following year. Mow as desired.
MA-3 Inspect and repair mulch and lining. Refertilize in late winter of the following year with 150 lb./acre 10-10-10 (3.5 lb./1,000 s.f.). Mow regularly to a height of 3-4 inches.
MA-4 Topdress with 10-10-10 fertilizer if growth is not fully adequate.
MA-5 Topdress with 50 lb./acre (1 lb./1,000 s.f.) nitrogen in March. If cover is needed through the following summer, overseed with 50 lb./acre Kobe lespedeza.

PERMANENT SEEDING REQUIREMENTS (N.C. NO. 1CP)

SEEDING MIXTURE

Species	Rate (lb./acre)
Tall fescue	80
Pensacola Bahiagrass	50
Sericea lespedeza	30
Kobe lespedeza	10

SEEDING NOTES

1. From Sept.1-Mar.1, use unscarified sericea seed.
2. On poorly drained sites omit sericea and increase Kobe to 30 lb/acre.
3. Where a neat appearance is desired, omit sericea and increase Kobe to 40 lb/acre.

NURSE PLANTS

Between Apr.15 and Aug.15, add 10lb/acre German millet or 15 lb/acre Sudangrass. Prior to May1 or after Aug.15, add 25 lb/acre rye (grain).

SEEDING DATES

	BEST	POSSIBLE
Early spring:	Aug.25-Sept.15	Aug.20-Oct.25
Fall:	Sept. 1-Sept.30	Sept. 1-Oct.31

SOIL AMENDMENTS

Apply lime and fertilizer according to soil tests, or apply 3000-5000 lb/acre ground agricultural limestone (use the lower rate on sandy soils) and 1,000 lb/acre 10-10-10 fertilizer.

MULCH

Apply 4,000 lb./acre small grain straw or equivalent cover of another suitable mulch. Anchor straw by tacking with asphalt, netting, or roving or by crimping with a mulch anchoring tool. A disk with blades set nearly straight can be used as a mulch anchoring tool.

MAINTENANCE

If growth is less than fully adequate, refertilize in the second year, according to soil tests or topdress with 500 lb/acre 10-10-10 fertilizer. Mow as needed when sericea is omitted from the mixture. Reseed, fertilize and mulch damaged areas immediately.

TEMPORARY SEEDING SPECIFICATIONS

TEMPORARY SEEDING RECOMMENDATIONS FOR LATE WINTER AND EARLY SPRING

Seeding Mixture

species	Rate(lb./acre)
Rye (grain)	120
Annual lespedza (Kobe in Piedmont and Coastal Plain,Korean in Mountains)	50

Omit annual lespedeza when duration of temporary cover is not to extend beyond June.

SEEDING DATES

Mountains-Above 2500ft.:Feb. 15 - May 15
Below 2500ft.:Feb. 1 - May 1
Piedmont-Jan. 1 - May 1
Coastal Plain-Dec. 1 - Apr. 15

SOIL AMENDMENTS

Follow recommendations of soil tests or apply 2,000 lb./acre ground agricultural limestone and 750 lb./acre 10-10-10 fertilizer.

MULCH

Apply 4,000 lb./acre straw. Anchor straw by tacking with asphalt, netting, or a mulch anchoring tool. A disk with blades set nearly straight can be used as a mulching tool.

MAINTENANCE

Refertilize if growth is not fully adequate. Reseed, refertilize and mulch immediately following erosion or other damage.

TEMPORARY SEEDING RECOMMENDATIONS FOR SUMMER

Seeding Mixture

species	Rate(lb./acre)
German millet	40

In the Piedmont and Mountains, a small-stemmed Sudangrass may be substituted at a rate of 50 lb./acre.

SEEDING DATES

Mountains-May 15 - Aug.15
Piedmont-May 1 - Aug. 15
Coastal Plain-Apr. 15 - Aug. 15

SOIL AMENDMENTS

Follow recommendations of soil tests or apply 2,000 lb./acre ground agricultural limestone and 750 lb./acre 10-10-10 fertilizer.

MULCH

Apply 4,000 lb./acre straw. Anchor straw by tacking with asphalt, netting, or a mulch anchoring tool. A disk with blades set nearly straight can be used as a mulching tool.

MAINTENANCE

Refertilize if growth is not fully adequate. Reseed, refertilize and mulch immediately following erosion or other damage.

TEMPORARY SEEDING RECOMMENDATIONS FOR FALL

Seeding Mixture

species	Rate(lb./acre)
Rye (grain)	120

SEEDING DATES

Mountains-Aug.15 - Dec. 15
Coastal Plain and Piedmont-Aug. 15 - Dec. 30

SOIL AMENDMENTS

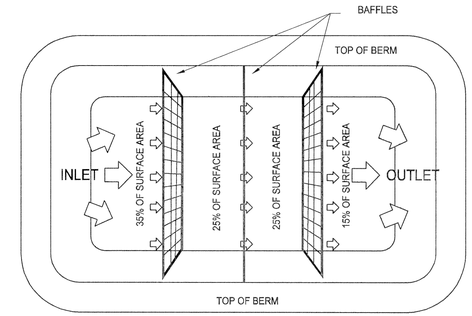
Follow recommendations of soil tests or apply 2,000 lb./acre ground agricultural limestone and 1,000 lb./acre 10-10-10 fertilizer.

MULCH

Apply 4,000 lb./acre straw. Anchor straw by tacking with asphalt, straight can be used as a mulching tool.

MAINTENANCE

Repair and refertilize damaged areas immediately. Topdress with netting, or a mulch anchoring tool. A disk with blades set nearly 50 lb./acre of nitrogen in March. If it is necessary to extend temporary cover beyond June 15, overseed with 50 lb./acre Kobe (Piedmont and Coastal Plain) or Korean (Mountains)lespedeza in late February or early March.

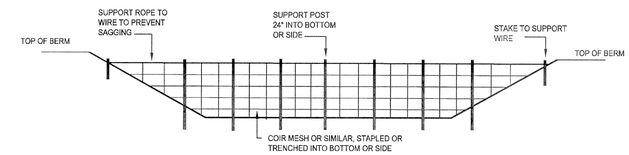


NC EROSION CONTROL MANUAL FIGURE 6.65a

NOTE: BAFFLES NEED TO BE INSTALLED CORRECTLY IN ORDER TO FULLY PROVIDE THEIR BENEFITS. REFER TO FIGURE 6.65b AND THE FOLLOWING KEY POINTS:

THE BAFFLE MATERIAL NEEDS TO BE SECURED AT THE BOTTOM AND SIDES USING STAPLES OR BY TRENCHING AS FOR SILT FENCE.

MOST OF THE SEDIMENT WILL ACCUMULATE IN THE FIRST BAY, SO THIS SHOULD BE READILY ACCESSIBLE FOR MAINTENANCE.



NC EROSION CONTROL MANUAL FIGURE 6.65b
CROSS-SECTION OF A POROUS BAFFLE IN A SEDIMENT BASIN.

RISER BASIN BAFFLE DETAIL

NOT TO SCALE

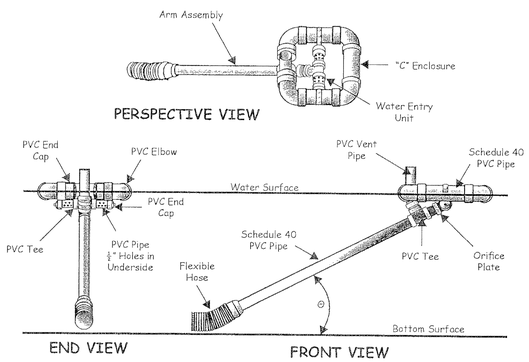
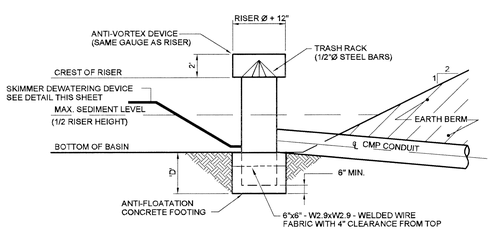


Figure 6.64a Schematic of a skimmer, from Pennsylvania Erosion and Sediment Pollution Control Manual, March, 2000.

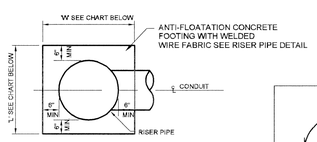
SKIMMER DEWATERING DEVICE DETAIL

NOT TO SCALE



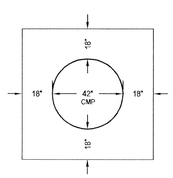
RISER PIPE DETAIL

NOT TO SCALE



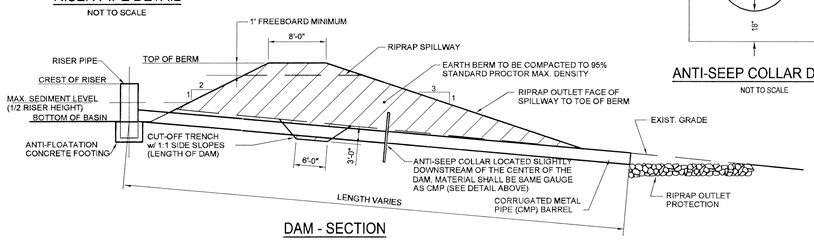
RISER FOOTING DETAIL

NOT TO SCALE



ANTI-SEEP COLLAR DETAIL

NOT TO SCALE

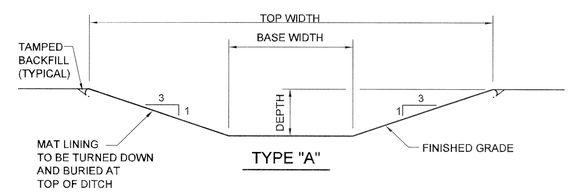


DAM - SECTION

BASIN NO.	BOTTOM		SPILLWAY		BERM EL.	RISER		BARREL			FOOTING FOR RISER PIPE				BARREL OUTLET PROTECTION					SKIMMER DEWATERING DEVICE			BAFFLES
	SIZE	EL.	WIDTH	EL.		DIA.	INV. IN	DIA.	LENGTH	INV.IN	TOP EL.	'L'	'W'	'D'	'L'	'W'	d_{50}	THICK.	EL.	BASIN VOLUME (CU. FT.)	ORIFICE DIA.SIZE	DEWATERING TIME (DAYS)	NUMBER REQUIRED
#1	57'x392'	64.0'	20'	67.0'	68.0'	60"	66.0'	42"	124'	64.0'	64.0'	6'	6'	1'	20'	23.5'	12"	27" MIN.	63.5'	53,256	4"	2	3

SEDIMENT BASIN DETAIL

NOT TO SCALE



TYPE "A"

DIVERSION DITCH SCHEDULE								
DITCH NO.	TYPE	TOP WIDTH	DEPTH	BASE WIDTH	VELOCITY (f.p.s.)	RIP RAP d50	RIP RAP THICK.	TEMP. LINER
1	A	13'	1	7'	4.09	-	-	STRAW W/NET

DIVERSION DITCH DETAIL

NOT TO SCALE

Municipal Services
P.O. BOX 97 GARNER, N.C. 27529
(919) 772-5393
LICENSE NUMBER: C-0261

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(252) 726-9481

MUNICIPAL SOLID WASTE LANDFILL FACILITY
LENOIR COUNTY
NORTH CAROLINA

DATE	BY	REV.	DESCRIPTION

ENGINEERING PLAN – PHASE 2
EROSION CONTROL DETAILS

SCALE: NOT TO SCALE
DATE: 11/2/09
DRWN. BY: L. HAMPTON
CHKD. BY: J. WOODIE
PROJECT NUMBER: G08095
DRAWING NO.: E3
SHEET NO.: 5 OF 15

NORTH CAROLINA PROFESSIONAL SEAL 16282 ENGINEER JIMMY D. WOODIE 11/25/2009

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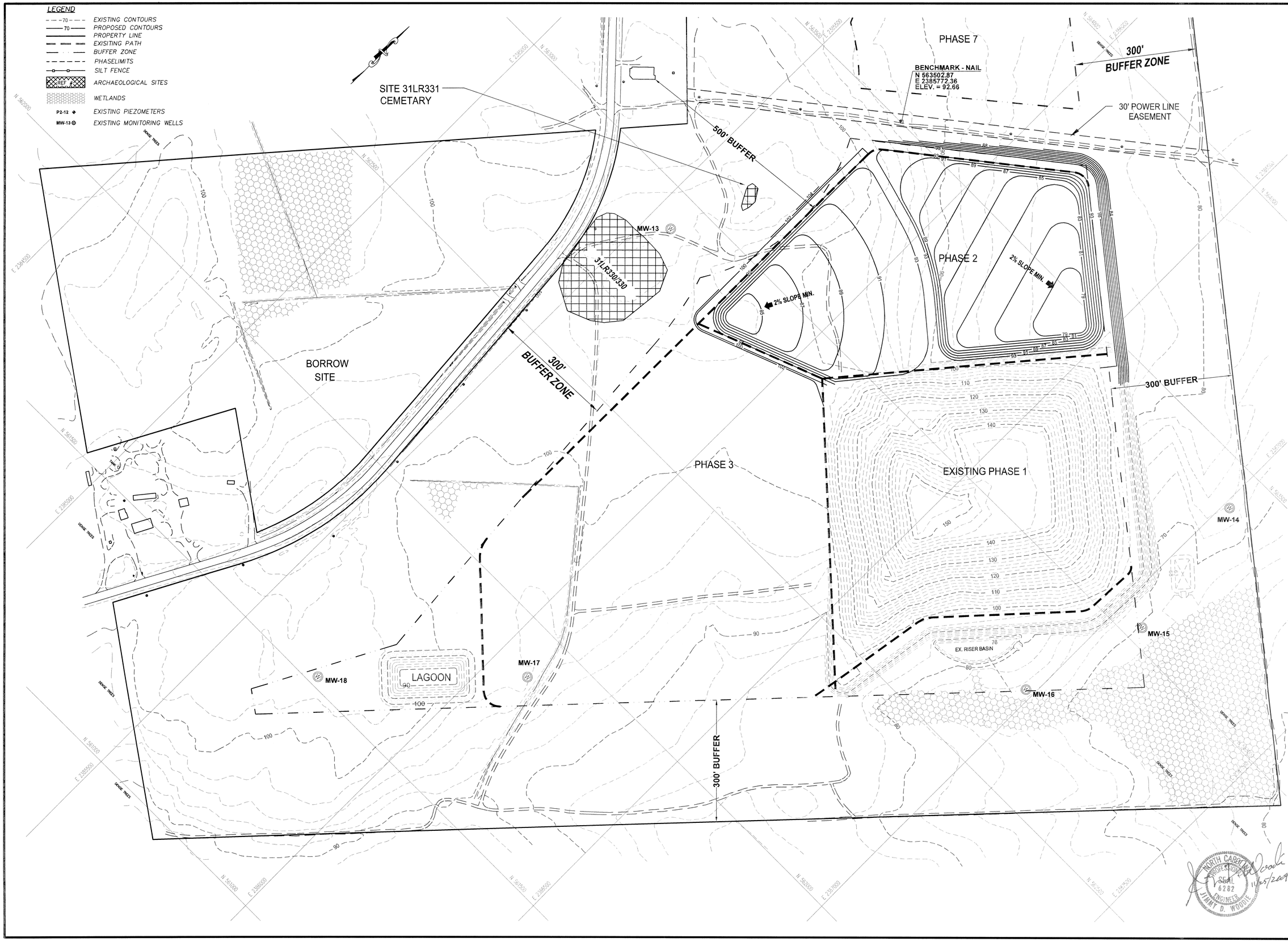

LICENSE NUMBER: C-0281

Municipal Services Engineering Company, P.A.

P.O. BOX 97 GARNER, N.C. 27529 (919) 772-5393

P.O. BOX 349 BOONE, N.C. 28607 (828) 262-1767

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MUNICIPAL SOLID WASTE LANDFILL FACILITY
LENOIR COUNTY NORTH CAROLINA

DATE	BY	REV.	DESCRIPTION

ENGINEERING PLAN – PHASE 2
PROPOSED SUBGRADE

SCALE:	1" = 100'
DATE:	10/5/09
DRWN. BY:	L. HAMPTON
CHKD. BY:	J. WOODIE
PROJECT NUMBER	G08095
DRAWING NO.	E4
SHEET NO.	6 OF 15

NORTH CAROLINA PROFESSIONAL SEAL 6282 ENGINEER JIMMY D. WOODIE 11/05/2009

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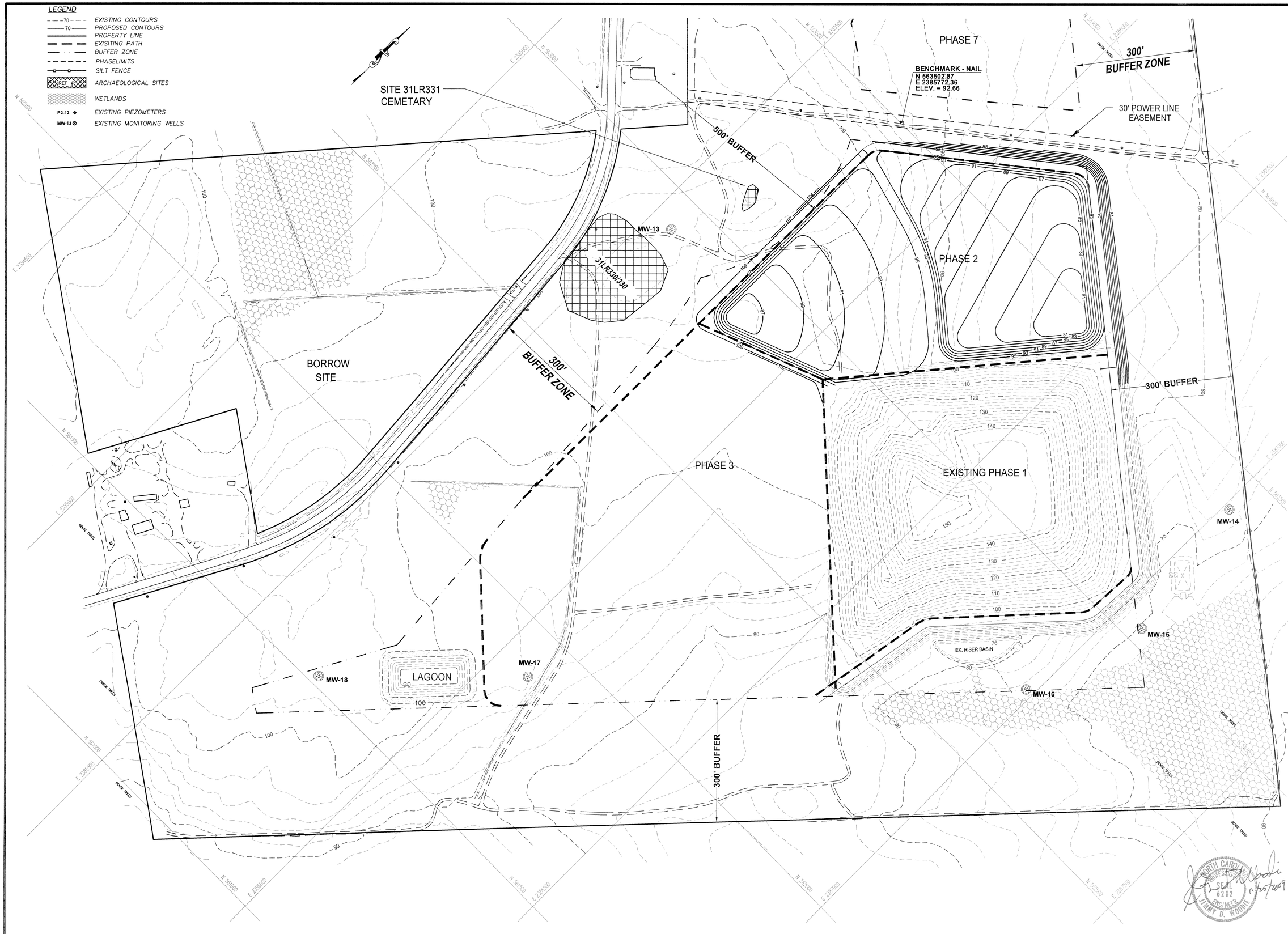

Municipal Engineering Services Company, P.A.

LICENSE NUMBER: C-0281

P.O. BOX 97 GARNER, N.C. 27529 (919) 772-5393

P.O. BOX 349 BOONE, N.C. 28607 (828) 262-1767

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MUNICIPAL SOLID WASTE LANDFILL FACILITY
LENOIR COUNTY
NORTH CAROLINA

DATE	BY	REV.	DESCRIPTION

ENGINEERING PLAN – PHASE 2
TOP OF COHESIVE SOIL LINER

SCALE:	1" = 100'
DATE:	10/5/09
DRWN. BY:	L. HAMPTON
CHKD. BY:	J. WOODIE
PROJECT NUMBER	G08095
DRAWING NO.	E5
SHEET NO.	7 OF 15

NORTH CAROLINA PROFESSIONAL SEAL 6282 ENGINEER JIMMY D. WOODIE

10/5/2009

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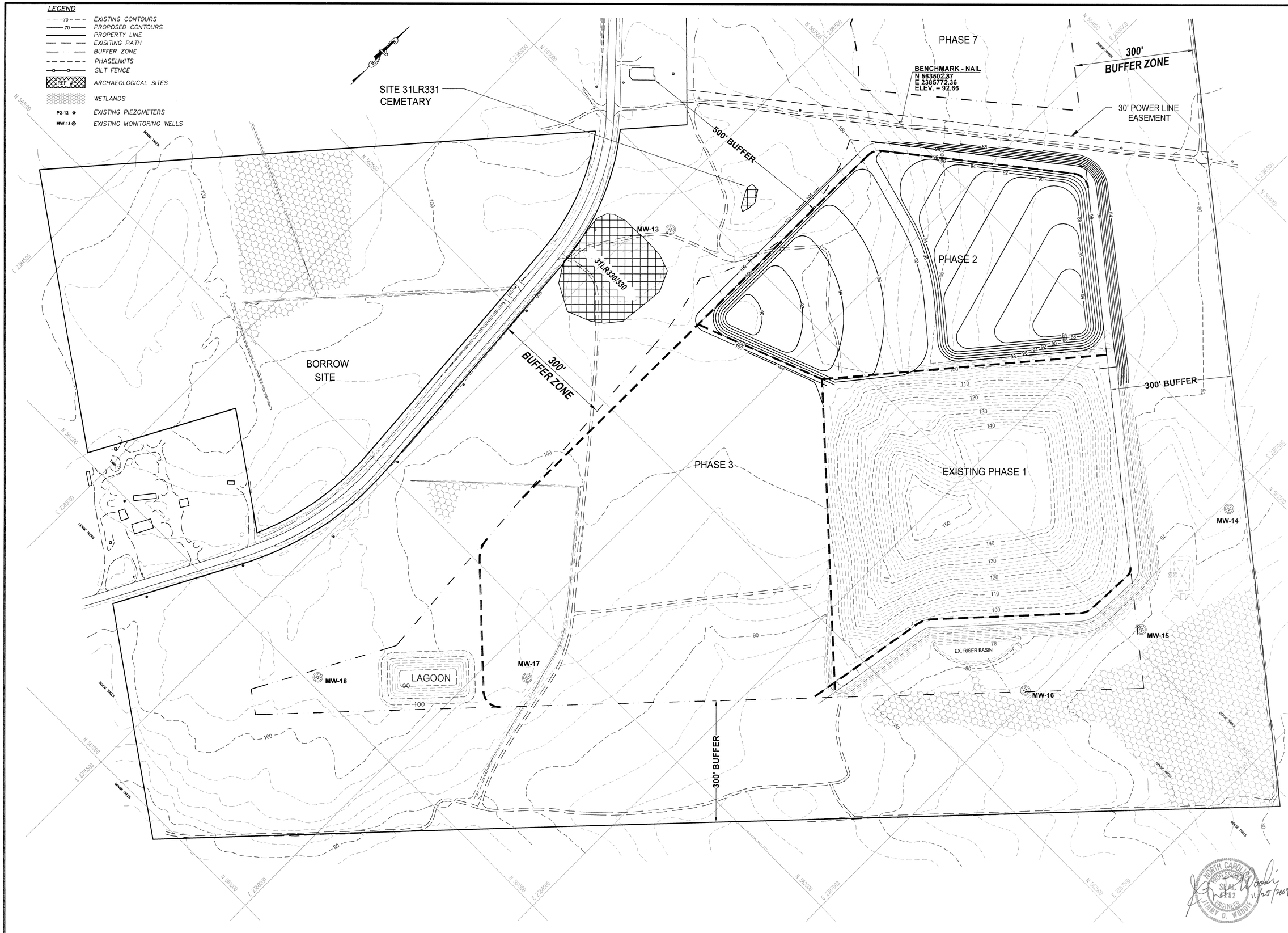
LEGEND

- EXISTING CONTOURS
- PROPOSED CONTOURS
- PROPERTY LINE
- EXISITING PATH
- BUFFER ZONE
- PHASELIMITS
- SILT FENCE
- ARCHAEOLOGICAL SITES
- WETLANDS
- P2-12 EXISTING PIEZOMETERS
- MW-13 EXISTING MONITORING WELLS



Municipal Services
P.O. BOX 97 GARNER, N.C. 27529
(919) 772-5393
LICENSE NUMBER: C-0281

Engineering Company, P.A.
P.O. BOX 349 BOONE, N.C. 28607
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P.O. BOX 828 MOREHEAD CITY, N.C. 28557
(252) 726-9481

MUNICIPAL SOLID WASTE LANDFILL FACILITY
LENOIR COUNTY NORTH CAROLINA

DATE	BY	REV.	DESCRIPTION

ENGINEERING PLAN – PHASE 2
TOP OF PROTECTIVE COVER

SCALE:	1" = 100'
DATE:	10/5/09
DRWN. BY:	L. HAMPTON
CHKD. BY:	J. WOODIE
PROJECT NUMBER	G08095
DRAWING NO.	E6
SHEET NO.	8 OF 15

NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 19882 JIMMY D. WOODIE
11/05/2009

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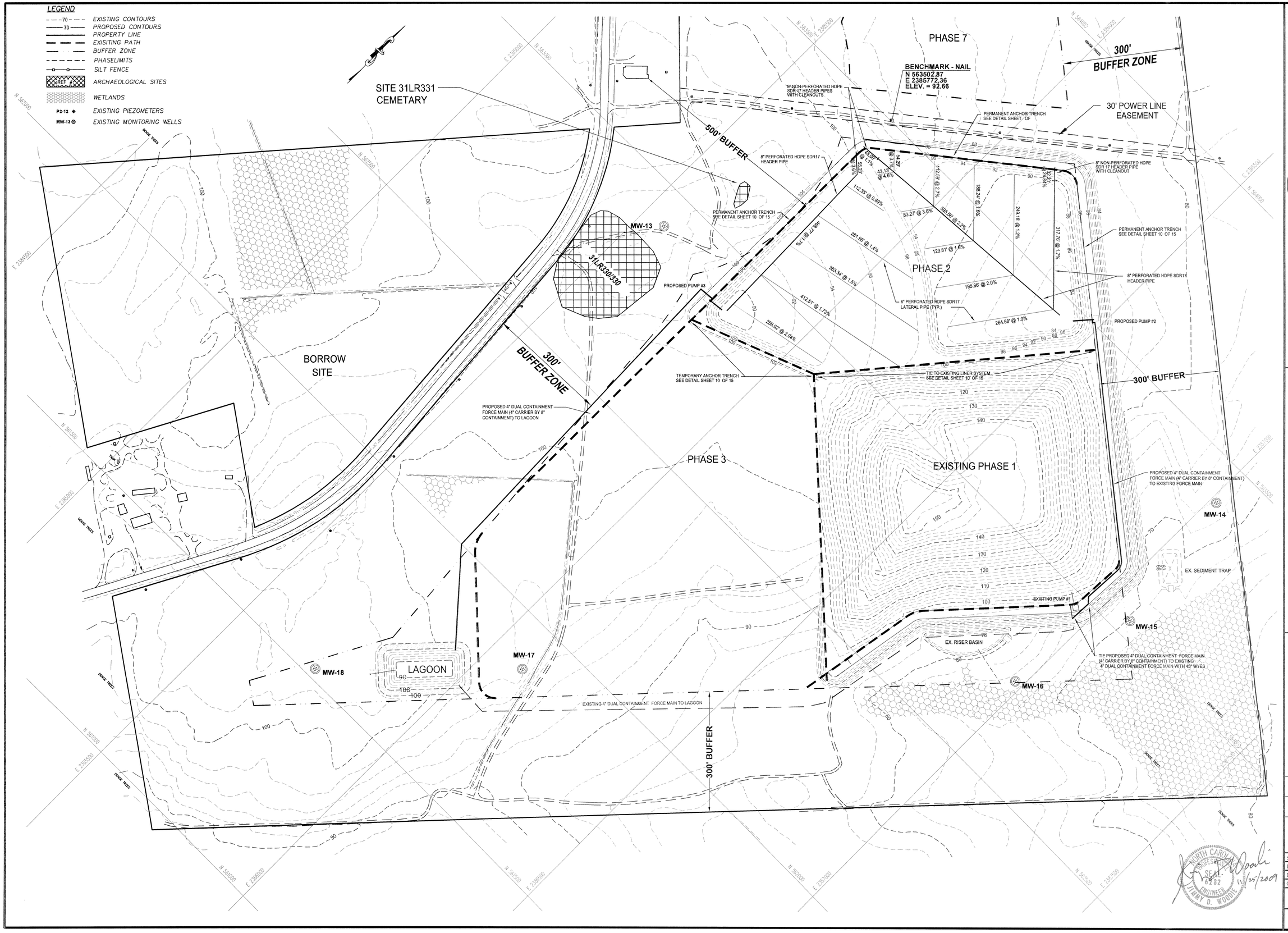

Municipal Engineering Services Company, P.A.
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P.O. BOX 349 BOONE, N.C. 28607 (828) 262-1767
P.O. BOX 828 MOREHEAD CITY, N.C. 28557 (252) 726-9481
LICENSE NUMBER: C-0281

MUNICIPAL SOLID WASTE LANDFILL FACILITY
LENOIR COUNTY NORTH CAROLINA

DATE	BY	REV.	DESCRIPTION

ENGINEERING PLAN – PHASE 2
LEACHATE COLLECTION SYSTEM

SCALE:	1" = 100'
DATE:	10/5/09
DRWN. BY:	L. HAMPTON
CHKD. BY:	J. WOODIE
PROJECT NUMBER	G08095
DRAWING NO.	E7
SHEET NO.	9 OF 15

NORTH CAROLINA PROFESSIONAL SEAL 6732 ENGINEER JIMMY D. WOODIE
11/25/2009

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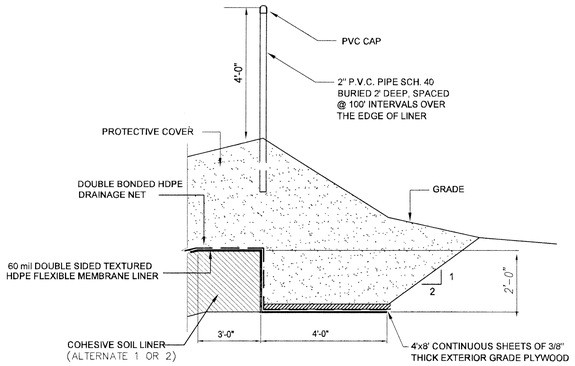
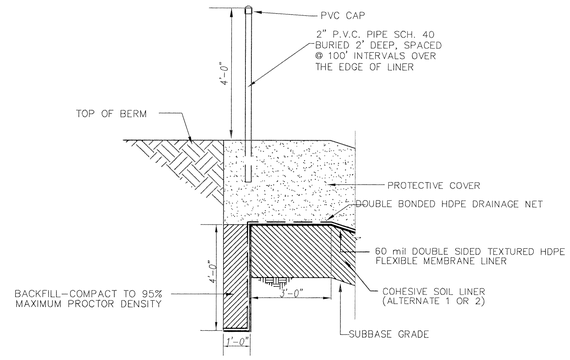


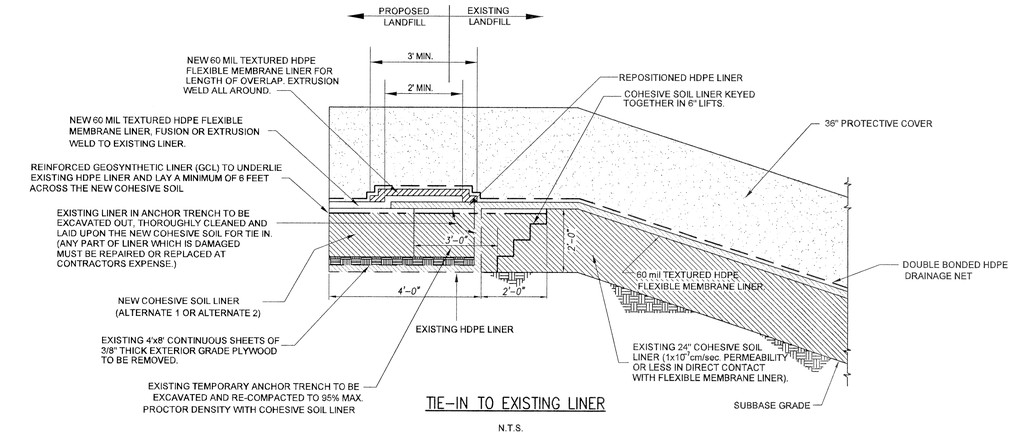
TEMPORARY ANCHOR TRENCH DETAIL

N.T.S.



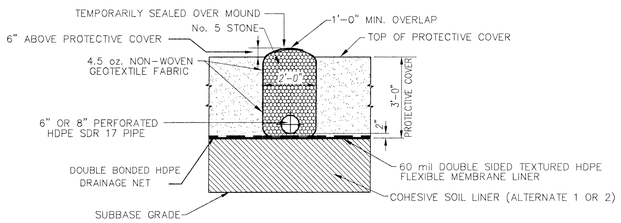
PERMANENT ANCHOR TRENCH DETAIL

N.T.S.



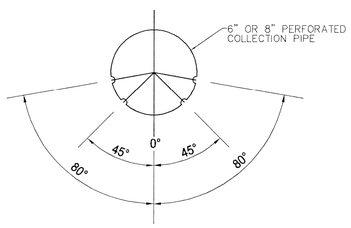
TIE-IN TO EXISTING LINER

N.T.S.



LEACHATE COLLECTION TRENCH DETAIL

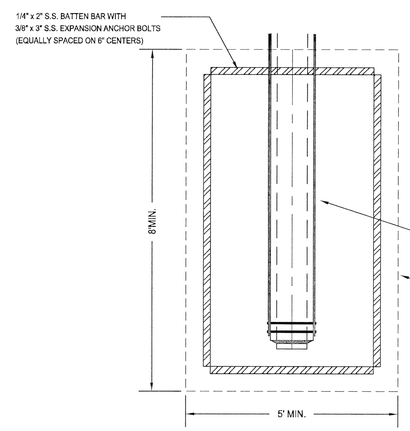
N.T.S.



1. 0° CORRESPONDS TO PIPE INVERT.
2. PROVIDE FOUR 1/2" DIAMETER PERFORATIONS AS SHOWN; 6" O.C.

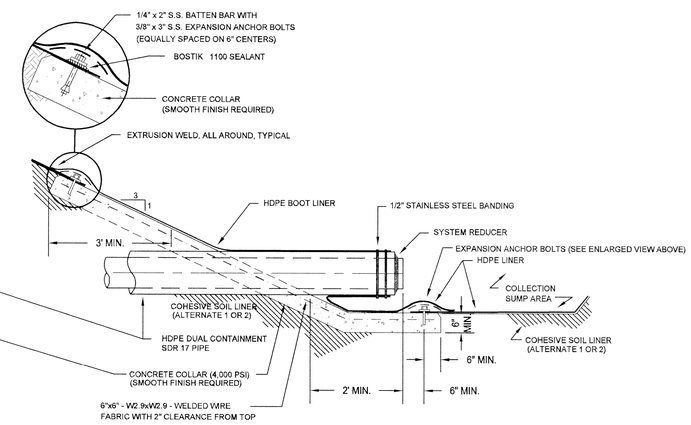
LEACHATE COLLECTION SYSTEM PERFORATION PATTERN DETAIL

N.T.S.



PLAN VIEW

N.T.S.



SECTION VIEW

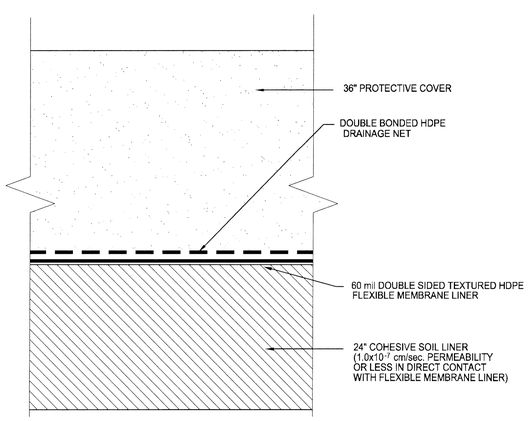
N.T.S.

NOTE:

EARTH ADJACENT TO THE CONCRETE COLLAR SHALL BE COMPACTED TO 95 % MAX. PROCTOR DENSITY TO PREVENT FUTURE DIFFERENTIAL SETTLEMENT. ALL CONCRETE COLLARS ARE TO BE SMOOTH AND CHAMFERED A MINIMUM OF 1" (TYP.) AT ALL CORNER THAT ARE IN CONTACT WITH THE LINER.

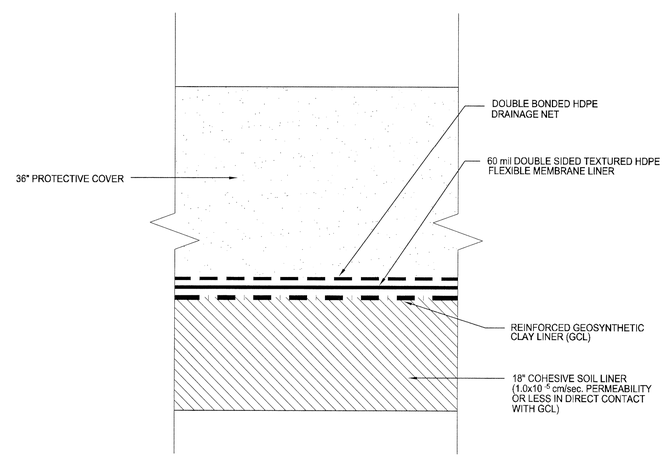
TYPICAL PIPE PENETRATION DETAIL

N.T.S.



COHESIVE SOIL LINER ALTERNATE 1 DETAIL

N.T.S.



COHESIVE SOIL LINER ALTERNATE 2 DETAIL

N.T.S.

Municipal Engineering Services Company, P.A.
LICENSE NUMBER: C-0281
P.O. BOX 97 GARNER, N.C. 27529 (919) 772-5393
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MUNICIPAL SOLID WASTE LANDFILL FACILITY
LENOIR COUNTY
NORTH CAROLINA

DATE	BY	REV.	DESCRIPTION

ENGINEERING PLAN – PHASE 2
CONSTRUCTION DETAILS

NORTH CAROLINA PROFESSIONAL SEAL 5282 ENGINEER JIMMY D. WOODIE
11/25/2009

SCALE:	AS SHOWN
DATE:	10/8/09
DRWN. BY:	L. HAMPTON
CHKD. BY:	J. WOODIE
PROJECT NUMBER	G08095
DRAWING NO.	E8
SHEET NO.	10 OF 15

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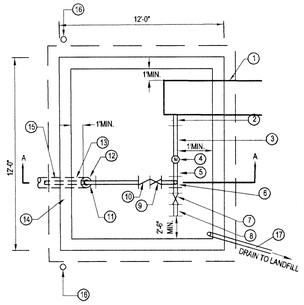
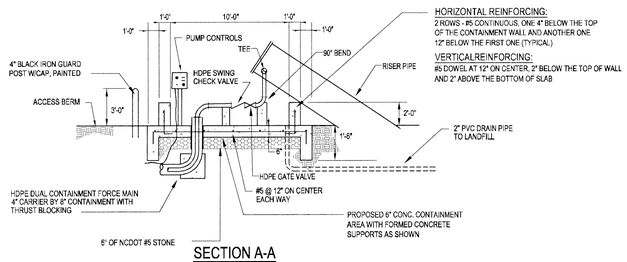


1. 24" HDPE SDR 17 SUMP RISER
2. EXIT ASSEMBLY WITH PRESSURE GAUGE AND 3/4" SAMPLE TAP
3. MIN. 18" LONG 4" FLANGED HDPE PIPE
4. 4" BRONZE TURBINE METER, KENT SERIES 3000, MASTER METER, OR APPROVED EQUAL
5. MIN 18" LONG 4" FLANGED HDPE PIPE
6. 4" x 4" FANGED HDPE TEE WITH 2" FLANGED HDPE 90° VERTICAL BEND BELOW TEE
7. 4" FLANGED HDPE GATE VALVE
8. 4" STAINLESS QUICK-DISCONNECT FITTING
9. 4" FLANGED HDPE GATE VALVE
10. 4" FLANGED HDPE SWING CHECK VALVE
11. 1 - 90°, 4" FLANGED HDPE VERTICAL BEND
12. HDPE DUAL CONTAINMENT SOLID STOP WITH WATER STOP BEGIN DUAL CONTAINMENT FORCE MAIN
13. HDPE DUAL CONTAINMENT 90° VERTICAL BEND
14. CONCRETE CONTAINMENT AREA
15. HPDE DUAL CONTAINMENT FORCE MAIN (4" CARRIER BY 8" CONTAINMENT)
16. GUARD POST
17. 2" PVC DRAIN PIPE

SUMP RISER PAD AND PIPING DETAIL

NOT TO SCALE

NOTE: ALL FITTINGS BY PLASTIC FUSION FABRICATORS OR APPROVED EQUAL

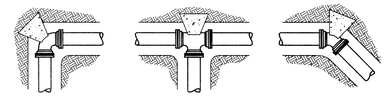


HORIZONTAL REINFORCING:
2 ROWS - #5 CONTINUOUS, ONE 4" BELOW THE TOP OF THE CONTAINMENT WALL AND ANOTHER ONE 12" BELOW THE FIRST ONE (TYPICAL)

VERTICALREINFORCING:
#5 DOWEL AT 12" ON CENTER, 2" BELOW THE TOP OF WALL AND 2" ABOVE THE BOTTOM OF SLAB

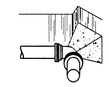
SECTION A-A

NOT TO SCALE



NOTES

1. ALL BENDS AND TEES SHALL HAVE CONCRETE THRUST BLOCKING.
2. MINIMUM BEARING AREA SHALL BE AS GIVEN IN TABLE.
3. CONCRETE SHALL BE 2500 P.S.I. MINIMUM.
4. CONCRETE SHALL NOT CONTACT BOLTS OR FLANGES OF MECHANICAL JOINT FITTINGS.



REACTION BEARING AREAS FOR HORIZONTAL WATER PIPE BENDS

BASED ON TEST PRESSURE OF 200 P.S.I. AND SAFETY FACTOR OF 1.5

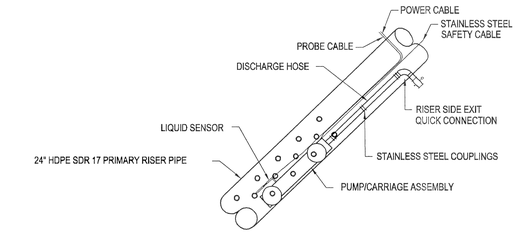
SIZE AND DEGREE OF PIPE BEND		STATIC THRUST IN POUNDS	S_b	SOFT CLAY (#/SF)	SILT (#/SF)	GRAVEL OR COURSE SAND (#/SF)	SANDY SILT (#/SF)	SAND (#/SF)	SANDY CLAY (#/SF)	HARD CLAY (#/SF)
				1,000	1,500	1,600	3,000	4,000	6,000	9,000
			BEARING AREA (A.) IN SF							
8" PIPE	11 1/4"	2,521		4	3	2	1	1	1	0
	22 1/2"	5,018		8	5	5	3	2	1	1
	45°	9,843		15	10	9	5	4	2	2
	90°	18,187		27	18	17	9	7	5	3
	PLUG & BRANCH	12,860		19	13	12	6	5	3	2

REACTION BEARING AREAS ARE IN SQUARE FEET MEASURED IN A VERTICAL PLANE IN THE TRENCH SIDE AT AN ANGLE OF 90 DEGREES TO THE THRUST VECTOR.

USE 6"-90 DEGREE BEND VALUE FOR THE HYDRANTS FOR ADDITIONAL SAFETY FACTOR.

THRUST BLOCKING DETAIL

NOT TO SCALE

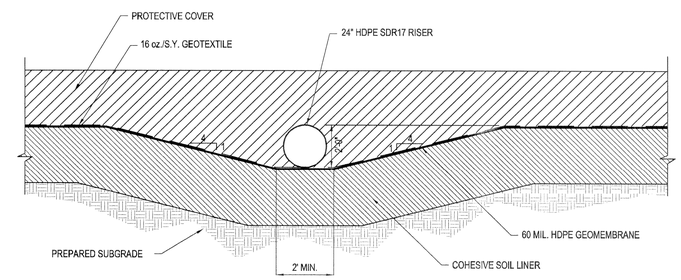


LEACHATE SUMP RISER SCHEMATIC

NOT TO SCALE

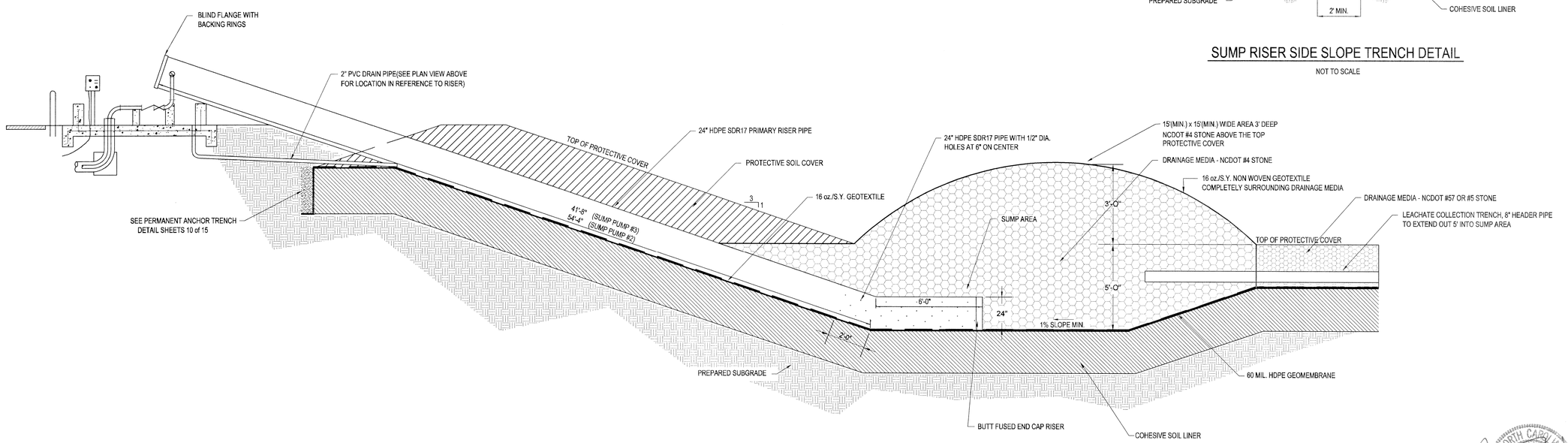
THE PUMP SHALL BE CONSTRUCTED OF ALL 304 STAINLESS STEEL MATERIALS WITH A TEFLON IMPELLER SEAL RING, AND INTERMEDIATE BEARINGS. THE MOTOR SHALL BE A 5 H.P., SINGLE PHASE, 230 VOLT, CONSTRUCTED OF STAINLESS STEEL WETTED PARTS. POWER CABLE LENGTH SHALL BE NO LESS THAN 75 FEET AND SUITABLE FOR LEACHATE SERVICE.

THE PUMP SHALL INCLUDE A PATENTED STAINLESS STEEL CARRIAGE. THE CARRIAGE SHALL BE DESIGNED FOR SIDE SLOPE RISER LEACHATE APPLICATIONS. THE PUMP ASSEMBLY SHALL HAVE A LOW CENTER OF GRAVITY AND ALL WHEELS OF THE CARRIAGE SHALL REMAIN IN CONTACT WITH THE INSIDE SURFACE OF THE RISER PIPE. THE PUMP SHALL BE EASILY REMOVED FROM THE CARRIAGE SHOULD THE PUMP OR MOTOR REQUIRE SERVICE OR REPLACEMENT. THE PUMP AND CARRIAGE SHALL BE CAPABLE OF ENTRY INTO AN 24" HDPE SDR 17 PIPE AND MUST BE ABLE TO TRAVEL OVER ANY WELDING BEADS AND PERFORATIONS WHICH ARE COMMON TO LEACHATE COLLECTION RISER PIPE FABRICATION. A 50 FOOT RETRIEVABLE CABLE ASSEMBLY OF 1/4" STAINLESS STEEL WITH SNAP HOOK AND EYE BOLT SHALL BE PROVIDED.



SUMP RISER SIDE SLOPE TRENCH DETAIL

NOT TO SCALE



TYPICAL SUMP AND RISER SECTION

NOT TO SCALE

Municipal Services Engineering Company, P.A.
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LICENSE NUMBER: C-0261

MUNICIPAL SOLID WASTE LANDFILL FACILITY
LENOIR COUNTY NORTH CAROLINA

DATE	BY	REV.	DESCRIPTION

ENGINEERING PLAN – PHASE 2
SUMP, PUMP, RISER, PAD AND DETAILS

NORTH CAROLINA PROFESSIONAL SEAL 6202 ENGINEER JIMMY D. WOODIE 11/25/2009

SCALE:	AS SHOWN
DATE:	10/8/09
DRWN. BY:	L. HAMPTON
CHKD. BY:	J. WOODIE
PROJECT NUMBER	G08095
DRAWING NO.	E9
SHEET NO.	11 OF 15

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LEGEND

- EXISTING CONTOURS
- PROPERTY LINE
- EXISITING PATH
- BUFFER ZONE
- PHASELIMITS
- ARCHAEOLOGICAL SITES
- WETLANDS
- MW-13 EXISTING MONITORING WELLS

SITE 31LR331
CEMETARY

BENCHMARK - NAIL
N 563502.87
E 2385772.36
ELEV. = 92.66

PHASE 7

300'
BUFFER ZONE

30' POWER LINE
EASEMENT

500' BUFFER

MW-13

31LR330/330

INITIAL PLACEMENT OF WASTE

PHASE 2

24" GATE VALVE AND 99 L.F. OF 24" SMOOTH WALL HDPE STORMWATER DIVERSION PIPE

OUTLET PROTECTION
LENGTH = 18'
WIDTH AT BASE=20'
Ø50 = 6" RIP-RAP
MIN. THICKNESS=13.5"

PROPOSED PUMP #2

300' BUFFER

BORROW
SITE

300'
BUFFER ZONE

PHASE 3

EXISTING PHASE 1

MW-14

MW-15

EX. RISER BASIN

MW-16

MW-17

MW-18

LAGOON

EXISTING 4" DUAL CONTAINMENT FORCE MAIN TO LAGOON

300' BUFFER

DENSE TREES

NORTH CAROLINA PROFESSIONAL SEAL 22802 ENGINEER JIMMY D. WOODIE

11/25/2009

Municipal Services Engineering Company, P.A.

LICENSE NUMBER: C-0281

P.O. BOX 97 GARNER, N.C. 27529
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(828) 262-1767

P.O. BOX 828 MOREHEAD CITY, N.C. 28557
(252) 726-8481

MUNICIPAL SOLID WASTE LANDFILL FACILITY
LENOIR COUNTY NORTH CAROLINA

DATE	BY	REV.	DESCRIPTION

ENGINEERING PLAN – PHASE 2
INITIAL PLACEMENT OF WASTE AND STORMWATER DIVERSION

SCALE:	1" = 100'
DATE:	10/5/09
DRWN. BY:	L. HAMPTON
CHKD. BY:	J. WOODIE
PROJECT NUMBER	G08095
DRAWING NO.	E10
SHEET NO.	12 OF 15

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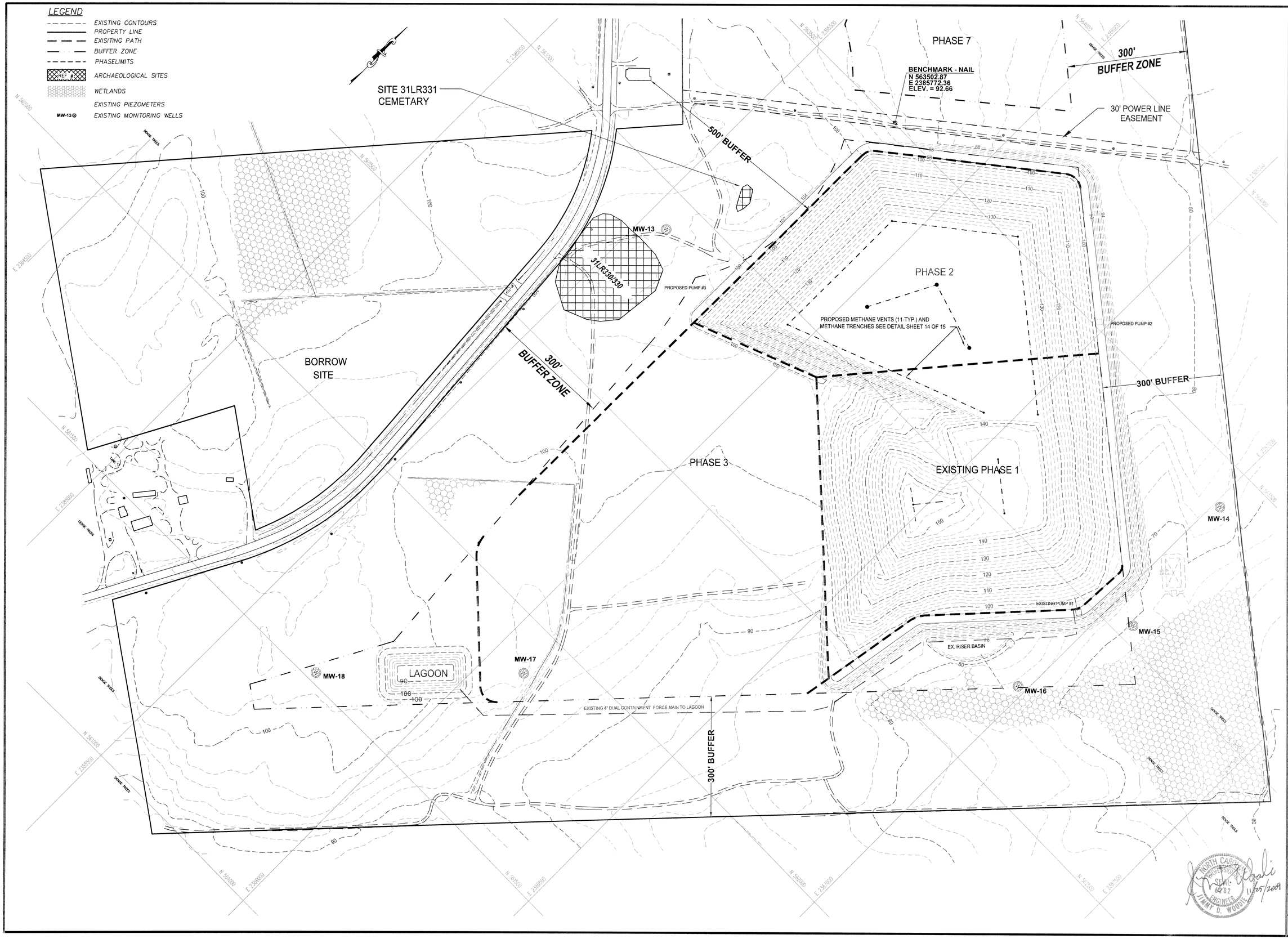

Municipal Services
LICENSE NUMBER: C-0281
P.O. BOX 97 GARNER, N.C. 27529
(919) 772-5393

Engineering Company, P.A.
P.O. BOX 349 BOONE, N.C. 28607
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MUNICIPAL SOLID WASTE LANDFILL FACILITY
LENOIR COUNTY NORTH CAROLINA

DATE	BY	REV.	DESCRIPTION

ENGINEERING PLAN – PHASE 2
FINAL FILL WITH METHANE VENTING

SCALE:	1" = 100'
DATE:	10/20/09
DRWN. BY:	L. HAMPTON
CHKD. BY:	J. WOODIE
PROJECT NUMBER	G08095
DRAWING NO.	E11
SHEET NO.	13 OF 15

NORTH CAROLINA PROFESSIONAL SEAL 042 ENGINEER JIMMY D. WOODIE
11/25/2009

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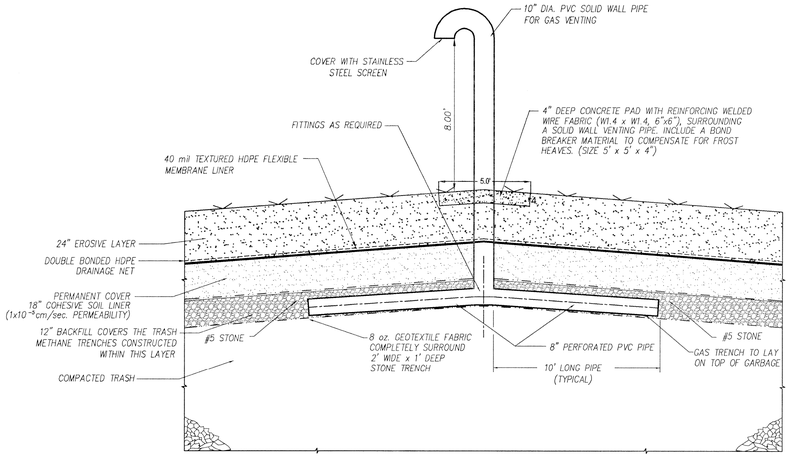
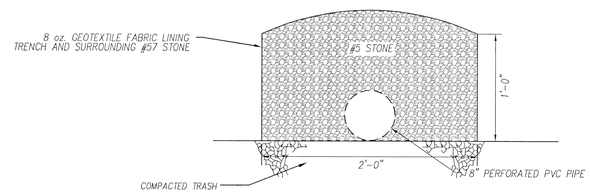


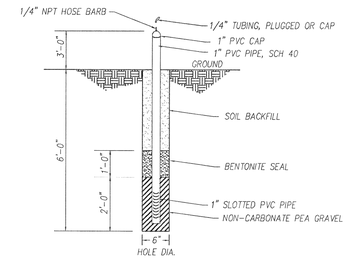
TYPICAL METHANE GAS COLLECTION TRENCH CLOSURE DETAIL AND CAP COVER DETAIL

N.T.S.



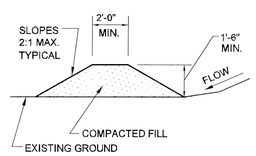
PERMANENT METHANE TRENCH DETAIL

N.T.S.



METHANE GAS MONITORING PROBE

N.T.S.



TEMPORARY STORMWATER DIVERSION BERM DETAIL

N.T.S.

NORTH CAROLINA PROFESSIONAL SEAL 7282 ENGINEER JIMMY D. WOODIE

J. Woodie 11/25/2009

Municipal Services Engineering Company, P.A.
LICENSE NUMBER: C-0281
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MUNICIPAL SOLID WASTE LANDFILL FACILITY
LENOIR COUNTY
NORTH CAROLINA

DATE	BY	REV.	DESCRIPTION

ENGINEERING PLAN–PHASE 2
OPERATION DETAILS

SCALE: 1:1
DATE: 10/22/09
DRWN. BY: L. HAMPTON
CHKD. BY: J. WOODIE
PROJECT NUMBER G08095
DRAWING NO. E12
SHEET NO. 14 OF 15

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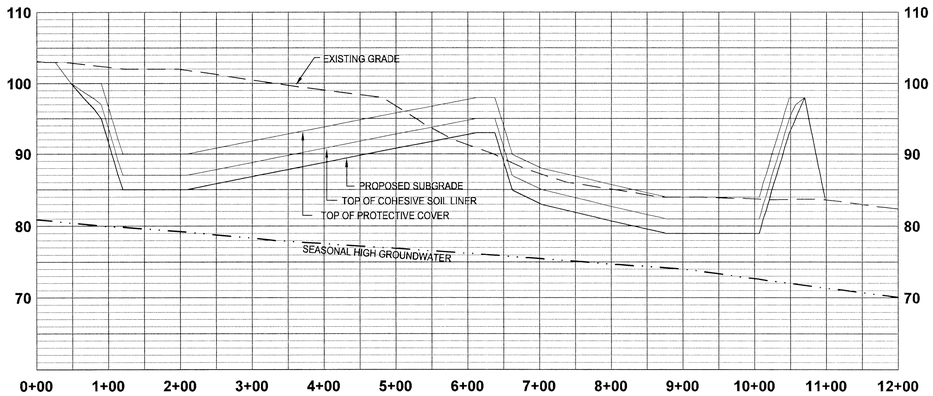
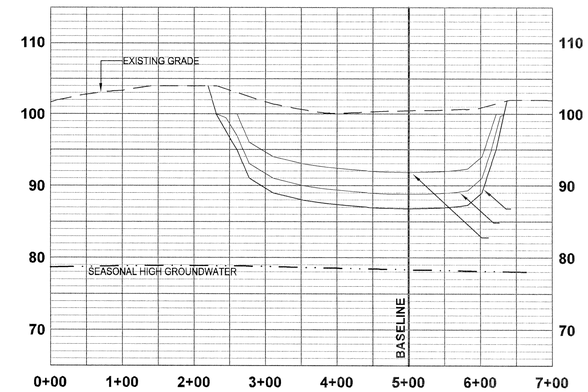


BASELINE PROFILE

SCALE: HOR.: 1" = 100'
VERT.: 1" = 10'

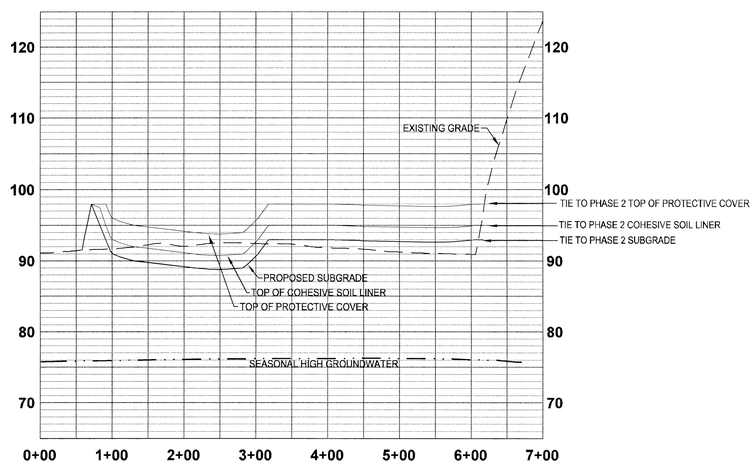


STATION 3+00

SCALE: HOR.: 1" = 100'
VERT.: 1" = 10'

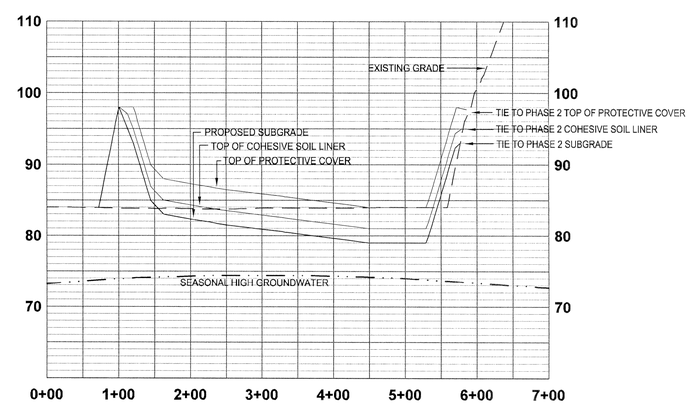
NOTE

THESE CROSS SECTIONS ARE INTENDED TO SHOW THE CROSS SECTIONS AT SPECIFIC POINTS AS DEFINED BY THE BASELINE GRID ON SHEET 3 OF 15. THEY ARE NOT INTENDED TO BE THE SOLE MEANS FOR CALCULATING THE EARTHWORK FOR THIS PROJECT.



STATION 6+00

SCALE: HOR.: 1" = 100'
VERT.: 1" = 10'



STATION 9+00

SCALE: HOR.: 1" = 100'
VERT.: 1" = 10'

Municipal Engineering Services Company, P.A.
LICENSE NUMBER: C-0281
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MUNICIPAL SOLID WASTE LANDFILL FACILITY
LENOIR COUNTY
NORTH CAROLINA

DATE	BY	REV.	DESCRIPTION

ENGINEERING PLAN – PHASE 2
BASELINE PROFILE AND CROSS SECTIONS

SCALE: 1" = 100'
DATE: 10/5/09
DRWN. BY: L. HAMPTON
CHKD. BY: J. WOODIE
PROJECT NUMBER G08095
DRAWING NO. E13
SHEET NO. 15 OF 15

NORTH CAROLINA PROFESSIONAL SEAL 6282 ENGINEER JIMMY D. WOODIE
11/25/2009

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SECTION 3.0

MATERIALS AND CONSTRUCTION PRACTICES

All tests indicated in this section are described in Section 4.0 Construction Quality Assurance Plan. Tests mentioned in this section are the same tests indicated in Section 4.0.

3.1 Construction Sequence

1. Clear all areas necessary for construction of Riser Basins.
2. Construct Riser Basins.
3. Permanently seed all disturbed areas.
4. Prepare Subbase.
5. Construct Base Liner System.
6. Construct Penetrations.
7. Construct Protective cover over the Base Liner System.
8. Excavate the Leachate Trenches.
9. Construct Leachate Collection System.
10. Construct the pumps and force main from Leachate Collection System to the Lagoon.
11. Permanently seed any disturbed areas

3.2 Subbase

The fill subgrade will be placed in 8" loose lifts and compacted to at least 95% of maximum dry density and near optimum moisture contents; as determined by Standard Proctor Compaction Test (ASTM D698)' in 6" compacted lifts. Each compacted lift will be tested at one test per six inch (6") lift for each 200 linear feet or fraction thereof of compacted berm (s) less than 50 feet in base width and one test per six (6) inch lift for each 10,000 square feet or fraction thereof of compacted mass fill. If an area fails, it shall be recompacted, reworked or replaced and retested.

Before beginning construction of the base liner system, the project engineer shall visually inspect the exposed surface to evaluate the suitability of the subgrade and document that the surface is properly prepared and that the elevations are consistent with the Division approved engineering plans. The elevations will be verified from survey data based on a 50 foot grid across the subbase.

At a minimum, the subgrade shall be proof-rolled at cut sections utilizing a fully loaded tandem dump truck or equivalent. If movement of the subbase is observed under the tires, the section of movement will be removed and replaced with suitable fill material. This newly placed fill material will then be tested for proper density and moisture.

3.3 Base Liner System

3.3.1 Materials and Construction Practices for Cohesive Soil Liner

All materials and equipment shall be new and shall be of first class ingredients and construction, designed and guaranteed to perform the service required and shall conform with the following standard specifications or shall be the product of the listed manufacturers or similar and equal thereto as approved by the Engineer.

The soil for the cohesive soil liner shall consist of the red, orange, clayey silt on-site soils passing the No. 200 Sieve and a permeability of 1.0×10^{-7} cm/sec or less for the base liner system is achieved. Off-site cohesive soils may be used if approved by the Engineer and provides a permeability of 1.0×10^{-7} cm/sec or lower for the base liner system. Wyoming bentonite or an approved equivalent may be blended with the soil to lower the soil's permeability.

A permeability "window" shall be developed for each type of soil from the borrow material that will be used for construction of the cohesive soil liner. The window is developed from the accepted remolded samples and moisture contents from the semi-log plot. A straight line is typically drawn between the acceptable points on the moisture-density curve to indicate a range of probable acceptable permeability results. The window will be used in the construction of the test strip to verify the laboratory remolded permeability results.

A test strip of compacted cohesive soil liner shall be prepared to create a permeability "window" prior to general installation of the cohesive soil liner. The test strip will be used to verify the results from the remolded permeabilities from the borrow site utilizing the permeability window(s) for each soil type that is going to be used for construction of the cohesive soil liner. The test strip shall be approximately 2,500 sq. ft. in surface area and constructed to conform geometrically to the site topography with a minimum lateral dimension in any direction of 25 ft. The test strip shall consist of at least four compacted 6 inch lifts of cohesive soil liner. The test strip may be used as an integral part of the overall cohesive soil liner if it meets the required specification for the liner.

After the test strip passes, soil liner will be placed to the total thickness shown on the plans in maximum 8-inch thick loose lifts with a maximum 6" compacted lift. A sheepsfoot roller or approved alternative may be used to compact the soil liner provided the compaction and permeability requirements can be achieved. Each lift shall be tested for permeability, moisture content, particle size distribution analysis, Atterberg limits, moisture-density-permeability relation, and if needed percent bentonite admixed with soil, prior to the placement of the succeeding lift and visually inspected to confirm that all soil clods have been broken and that the surface is sufficiently scarified so that adequate bonding can be achieved. Soils for cohesive soil liner shall be screened, disked, or prepared using any other, approved method as necessary to obtain a homogeneous cohesive soil with clod sizes in a soil matrix no larger than about 1.5 inches in maximum diameter. The soil liner must be a minimum of 2.0 feet thick. No additional construction shall proceed on the soil liner at the area being tested until the Engineer has reviewed the results of the tests and judged the desired permeability is being achieved. If the soil for the cohesive soil liner is incapable of achieving the required permeability when compacted, bentonite or approved alternative may be mixed with the soils to decrease the permeability. The amount of additive required must be determined in the laboratory.

The thickness and grade of the soil liner will be verified by the engineer before placement of the geomembrane liner. The thickness and grade will be verified by surveying the clay at 50' grid points where the elevations of the subbase will be checked with the top of soil liner to verify 2.0 feet of soil liner. The grade will then be verified with the surveyed information. The survey will be performed by NC licensed surveyors.

Surfaces to be lined shall be smooth and free of debris, roots, and angular or sharp rocks larger than three-eight (3/8) inches in diameter to a depth of six (6) inches. The cohesive soil liner shall have no sudden sharp or abrupt changes in grade. The Contractor shall protect the cohesive soil liner from desiccation, flooding and freezing. Protection, if required, may consists of a thin plastic protective cover, (or other material as approved by the engineer) installed over the completed cohesive soil liner until such time as the placement of flexible membrane liner begins. Areas found to have any desiccation cracks or which exhibit swelling, heaving or other similar conditions will be replaced or reworked by the contractor to remove these defects.

The anchor trench shall be excavated by the Contractor to lengths and widths shown on the design drawings prior to geomembrane placement. Anchor trenches excavated in clay soils susceptible to desiccation cracks should be excavated only the distance required for that days liner placement to minimize the potential of desiccation cracking of the clay soils. Corners in the anchor trench shall be slightly rounded where the geomembrane adjoins the trench to minimize sharp bends in the geomembrane.

Upon request, the Flexible Membrane Liner manufacturer installer shall provide the Engineer with a written acceptance of the surface prior to commencing installation. Subsequent repairs to the cohesive soil liner and the surface shall remain the responsibility of the contractor.

3.3.2. Materials and Construction Practices for Flexible Membrane Liner

All materials and equipment shall be furnished by an established and reputable manufacturer or supplier. All materials and equipment shall be new and shall be of first class ingredients and construction, designed and guaranteed to perform the service required and shall conform with the following standard specifications or shall be the product of the listed manufacturers or similar and equal thereto as approved by the Engineer.

60 mil High Density Polyethylene (HDPE) – Geosynthetic Research Institute (GRI) GM 13 – is to be placed in direct contact with moist cohesive soil liner. The Landfill itself is single lined and will only have a Textured Geomembrane. The extrusion rods and/or brads used in seaming the rolls together shall be derived from the same base resin as the liner.

Prior to commencement of liner deployment, layout drawings shall be produced to indicate the panel configuration and location of seams for the project. Each panel used for the installation shall be given a numeric or alpha-numeric identification number consistent with the layout drawing. This identification number shall be related to manufacturing roll number that identifies the resin type, batch number and date of manufacture. The Flexible Membrane Liner Manufacturer/Installer shall install field panels at the location indicated on the layout drawing. If the panels are deployed in a location other than that indicated on the layout drawings, the revised location shall be noted in the field on a layout drawing which will be modified at the completion of the project to reflect actual panel locations.

Geomembrane deployment shall not be carried out during any precipitation, nor in the presence of excessive moisture (i.e. fog, dew), in an area of standing water, or during high winds. The method and equipment used to deploy the panels must not damage the geomembrane or the supporting subgrade surface. No personnel working on the geomembrane will smoke, wear shoes that can damage the geomembrane, or engage in actions which could result in damage to the geomembrane. Adequate temporary loading and/or anchoring, (i.e. sandbags, tires), which will not damage the geomembrane, will be placed to prevent uplift of the geomembrane by wind. If uplift occurs, additional sandbags will be placed in necessary areas. The geomembrane will be deployed in a manner to minimize wrinkles. Any area of a panel seriously damaged (torn, twisted, or crimped) will be marked, cut out and removed from the work area with resulting seaming and/or repairs performed. In general, seams shall be oriented parallel to the slope, i.e., oriented along, not across the slope. Whenever possible, horizontal seams should be located not less than five (5) feet from the toe of the slope. Each seam made in the field shall be numbered in a manner that is compatible with the panel layout drawing for documentation of seam testing results.

All personnel performing seaming operations shall be trained in the operation of the specific seaming equipment being used and will qualify by successfully welding a test seam. The project foreman will provide direct supervision of all personnel seaming to verify proper welding procedures are followed. Qualified liner installers, seamers, and the liner foreman shall meet a minimum requirement of 1,000,000 square feet of geomembrane installation. There are no other minimum qualifications needed by other parties.

The flexible membrane liner will be welded together by fusion and extrusion fillet welding methods. Fusion Welding consists of placing a heated wedge, mounted on a self propelled vehicular unit, between two (2) overlapped sheets such that the surface of both sheets are heated above the polyethylene's melting point. After being heated by the wedge, the overlapped panels pass through a set of preset pressure wheels which compress the two (2) panels together so that a continuous homogeneous fusion weld is formed. The fusion welder is equipped with a temperature readout device which continuously monitors the temperature of the wedge. Extrusion fillet welding consists of introducing a ribbon of molten resin along the edge of the seam overlap of the two (2) sheets to be welded. The molten polymer causes some of the material of each sheet to be liquefied resulting in a homogeneous bond between the molten weld bead and the surfaces of the sheets.

The Flexible Membrane Liner Manufacturer/Installer will rely on the experience of the Project Superintendent and the results of test seams to determine seaming restrictions by weather. Many factors, such as ambient temperature, humidity, wind, sunshine, etc., can affect the integrity of field seams and must be taken into account when deciding whether or not seaming should proceed. Responsibility for monitoring these conditions shall lie with the Project Superintendent; however, the Engineer may suspend any seaming operation which is, in his opinion, at the risk of providing the Owner with a quality product. Test seams are required prior to daily production seaming to determine if the weather conditions will affect the Flexible Membrane Liner System's ability to produce quality seams. Additional non-destructive and destructive testing of production seams may substantiate the decision made by the Project Superintendent to seam on any given day. Fusion Welding is done by first overlapping panels of geomembrane approximately four (4) inches, next clean the seam area prior to seaming to assure the area is clean and free of moisture, dust, dirt, debris of any kind. No grinding is required for fusion welding. Next, adjust the panels so that seams are aligned with the fewest possible number of wrinkles and "fishmouths". A movable protective layer may be used, at the discretion of the Flexible Geomembrane Liner System Project Superintendent, directly below the overlap of geomembrane that is to be seamed to prevent build-up of moisture between the panels.

Extrusion Welding is done by overlapping panels of geomembrane a minimum of three (3) inches and temporarily bond the panels of geomembrane to be welded taking care not to damage the geomembrane. Next grind seam overlap prior to welding within one (1) hour of welding operation in a manner that does not damage the geomembrane. Limit grinding to ¼" outside of the extrusion weld area. Clean the seam area prior to seaming to assure the area is clean and free of moisture, dust, dirt, and debris of any kind. Purge the extruder prior to beginning the seam to remove all heat degraded extrudate from the barrel. Keep welding rod clean and off the ground.

At a minimum, test seams shall be made upon each start of work for each seaming crew, 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. Test seams shall be made on fragment pieces of the geomembrane liner and under the same conditions as actual seams. The test seam shall be at least three (3) feet long and should be made by joining two (2) pieces of geomembrane at least 9" in width. Visually inspect the seam for squeeze out, footprint, pressure and general appearance. Two random samples one (1) inch wide shall be cut from the test seam. The specimens shall then be tested in peel using a field tensiometer and shall not fail in the seam. If a specimen fails the entire procedure shall be repeated. If any of the second set of specimens fail, the seaming apparatus shall not be accepted and shall not be used for seaming until the deficiencies are corrected and a passing test seam is achieved. After completion of these tests, the remaining portion of test seam can be discarded. Documentation of the test seams will be maintained listing seam identification number, welder's name, temperature control setting and test results. Passing test results records shall be maintained.

Seaming shall extend to the outside edge of panels to be placed in the anchor trench. While welding a seam, monitor and maintain the proper overlap. Inspect seam area to assure area is clean and free of moisture, dust, dirt, debris of any kind. While welding a seam, monitor temperature gauges to assure proper settings are maintained and that the seaming apparatus is operating properly. Align wrinkles at the seam overlap to allow welding through the wrinkle. Fishmouths or wrinkles at seam and overlaps that cannot be welded through shall be cut along the ridge in order to achieve a flat overlap. The cut fishmouth or wrinkle shall be seamed. Any portion where the overlap is inadequate shall be patched with an oval or round patch of the same geomembrane extending a minimum of six (6) inches beyond the cut in all directions. All cross/butt seams between two (2) rows of seamed panels shall be welded during the coolest time of the day to allow for contraction of the geomembrane. All "T" joints shall have the overlap from the wedge welder seam trimmed back to allow an extrusion fillet weld. Then grind two (2) inches minimum on either side of the wedge seam, then extrusion weld all of the area prepared by grinding.

The installation crews will non-destructively test all field seams over their full length using air pressure testing, vacuum testing or other approved methods, to verify the continuity and integrity of the seams.

Air pressure testing will be conducted. The welded seam created by double hot-wedge fusion welding process is composed of two distinct welded seams separated by an unwelded channel approximately 3/8 of an inch between the two welded seams permits the double hot-wedge fusion seams to be tested by inflating the sealed channel with air to a predetermined pressure, and observing the stability of the pressurized channel over time. An air pump with rubber hose and sharp hollow needle (manual or motor driven) capable of generating and sustaining a pressure between 25 to 30 psi will be used to test the seam. Seal both ends of the seam to be tested. Insert needle or other approved pressure feed device into the sealed channel created by the fusion weld. Inflate the test channel to a pressure between 27 to 30 psi, close valve, and observe initial pressure after approximately 2 minutes. For the 60 mil HDPE liner the seam has to have a minimum initial pressure of 27 psi and a maximum initial pressure of 30 psi. Initial pressure settings are read after a two minute "relaxing period". The purpose of this "relaxing period" is to permit the air temperature and pressure to stabilize. Observe and record the air pressure five (5) minutes after "relaxing period" ends and when initial pressure setting is used. If loss of pressure exceeds 3 psi or if the pressure does not stabilize, locate faulty area and repair. At the conclusion of the pressure test the end of the seam opposite the pressure gauge is cut. A decrease in gauge pressure must be observed or the air channel will be considered "blocked" and the test will have to be repeated after the blockage is corrected. Remove needle or other approved pressure feed device and seal resulting hole by extrusion welding.

In the event of a Non-Complying Air Pressure Test, check the seam end seals and retest seams. If non-compliance with specified maximum pressure differential re-occurs, repair the seam. When two (2) passing samples are located, the seam between these two (2) locations will be considered non-complying. Capping or removal are the only two (2) acceptable methods of repairing failed seams. Non-destruct test the entire length of the repaired seam.

Vacuum testing will be conducted when the geometry of the weld makes air pressure testing impossible or impractical or when attempting to locate the precise location of a defect believed to exist after air pressure testing. The penetration will be tested using this method.

Vacuum box assembly consists of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, port hole or valve assembly, a vacuum gauge, vacuum pump assembly equipped with a pressure controller and pipe connection, a rubber pressure/vacuum hose with fittings and connections, a bucket and means to apply a soapy solution.

The procedure for Vacuum Testing is to trim excess overlap from seam, if any. Turn on the vacuum pump to reduce the vacuum box to approximately 5 inch of mercury, i.e., 5 psi. Apply a generous amount of a solution of strong liquid detergent and water to the area to be tested. Place the vacuum box over the area to be tested and apply sufficient downward pressure to "seat" the seal strip against the liner. Close the bleed valve and open the vacuum valve. Apply a minimum of 5 in. Hg vacuum to the area as indicated by the gauge on the vacuum box. Ensure that a leak tight seal is created. For a period of not less than 30 seconds, examine the geomembrane through the viewing window for the presence of soap bubbles. If no bubbles appear after 30 seconds, close the vacuum valve and open the bleed valve, move the box over the next adjoining area with a minimum 3 in. overlap, and repeat the process. The procedure for Non-Complying Testis to mark all areas where soap bubbles appear and repair the marked areas. Retest repaired areas.

The procedure for Destructive Testing is to determine and evaluate seam strength. These tests require direct sampling and thus subsequent patching. Therefore destructive testing should be held to a minimum to reduce the amount of repairs to the geomembrane. All destructive tests will be done according to ASTM D4437. The sample should be twelve (12) inches wide with a seam fourteen (14) inches long centered lengthwise in the sample. The sample may be increased in size to accommodate independent laboratory testing by the owner at the owner's request or by specific project specifications. A one (1) inch sample shall be cut from each end of the test seam for field testing. The two (2), one (1) inch wide samples shall be tested in the field in a tensiometer for peel ASTM D4437. Tensile strength is essentially a measurement of the greatest tension stress a substance can bear without tearing. If the

liner tears before any part of the seam does the test is successful. If any field sample fails to pass, it will be assumed the sample fails destructive testing. Destructive samples will be taken every 500 ft. of seam.

In the event of Destructive Test Failure, cut additional field samples for testing. In the case of a field production seam, the samples must lie a minimum of ten (10) feet in each direction from the location of the failed sample. Perform a field test for peel strength. If these field samples pass, then laboratory samples can be cut and forwarded to the laboratory for full testing. All destructive seam samples sent to the Flexible Membrane Liner System's laboratory shall be numbered. If the laboratory samples pass then repair the seam between the two (2) passing samples locations. All passing seams must be bounded by two (2) locations from which samples passing laboratory destructive tests have been taken. Capping or removal of the failed seam are the only two (2) acceptable methods for repairing failed seams.

The Project Superintendent shall conduct a detailed walk through and visually check all seams and non-seam areas of the geomembrane for defects, holes, blisters and signs of damage during installation. All other installation personnel shall, at all times, be on the lookout for any damaged areas. Damaged areas shall be marked and repaired.

Any portion of the geomembrane showing a flaw or failing a destructive or non-destructive test shall be repaired. Several procedures exist for repair and the decision as to the appropriate repair procedure shall be made by the Project Superintendent. Repairs need to be made in a timely matter to protect the moist cohesive soil liner and flexible membrane liner. If inclement weather is approaching, steps need to be made to protect the cohesive soil liner such as a temporary cover. If cohesive soil liner is damaged, it must be reworked. Procedures available for repair are (1)Patching - used to repair large holes, tears and destructive sample locations. All patches shall extend at least six (6) inches beyond the edges of the defect and all corners of patches shall be rounded, (2) Grinding and welding - used to repair sections of extruded seams, (3) Spot welding or seaming - used to repair small tears, pinholes or other minor localized flaws, (4) Capping - used to repair lengths of failed seams, (5) Removal of a bad seam and replacement with a strip of new material seamed into place.

Every repair shall be non-destructively tested. Repairs which pass the non-destructive test shall be deemed adequate. Large repairs may require a destructive test. Repair test results shall be logged. The repair location shall be recorded on an as built drawing.

3.4 Alternate Liner System

3.4.1 Materials and Construction Practices for Cohesive Soil Liner

All materials and equipment shall be new and shall be of first class ingredients and construction, designed and guaranteed to perform the service required and shall conform with the following standard specifications or shall be the product of the listed manufacturers or similar and equal thereto as approved by the Engineer.

The soil for the cohesive soil liner shall consist of the red, orange, clayey silt on-site soils, if the mica content is less than 0.5 percent by weight passing the No. 200 Sieve and a permeability of 1.0×10^{-5} cm/sec or less, is achieved. Off-site cohesive soils may be used if approved by the Engineer and provides a permeability of 1.0×10^{-5} cm/sec or lower. Wyoming bentonite or an approved equivalent may be blended with the soil to lower the soil's permeability.

A permeability "window" shall be developed for each type of soil from the borrow material that will be used for construction of the cohesive soil liner. The window is developed from the accepted remolded samples and moisture contents from the semi-log plot. A straight line is typically drawn between the acceptable points on the moisture-density curve to indicate a range of probable acceptable permeability results. The window will be used in the construction of the test strip to verify the laboratory remolded permeability results.

A test strip of compacted cohesive soil liner shall be prepared to create a permeability "window" prior to general installation of the cohesive soil liner. The test strip will be used to verify the results from the remolded permeabilities from the borrow site utilizing the permeability window(s) for each soil type that is going to be used for construction of the cohesive soil liner. The test strip shall be approximately 2,500 sq. ft. in surface area and constructed to conform geometrically to the site topography with a minimum lateral dimension in any direction of 25 ft. The test strip shall consist of at least three compacted 6 inch lifts of cohesive soil liner. The test strip may be used as an integral part of the overall cohesive soil liner if it meets the required specification for the liner.

After the test strip passes, soil liner will be placed to the total thickness shown on the plans in maximum 8-inch thick loose lifts with a maximum 6" compacted lift. A sheepsfoot roller or approved alternative may be used to compact the soil liner provided the compaction and permeability requirements can be achieved. Each lift shall be tested for permeability, moisture content, particle size distribution analysis, Atterberg limits, moisture-density-permeability relation, and if needed percent bentonite admixed with soil, prior to the placement of the succeeding lift and visually inspected to confirm that all soil clods have been broken and that the surface is sufficiently scarified so that adequate bonding can be achieved. Soils for cohesive soil liner shall be screened, disked, or prepared using any other, approved method as necessary to obtain a homogeneous cohesive soil with clod sizes in a soil matrix no larger than about 1.5 inches in maximum diameter. The soil liner must be a minimum of 1.5 feet thick. No additional construction shall proceed on the soil liner at the area being tested until the Engineer has reviewed the results of the tests and judged the desired permeability is being achieved. If the soil for the cohesive soil liner is incapable of achieving the required permeability when compacted, bentonite or approved alternative may be mixed with the soils to decrease the permeability. The amount of additive required must be determined in the laboratory.

The thickness and grade of the soil liner will be verified by the engineer before placement of the geomembrane liner. The thickness and grade will be verified by surveying the clay at 50' grid points where the elevations of the subbase will be checked with the top of soil liner to verify 1.5 feet of soil liner. The grade will then be verified with the surveyed information. The survey will be performed by NC licensed surveyors.

Surfaces to be lined shall be smooth and free of debris, roots, and angular or sharp rocks larger than three-eight (3/8) inches in diameter to a depth of six (6) inches. The cohesive soil liner shall have no sudden sharp or abrupt changes in grade. The Contractor shall protect the cohesive soil liner from desiccation, flooding and freezing. Protection, if required, may consists of a thin plastic protective cover, (or other material as approved by the engineer) installed over the completed cohesive soil liner until such time as the placement of flexible membrane liner begins. Areas found to have any desiccation cracks or which exhibit swelling, heaving or other similar conditions will be replaced or reworked by the contractor to remove these defects.

The anchor trench shall be excavated by the Contractor to lengths and widths shown on the design drawings prior to geomembrane placement. Anchor trenches excavated in clay soils susceptible to desiccation cracks should be excavated only the distance required for that days liner placement to minimize the potential of desiccation cracking of the clay soils. Corners in the anchor trench shall be slightly rounded where the geomembrane adjoins the trench to minimize sharp bends in the geomembrane.

Upon request, the Flexible Membrane Liner manufacturer installer shall provide the Engineer with a written acceptance of the surface prior to commencing installation. Subsequent repairs to the cohesive soil liner and the surface shall remain the responsibility of the contractor.

3.4.2. Materials and Construction Practices for Geosynthetic Clay Liner(GCL)

The Contractor shall furnish all labor, materials, supervision and equipment to complete the installation of the GCL, including, but not limited to, liner layout, seaming, patching, and all necessary and incidental items required to complete the Work, in accordance with the Contract Drawings and these Specifications.

Sufficient liner material shall be furnished to cover all lined areas shown on the Drawings, including overlaps at field seams and anchor trenches.

The GCL Manufacturer must have produced at least 10 million square feet (1 million square meters) of GCL, with at least 8 million square feet (800,000 square meters) installed. The manufacturer shall submit certification that GCL manufactured for the Project has been produced in accordance with these Specifications along with results from a quality control program. This information must be submitted for review prior to material delivery. The Engineer reserves the right to halt installation until proper certification is submitted and determined acceptable for use.

The Contractor shall submit to the Engineer, six (6) full sets of panel layout construction drawings. Drawings shall be submitted to the Engineer at least two (2) weeks prior to installation.

The manufacturer of the GCL used in this work shall approve all shop drawings and a proposed liner layout to cover the lined area shown on the Drawings.

Details shall be included to show the termination of the liner at the perimeter of lined areas, the methods of sealing around penetrations, and methods of anchoring. A specific anchor trench detail shall be provided.

The Contractor shall submit to the Engineer a physical sample of the liner to be used. The sample shall be labeled with the manufacturer's name, product identification, lot number and roll number.

Upon shipment, the Contractor shall furnish the GCL manufacturer's Quality Assurance/Quality Control (QA/QC) certifications to verify that the materials supplied for the project are in accordance with the requirements of this specification. The Contractor shall also submit to the Engineer inventory tickets, roll numbers or batch identifications, packing papers, and invoices for the liner used.

As installation proceeds, the Contractor shall submit certificates of subgrade acceptance to the Engineer, signed by the Contractor and the GCL Installer for each area that is covered by the GCL.

The Contractor shall provide personnel resumes demonstrating compliance with the following requirements.

1. A project reference list for the GCL(s) consisting of the principal details of at least ten projects totaling at least 10 million square feet (100,000 square meters) in size.

2. A minimum of one field superintendent per shift shall be designated by the Contractor and approved by the Engineer. Each field superintendent shall have a minimum of three years and five million square feet of field experience in installing GCL's. Any change or replacement of superintendent during the Project must be approved by the Engineer.

3. Liner placement technicians shall have a minimum of one year and one million square feet of GCL placement experience.

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. The Contractor also must obtain prior approval of the alternative GCL by the Project Engineer.

Reinforced GCL must be used on all areas of the site. An acceptable GCL product is Bentomat® ST as manufactured by CETCO or an engineer-approved equal. All areas of the project requiring reinforced GCL will be furnished with Bentomat® ST or an engineer-approved equal. The minimum acceptable dimensions of full-size GCL panels shall be 150 feet (45.7m) in length and 15 feet (4.6m) in width for Bentomat. Short rolls [(those manufactured to a length greater than 70 feet (21m) but less than a full-length roll)] may be supplied at a rate of no greater than 3 per truckload or 3 rolls for every 36,000 square feet (3,500 square meters) of GCL, whichever is less. A 6-inch (150mm) overlap guideline shall be imprinted on both edges of the upper geotextile component of the GCL as a means for providing assurance of the overlap dimension. Lines shall be printed in easily visible, non-toxic ink.

The GCL manufacturer/Contractor shall provide the Engineer with manufacturing QA/QC certifications for each shipment of GCL, prior to the deployment of GCL. The certifications shall be signed by a responsible party employed by the GCL manufacturer, such as the QA/QC Manager, Production Manager, or Technical Services Manager, and shall include:

A. Certificates of analysis for the bentonite clay used in GCL production demonstrating compliance with the parameters swell index and fluid loss shown in CETCO's Technical Data Sheet TR404bm.

B. Manufacturer's test data for finished GCL products(s) of bentonite mass/area, GCL tensile strength, and GCL peel strength demonstrating compliance with the index parameters shown in CETCO's Technical Data Sheet TR404bm.

C. GCL lot and roll numbers supplied for the project (with corresponding shipping information).

D. Manufacturer's test data for finished GCL product(s) including GCL index flux, permeability, and hydrated internal shear strength data demonstrating compliance with the performance parameters shown in CETCO's Technical Data Sheet TR404bm.

Prior to shipment, the GCL manufacturer shall label each roll, identifying: product identification information (Manufacturer's name and address, brand name, product code), lot number, roll number, roll length, width, and weight.

The GCL shall be wound around a rigid core whose diameter is sufficient to facilitate handling. The core is not necessarily intended to support the roll for lifting but should be sufficiently strong to prevent collapse during transit. All rolls shall be labeled and bagged in packaging that is resistant to photo degradation by ultraviolet (UV) light.

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.

CETCO GCL's are delivered in rolls weighing from 2,500 - 2,700 lbs (1,140-1,225 kg). It is necessary to support this weight using an appropriate core pipe. For any installation, the core pipe must not deflect more than 3 inches (75 mm) as measured from end to midpoint when a full GCL roll is lifted. Lifting chains or straps rated for at least twice the load of the GCL should be used in combination with a spreader bar made from an I-beam. The spreader bar ensures that the lifting chains or straps do not chafe against the ends of the GCL roll, which must be able to rotate freely during installation.
A front end-loader, backhoe, dozer, or other equipment can be furnished with the spreader bar and core bar. Alternatively, a forklift with a "stinger" attachment may be used for on-site handling and, in certain cases, installation. **A forklift without a stinger attachment shall not be used to lift or handle the GCL rolls.**

When installing over certain geosynthetic materials, a 4-wheel all-terrain vehicle (ATV) can be used to deploy the GCL from behind. An ATV can be driven directly on the GCL provided that no sudden stops, starts, or turns are made.

Additional equipment needed for installation of CETCO's GCL's include:

- Utility knife and spare blades (for cutting the GCL).
- Granular bentonite or bentonite mastic (for overlapped seams of GCLs with needle punched non-woven geotextiles and for sealing around structures and details).
- Waterproof tarpaulins (for temporary cover on installed material as well as or stockpiled rolls).
- Optional chalk line marker to simplify bentonite placement at seams (when installing a GCL with needle punched non-woven geotextile components).
- Optional flat-bladed vise grips (for positioning the GCL panel by hand).

The manufacturer assumes responsibility for initial loading the GCL. Shipping will be the responsibility of the party paying the freight. Unloading, on-site handling, and storage of the GCL are the responsibility of the Contractor, Installer, or other designated party. A visual inspection of each roll should 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. The party responsible for unloading the GCL should contact the Manufacturer prior to shipment to ascertain the appropriateness of the proposed unloading methods and equipment.

Storage of the GCL rolls shall be the responsibility of the installer. A dedicated storage area shall be selected at the job site that is away from high traffic areas and is level, dry, and well-drained. Rolls should be stored in a manner that prevents sliding or rolling from the stacks and may be accomplished by the use of chock blocks or by use of the dunnage shipped between rolls. Rolls should be stacked at a height no higher than that at which the lifting apparatus can be safely handled (typically no higher than four). Rolls shall never be stacked on end. All stored GCL materials and the accessory bentonite must be covered with a plastic sheet or tarpaulin until their installation. The integrity and legibility of the labels shall be preserved during storage.

Any surface upon which the GCL is installed shall be prepared and compacted in accordance with the project specifications and drawings. The surface shall be smooth, firm, and unyielding, and free of vegetation, any debris, sticks, sharp rocks, void spaces, ice, abrupt elevation changes, standing water, cracks larger than one-quarter inch (6mm) in width, and any other foreign matter that could contact the GCL. 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 No. 60 sieve (0.250 mm). Immediately prior to GCL deployment, the subgrade shall be final-graded to fill in all voids or cracks and then smooth-rolled to provide the best practicable surface for the GCL. At completion of this activity, no wheel ruts, footprints or other irregularities shall exist in the subgrade. Furthermore, all protrusions extending more than one-half inch (12mm) from the surface shall either be removed, crushed or pushed into the surface with a smooth-drum compactor. On a continuing basis, the Contractor/GCL Installer shall submit certifications of subgrade acceptance to the Engineer, and the project CQA inspector shall verify acceptance of the subgrade before GCL placement.

It shall be the installer's responsibility thereafter to indicate to the Engineer any change in the condition of the subgrade that could cause the subgrade to be out of compliance with any of the requirements listed in this Section. At the top of sloped areas of the job site, an anchor trench for the GCL shall be excavated in accordance with the project plans and specifications. The

excavated trench shall be verified by the CQA Inspector 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.

Placement of the GCL shall be conducted in accordance with the manufacturer's recommendations and with the direction provided herein. Any deviations from these procedures must be pre-approved by the CQA Engineer.

The contractor shall not install any GCL on this project, at any time, in the absence of the CQA inspector. During start-up of the GCL installation, an agent or representative of the Manufacturer shall provide on-site assistance and instruction to the Contractor and CQA Engineer regarding the appropriate installation techniques. The CQA Inspector/Engineer shall inspect each panel, after placement and prior to seaming, for damage and/or defects. All defects and deficiencies shall be properly documented by the GCL Installer and CQA Inspector. Defective or damaged panels shall be replaced or repaired, as approved by the CQA Inspector/Engineer. The Contractor will correct defects and deficiencies to the satisfaction of the Engineer. The CQA Inspector shall observe and verify all repaired defects. Reinforced GCL shall be placed on all areas of the site. GCL rolls should be delivered to the working area of the site in their original packaging. Immediately prior to deployment, the packaging should be carefully removed without damaging the GCL. The orientation of the GCL (i.e., which side faces up) may be important if the GCL has two different geotextiles. Unless otherwise specified, however, the GCL shall be placed with the white side (non-woven) geotextile facing down. The GCL shall be properly weighted to avoid uplift due to wind. Equipment which could damage the GCL shall not be allowed to travel directly on it. Acceptable installation, therefore, may be accomplished such that the GCL is unrolled in front of the backwards-moving equipment. If the installation equipment causes rutting of the subgrade, the subgrade must be restored to its originally accepted condition before placement continues. Equipment necessary to perform the installation (generators, compressors, etc.) shall have a scrap GCL sheet placed underneath to protect the installed GCL from possible damage. The GCL shall be kept free of debris, unnecessary tools and materials. In general, the GCL area shall remain neat in appearance. All damage shall be recorded and located in the record drawings. Care must 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 geosynthetic subgrade covering commonly known as a slip sheet or rub sheet may be used to reduce friction damage during placement. The GCL shall be placed so that seams are parallel to the direction of the slope. End-of-roll seams should be located at least 3 feet (1m) from the toe and crest of slopes steeper than 4H:1V. GCL rolls shall **not** be released on the slope and allowed to unroll freely by gravity. All GCL panels shall be placed free of tension or stress and lie flat on the underlying surface, with no wrinkles or fold, especially at the exposed edges of the panels. Similarly, the geomembrane placed over GCL shall lie flat and in contact with the underlying GCL with no wrinkles or fold. The GCL shall not be installed in standing/ponded water, during rainy weather/precipitation, excessive moisture, and during extremely/excessive high wind. Only as much GCL shall be deployed as can be covered at the end of the working day with the geomembrane. In no case shall the GCL be exposed to the elements at the end of the day. The GCL shall not be left uncovered overnight. If the GCL is hydrated when no confining stress is present, it will be necessary to remove and replace the hydrated material. The project Engineer, CQA inspector, and GCL supplier should be consulted for specific guidance if premature hydration occurs. The GCL shall not get wet before or during installation. The GCL mat shall not be installed during periods of any precipitation. If a precipitation event occurs after the installation of a GCL panel, but prior to covering with the geomembrane panel, a thin film plastic sheeting may be used to cover and to temporarily protect the GCL from moisture, if approved by the Project Engineer.

Panels shall be placed from the highest elevation to the lowest within the area to be lined, to facilitate drainage in the event of precipitation. It is not permissible to stretch the GCL in order to fit a designated area. Panels shall not be dragged across the subgrade into position except where necessary to obtain the correct overlap for adjacent panels.

As directed by the project drawings and specifications, 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 any sharp corners. The GCL should cover the entire trench floor but does not extend up the rear trench wall. The amount of trench open at any time shall be limited to one day of GCL installation capacity. The anchor trench shall be adequately drained to prevent water ponding and softening the adjacent soils. Loose soil shall be removed from the floor of the trench. The soil backfill should be placed in the trench to provide resistance against pullout. The size and shape of the trench, as well as the appropriate backfill procedures, should be in accordance with the project drawings and specifications.

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 for Bentomat® ST.

The minimum dimension of the longitudinal overlap should be 6 inches (150 mm). End-of-roll overlapped seams should be similarly constructed, but the minimum overlap should measure 24 inches (600 mm). In the opinion of the CQA Engineer/Inspector, any seam, or edge of GCL material exposed for more than 24 hours or considered partially hydrated when seaming occurs shall receive a 3-foot overlap (rain lap) from the adjoining GCL panel. All seams shall have a seam number that corresponds with the panel layout numbers. The numbering system shall be used in the development of the record drawings. Seam numbers shall be derived from the combination of the two panel numbers that are to be seamed. Seam areas or runs shall also be flat and clear of any large rocks, debris, or ruts. Contacting surfaces shall be clean and clear of dirt or native soil with all edges pulled tight to maximize contact and to smooth out any wrinkles or creases. All seams constructed on sloped surface shall be vertical seams. Seams at the ends of the panels should be constructed such that they are shingled in the direction of the grade to prevent the potential for runoff flow to enter the overlap zone. Bentonite-enhanced seams are constructed between the overlapping adjacent panels described above. The underlying edge of the longitudinal overlap is exposed and then a continuous bead of granular sodium bentonite is applied along a zone defined by the edge of the underlying panel and the 6 inch (150 mm) line. A similar bead of granular sodium bentonite is applied at the end-of-roll overlap. The bentonite shall be applied at a minimum application rate of one quarter pound per lineal foot (0.4 kg/m).

Cutting the GCL should be performed using a sharp utility knife. Frequent blade changes are recommended to avoid irregular tearing of the geotextile components of the GCL during the cutting process. The GCL shall be sealed around penetrations and structures embedded in the subgrade. Granular bentonite or a bentonite mastic shall be used liberally (approximately 2 lbs/in ft or 3 kg/m) to seal the GCL to these structures. When the GCL is placed over an earthen subgrade, a "notch" (approximately 3 inches wide and 8 inches deep) shall be cut against the edge of the subgrade area around the penetration. The mat shall be brought up to the edge of the structure and trimmed to fit into the notch. The Contractor shall then hand apply a pure bead of bentonite into half the notch. The mat shall then be inserted into the notch, with the remaining volume of the notch refilled with the pure bentonite and compacted. A secondary collar of GCL should be placed around the penetration. It is helpful to first trace an outline of the penetration on the GCL and then cut a "star" pattern in the collar to enhance the collar's fit to the penetration. Vertical penetrations are prepared by notching into the subgrade. The penetration is completed with two separate pieces of GCL. A secondary collar is option in this case. When the GCL is terminated at a structure or wall that is embedded into the subgrade, the subgrade should be notched as described in Items B and D above. The notch is filled with granular bentonite, and the GCL should be placed over the notch and up against the structure. The connection to the structure can be accomplished by placement of soil or stone backfill in this area.

If the GCL is damaged (torn, punctured, perforated, etc.) during installation, it may be possible to repair it by cutting a patch to fit over the damaged area. The patch shall be obtained from a new GCL roll and shall be cut to size such that minimum overlap of 12 inches (300 mm) is achieved

around all of the damaged area. Dry bentonite or bentonite mastic should be applied around the damaged area at the rate of one-half pound per lineal foot prior to placement of the patch. Any epoxy-based adhesives shall be used to keep the patch in position during backfill operations.

Although direct vehicular contact with the GCL is to be avoided, lightweight, low ground pressure vehicles [such as 4-wheel all-terrain vehicles (ATV)] may be used to facilitate the installation of any geosynthetic material placed over the GCL, provided the ATV makes no sudden stops, starts, or turns. The GCL supplier or CQA engineer should be contacted with specific recommendations on the appropriate procedures in this situation. When a textured geomembrane is installed over the GCL, a temporary geosynthetic covering known as a slip sheet or rub sheet should be used to minimize friction during placement and to allow the textured geomembrane to be more easily moved into its final position. Any leading edge of panels left uncovered shall be protected at the end of the working day with a waterproof sheet which is adequately secured with sandbags or other ballast. Soil cover shall be placed over the GCL/geomembrane using low ground pressure construction equipment that minimizes stresses on the GCL/geomembrane, according to the existing project specification requirements for protective cover soil installation over geomembrane liner.

3.4.3. Materials and Construction Practices for Flexible Membrane Liner

All materials and equipment shall be furnished by an established and reputable manufacturer or supplier. All materials and equipment shall be new and shall be of first class ingredients and construction, designed and guaranteed to perform the service required and shall conform with the following standard specifications or shall be the product of the listed manufacturers or similar and equal thereto as approved by the Engineer.

60 mil High Density Polyethylene (HDPE) – Geosynthetic Research Institute (GRI) GM 13 – is to be placed in direct contact with moist cohesive soil liner. The Landfill itself is single lined and will only have a Textured Geomembrane. The extrusion rods and/or brads used in seaming the rolls together shall be derived from the same base resin as the liner.

Prior to commencement of liner deployment, layout drawings shall be produced to indicate the panel configuration and location of seams for the project. Each panel used for the installation shall be given a numeric or alpha-numeric identification number consistent with the layout drawing. This identification number shall be related to manufacturing roll number that identifies the resin type, batch number and date of manufacture. The Flexible Membrane Liner Manufacturer/Installer shall install field panels at the location indicated on the layout drawing. If the panels are deployed in a location other than that indicated on the layout drawings, the revised location shall be noted in the field on a layout drawing which will be modified at the completion of the project to reflect actual panel locations.

Geomembrane deployment shall not be carried out during any precipitation, nor in the presence of excessive moisture (i.e. fog, dew), in an area of standing water, or during high winds. The method and equipment used to deploy the panels must not damage the geomembrane or the supporting subgrade surface. No personnel working on the geomembrane will smoke, wear shoes that can damage the geomembrane, or engage in actions which could result in damage to the geomembrane. Adequate temporary loading and/or anchoring, (i.e. sandbags, tires), which will not damage the geomembrane, will be placed to prevent uplift of the geomembrane by wind. If uplift occurs, additional sandbags will be placed in necessary areas. The geomembrane will be deployed in a manner to minimize wrinkles. Any area of a panel seriously damaged (torn, twisted, or crimped) will be marked, cut out and removed from the work area with resulting seaming and/or repairs performed. In general, seams shall be oriented parallel to the slope, i.e., oriented along, not across the slope. Whenever possible, horizontal seams should be located not less than five (5) feet from the toe of the slope. Each seam made in the field shall be numbered in a manner that is compatible with the panel layout drawing for documentation of seam testing results.

All personnel performing seaming operations shall be trained in the operation of the specific seaming equipment being used and will qualify by successfully welding a test seam. The project foreman will provide direct supervision of all personnel seaming to verify proper welding procedures are followed. Qualified liner installers, seamers, and the liner foreman shall meet a minimum requirement of 1,000,000 square feet of geomembrane installation. There are no other minimum qualifications needed by other parties.

The flexible membrane liner will be welded together by fusion and extrusion fillet welding methods. Fusion Welding consists of placing a heated wedge, mounted on a self propelled vehicular unit, between two (2) overlapped sheets such that the surface of both sheets are heated above the polyethylene's melting point. After being heated by the wedge, the overlapped panels pass through a set of preset pressure wheels which compress the two (2) panels together so that a continuous homogeneous fusion weld is formed. The fusion welder is equipped with a temperature readout device which continuously monitors the temperature of the wedge. Extrusion fillet welding consists of introducing a ribbon of molten resin along the edge of the seam overlap of the two (2) sheets to be welded. The molten polymer causes some of the material of each sheet to be liquefied resulting in a homogeneous bond between the molten weld bead and the surfaces of the sheets.

The Flexible Membrane Liner Manufacturer/Installer will rely on the experience of the Project Superintendent and the results of test seams to determine seaming restrictions by weather. Many factors, such as ambient temperature, humidity, wind, sunshine, etc., can affect the integrity of field seams and must be taken into account when deciding whether or not seaming should proceed. Responsibility for monitoring these conditions shall lie with the Project Superintendent; however, the Engineer may suspend any seaming operation which is, in his opinion, at the risk of providing the Owner with a quality product. Test seams are required prior to daily production seaming to determine if the weather conditions will affect the Flexible Membrane Liner System's ability to produce quality seams. Additional non-destructive and destructive testing of production seams may substantiate the decision made by the Project Superintendent to seam on any given day. Fusion Welding is done by first overlapping panels of geomembrane approximately four (4) inches, next clean the seam area prior to seaming to assure the area is clean and free of moisture, dust, dirt, debris of any kind. No grinding is required for fusion welding. Next, adjust the panels so that seams are aligned with the fewest possible number of wrinkles and "fishmouths". A movable protective layer may be used, at the discretion of the Flexible Geomembrane Liner System Project Superintendent, directly below the overlap of geomembrane that is to be seamed to prevent build-up of moisture between the panels.

Extrusion Welding is done by overlapping panels of geomembrane a minimum of three (3) inches and temporarily bond the panels of geomembrane to be welded taking care not to damage the geomembrane. Next grind seam overlap prior to welding within one (1) hour of welding operation in a manner that does not damage the geomembrane. Limit grinding to ¼" outside of the extrusion weld area. Clean the seam area prior to seaming to assure the area is clean and free of moisture, dust, dirt, and debris of any kind. Purge the extruder prior to beginning the seam to remove all heat degraded extrudate from the barrel. Keep welding rod clean and off the ground.

At a minimum, test seams shall be made upon each start of work for each seaming crew, 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. Test seams shall be made on fragment pieces of the geomembrane liner and under the same conditions as actual seams. The test seam shall be at least three (3) feet long and should be made by joining two (2) pieces of geomembrane at least 9" in width. Visually inspect the seam for squeeze out, footprint, pressure and general appearance. Two random samples one (1) inch wide shall be cut from the test seam. The specimens shall then be tested in peel using a field tensiometer and shall not fail in the seam. If a specimen fails the entire procedure shall be repeated. If any of the second set of specimens fail, the seaming apparatus shall not be accepted and shall not be used for seaming until the deficiencies are corrected and a passing test seam is achieved. After completion of these tests, the remaining portion of test seam can be discarded. Documentation of the test seams will be maintained listing seam

identification number, welder's name, temperature control setting and test results. Passing test results records shall be maintained.

Seaming shall extend to the outside edge of panels to be placed in the anchor trench. While welding a seam, monitor and maintain the proper overlap. Inspect seam area to assure area is clean and free of moisture, dust, dirt, debris of any kind. While welding a seam, monitor temperature gauges to assure proper settings are maintained and that the seaming apparatus is operating properly. Align wrinkles at the seam overlap to allow welding through the wrinkle. Fishmouths or wrinkles at seam and overlaps that cannot be welded through shall be cut along the ridge in order to achieve a flat overlap. The cut fishmouth or wrinkle shall be seamed. Any portion where the overlap is inadequate shall be patched with an oval or round patch of the same geomembrane extending a minimum of six (6) inches beyond the cut in all directions. All cross/butt seams between two (2) rows of seamed panels shall be welded during the coolest time of the day to allow for contraction of the geomembrane. All "T" joints shall have the overlap from the wedge welder seam trimmed back to allow an extrusion fillet weld. Then grind two (2) inches minimum on either side of the wedge seam, then extrusion weld all of the area prepared by grinding.

The installation crews will non-destructively test all field seams over their full length using air pressure testing, vacuum testing or other approved methods, to verify the continuity and integrity of the seams.

Air pressure testing will be conducted. The welded seam created by double hot-wedge fusion welding process is composed of two distinct welded seams separated by an unwelded channel approximately 3/8 of an inch between the two welded seams permits the double hot-wedge fusion seams to be tested by inflating the sealed channel with air to a predetermined pressure, and observing the stability of the pressurized channel over time. An air pump with rubber hose and sharp hollow needle (manual or motor driven) capable of generating and sustaining a pressure between 25 to 30 psi will be used to test the seam. Seal both ends of the seam to be tested. Insert needle or other approved pressure feed device into the sealed channel created by the fusion weld. Inflate the test channel to a pressure between 27 to 30 psi, close valve, and observe initial pressure after approximately 2 minutes. For the 60 mil HDPE liner the seam has to have a minimum initial pressure of 27 psi and a maximum initial pressure of 30 psi. Initial pressure settings are read after a two minute "relaxing period". The purpose of this "relaxing period" is to permit the air temperature and pressure to stabilize. Observe and record the air pressure five (5) minutes after "relaxing period" ends and when initial pressure setting is used. If loss of pressure exceeds 3 psi or if the pressure does not stabilize, locate faulty area and repair. At the conclusion of the pressure test the end of the seam opposite the pressure gauge is cut. A decrease in gauge pressure must be observed or the air channel will be considered "blocked" and the test will have to be repeated after the blockage is corrected. Remove needle or other approved pressure feed device and seal resulting hole by extrusion welding.

In the event of a Non-Complying Air Pressure Test, check the seam end seals and retest seams. If non-compliance with specified maximum pressure differential re-occurs, repair the seam. When two (2) passing samples are located, the seam between these two (2) locations will be considered non-complying. Capping or removal are the only two (2) acceptable methods of repairing failed seams. Non-destruct test the entire length of the repaired seam.

Vacuum testing will be conducted when the geometry of the weld makes air pressure testing impossible or impractical or when attempting to locate the precise location of a defect believed to exist after air pressure testing. The penetration will be tested using this method.

Vacuum box assembly consists of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, port hole or valve assembly, a vacuum gauge, vacuum pump assembly equipped with a pressure controller and pipe connection, a rubber pressure/vacuum hose with fittings and connections, a bucket and means to apply a soapy solution.

The procedure for Vacuum Testing is to trim excess overlap from seam, if any. Turn on the vacuum pump to reduce the vacuum box to approximately 5 inch of mercury, i.e., 5 psi. Apply a generous

amount of a solution of strong liquid detergent and water to the area to be tested. Place the vacuum box over the area to be tested and apply sufficient downward pressure to "seat" the seal strip against the liner. Close the bleed valve and open the vacuum valve. Apply a minimum of 5 in. Hg vacuum to the area as indicated by the gauge on the vacuum box. Ensure that a leak tight seal is created. For a period of not less than 30 seconds, examine the geomembrane through the viewing window for the presence of soap bubbles. If no bubbles appear after 30 seconds, close the vacuum valve and open the bleed valve, move the box over the next adjoining area with a minimum 3 in. overlap, and repeat the process. The procedure for Non-Complying Testis to mark all areas where soap bubbles appear and repair the marked areas. Retest repaired areas.

The procedure for Destructive Testing is to determine and evaluate seam strength. These tests require direct sampling and thus subsequent patching. Therefore destructive testing should be held to a minimum to reduce the amount of repairs to the geomembrane. All destructive tests will be done according to ASTM D4437. The sample should be twelve (12) inches wide with a seam fourteen (14) inches long centered lengthwise in the sample. The sample may be increased in size to accommodate independent laboratory testing by the owner at the owner's request or by specific project specifications. A one (1) inch sample shall be cut from each end of the test seam for field testing. The two (2), one (1) inch wide samples shall be tested in the field in a tensiometer for peel ASTM D4437. Tensile strength is essentially a measurement of the greatest tension stress a substance can bear without tearing. If the liner tears before any part of the seam does the test is successful. If any field sample fails to pass, it will be assumed the sample fails destructive testing. Destructive samples will be taken every 500 ft. of seam.

In the event of Destructive Test Failure, cut additional field samples for testing. In the case of a field production seam, the samples must lie a minimum of ten (10) feet in each direction from the location of the failed sample. Perform a field test for peel strength. If these field samples pass, then laboratory samples can be cut and forwarded to the laboratory for full testing. All destructive seam samples sent to the Flexible Membrane Liner System's laboratory shall be numbered. If the laboratory samples pass then repair the seam between the two (2) passing samples locations. All passing seams must be bounded by two (2) locations from which samples passing laboratory destructive tests have been taken. Capping or removal of the failed seam are the only two (2) acceptable methods for repairing failed seams.

The Project Superintendent shall conduct a detailed walk through and visually check all seams and non-seam areas of the geomembrane for defects, holes, blisters and signs of damage during installation. All other installation personnel shall, at all times, be on the lookout for any damaged areas. Damaged areas shall be marked and repaired.

Any portion of the geomembrane showing a flaw or failing a destructive or non-destructive test shall be repaired. Several procedures exist for repair and the decision as to the appropriate repair procedure shall be made by the Project Superintendent. Repairs need to be made in a timely matter to protect the moist cohesive soil liner and flexible membrane liner. If inclement weather is approaching, steps need to be made to protect the cohesive soil liner such as a temporary cover. If cohesive soil liner is damaged, it must be reworked. Procedures available for repair are (1)Patching - used to repair large holes, tears and destructive sample locations. All patches shall extend at least six (6) inches beyond the edges of the defect and all corners of patches shall be rounded, (2) Grinding and welding - used to repair sections of extruded seams, (3) Spot welding or seaming - used to repair small tears, pinholes or other minor localized flaws, (4) Capping - used to repair lengths of failed seams, (5) Removal of a bad seam and replacement with a strip of new material seamed into place.

Every repair shall be non-destructively tested. Repairs which pass the non-destructive test shall be deemed adequate. Large repairs may require a destructive test. Repair test results shall be logged. The repair location shall be recorded on an as-built drawing.

3.5 HDPE Double Bonded Drainage Net

3.5.1 Materials and Construction Practices

The geonets will be handled in such a manner as to ensure the geonets are not damaged in any way. On slopes, the geonets will be secured in the anchor trench and then rolled down the slope in such a manner as to continually keep the geonet sheet in tension. If necessary, the geonet will be positioned by hand after being unrolled to minimize wrinkles. Geonets can be placed in the horizontal direction (i.e., across the slope) in some special locations (e.g., where extra layers are required or where slope is less than 10:1).

Geonets will not be welded to the geomembrane. Geonets will be cut using approved cutters,(i.e., hook blade, scissors, etc.) Care should be taken to prevent damage to underlying layers. Care must be taken not to entrap dirt in the geonet that could cause clogging of the drainage system, and or stones that could damage the adjacent geomembrane.

Adjacent rolls of geonet will be overlapped by at least four inches and securely tied. Tying can be achieved by plastic fasteners. Tying devices will be white or yellow for easy inspection. Metallic devices are not allowed. Tying will be five to ten feet along the bottom of the slope. Tying will be every five feet along the slope, every two feet across the slope and at the top of the berm. Tying in the anchor trench will be done in one foot intervals. In the corners of the side slopes where overlaps between perpendicular geonet strips are required, an extra layer of geonet will be unrolled along the slope, on top of the previously installed geonets, from the top to bottom of the slope.

Any holes or tears in the geonet will be repaired by placing a patch extending two feet beyond edges of the hole or tear. The patch will be secured to the original geonet by tying every twelve inches. If the hole or tear width across the roll is more than 50% the width of the roll, the damaged area will be cut out and the two portions of the geonet will be joined.

3.6 Protective Cover

3.6.1. Materials and Construction Practices

The soil for the select site backfill shall consist of suitable site soil free of debris, roots, rocks and organics. The soil shall contain no particles or objects greater than 3/4 inch in largest dimension, which has been screened. No permeability, grain size, or other tests are required for this material. This material is not being used as a drainage media, leachate collection lines are installed every fifty feet and designed to collect water flowing on top of the protective cover.

The soil for backfill shall consist of suitable site soil free of debris, roots, rocks, and organics. There are no permeability, grain size, or any other test required for this material. This material is not being used as a drainage media, leachate collection lines are installed every fifty feet and designed to collect water flowing on top of the protective cover.

Installation of the protective cover shall be the responsibility of the contractor. Before proceeding with placement of the protective cover over the liner, the Contractor shall furnish to the Engineer with the manufacturer's certification that the lining has been satisfactorily installed in accordance with the manufacturer's recommendations.

The protective cover shall be composed of select backfill and backfill. The cover shall be installed using low ground pressure equipment such as a Caterpillar D6H LGP, or approved equal, with ground pressure not exceeding 4.71 psi until the depth of cover exceeds three feet.

A minimum of 12 inches of cover between low ground pressure equipment such as the Caterpillar D6H LGP, or approved equal, and the liner is required at all times. Roadways for entering and for transporting material over slopes and floor shall have a minimum depth of four feet. Avoid undue stress

on the liner at all times. Cover material must be pushed up side slopes, never down to help minimize wrinkles. A worker must walk along side earth moving equipment and remove all rocks, stones, roots or other debris that could cause damage to the liner. Material must be placed to minimize wrinkles, wrinkles in excess of two feet in height are unacceptable. If a wrinkle is more than two feet in height, soil will be placed on top of the wrinkle to decrease the height. Equipment operators must avoid sharp turns or quick stops that could pinch and tear the liner. If damage does occur, report it to the Project Manager immediately so that repairs can be performed without needless delay. Cover shall be placed and maintained in a uniform thickness, free of ruts and irregularities. Do not work wet cover material that cannot support equipment. Equipment operators and all other personnel must be qualified and must exercise good judgment and common sense at all times.

3.7 Liner Tie-In

3.7.1. Materials and Construction Practices

The edge of the existing HDPE liner shall be exposed. The HDPE liner will be rolled back to expose the cohesive soil. The existing cohesive soil will be keyed into to each subsequent lift of the next phase's cohesive soil. If geosynthetic clay liner (GCL) is used, the GCL shall cover the keyed in area of both the existing and new cohesive soil liners and be in direct contact with the existing and new HDPE liners.

The new HDPE liner shall be overlapped over the existing HDPE liner and an extrusion or fusion weld completed along the entire length of the overlapped liners at the tie in and then non-destructively tested. Once the extrusion weld has been completed, a three foot cap will be placed over entire tie in seam and the seams non-destructively tested.

3.8 Leachate Collection System

3.8.1. Materials and Construction Practices

All materials and equipment shall be furnished by an established and reputable manufacturer or supplier. All materials and equipment shall be new and shall be of first class ingredients and construction, designed and guaranteed to perform the service required and shall conform with the following standard specifications, or shall be the product of the listed manufacturers, or similar and equal; thereto, as approved by the Engineer.

The Leachate Collection System consists of No. 5 stone, 4.5 oz. Non-woven Geotextile fabric, and SDR 17 HDPE pipe will be used in the construction of the Leachate Collection System.

A 2' wide by 3' deep trench will be dug out of the protective cover as indicated on the operation drawings located in section 5 of this document. Excavation for the leachate collection shall be done only after the three foot of protective cover has been installed over the flexible membrane liner. Mechanical equipment can be used for the first two and one-half feet of excavation. The remaining one-half foot or whatever protective cover remains above the flexible membrane liner shall be excavated by hand so as to not damage the liner. If damage occurs to the liner the Engineer or Owner shall be notified immediately and the repair shall take place shortly thereafter.

The 4.5oz non-woven geotextile fabric will be placed in the trench such that it can completely surround the trench. No. 5 stone will be placed at a depth of 2" in the whole length of the trench. Next the butt fused perforated SDR 17 6" or 8" HDPE pipe will be placed on top of the 2" thick stone and then covered with the No. 5 stone. After the placement of the stone the 4.5oz geotextile will be closed over top of the trench. All the leachate collection pipe, as shown on the operation drawings, is connected in a way such that all leachate runs to the low spot in the landfill where it will be gravity fed into the sewer line.

Butt Fusion for HDPE pipe. Clean pipe ends inside and outside with a clean cloth to remove dirt, water, grease and other foreign materials. Square (face) the pipe ends using facing tool of the fusion machine. Check line-up of pipe ends in fusion machine to see that pipe ends meet squarely and completely over the entire surface to be fused. This is commonly referred to as "adjusting high-low". It is advisable at this point to make sure the clamps are tight so that the pipe does not slip during the fusion process. Insert clean heater plate between aligned ends, and bring ends firmly in contact with plate, but do not apply pressure while achieving melt pattern. Carefully move the pipe ends away from the heater plate and remove the plate. (If the softened material sticks to the heater plate, discontinue the joint. Clean heater plate, re-square pipe ends and start over.)

Note: One pipe end usually moves away from the heater plate first. It is good practice to "bump" the plate away from the other side and then lift it out. Never drag or slide it over the melted pipe end.
Bring melted ends together rapidly. Do not slam. Apply enough pressure to form a double roll back to the body of the pipe brad around the entire circumference of the pipe about 1/8" to 3/16" wide. Pressure is necessary to cause the heated material to flow together. Allow the joint to cool and solidify properly. This occurs when the brad feels hard and your finger can remain comfortably on the brad. Remove the pipe from the clamps and inspect the joint appearance.

Knife Gate Valves will be placed in several places to control storm water and leachate as indicated in the operation drawings.

3.9 Sewer Line

3.9.1. Materials and Construction Practices

The sewer line consists of a SDR 17 HDPE dual containment pipe, 8" carrier by 12" containment, Polyethylene manholes are placed along the sewer line. The sewer line runs to the Leachate Lagoon where it is aerated as needed, recirculated or pumped to its appropriate location.

All Gravity Flow Pipeline shall be installed using a laser for control of vertical and horizontal alignment. The Contractor shall follow accepted practices in the utilization of the laser. A certified laser operator shall be present on the job at all times. Care shall be exercised to assure that the alignment control range of the instrument is not exceeded; but in no case, shall the range exceed 500 feet. Care shall be taken to prevent vibration of or direct sunlight on the instrument. Where present, a blower shall be provided to purge glue vapors from the pipe. An air velocity meter shall be provided so that the velocity of air in the pipe will not be great enough to cause the light beam to be distorted. The Contractor shall coordinate the work to minimize the number of take downs and set ups at each point. Periodic checks of the laser shall be made to assure that alignment is maintained.

Each pipe shall be laid on an even, firm bed, so that no uneven strain will come to any part of the pipe. Before each piece of pipe is lowered into the trench, it shall be thoroughly inspected to insure its being clean. Each piece of pipe shall be lowered separately. No piece of pipe or fitting which is known to be defective, shall be laid or placed in the lines. If any defective pipe or fitting shall be discovered after the pipe is laid it shall be removed and replaced with a satisfactory pipe or fitting without additional charge. In case a length of pipe is cut to fit in a line, it shall be so cut as to leave a smooth end at right angles to the longitudinal axis of the pipe.

Butt Fusion for HDPE pipe. Clean pipe ends inside and outside with a clean cloth to remove dirt, water, grease and other foreign materials. Square (face) the pipe ends using facing tool of the fusion machine. Check line-up of pipe ends in fusion machine to see that pipe ends meet squarely and completely over the entire surface to be fused. This is commonly referred to as "adjusting high-low". It is advisable at this point to make sure the clamps are tight so that the pipe does not slip during the fusion process. Insert clean heater plate between aligned ends, and bring ends firmly in contact with plate, but do not apply pressure while achieving melt pattern. Carefully move the pipe ends away from the heater plate and remove the plate. (If the softened material sticks to the heater plate, discontinue the joint. Clean heater plate, re-square pipe ends and start over.)

Note: One pipe end usually moves away from the heater plate first. It is good practice to "bump" the plate away from the other side and then lift it out. Never drag or slide it over the melted pipe end.

Bring melted ends together rapidly. Do not slam. Apply enough pressure to form a double roll back to the body of the pipe brad around the entire circumference of the pipe about 1/8" to 3/16" wide. Pressure is necessary to cause the heated material to flow together. Allow the joint to cool and solidify properly. This occurs when the brad feels hard and your finger can remain comfortably on the brad. Remove the pipe from the clamps and inspect the joint appearance.

HDPE Dual Containment Force main - ASTM D3350. All HDPE pipe shall be tested at its rated working pressure. In no case shall there be any visible leakage, nor shall there be leakage between any section of pipe.

3.10 Closure Cohesive Soil Cap

3.10.1. Materials and Construction Practices

All materials and equipment shall be new and shall be of first class ingredients and construction, designed and guaranteed to perform the service required and shall conform with the following standard specifications or shall be the product of the listed manufacturers or similar and equal thereto as approved by the Engineer.

The soil for the cohesive soil cap shall consist of on-site soils if a permeability of 1.0×10^{-5} cm/sec or less is achieved. Off-site cohesive soils may be used if approved by the Engineer and provides a permeability of 1.0×10^{-5} cm/sec or lower Wyoming bentonite or an approved equivalent may be blended with the soil to lower the soil's permeability.

A permeability "window" shall be developed for each type of soil from the borrow material that will be used for construction of the cohesive soil cap. The window is developed from the accepted remolded samples and moisture contents from the semi-log plot. A straight line is typically drawn between the acceptable points on the moisture-density curve to indicate a range of probable acceptable permeability results. The window will be used in the construction of the test strip to verify the laboratory remolded permeability results.

A test strip of compacted cohesive soil cap shall be prepared to create a permeability "window" prior to general installation of the cohesive soil cap. The test strip will be used to verify the results from the remolded permeabilities from the borrow site utilizing the permeability window(s) for each soil type that is going to be used for construction of the cohesive soil cap. The test strip shall be approximately 2,500 sq. ft. in surface area and constructed to conform geometrically to the site topography with a minimum lateral dimension in any direction of 25 ft. The test strip shall consist of at least three (3) compacted 6 inch lifts of cohesive soil cap. The test strip may be used as an integral part of the overall cohesive soil cap if it meets the required specification for the cap.

After the test strip passes, soil will be placed to the total thickness shown on the plans in maximum 8-inch thick loose lifts with a maximum 6" compacted lift. A sheepsfoot roller or approved alternative may be used to compact the soil cap provided the compaction and permeability requirements can be achieved. Each lift shall be tested for permeability, moisture content, particle size distribution analysis, Atterberg limits, moisture-density-permeability relation, and if needed percent bentonite admixed with soil, prior to the placement of the succeeding lift and visually inspected to confirm that all soil clods have been broken and that the surface is sufficiently scarified so that adequate bonding can be achieved. Soils for cohesive soil cap shall be screened, disked, or prepared using any other, approved method as necessary to obtain a homogeneous cohesive soil with clod sizes in a soil matrix no larger than about 1.5 inches in maximum diameter. The clay cap must be a minimum of 1.5 feet thick. No additional construction shall proceed on the soil cap at the area being tested until the Engineer has reviewed the results of the tests and judged the desired permeability is being achieved. If the soil for

the cohesive soil cap is incapable of achieving the required permeability when compacted, bentonite or approved alternative may be mixed with the soils to decrease the permeability. The amount of additive required must be determined in the laboratory.

The thickness and grade of the clay cap will be verified by the engineer before placement of the geomembrane liner. The thickness and grade will be verified by surveying the cap at 50' grid points where the elevations of the subbase will be checked with the top of soil cap to verify 1.5 feet of cap. The grade will then be verified with the surveyed information. The survey will be performed by NC licensed surveyors.

Surfaces to be lined shall be smooth and free of debris, roots, and angular or sharp rocks larger than three-eight (3/8) inches in diameter to a depth of six (6) inches. The cohesive soil cap shall have no sudden sharp or abrupt changes in grade. The Contractor shall protect the cohesive soil cap from desiccation, flooding and freezing. Protection, if required, may consists of a thin plastic protective cover, (or other material as approved by the engineer) installed over the completed cohesive soil cap until such time as the placement of flexible membrane liner begins. Areas found to have any desiccation cracks or which exhibit swelling, heaving or other similar conditions will be replaced or reworked by the contractor to remove these defects.

The anchor trench shall be excavated by the Contractor to lengths and widths shown on the design drawings prior to geomembrane placement. Anchor trenches excavated in clay soils susceptible to desiccation cracks should be excavated only the distance required for that days liner placement to minimize the potential of desiccation cracking of the clay soils. Corners in the anchor trench shall be slightly rounded where the geomembrane adjoins the trench to minimize sharp bends in the geomembrane.

Upon request, the Flexible Membrane Liner manufacturer installer shall provide the Engineer with a written acceptance of the surface prior to commencing installation. Subsequent repairs to the cohesive soil cap and the surface shall remain the responsibility of the contractor.

3.11 Closure Flexible Membrane Liner

3.11.1 Materials and Construction Practices

All materials and equipment shall be furnished by an established and reputable manufacturer or supplier. All materials and equipment shall be new and shall be of first class ingredients and construction, designed and guaranteed to perform the service required and shall conform with the following standard specifications or shall be the product of the listed manufacturers or similar and equal thereto as approved by the Engineer.

40 mil Linear Low Density Polyethylene (LLDPE) is to be placed in direct contact with moist cohesive soil cap. The extrusion cap and/or brads used in seaming the rolls together shall be derived from the same base resin as the liner.

Prior to commencement of liner deployment, layout drawings shall be produced to indicate the panel configuration and location of seams for the project. Each panel used for the installation shall be given a numeric or alpha-numeric identification number consistent with the layout drawing. This identification number shall be related to manufacturing roll number that identifies the resin type, batch number and date of manufacture. The Flexible Membrane Liner Manufacturer/Installer shall install field panels at the location indicated on the layout drawing. If the panels are deployed in a location other than that indicated on the layout drawings, the revised location shall be noted in the field on a layout drawing which will be modified at the completion of the project to reflect actual panel locations.

Geomembrane deployment shall not be carried out during any precipitation, nor in the presence of excessive moisture (i.e. fog, dew), in an area of standing water, or during high winds. The method and equipment used to deploy the panels must not damage the geomembrane or the supporting subgrade

surface. No personnel working on the geomembrane will smoke, wear shoes that can damage the geomembrane, or engage in actions which could result in damage to the geomembrane. Adequate temporary loading and/or anchoring, (i.e. sandbags, tires), which will not damage the geomembrane, will be placed to prevent uplift of the geomembrane by wind. If uplift occurs, additional sandbags will be placed in necessary areas. The geomembrane will be deployed in a manner to minimize wrinkles. Any area of a panel seriously damaged (torn, twisted, or crimped) will be marked, cut out and removed from the work area with resulting seaming and/or repairs performed. In general, seams shall be oriented parallel to the slope, i.e., oriented along, not across the slope. Whenever possible, horizontal seams should be located not less than five (5) feet from the toe of the slope. Each seam made in the field shall be numbered in a manner that is compatible with the panel layout drawing for documentation of seam testing results.

All personnel performing seaming operations shall be trained in the operation of the specific seaming equipment being used and will qualify by successfully welding a test seam. The project foreman will provide direct supervision of all personnel seaming to verify proper welding procedures are followed. Qualified liner installers, seamers, and the liner foreman shall meet a minimum requirement of 1,000,000 square feet of geomembrane installation. There are no other minimum qualifications needed by other parties.

The flexible membrane liner will be welded together by fusion and extrusion fillet welding methods. Fusion Welding consists of placing a heated wedge, mounted on a self propelled vehicular unit, between two (2) overlapped sheets such that the surface of both sheets are heated above the polyethylene's melting point. After being heated by the wedge, the overlapped panels pass through a set of preset pressure wheels which compress the two (2) panels together so that a continuous homogeneous fusion weld is formed. The fusion welder is equipped with a temperature readout device which continuously monitors the temperature of the wedge. Extrusion fillet welding consists of introducing a ribbon of molten resin along the edge of the seam overlap of the two (2) sheets to be welded. The molten polymer causes some of the material of each sheet to be liquefied resulting in a homogeneous bond between the molten weld bead and the surfaces of the sheets.

The Flexible Membrane Liner Manufacturer/Installer will rely on the experience of the Project Superintendent and the results of test seams to determine seaming restrictions by weather. Many factors, such as ambient temperature, humidity, wind, sunshine, etc., can affect the integrity of field seams and must be taken into account when deciding whether or not seaming should proceed. Responsibility for monitoring these conditions shall lie with the Project Superintendent; however, the Engineer may suspend any seaming operation which is, in his opinion, at the risk of providing the Owner with a quality product. Test seams are required prior to daily production seaming to determine if the weather conditions will affect the Flexible Membrane Liner System's ability to produce quality seams. Additional non-destructive and destructive testing of production seams may substantiate the decision made by the Project Superintendent to seam on any given day. Fusion Welding is done by first overlapping panels of geomembrane approximately four (4) inches, next clean the seam area prior to seaming to assure the area is clean and free of moisture, dust, dirt, debris of any kind. No grinding is required for fusion welding. Next, adjust the panels so that seams are aligned with the fewest possible number of wrinkles and "fishmouths". A movable protective layer may be used, at the discretion of the Flexible Geomembrane Liner System Project Superintendent, directly below the overlap of geomembrane that is to be seamed to prevent build-up of moisture between the panels.

Extrusion Welding is done by overlapping panels of geomembrane a minimum of three (3) inches and temporarily bond the panels of geomembrane to be welded taking care not to damage the geomembrane. Next grind seam overlap prior to welding within one (1) hour of welding operation in a manner that does not damage the geomembrane. Limit grinding to ¼" outside of the extrusion weld area. Clean the seam area prior to seaming to assure the area is clean and free of moisture, dust, dirt, and debris of any kind. Purge the extruder prior to beginning the seam to remove all heat-degraded extrudate from the barrel. Keep welding rod clean and off the ground.

Test seams shall be performed at the beginning of each seaming period and at approximately every 4-working hour intervals for each seaming apparatus used that day. Test seams shall be made on fragment pieces of the geomembrane liner and under the same conditions as actual seams. The test seam shall be at least three (3) feet long and should be made by joining two (2) pieces of geomembrane at least 9" in width. Visually inspect the seam for squeeze out, footprint, pressure and general appearance. Two random samples one (1) inch wide shall be cut from the test seam. The specimens shall then be tested in peel using a field tensiometer and shall not fail in the seam. If a specimen fails the entire procedure shall be repeated. If any of the second set of specimens fail, the seaming apparatus shall not be accepted and shall not be used for seaming until the deficiencies are corrected and a passing test seam is achieved. After completion of these tests, the remaining portion of test seam can be discarded. Documentation of the test seams will be maintained listing seam identification number, welder's name, temperature control setting and test results. Passing test results records shall be maintained.

Seaming shall extend to the outside edge of panels to be placed in the anchor trench. While welding a seam, monitor and maintain the proper overlap. Inspect seam area to assure area is clean and free of moisture, dust, dirt, debris of any kind. While welding a seam, monitor temperature gauges to assure proper settings are maintained and that the seaming apparatus is operating properly. Align wrinkles at the seam overlap to allow welding through the wrinkle. Fishmouths or wrinkles at seam and overlaps that cannot be welded through shall be cut along the ridge in order to achieve a flat overlap. The cut fishmouth or wrinkle shall be seamed. Any portion where the overlap is inadequate shall be patched with an oval or round patch of the same geomembrane extending a minimum of six (6) inches beyond the cut in all directions. All cross/butt seams between two (2) rows of seamed panels shall be welded during the coolest time of the day to allow for contraction of the geomembrane. All "T" joints shall have the overlap from the wedge welder seam trimmed back to allow an extrusion fillet weld. Then grind two (2) inches minimum on either side of the wedge seam, then extrusion weld all of the area prepared by grinding.

The installation crews will non-destructively test all field seams over their full length using air pressure testing, vacuum testing or other approved methods, to verify the continuity and integrity of the seams.

Air pressure testing will be conducted. The welded seam created by double hot-wedge fusion welding process is composed of two distinct welded seams separated by an unwelded channel approximately 3/8 of an inch between the two welded seams permits the double hot-wedge fusion seams to be tested by inflating the sealed channel with air to a predetermined pressure, and observing the stability of the pressurized channel over time. An air pump with rubber hose and sharp hollow needle (manual or motor driven) capable of generating and sustaining a pressure between 25 to 30 psi will be used to test the seam. Seal both ends of the seam to be tested. Insert needle or other approved pressure feed device into the sealed channel created by the fusion weld. Inflate the test channel to a pressure between 25 to 30 psi, close valve, and observe initial pressure after approximately 2 minutes. For the 40 mil LLDPE liner the seam has to have a minimum initial pressure of 25 psi and a maximum initial pressure of 30 psi. Initial pressure settings are read after a two minute "relaxing period". The purpose of this "relaxing period" is to permit the air temperature and pressure to stabilize. Observe and record the air pressure five (5) minutes after "relaxing period" ends and when initial pressure setting is used. If loss of pressure exceeds 4 psi or if the pressure does not stabilize, locate faulty area and repair. At the conclusion of the pressure test the end of the seam opposite the pressure gauge is cut. A decrease in gauge pressure must be observed or the air channel will be considered "blocked" and the test will have to be repeated after the blockage is corrected. Remove needle or other approved pressure feed device and seal resulting hole by extrusion welding.

In the event of a Non-Complying Air Pressure Test, check the seam end seals and retest seams. If non-compliance with specified maximum pressure differential re-occurs, repair the seam. When two (2) passing samples are located, the seam between these two (2) locations will be considered non-complying. Capping or removal of the non-complying seam are the only two (2) acceptable methods for repairing failed seams. Non-destruct test the entire length of the repaired seam.

Vacuum testing will be conducted when the geometry of the weld makes air pressure testing impossible or impractical or when attempting to locate the precise location of a defect believed to exist after air pressure testing. The penetration will be tested using this method.

Vacuum box assembly consists of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, port hole or valve assembly, a vacuum gauge, vacuum pump assembly equipped with a pressure controller and pipe connection, a rubber pressure/vacuum hose with fittings and connections, a bucket and means to apply a soapy solution.

The procedure for Vacuum Testing is to trim excess overlap from seam, if any. Turn on the vacuum pump to reduce the vacuum box to approximately 5 inch of mercury, i.e., 5 psi gauge. Apply a generous amount of a solution of strong liquid detergent and water to the area to be tested. Place the vacuum box over the area to be tested and apply sufficient downward pressure to "seat" the seal strip against the liner. Close the bleed valve and open the vacuum valve. Apply a minimum of 5 in. Hg vacuum to the area as indicated by the gauge on the vacuum box. Ensure that a leak tight seal is created. For a period of not less than 30 seconds, examine the geomembrane through the viewing window for the presence of soap bubbles. If no bubbles appear after 30 seconds, close the vacuum valve and open the bleed valve, move the box over the next adjoining area with a minimum 3 in. overlap, and repeat the process. The procedure for Non-Complying Test is to mark all areas where soap bubbles appear and repair the marked areas. Retest repaired areas.

The procedure for Destructive Testing is to determine and evaluate seam strength. These tests require direct sampling and thus subsequent patching. Therefore destructive testing should be held to a minimum to reduce the amount of repairs to the geomembrane. All destructive tests will be done according to ASTM D4437. The sample should be twelve (12) inches wide with a seam fourteen (14) inches long centered lengthwise in the sample. The sample may be increased in size to accommodate independent laboratory testing by the owner at the owner's request or by specific project specifications. A one (1) inch sample shall be cut from each end of the test seam for field testing. The two (2), one (1) inch wide samples shall be tested in the field in a tensiometer for peel ASTM D4437. Tensile strength is essentially a measurement of the greatest tension stress a substance can bear without tearing. If the liner tears before any part of the seam does, the test is successful. If any field sample fails to pass, it will be assumed the sample fails destructive testing. Destructive samples will be taken every 500 ft. of seam.

In the event of Destructive Test Failure, cut additional field samples for testing. In the case of a field production seam, the samples must lie a minimum of ten (10) feet in each direction from the location of the failed sample. Perform a field test for peel strength. If these field samples pass, then laboratory samples can be cut and forwarded to the laboratory for full testing. All destructive seam samples sent to the Flexible Membrane Liner System's laboratory shall be numbered. If the laboratory samples pass then repair the seam between the two (2) passing samples locations. All passing seams must be bounded by two (2) locations from which samples passing laboratory destructive tests have been taken. Capping or removal of the failed seam is the only two (2) acceptable methods for repairing failed seams.

The Project Superintendent shall conduct a detailed walk through and visually check all seams and non-seam areas of the geomembrane for defects, holes, blisters and signs of damage during installation. All other installation personnel shall, at all times, be on the lookout for any damaged areas. Damaged areas shall be marked and repaired.

Any portion of the geomembrane showing a flaw or failing a destructive or non-destructive test shall be repaired. Several procedures exist for repair and the decision as to the appropriate repair procedure shall be made by the Project Superintendent. Repairs need to be made in a timely matter to protect the moist cohesive soil cap and flexible membrane liner. If inclement weather is approaching, steps need to be made to protect the cohesive soil cap such as a temporary cover. If cohesive soil cap is damaged, it must be reworked. Procedures available for repair are (1) Patching - used to repair large holes, tears and destructive sample locations. All patches shall extend at least six (6) inches beyond the edges of

the defect and all corners of patches shall be rounded, (2) Grinding and welding - used to repair sections of extruded seams, (3) Spot welding or seaming - used to repair small tears, pinholes or other minor localized flaws, (4) Capping - used to repair lengths of failed seams, (5) Removal of a bad seam and replacement with a strip of new material seamed into place.

Every repair shall be non-destructively tested. Repairs which pass the non-destructive test shall be deemed adequate. Large repairs may require a destructive test. Repair test results shall be logged. The repair location shall be recorded on an as-built drawing.

3.12 Closure HDPE Double Bonded Drainage Net

3.12.1 Materials and Construction Practices

The geonets will be handled in such a manner as to ensure the geonets are not damaged in any way. On slopes, the geonets will be secured in the anchor trench and then rolled down the slope in such a manner as to continually keep the geonet sheet in tension. If necessary, the geonet will be positioned by hand after being unrolled to minimize wrinkles. Geonets can be placed in the horizontal direction (i.e., across the slope) in some special locations (e.g., where extra layers are required or where slope is less than 10:1).

Geonets will not be welded to the geomembrane. Geonets will be cut using approved cutters,(i.e., hook blade, scissors, etc.) Care should be taken to prevent damage to underlying layers. Care must be taken not to entrap dirt in the geonet that could cause clogging of the drainage system, and or stones that could damage the adjacent geomembrane.

Adjacent rolls of geonet will be overlapped by at least four inches and securely tied. Tying can be achieved by plastic fasteners. Tying devices will be white or yellow for easy inspection. Metallic devices are not allowed. Tying will be five to ten feet along the bottom of the slope. Tying will be every five feet along the slope, every two feet across the slope and at the top of the berm. Tying in the anchor trench will be done in one foot intervals. In the corners of the side slopes where overlaps between perpendicular geonet strips are required, an extra layer of geonet will be unrolled along the slope, on top of the previously installed geonets, from the top to bottom of the slope.

Any holes or tears in the geonet will be repaired by placing a patch extending two feet beyond edges of the hole or tear. The patch will be secured to the original geonet by tying every twelve inches. If the hole or tear width across the roll is more than 50% the width of the roll, the damaged area will be cut out and the two portions of the geonet will be joined.

3.13 Closure Protective Cover

3.13.1 Materials and Construction Practices

The soil for the select site backfill shall consist of suitable site soil free of debris, roots, rocks and organics. The soil shall contain no particles or objects greater than 3/4 inch in largest dimension, which has been screened. No permeability, grain size, or other tests are required for this material.

Installation of the protective cover shall be the responsibility of the contractor. Before proceeding with placement of the protective cover over the liner, the Contractor shall furnish to the Engineer with the manufacturer's certification that the lining has been satisfactorily installed in accordance with the manufacturer's recommendations.

The protective cover shall be composed of 24" of select backfill. The cover shall be installed using low ground pressure equipment such as a Caterpillar D6H LGP, or approved equal, with ground pressure not exceeding 4.71 psi until the depth of cover exceeds three feet.

A minimum of 12 inches of cover between low ground pressure equipment such as the Caterpillar D6H LGP, or approved equal, and the liner is required at all times. Roadways for entering and for transporting material over slopes and floor shall have a minimum depth of four feet. Avoid undue stress on the liner at all times. Cover material must be pushed up side slopes, never down to help minimize wrinkles. A worker must walk along side earth moving equipment and remove all rocks, stones, roots or other debris that could cause damage to the liner. Material must be placed to minimize wrinkles, wrinkles in excess of two feet in height are unacceptable. If a wrinkle is more than two feet in height, soil will be placed on top of the wrinkle to decrease the height. Equipment operators must avoid sharp turns or quick stops that could pinch and tear the liner. If damage does occur, report it to the Project Manager immediately so that repairs can be performed without needless delay. Cover shall be placed and maintained in a uniform thickness, free of ruts and irregularities. Do not work wet cover material that cannot support equipment. Equipment operators and all other personnel must be qualified and must exercise good judgment and common sense at all times.

3.14 Closure Methane Venting System

3.14.1 Materials and Construction Practices

The Methane Gas Venting System will consist of No. 5 stone, 8 oz. Geotextile fabric, and 8" PVC pipe will be used in the construction of the Gas venting system.

A 2' wide by 1' deep trench will be dug out of the intermediate cover as indicated on the operation drawings located in section 5 of this document. An 8 oz. geotextile fabric will be placed inside the trench such that it can completely surround the trench. No. 5 stone will be placed solely in the whole length of the trench except for the first 10' in all directions of the 10" PVC solid walled vent pipe, where 8" PVC pipe shall be placed and covered with the No. 5 stone. After the placement of the stone the 8oz geotextile will be closed over top of the trench.

SECTION 4.0

CONSTRUCTION QUALITY ASSURANCE PLAN

4.1 Introduction

The Division of Solid Waste Management requires that the Engineer certifies the constructed landfill is built according to approved plans and specifications. The Engineer that will accomplish this task is the one who did the planning and has written the specifications.

Before construction can begin a pre-construction meeting will be held and the responsibilities and duties of each party will be discussed.

The Contractor is responsible for following and meeting the requirements set forth in the contract documents. The Contractors will provide to the Owner of the landfill and the Engineer a completed landfill constructed by Division of Solid Waste approved plans and specifications. The Contractor will give the Engineer a schedule for completion of the landfill including dates for expected construction of the clay test pad, base liner system installation, installation of protective cover, installation of leachate collection system, and estimated time for project completion. The contractor is responsible for providing a foreman to remain on site at all times during construction, provide qualified personnel to conduct quality control, scheduling and coordinating the subcontractors, provide progress reports and as-built drawings, and coordinating construction activities with the Engineer. The foreman is responsible for supervising and coordinating with his crew, subcontractors, quality control personnel, attending all meetings and notifying the Engineer's Construction Observer when any discrepancies occur. The Contractor will meet with the Construction Observer on a daily basis to discuss the days construction activities. The results of all tests and any change in schedule shall be given to the Construction Observer as soon they are known by the contractor. The Contractor must be registered in the state of North Carolina.

Qualified liner installers, seamers, and the liner foreman shall meet a minimum requirement of 1,000,000 square feet of geomembrane installation. The Liner Foreman is responsible for coordinating the installation of the geomembrane liner. The Liner Forman will report to the Contractors Foreman, and Engineer's Construction Observer on a daily basis. The Liner Foreman is responsible for obtaining the geomembrane samples needed for field and laboratory testing as indicated in the plans and specifications.

The Engineer is responsible for providing the engineering design, drawings and specifications, contract documents and CQA needed for construction of the landfill. The Engineer is responsible for conduction of the pre-construction meeting, which will lay out the foundation for the project. The engineer will approve any design changes and certify to the Division of Solid Waste Management that the landfill was constructed according to the requirements of Rule .1621 Construction Quality Assurance Plan and .1624 Construction requirements for MSWLF Facilities, and Division approved plans and specifications. This will be accomplished by on site observation, independent laboratory soil testing to test site specific soil properties including permeability and independent material testing laboratories for destructive testing of the flexible membrane liner. The Engineer will be providing Quality Assurance by spot testing alongside the contractor, who will be providing the Quality Control. The Engineer will certify that the construction was completed in accordance with the CQA manual. The Engineer must be a professional engineer registered in North Carolina

The Construction Observer (CO) is the Engineer's representative on-site. It is the CO's responsibility to know and interpret the plans and specifications of the project. On a daily basis the CO will coordinate with the Foreman to help ensure a quality product for the Owner. The CO will keep a daily log on the activities of the Contractor, keep notes on all meetings, and handle all quality assurance activities indicated in this document. The CO will keep a log of all material delivered on site and ensure the materials meets or exceeds the specifications indicated in this report. If the need arises additional meetings will be scheduled as seen fit by the CO.

4.2 Inspection Activities and Sampling Strategies

4.2.1. Base Liner System Subbase

The fill subgrade will be placed in 8" loose lifts and compacted to at least 95% of maximum dry density and near optimum moisture contents; as determined by Standard Proctor Compaction Test (ASTM D698) in 6" compacted lifts. No aggregate particles greater than 6" in any direction will be allowed in the subgrade or berm/embankment. Each compacted lift will be tested at one test per six inch (6") lift for each 200 lineal feet or fraction thereof of compacted berm(s) less than 50 feet in base width and one test per six (6) inch lift for each 10,000 square feet or fraction thereof of compacted mass fill. If an area fails, it shall be recompacted, reworked or replaced and retested.

Before beginning construction of the base liner system, the project engineer shall visually inspect the exposed surface to evaluate the suitability of the subgrade and document that the surface is properly prepared and that the elevations are consistent with the Division approved engineering plans. The elevations will be verified from survey data based on a 50 foot grid across the subbase.

At a minimum, the subgrade shall be proof-rolled at cut sections utilizing a fully loaded tandem dump truck or equivalent. If movement of the subbase is observed under the tires, the section of movement will be removed and replaced with suitable fill material. This newly placed fill material will then be tested for proper density and moisture.

4.2.2 Base Liner System Cohesive Soil Liner

All materials and equipment shall be new and shall be of first class ingredients and construction, designed and guaranteed to perform the service required and shall conform with the following standard specifications or shall be the product of the listed manufacturers or similar and equal thereto as approved by the Engineer.

Cohesive Soil Liner Borrow Material

Test Name	Test Method	Contractor/Engineer Frequency
Moisture/Density	ASTM D698/D1557	1 per 5000 c.y.
Remolded Permeability	ASTM D5084	1 per 5000 c.y.
Atterberg Limits	ASTM D4318	1 per 5000 c.y.
Visual Classification	ASTM D2488	1 per 5000 c.y.
Grain Size Distribution	ASTM D422	1 per 5000 c.y.

Cohesive Soil Liner Test Pad

Test Name	Test Method	Contractor/Engineer Frequency
Field Moisture/Density	ASTM D1556 (sand cone) ASTM D2922/D3017 (nuclear gauge) ASTM D2937 (drive cylinder)	3 per lift
Permeability	ASTM D5084	1 per lift
Remolded Permeability	ASTM D5084	1 per lift
Atterberg Limits	ASTM D4318	1 per lift
Visual Classification	ASTM D2488	1 per lift
Grain Size Distribution	ASTM D422	1 per lift

In-Place Cohesive Soil Liner

Test Name	Test Method	Contractor/Engineer Frequency
Field Moisture/Density	ASTM D1556 (sand cone) ASTM D2922/D3017 (nuclear gauge) ASTM D2937 (drive cylinder)	1 per lift per acre
Permeability	ASTM D5084	1 per lift per acre
Atterberg Limits	ASTM D4318	1 per lift per acre
Visual Classification	ASTM D2488	1 per lift per acre
Grain Size Distribution	ASTM D422	1 per lift per acre

(a) Suitable on-site and/or off-site soils may be used as cohesive soil liner if it can achieve an in-place permeability of 1.0×10^{-7} cm/sec or less for the base liner system or 1.0×10^{-5} cm/sec or less for the alternate base liner system and meets all testing requirements indicated in the material testing paragraph in this section. Wyoming bentonite or an approved equivalent may be blended with the soil to lower the soil's permeability.

(b) A permeability "window" shall be developed for each type of soil from the borrow material that will be used for construction of the cohesive soil liner. The window shall be plotted on a semi-log plot with moisture content versus density. Laboratory testing to develop the window shall include a series of remolded samples compacted to various dry densities and moisture contents utilizing the same compactive effort (ASTM D 698 or D 1557). The remolded samples shall be tested for permeability to determine whether or not the particular soil type will provide the maximum permeability (1.0×10^{-7} cm/sec or 1.0×10^{-5} cm/sec) at various dry densities and moisture contents. The window is then developed from the accepted remolded samples and moisture contents from the semi-log plot. A straight line is typically drawn between the acceptable points on the moisture-density curve to indicate a range of probable acceptable permeability results. The window will be used in the construction of the test strip to verify the laboratory remolded permeability results.

(c) Atterberg limits and grain size distribution shall also be conducted on the bulk samples used to prepare the permeability window ASTM D2488, D4318, D422. These tests can be used as indices on random samples collected from the borrow site during construction to verify the soil type is the same as was used to develop the "window". As a minimum, sufficient visual classifications and Atterberg limits shall be conducted in association with each permeability test to verify that the construction materials meet specifications.

(d) A test strip of compacted cohesive soil liner shall be prepared to verify the permeability "window" prior to general installation of the cohesive soil liner. The test strip will be used to verify the results from the remolded permeabilities from the borrow site utilizing the permeability window(s) for each soil type that is going to be used for construction of the cohesive soil liner. At a minimum, the verification will consist of three moisture density tests, one Atterberg limits test, one grain size distribution test (ASTM D698, ASTM D2488, D4318, and D422), and one Shelby Tube sample for each lift constructed in the test pad. Laboratory permeability tests shall be performed on tube (Shelby or drive tubes) samples of the cohesive soil liner after placement and compaction. The permeability must be a maximum of 1.0×10^{-7}cm/sec or 1.0×10^{-5} cm/sec for alternate liner systems. Tests shall be performed in accordance with the ASTM D5084. The test strip shall be approximately 2,500 sq. ft. in surface area and constructed to conform geometrically to the site topography with a minimum lateral dimension in any direction of 25 ft. The test strip shall consist of at least four compacted 6 inch lifts of cohesive soil liner. Placement and testing of the test strip shall be in conformance with the construction specifications and requirements for general installation of the cohesive soil liner. Test results from the test strip shall be used to guide placement and achievement of the required maximum permeabilities of the cohesive soil liners. The test strip may be used as an integral part of

the overall cohesive soil liner if it meets the required specification for the liner. All results shall be given to the Construction Observer.

(e) The soils shall be placed to the total thickness shown on the plans in maximum 8-inch thick loose lifts with a maximum 6" compacted lift compacted preferably at a moisture content between 0 to 3% above optimum moisture content to 95% standard Proctor maximum dry density (ASTM Test Designation D698). A sheepsfoot roller or approved alternative may be used to compact the soil liner provided the compaction and permeability requirements can be achieved. Each lift shall be tested for permeability, moisture content, particle size distribution analysis, Atterberg limits, moisture-density-permeability relation, and if needed percent bentonite admixed with soil, prior to the placement of the succeeding lift and visually inspected to confirm that all soil clods have been broken and that the surface is sufficiently scarified so that adequate bonding can be achieved. Soils for cohesive soil liner shall be screened, disked, or prepared using any other approved method as necessary to obtain a homogeneous cohesive soil with clod sizes in a soil matrix no larger than about 1.5 inches in maximum diameter. After each lift, the surface shall be scarified prior to the placement of the next lift to provide good bonding from one lift to the next.

(f) The cohesive soil liner shall be tested to evaluate the coefficient of permeability. The coefficient of permeability of the soil liner shall be equal to or less than 1.0×10^{-7} cm/sec (1.0×10^{-5} cm/sec for alternate base liner) after placement and compaction. The soil liner must be a minimum of 2.0 feet thick (1.5 feet thick for alternate base liner).

(g) Laboratory permeability tests shall be performed on tube (Shelby or drive tubes) samples of the cohesive soil liner after placement and compaction. The permeability must be a maximum of 1.0×10^{-7} cm/sec (1.0×10^{-5} cm/sec for alternate base liner). Tests shall be performed in accordance with the ASTM D5084 with a hydraulic gradient of 20 and confining pressure of 10 psi.

(h) The soil liner shall be tested a minimum of one soil sample per lift per acre for laboratory permeability. All permeability testing will be on random samples judged by the Engineer to be representative of the most permeable soil conditions for the area being tested. The project engineer shall certify that the materials used in construction were tested according to the Division approved plans. If after placement of the soil liner it fails the required tests, the material will either be reworked or replaced. The soil liner must remain moist at all times, if any section becomes dry, rework the dry area and moisten.

(i) A minimum of two (2) inches of soil shall be removed prior to securing each sample for permeability testing. The sampling tube shall be advanced vertically into the soil with as little soil disturbance as possible and should be pushed using a uniform pressure. The sampling tube (Shelby tube), when extracted, shall be free of dents, and the ends shall not be distorted. A backhoe or approved alternative should be used to advance the sampling tube (Shelby tube) as long as disturbance is minimized. Drive tube samples of the liner may be obtained for permeability testings. If the Engineer judges the sample to be too disturbed, another sample shall be taken. Once an acceptable sample has been secured and properly prepared, all sample excavations shall be backfilled to grade with a 50% mixture of bentonite and similar soils in maximum 3-inch loose lifts and hand tamped with a blunt tool to achieve a tight seal equivalent to the original density.

(j) No additional construction shall proceed on the soil layers at the area being tested until the Engineer has reviewed the results of the tests and judged the desired permeability is being achieved.

(k) As a minimum, sufficient visual classifications (ASTM Test Designation D2488), gradation analyses (ASTM Test Designation D422) and Atterberg limits (ASTM Test Designation D4318) shall be conducted in association with each permeability test to verify that the construction materials meet specifications. The minimum number of tests will be 1 per lift per acre.

(l) If the soil for the cohesive soil liner is incapable of achieving the required permeability when compacted, bentonite or approved alternative may be mixed with the soils to decrease the permeability. The amount of additive required must be determined in the laboratory. Where additives are required, the soil shall be placed in maximum 8-inch thick loose lifts and compacted preferably between 0 to +3% optimum moisture content to 95% standard Proctor maximum dry density (ASTM Test Designation D698) for the soil-additive mixture. All other compaction procedures for the soil apply.

(m) Surfaces to be lined shall be smooth and free of debris, roots, and angular or sharp rocks larger than three-eight (3/8) inches in diameter to a depth of six (6) inches. The cohesive soil liner shall have no sudden sharp or abrupt changes in grade.

(n) The Contractor shall protect the cohesive soil liner from desiccation, flooding and freezing. Protection, if required, may consists of a thin plastic protective cover, (or other material as approved by the engineer) installed over the completed cohesive soil liner until such time as the placement of flexible membrane liner begins. Areas found to have any desiccation cracks or which exhibit swelling, heaving or other similar conditions shall be replaced or reworked by the contractor to remove these defects.

(o) The thickness and grade of the soil liner will be verified by the surveyor before placement of the geomembrane liner. The soil liner will be surveyed at 50' grid points where the elevations of the subbase will be checked with the top of soil liner to verify 2.0 feet of soil liner (1.5 feet of soil liner for the alternate base liner). The grade will then be verified with the surveyed information. The survey will be performed by NC licensed surveyors.

(p) The anchor trench shall be excavated by the Contractor to lengths and widths shown on the design drawings prior to geomembrane placement. Anchor trenches excavated in cohesive soils susceptible to desiccation cracks should be excavated only the distance required for that days liner placement to minimize the potential of desiccation cracking of the cohesive soils. Corners in the anchor trench shall be slightly rounded where the geomembrane adjoins the trench to minimize sharp bends in the geomembrane.

(q) Surface Acceptance. Upon request, the Flexible Membrane Liner manufacturer installer shall provide the Engineer with a written acceptance of the surface prior to commencing installation. Subsequent repairs to the cohesive soil liner and the surface shall remain the responsibility of the contractor.

4.2.3 Alternate Base Liner System Specifications

(1.1) General

This specification covers the technical requirements for the furnishing and installation of the Geosynthetic Clay Liner (GCL) described herein. All materials used shall meet the requirements of this specification, and all work shall be performed in accordance with the procedures provided herein and the contract drawings.

The Contractor shall furnish all labor, materials, supervision and equipment to complete the installation of the GCL, including, but not limited to, liner layout, seaming, patching, and all necessary and incidental items required to complete the Work, in accordance with the Contract Drawings and these Specifications.

Sufficient liner material shall be furnished to cover all lined areas shown on the Drawings, including overlaps at field seams and anchor trenches.

It is the intent of these Specifications to ensure a quality finished product. It shall be the responsibility of the Contractor to ensure that this requirement is met.

(1.2) Definitions

For the purposes of this specification guideline, the following terms are defined below:

Geosynthetic Clay Liner (GCL) - A manufactured hydraulic barrier consisting of clay bonded to a layer or layers of geosynthetics. The GCL may be reinforced or unreinforced as required by site conditions. This site will require reinforced GCL over the entire area.

Geomembrane - An essentially impermeable geosynthetic composed of one or more geosynthetic sheets.

Geotextile - Any permeable textile used with foundation, soil, rock, earth, or any other geotechnical engineering related material as an integral part of a human-made project, structure, or system.

Minimum Average Roll Value - The minimum average value of a particular physical property of a material, for 95 percent of all the material in the lot.

Overlap - Where two adjacent GCL panels contact, the distance measuring perpendicular from the overlying edge of one panel to the underlying edge of the other.

(1.3) Submittals/Qualifications

A. The GCL Manufacturer must have produced at least 10 million square feet (1 million square meters) of GCL, with at least 8 million square feet (800,000 square meters) installed. The manufacturer shall submit certification that GCL manufactured for the Project has been produced in accordance with these Specifications along with results from a quality control program. This information must be submitted for review prior to material delivery. The Engineer reserves the right to halt installation until proper certification is submitted and determined acceptable for use.

B. The Contractor shall submit to the Engineer, six (6) full sets of panel layout construction drawings. Drawings shall be submitted to the Engineer at least two (2) weeks prior to installation.

C. The manufacturer of the GCL used in this work shall approve all shop drawings and a proposed liner layout to cover the lined area shown on the Drawings.

D. Details shall be included to show the termination of the liner at the perimeter of lined areas, the methods of sealing around penetrations, and methods of anchoring. A specific anchor trench detail shall be provided.

E. The Contractor shall submit to the Engineer a physical sample of the liner to be used. The sample shall be labeled with the manufacturer's name, product identification, lot number and roll number.

F. Upon shipment, the Contractor shall furnish the GCL manufacturer's Quality Assurance/Quality Control (QA/QC) certifications to verify that the materials supplied for the project are in accordance with the requirements of this specification. The Contractor shall also submit to the Engineer inventory tickets, roll numbers or batch identifications, packing papers, and invoices for the liner used.

G. As installation proceeds, the Contractor shall submit certificates of subgrade acceptance to the Engineer, signed by the Contractor and the GCL Installer for each area that is covered by the GCL.

H. The Contractor shall provide personnel resumes demonstrating compliance with the following requirements.

4. A project reference list for the GCL(s) consisting of the principal details of at least ten projects totaling at least 10 million square feet (100,000 square meters) in size.

5. A minimum of one field superintendent per shift shall be designated by the Contractor and approved by the Engineer. Each field superintendent shall have a minimum of three years and five million square feet of field experience in installing GCL's. Any change or replacement of superintendent during the Project must be approved by the Engineer.

6. Liner placement technicians shall have a minimum of one year and one million square feet of GCL placement experience.

(1.4) Construction Quality Assurance (CQA)

A. The Project Engineer shall provide an inspector for CQA of the GCL installation. The inspector shall be responsible for observing and documenting activities related to the CQA of the GCL. The contractor shall not install any GCL on this project, at any time, in the absence of the CQA inspector.

B. Testing of the GCL, as necessary to support the CQA effort, shall be performed by a third party laboratory retained by the Engineer and independent from the GCL manufacturer and installer.

(2) Products

(2.1) General

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. The Contractor also must obtain prior approval of the alternative GCL by the Project Engineer.

B. Reinforced GCL must be used on all areas of the site.

(2.2) Materials

A. An acceptable GCL product is Bentomat® ST as manufactured by CETCO or an engineer-approved equal.

B. All areas of the project requiring reinforced GCL will be furnished with Bentomat® ST or an engineer-approved equal.

C. The GCL(s) and their components shall have the properties shown in the attached CETCO's Technical Data Sheet (TR404bm).

D. The minimum acceptable dimensions of full-size GCL panels shall be 150 feet (45.7m) in length and 15 feet (4.6m) in width for Bentomat. Short rolls [(those manufactured to a length greater than 70 feet (21m) but less than a full-length roll)] may be supplied at a rate of no greater than 3 per truckload or 3 rolls for every 36,000 square feet (3,500 square meters) of GCL, whichever is less.

E. A 6-inch (150mm) overlap guideline shall be imprinted on both edges of the upper geotextile component of the GCL as a means for providing assurance of the overlap dimension. Lines shall be printed in easily visible, non-toxic ink.

(2.3) Product Quality Documentation

The GCL manufacturer/Contractor shall provide the Engineer with manufacturing QA/QC certifications for each shipment of GCL, prior to the deployment of GCL. The certifications shall be signed by a responsible party employed by the GCL manufacturer, such as the QA/QC Manager, Production Manager, or Technical Services Manager, and shall include:

E. Certificates of analysis for the bentonite clay used in GCL production demonstrating compliance with the parameters swell index and fluid loss shown in CETCO's Technical Data Sheet TR404bm.

F. Manufacturer's test data for finished GCL products(s) of bentonite mass/area, GCL tensile strength, and GCL peel strength demonstrating compliance with the index parameters shown in CETCO's Technical Data Sheet TR404bm.

G. GCL lot and roll numbers supplied for the project (with corresponding shipping information).

H. Manufacturer's test data for finished GCL product(s) including GCL index flux, permeability, and hydrated internal shear strength data demonstrating compliance with the performance parameters shown in CETCO's Technical Data Sheet TR404bm.

CETCO
COLLOID ENVIRONMENTAL TECHNOLOGIES COMPANY

TECHNICAL DATA SHEET

BENTOMAT "ST" CERTIFIED PROPERTIES

MATERIAL PROPERTY	TEST METHOD	TEST FREQUENCY, ft^2 (m^2)	REQUIRED VALUES
Bentonite Swell Index[1]	ASTM D 5890	1 per 50 tonnes	24 mL/2g min.
Bentonite Fluid Loss[1]	ASTM D 5891	1 per 50 tonnes	18 mL max.
Bentonite Mass/Area[2]	ASTM D 5993	40,000 ft^2 (4,000 m^2)	0.75 lb/ft^2 (3.6 kg/m^2)
GCL Grab Strength[3]	ASTM D 4632	200,000 ft^2 (20,000 m^2)	90 lbs (400 N)
GCL Peel Strength[3]	ASTM D 4632	40,000 ft^2 (4,000 m^2)	15 lbs (65 N)
GCL Index Flux[4]	ASTM D 5887	Weekly	1×10^{-8} $m^3/m^2/sec$
GCL Permeability[4]	ASTM D 5084	Weekly	5×10^{-9} cm/sec
GCL Hydrated Internal Shear Strength[5]	ASTM D 5321	Periodic	500 psf (24 kPa) typical

Bentomat "ST" is a reinforced GCL consisting of a layer of sodium bentonite between a woven and a non-woven geotextile which are needlepunched together.

Notes:

1. Bentonite property tests performed at CETCO's bentonite processing facility before shipment to CETCO's GCL production facilities.
2. Bentonite mass/area reported at 0 percent moisture content..
3. All tensile testing is performed in the machine direction, with results as minimum average roll values unless otherwise indicated.
4. Index flux and permeability testing with deaired distilled/deionized water at 80 psi (551 kPa) cell pressure, 77 psi (531 kPa) headwater pressure and 75 psi (517 kPa) tailwater pressure. Reported value is equivalent to 925 gal/acre/day. This flux value is equivalent to a permeability of 5×10^{-9} cm/sec for typical GCL thickness. This flux value should not be used for equivalency calculations unless the gradients used represent field conditions. A flux test using gradients that represent field conditions must be performed to determine equivalency. The last 20 weekly values prior the end of the production date of the supplied GCL may be provided.
5. Peak value measured at 200 psf (30 kPa) normal stress. Site-specific materials, GCL products, and test conditions must be used to verify internal and interface strength of the proposed design.

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The information and data contained herein are believed to be accurate and reliable. CETCO

(2.4) Material Conformance Testing

The CQA Engineer shall perform the material conformance tests listed in Table 1.

Table 1: QA Testing Program for GCL Material Conformance

PROPERTY	TEST METHOD	UNITS	VALUE[1]	TEST FREQUENCY
Hydraulic Conductivity	ASTM D5084[2]	cm/s	$\leq 5.0 \times 10^{-9}$	200,000 ft^2
Bentonite Content	ASTM D3776[3]	psf	0.75 (@0% moisture)	200,000 ft^2
Thickness	ASTM D1777	inch	0.20	200,000 ft^2
Grab Tensile Strength	ASTM D4632	lbs	90	200,000 ft^2
Interface Friction Test	ASTM D5321[6]	degrees	≥ 13.5[4]	1
Interface Friction Test	ASTM D5321[6]	degrees	≥ 13.0[5]	1
Shear Strength	ASTM D5321	psf	500	1

[1] Minimum Average Roll Values (MARV).
[2] Conduct test at 5 psi effective stress.
[3] Alternatively, use ASTM D5993 for measuring the mass per unit area of GCL.
[4] GCL against the soil liner (peak value).
[5] GCL (woven geotextile) against the textured FML (peak value).
[6] Conduct test at 3 psi effective stress and hydrate the GCL.

Samples for material conformance testing shall be obtained upon delivery of the GCL. Samples shall be taken across the entire width of the roll. Samples shall be 1 foot to 3 feet long by the roll width. All material conformance testing shall be performed by a third party Geosynthetics Laboratory retained by the Engineer. All test results must be available at the Engineer's office prior to the deployment of any GCL roll at the site. The CQA Engineer will examine all results from laboratory testing.

(2.5) 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.

(2.6) Packaging

A. The GCL shall be wound around a rigid core whose diameter is sufficient to facilitate handling. The core is not necessarily intended to support the roll for lifting but should be sufficiently strong to prevent collapse during transit.

B. All rolls shall be labeled and bagged in packaging that is resistant to photo degradation by ultraviolet (UV) light.

(2.7) 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.

(2.8) Equipment Requirements

A. CETCO GCLs are delivered in rolls weighing from 2,500 - 2,700 lbs (1,140-1,225 kg). It is necessary to support this weight using an appropriate core pipe. For any installation, the core pipe must not deflect more than 3 inches (75 mm) as measured from end to midpoint when a full GCL roll is lifted.

B. Lifting chains or straps rated for at least twice the load of the GCL should be used in combination with a spreader bar made from an I-beam. The spreader bar ensures that the lifting chains or straps do not chafe against the ends of the GCL roll, which must be able to rotate freely during installation.

C. A front end-loader, backhoe, dozer, or other equipment can be furnished with the spreader bar and core bar. Alternatively, a forklift with a "stinger" attachment may be used for on-site handling and, in certain cases, installation. **A forklift without a stinger attachment shall not be used to lift or handle the GCL rolls.**

D. When installing over certain geosynthetic materials, a 4-wheel all-terrain vehicle (ATV) can be used to deploy the GCL from behind. An ATV can be driven directly on the GCL provided that no sudden stops, starts, or turns are made.

E. Additional equipment needed for installation of CETCO's GCLs includes:

- Utility knife and spare blades (for cutting the GCL).
- Granular bentonite or bentonite mastic (for overlapped seams of GCLs with needle punched non-woven geotextiles and for sealing around structures and details).
- Waterproof tarpaulins (for temporary cover on installed material as well as or stockpiled rolls).
- Optional chalk line marker to simplify bentonite placement at seams (when installing a GCL with needle punched non-woven geotextile components).
- Optional flat-bladed vise grips (for positioning the GCL panel by hand).

(3) EXECUTION

(3.1) Shipping and Handling

A. The manufacturer assumes responsibility for initial loading the GCL. Shipping will be the responsibility of the party paying the freight. Unloading, on-site handling, and storage of the GCL are the responsibility of the Contractor, Installer, or other designated party.

B. A visual inspection of each roll should 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.

The party responsible for unloading the GCL should contact the Manufacturer prior to shipment to ascertain the appropriateness of the proposed unloading methods and equipment.

(3.2) Storage

A. Storage of the GCL rolls shall be the responsibility of the installer. A dedicated storage area shall be selected at the job site that is away from high traffic areas and is level, dry, and well-drained.

B. Rolls should be stored in a manner that prevents sliding or rolling from the stacks and may be accomplished by the use of chock blocks or by use of the dunnage shipped between rolls. Rolls should be stacked at a height no higher than that at which the lifting apparatus can be safely handled (typically no higher than four). Rolls shall never be stacked on end.

C. All stored GCL materials and the accessory bentonite must be covered with a plastic sheet or tarpaulin until their installation.

D. The integrity and legibility of the labels shall be preserved during storage.

(3.3) Earthwork/Subgrade Preparation

A. Any surface upon which the GCL is installed shall be prepared and compacted in accordance with the project specifications and drawings. The surface shall be smooth, firm, and unyielding, and free of vegetation, any debris, sticks, sharp rocks, void spaces, ice, abrupt elevation changes, standing water, cracks larger than one-quarter inch (6mm) in width, and any other foreign matter that could contact 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 No. 60 sieve (0.250 mm).

C. Immediately prior to GCL deployment, the subgrade shall be final-graded to fill in all voids or cracks and then smooth-rolled to provide the best practicable surface for the GCL. At completion of this activity, no wheel ruts, footprints or other irregularities shall exist in the subgrade. Furthermore, all protrusions extending more than one-half inch (12mm) from the surface shall either be removed, crushed or pushed into the surface with a smooth-drum compactor.

D. On a continuing basis, the Contractor/GCL Installer shall submit certifications of subgrade acceptance to the Engineer, and the project CQA inspector shall verify acceptance of the subgrade before GCL placement.

E. It shall be the installer's responsibility thereafter to indicate to the Engineer any change in the condition of the subgrade that could cause the subgrade to be out of compliance with any of the requirements listed in 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 plans and specifications. The excavated trench shall be verified by the CQA Inspector 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.

(3.4) <u>GCL Placement</u>

Placement of the GCL shall be conducted in accordance with the manufacturer's recommendations and with the direction provided herein. Any deviations from these procedures must be pre-approved by the CQA Engineer.

A. The contractor shall not install any GCL on this project, at any time, in the absence of the CQA inspector. During start-up of the GCL installation, an agent or representative of the Manufacturer shall provide on-site assistance and instruction to the Contractor and CQA Engineer regarding the appropriate installation techniques.

B. The CQA Inspector/Engineer shall inspect each panel, after placement and prior to seaming, for damage and/or defects. All defects and deficiencies shall be properly documented by the GCL Installer and CQA Inspector. Defective or damaged panels shall be replaced or repaired, as approved by the CQA Inspector/Engineer. The Contractor will correct defects and deficiencies to the satisfaction of the Engineer. The CQA Inspector shall observe and verify all repaired defects.

C. Reinforced GCL shall be placed on all areas of the site.

D. GCL rolls should be delivered to the working area of the site in their original packaging. Immediately prior to deployment, the packaging should be carefully removed without damaging the GCL. The orientation of the GCL (i.e., which side faces up) may be important if the GCL has two different geotextiles. Unless otherwise specified, however, the GCL shall be placed with the white side (non-woven) geotextile facing down.

E. The GCL shall be properly weighted to avoid uplift due to wind.

F. Equipment which could damage the GCL shall not be allowed to travel directly on it. Acceptable installation, therefore, may be accomplished such that the GCL is unrolled in front of the backwards-moving equipment. If the installation equipment causes rutting of the subgrade, the subgrade must be restored to its originally accepted condition before placement continues. Equipment necessary to perform the installation (generators, compressors, etc.) shall have a scrap GCL sheet placed underneath to protect the installed GCL from possible damage.

G. The GCL shall be kept free of debris, unnecessary tools and materials. In general, the GCL area shall remain neat in appearance. All damage shall be recorded and located in the record drawings.

H. Care must 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 geosynthetic subgrade covering commonly known as a slip sheet or rub sheet may be used to reduce friction damage during placement.

I. The GCL shall be placed so that seams are parallel to the direction of the slope. End-of-roll seams should be located at least 3 feet (1m) from the toe and crest of slopes steeper than 4H:1V. GCL rolls shall **not** be released on the slope and allowed to unroll freely by gravity.

J. All GCL panels shall be placed free of tension or stress and lie flat on the underlying surface, with no wrinkles or fold, especially at the exposed edges of the panels. Similarly, the geomembrane placed over GCL shall lie flat and in contact with the underlying GCL with no wrinkles or fold.

K. The GCL shall not be installed in standing/ponded water, during rainy weather/precipitation, excessive moisture, and during extremely/excessive high wind. Only as much GCL shall be deployed as can be covered at the end of the working day with the geomembrane. In no case shall the GCL be exposed to the elements at the end of the day. The GCL shall not be left uncovered overnight. If the GCL is hydrated when no confining stress is present, it will be necessary to remove and replace the hydrated material. The project Engineer, CQA inspector, and GCL supplier should be consulted for specific guidance if premature hydration occurs.

L. The GCL shall not get wet before or during installation. The GCL mat shall not be installed during periods of any precipitation. If a precipitation event occurs after the installation of a GCL panel, but prior to covering with the geomembrane panel, a thin film plastic sheeting may be used to cover and to temporarily protect the GCL from moisture, if approved by the Project Engineer.

M. Panels shall be placed from the highest elevation to the lowest within the area to be lined, to facilitate drainage in the event of precipitation.

N. It is not permissible to stretch the GCL in order to fit a designated area. Panels shall not be dragged across the subgrade into position except where necessary to obtain the correct overlap for adjacent panels.

(3.5) <u>Anchorage</u>

A. As directed by the project drawings and specifications, 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 any sharp corners. The GCL should cover the entire trench floor but does not extend up the rear trench wall.

B. The amount of trench open at any time shall be limited to one day of GCL installation capacity. The anchor trench shall be adequately drained to prevent water ponding and softening the adjacent soils. Loose soil shall be removed from the floor of the trench. The soil backfill should be placed in the trench to provide resistance against pullout. The size and shape of the trench, as well as the appropriate backfill procedures, should be in accordance with the project drawings and specifications.

(3.6) <u>Seaming</u>

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 for Bentomat® ST.

B. The minimum dimension of the longitudinal overlap should be 6 inches (150 mm). End-of-roll overlapped seams should be similarly constructed, but the minimum overlap should measure 24 inches (600 mm). In the opinion of the CQA Engineer/Inspector, any seam, or edge of GCL material exposed for more than 24 hours or considered partially hydrated when seaming occurs shall receive a 3-foot overlap (rainlap) from the adjoining GCL panel.

C. All seams shall have a seam number that corresponds with the panel layout numbers. The numbering system shall be used in the development of the record drawings. Seam numbers shall be derived from the combination of the two panel numbers that are to be seamed.

D. Seam areas or runs shall also be flat and clear of any large rocks, debris, or ruts. Contacting surfaces shall be clean and clear of dirt or native soil with all edges pulled tight to maximize contact and to smooth out any wrinkles or creases.

E. All seams constructed on sloped surface shall be vertical seams.

F. Seams at the ends of the panels should be constructed such that they are shingled in the direction of the grade to prevent the potential for runoff flow to enter the overlap zone.

G. Bentonite-enhanced seams are constructed between the overlapping adjacent panels described above. The underlying edge of the longitudinal overlap is exposed and then a continuous bead of granular sodium bentonite is applied along a zone defined by the edge of the underlying panel and the 6 inch (150 mm) line. A similar bead of granular sodium bentonite is applied at the end-of-roll overlap. The bentonite shall be applied at a minimum application rate of one quarter pound per lineal foot (0.4 kg/m).

(3.7) <u>Detail Work/Sealing Around Penetration and Structures</u>

A. Cutting the GCL should be performed using a sharp utility knife. Frequent blade changes are recommended to avoid irregular tearing of the geotextile components of the GCL during the cutting process. The GCL shall be sealed around penetrations and structures embedded in the subgrade. Granular bentonite or a bentonite mastic shall be used liberally (approximately 2 lbs/in ft or 3 kg/m) to seal the GCL to these structures.

B. When the GCL is placed over an earthen subgrade, a "notch" (approximately 3 inches wide and 8 inches deep) shall be cut against the edge of the subgrade area around the penetration. The mat shall be brought up to the edge of the structure and trimmed to fit into the notch. The Contractor shall then hand apply a pure bead of bentonite into half the notch. The mat shall then be inserted into the notch, with the remaining volume of the notch refilled with the pure bentonite and compacted.

C. A secondary collar of GCL should be placed around the penetration. It is helpful to first trace an outline of the penetration on the GCL and then cut a "star" pattern in the collar to enhance the collar's fit to the penetration.

D. Vertical penetrations are prepared by notching into the subgrade. The penetration is completed with two separate pieces of GCL. A secondary collar is option in this case.

E. When the GCL is terminated at a structure or wall that is embedded into the subgrade, the subgrade should be notched as described in Items B and D above. The notch is filled with granular bentonite, and the GCL should be placed over the notch and up against the structure. The connection to the structure can be accomplished by placement of soil or stone backfill in this area.

(3.8) Damage Repair

A. If the GCL is damaged (torn, punctured, perforated, etc.) during installation, it may be possible to repair it by cutting a patch to fit over the damaged area. The patch shall be obtained from a new GCL roll and shall be cut to size such that minimum overlap of 12 inches (300 mm) is achieved around all of the damaged area. Dry bentonite or bentonite mastic should be applied around the damaged area at the rate of one-half pound per lineal foot prior to placement of the patch. Any epoxy-based adhesives shall be used to keep the patch in position during backfill operations.

(3.9) Placement of Overlaying Materials

A. Although direct vehicular contact with the GCL is to be avoided, lightweight, low ground pressure vehicles [such as 4-wheel all-terrain vehicles (ATV)] may be used to facilitate the installation of any geosynthetic material placed over the GCL, provided the ATV makes no sudden stops, starts, or turns. The GCL supplier or CQA engineer should be contacted with specific recommendations on the appropriate procedures in this situation.

B. When a textured geomembrane is installed over the GCL, a temporary geosynthetic covering known as a slip sheet or rub sheet should be used to minimize friction during placement and to allow the textured geomembrane to be more easily moved into its final position.

C. Any leading edge of panels left uncovered shall be protected at the end of the working day with a waterproof sheet which is adequately secured with sandbags or other ballast.

D. Soil cover shall be placed over the GCL/geomembrane using low ground pressure construction equipment that minimizes stresses on the GCL/geomembrane, according to the existing project specification requirements for protective cover soil installation over geomembrane liner.

4.2.4. Base Liner System Flexible Membrane Liner Method of Deployment

All materials and equipment shall be furnished by an established and reputable manufacturer or supplier. All materials and equipment shall be new and shall be of first class ingredients and construction, designed and guaranteed to perform the service required and shall conform with the following standard specifications or shall be the product of the listed manufacturers or similar and equal thereto as approved by the Engineer.

Flexible Membrane Liner Tests

Test Name	Description	Test Method	Frequency
Air Test	Air Test Seams		Every Seam
Vacuum Test	Every welded area		Where air test impossible
Destructive Tests	Seam Strength	ASTM D4437	Every 500' of seam

Qualified liner installers, seamers, and the liner foreman shall meet a minimum requirement of 1,000,000 square feet of geomembrane installation. There are no other minimum qualifications needed by other parties.

60 mil High Density Polyethylene (HDPE) - Geosynthetic Research Institute (GRI) GM13 - Is to be placed in direct contact with moist cohesive soil liner. The Landfill itself is single lined and will only have a single Textured Geomembrane. The extrusion rods and/or brads used in seaming the rolls together shall be derived from the same base resin as the liner and shall meet the following minimum properties:

ENGLISH UNITS

Table 2(a) - High Density Polyethylene (HDPE) Geomembrane - Textured

Property	Test Method	Test Value							Testing Frequency (minimum)
		30 mils	40 mils	50 mils	60 mils	80 mils	100 mils	120 mils	
Thickness (min. ave.) • lowest individual for 8 out of 10 values • lowest individual for any of the 10 values	D 5994	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	per roll
Asperity Height (min. ave.) *(1)*	GM 12	10 mil	10 mil	10 mil	10 mil	10 mil	10 mil	10 mil	every 2nd roll *(2)*
Density (min. ave.)	D 1505/D792	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	200,000 lb
Tensile Properties (min. ave.) *(3)* • yield stress • break stress • yield elongation • break elongation	D 638 Type IV	 63 lb/in. 45 lb/in. 12% 100%	 84 lb/in. 60 lb/in. 12% 100%	 105 lb/in. 75 lb/in. 12% 100%	 126 lb/in. 90 lb/in. 12% 100%	 168 lb/in. 120 lb/in. 12% 100%	 210 lb/in. 150 lb/in. 12% 100%	 252 lb/in. 180 lb/in. 12% 100%	20,000 lb
Tear Resistance (min. ave.)	D 1004	21 lb	28 lb	35 lb	42 lb	56 lb	70 lb	84 lb	45,000 lb
Puncture Resistance (min. ave.)	D 4833	45 lb	60 lb	75 lb	90 lb	120 lb	150 lb	180 lb	45,000 lb
Stress Crack Resistance *(4)*	D 5397 (App.)	200 hr.	200 hr.	200 hr.	200 hr.	200 hr.	200 hr.	200 hr.	per GRI-GM 10
Carbon Black Content (range)	D 1603 *(5)*	2.0 - 3.0%	2.0 - 3.0%	2.0 - 3.0%	2.0 - 3.0%	2.0 - 3.0%	2.0 - 3.0%	2.0 - 3.0%	20,000 lb
Carbon Black Dispersion	D 5596	note *(6)*	note *(6)*	note *(6)*	note *(6)*	note *(6)*	note *(6)*	note *(6)*	45,000 lb
Oxidative Induction Time (OIT) (min. ave.) *(7)* (a) Standard OIT — or — (b) High Pressure OIT	 D 3895 D 5885	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	200,000 lb
Oven Aging at 85°C *(7), (8)* (a) Standard OIT (min. ave.) - % retained after 90 days — or — (b) High Pressure OIT (min. ave.) - % retained after 90 days	D 5721 D 3895 D 5885	 55% 80%	 55% 80%	 55% 80%	 55% 80%	 55% 80%	 55% 80%	 55% 80%	per each formulation
UV Resistance *(9)* (a) Standard OIT — or — (b) High Pressure OIT (min. ave.) - % retained after 1600 hrs *(11)*	GM11 D 3895 D 5885	 N.R. *(10)* 50%	 N.R. *(10)* 50%	 N.R. *(10)* 50%	 N.R. *(10)* 50%	 N.R. *(10)* 50%	 N.R. *(10)* 50%	 N.R. *(10)* 50%	per each formulation

(1) Of 10 readings; 8 out of 10 must be ≥ 7 mil, and lowest individual reading must be ≥ 5 mil
(2) Alternate the measurement side for double sided textured sheet
(3) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction
Yield elongation is calculated using a gage length of 1.3 inches
Break elongation is calculated using a gage length of 2.0 inches
(4) The SP-NCTL test is not appropriate for testing geomembranes with textured or irregular rough surfaces. Test should be conducted on smooth edges of textured rolls or on smooth sheets made from the same formulation as being used for the textured sheet materials.
The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value via MQC testing.
(5) Other methods such as D 4218 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to D1603 (tube furnace) can be established.
(6) Carbon black dispersion for 10 different views:
• all 10 in Categories 1 or 2
(7) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.
(8 It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.
(9) The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.
(10) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.
(11) UV resistance is based on percent retained value regardless of the original HP-OIT value.

Preparation for Geomembrane Deployment

(a) Panel Layout

Prior to commencement of liner deployment, layout drawings shall be produced to indicate the panel configuration and location of seams for the project.

(b) Identification

Each panel used for the installation shall be given a numeric or alpha-numeric identification number consistent with the layout drawing. This identification number shall be related to manufacturing roll number that identifies the resin type, batch number and date of manufacture.

(c) Verification

The manufacturers certification will be given to the construction observer. The construction observer will inspect all certifications. If the certification does not meet specifications, it will be rejected. Adequate laboratory QA/QC conformance testing shall be performed by the contractor/engineer to verify minimum requirements outlined on Table 2(a) of GM13-9 of 12. QC testing information is for each roll of material delivered to the site. A third party QA lab will test for thickness, density, carbon black content, carbon black dispersion and tensile properties for one roll out of four delivered to the site.

(2) Field Panel Placement

(a) Location

The Flexible Membrane Liner Manufacturer/Installer shall install field panels at the location indicated on the layout drawing. If the panels are deployed in a location other than that indicated on the layout drawings, the revised location shall be noted in the field on a layout drawing which will be modified at the completion of the project to reflect actual panel locations.

(b) Weather Conditions

Geomembrane deployment shall not be carried out during any precipitation, nor in the presence of excessive moisture (i.e. fog, dew), in an area of standing water, or during high winds.

(c) Method of Deployment

(1) The method and equipment used to deploy the panels must not damage the geomembrane or the supporting subgrade surface.

(2) No personnel working on the geomembrane will smoke, wear shoes that can damage the geomembrane, or engage in actions which could result in damage to the geomembrane.

(3) Adequate temporary loading and/or anchoring, (i.e. sandbags, tires), which will not damage the geomembrane, will be placed to prevent uplift of the geomembrane by wind. If uplift occurs, additional sandbags will be placed in necessary areas.

(4) The geomembrane will be deployed in a manner to minimize wrinkles. The geomembrane will have no fold overs.

(5) Any damage to a panel of the geomembrane will be repaired. Any area of a panel seriously damaged (torn, twisted, or crimped) will be marked, cut out and removed from the work area with resulting seaming and/or repairs performed.

(3) Field Seaming

(a) Layout

In general, seams shall be oriented parallel to the slope, i.e., oriented along, not across the slope. Whenever possible, horizontal seams should be located not less than five (5) feet from the toe of the slope. Each seam made in the field shall be numbered in a manner that is compatible with the panel layout drawing for documentation of seam testing results.

(b) Personnel

All personnel performing seaming operations shall be trained in the operation of the specific seaming equipment being used and will qualify by successfully welding a test seam. The project foreman will provide direct supervision of all personnel seaming to verify proper welding procedures are followed. Qualified liner installers, seamers, and the liner foreman shall meet a minimum requirement of 1,000,000 square feet of geomembrane installation. There are no other minimum qualifications needed by other parties.

(c) Equipment

(1) Fusion Welding

Fusion Welding consists of placing a heated wedge, mounted on a self propelled vehicular unit, between two (2) overlapped sheets such that the surface of both sheets are heated above the polyethylene's melting point. After being heated by the wedge, the overlapped panels pass through a set of preset pressure wheels which compress the two (2) panels together so that a continuous homogeneous fusion weld is formed. The fusion welder is equipped with a temperature readout device which continuously monitors the temperature of the wedge.

(2) Extrusion Fillet Welding

Extrusion fillet welding consists of introducing a ribbon of molten resin along the edge of the seam overlap of the two (2) sheets to be welded. The molten polymer causes some of the material of each sheet to be liquefied resulting in a homogeneous bond between the molten weld bead and the surfaces of the sheets. The extrusion welder is equipped with gauges giving the temperature in the apparatus and the preheat temperature at the nozzle.

(d) Weather Conditions

The Flexible Membrane Liner Manufacturer/Installer will rely on the experience of the Project Superintendent and the results of test seams to determine seaming restrictions by weather. Many factors, such as ambient temperature, humidity, wind, sunshine, etc., can affect the integrity of field seams and must be taken into account when deciding whether or not seaming should proceed. Responsibility for monitoring these conditions shall lie with the Project Superintendent; however, the Engineer may suspend any seaming operation which is, in his opinion, at the risk of providing the Owner with a quality product. Test seams are required prior to daily production seaming to determine if the weather conditions will affect the Flexible Membrane Liner System's ability to produce quality seams. Additional non-destructive and destructive testing of production seams substantiate the decision made by the Project Superintendent to seam on any given day.

(4) Seam Preparation

(a) Fusion Welding

(1) Overlap the panels of geomembrane approximately four (4) inches.

(2) Clean the seam area prior to seaming to assure the area is clean and free of moisture, dust, dirt, debris of any kind. No grinding is required for fusion welding.

(3) Adjust the panels so that seams are aligned with the fewest possible number of wrinkles and "fishmouths".

(4) A movable protective layer may be used, at the discretion of the Flexible Geomembrane Liner System Project Superintendent, directly below the overlap of geomembrane that is to be seamed to prevent build-up of moisture between the panels.

(b) Extrusion Welding

(1) Overlap the panels of geomembrane a minimum of three (3) inches.

(2) Temporarily bond the panels of geomembrane to be welded taking care not to damage the geomembrane.

(3) Grind seam overlap prior to welding within one (1) hour of welding operation in a manner that does not damage the geomembrane. Limit grinding to ¼" outside of the extrusion weld area.

(4) Clean the seam area prior to seaming to assure the area is clean and free of moisture, dust, dirt, and debris of any kind.

(5) Purge the extruder prior to beginning the seam to remove all heat degraded extrudate from the barrel.

(6) Keep welding rod clean and off the ground.

(5) Test Seams

Test seams shall be performed at the beginning of each seaming period and at approximately every 4-working hour intervals for each seaming apparatus used that day. Test seams shall be made on fragment pieces of the geomembrane liner and under the same conditions as actual seams.

(a) Test Seam Length

The test seam shall be at least three (3) feet long and should be made by joining two (2) pieces of geomembrane at least 9" in width.

(b) Sample Procedure

(1) Visually inspect the seam for squeeze out, footprint, pressure and general appearance.

(2) Two random samples one (1) inch wide shall be cut from the test seam. The specimens shall then be tested in peel using a field tensiometer and shall not fail in the seam. If a specimen fails the entire procedure shall be repeated.

(3) If any of the second set of specimens fail, the seaming apparatus shall not be accepted and shall not be used for seaming until the deficiencies are corrected and a passing test seam is achieved.

(4) After completion of these tests, the remaining portion of test seam can be discarded. Documentation of the test seams will be maintained listing seam identification number, welder's name, temperature control setting and test results.

(5) Passing test results records shall be maintained.

(6) General Seaming Procedures

(a) Seaming shall extend to the outside edge of panels to be placed in the anchor trench.

(b) While welding a seam, monitor and maintain the proper overlap.

(c) Inspect seam area to assure area is clean and free of moisture, dust, dirt, debris of any kind.

(d) While welding a seam, monitor temperature gauges to assure proper settings are maintained and that the seaming apparatus is operating properly.

(e) Align wrinkles at the seam overlap to allow welding through the wrinkle.

(f) Fishmouths or wrinkles at seam and overlaps that cannot be welded through shall be cut along the ridge in order to achieve a flat overlap. The cut fishmouth or wrinkle shall be seamed. Any portion where the overlap is inadequate shall be patched with an oval or round patch of the same geomembrane extending a minimum of six (6) inches beyond the cut in all directions.

(g) All cross/butt seams between two (2) rows of seamed panels shall be welded during the coolest time of the day to allow for contraction of the geomembrane.

(h) All "T" joints shall have the overlap from the wedge welder seam trimmed back to allow an extrusion fillet weld. Then grind ¼ of an inch minimum on either side of the wedge seam, then extrusion weld all of the area prepared by grinding.

4.2.5 Base Liner System Flexible Membrane Liner Tests

The installation crews will non-destructively test all field seams over their full length using air pressure testing, vacuum testing or other approved methods, to verify the continuity and integrity of the seams.

(a) Air Pressure Testing

The welded seam created by double hot-wedge fusion welding process is composed of two distinct welded seams separated by an unwelded channel approximately 3/8 of an inch between the two welded seams permits the double hot-wedge fusion seams to be tested by inflating the sealed channel with air to a predetermined pressure, and observing the stability of the pressurized channel over time.

(1) Equipment for Air Testing

An air pump (manual or motor driven) capable of generating and sustaining a pressure between 25 to 30 psi.

A rubber hose with fittings and connections.

A sharp hollow needle, or other approved pressure feed device with a pressure gauge capable of reading and sustaining a pressure between 25 to 30 psi.

(2) Procedure for Air Testing

Seal both ends of the seam to be tested.

Insert needle or other approved pressure feed device into the sealed channel created by the fusion weld.

Inflate the test channel to a pressure between 25 to 30 psi, in accordance with the following schedule, close valve, and observe initial pressure after approximately 2 minutes.

INITIAL PRESSURE SCHEDULE *

Material (Mil)	Min. Psi	Max. Psi
40	25	30
60	27	30
80	30	30
100	30	30

* Initial pressure settings are read after a two minute "relaxing period". The purpose of this "relaxing period" is to permit the air temperature and pressure to stabilize.

Observe and record the air pressure five (5) minutes after "relaxing period" ends and when initial pressure setting is used. If loss of pressure exceeds the following or if the pressure does not stabilize, locate faulty area and repair.

MAXIMUM PERMISSIBLE PRESSURE DIFFERENTIAL AFTER 5 MINUTES - HDPE

Material (Mil)	Pressure Diff.
40	4 psi
60	3 psi
80	3 psi
100	3 psi

At the conclusion of the pressure test the end of the seam opposite the pressure gauge is cut. A decrease in gauge pressure must be observed or the air channel will be considered "blocked" and the test will have to be repeated after the blockage is corrected.

Remove needle or other approved pressure feed device and seal resulting hole by extrusion welding.

(3) In the event of a Non-Complying Air Pressure Test, the following procedure shall be followed:

Check seam end seals and retest seams.

If non-compliance with specified maximum pressure differential re-occurs, repair the seam. Capping or removal/reseam of the non-complying seam are the only two (2) acceptable methods of repairing failed seams.

Non-destruct test the entire length of the repaired seam.

(b) Vacuum Testing

This test is used when the geometry of the weld makes air pressure testing impossible or impractical or when attempting to locate the precise location of a defect believed to exist after air pressure testing. The penetration will be tested using this method.

(1) Equipment for Vacuum Testing

Vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, port hole or valve assembly, and a vacuum gauge.

Vacuum pump assembly equipped with a pressure controller and pipe connection.

A rubber pressure/vacuum hose with fittings and connections.

A bucket and means to apply a soapy solution.

A soapy solution.

(2) Procedure for Vacuum Testing

Trim excess overlap from seam, if any.

Turn on the vacuum pump to reduce the vacuum box to approximately 5 inch of mercury, i.e., 5 psi gauge.

Apply a generous amount of a solution of strong liquid detergent and water to the area to be tested.

Place the vacuum box over the area to be tested and apply sufficient downward pressure to "seat" the seal strip against the liner.

Close the bleed valve and open the vacuum valve.

Apply a minimum of 5 in. Hg vacuum to the area as indicated by the gauge on the vacuum box.

Ensure that a leak tight seal is created.

For a period of not less than 30 seconds, examine the geomembrane through the viewing window for the presence of soap bubbles.
If no bubbles appear after 30 seconds, close the vacuum valve and open the bleed valve, move the box over the next adjoining area with a minimum 3 in. overlap, and repeat the process.

(3) Procedure for Non-Complying Test

Mark all areas where soap bubbles appear and repair the marked areas.

Retest repaired areas.

(c) Destructive Testing

(1) Concept

The purpose of destructive testing is to determine and evaluate seam strength. These tests require direct sampling and thus subsequent patching. Therefore destructive testing should be held to a minimum to reduce the amount of repairs to the geomembrane.

(2) Procedure for Destructive Testing

All Destructive tests will be done according to ASTM D4437. Destructive test samples shall be marked and cut out randomly at a minimum average frequency of one test location every 500 feet of seam length.

Additional destructive tests may be taken in areas of contamination, offset welds, visible crystallinity or other potential cause of faulty welds at the discretion of the Project Superintendent and Engineer.

Sample Size

The sample should be twelve (12) inches wide with a seam fourteen (14) inches long centered lengthwise in the sample. The sample may be increased in size to accommodate independent laboratory testing by the owner at the owner's request or by specific project specifications.

A one (1) inch sample shall be cut from each end of the test seam for field testing.

The two (2), one (1) inch wide samples shall be tested in the field in a tensiometer for peel ASTM D4437. Tensile strength is essentially a measurement of the greatest tension stress a substance can bear without tearing. If the liner tears before any part of the seam does the test is successful. If any field sample fails to pass, it will be assumed the sample fails destructive testing. The passing destructive test requirements for a 60-mil liner seam is: minimum peel adhesion of 78 ppi, minimum shear strength of 120 ppi, and Film Tear Bond (FTB).

(3) Procedure in the event of Destructive Test Failure

Cut additional field samples for testing. In the case of a field production seam, the samples must lie a minimum of ten (10) feet in each direction from the location of the failed sample. Perform a field test for peel strength. If these field samples pass, then laboratory samples can be cut and forwarded to the laboratory for full testing.

If the laboratory samples pass then repair the seam between the two (2) passing samples locations.

Capping or removal of the failed seam is the only two (2) acceptable methods for repairing failed seams.

All destructive seam samples sent to the Flexible Membrane Liner System's laboratory shall be numbered.

(d) Quality Assurance Laboratory Testing

(1) Destructive samples sent to the laboratory will be tested for "shear strength" and "peel adhesion" (ASTM D4437 as modified by NSF). Five (5) specimens shall be tested for each test method with data recorded. Four (4) out of the five (5) specimens must pass for each test in order for the seam to pass the destructive test.

(2) Defects and Repairs

(a) The Project Superintendent shall conduct a detailed walk through and visually check all seams and non-seam areas of the geomembrane for defects, holes, blisters and signs of damage during installation.

(b) All other installation personnel shall, at all times, be on the lookout for any damaged areas. Damaged areas shall be marked and repaired.

(c) Repair Procedures

Any portion of the geomembrane showing a flaw or failing a destructive or non-destructive test shall be repaired. Several procedures exist for repair and the decision as to the appropriate repair procedure shall be made by the Project Superintendent. Repairs need to be made in a timely manner to protect the moist cohesive soil liner and flexible membrane liner. If inclement weather is approaching, steps need to be made to protect the cohesive soil liner such as a temporary cover. If cohesive soil liner is damaged, it must be reworked. Procedures available for liner repair:

Patching - used to repair large holes, tears and destructive sample locations. All patches shall extend at least six (6) inches beyond the edges of the defect and all corners of patches shall be rounded.

Grinding and welding - used to repair sections of extruded seams.

Spot welding or seaming - used to repair small tears, pinholes or other minor localized flaws.

Capping - used to repair lengths of failed seams.

Removal of a bad seam and replacement with a strip of new material seamed into place.

(d) Verification of Repairs

Every repair shall be non-destructively tested. Repairs which pass the non-destructive test shall be deemed adequate. Large repairs may require a destructive test. Repair test results shall be logged. The repair location shall be recorded on an as-built drawing.

4.2.6 Protective Cover for Landfill Construction

HPDE Geocomposite Drainage Netting manufactured by SKAPS Industries, or approved equal. Q/C testing information/certification for each property on geocomposite will be provided by the contractor/manufacture for the rolls delivered.

GEOCOMPOSITE PROPERTIES

PROPERTY	TEST	UNITS	MINIMUM AVERAGE ROLL VALUE
Thickness	ASTM D 5199	inch	0.305
Transmissivity[1] (15,000 psf)	ASTM D 4716	m^2/sec	$3x10^{-5}$
Ply Adhesion	ASTM D 413 or F 904	lb/in	2.0

COMPONENT PROPERTIES

GEONET	TEST	UNITS	MINIMUM AVERAGE ROLL VALUE
Polymer Density	ASTM D 1505	g/cm^3	0.94
Carbon Black Content	ASTM D 4218	%	2.0
Thickness	ASTM D 5199	inches	0.200
Mass per unit area	ASTM D 5261	lbs/ft^2	0.162
Transmissivity[1]	ASTM D 4716	m^2/sec	$1x10^{-3}$@ 15,000 psf
Tensile Strength	ASTM D 5035	lbs/in	45

GEOTEXTILE	TEST	UNITS	MINIMUM AVERAGE ROLL VALUE
Fabric Weight	ASTM D 5261	oz/yd^2	7.1
Thickness	ASTM D 5199	mils	95
Grab Strength	ASTM D 4632	lbs	210
Water Flow Rate	ASTM D 4491	gpm/ft^2	110
Apparent opening size (AOS)	ASTM D 4751	mm (Sieve Size)	0.150 (100)

1. Measured using water @ 20° C (68° F) with a gradient of one, between two steel plates, after one hour. Value may vary, based on dimensions of the transmissivity specimen and specific laboratory.
2. Component properties are tested prior to the lamination process. They cannot be tested on the final product.

The geocomposite will be handled in such a manner as to ensure the geocomposite are not damaged in any way. On slopes, the geocomposite will be secured in the anchor trench and then rolled down the slope in such a manner as to continually keep the geocomposite sheet in tension. If necessary, the geocomposite will be positioned by hand after being unrolled to minimize wrinkles. Geocomposite can be placed in the horizontal direction (i.e., across the slope) in some special locations (e.g., where extra layers are required or where slope is less than 10:1).

Geocomposite will not be welded to the geomembrane. Geocomposite will be cut using approved cutters,(i.e., hook blade, scissors, etc.) Care should be taken to prevent damage to underlying layers. Care must be taken not to entrap dirt in the geocomposite that could cause clogging of the drainage system, and or stones that could damage the adjacent geomembrane.

Adjacent rolls of geocomposite will be overlapped by at least four inches and securely tied. Tying can be achieved by plastic fasteners. Tying devices will be white or yellow for easy inspection. Metallic devices are not allowed. Tying will be five to ten feet along the bottom of the slope. Tying will be every five feet along the slope, every two feet across the slope and at the top of the berm. Tying in the

anchor trench will be done in one foot intervals. In the corners of the side slopes where overlaps between perpendicular geocomposite strips are required, an extra layer of geocomposite will be unrolled along the slope, on top of the previously installed geocomposite, from the top to bottom of the slope.

Any holes or tears in the geocomposite will be repaired by placing a patch extending two feet beyond edges of the hole or tear. The patch will be secured to the original geocomposite by tying every twelve inches. If the hole or tear width across the roll is more than 50% the width of the roll, the damaged area will be cut out and the two portions of the geocomposite will be joined.

The engineer will visually inspect the drainage layer before placement of the protective soil, if any defects are detected they will be repaired before placement of protective soil.

Select Backfill

The soil for the select backfill shall consist of suitable soil free of debris, roots, rocks and organics. The soil shall contain no particles or objects greater than 3/4 inch in largest dimension, which has been screened. There are no permeability, grain size, or any other test required for this material. This material is not being used as a drainage media; leachate collection lines are installed and designed to collect water flowing on top of the protective cover.

Backfill

The soil for backfill shall consist of suitable soil free of debris, roots, rocks, and organics. There are no permeability, grain size, or any other test required for this material. This material is not being used as a drainage media; leachate collection lines are installed and designed to collect water flowing on top of the protective cover.

Protective Soil Cover

Installation of the protective cover shall be the responsibility of the contractor. Before proceeding with placement of the protective cover over the liner, the Contractor shall furnish to the Engineer with the manufacturer's certification that the lining has been satisfactorily installed in accordance with the manufacturer's recommendations.

The protective cover shall be composed of select backfill and backfill. The cover shall be installed using low ground pressure equipment such as a Caterpillar D6H LGP, or approved equal, with ground pressure not exceeding 4.71 psi until the depth of cover exceeds three feet.

When installing the cover, the contractor shall adhere to the following guidelines:

(1) A minimum of 12 inches of cover between low ground pressure equipment such as the Caterpillar D6H LGP, or approved equal, and the liner is required at all times. Roadways for entering and for transporting material over slopes and floor shall have a minimum depth of four feet.

(2) Avoid undue stress on the liner at all times. Cover material must be pushed up side slopes, never down to help minimize wrinkles. Material must be placed to minimize wrinkles, wrinkles in excess of two feet in height are unacceptable. If a wrinkle is more than two feet in height, soil will be placed on top of the wrinkle to decrease the height. Fold over of the liner will not be allowed. A worker must walk along side earth moving equipment and remove all rocks, stones, roots or other debris that could cause damage to the liner. Equipment operators must avoid sharp turns or quick stops that could pinch and tear the liner.

(3) If damage does occur, report it to the Project Manager immediately so that repairs can be performed without needless delay.

(4) Cover shall be placed and maintained in a uniform thickness, free of ruts and I Irregularities.

(5) Do not work wet cover material that cannot support equipment.

(6) Equipment operators and all other personnel must be qualified and must exercise good judgment and common sense at all times.

4.2.7 Leachate Collection System

All materials and equipment shall be furnished by an established and reputable manufacturer or supplier. All materials and equipment shall be new and shall be of first class ingredients and construction, designed and guaranteed to perform the service required and shall conform with the following standard specifications, or shall be the product of the listed manufacturers, or similar and equal; thereto, as approved by the Engineer.

(1) High Density Polyethylene Pipe

The polyethylene pipe shall be high performance, ultra-high molecular weight, high density polyethylene pipe, conforming to ASTM D1248 (Type III, Class C, Category 5, Grade P34). Minimum cell classification values shall be 335434C as referenced in ASTM D3350. The pipe shall be SDR 17. The pipe shall contain 2 percent carbon black. The pipe shall be "Driscopipe," as manufactured by Phillips Products Company, or equal.

(2) Stone Surrounding Perforated Collection Piping

Stone for leachate collection system shall meet the requirements of NC DOT aggregate, standard size No. 5 and shall contain no fines. Stone must pass the sieve analysis test for No. 5 stone performed at the quarry.

(3) Geotextile Filter Fabric

Filter fabric surrounding the stone/collection piping shall be non-woven needle punched drainage fabric with the following minimum properties:

1)	Weight	4.5 oz/yd^2	ASTM D-5261
2)	Thickness	60 mils	ASTM D-1777
3)	Grab Strength	125 lbs.	ASTM D-4632
4)	Grab Elongation	60%	ASTM D-4632
5)	Trapezoidal Tear Strength	60 lbs.	ASTM D-4533
6)	Puncture Strength	65 lbs.	ASTM D-4833
7)	Mullen Burst Strength	185 psi	ASTM D-3786
8)	Permittivity	1.8 sec^{-1}	ASTM D-4491
9)	Apparent Opening Size (AOS)	0.212 mm (US sieve size 70)	ASTM D-4751

Filter fabric shall be manufactured by Polyfelt, Mirafi, or approved equal.

(4) Knife Gate Valves

Knife Gate Valves shall be bonnetless, wafer type made with a cast iron body, with several support ribs for a strong flanged connection. All sizes shall have a fabricated stainless steel liner. Standard flange holes will be drilled and tapped. Flange drilling dimensions will meet M.S.C. SP-81 and A.N.S.I. B16.5, Class 125/150 requirements. The raised face flange shall meet M.S.S. SP-81 face-to-face dimensions. Valves shall have all wetted parts of stainless steel. Stainless steel liner shall extend through the valve chest to the top of the packing gland. Both sides of the gate shall be finished ground. The stem shall be stainless steel and shall have double pitch threads. The yoke nut shall be acid-resisting bronze. The valve shall have a raised seat with a relieved area around the seat to prevent jamming. The valve gate shall be suitable for 125 psi pressure differential. Packing gland shall have three (3) layers of fiber packing with a 4th elastomer seal. Resilient seated knife gate valves shall have a round port with a replaceable resilient seat interlocked by a metal retaining ring. The metal ring shall act as a wiper blade to clean the gate before it passes over the seat. The resilient seat shall be captured and locked in place on three (3) sides only exposing one surface for sealing which prevents blowout. Knife gate valves shall be a series 304G as manufactured by Red Valve or equal.

(5) Polyethylene Manholes

Polyethylene manholes shall be produced using polyethylene compounds conforming to the requirement of Type III, Category "3", Class B, as defined and described in ASTM D-1248. Clean reworked material or reprocessed material may be used in the manufacture provided that the manhole components meet all the requirements of the product specification.

Polyethylene manholes shall be produced in the rotational molding process. The manhole will consist of an appropriate combination of base, elevation, and top section based on project requirements. Interior access to all manholes shall be designed so that a portable ladder or permanent step system can be supported by the installed manhole. Manholes may be supplied with factory molded steps. Man way reducers shall be concentric with respect to the larger portion of the manhole. The manhole shall be designed to accept and shall be furnished with concrete filled polyethylene manhole lids weighing not less than 190 pounds and must be compatible with a Dewey Brothers RCR-2001 standard cast iron frame. Manhole segment joints shall be designed to function as a full tongue and grove with the groove portion no less than 2.75 inches in depth, and shall include water tight gaskets and/or sealing compounds as recommended by the manufacturer.

Polyethylene manholes shall have a nominal cylinder internal diameter of 48 inches. The man way reducer nominal inside diameter shall be 27.75 inches. Wall thickness of all components shall be determined in accordance with ASTM D-2122 and shall be a minimum of .330 inches.

(6) Trenching for Leachate Piping

The Engineer shall provide on the Contract Drawings a horizontal layout for the proposed leachate collection system along with a minimum of two (2) bench marks. The Contractor shall be responsible for verifying the accuracy of any and all bench marks prior to use. No claim for extra work will be allowed for alleged inaccuracy for any bench mark. It shall be the Contractor's responsibility to protect the original line and bench marks set by the Engineer. Should this information become destroyed or damaged, the cost of the replacement will be borne by the Contractor.

Excavation for the leachate collection shall be done only after the three foot of protective cover has been installed over the flexible membrane liner.

Mechanical equipment can be used for the first two and one-half feet of excavation. The remaining one-half foot or whatever protective cover remains above the flexible membrane liner

shall be excavated by hand so as to not damage the liner. If damage occurs to the liner the Engineer or Owner shall be notified immediately and the repair shall take place shortly thereafter.

(7) Installation of Geotextile Filter Fabric

Geotextile filter fabric shall be installed along the entire length of the trenching or as required by Project Specifications on top of the exposed flexible membrane liner/geocomposite net. This fabric is intended to protect the liner/net from the stone that surrounds the perforated collection piping.

In addition, the fabric shall be installed up the walls of the trench with enough excess at the top so that the stone can be completely covered with filter fabric.

(8) Videoing of Lines

All the lines that have cleanouts attached shall be videoed after installation to assure that the lines are clean and free of debris. The video shall include the entire length of the line that has been constructed. The video shall become part of the QC documentation.

4.2.8 Sewer Line

All HDPE pipe shall be laid in conformance with the ASTM standard for installing flexible thermoplastic pipe ASTM D2321. This specification shall be strictly conformed to unless otherwise noted by the Project Specifications or required by the Engineer on site because of local conditions.

All Dual Containment HDPE PIPE shall confirm to ASTM D3350.

(1) Construction Methods

All Gravity Flow Pipeline shall be installed using a laser for control of vertical and horizontal alignment. The Contractor shall follow accepted practices in the utilization of the laser. A certified laser operator shall be present on the job at all times. Care shall be exercised to assure that the alignment control range of the instrument is not exceeded; but in no case, shall the range exceed 500 feet. Care shall be taken to prevent vibration of or direct sunlight on the instrument. Where present, a blower shall be provided to purge glue vapors from the pipe. An air velocity meter shall be provided so that the velocity of air in the pipe will not be great enough to cause the light beam to be distorted. The Contractor shall coordinate the work to minimize the number of take downs and set ups at each point. Periodic checks of the laser shall be made to assure that alignment is maintained.

Each pipe shall be laid on an even, firm bed, so that no uneven strain will come to any part of the pipe. Before each piece of pipe is lowered into the trench, it shall be thoroughly inspected to insure its being clean. Each piece of pipe shall be lowered separately. No piece of pipe or fitting which is known to be defective shall be laid or placed in the lines. If any defective pipe or fitting shall be discovered after the pipe is laid it shall be removed and replaced with a satisfactory pipe or fitting without additional charge. In case a length of pipe is cut to fit in a line, it shall be so cut as to leave a smooth end at right angles to the longitudinal axis of the pipe.

(2) Butt Fusion for HDPE pipe

Clean pipe ends inside and outside with a clean cloth to remove dirt, water, grease and other foreign materials.

Square (face) the pipe ends using facing tool of the fusion machine.

Check line-up of pipe ends in fusion machine to see that pipe ends meet squarely and completely over the entire surface to be fused. This is commonly referred to as "adjusting high-low". It is advisable at this point to make sure the clamps are tight so that the pipe does not slip during the fusion process.

Insert clean heater plate between aligned ends, and bring ends firmly in contact with plate, but do not apply pressure while achieving melt pattern. Carefully move the pipe ends away from the heater plate and remove the plate. (If the softened material sticks to the heater plate, discontinue the joint. Clean heater plate, re-square pipe ends and start over.)

Note: One pipe end usually moves away from the heater plate first. It is good practice to "bump" the plate away from the other side and then lift it out. Never drag or slide it over the melted pipe end.

Bring melted ends together rapidly. Do not slam. Apply enough pressure to form a double roll back to the body of the pipe brad around the entire circumference of the pipe about 1/8" to 3/16" wide. Pressure is necessary to cause the heated material to flow together.

Allow the joint to cool and solidify properly. This occurs when the brad feels hard and your finger can remain comfortably on the brad. Remove the pipe from the clamps and inspect the joint appearance.

(3) Tests

HDPE Dual Containment Force main - ASTM D3350. All HDPE pipe shall be tested at its rated working pressure. In no case shall there be any visible leakage, nor shall there be leakage between any section of pipe.

4.2.9 Closure Cap System

All materials and equipment shall be furnished by an established and reputable manufacturer or supplier. All materials and equipment shall be new and shall be of first class ingredients and construction, designed and guaranteed to perform the service required and shall conform with the following standard specifications or shall be the product of the listed manufacturers or similar and equal thereto as approved by the Engineer.

4.2.10 Closure Cohesive Soil Cap

All materials and equipment shall be furnished by an established and reputable manufacturer or supplier. All materials and equipment shall be new and shall be of first class ingredients and construction, designed and guaranteed to perform the service required and shall conform with the following standard specifications or shall be the product of the listed manufacturers or similar and equal thereto as approved by the Engineer.

Cohesive Soil Cap Borrow Material

Test Name	Test Method	Contractor/Engineer Frequency
Moisture/Density	ASTM D698/D1557	1 per 5000 c.y.
Remolded Permeability	ASTM D5084	1 per 5000 c.y.
Atterberg Limits	ASTM D4318	1 per 5000 c.y.
Visual Classification	ASTM D2488	1 per 5000 c.y.
Grain Size Distribution	ASTM D422	1 per 5000 c.y.

Cohesive Soil Cap Test Pad

Test Name	Test Method	Contractor/Engineer Frequency
Field Moisture/Density	ASTM D1556 (sand cone) ASTM D2922/D3017 (nuclear gauge) ASTM D2937 (drive cylinder)	3 per lift
Permeability	ASTM D5084	1 per lift
Remolded Permeability	ASTM D5084	1 per lift
Atterberg Limits	ASTM D4318	1 per lift
Visual Classification	ASTM D2488	1 per lift
Grain Size Distribution	ASTM D422	1 per lift

In-Place Cohesive Soil Cap

Test Name	Test Method	Contractor/Engineer Frequency
Field Moisture/Density	ASTM D1556 (sand cone) ASTM D2922/D3017 (nuclear gauge) ASTM D2937 (drive cylinder)	1 per lift per acre
Permeability	ASTM D5084	1 per lift per acre
Atterberg Limits	ASTM D4318	1 per lift per acre
Visual Classification	ASTM D2488	1 per lift per acre
Grain Size Distribution	ASTM D422	1 per lift per acre

(a) Suitable on-site and/or off-site soils may be used as cohesive soil cap if it can achieve an in-place permeability of 1.0×10^{-5} cm/sec or less and meets all testing requirements indicated in the material testing paragraph in this section. Wyoming bentonite or an approved equivalent may be blended with the soil to lower the soil's permeability.

(b) A permeability "window" shall be developed for each type of soil from the borrow material that will be used for construction of the cohesive soil cap. The window shall be plotted on a semi-log plot with moisture content versus density. Laboratory testing to develop the window shall include a series of remolded samples compacted to various dry densities and moisture contents utilizing the same compactive effort (ASTM D 698 or D 1557). The remolded samples shall be tested for permeability to determine whether or not the particular soil type will provide the maximum permeability (1.0×10^{-5} cm/sec) at various dry densities and moisture contents. The window is then developed from the accepted remolded samples and moisture contents from the semi-log plot. A straight line is typically drawn between the acceptable points on the moisture-density curve to indicate a range of probable acceptable permeability results. The window will be used in the construction of the test strip to verify the laboratory remolded permeability results.

(c) Atterberg limits and grain size distribution shall also be conducted on the bulk samples used to prepare the permeability window ASTM D2488, D4318, D422. These tests can be used as indices on random samples collected from the borrow site during construction to verify the soil type is the same as was used to develop the "window". As a minimum, sufficient visual classifications and Atterberg limits shall be conducted in association with each permeability test to verify that the construction materials meet specifications.

(d) A test strip of compacted cohesive soil cap shall be prepared to verify the permeability "window" prior to general installation of the cohesive soil cap. The test strip will be used to verify the results from the remolded permeabilities from the borrow site utilizing the permeability window(s) for each soil type that is going to be used for construction of the cohesive soil cap. At a minimum, the verification will consist of three moisture density tests, one Atterberg limits test, one grain size distribution test (ASTM D2488,

D4318, and D422), and one Shelby Tube sample for each lift constructed in the test pad. Laboratory permeability tests shall be performed on tube (Shelby or drive tubes) samples of the cohesive soil cap after placement and compaction. The permeability must be a maximum of 1.0 x10^{-5}cm/sec. Tests shall be performed in accordance with the ASTM D5084. The test strip shall be approximately 2,500 sq. ft. in surface area and constructed to conform geometrically to the site topography with a minimum lateral dimension in any direction of 25 ft. The test strip shall consist of at least three compacted 6 inch lifts of cohesive soil cap. Placement and testing of the test strip shall be in conformance with the construction specifications and requirements for general installation of the cohesive soil cap. Test results from the test strip shall be used to guide placement and achievement of the required maximum permeability of 1.0 x 10^{-5} cm/sec of the cohesive soil cap. The test strip may be used as an integral part of the overall cohesive soil cap if it meets the required specification for the cap. All results shall be given to the Construction Observer.

(e) The soils shall be placed to the total thickness shown on the plans in maximum 8-inch thick loose lifts with a maximum 6" compacted lift compacted preferably at a moisture content between 0 to 3% above optimum moisture content to 95% standard Proctor maximum dry density (ASTM Test Designation D698). A sheepsfoot roller or approved alternative may be used to compact the soil cap provided the compaction and permeability requirements can be achieved. Each lift shall be tested for permeability, moisture content, particle size distribution analysis, Atterberg limits, moisture-density-permeability relation, and if needed percent bentonite admixed with soil, prior to the placement of the succeeding lift and visually inspected to confirm that all soil clods have been broken and that the surface is sufficiently scarified so that adequate bonding can be achieved. Soils for cohesive soil cap shall be screened, disked, or prepared using any other approved method as necessary to obtain a homogeneous cohesive soil with clod sizes in a soil matrix no larger than about 1.5 inches in maximum diameter. After each lift, the surface shall be scarified prior to the placement of the next lift to provide good bonding from one lift to the next.

(f) The cohesive soil cap shall be tested to evaluate the coefficient of permeability. The coefficient of permeability of the soil cap shall be equal to or less than 1.0 x 10^{-5} cm/sec after placement and compaction. The soil cap must be a minimum of 1.5 feet thick.

(g) Laboratory permeability tests shall be performed on tube (Shelby or drive tubes) samples of the cohesive soil cap after placement and compaction. The permeability must be a maximum of 1.0 x 10^{-5} cm/sec. Tests shall be performed in accordance with ASTM D5084.

(h) The soil cap shall be tested a minimum of one soil sample per lift per acre for laboratory permeability. All permeability testing will be on random samples judged by the Engineer to be representative of the most permeable soil conditions for the area being tested. The project engineer shall certify that the materials used in construction were tested according to the Division approved plans. If after placement of the soil cap it fails the required tests, the material will either be reworked or replaced. The soil cap must remain moist at all times, if any section becomes dry, rework the dry area and moisten.

(i) A minimum of two (2) inches of soil shall be removed prior to securing each sample for permeability testing. The sampling tube shall be advanced vertically into the soil with as little soil disturbance as possible and should be pushed using a uniform pressure. The sampling tube (Shelby tube), when extracted, shall be free of dents, and the ends shall not be distorted. A backhoe or approved alternative should be used to advance the sampling tube (Shelby tube) as long as disturbance is minimized. Drive tube samples of the cap may be obtained for permeability testings. If the Engineer judges the sample to be too disturbed, another sample shall be taken. Once an acceptable sample has been secured and properly prepared, all sample excavations shall be backfilled to grade with a 50% mixture of bentonite and similar soils in maximum 3-inch loose lifts and hand tamped with a blunt tool to achieve a tight seal equivalent to the original density.

(j) No additional construction shall proceed on the soil layers at the area being tested until the Engineer has reviewed the results of the tests and judged the desired permeability is being achieved.

(k) As a minimum, sufficient visual classifications (ASTM Test Designation D2488) , analyses (ASTM Test Designation D422) and Atterberg limits (ASTM Test Designation D4318) shall be conducted in association with each permeability test to verify that the construction materials meet specifications. The minimum number of tests will be 1 per lift per acre.

(l) If the soil for the cohesive soil cap is incapable of achieving the required permeability when compacted, bentonite or approved alternative may be mixed with the soils to decrease the permeability. The amount of additive required must be determined in the laboratory. Where additives are required, the soil shall be placed in maximum 8-inch thick loose lifts and compacted preferably between 0 to +3% optimum moisture content to 95% standard Proctor maximum dry density (ASTM Test Designation D698) for the soil-additive mixture. All other compaction procedures for the soil apply.

(m) Surfaces to be lined shall be smooth and free of debris, roots, and angular or sharp rocks larger than three-eight (3/8) inches in diameter to a depth of six (6) inches. The cohesive soil cap shall have no sudden sharp or abrupt changes in grade.

(n) The Contractor shall protect the cohesive soil cap from desiccation, flooding and freezing. Protection, if required, may consists of a thin plastic protective cover, (or other material as approved by the engineer) installed over the completed cohesive soil cap until such time as the placement of flexible membrane liner begins. Areas found to have any desiccation cracks or which exhibit swelling, heaving or other similar conditions shall be replaced or reworked by the contractor to remove these defects.

(o) The thickness and grade of the soil cap will be verified by the surveyor before placement of the geomembrane liner. The soil cap will be surveyed at 100' grid points where the elevations of the top of landfill will be checked with the top of soil cap to verify 1.5 feet of soil cap. The grade will then be verified with the surveyed information. The survey will be performed by NC licensed surveyors.

(p) Surface Acceptance. Upon request, the Flexible Membrane Liner manufacturer installer shall provide the Engineer with a written acceptance of the surface prior to commencing installation. Subsequent repairs to the cohesive soil cap and the surface shall remain the responsibility of the contractor.

4.2.11 Closure Flexible Membrane Liner Method of Deployment

All materials and equipment shall be furnished by an established and reputable manufacturer or supplier. All materials and equipment shall be new and shall be of first class ingredients and construction, designed and guaranteed to perform the service required and shall conform with the following standard specifications or shall be the product of the listed manufacturers or similar and equal thereto as approved by the Engineer.

Flexible Membrane Liner Tests

Test Name	Description	Test Method	Frequency
Air Test	Air Test Seams		Every Seam
Vacuum Test	Every welded area		Where air test impossible
Destructive Tests	Seam Strength	ASTM D4437	Every 500' of seam

Qualified liner installers, seamers, and the liner foreman shall meet a minimum requirement of 1,000,000 square feet of geomembrane installation. There are no other minimum qualifications needed by other parties.

40 mil Linear Low Density Polyethylene (LLDPE) is to be placed in direct contact with moist cohesive soil cap. The extrusion rods and/or brads used in seaming the rolls together shall be derived from the same base resin as the liner and shall meet the following minimum properties:

Smooth 40 mil LLDPE Liner Specifications

Property	Test Method	Test Value	Contractor/Engineer Test Frequency
Thickness (min. avg.)	D5199	nom. (mil)	Per roll
- lowest individual for 8 out of 10 values		-10%.	
Density (max.)	D1505/D792	0.939	200,000 lb
Tensile Properties (1)(min. avg.)	D638 Type IV		20,000 lb
- yield stress lb/in		64	
- break stress lb/in		152	
- yield strain %		13	
- break strain %		800	
2% Modulus - psi (max.)	D5323	30,000	20,000 lb
Tear Resistance- lb/in (min avg.)	D1004	22	45,000 lb
Puncture Resistance- lb/in (min avg.)	D4833	56	45,000 lb
Axi-Symmetric Break Strain- % (min)	D5617	30	200,000 lb
Stress Crack Resistance- hr (2)	D5397 (App.)	n/a	per GRI-GM10
Carbon Black Content- %	D1603 (3)	2.0-3.0	20,000 lb
Carbon Black Dispersion	D5597	note (4)	45,000 lb
Oxidative Induction Time (OIT) (min ave,) (5)			
(a) Standard OIT	D3895	120 min.	
-or-			200,000 lb
(b) High Pressure OIT	D5885	500 min.	
Oven Aging at 85°C (6)	D5721		
(a) Standard OIT (min. ave) -% retained after 90 days	D3895	55	per each formulation
-or-			
(b) High Pressure OIT (min ave) -% retained after 90 days	D5885	80	
UV Resistance (7)			
(a) Standard OIT (min avg.)	D3890	N.R. (8)	
-or-			per each formulation
High Pressure OIT (min avg.) -% retained after 1600 hrs (9)	D5885	50	

(1) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction yield elongation is calculated using a gage length of 33 mm Break elongation is calculated using a gage length of 50 mm
(2) The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value via MQC testing.
(3) Other methods such as D4128 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to D1603 (tube furnace) can be established.
(4) Carbon black dispersion for 10 different views: - all 10 in Categories 1 or 2
(5) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.
(6) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.
(7) The condition of the test should be 20 hr UV cycle at 75°C followed by 4hr condensation at 60°C.
(8) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.
(9) UV resistance is based on percent retained value regardless of the original HP-OIT value.

(1) Preparation for Geomembrane Deployment

(a) Panel Layout

Prior to commencement of liner deployment, layout drawings shall be produced to indicate the panel configuration and location of seams for the project.

(b) Identification

Each panel used for the installation shall be given a numeric or alpha-numeric identification number consistent with the layout drawing. This identification number shall be related to manufacturing roll number that identifies the resin type, batch number and date of manufacture.

(c) Verification

The manufacturers certification will be given to the construction observer. The construction observer will inspect all certifications. If the certification does not meet specifications, it will be rejected. Adequate laboratory QA/QC conformance testing shall be performed by contractor/engineer to verify minimum requirements.

(2) Field Panel Placement

(a) Location

The Flexible Membrane Liner Manufacturer/Installer shall install field panels at the location indicated on the layout drawing. If the panels are deployed in a location other than that indicated on the layout drawings, the revised location shall be noted in the field on a layout drawing which will be modified at the completion of the project to reflect actual panel locations.

(b) Weather Conditions

Geomembrane deployment shall not be carried out during any precipitation, nor in the presence of excessive moisture (i.e. fog, dew), in an area of standing water, or during high winds.

(c) Method of Deployment

(1) The method and equipment used to deploy the panels must not damage the geomembrane or the supporting subgrade surface.

(2) No personnel working on the geomembrane will smoke, wear shoes that can damage the geomembrane, or engage in actions which could result in damage to the geomembrane.

(3) Adequate temporary loading and/or anchoring, (i.e. sandbags, tires), which will not damage the geomembrane, will be placed to prevent uplift of the geomembrane by wind. If uplift occurs, additional sandbags will be placed in necessary areas.

(4) The geomembrane will be deployed in a manner to minimize wrinkles. The geomembrane will have no fold overs.

(5) Any damage to a panel of the geomembrane will be repaired. Any area of a panel seriously damaged (torn, twisted, or crimped) will be marked, cut out and removed from the work area with resulting seaming and/or repairs performed.

(3) Field Seaming

(a) Layout

In general, seams shall be oriented parallel to the slope, i.e., oriented along, not across the slope. Whenever possible, horizontal seams should be located not less than five (5) feet from the toe of the slope. Each seam made in the field shall be numbered in a manner that is compatible with the panel layout drawing for documentation of seam testing results.

(b) Personnel

All personnel performing seaming operations shall be trained in the operation of the specific seaming equipment being used and will qualify by successfully welding a test seam. The project foreman will provide direct supervision of all personnel seaming to verify proper welding procedures are followed. Qualified liner installers, seamers, and the liner foreman shall meet a minimum requirement of 1,000,000 square feet of geomembrane installation. There are no other minimum qualifications needed by other parties.

(c) Equipment

(1) Fusion Welding

Fusion Welding consists of placing a heated wedge, mounted on a self propelled vehicular unit, between two (2) overlapped sheets such that the surface of both sheets are heated above the polyethylene's melting point. After being heated by the wedge, the overlapped panels pass through a set of preset pressure wheels which compress the two (2) panels together so that a continuous homogeneous fusion weld is formed. The fusion welder is equipped with a temperature readout device which continuously monitors the temperature of the wedge.

(2) Extrusion Fillet Welding

Extrusion fillet welding consists of introducing a ribbon of molten resin along the edge of the seam overlap of the two (2) sheets to be welded. The molten polymer causes some of the material of each sheet to be liquefied resulting in a homogeneous bond between the molten weld bead and the surfaces of the sheets. The extrusion welder is equipped with gauges giving the temperature in the apparatus and the preheat temperature at the nozzle.

(d) Weather Conditions

The Flexible Membrane Liner Manufacturer/Installer will rely on the experience of the Project Superintendent and the results of test seams to determine seaming restrictions by weather. Many factors, such as ambient temperature, humidity, wind, sunshine, etc., can affect the integrity of field seams and must be taken into account when deciding whether or not seaming should proceed. Responsibility for monitoring these conditions shall lie with the Project Superintendent; however, the Engineer may suspend any seaming operation which is, in his opinion, at the risk of providing the Owner with a quality product. Test seams are required prior to daily production seaming to determine if the weather conditions will affect the Flexible Membrane Liner System's ability to produce quality seams. Additional non-destructive and destructive testing of production seams substantiate the decision made by the Project Superintendent to seam on any given day.

(4) Seam Preparation

(a) Fusion Welding

(1) Overlap the panels of geomembrane approximately four (4) inches.

(2) Clean the seam area prior to seaming to assure the area is clean and free of moisture, dust, dirt, debris of any kind. No grinding is required for fusion welding.

(3) Adjust the panels so that seams are aligned with the fewest possible number of wrinkles and "fishmouths".

(4) A movable protective layer may be used, at the discretion of the Flexible Geomembrane Liner System Project Superintendent, directly below the overlap of geomembrane that is to be seamed to prevent build-up of moisture between the panels.

(b) Extrusion Welding

(1) Overlap the panels of geomembrane a minimum of three (3) inches.

(2) Temporarily bond the panels of geomembrane to be welded taking care not to damage the geomembrane.

(3) Grind seam overlap prior to welding within one (1) hour of welding operation in a manner that does not damage the geomembrane. Limit grinding to ¼" outside of the extrusion weld area.

(4) Clean the seam area prior to seaming to assure the area is clean and free of moisture, dust, dirt, and debris of any kind.

(5) Purge the extruder prior to beginning the seam to remove all heat degraded extrudate from the barrel.

(6) Keep welding rod clean and off the ground.

(5) Test Seams

Test seams shall be performed at the beginning of each seaming period and at approximately every 4-working hour intervals for each seaming apparatus used that day. Test seams shall be made on fragment pieces of the geomembrane liner and under the same conditions as actual seams.

(a) Test Seam Length

The test seam shall be at least three (3) feet long and should be made by joining two (2) pieces of geomembrane at least 9" in width.

(b) Sample Procedure

(1) Visually inspect the seam for squeeze out, footprint, pressure and general appearance.

(2) Two random samples one (1) inch wide shall be cut from the test seam. The specimens shall then be tested in peel using a field tensiometer and shall not fail in the seam. If a specimen fails the entire procedure shall be repeated.

(3) If any of the second set of specimens fail, the seaming apparatus shall not be accepted and shall not be used for seaming until the deficiencies are corrected and a passing test seam is achieved.

(4) After completion of these tests, the remaining portion of test seam can be discarded. Documentation of the test seams will be maintained listing seam identification number, welder's name, temperature control setting and test results.

(5) Passing test results records shall be maintained.

(6) General Seaming Procedures

(a) Seaming shall extend to the outside edge of panels to be anchored.

(b) While welding a seam, monitor and maintain the proper overlap.

(c) Inspect seam area to assure area is clean and free of moisture, dust, dirt, debris of any kind.

(d) While welding a seam, monitor temperature gauges to assure proper settings are maintained and that the seaming apparatus is operating properly.

(e) Align wrinkles at the seam overlap to allow welding through the wrinkle.

(f) Fishmouths or wrinkles at seam and overlaps that cannot be welded through shall be cut along the ridge in order to achieve a flat overlap. The cut fishmouth or wrinkle shall be seamed. Any portion where the overlap is inadequate shall be patched with an oval or round patch of the same geomembrane extending a minimum of six (6) inches beyond the cut in all directions.

(g) All cross/butt seams between two (2) rows of seamed panels shall be welded during the coolest time of the day to allow for contraction of the geomembrane.

(h) All "T" joints shall have the overlap from the wedge welder seam trimmed back to allow an extrusion fillet weld. Then grind ¼ of an inch minimum on either side of the wedge seam, then extrusion weld all of the area prepared by grinding.

4.2.12 Closure Flexible Membrane Liner Tests

The installation crews will non-destructively test all field seams over their full length using air pressure testing, vacuum testing or other approved methods, to verify the continuity and integrity of the seams.

(a) Air Pressure Testing

The welded seam created by double hot-wedge fusion welding process is composed of two distinct welded seams separated by an unwelded channel approximately 3/8 of an inch between the two welded seams permits the double hot-wedge fusion seams to be tested by inflating the sealed channel with air to a predetermined pressure, and observing the stability of the pressurized channel over time.

(1) Equipment for Air Testing

An air pump (manual or motor driven) capable of generating and sustaining a pressure between 25 to 30 psi.

A rubber hose with fittings and connections.

A sharp hollow needle, or other approved pressure feed device with a pressure gauge capable of reading and sustaining a pressure between 25 to 30 psi.

(2) Procedure for Air Testing

Seal both ends of the seam to be tested.

Insert needle or other approved pressure feed device into the sealed channel created by the fusion weld.

Inflate the test channel to a pressure between 25 to 30 psi, in accordance with the following schedule, close valve, and observe initial pressure after approximately 2 minutes.

INITIAL PRESSURE SCHEDULE *

Material (Mil)	Min. Psi	Max. Psi
40	25	30
60	27	30
80	30	30
100	30	30

* Initial pressure settings are read after a two minute "relaxing period". The purpose of this "relaxing period" is to permit the air temperature and pressure to stabilize.

Observe and record the air pressure five (5) minutes after "relaxing period" ends and when initial pressure setting is used. If loss of pressure exceeds the following or if the pressure does not stabilize, locate faulty area and repair.

MAXIMUM PERMISSIBLE PRESSURE DIFFERENTIAL AFTER 5 MINUTES - LLDPE

Material (Mil)	Pressure Diff.
40	4 psi
60	3 psi
80	3 psi
100	3 psi

At the conclusion of the pressure test the end of the seam opposite the pressure gauge is cut. A decrease in gauge pressure must be observed or the air channel will be considered "blocked" and the test will have to be repeated after the blockage is corrected.

Remove needle or other approved pressure feed device and seal resulting hole by extrusion welding.

(3) In the event of a Non-Complying Air Pressure Test, the following procedure shall be followed:

Check seam end seals and retest seams.

If non-compliance with specified maximum pressure differential re-occurs, repair the seam. Capping or removal/reseam of the non-complying seam are the only two (2) acceptable methods for repairing failed seams. Non-destruct test the entire length of the repaired seam.

(b) Vacuum Testing

This test is used when the geometry of the weld makes air pressure testing impossible or impractical or when attempting to locate the precise location of a defect believed to exist after air pressure testing. The penetration will be tested using this method.

(1) Equipment for Vacuum Testing

Vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, port hole or valve assembly, and a vacuum gauge.

Vacuum pump assembly equipped with a pressure controller and pipe connection.

A rubber pressure/vacuum hose with fittings and connections.

A bucket and means to apply a soapy solution.

A soapy solution.

(2) Procedure for Vacuum Testing

Trim excess overlap from seam, if any.

Turn on the vacuum pump to reduce the vacuum box to approximately 5 inch of mercury, i.e., 5 psi gauge.

Apply a generous amount of a solution of strong liquid detergent and water to the area to be tested.

Place the vacuum box over the area to be tested and apply sufficient downward pressure to "seat" the seal strip against the liner.

Close the bleed valve and open the vacuum valve.

Apply a minimum of 5 in. Hg vacuum to the area as indicated by the gauge on the vacuum box.

Ensure that a leak tight seal is created.

For a period of not less than 30 seconds, examine the geomembrane through the viewing window for the presence of soap bubbles.

If no bubbles appear after 30 seconds, close the vacuum valve and open the bleed valve, move the box over the next adjoining area with a minimum 3 in. overlap, and repeat the process.

(3) Procedure for Non-Complying Test

Mark all areas where soap bubbles appear and repair the marked areas. Retest repaired areas.

(c) Destructive Testing

(1) Concept

The purpose of destructive testing is to determine and evaluate seam strength. These tests require direct sampling and thus subsequent patching. Therefore destructive testing should be held to a minimum to reduce the amount of repairs to the geomembrane.

(2) Procedure for Destructive Testing

All Destructive tests will be done according to ASTM D4437. Destructive test samples shall be marked and cut out randomly at a minimum average frequency of one test location every 500 feet of seam length.

Additional destructive tests may be taken in areas of contamination, offset welds, visible crystallinity or other potential cause of faulty welds at the discretion of the Project Superintendent and Engineer.

Sample Size

The sample should be twelve (12) inches wide with a seam fourteen (14) inches long centered lengthwise in the sample. The sample may be increased in size to accommodate independent laboratory testing by the owner at the owner's request or by specific project specifications.

A one (1) inch sample shall be cut from each end of the test seam for field testing.

The two (2), one (1) inch wide samples shall be tested in the field in a tensiometer for peel ASTM D4437. Tensile strength is essentially a measurement of the greatest tension stress a substance can bear without tearing. If the liner tears before any part of the seam does, the test is successful. If any field sample fails to pass, it will be assumed the sample fails destructive testing. The passing destructive test requirements for 40-mil liner seam is: minimum peel adhesion of 52 ppi, minimum shear strength of 80 ppi, and Film Tear Bond (FTB).

(3) Procedure in the event of Destructive Test Failure

Cut additional field samples for testing. In the case of a field production seam, the samples must lie a minimum of ten (10) feet in each direction from the location of the failed sample. Perform a field test for peel strength. If these field samples pass, then laboratory samples can be cut and forwarded to the laboratory for full testing.

If the laboratory samples pass then repair the seam between the two (2) passing samples locations.

Capping or removal/reseam of the non-complying seam are the only two (2) acceptable methods for repairing failed seams.

All destructive seam samples sent to the Flexible Membrane Liner System's laboratory shall be numbered.

(d) Quality Assurance Laboratory Testing

(1) Destructive samples sent to the laboratory will be tested for "shear strength" and "peel adhesion" (ASTM D4437 as modified by NSF). Five (5) specimens shall be tested for each test method with data recorded. Four (4) out of the five (5) specimens must pass for each test in order for the seam to pass the destructive test.

(2) Defects and Repairs

(a) The Project Superintendent shall conduct a detailed walk through and visually check all seams and non-seam areas of the geomembrane for defects, holes, blisters and signs of damage during installation.

(b) All other installation personnel shall, at all times, be on the lookout for any damaged areas. Damaged areas shall be marked and repaired.

(c) Repair Procedures

Any portion of the geomembrane showing a flaw or failing a destructive or non-destructive test shall be repaired. Several procedures exist for repair and the decision as to the appropriate repair procedure shall be made by the Project Superintendent. Repairs need to be made in a timely manner to protect the moist cohesive soil liner and flexible membrane liner. If inclement weather is approaching, steps need to be made to protect the cohesive soil cap such as a temporary cover. If cohesive soil cap is damaged, it must be reworked. Procedures available for liner repair:

Patching - used to repair large holes, tears and destructive sample locations. All patches shall extend at least six (6) inches beyond the edges of the defect and all corners of patches shall be rounded.

Grinding and welding - used to repair sections of extruded seams.

Spot welding or seaming - used to repair small tears, pinholes or other minor localized flaws.

Capping - used to repair lengths of failed seams.

Removal of a bad seam and replacement with a strip of new material seamed into place.

(d) Verification of Repairs

Every repair shall be non-destructively tested. Repairs which pass the non-destructive test shall be deemed adequate. Large repairs may require a destructive test. Repair test results shall be logged. The repair location shall be recorded on an as-built drawing.

4.2.13 Closure Protective Cover

(1) HPDE Geocomposite Drainage Netting manufactured by SKAPS Industries, or approved equal.

GEOCOMPOSITE PROPERTIES

PROPERTY	TEST	UNITS	MINIMUM AVERAGE ROLL VALUE
Thickness	ASTM D 5199	inch	0.305
Transmissivity[1] (15,000 psf)	ASTM D 4716	m^2/sec	$3x10^{-5}$
Ply Adhesion	ASTM D 413 or F 904	lb/in	2.0

COMPONENT PROPERTIES

GEONET	TEST	UNITS	MINIMUM AVERAGE ROLL VALUE
Polymer Density	ASTM D 1505	g/cm^3	0.94
Carbon Black Content	ASTM D 4218	%	2.0
Thickness	ASTM D 5199	inches	0.200
Mass per unit area	ASTM D 5261	lbs/ft^2	0.162
Transmissivity[1]	ASTM D 4716	m^2/sec	$1x10^{-3}$@ 15,000 psf
Tensile Strength	ASTM D 5035	lbs/in	45

GEOTEXTILE	TEST	UNITS	MINIMUM AVERAGE ROLL VALUE
Fabric Weight	ASTM D 5261	oz/yd^2	7.1
Thickness	ASTM D 5199	mils	95
Grab Strength	ASTM D 4632	lbs	210
Water Flow Rate	ASTM D 4491	gpm/ft^2	110
Apparent opening size (AOS)	ASTM D 4751	mm (Sieve Size)	0.150 (100)

1. Measured using water @ 20° C (68° F) with a gradient of one, between two steel plates, after one hour. Value may vary, based on dimensions of the transmissivity specimen and specific laboratory.
2. Component properties are tested prior to the lamination process. They cannot be tested on the final product.

The geocomposite will be handled in such a manner as to ensure the geocomposite are not damaged in any way. On slopes, the geocomposite will be secured in the anchor trench and then rolled down the slope in such a manner as to continually keep the geocomposite sheet in tension. If necessary, the geocomposite will be positioned by hand after being unrolled to minimize wrinkles. Geocomposite can be placed in the horizontal direction (i.e., across the slope) in some special locations (e.g., where extra layers are required or where slope is less than 10:1).

Geocomposite will not be welded to the geomembrane. Geocomposite will be cut using approved cutters,(i.e., hook blade, scissors, etc.) Care should be taken to prevent damage to underlying layers. Care must be taken not to entrap dirt in the geocomposite that could cause clogging of the drainage system, and or stones that could damage the adjacent geomembrane.

Adjacent rolls of geocomposite will be overlapped by at least four inches and securely tied. Tying can be achieved by plastic fasteners. Tying devices will be white or yellow for easy inspection. Metallic devices are not allowed. Tying will be five to ten feet along the bottom of the slope. Tying will be every five feet along the slope, every two feet across the slope and at the top of the berm. Tying in the anchor trench will be done in one foot intervals. In the corners of the side slopes where overlaps between perpendicular geocomposite strips are required, an extra layer of geocomposite will be

unrolled along the slope, on top of the previously installed geocomposite, from the top to bottom of the slope.
Any holes or tears in the geocomposite will be repaired by placing a patch extending two feet beyond edges of the hole or tear. The patch will be secured to the original geocomposite by tying every twelve inches. If the hole or tear width across the roll is more than 50% the width of the roll, the damaged area will be cut out and the two portions of the geocomposite will be joined.

The engineer will visually inspect the drainage layer before placement of the erosive layer, if any defects are detected they will be repaired before placement of erosive layer.

(2) Erosive Layer

The soil for the erosive layer shall consist of any soils suitable of supporting vegetative growth. The erosive layer shall be installed using low ground pressure equipment such as a Caterpillar D6H LGP, or approved equal, with ground pressure not exceeding 4.71 psi. When installing the erosive layer, the contractor shall adhere to the following guidelines:

(a) A minimum of twelve inches (12") of cover between low ground pressure equipment and the liner is required at all times. Roadways for entering and for transporting material over slopes and capped/lined areas shall have a minimum depth of four feet (4').

(b) Avoid undue stress on the liner at all times. Cover material must be pushed up slopes, never down to help minimize wrinkles. Material must be placed to minimize wrinkles, wrinkles in excess of two feet in height are unacceptable. If a wrinkle is more than two feet in height, soil will be placed on top of the wrinkle to decrease the height. Fold over of the liner will not be allowed. A worker must walk along side earth moving equipment and remove all rocks, stones, roots or other debris that could cause damage to the liner. Equipment operators must avoid sharp turns or quick stops that could pinch and tear the liner.

(c) If damage does occur, report it to the Project Manager immediately so that repairs can be performed without needless delay.

(d) Do not work wet cover material that cannot support equipment.

(e) Equipment operators and all other personnel must be qualified and must exercise good judgment and common sense at all times.

(3) Vegetative Layer

Native vegetation will be used as approved by the Erosion Control Plan.

4.2.14 Closure Methane Venting System

NC.D.O.T. No.5 stone, Geotextile fabric, and 8" and 10" plastic pipes will be used in the construction of the gas venting system.

(1) Stone in Trenches and Surrounding Perforated Collection Piping

Stone for methane collection system shall meet the requirements of NC DOT aggregate, standard size No. 5 and shall contain no fines. Stone must pass the sieve analysis test for No. 5 stone performed at the quarry.

(2) Geotextile Fabric

Geotextile fabric surrounding the stone/piping shall be non-woven needle punched fabric with the following minimum properties:

1)	Weight	8.0 oz/yd^2	ASTM D-3776
2)	Grab Strength	205 lbs.	ASTM D-4632
3)	Grab Elongation	50%	ASTM D-4632
4)	Trapezoidal Tear Strength	85 lbs.	ASTM D-4533
5)	Puncture Strength	100 lbs.	ASTM D-4833
6)	Mullen Burst Strength	320 psi	ASTM D-3786
7)	Permittivity	1.4 sec^{-1}	ASTM D-4491

Geotextile fabric shall be manufactured by Polyfelt , TNS Advanced Technologies, or approved equal.

(3) Plastic Pipe

Plastic gravity sewer pipe and fittings used for methane vent shall be unplasticized polyvinyl chloride (PVC) and conform to the requirements of ASTM Designation D-3034 on ASTM F679, Type PSM, Class 12454-B, SDR-35 with elastomeric gasket joints. PVC pipe and fittings shall be as manufactured by J-M Pipe, Certainteed, H&W Industries or equal. The methane riser pipe shall be a 10 inch solid wall PVC pipe.

4.3 Documentation

At the completion of the contract, it is the Engineer's responsibility to provide to the Owner and eventually to the Division of Solid Waste Management the following:

1. As-built drawings of the subgrade, liner system, leachate collection.
2. Documentation of all subbase standard Proctor tests.
3. Documentation of all cohesive soil liner tests including test pads, permeability, standard Proctor and Atterberg limits.
4. Documentation of all destructive and non-destructive tests, methods and results and repairs.
5. Geomembrane panel layout with test locations and repairs illustrated.
6. Summary from the Project Engineer.
7. Any other pertinent documentation.

The CQA report shall be sealed by the Project Engineer and a certification that construction was completed in accordance with the CQA plan, Conditions of the permit to construct, the requirements of rule .1624 Construction Requirements for MSWLF Facilities, and acceptable engineering practices.

Shop Drawings

Contractor is required to submit to the Engineer a descriptive detail and any shop and setting drawings. On composite liner system, such submission shall include the following:

(1) Flexible Membrane Liner Panel Layout Drawings,
(2) Flexible Membrane Liner Penetration Details,
(3) Flexible Membrane Liner Anchoring Detail,
(4) Flexible Membrane Liner Seaming Detail,
(5) Single Flexible Membrane Liner Anchoring to Structure Detail,
(6) Flexible Membrane Liner Extension Detail, and
(7) Certified experience records for manufacturer, fabricator and installer, listing installations of Flexible Membrane Liners.

SEAM TESTING

Project Name _____ Project Number _____ Superintendent _____

NSC FIELD SEAM NO.	SEAM DATE	SHOP DWGN SEAM NO.	WELDER AND SEAMER ID. NO.	TEST DATE	START		END		AIR TEST RESULTS	COMMENTS	REPAIR DATE	WELDER AND GUN ID. NO.	REPAIR VACUUM TEST DATE	SEAM (INITIAL) (DATE)
					PRESS.	TIME	PRESS.	TIME						

Page _____ of _____

DESTRUCTIVE TEST SAMPLES

Project Name _____ Project Number _____ Supervisor _____

DATE	WELDER ID.	SEAMER	SEAM NO.	LOCATION	SAMPLE ID.

Page _____ of _____

TEST SEAM RECORDS

Project Name _____ Project Number _____ Supervisor _____

TEST DATE	TIME	LBS./IN.	PASS/FAIL	MACHINE NUMBER	TEMP. SETTING	OPERATOR

Page _____ of _____

REPAIR REPORT

Project Name _____ Project Number _____ Supervisor _____

FIELD SEAM #	PANEL #	REPAIR DATE	WELDER AND SEAMER ID. #	LOCATION OF REPAIR	REPAIR VACUUM TEST DATE	REPAIR ACCEPTED (INITIAL) (DATE)

Page _____ of _____

SECTION 5.0

OPERATION PLAN

5.1 Introduction

The County Landfill will only accept Municipal Solid Wastes (MSW) from the County. The County will construct a 9.23 acre Municipal Solid Waste Landfill (Phase 2) according to Subtitle D requirements. The facility will be constructed with 24 inches of cohesive soil (permeability of 1.0×10^{-7} cm/sec), or 18 inches of cohesive soil (permeability of 1.0×10^{-5} cm/sec) with reinforced geosynthetic clay liner (GCL), 60 mil High Density Polyethylene liner (HDPE), 36 inches of protective cover over the liner and a leachate collection system which flows to the existing leachate lagoon.

The perimeter of the lined area will be marked off by 2 inch PVC pipe at 100' intervals that will be placed in the anchor trenches. Solid waste will not be placed within four (4) feet of this boundary to assure that it is being placed directly above the liner system so that no leachate can flow outside of this area.

All storm water that comes in contact with solid waste will be handled as leachate. The leachate is collected in the sump area, where it is pumped by force main to the lagoon.

Leachate will be treated at the Kinston Wastewater Treatment Plant. The leachate will have to be tested according to the pretreatment conditions outlined in the pre-treatment agreement. The leachate will be pumped to the Treatment Plant.

Leachate will be recirculated. (See Appendix IV)

The leachate lagoon will be inspected on a monthly basis and a report generated and placed in the landfill records. The report will include the date the liner was inspected, the inspector, general observations since the last inspection, visible abrasions, possible stress cracks, or obvious punctures. Stress cracks can occur in wrinkles that are generated from heat expansion or contraction due to freezing. Also, the HDPE liner may deteriorate due to ultra violet light and this can appear as an abrasion where material can be scraped away with a hard object. If any damage or possible weak spots due to ultra violet exposure has been detected, a qualified HDPE installation company shall be notified immediately so that a repair patch can be installed. The leachate level shall not be allowed to exceed the depth of the damaged liner until it has been repaired and tested by the liner installation company. Once this has been accomplished all testing documentation shall be placed in the operating records.

Daily cover will be the combination of soil and synthetic cover. The synthetic cover will be used on days that the next day's fill will be placed directly on top of the fill. Soil cover will be used when the next day's waste will not be placed directly on top or the synthetic cover is not large enough to cover the entire area. Soil cover will be placed at least once a week. (See cover requirements under operational requirements).

The County will implement a program at the landfill for detecting and preventing the disposal of hazardous and liquid wastes. The program consists of random inspection of incoming loads at a minimum of 1% of the weekly traffic. Landfill personnel will be trained to recognize hazardous and liquid wastes. Records will be kept on the training and the inspections. (See Section 5.3-Appendix I).

The County will monitor for explosive gases at landfill structures and the perimeter of the landfill. There are four(4) existing methane monitoring probes. Nine(9) additional methane monitoring probes will be installed. The concentration of methane gases generated by the landfill cannot exceed 25 percent of the lower explosive limit for methane in the structures, and it cannot exceed 100 percent of the lower explosive limit for methane of the landfill property boundary. (See Section 5.5-Appendix III) If methane gas is found to exceed the acceptable limits at either the property boundary or landfill structures, it is the County's responsibility to do the following:

1. Immediately take all necessary steps to ensure protection of human health, i.e. no smoking, temporarily abandon the structure and notify the Division of Solid Waste Management.

2. Within seven days of detection, place in the operating record the methane gas levels detected and a description of the steps taken to protect human health; and

3. Within 60 days of detection, implement a remediation plan for the methane gas releases, place a copy of the plan in the operating record, and notify the Division of Solid Waste management that the plan has been implemented. The plan will describe the nature and extent of the problem and the proposed remedy.

Off and on site erosion will be controlled through erosion control structures and devices. Provisions for a vegetative ground cover sufficient to restrain erosion will be accomplished within 15 working days or 90 calendar days upon completion of any phase of landfill development.

The County will record and retain at the landfill an operating record of the following information:

(1) Inspection records, waste determination records, and training procedures;
(2) Amounts by weight of solid waste received at the landfill;
(3) Waste determination, Leachate sampling data, leachate levels, meteorological data ;
(4) Gas monitoring results and any remediation plans;
(5) Any demonstration, certification, findings, monitoring, testing or analytical data required for surface and groundwater monitoring;
(6) Any monitoring, testing or analytical data required for closure or post-closure;
(7) Any cost estimates and financial assurance documentation.

All information contained in the operating record will be furnished upon request to the Division of Solid Waste Management or be made available at all reasonable times for inspection by the Division.

Ground and surface water will be sampled and analyzed according to Subtitle D Appendix I detection monitoring requirements. The monitoring frequency for all Appendix I(Section 5.3) detection monitoring constituents will be at least semiannual during the life of the facility (including closure) and the post-closure period. A minimum of four independent samples from each well (background and down gradient) will be collected and analyzed for the Appendix I constituents during the first semiannual sampling event. At least one sample from each well (background and down gradient) will be collected and analyzed during subsequent semiannual sampling events.

If the County determines that there is a statistically significant increase over background for one or more of the constituents listed in Appendix I at any monitoring well at the relevant point of compliance, the County will, within 14 days of the finding, report to the Division of Solid Waste and place a notice in the operating record indicating which constituents have shown statistically significant changes from background levels. The County will establish an assessment monitoring program within 90 days. The County may demonstrate that a source other than the landfill caused the contamination or that the statistically significant increase resulted from an error in sampling, analysis, statistical evaluation, or natural variation in ground-water quality. A report documenting these demonstrations will be certified by a Licensed Geologist or Professional Engineer and approved by the Division of Solid Waste. A copy of this report will be placed in the operating record. If a successful demonstration is made, documented, and approved by the Division, the County may continue detection monitoring. If after 90 days, a successful demonstration is not made, the County will initiate an assessment monitoring program.

5.2 Operational Requirements

1. Waste Acceptance and Disposal Requirements

   a. The Municipal Solid Waste Landfill (MSWLF) will only accept those solid wastes which it is permitted to receive. The County will notify the Division within 24 hours of attempted disposal of any waste the landfill is not permitted to receive. Signs are placed at the entrance to the Landfill stating that Hazardous and Liquid wastes are not accepted and that random waste screening is performed.

   b. The following wastes are prohibited from disposal at the MSWLF:

      i. Hazardous waste as defined within 15A NCAC 13A, to also include hazardous waste from conditionally exempt small quantity generators.

      ii. Polychlorinated biphenyls (PCB) wastes as defined in 40 CFR 761.

      iii. Bulk or non-containerized liquid waste will not be placed in the landfill unless:

         (i) The waste is household waste other than septic waste and waste oil,
         (ii) The waste is leachate or gas condensate derived from the landfill.

      iv. White Goods, Yard Waste, Tires.

      v. Containers holding liquid wastes will not be placed in the landfill unless:

         (i) The container is a small container similar in size to that normally found in household waste;
         (ii) The container is designed to hold liquids for use other than storage; or
         (iii) The waste is household waste.

      vi. For the purpose of this paragraph:

         (i) Liquid waste means any waste material that is determined to contain "free liquids" as defined by Method 9095 (Paint Filter Liquids Test), S. W. 846.

   c. Spoiled foods, animal carcasses, abattoir waste, hatchery waste, and other animal waste delivered to the disposal site will be covered immediately.

   d. The following are items that are banned in the future from the landfill:

      i. Beverage containers that are required to be recycled under G.S. 18B-1006.1 (Effective January 1, 2008).

      ii. Recyclable rigid plastic containers that are required to be labeled as provided BELOW that have a neck smaller than the body of the container and that accept a screw top, snap cap, or other closure. The prohibition on disposal of recyclable rigid plastic containers in landfills does not apply to rigid plastic containers that are intended for use in the sale or distribution or motor oil. (Effective October 1, 2009)

         (a) For polyethylene terephthalate, the letters "PETE" and the number 1.
         (b) For high density polyethylene, the letters "HDPE" and the number 2.
         (c) For vinyl, the letter "V" and the number 3.
         (d) For low density polyethylene, the letters "LDPE" and the number 4.

(e) For polypropylene, the letters "PP" and the number 6.
(f) For polystyrene, the letters "PS" and the number 7.
(g) For any other, the letters "OTHER" and the number 7.

iii. Motor vehicle oil filters (effective October 1, 2009).

iv. Wooden pallets, except that wooden pallets maybe disposed of in a landfill that is permitted to only accept construction and demolition debris (effective October 1, 2009).

v. Discarded computer equipment (effective April 1, 2011).

e. Asbestos waste will be accepted and managed in accordance with 40 CFR 61. The waste will be covered immediately with soil in a manner that will not cause airborne conditions and must be disposed of separate and apart from other solid wastes:

i. At the bottom of the working face or;
ii. In an area not contiguous with other disposal areas. Separate areas will be clearly designated so that asbestos is not exposed by future land disturbing activities.

f. Wastewater treatment sludges may be accepted either as a soil conditioner incorporated into or applied onto vegetative growth layer but in no case greater than six inches in depth. Or wastewater treatment sludges may be co-disposed in the lined area.

g. The County will continue a program at the Landfill for detecting and preventing the disposal of hazardous and liquid wastes. (Section 5.3-Appendix I) This program will include, at a minimum:

i. Random inspections of incoming loads or other comparable procedures;
ii. Records of any inspections;
iii. Training of facility personnel to recognize hazardous and liquid wastes.
iv. If hazardous wastes are identified by facility personnel, Emergency Management or personnel trained, shall be notified to identify the waste and address removal, storage and final deposition of the waste.

h. Waste placement will be within the areal limits of the base liner system and in a manner consistent with the effective permit.

2. Cover material requirements.

a. Except as in Part (b), The County must cover disposed solid waste with six inches of earthen material at the end of each operating day, or at more frequent intervals if necessary, to control disease vectors, fires, odors blowing litter, and scavenging.

b. Alternative materials such as synthetic cover may be used as daily cover on the working face until it is necessary to cover with earthen material. The alternative material must be approved by the Division of Solid Waste and applied according to manufacturers recommendations. At a minimum soil cover will be used once a week. (Section 5.4-Appendix II)

c. Areas which will not have additional wastes placed on them for 12 months or more, but where final termination of disposal operations has not occurred, will be covered with a minimum of one foot of intermediate cover.

3. Disease vector control

a. The County will prevent or control on-site populations of disease vectors using techniques appropriate for protection of human health and the environment. At the end of every day, waste will be covered either by synthetic cover or 6" of soil cover. At a minimum soil will be used once a week. Any waste that requires immediate cover, will be covered immediately with soil.

b. "Disease vectors" means any rodents, flies, mosquitoes, or other animals, including insects, capable of transmitting disease to humans.

4. Explosive gases control

a. The County must ensure that:

i. The concentration of methane gas generated by the landfill does not exceed 25 percent of the lower explosive limit for methane in landfill structures (excluding gas control or recovery system components); and

ii. The concentration of methane gas does not exceed 100 percent of the lower explosive limit for methane at the landfill property boundary.

b. The County will implement a routine methane monitoring program to ensure that the standards of 4 (a) are met. (Section 5.5-Appendix III)

i. The type and frequency of monitoring must be determined based on the following factors:

(i) Soil conditions;
(ii) The hydrogeologic conditions surrounding the facility;
(iii) The hydraulic conditions surrounding the facility;
(iv) The location of facility structures and property boundaries.

ii. The minimum frequency of monitoring will be quarterly.

c. If methane gas levels exceeding the limits specified in 4 (a) are detected, the owner or operator will:

i. Immediately take all necessary steps to ensure protection of human health, i.e. no smoking, temporarily abandon the structure and notify the Division of Solid Waste Management.

ii. Within seven days of detection, place in the operating record the methane gas levels detected and a description of the steps taken to protect human health; and

iii. Within 60 days of detection, implement a remediation plan for the methane gas releases, place a copy of the plan in the operating record, and notify the Division of Solid Waste Management that the plan has been implemented. The plan will describe the nature and extent of the problem and the proposed remedy.

d. "Lower explosive limit" means the lowest percent by volume of a mixture of explosive gases in air that will propagate a flame at 25° C and atmospheric pressure.

5. Air Criteria

a. The County will ensure that the landfill does not violate any applicable requirements developed under a State Implementation Plan (SIP) approved or promulgated by the US. EPA Administrator pursuant to Section 110 of the Clean Air Act, as amended.

b. Open burning of solid waste, except for the infrequent burning of land clearing debris generated on site or debris from emergency clean-up operations, is prohibited. Any such infrequent burning will be approved by the Division of Solid Waste Management.

c. Earth moving equipment will be provided to control accidental fires and leachate tank trucks used for water or leachate that would be recirculated can also be used. Arrangements have been made with the local fire department to provide actual fire protection. This Fire department has access at all times to the landfill to provide fire fighting services when needed. Landfill personnel can use soil to isolate the fire so it will not spread any further but actual fighting of the fire should be the responsibility of the trained fire department.

d. Fires that occur at the landfill will be reported to the Division of Solid Waste Management within 24 hours and written notification will be submitted within 15 days.

6. Access and safety requirements

a. The landfill will be adequately secured by means of gates, chains, beams, fences and other security measures approved by the Division of Solid Waste Management to prevent unauthorized entry.

b. An attendant will be on duty at the site at all times while it is open for public use to ensure compliance with operational requirements.

c. The access road to the site will be of all-weather construction and maintained in good condition.

d. Dust control measures will be implemented when necessary. If dust problems should arise, the County will use any reasonable means necessary to reduce it. At a minimum the County will spray water on necessary areas.

e. Signs providing information on tipping or disposal procedures, the hours during which the site is open for public use, the permit number and other pertinent information will be posted at the site entrance.

f. Signs will be posted stating that no hazardous or liquid waste can be received.

g. Traffic signs or markers will be provided as necessary to promote an orderly traffic pattern to and from the discharge area and to maintain efficient operating conditions.

h. The removal of solid waste from the landfill will be prohibited unless the County approves and the removal is not performed on the working face.

i. Barrels and drums will not be disposed of unless they are empty and perforated sufficiently to ensure that no liquid or hazardous waste is contained therein, except fiber drums containing asbestos.

7. Erosion and Sedimentation Control Requirements

a. Adequate sediment control measures (structures or devices), will be utilized to prevent silt from leaving the landfill.

b. Adequate sediment control measures (structures or devices), will be utilized to prevent excessive on-site erosion.

c. Provisions for a vegetative ground cover sufficient to restrain erosion will be accomplished within **21 calendar days** upon completion of any phase of landfill development.

8. Drainage Control and Water Protection Requirements

a. Surface water will be diverted from the operational area and will not be impounded over waste..

b. Solid waste will not be disposed of in water.

c. Leachate will be contained on site and properly treated prior to discharge.

d. The landfill will not:

(i) 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.

(ii) Cause the discharge of a nonpoint source of pollution to waters of the United States, including wetlands, that violates any requirements of an area-wide or state-wide water quality management plan that has been approved under Section 208 or 319 of the Clean Water Act, as amended.

9. Liquids Restriction

a. Bulk or non-containerized liquid waste will not be placed in the landfill unless:

(i) The waste is household waste other than septic waste and waste oil,

(ii) The waste is leachate or gas condensate derived from the landfill.

b. Containers holding liquid wastes will not be placed in the landfill unless:

(i) The container is a small container similar in size to that normally found in household waste;

(ii) The container is designed to hold liquids for use other than storage; or

(iii) The waste is household waste.

c. For the purpose of this paragraph:

(i) Liquid waste means any waste material that is determined to contain "free liquids" as defined by Method 9095 (Paint Filter Liquids Test), S. W. 846.

d. Test for free liquids:

Sludges or other wastes may be tested for free liquids after previous screening tests have shown that the waste is not hazardous and does not contain PCB's. The specified test to determine whether or not a material is considered to be a liquid is the Paint Filter Test method 9095. The procedure for conducting this test is as follows:

(i) Obtain standard 400- micron paint filter;

(ii) Place a properly-sized, clean, dry funnel in a ring stand or similar device;

(iii) Fold the filter and line the funnel with it;

(iv) Place a 100 ml sample of waste into the funnel;

(v) Place a clean, dry container under the funnel; and,

(vi) Check in exactly 5 minutes to see if any liquid is in the container.

(vii) If any liquid passes through the filter in 5 minutes or less, the waste is considered to be a liquid. The filtrate can be water, oil or any combination of any non-hazardous liquids.

10. Record keeping Requirements

a. The County's MSWLF will record and retain at the facility, or an alternative location near the facility approved by the Division of Solid Waste Management, in an operating record the following information as it becomes available.

(i) Inspection records, waste determination records, and training procedures;

(ii) Amounts by weight of solid waste received at the landfill to include source of generation.

(iii) Waste determination, Leachate sampling data, leachate levels, meteorological data ;

(iv) Gas monitoring results and any remediation plans;

(v) Any demonstration, certification, findings, monitoring, testing or analytical data required for surface and groundwater monitoring;

(vi) Any monitoring, testing or analytical data required for closure or post-closure; and,

(vii) Any cost estimates and financial assurance documentation.

b. All information contained in the operating record will be furnished upon request to the Division of Solid Waste Management or be made available at all reasonable times for inspection by the Division.

c. The County will maintain a copy of the operation plan at the landfill.

11. Spreading and Compacting Requirements

a. The initial lift of solid waste will be placed over cell 1 that is bounded by the leachate collection ditch. This lift will be covered with six (6) inches of daily cover. This lift will absorb the rain water and allow some of it to evaporate prior to reaching the leachate collection system. When a heavy rain does occur, the impact on the leachate collection system will not be immediate. Prior to placement of solid waste over any leachate pipe, the geotextile fabric that is covering the stone will be folded back so that solid waste will be in direct contact with the stone. This method will not allow biological growth to develop on the geotextile which could eventually clog the system.

b. The initial lift of solid waste will be placed loosely at a depth of 4 feet. As this lift is being placed, a spotter should be placed in the landfill to assure that the compactor does not drive any long, sharp objects through the protective cover into the liner system. If an object were to penetrate the liner system, the protective cover must be removed and the penetration repaired. The subsequent lifts can be placed up to final grades. Heavy landfill equipment including articulating dump trucks, and compactor will only be allowed on areas that have a minimum of 4' of solid waste. Only low pressure equipment such as a D6 LGP Caterpillar will be allowed on the protective cover.

c. The landfill will restrict solid waste into the smallest area feasible, typically 60' x 75' area.

d. Solid waste will be compacted as densely as practical into cells. The compactor should run over an area of solid waste a minimum of 6 times.

e. Appropriate methods such as fencing and diking will be provided within the area to confine solid waste subject to be blown by the wind. At the conclusion of each day of operation, all windblown material resulting from the operation will be collected and returned to the area.

12. Leachate Management Plan

a. The County will periodically maintain the leachate collection system by visual inspection and periodic flushing of the collection lines.

b. The County will maintain records for the amount of leachate collected.

c. The County will quality sample their leachate bi-annually for Appendix I (Section 5.3) constituents, pH, BOD, COD, TDS, phosphate, nitrate, and sulfate. The sample will be obtained from the lagoon and sampled the same time as the monitoring wells.

d. The leachate is being treated by Kinston Wastewater Treatment Plant.

e. Under extreme operational conditions, the County has the option of shutting down the flow of leachate to the lagoon by shutting off the pump. The leachate will be temporarily stored within the MSWLF units until such a time the flow of leachate can continue to the lagoon. If any rain or other event requires storage of leachate or storm water in the cell, the Division of Solid Waste will be notified immediately followed by written communication.

f. Leachate will be recirculated. (See Section 5.6-Appendix IV)

g. The leachate lines shall be flushed at least once per year. This can be done by using a tanker full of either leachate or plain water. The liquid can either be pumped or gravity flow into the cleanouts provided at the ends of the lines. Once the water is unloaded into the collection system, there needs to be a visual inspection at the lagoon to assure that the water unloaded into the system appears at the lagoon in a short period of time. This is observed as an increase in the flow that is observed prior to unloading the water into the system.

In the event that it cannot be visually determined whether or not the flow in the leachate line at the lagoon has not increased, a flow measuring device shall be used at the end of the leachate line flowing into the lagoon. The measurements need to be done prior to dumping water into the collection system and after.

If it is determined that a blockage is in the line, the line shall be pressure cleaned and videoed to assure that the blockage has been removed.

Records of all flushing either by gravity or pressurized shall become part of the operating record. Any videos that have been taken shall also become part of the operating record.

5.3 Appendix I

A. INTRODUCTION

The municipal solid waste stream is made up of wastes from all sectors of society. The waste is often categorized by its source or its characteristics. Terms used include commercial, industrial, residential, biomedical, hazardous, household, solid, liquid, demolition/construction, sludge, etc. Regardless of how one classifies wastes, the bottom line is that wastes are delivered to the landfill and a management decision must be made to either reject or accept them. This responsibility rests with the manager of the landfill. Wastes which are not authorized to be accepted at the landfill create a number of potential problems including: (1) liability due to future releases of contaminants; (2) bad publicity if media learns of unacceptable waste entering the landfill; (3) potential for worker injury; (4) exposure to civil or criminal penalties; (5) damage to landfill environmental control systems.

B. HAZARDOUS WASTE REGULATIONS AND MANAGEMENT

In the United States, hazardous waste is regulated under RCRA, Subtitle C. A waste is hazardous if it is listed as a hazardous waste by the Administrator of the Environmental Protection Agency (EPA) in the Code of Federal Regulations, Title 40, Part 261, or if it meets one or more of the hazardous waste criteria as defined by EPA. These criteria are:

- Ignitability
- Corrosivity
- Reactivity
- Toxicity

1. Ignitability

Ignitable waste is a waste that burns readily, causes a fire by friction under normal circumstances, or is an oxidizer. Any waste having a flash point of <140F falls in this category. Flash point is that temperature at which a liquid gives off vapors that will ignite when an open flame is applied. Under Department of Transportation (DOT) definitions, a flammable liquid has a flash point of >100 F. A combustible liquid has a flash point between 100 and 200 F. Therefore, a flammable liquid is always hazardous while a combustible liquid may or may not be hazardous depending upon its flash point.

2. Corrosivity

A corrosive waste is one having a very high or a very low pH. The pH of a liquid is a measure of how acidic or basic (alkaline) the material is. The pH scale ranges from 0 to 14. High numbers are basic and low numbers are acidic. A substance having a pH $\leq$2.0 or $\geq$12.5 is defined as hazardous under RCRA.

3. Reactivity

A waste is reactive if it is normally unstable: reacts violently with water; forms an explosive mixture with water; contains quantities of cyanide or sulfur that could be released to the air; or can easily be detonated or exploded. These wastes may fall into any one of several DOT categories.

4. Toxicity Characteristic Leaching Procedure (TCLP)

A waste is TCLP toxic if the concentration of any constituent in Table 1 exceeds the standard assigned to that substance. The TCLP is a methodology which attempts to simulate the conditions within a landfill. An acidic solution is passed through a sample of waste and the resultant "leachate" is analyzed for contaminants. The TCLP is designed to detect heavy metals, pesticides and a few other organic and inorganic compounds. The purpose of the test is to prevent groundwater contamination by highly toxic materials. TCLP tests the mobility of 40 different elements and compounds.

Except in certain specified circumstances, regulated quantities of hazardous waste must be disposed of at a permitted hazardous waste disposal facility. In accordance with 40 CFR Part 261.3, **any material contaminated by a hazardous waste is also deemed to be a hazardous waste and must be managed as such.** Hazardous waste from conditionally exempt small quantity generators are to be disposed of in a Hazardous waste disposal facility. RCRA permits are also required to store, transport, and treat hazardous waste.

C. POLYCHLORINATED BIPHENYL'S (PCBs)

1. Introduction

PCBs are nonflammable and conduct heat without conducting electricity. These compounds were most frequently used as an additive to oil or other liquids in situations where heat was involved. The PCBs enhance the heat conducting properties of the liquid and thereby increase the heat dissipation or cooling effect obtained. They have also been used in lubricants and paint. In the United States one of the most common applications was in electric transformers. The only effective method for destroying PCBs is high Temperature incineration which is relatively expensive due to a shortage of PCB incineration capacity.

TABLE 1

T.C.L.P. CONSTITUENTS & REGULATORY LEVELS (mg/L)			
CONSTITUENT	REG LEVEL	CONSTITUENT	REG LEVEL
Arsenic	5.0	Hexachlorobenzene	0.13
Barium	100	Hexachloro-1,3-butadiene	0.5
Benzene	0.5	Hexachloroethane	3.0
Cadmium	1.0	Lead	5.0
Carbon Tetrachloride	0.5	Lindane	0.4
Chlordane	0.03	Mercury	0.2
Chlorobenzene	100	Methoxychlor	10.0
Chloroform	6.0	Methyl ethyl ketone	200
Chromium	5.0	Nitrobenzene	2.0
m-Cresol	200	Pentachlorophenol	100
o-Cresol	200	Pyridine	5.0
p-Cresol	200	Selenium	1.0
Cresol	200	Silver	5.0
1,4-Dichlorobenzene	10.0	Tetrachloroethylene	0.7
1,2-Dichloroethane	0.7	Toxaphene	0.5
1,1-Dichloroethylene	0.5	Trichloroethylene	0.5
2,4-Dichlorophenoxyacetic acid	0.7	2,4,5-Trichlorophenol	400
2,4-Dinitrotoluene	0.13	2,4,6-Trichlorophenol	2.0
Endrin	0.02	2,4,5-TP (Silvex)	1.0
Heptachlor (and its hydroxide)	0.008	Vinyl Chloride	0.2

By law PCB's are no longer used as dielectrics in transformers and capacitors manufactured after 1979. There are many millions of pounds of PCBs still in use or in storage. One example is the ballasts used in fluorescent light fixtures. It has been estimated that there are between 0.5 million and 1.5 billion ballasts currently in use in this country. Due to the long life of these units, about half of these may be of pre-1979 manufacture and contain PCBs. Since each ballast contains about one ounce of nearly pure PCB fluid, there are about **20 to 30 million pounds** of PCBs in existing lighting fixtures. These items are not the subject to RCRA Subtitle D Waste Screening!

Commercial or industrial sources of PCB wastes that should be addressed by the program include:

- Mineral oil and dielectric fluids containing PCBs;
- Contaminated soil, dredged material, sewage sludge, rags, and other debris from a release of PCBs;
- Transformers and other electrical equipment containing dielectric fluids; and
- Hydraulic machines.

2. PCB Regulatory Requirements

As contrasted to hazardous wastes, the Toxic Substance Control Act regulates PCBs based on the concentration of PCBs in the waste rather than the source or characteristic of the waste. The regulations concerning PCB disposal are spelled out in 40 CFR Part 761. Subtitle D of RCRA merely requires that PCB waste not be disposed in a MSW landfill. PCB management requirements include:

Waste containing more than 500 ppm of PCBs must be incinerated. Waste containing from 50 to 500 ppm must be disposed of by incineration, approved burning, or in chemical waste landfill permitted to receive such wastes. The regulations are silent concerning wastes containing less than 50 ppm of PCBs; however, the regulations cannot be circumvented by diluting stronger wastes.

D. FUNDAMENTALS OF WASTE SCREENING

1. Know Your Generators and Haulers

Since the level of sophistication of your waste screening program will be a reflection of the likelihood of hazardous waste and PCB waste being in your incoming waste, **knowledge of the commercial industrial base of your service area is critical.** Some examples are the automotive industry, which generates solvents, paint wastes, lead acid batteries, grease and oil; the dry cleaning industry, which may generate filters containing dry cleaning solvents; metal platers which generate heavy metal wastes; and other industries which generate a variety of undesirable wastes; e.g. chemical and related products, petroleum refining, primary metals, electrical and electronic machinery, etc.

Landfill managers should also know the haulers and trucks serving the businesses in their community which are likely to carry unacceptable wastes.

Some local governments and solid waste management agencies have enacted legislation requiring haulers to provide a manifest showing the customers whose wastes make up that particular load. Such a manifest is an extremely useful tool when a load is found to contain prohibited wastes. It is unwise to accept wastes from unknown, unlicensed, or otherwise questionable haulers.

2. Inspections

An inspection is typically a visual observation of the incoming waste loads by an individual who is trained to identify regulated hazardous or PCB wastes that would not be acceptable for disposal at the MSWLF unit. The training of landfill personnel will be conducted by a local EMS official or a SWANA

certification. An inspection is considered satisfactory if the inspector knows the nature of all materials received in the load and is able to discern whether the materials are potentially regulated hazardous wastes or PCB wastes.

Ideally, all loads should be screened; however, it is generally not practical to inspect in detail all incoming loads. Random inspections, therefore, can be used to provide a reasonable means to adequately control the receipt of inappropriate wastes. Random inspections are simply inspections made on less than every load. At a minimum the inspection frequency will not be less than one percent of the waste stream.

The frequency of random inspections may be based on the type and quantity of wastes received daily, and the accuracy and confidence desired in conclusions drawn from inspection observations. Because statistical parameters are not provided in the regulation, a reasoned, knowledge-based approach may be taken. A random inspection program may take many forms such as inspecting every incoming load one day out of every month or inspecting one or more loads from transporters of wastes of unidentifiable nature each day. If these inspections indicate that unauthorized wastes are being brought to the MSWLF site, the random inspection program should be modified to increase the frequency of inspections.

Inspection priority also can be given to haulers with unknown service areas, to loads brought to the facility in vehicles not typically used for disposal of municipal solid waste, and to loads transported by previous would-be offenders. For wastes of unidentifiable nature received from sources other than households (e.g., industrial or commercial establishments), the inspector should question the transporter about the source/composition of the materials.

An inspection flow chart to identify, accept, or refuse solid waste is provided as Figure 1.

Inspections of materials may be accomplished by discharging the vehicle load in an area designed to contain potentially hazardous wastes that may arrive at the facility. The waste should be carefully spread for observation using a front end loader or other piece of equipment. The Division of Solid Waste recommends that waste should be hand raked to spread the load. Personnel should be trained to identify suspicious wastes. Some indications of suspicious wastes are:

- Hazardous placards or markings;
- Liquids;
- Powders or dusts;
- Sludges;
- Bright or unusual colors;
- Drums or commercial size containers; or
- Chemical odors.

The County will follow these procedures when suspicious wastes are discovered.

- Segregate the wastes;
- Question the driver;
- Review the manifest (if applicable);
- Contact possible source;
- Call the State Solid Waste Management Department;
- Use appropriate protective equipment;
- Contact laboratory support if required; and
- Notify the local Hazardous Material Response Team.

Containers with contents that are not easily identifiable, such as unmarked 55-gallon drums, should be opened only by properly trained personnel. Because these drums could contain hazardous waste, they should be refused whenever possible. Upon verifying that the solid waste is acceptable, it may then be transferred to the working face for disposal.

Testing typically would include the Toxicity Characteristic Leaching Procedure (TCLP) and other tests for characteristics of hazardous wastes including corrositivity, ignitability, and reactivity. Wastes that are suspected of being hazardous should be handled and stored as a hazardous waste until a determination is made.

If the wastes temporarily stored at the site are determined to be hazardous, Lenoir County is responsible for the management of the waste. If the wastes are to be transported from the facility, the waste must be: (1) stored at the MSWLF facility in accordance with requirements of a hazardous waste generator, (2) manifested, (3) transported by a licensed Treatment, Storage, or Disposal (TSD) facility for disposal.

E. RECORD KEEPING AND NOTIFICATION REQUIREMENTS

Records must be kept pursuant to an incident where regulated hazardous waste or prohibited waste is found at the landfill. It is also recommended that records be kept of all screening activities and incidents, whether or not, regulated or prohibited wastes are found. This will help prove that the landfill owner/operator has acted in a prudent and reasonable manner.

The best way to prove compliance with this requirement is to document each inspection including:

Date and time of waste detection
Hauler name (company and driver)
Waste(s) detected
Waste generator(s) if able to identify
Action(s) taken to manage or return material(s)
Efforts taken if extreme toxicity or hazard was discovered
Landfill employee in responsible charge

40 CFR Part 258 requires that records should be maintained at or near the landfill site during its active life and as long after as may be required by the appropriate state or local regulations.

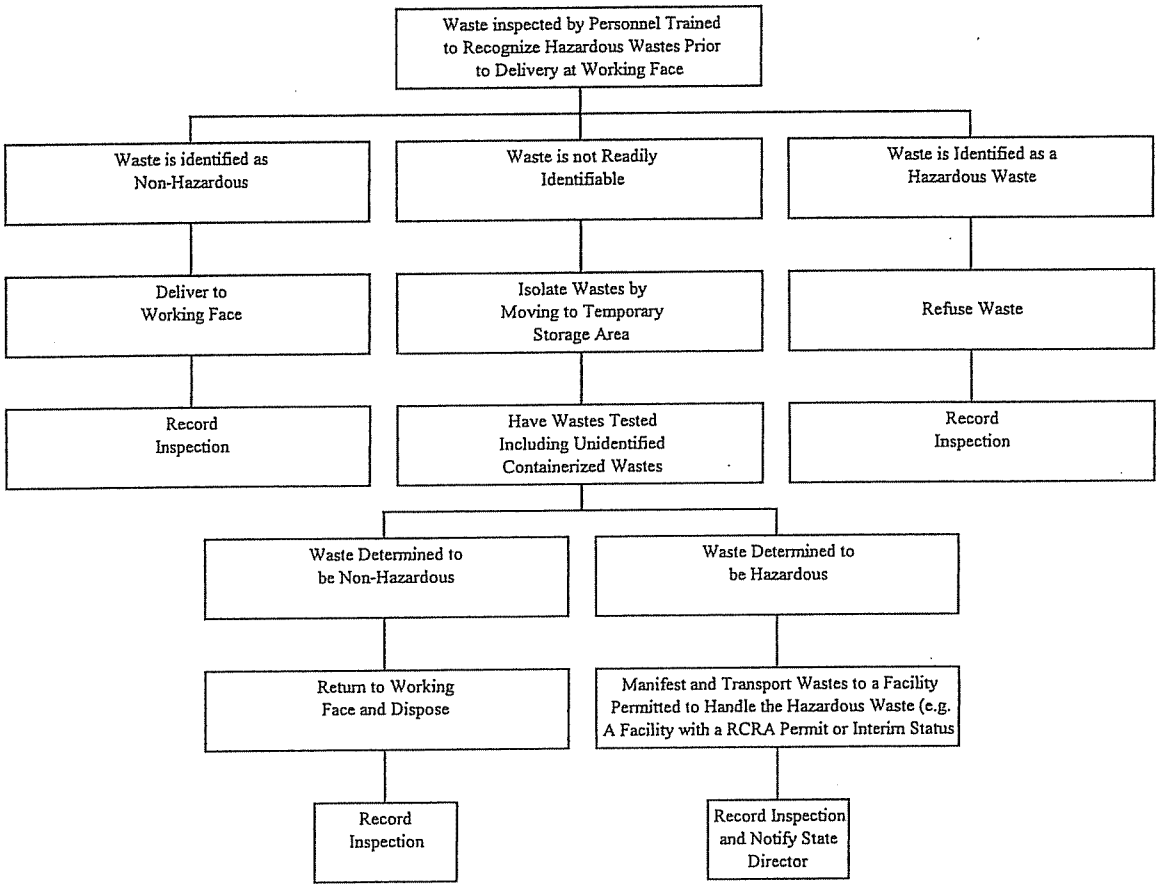


FIGURE 1
Hazardous Waste Inspection Decision Tree
Inspection Prior to Working Face

WASTE SCREENING CHECK LIST

CONTAINERS	YES	NO
FULL	____	____
PARTIALLY FULL	____	____
EMPTY	____	____
CRUSHED	____	____
PUNCTURED	____	____
POWDERS/DUSTS		
IDENTIFIED	____	____
UNKNOWN	____	____
SATURATION	____	____
LABEL/HAZARDOUS	____	____
ODOR/FUMES		
STRONG	____	____
FAINT	____	____
HEAT	____	____
ITEMS FOUND		
BATTERIES	____	____
OIL	____	____
BIOMEDICAL	____	____
RADIOACTIVE	____	____
ASHES/RESIDUE	____	____
SOD/SOIL	____	____
LIQUID	____	____
HAZARDOUS	____	____
PCB'S	____	____

CHECK ALL THAT APPLY

DETAILED SCREENING REPORT

WASTE SOURCE_____
ADDRESS_____
_____
_____

PROBABLE [ ] SUSPECTED [ ] CONFIRMED [ ]

WASTE
HAULER_____
ADDRESS_____
_____
_____

DRIVER'S NAME_____
DETAIL_____
_____
_____

NOTIFIED:

WASTE SOURCE [ ] HAULING MANAGEMENT [ ] SITE MANAGEMENT [ ]

STATE [ ] FEDERAL [ ]

NAME_____
WITNESS (IF ANY)_____
DATE_____TIME_____ AM PM
_____

ACTION REQUIRED

5.4 Appendix II

LENOIR COUNTY - SYNTHETIC COVER OPERATION PLAN

1. Determine the size of the area to be covered. Be sure to allow for five to ten feet extra on each measurement to ensure that the refuse is completely covered.

2. The synthetic cover is shipped to the landfill site with panels folded accordion-type, then rolled up. Unroll the cover along the working face (depending upon operations), and attach the leading edge of the unrolled panel to existing landfill equipment with ropes (i.e., to the top of the blade).

3. Pull the sewn panels of cover across the compacted trash. The synthetic cover maybe pulled from any direction, which may vary from day to day. Keep the leading edge between the two machines (or people) as high as possible to eliminate drag.

4. Anchor the edges of synthetic cover every 20 feet with tires or sandbags to hold the synthetic cover in place. If it is windy, more anchoring may be required. Make sure a large enough panel has been ordered to completely cover the refuse (base this on the heaviest day to the week). If complete coverage is not possible, cover the exposed refuse with soil; but take care not to place too much dirt on the synthetic cover if it is to be re-used.

5. On the next day of operations, remove the tires and/or sandbags. Simply pull the synthetic cover across itself (to reduce drag) and off the refuse to an area that is inactive. Anchor the edges again to prevent wind from lifting the blanket. At the end of the day, pull the synthetic cover back across the refuse by repeating steps 3 and 4 until a new panel is needed.

Synthetic Cover is designed to be used as landfill daily cover on a working face. For best results, it is recommended that the area to be covered be kept as close to a square shape as possible not to exceed 75' X 75' in size. Not only does this procedure allow for easier coverage, it allows for better management of the working face and saves time at the end of the working day.

The County will use a panel of synthetic cover that is pulled over the working face on a daily basis by two pieces of landfill equipment. At the end of the working day, the panel will be secured in place. This is attained by one of two methods : the panel may be heavy enough to hold itself in place due to accumulation of soil and is left in that manner; or tires are placed on the panel to secure it in place.

The working face is operated in this manner, brought to an intermediate grade and then covered with the required six (6) inches of soil. The process will continue until a lift is completed. The process is then started over on the next lift until the landfill is filled to final grade and a section is closed. At a minimum six (6) inches of soil cover will be used once a week.

TIPS TO REMEMBER

1. Always pull the fabric across itself during installation and removal to make each panel last as long as possible.

2. Avoid driving on the panel(s); this may cause punctures and tears.
3. Tie the panel(s) to the top of the dozer blade and raise the blade to minimize dragging on refuse.

4. Use tires or sandbags to hold the panel(s) down overnight. Soil can be used if you plan to leave panel(s) in place and cover with refuse.

5. Minimize stress between dozer/compactors while pulling on the panel(s).

5.5 Appendix III

LENOIR COUNTY - EXPLOSIVE GAS CONTROL PLAN

Quarterly, the County Landfill will monitor the explosive gas at the landfill structures and at or near the landfill boundary. . The permanent probes will consist of a plastic stand pipe similar to a piezometer used for groundwater detection. A typical permanent methane probe is detailed in the operation drawings. The permanent probe will be constructed at a depth of six (6) feet. A 6" diameter hole will contain a one (1) inch slotted PVC pipe. The bottom two (2) feet will be backfilled with non-carbonate pea gravel with a bentonite seal one (1) foot thick above it. The remaining three (3) feet will be backfilled with *in situ* soils. The one (1) inch PVC pipe will be approximately three (3) feet above the existing grade. The PVC pipe will be capped with a one (1) inch PVC cap, one quarter (1/4) inch NPT hose barb, and 1" tubing, plugged or capped.

The location and spacing of the methane monitoring probes is somewhat arbitrary. The locations were determined by the relationship of solid waste with property lines and landfill structures. The spacing of the monitoring probes is between 200 and 400 feet. The migration of methane gas is induced by pressure gradients. The methane will move from areas of high pressure to those of low pressure following the path of least resistance. The methane will migrate vertically until it reaches the landfill cap, where it will begin to flow horizontally. This occurs until it finds a pathway out, either by the installed methane collection trenches or migration through the permeable *in situ* soils. Since methane is lighter than air, it wants to escape into the atmosphere. It has been our experience that whenever gas is migrating no matter what the spacing or depth of the monitoring probes, the gas will fill the void created by the monitoring point and an explosive meter will monitor the level. The various depths of the monitoring probes are to ensure a stable monitoring point. The only time a shallow monitoring point has not worked is in a very heavy, impermeable clay layer that acts as a seal to the migration of the gas. If a clay layer is encountered during the construction of the monitoring points, it will either be moved beyond the clay or excavated to a depth that is in the conductive zone below the clay.

The permanent probes will surround Phase 2.The County's landfill is designed with a base liner system and cap system, there should be no migration of methane in the permeable *in situ* soils.

The gas can be detected by use of an instrument that reports the percent of lower explosive limit. The instrument being used is the Gas Tech GP 204.

Based on current conditions, there are four(4) existing monitoring points and nine(9) proposed monitoring points that will be installed at the facility prior to waste activities commencing at Phase 2. Quarterly, a County employee will visit each monitoring point either the temporary or permanent. The monitoring points consist of all methane probes and leachate collection system cleanouts. Using the detection instrument, he will determine if methane gas has filled the probes. If the probe is near the property line and methane gas is detected at or beyond the lower explosive limit (100% LEL), it must then be determined if the gas is migrating across the landfill boundary. If the probe is on the boundary or methane gas has migrated beyond the boundary , a remediation plan must be completed by Lenoir County.

Other points of monitoring will be the landfill structures. Each structure will be monitored for methane using the following methods:

1. All crawl spaces will be monitored;
2. All corners in the structure will be monitored;
3. Any holes, cracks and pipes through the foundation will be monitored

If methane gas is detected beyond 25% of its lower explosive limit in any structure, check the calibration of the monitor and resample. If the reading is still above 25%, evacuate the building and try to find the source of gas. If the source is found try to remove the source. If this fails a remediation plan is stated in the operational requirements.

5.6 Appendix IV

LENOIR COUNTY - RECIRCULATION PLAN

The County does intend to utilize recirculation as a means of disposal of their leachate. The intention is to utilize recirculation as a method by which some relief can be given to the pumping. This relief will come in the form of evaporation and retention of water within the solid waste. The remaining leachate will be pumped and hauled to the Kinston Wastewater Treatment Plant for disposal. The County must obtain a permit from the Division of Solid Waste before leachate recirculation can begin.

No water that comes in contact with the present surface of solid waste runs off anywhere other than the leachate collection system.

The County will spread the leachate over the surface of the solid waste, that is at a minimum five feet (5') deep, within the landfill. The spreading will be accomplished by one of two methods. The first method is by simply backing their leachate hauling truck into the landfill. A spreader hose will then be attached to the leachate tank and County personnel will manually discharge the leachate over the solid waste. The second method will utilize the tank truck except the leachate will be used to wet down solid waste that is piled up from being dumped from a truck or trucks. Once this pile is wet, it will be spread around the working face by the trash compactor.

At a later date, a pump system may be incorporated into the system. The pump system will pump directly from the leachate lagoon and the leachate spread in a manner as it was from the tank truck.

Monthly monitoring will be performed to measure the leachate head at the leachate head detection well and analyze the leachate for BOD, COD, temperature and pH.

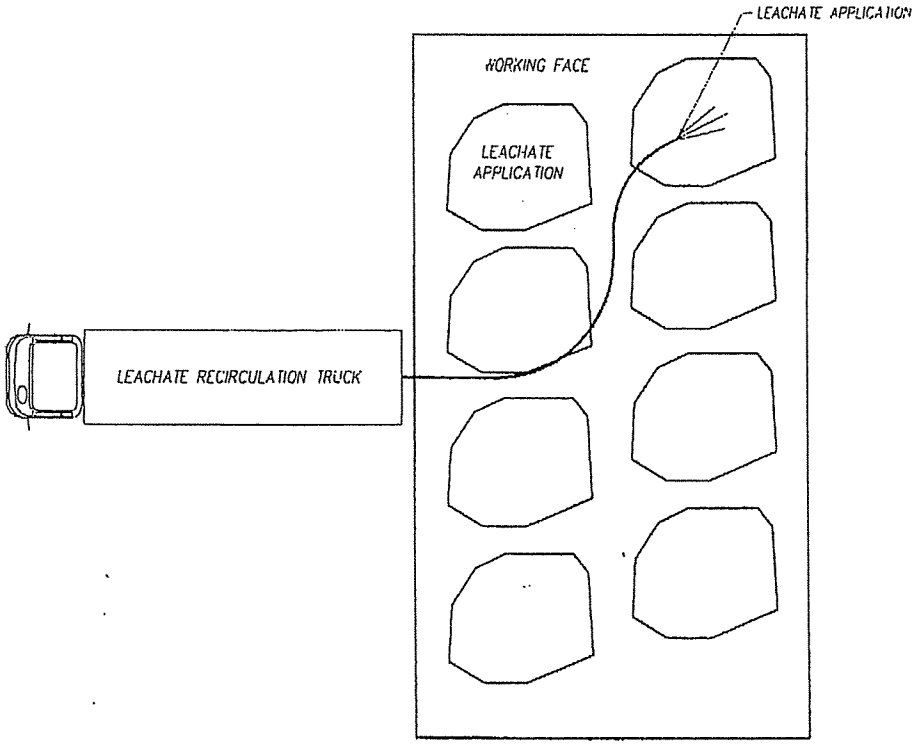
The following conditions will be met by the County:

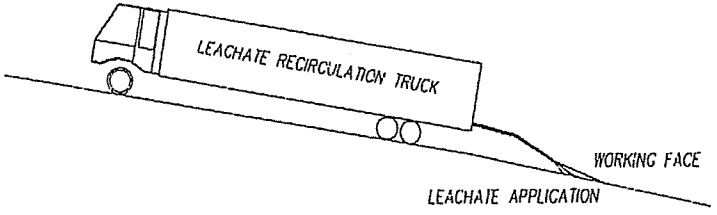
- A rain gauge and thermometer will be placed on site
- A base line sampling of leachate has been performed (See Attachment 1)
- A brief description of the equipment and its associated specifications is submitted (see Attachment 2)
- Weekly record of leachate head measurements (see Attachment 3)
- Weekly record of leachate recirculated and leachate disposed (see Attachment 4)
- Weekly record of visual monitoring log (see Attachment 5)
- Weekly record of rainfall and lagoon depth (see Attachment 6)
- Records will be kept on a weekly basis
- No leachate will be applied on less than one lift (8 feet) of waste
- No leachate will be recirculated when it is raining, or when the waste is too wet
- No run off or side seepage will be allowed
- Odors will be controlled
- Leachate depth will be monitored in the leachate head detection well to ensure that the head on the liner does not exceed one foot for more than 24 hours.
- The application system will be properly maintained and documented
- Leachate will be tested every 30 days and a progress report will be submitted annually

ATTACHMENT 1

BASELINE DATA

TO BE ADDED IN THE FUTURE





ATTACHMENT 2

ATTACHMENT 3

LENOIR COUNTY LEACHATE HEAD READINGS

DATE	DEPTH AT HEAD TEST WELL

ATTACHMENT 4

LENOIR COUNTY LEACHATE RECIRCULATION DATA

DATE	VOLUME RECIRCULATED	RECIRCULATION AREA (Section of Landfill)	VOLUME HAULED FOR DISPOSAL

ATTACHMENT 5

LENOIR COUNTY VISUAL MONITORING LOG

DATE	INDIVIDUAL MONITORING	OBSERVATIONS

ATTACHMENT 6

LENOIR COUNTY RAINFALL AND LAGOON DEPTH LOG

DATE	RAINFALL (INCHES)	LAGOON DEPTH (FEET)

5.7 Operation Drawings

5.7.1 Title Sheet
5.7.2 Index Sheet
5.7.3 Facility Operations
5.7.4 Initial Placement of Waste
5.7.5 Initial Fill Plan
5.7.6 2nd Year Fill Plan
5.7.7 3rd Year Fill Plan
5.7.8 4th Year Fill Plan
5.7.9 Final Fill with Intermediate Cover
5.7.10 Final Fill with Methane Venting and Monitoring System
5.7.11 Operation Details

LENOIR COUNTY
MUNICIPAL SOLID WASTE
LANDFILL FACILITY

OPERATION PLAN - PHASE 2

Permit Number: 5409-MSWLF

Site Location: 2949 Hodges Farm Road
La Grange, NC 28551

Applicant: Lenoir County

Applicant's Address: 130 South Queen Street
Kinston, NC 28502

BOARD OF COMMISSIONERS

George W. Graham, Jr. - Chairman
Claude Stroud - Vice-Chairman
Jackie Brown
Reuben Davis
Chris Humphrey
Thomas A. Pharo
Linda Rouse Sutton

COUNTY MANAGER

Michael W. Jarman

SOLID WASTE DIRECTOR

Tom Miller

Engineer
Municipal Engineering Services Company, P.A.
Garner, NC - Morehead City, NC - Boone, NC

NORTH CAROLINA PROFESSIONAL SEAL 10432 ENGINEER JIMMY D. WOODIE
11/25/2009

by _____
Professional Engineer
(Garner Office)

Municipal Engineering Services Company, P.A.
LICENSE NUMBER: C-0281
P.O. BOX 97 GARNER, N.C. 27529 (919) 772-5393
P.O. BOX 349 BOONE, N.C. 28607 (828) 262-1767
P.O. BOX 828 MOREHEAD CITY, N.C. 28557 (252) 726-9481

SCALE:	1:1
DATE:	10/22/09
DRWN. BY:	L. HAMPTON
CHKD. BY:	J. WOODIE
PROJECT NUMBER	G08095
DRAWING NO. T1	SHEET NO. 1 OF 11

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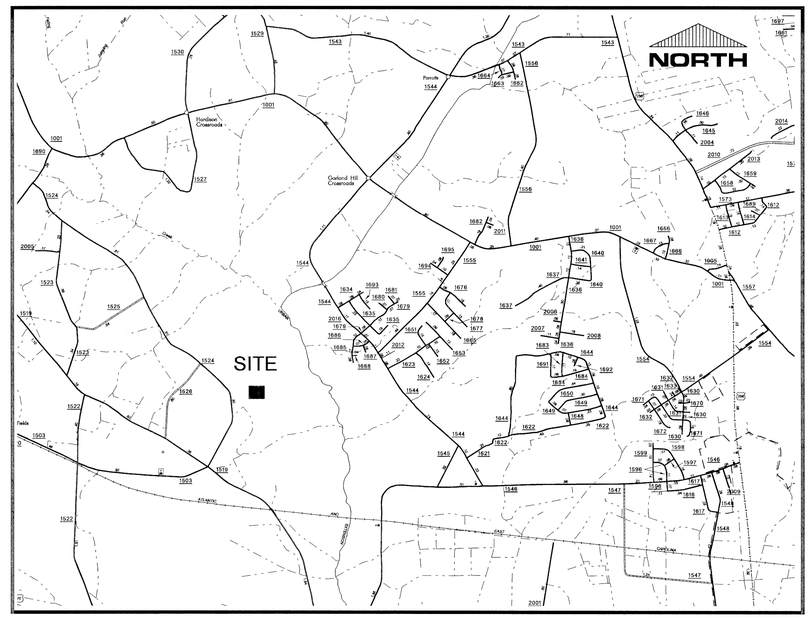
INDEX

SHEET NO.	DRAWING NO.	DESCRIPTION
1	T1	TITLE SHEET
2	T2	INDEX AND VICINITY MAP
3	P1	FACILITY OPERATIONS
4	P2	INITIAL PLACEMENT OF WASTE
5	P3	INITIAL FILL PLAN
6	P4	2nd YEAR FILL PLAN
7	P5	3rd YEAR FILL PLAN
8	P6	4th YEAR FILL PLAN
9	P7	FINAL FILL WITH INTERMEDIATE COVER
10	P8	METHANE VENTING AND MONITORING PLAN
11	P9	OPERATION DETAILS



VICINITY MAP

LICENSE NUMBER: C-0281

Municipal Services
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(919) 772-5393

Engineering Company, P.A.
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MUNICIPAL SOLID WASTE
LANDFILL FACILITY
LENOIR COUNTY
NORTH CAROLINA

DATE	BY	REV.	DESCRIPTION

INDEX AND VICINITY MAP

NORTH CAROLINA PROFESSIONAL SEAL 022 ENGINEER JAMES D. WOODIE
11/25/2009

SCALE:	1:1
DATE:	5/21/08
DRWN. BY:	L. HAMPTON
CHKD. BY:	J. WOODIE
PROJECT NUMBER	G08095
DRAWING NO.	T2
SHEET NO.	2 OF 11

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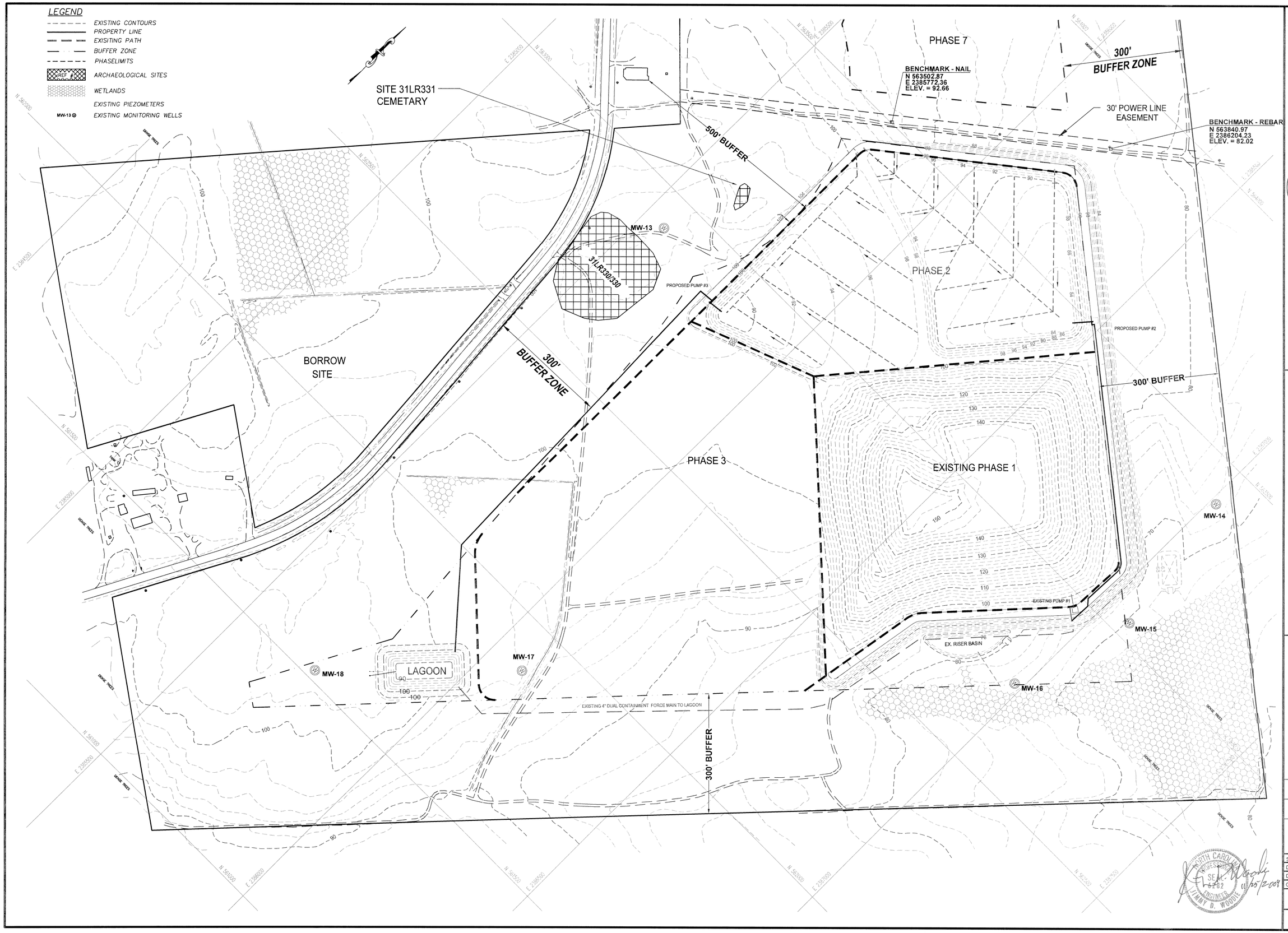

Engineering Company, P.A.
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P.O. BOX 828 MOREHEAD CITY, N.C. 28557
(252) 726-9481

Municipal Services
P.O. BOX 97 GARNER, N.C. 27529
(919) 772-5393
LICENSE NUMBER: C-0281

MUNICIPAL SOLID WASTE LANDFILL FACILITY
LENOIR COUNTY NORTH CAROLINA

DATE	BY	REV.	DESCRIPTION

OPERATION PLAN – PHASE 2
FACILITY OPERATIONS

SCALE:	1" = 100'
DATE:	10/20/09
DRWN. BY:	L. HAMPTON
CHKD. BY:	J. WOODIE
PROJECT NUMBER	G08095
DRAWING NO.	P1
SHEET NO.	3 OF 11

NORTH CAROLINA PROFESSIONAL SEAL 17202 ENGINEER JIMMY D. WOODIE 11/05/2009

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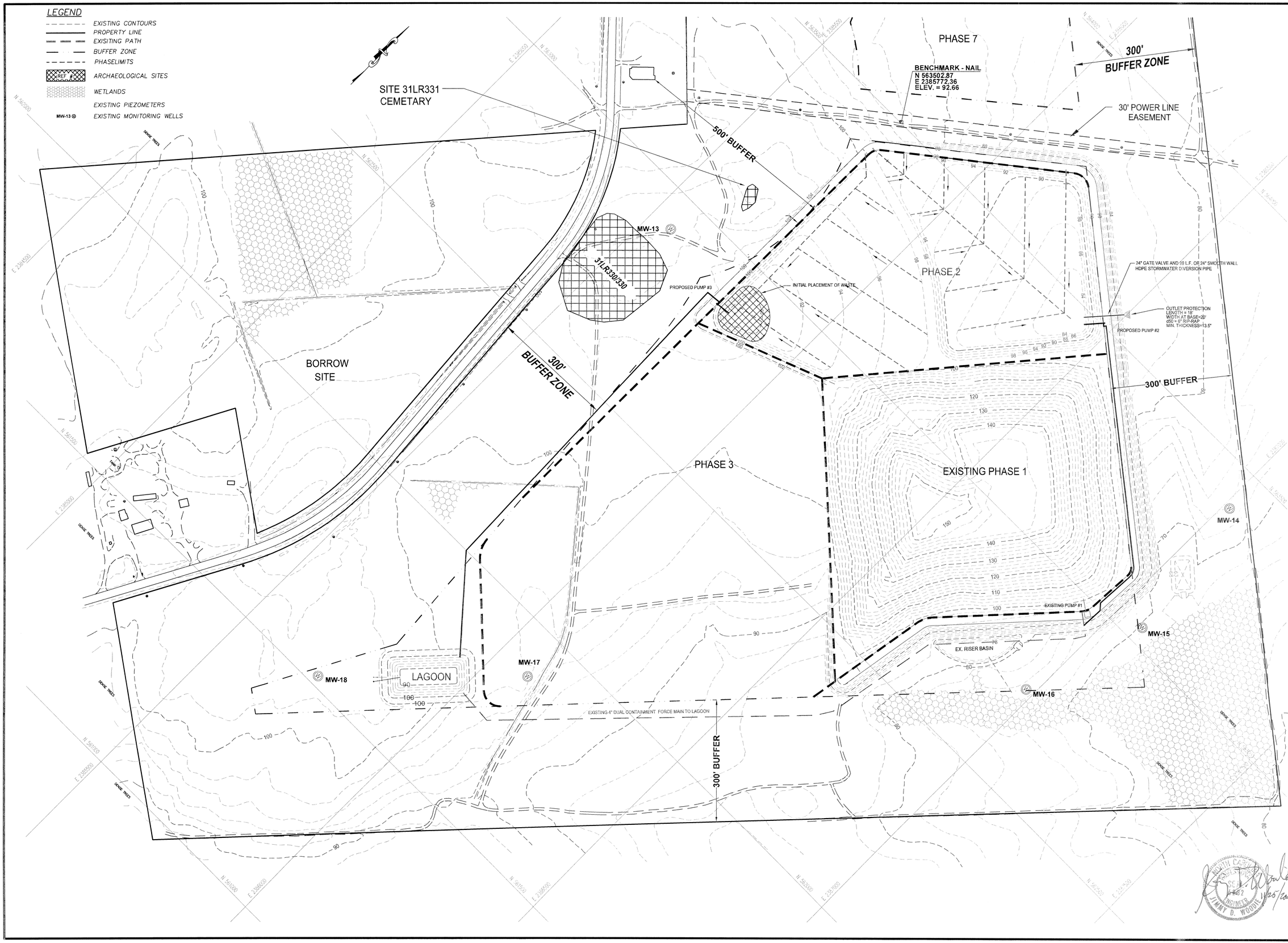

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(252) 726-9481

MUNICIPAL SOLID WASTE LANDFILL FACILITY
LENOIR COUNTY NORTH CAROLINA

DATE	BY	REV.	DESCRIPTION

OPERATION PLAN – PHASE 2
INITIAL PLACEMENT OF WASTE AND STORMWATER DIVERSION

SCALE:	1" = 100'
DATE:	10/20/09
DRWN. BY:	L. HAMPTON
CHKD. BY:	J. WOODIE
PROJECT NUMBER	G08095
DRAWING NO.	P2
SHEET NO.	4 OF 11

NORTH CAROLINA PROFESSIONAL SEAL 19482 ENGINEER JIMMY D. WOODIE 11/25/2009

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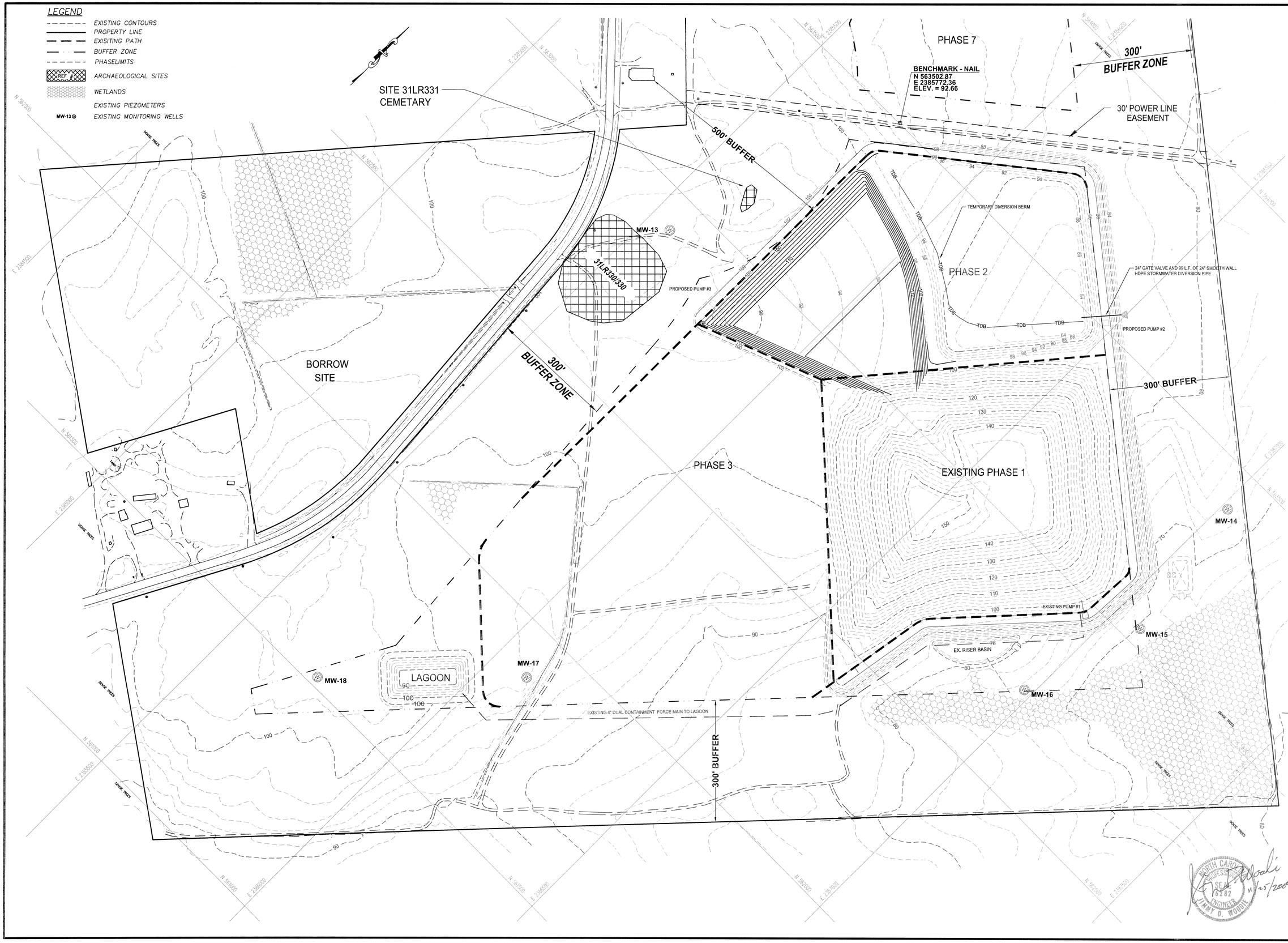

Municipal Services
LICENSE NUMBER: C-0281
Engineering Company, P.A.
P.O. BOX 97 GARNER, N.C. 27529 (919) 772-5393
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MUNICIPAL SOLID WASTE LANDFILL FACILITY
LENOIR COUNTY NORTH CAROLINA

DATE	BY	REV.	DESCRIPTION

OPERATION PLAN – PHASE 2
INITIAL FILL PLAN

SCALE:	1" = 100'
DATE:	10/20/09
DRWN. BY:	L. HAMPTON
CHKD. BY:	J. WOODIE
PROJECT NUMBER	G08095
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NORTH CAROLINA PROFESSIONAL SEAL 16182 ENGINEER JIMMY D. WOODIE
11/25/2009

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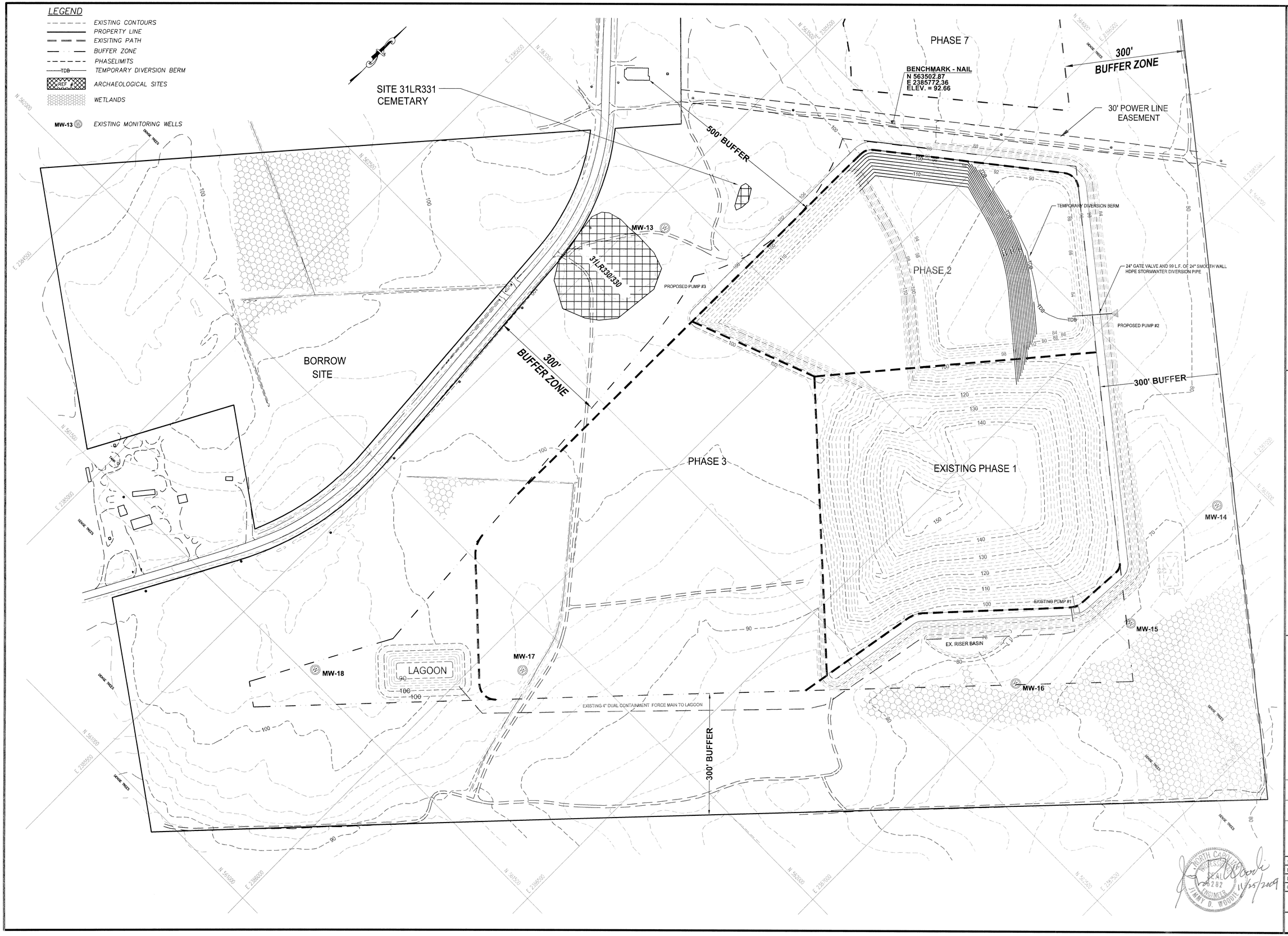

Municipal Engineering Services Company, P.A.
LICENSE NUMBER: C-0281
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MUNICIPAL SOLID WASTE LANDFILL FACILITY
LENOIR COUNTY NORTH CAROLINA

DATE	BY	REV.	DESCRIPTION

OPERATION PLAN – PHASE 2
2nd YEAR FILL PLAN

SCALE:	1" = 100'
DATE:	10/20/09
DRWN. BY:	L. HAMPTON
CHKD. BY:	J. WOODIE
PROJECT NUMBER	G08095
DRAWING NO.	P4
SHEET NO.	6 OF 11

NORTH CAROLINA PROFESSIONAL SEAL 6282 ENGINEER JIMMY D. WOODIE 11/25/2009

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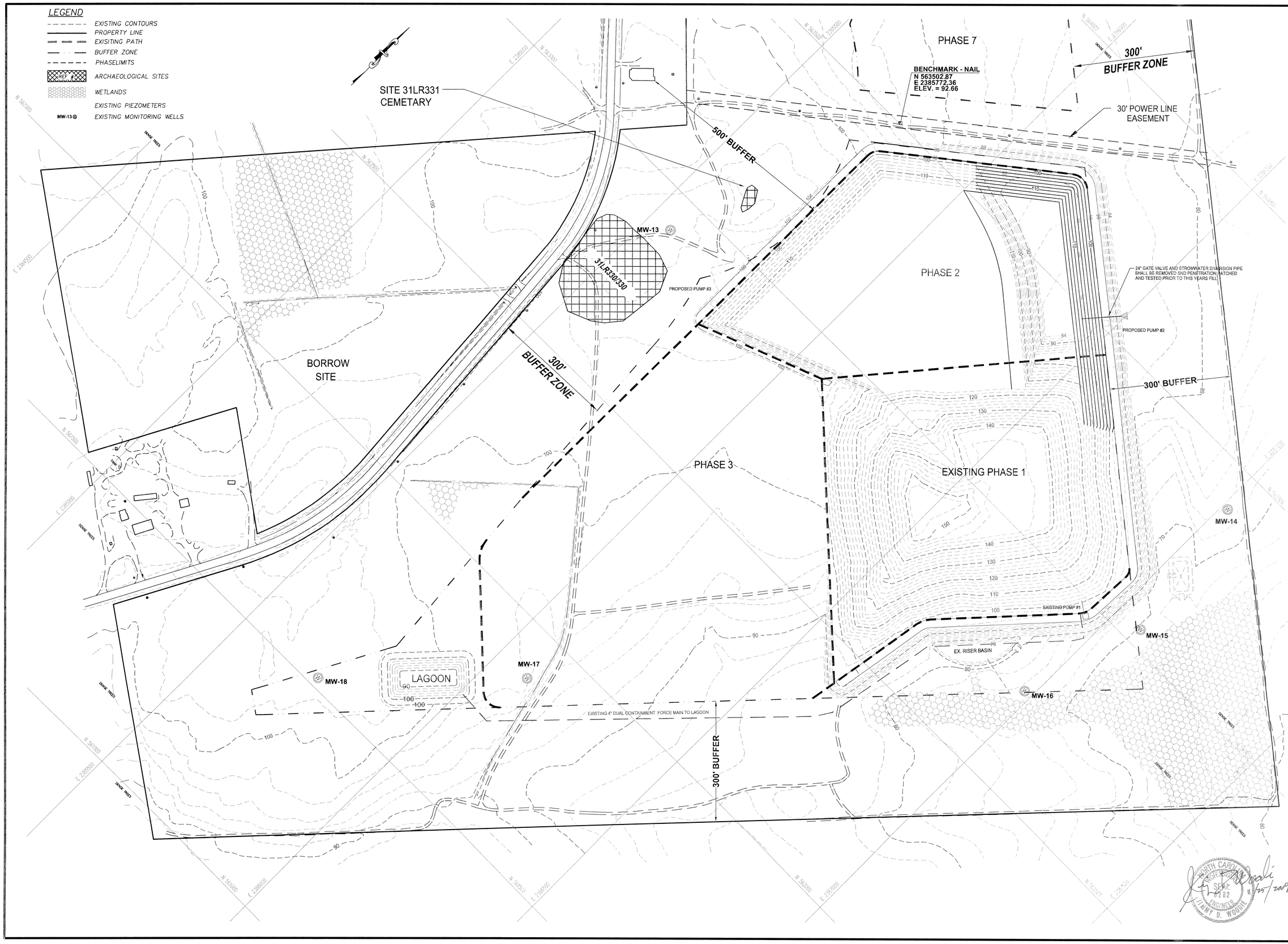

LICENSE NUMBER: C-0281

Municipal Services Engineering Company, P.A.

P.O. BOX 97 GARNER, N.C. 27529 (919) 772-5393

P.O. BOX 349 BOONE, N.C. 28607 (828) 262-1767

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MUNICIPAL SOLID WASTE LANDFILL FACILITY
LENOIR COUNTY NORTH CAROLINA

DATE	BY	REV.	DESCRIPTION

OPERATION PLAN – PHASE 2
3rd YEAR FILL PLAN

SCALE:	1" = 100'
DATE:	10/20/09
DRWN. BY:	L. HAMPTON
CHKD. BY:	J. WOODIE
PROJECT NUMBER	G08095
DRAWING NO. P5	SHEET NO. 7 OF 11

NORTH CAROLINA PROFESSIONAL SEAL 032 ENGINEER JIMMY D. WOODIE

11/20/2009

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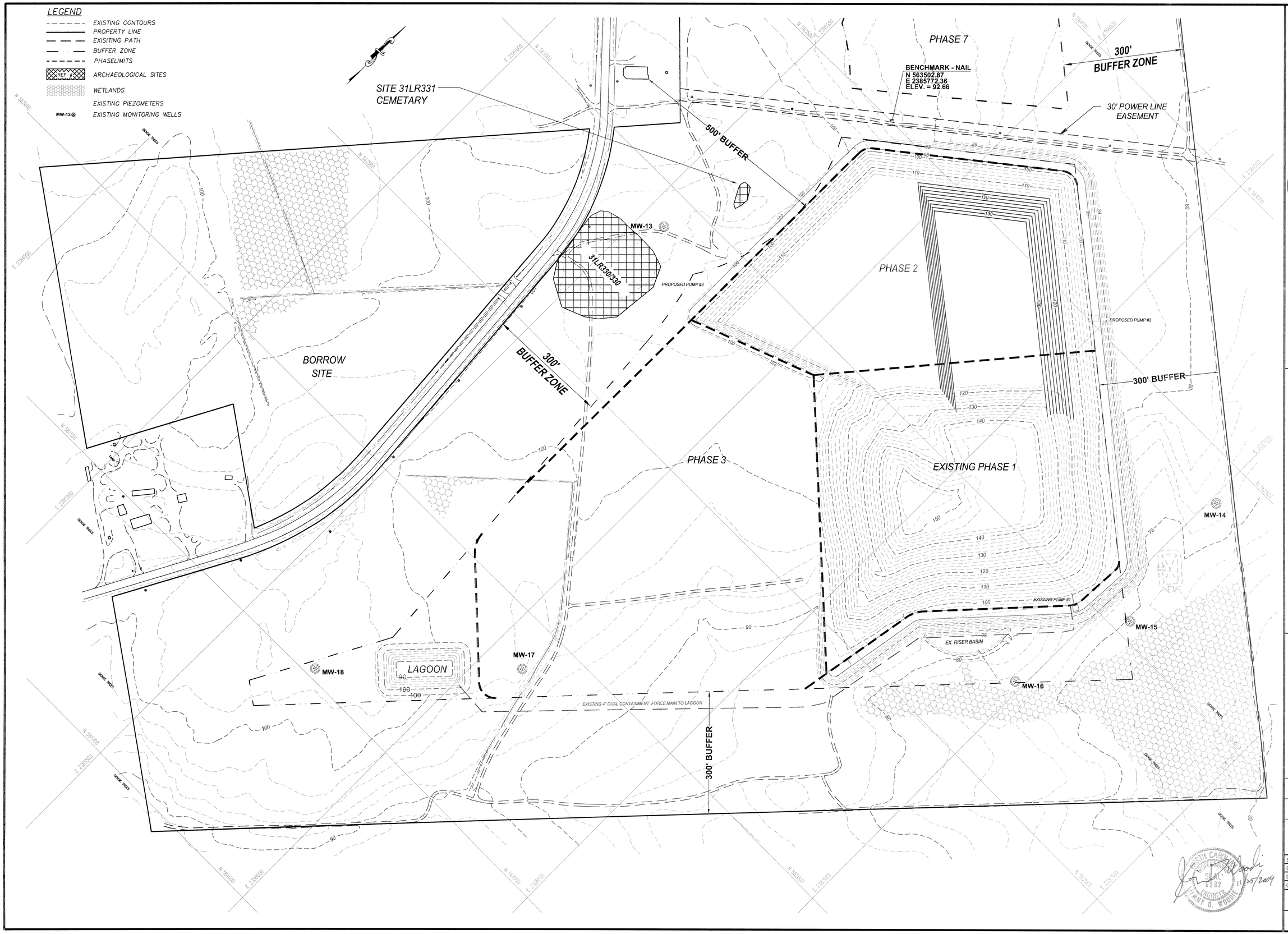

LICENSE NUMBER: C-0281

Municipal Services Engineering Company, P.A.

P.O. BOX 97 GARNER, N.C. 27529 (919) 772-5393

P.O. BOX 349 BOONE, N.C. 28607 (828) 262-1767

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MUNICIPAL SOLID WASTE LANDFILL FACILITY
LENOIR COUNTY NORTH CAROLINA

DATE	BY	REV.	DESCRIPTION

OPERATION PLAN – PHASE 2
4th YEAR FILL PLAN

SCALE:	1" = 100'
DATE:	10/20/09
DRWN. BY:	L. HAMPTON
CHKD. BY:	J. WOODIE
PROJECT NUMBER	G08095
DRAWING NO.	P6
SHEET NO.	8 OF 11

NORTH CAROLINA PROFESSIONAL SEAL 5282 ENGINEER JIMMY D. WOODIE

10/20/2009

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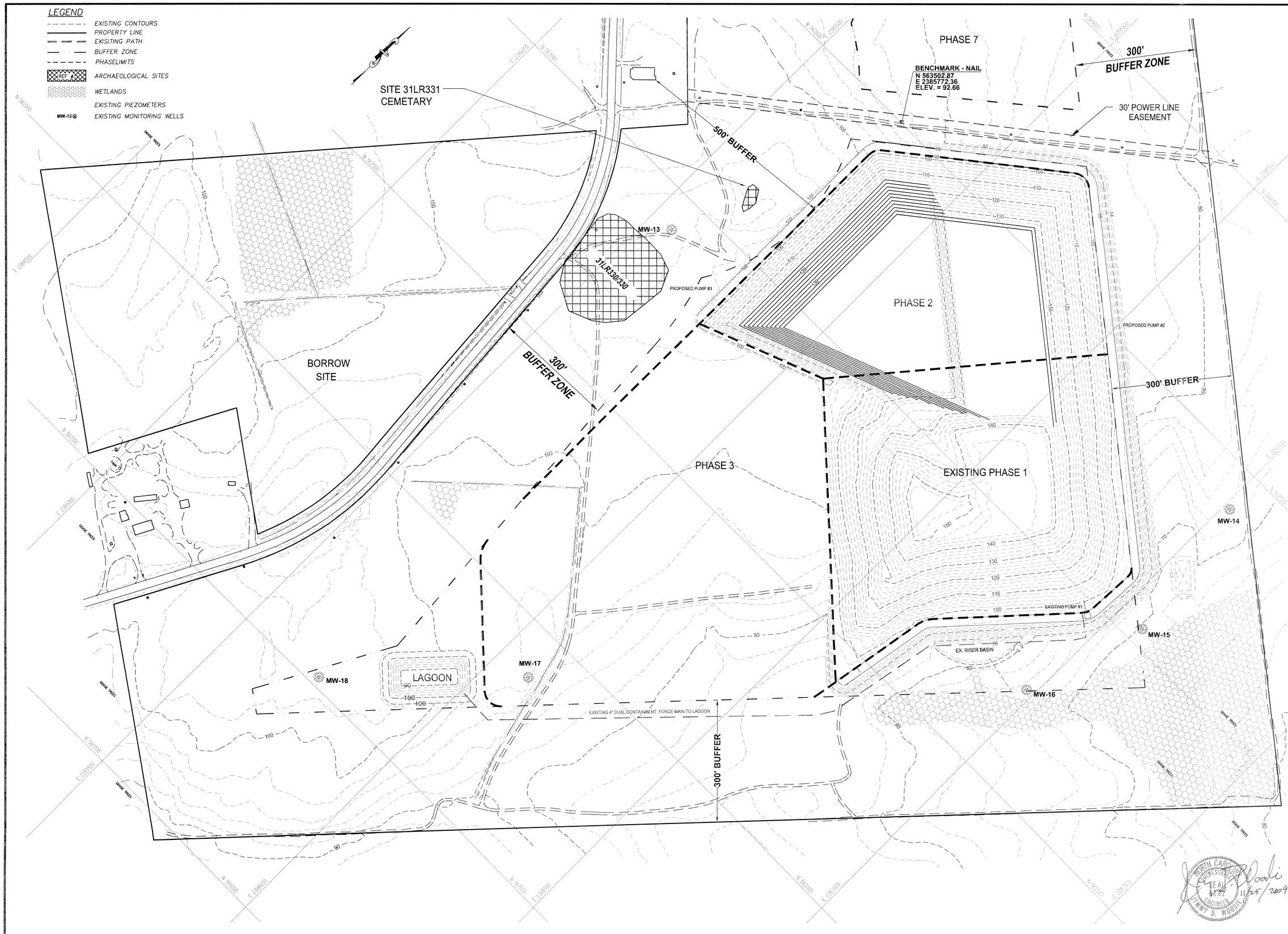

Engineering Company, P.A.
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(828) 262-1767
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(252) 726-9481

Municipal Services
LICENSE NUMBER: C-0281
P.O. BOX 97 GARNER, N.C. 27529
(919) 772-5393

MUNICIPAL SOLID WASTE LANDFILL FACILITY
LENOIR COUNTY NORTH CAROLINA

DATE	BY	REV.	DESCRIPTION

OPERATION PLAN – PHASE 2
FINAL FILL WITH INTERMEDIATE COVER

SCALE:	1" = 100'
DATE:	10/20/09
DRWN. BY:	L. HAMPTON
CHKD. BY:	J. WOODIE
PROJECT NUMBER	G08095
DRAWING NO.	P4
SHEET NO.	9 OF 11

NORTH CAROLINA PROFESSIONAL SEAL 019864 ENGINEER JIMMY D. WOODIE
11/25/2009

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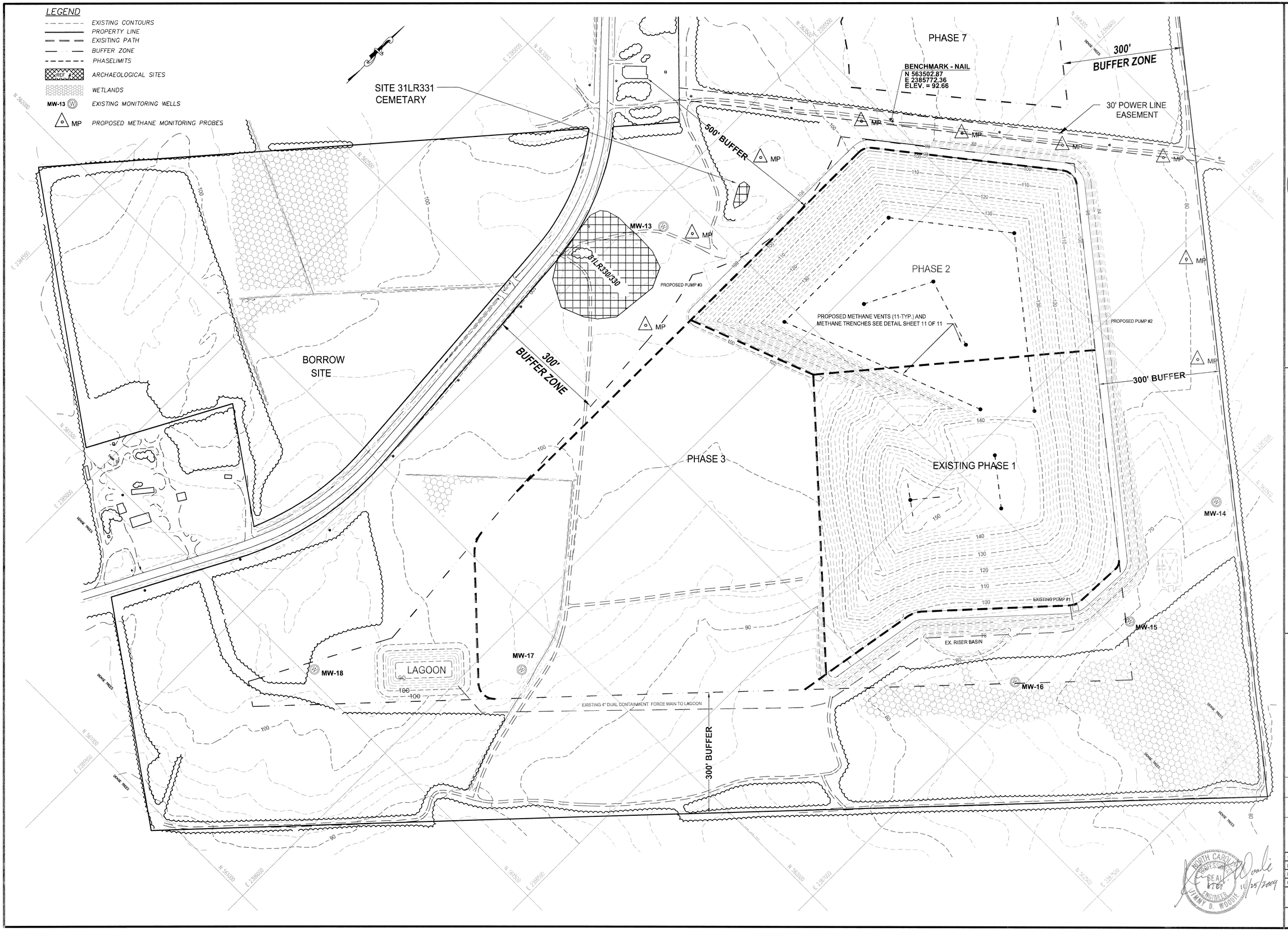

Municipal Services Engineering Company, P.A.

LICENSE NUMBER: C-0281

P.O. BOX 97 GARNER, N.C. 27529 (919) 772-5393

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MUNICIPAL SOLID WASTE LANDFILL FACILITY
LENOIR COUNTY NORTH CAROLINA

DATE	BY	REV.	DESCRIPTION

OPERATION PLAN – PHASE 2
METHANE VENTING AND MONITORING PLAN

SCALE:	1" = 100'
DATE:	10/20/09
DRWN. BY:	L. HAMPTON
CHKD. BY:	J. WOODIE
PROJECT NUMBER	G08095
DRAWING NO.	SHEET NO.
P8	10 OF 11

NORTH CAROLINA PROFESSIONAL SEAL 022 ENGINEER JIMMY D. WOODIE

10/25/2009

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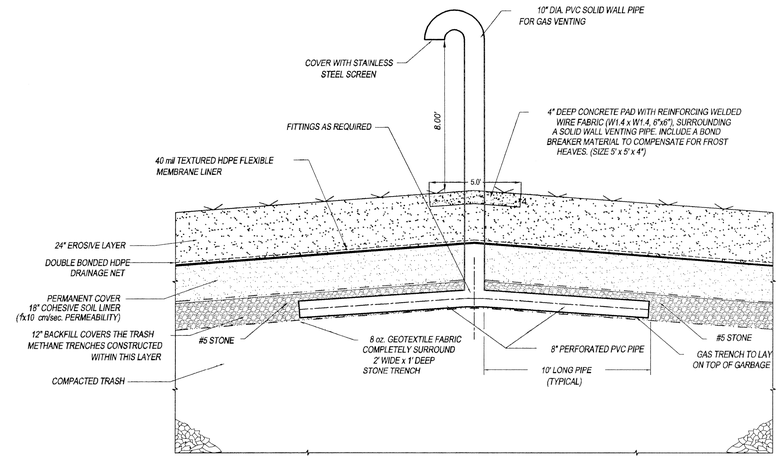

TYPICAL METHANE GAS COLLECTION TRENCH CLOSURE DETAIL
AND CAP COVER DETAIL

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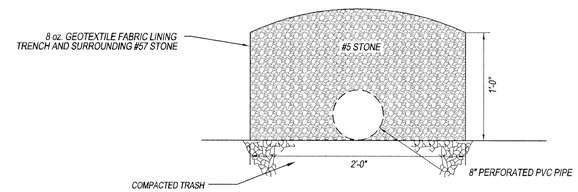

PERMANENT METHANE TRENCH DETAIL

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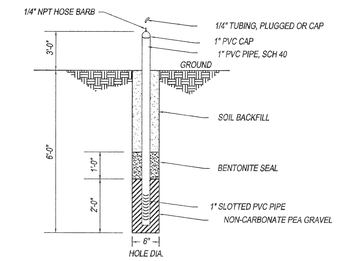

METHANE GAS MONITORING PROBE

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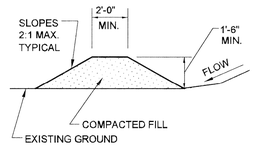

TEMPORARY STORMWATER DIVERSION BERM DETAIL

N.T.S.

Municipal Services Engineering Company, P.A.
LICENSE NUMBER: C-0281
P.O. BOX 97 GARNER, N.C. 27529 (919) 772-5393
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MUNICIPAL SOLID WASTE
LANDFILL FACILITY
LENOIR COUNTY
NORTH CAROLINA

DATE	BY	REV.	DESCRIPTION

OPERATION PLAN-PHASE 2
OPERATION DETAILS

SCALE:	1:1
DATE:	10/22/09
DRWN. BY:	L. HAMPTON
CHKD. BY:	J. WOODIE
PROJECT NUMBER	G08095
DRAWING NO.	P9
SHEET NO.	11 OF 11

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SECTION 6.0

CLOSURE PLAN

6.1 Introduction

The County will cap their landfill within 180 days after the final receipt of solid waste. The cap system will consist of 12 inches bridging material (temporary cover), 18 inches of cohesive soil liner with a permeability no greater than 1.0×10^{-5} cm/sec, 40 mil Linear Low Density Polyethylene (LLDPE), drainage layer, 24 inches of protective/erosive layer. The post-settlement surface slopes on the cap system will be a minimum of 5 percent and a maximum of 25 percent. The cap contains gas venting system consisting of a series of washed stone trenches below the soil liner that will be vented through 10" diameter PVC pipes that penetrate the cap. The cap system will also include the proper seeding and mulching of the erosive layer and other erosion control devices.

The largest area to be closed within the permitted life will be 20 acres.

The estimate of the maximum inventory of wastes ever on-site over the active life to date of the landfill facility is 511,000 cubic yards.

Prior to beginning closure, the County shall notify the Division of Solid Waste that a notice of the intent to close the unit has been placed in the operating record. The County shall begin closure activities no later than thirty (30) days after the date on which the landfill receives the final wastes or if the landfill has remaining capacity and there is a reasonable likelihood that the landfill will receive additional wastes, no later than one year after the most recent receipt of wastes. Extensions beyond the one-year deadline for beginning closure may be granted by the Division of Solid Waste if the County demonstrates that the landfill has the capacity to receive additional waste and the County has taken and will continue to take all steps necessary to prevent threats to human health and the environment from the closed landfill.

The County shall complete closure activities in accordance with the closure plan within 180 days following the final receipt of waste. Extensions of the closure period may be granted by the Division of Solid Waste if the County demonstrates that closure will, of necessity, take longer than one hundred eighty (180) days and the County has taken and will continue to take all steps to prevent threats of human health and environment from the enclosed landfill.

Estimated schedule of closure will be approximately 24 years.

Following closure of the landfill, the County shall notify the Division that a certification, signed by the project engineer verifying that closure has been completed in accordance with the closure plan, and has been placed in the operating record. The County shall record a notation on the deed to the landfill property and notify the Division of Solid Waste that the notation has been recorded and a copy has been placed in the operating record. The notation on the deed shall in perpetuity notify any potential purchaser of the property that the land has been used as a landfill and its use is restricted under the closure plan approved by the Division of Solid Waste. The County may request permission from the Division to remove the notation from the deed if all waste are removed from the landfill.

6.2 Cap System

All materials and equipment shall be furnished by an established and reputable manufacturer or supplier. All materials and equipment shall be new and shall be of first class ingredients and construction, designed and guaranteed to perform the service required and shall conform with the following standard specifications or shall be the product of the listed manufacturers or similar and equal thereto as approved by the Engineer.

6.3 Cohesive Soil Cap

All materials and equipment shall be furnished by an established and reputable manufacturer or supplier. All materials and equipment shall be new and shall be of first class ingredients and construction, designed and guaranteed to perform the service required and shall conform with the following standard specifications or shall be the product of the listed manufacturers or similar and equal thereto as approved by the Engineer.

Cohesive Soil Cap Borrow Material

Test Name	Test Method	Contractor/Engineer Frequency
Moisture/Density	ASTM D698/D1557	1 per 5000 c.y.
Remolded Permeability	ASTM D5084	1 per 5000 c.y.
Atterberg Limits	ASTM D4318	1 per 5000 c.y.
Visual Classification	ASTM D2488	1 per 5000 c.y.
Grain Size Distribution	ASTM D422	1 per 5000 c.y.

Cohesive Soil Cap Test Pad

Test Name	Test Method	Contractor/Engineer Frequency
Field Moisture/Density	ASTM D1556 (sand cone) ASTM D2922/D3017 (nuclear gauge) ASTM D2937 (drive cylinder)	3 per lift
Permeability	ASTM D5084	1 per lift
Remolded Permeability	ASTM D5084	1 per lift
Atterberg Limits	ASTM D4318	1 per lift
Visual Classification	ASTM D2488	1 per lift
Grain Size Distribution	ASTM D422	1 per lift

In-Place Cohesive Soil Cap

Test Name	Test Method	Contractor/Engineer Frequency
Field Moisture/Density	ASTM D1556 (sand cone) ASTM D2922/D3017 (nuclear gauge) ASTM D2937 (drive cylinder)	1 per lift per acre
Permeability	ASTM D5084	1 per lift per acre
Atterberg Limits	ASTM D4318	1 per lift per acre
Visual Classification	ASTM D2488	1 per lift per acre
Grain Size Distribution	ASTM D422	1 per lift per acre

(a) Suitable on-site and/or off-site soils may be used as cohesive soil cap if it can achieve an in-place permeability of 1.0×10^{-5} cm/sec or less and meets all testing requirements indicated in the material testing paragraph in this section. Wyoming bentonite or an approved equivalent may be blended with the soil to lower the soil's permeability.

(b) A permeability "window" shall be developed for each type of soil from the borrow material that will be used for construction of the cohesive soil cap. The window shall be plotted on a semi-log plot with moisture content versus density. Laboratory testing to develop the window shall include a series of remolded samples compacted to various dry densities and moisture contents utilizing the same compactive effort (ASTM D 698 or D 1557). The remolded samples shall be tested for permeability to determine whether or not the particular soil type will provide the maximum permeability (1.0×10^{-5} cm/sec) at various dry densities and moisture contents. The window is then developed from the accepted remolded samples and moisture contents from the semi-log plot. A straight line is typically drawn between the acceptable points on the moisture-density curve to indicate a range of probable acceptable permeability results. The window will be used in the construction of the test strip to verify the laboratory remolded permeability results.

(c) Atterberg limits and grain size distribution shall also be conducted on the bulk samples used to prepare the permeability window ASTM D2488, D4318, D422. These tests can be used as indices on random samples collected from the borrow site during construction to verify the soil type is the same as was used to develop the "window". As a minimum, sufficient visual classifications and Atterberg limits shall be conducted in association with each permeability test to verify that the construction materials meet specifications.

(d) A test strip of compacted cohesive soil cap shall be prepared to verify the permeability "window" prior to general installation of the cohesive soil cap. The test strip will be used to verify the results from the remolded permeabilities from the borrow site utilizing the permeability window(s) for each soil type that is going to be used for construction of the cohesive soil cap. At a minimum, the verification will consist of three moisture density tests, one Atterberg limits test, one grain size distribution test (ASTM D2488, D4318, and D422), and one Shelby Tube sample for each lift constructed in the test pad. Laboratory permeability tests shall be performed on tube (Shelby or drive tubes) samples of the cohesive soil cap after placement and compaction. The permeability must be a maximum of 1.0 $x10^{-5}$cm/sec. Tests shall be performed in accordance with the ASTM D5084. The test strip shall be approximately 2,500 sq. ft. in surface area and constructed to conform geometrically to the site topography with a minimum lateral dimension in any direction of 25 ft. The test strip shall consist of at least three compacted 6 inch lifts of cohesive soil cap. Placement and testing of the test strip shall be in conformance with the construction specifications and requirements for general installation of the cohesive soil cap. Test results from the test strip shall be used to guide placement and achievement of the required maximum permeability of 1.0 x 10^{-5} cm/sec of the cohesive soil cap. The test strip may be used as an integral part of the overall cohesive soil cap if it meets the required specification for the cap. All results shall be given to the Construction Observer.

(e) The soils shall be placed to the total thickness shown on the plans in maximum 8-inch thick loose lifts with a maximum 6" compacted lift compacted preferably at moisture content between 0 to 3% above optimum moisture content to 95% standard Proctor maximum dry density (ASTM Test Designation D698). A sheepsfoot roller or approved alternative may be used to compact the soil cap provided the compaction and permeability requirements can be achieved. Each lift shall be tested for permeability, moisture content, particle size distribution analysis, Atterberg limits, moisture-density-permeability relation, and if needed percent bentonite admixed with soil, prior to the placement of the succeeding lift and visually inspected to confirm that all soil clods have been broken and that the surface is sufficiently scarified so that adequate bonding can be achieved. Soils for cohesive soil cap shall be screened, disked, or prepared using any other approved method as necessary to obtain a homogeneous cohesive soil with clod sizes in a soil matrix no larger than about 1.5 inches in maximum diameter. After each lift, the surface shall be scarified prior to the placement of the next lift to provide good bonding from one lift to the next.

(f) The cohesive soil cap shall be tested to evaluate the coefficient of permeability. The coefficient of permeability of the soil cap shall be equal to or less than 1.0 x 10^{-5} cm/sec after placement and compaction. The soil cap must be a minimum of 1.5 feet thick.

(g) Laboratory permeability tests shall be performed on tube (Shelby or drive tubes) samples of the cohesive soil cap after placement and compaction. The permeability must be a maximum of 1.0 x 10^{-5}cm/sec. Tests shall be performed in accordance with ASTM D5084.

(h) The soil cap shall be tested a minimum of one soil sample per lift per acre for laboratory permeability. All permeability testing will be on random samples judged by the Engineer to be representative of the most permeable soil conditions for the area being tested. The project engineer shall certify that the materials used in construction were tested according to the Division approved plans. If after placement of the soil cap it fails the required tests, the material will either be reworked or replaced. The soil cap must remain moist at all times, if any section becomes dry, rework the dry area and moisten.

(i) A minimum of two (2) inches of soil shall be removed prior to securing each sample for permeability testing. The sampling tube shall be advanced vertically into the soil with as little soil disturbance as possible and should be pushed using a uniform pressure. The sampling tube (Shelby tube), when extracted, shall be free of dents, and the ends shall not be distorted. A backhoe or approved alternative should be used to advance the sampling tube (Shelby tube) as long as disturbance is minimized. Drive tube samples of the cap may be obtained for permeability testings. If the Engineer judges the sample to be too disturbed, another sample shall be taken. Once an acceptable sample has been secured and properly prepared, all sample excavations shall be backfilled to grade with a 50% mixture of bentonite and similar soils in maximum 3-inch loose lifts and hand tamped with a blunt tool to achieve a tight seal equivalent to the original density.

(j) No additional construction shall proceed on the soil layers at the area being tested until the Engineer has reviewed the results of the tests and judged the desired permeability is being achieved.

(k) As a minimum, sufficient visual classifications (ASTM Test Designation D2488) , analyses (ASTM Test Designation D422) and Atterberg limits (ASTM Test Designation D4318) shall be conducted in association with each permeability test to verify that the construction materials meet specifications. The minimum number of tests will be 1 per lift per acre.

(l) If the soil for the cohesive soil cap is incapable of achieving the required permeability when compacted, bentonite or approved alternative may be mixed with the soils to decrease the permeability. The amount of additive required must be determined in the laboratory. Where additives are required, the soil shall be placed in maximum 8-inch thick loose lifts and compacted preferably between 0 to +3% optimum moisture content to 95% standard Proctor maximum dry density (ASTM Test Designation D698) for the soil-additive mixture. All other compaction procedures for the soil apply.

(m) Surfaces to be lined shall be smooth and free of debris, roots, and angular or sharp rocks larger than three-eight (3/8) inches in diameter to a depth of six (6) inches. The cohesive soil cap shall have no sudden sharp or abrupt changes in grade.

(n) The Contractor shall protect the cohesive soil cap from desiccation, flooding and freezing. Protection, if required, may consists of a thin plastic protective cover, (or other material as approved by the engineer) installed over the completed cohesive soil cap until such time as the placement of flexible membrane liner begins. Areas found to have any desiccation cracks or which exhibit swelling, heaving or other similar conditions shall be replaced or reworked by the contractor to remove these defects.

(o) The thickness and grade of the soil cap will be verified by the surveyor before placement of the geomembrane liner. The soil cap will be surveyed at 100' grid points where the elevations of the top of landfill will be checked with the top of soil cap to verify 1.5 feet of soil cap. The grade will then be verified with the surveyed information. The survey will be performed by NC licensed surveyors.

(p) Surface Acceptance. Upon request, the Flexible Membrane Liner manufacturer installer shall provide the Engineer with a written acceptance of the surface prior to commencing installation. Subsequent repairs to the cohesive soil cap and the surface shall remain the responsibility of the contractor.

6.4 Flexible Membrane Liner Method of Deployment

All materials and equipment shall be furnished by an established and reputable manufacturer or supplier. All materials and equipment shall be new and shall be of first class ingredients and construction, designed and guaranteed to perform the service required and shall conform with the following standard specifications or shall be the product of the listed manufacturers or similar and equal thereto as approved by the Engineer.

Flexible Membrane Liner Tests

Test Name	Description	Test Method	Frequency
Air Test	Air Test Seams		Every Seam
Vacuum Test	Every welded area		Where air test impossible
Destructive Tests	Seam Strength	ASTM D4437	Every 500' of seam

Qualified liner installers, seamers, and the liner foreman shall meet a minimum requirement of 1,000,000 square feet of geomembrane installation. There are no other minimum qualifications needed by other parties.
40 mil Linear Low Density Polyethylene (LLDPE) is to be placed in direct contact with moist cohesive soil cap. The extrusion rods and/or brads used in seaming the rolls together shall be derived from the same base resin as the liner and shall meet the following minimum properties:

Smooth 40 mil LLDPE Liner Specifications

Property	Test Method	Test Value	Contractor/Engineer Test Frequency
Thickness (min. ave.)	D5199	nom. (mil)	Per roll
- lowest individual for 8 out of 10 values		-10%.	
Density (max.)	D1505/D792	0.939	200,000 lb
Tensile Properties (1)(min. ave.)	D638 Type IV		20,000 lb
- yield stress lb/in		64	
- break stress lb/in		152	
- yield strain %		13	
- break strain %		800	
2% Modulus - psi (max.)	D5323	30,000	20,000 lb
Tear Resistance- lb/in (min ave.)	D1004	22	45,000 lb
Puncture Resistance- lb/in (min ave.)	D4833	56	45,000 lb
Axi-Symmetric Break Strain- % (min)	D5617	30	200,000 lb
Stress Crack Resistance- hr (2)	D5397 (App.)	n/a	per GRI-GM10
Carbon Black Content- %	D1603 (3)	2.0-3.0	20,000 lb
Carbon Black Dispersion	D5597	note (4)	45,000 lb
Oxidative Induction Time (OIT) (min ave,) (5)			
(a) Standard OIT	D3895	120 min.	200,000 lb
-or-			
(b) High Pressure OIT	D5885	500 min.	
Oven Aging at 85°C (6)	D5721		
(a) Standard OIT (min. ave) -% retained after 90 days	D3895	55	per each formulation
-or-			
(b) High Pressure OIT (min ave) -% retained after 90 days	D5885	80	
UV Resistance (7)			
(a) Standard OIT (min ave)	D3890	N.R. (8)	per each formulation
-or-			
(b) High Pressure OIT (min ave) -% retained after 1600 hrs (9)	D5885	50	

(1) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction yield elongation is calculated using a gage length of 33 mm Break elongation is calculated using a gage length of 50 mm
(2) The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value via MQC testing.
(3) Other methods such as D4128 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to D1603 (tube furnace) can be established.
(4) Carbon black dispersion for 10 different views: - all 10 in Categories 1 or 2
(5) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.
(6) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.
(7) The condition of the test should be 20 hr UV cycle at 75°C followed by 4hr condensation at 60°C.
(8) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.
(9) UV resistance is based on percent retained value regardless of the original HP-OIT value.

(1) Preparation for Geomembrane Deployment

(a) Panel Layout

Prior to commencement of liner deployment, layout drawings shall be produced to indicate the panel configuration and location of seams for the project.

(b) Identification

Each panel used for the installation shall be given a numeric or alpha-numeric identification number consistent with the layout drawing. This identification number shall be related to manufacturing roll number that identifies the resin type, batch number and date of manufacture.

(c) Verification

The manufacturers certification will be given to the construction observer. The construction observer will inspect all certifications. If the certification does not meet specifications, it will be rejected. Adequate laboratory QA/QC conformance testing shall be performed by contractor/engineer to verify minimum requirements.

(2) Field Panel Placement

(a) Location

The Flexible Membrane Liner Manufacturer/Installer shall install field panels at the location indicated on the layout drawing. If the panels are deployed in a location other than that indicated on the layout drawings, the revised location shall be noted in the field on a layout drawing which will be modified at the completion of the project to reflect actual panel locations.

(b) Weather Conditions

Geomembrane deployment shall not be carried out during any precipitation, nor in the presence of excessive moisture (i.e. fog, dew), in an area of standing water, or during high winds.

(c) Method of Deployment

(1) The method and equipment used to deploy the panels must not damage the geomembrane or the supporting subgrade surface.

(2) No personnel working on the geomembrane will smoke, wear shoes that can damage the geomembrane, or engage in actions which could result in damage to the geomembrane.

(3) Adequate temporary loading and/or anchoring, (i.e. sandbags, tires), which will not damage the geomembrane, will be placed to prevent uplift of the geomembrane by wind. If uplift occurs, additional sandbags will be placed in necessary areas.

(4) The geomembrane will be deployed in a manner to minimize wrinkles. The geomembrane will have no fold overs.

(5) Any damage to a panel of the geomembrane will be repaired. Any area of a panel seriously damaged (torn, twisted, or crimped) will be marked, cut out and removed from the work area with resulting seaming and/or repairs performed.

(3) Field Seaming

(a) Layout

In general, seams shall be oriented parallel to the slope, i.e., oriented along, not across the slope. Whenever possible, horizontal seams should be located not less than five (5) feet from the toe of the slope. Each seam made in the field shall be numbered in a manner that is compatible with the panel layout drawing for documentation of seam testing results.

(b) Personnel

All personnel performing seaming operations shall be trained in the operation of the specific seaming equipment being used and will qualify by successfully welding a test seam. The project foreman will provide direct supervision of all personnel seaming to verify proper welding procedures are followed. Qualified liner installers, seamers, and the liner foreman shall meet a minimum requirement of 1,000,000 square feet of geomembrane installation. There are no other minimum qualifications needed by other parties.

(c) Equipment

(1) Fusion Welding

Fusion Welding consists of placing a heated wedge, mounted on a self propelled vehicular unit, between two (2) overlapped sheets such that the surface of both sheets are heated above the polyethylene's melting point. After being heated by the wedge, the overlapped panels pass through a set of preset pressure wheels which compress the two (2) panels together so that a continuous homogeneous fusion weld is formed. The fusion welder is equipped with a temperature readout device which continuously monitors the temperature of the wedge.

(2) Extrusion Fillet Welding

Extrusion fillet welding consists of introducing a ribbon of molten resin along the edge of the seam overlap of the two (2) sheets to be welded. The molten polymer causes some of the material of each sheet to be liquefied resulting in a homogeneous bond between the molten weld bead and the surfaces of the sheets. The extrusion welder is equipped with gauges giving the temperature in the apparatus and the preheat temperature at the nozzle.

(d) Weather Conditions

The Flexible Membrane Liner Manufacturer/Installer will rely on the experience of the Project Superintendent and the results of test seams to determine seaming restrictions by weather. Many factors, such as ambient temperature, humidity, wind, sunshine, etc., can affect the integrity of field seams and must be taken into account when deciding whether or not seaming should proceed. Responsibility for monitoring these conditions shall lie with the Project Superintendent; however, the Engineer may suspend any seaming operation which is, in his opinion, at the risk of providing the Owner with a quality product. Test seams are required prior to daily production seaming to determine if the weather conditions will affect the Flexible Membrane Liner System's ability to produce quality seams. Additional non-destructive and destructive testing of production seams substantiate the decision made by the Project Superintendent to seam on any given day.

(4) Seam Preparation

(a) Fusion Welding

(1) Overlap the panels of geomembrane approximately four (4) inches.

(2) Clean the seam area prior to seaming to assure the area is clean and free of moisture, dust, dirt, debris of any kind. No grinding is required for fusion welding.

(3) Adjust the panels so that seams are aligned with the fewest possible number of wrinkles and "fishmouths".

(4) A movable protective layer may be used, at the discretion of the Flexible Geomembrane Liner System Project Superintendent, directly below the overlap of geomembrane that is to be seamed to prevent build-up of moisture between the panels.

(b) Extrusion Welding

(1) Overlap the panels of geomembrane a minimum of three (3) inches.

(2) Temporarily bond the panels of geomembrane to be welded taking care not to damage the geomembrane.

(3) Grind seam overlap prior to welding within one (1) hour of welding operation In a manner that does not damage the geomembrane. Limit grinding to ¼" outside of the extrusion weld area.

(4) Clean the seam area prior to seaming to assure the area is clean and free of moisture, dust, dirt, and debris of any kind.

(5) Purge the extruder prior to beginning the seam to remove all heat degraded extrudate from the barrel.

(6) Keep welding rod clean and off the ground.

(5) Test Seams

Test seams shall be performed at the beginning of each seaming period and at least once each four (4) hours for each seaming apparatus used that day. Test seams shall be made on fragment pieces of the geomembrane liner and under the same conditions as actual seams.

(a) Test Seam Length

The test seam shall be at least three (3) feet long and should be made by joining two (2) pieces of geomembrane at least 9" in width.

(b) Sample Procedure

(1) Visually inspect the seam for squeeze out, footprint, pressure and general appearance.

(2) Two random samples one (1) inch wide shall be cut from the test seam. The specimens shall then be tested in peel using a field tensiometer and shall not fail in the seam. If a specimen fails the entire procedure shall be repeated.

(3) If any of the second set of specimens fail, the seaming apparatus shall not be accepted and shall not be used for seaming until the deficiencies are corrected and a passing test seam is achieved.

(4) After completion of these tests, the remaining portion of test seam can be discarded. Documentation of the test seams will be maintained listing seam identification number, welder's name, temperature control setting and test results.

(5) Passing test results records shall be maintained.

(6) General Seaming Procedures

(a) Seaming shall extend to the outside edge of panels to be anchored. While welding a seam, monitor and maintain the proper overlap.

(b) Inspect seam area to assure area is clean and free of moisture, dust, dirt, debris of any kind.

(c) While welding a seam, monitor temperature gauges to assure proper settings are maintained and that the seaming apparatus is operating properly.

(d) Align wrinkles at the seam overlap to allow welding through the wrinkle.

(e) Fishmouths or wrinkles at seam and overlaps that cannot be welded through shall be cut along the ridge in order to achieve a flat overlap. The cut fishmouth or wrinkle shall be seamed. Any portion where the overlap is inadequate shall be patched with an oval or round patch of the same geomembrane extending a minimum of six (6) inches beyond the cut in all directions.

(f) All cross/butt seams between two (2) rows of seamed panels shall be welded during the coolest time of the day to allow for contraction of the geomembrane.

(g) All "T" joints shall have the overlap from the wedge welder seam trimmed back to allow an extrusion fillet weld. Then grind ¼ of an inch minimum on either side of the wedge seam, then extrusion weld all of the area prepared by grinding.

6.5 Flexible Membrane Liner Tests

The installation crews will non-destructively test all field seams over their full length using air pressure testing, vacuum testing or other approved methods, to verify the continuity and integrity of the seams.

(a) Air Pressure Testing

The welded seam created by double hot-wedge fusion welding process is composed of two distinct welded seams separated by an unwelded channel approximately 3/8 of an inch between the two welded seams permits the double hot-wedge fusion seams to be tested by inflating the sealed channel with air to a predetermined pressure, and observing the stability of the pressurized channel over time.

(1) Equipment for Air Testing

An air pump (manual or motor driven) capable of generating and sustaining a pressure between 25 to 30 psi.

A rubber hose with fittings and connections.

A sharp hollow needle, or other approved pressure feed device with a pressure gauge capable of reading and sustaining a pressure between 25 to 30 psi.

(2) Procedure for Air Testing

Seal both ends of the seam to be tested.

Insert needle or other approved pressure feed device into the sealed channel created by the fusion weld.

Inflate the test channel to a pressure between 25 to 30 psi, in accordance with the following schedule, close valve, and observe initial pressure after approximately 2 minutes.

INITIAL PRESSURE SCHEDULE *

Material (Mil)	Min. Psi	Max. Psi
40	25	30
60	27	30
80	30	30
100	30	30

* Initial pressure settings are read after a two minute "relaxing period". The purpose of this "relaxing period" is to permit the air temperature and pressure to stabilize.

Observe and record the air pressure five (5) minutes after "relaxing period" ends and when initial pressure setting is used. If loss of pressure exceeds the following or if the pressure does not stabilize, locate faulty area and repair.

MAXIMUM PERMISSIBLE PRESSURE DIFFERENTIAL AFTER 5 MINUTES - LLDPE

Material (Mil)	Pressure Diff.
40	4 psi
60	3 psi
80	3 psi
100	3 psi

At the conclusion of the pressure test the end of the seam opposite the pressure gauge is cut. A decrease in gauge pressure must be observed or the air channel will be considered "blocked" and the test will have to be repeated after the blockage is corrected.

Remove needle or other approved pressure feed device and seal resulting hole by extrusion welding.

(3) In the event of a Non-Complying Air Pressure Test, the following procedure shall be followed:

Check seam end seals and retest seams.
If non-compliance with specified maximum pressure differential re-occurs, cut one (1) inch samples from each end of the seam and additional samples.

Perform destructive peel tests on the samples using the field tensiometer.

If all samples pass destructive testing, remove the overlap left by the wedge welder and vacuum test the entire length of seam.

If a leak is located by the vacuum test, repair by extrusion welding. Test the repair by vacuum testing.

If no leak is discovered by vacuum testing, the seam will pass non-destructive testing.

If one or more samples fail the peel tests, additional samples will be taken.

When two (2) passing samples are located, the seam between these two (2) locations will be considered non-complying. Capping or removal of the non-complying seam is the only two (2) acceptable methods for repairing failed seams. Non-destruct test the entire length of the repaired seam.

(b) Vacuum Testing

This test is used when the geometry of the weld makes air pressure testing impossible or impractical or when attempting to locate the precise location of a defect believed to exist after air pressure testing. The penetration will be tested using this method.

(1) Equipment for Vacuum Testing

Vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, port hole or valve assembly, and a vacuum gauge.

Vacuum pump assembly equipped with a pressure controller and pipe connection.

A rubber pressure/vacuum hose with fittings and connections.

A bucket and means to apply a soapy solution.

A soapy solution.

(2) Procedure for Vacuum Testing

Trim excess overlap from seam, if any.

Turn on the vacuum pump to reduce the vacuum box to approximately 5 inch of mercury, i.e., 5 psi gauge.

Apply a generous amount of a solution of strong liquid detergent and water to the area to be tested.

Place the vacuum box over the area to be tested and apply sufficient downward pressure to "seat" the seal strip against the liner.

Close the bleed valve and open the vacuum valve.

Apply a minimum of 5 in. Hg vacuum to the area as indicated by the gauge on the vacuum box.

Ensure that a leak tight seal is created.

For a period of not less than 30 seconds, examine the geomembrane through the viewing window for the presence of soap bubbles.

If no bubbles appear after 30 seconds, close the vacuum valve and open the bleed valve, move the box over the next adjoining area with a minimum 3 in. overlap, and repeat the process.

(3) Procedure for Non-Complying Test

Mark all areas where soap bubbles appear and repair the marked areas.

Retest repaired areas.

(c) Destructive Testing

(1) Concept

The purpose of destructive testing is to determine and evaluate seam strength. These tests require direct sampling and thus subsequent patching. Therefore destructive testing should be held to a minimum to reduce the amount of repairs to the geomembrane.

(2) Procedure for Destructive Testing

All Destructive tests will be done according to ASTM D4437. Destructive test samples shall be marked and cut out randomly at a minimum average frequency of one test location every 500 feet of seam length.

Additional destructive tests may be taken in areas of contamination, offset welds, visible crystallinity or other potential cause of faulty welds at the discretion of the Project Superintendent and Engineer.

Sample Size

The sample should be twelve (12) inches wide with a seam fourteen (14) inches long centered lengthwise in the sample. The sample may be increased in size to accommodate independent laboratory testing by the owner at the owner's request or by specific project specifications.

A one (1) inch sample shall be cut from each end of the test seam for field testing.

The two (2), one (1) inch wide samples shall be tested in the field in a tensiometer for peel ASTM D4437. Tensile strength is essentially a measurement of the greatest tension stress a substance can bear without tearing. If the liner tears before any part of the seam does, the test is successful. If any field sample fails to pass, it will be assumed the sample fails destructive testing.

(3) Procedure in the event of Destructive Test Failure

Cut additional field samples for testing. In the case of a field production seam, the samples must lie a minimum of ten (10) feet in each direction from the location of the failed sample. Perform a field test for peel strength. If these field samples pass, then laboratory samples can be cut and forwarded to the laboratory for full testing.

If the laboratory samples pass then reconstruct the seam between the two (2) passing samples locations.

Heat tack the overlap along the length of the seam to be reconstructed and extrusion weld.

Vacuum test the extrusion weld.

If either of the samples fail, then additional samples are taken in accordance with the above procedure until two (2) passing samples are found to establish the zone in which the seam should be reconstructed.

All passing seams must be bounded by two (2) locations from which samples passing laboratory destructive tests have been taken.

In cases of reconstructed seams exceeding 150 feet, a destructive sample must be taken and pass destructive testing from within the zone in which the seam has been reconstructed.

All destructive seam samples sent to the Flexible Membrane Liner System's laboratory shall be numbered.

(d) Quality Assurance Laboratory Testing

(1) Destructive samples sent to the laboratory will be tested for "shear strength" and "peel adhesion" (ASTM D4437 as modified by NSF). Five (5) specimens shall be tested for each test method with data recorded. Four (4) out of the five (5) specimens must pass for each test in order for the seam to pass the destructive test.

(2) Defects and Repairs

(a) The Project Superintendent shall conduct a detailed walk through and visually check all seams and non-seam areas of the geomembrane for defects, holes, blisters and signs of damage during installation.

(b) All other installation personnel shall, at all times, be on the lookout for any damaged areas. Damaged areas shall be marked and repaired.

(c) Repair Procedures

Any portion of the geomembrane showing a flaw or failing a destructive or non-destructive test shall be repaired. Several procedures exist for repair and the decision as to the appropriate repair procedure shall be made by the Project Superintendent. Repairs need to be made in a timely manner to protect the moist cohesive soil liner and flexible membrane liner. If inclement weather is approaching, steps need to be made to protect the cohesive soil cap such as a temporary cover. If cohesive soil cap is damaged, it must be reworked. Procedures available for liner repair:

Patching - used to repair large holes, tears and destructive sample locations. All patches shall extend at least six (6) inches beyond the edges of the defect and all corners of patches shall be rounded.

Reconstruction - used to repair seams bounded by passing destruct samples.

Grinding and welding - used to repair sections of extruded seams.

Spot welding or seaming - used to repair small tears, pinholes or other minor localized flaws.

Capping - used to repair lengths of failed extruded seams.

Removal of a bad seam and replacement with a strip of new material seamed into place.

(d) Verification of Repairs

Every repair shall be non-destructively tested. Repairs which pass the non-destructive test shall be deemed adequate. Large repairs may require a destructive test. Repair test results shall be logged. The repair location shall be recorded on an as-built drawing.

6.6 Protective Cover

(1) HPDE Geocomposite Drainage Netting manufactured by SKAPS Industries, or approved equal

GEOCOMPOSITE PROPERTIES

PROPERTY	TEST	UNITS	MINIMUM AVERAGE ROLL VALUE
Thickness	ASTM D 5199	inch	0.305
Transmissivity[1] (15,000 psf)	ASTM D 4716	m^2/sec	$3x10^{-5}$
Ply Adhesion	ASTM D 413 or F 904	lb/in	2.0

COMPONENT PROPERTIES

GEONET	TEST	UNITS	MINIMUM AVERAGE ROLL VALUE
Polymer Density	ASTM D 1505	g/cm^3	0.94
Carbon Black Content	ASTM D 4218	%	2.0
Thickness	ASTM D 5199	inches	0.200
Mass per unit area	ASTM D 5261	lbs/ft^2	0.162
Transmissivity[1]	ASTM D 4716	m^2/sec	$1x10^{-3}$@ 15,000 psf
Tensile Strength	ASTM D 5035	lbs/in	45

GEOTEXTILE	TEST	UNITS	MINIMUM AVERAGE ROLL VALUE
Fabric Weight	ASTM D 5261	oz/yd^2	7.1
Thickness	ASTM D 5199	mils	95
Grab Strength	ASTM D 4632	lbs	210
Water Flow Rate	ASTM D 4491	gpm/ft^2	110
Apparent opening size (AOS)	ASTM D 4751	mm (Sieve Size)	0.150 (100)

1. Measured using water @ 20° C (68° F) with a gradient of one, between two steel plates, after one hour. Value may vary, based on dimensions of the transmissivity specimen and specific laboratory.
2. Component properties are tested prior to the lamination process. They cannot be tested on the final product.

The geocomposite will be handled in such a manner as to ensure the geocomposite are not damaged in any way. On slopes, the geocomposite will be secured in the anchor trench and then rolled down the slope in such a manner as to continually keep the geocomposite sheet in tension. If necessary, the geocomposite will be positioned by hand after being unrolled to minimize wrinkles. Geocomposite can be placed in the horizontal direction (i.e., across the slope) in some special locations (e.g., where extra layers are required or where slope is less than 10:1).

Geocomposite will not be welded to the geomembrane. Geocomposite will be cut using approved cutters,(i.e., hook blade, scissors, etc.) Care should be taken to prevent damage to underlying layers. Care must be taken not to entrap dirt in the geocomposite that could cause clogging of the drainage system, and or stones that could damage the adjacent geomembrane.

Adjacent rolls of geocomposite will be overlapped by at least four inches and securely tied. Tying can be achieved by plastic fasteners. Tying devices will be white or yellow for easy inspection. Metallic devices are not allowed. Tying will be five to ten feet along the bottom of the slope. Tying will be every five feet along the slope, every two feet across the slope and at the top of the berm. Tying in the anchor trench will be done in one foot intervals. In the corners of the side slopes where

overlaps between perpendicular geocomposite strips are required, an extra layer of geocomposite will be unrolled along the slope, on top of the previously installed geocomposite, from the top to bottom of the slope.

Any holes or tears in the geocomposite will be repaired by placing a patch extending two feet beyond edges of the hole or tear. The patch will be secured to the original geocomposite by tying every twelve inches. If the hole or tear width across the roll is more than 50% the width of the roll, the damaged area will be cut out and the two portions of the geocomposite will be joined.

The engineer will visually inspect the drainage layer before placement of the erosive layer, if any defects are detected they will be repaired before placement of erosive layer.

(2) Erosive Layer

The soil for the erosive layer shall consist of any soils suitable of supporting vegetative growth. The erosive layer shall be installed using low ground pressure equipment such as a Caterpillar D6H LGP, or approved equal, with ground pressure not exceeding 4.71 psi. When installing the erosive layer, the contractor shall adhere to the following guidelines:

(a) A minimum of twelve inches (12") of cover between low ground pressure equipment and the liner is required at all times. Roadways for entering and for transporting material over slopes and capped/lined areas shall have a minimum depth of four feet (4').

(b) Avoid undue stress on the liner at all times. Cover material must be pushed up slopes, never down to help minimize wrinkles. Material must be placed to minimize wrinkles; wrinkles in excess of two feet in height are unacceptable. If a wrinkle is more than two feet in height, soil will be placed on top of the wrinkle to decrease the height. Fold over of the liner will not be allowed. A worker must walk along side earth moving equipment and remove all rocks, stones, roots or other debris that could cause damage to the liner. Equipment operators must avoid sharp turns or quick stops that could pinch and tear the liner.

(c) If damage does occur, report it to the Project Manager immediately so that repairs can be performed without needless delay.

(d) Do not work wet cover material that cannot support equipment.

(e) Equipment operators and all other personnel must be qualified and must exercise good judgment and common sense at all times.

(3) Vegetative Layer

Native vegetation will be used as approved by the Erosion Control Plan.

6.7 Methane Venting System

Gas Venting System

NC.D.O.T. No 5 stone, Geotextile fabric, and 8" and 10" plastic pipes will be used in the construction of the Gas venting system.

(1) Stone in Trenches and Surrounding Perforated Collection Piping

Stone for methane collection system shall meet the requirements of NC DOT aggregate, standard size No. 5 and shall contain no fines. Stone must pass the sieve analysis test for No. 5 stone performed at the quarry.

(2) Geotextile Fabric

Geotextile fabric surrounding the stone/piping shall be non-woven needle punched fabric with the following minimum properties:

1)	Weight	8.0 oz/yd^2	ASTM D-3776
2)	Grab Strength	205 lbs.	ASTM D-4632
3)	Grab Elongation	50%	ASTM D-4632
4)	Trapezoidal Tear Strength	85 lbs.	ASTM D-4533
5)	Puncture Strength	100 lbs.	ASTM D-4833
6)	Mullen Burst Strength	320 psi	ASTM D-3786
7)	Permittivity	1.4 sec^{-1}	ASTM D-4491

Geotextile fabric shall be manufactured by Polyfelt , TNS Advanced Technologies, or approved equal.

(3) Plastic Pipe

Plastic gravity sewer pipe and fittings used for methane vent shall be unplasticized polyvinyl chloride (PVC) and conform to the requirements of ASTM Designation D-3034 on ASTM F679, Type PSM, Class 12454-B, SDR-35 with elastomeric gasket joints. PVC pipe and fittings shall be as manufactured by J-M Pipe, Certainteed, H&W Industries or equal. The methane riser pipe shall be a 10 inch solid wall PVC pipe.

6.8 Closure Costs

The largest area to be closed within the permitted life will be Phase 1 and 2 (20 Ac.). The estimated costs shown below are only for Phase 1 and 2. Post Closure will be 30 years after closure.

Closure Costs:
Closure will consist of the following which costs are estimated as being done by a third party.

1. 18" of $1x10^{-5}$ cm/sec. soil cover;
2. 40 Mil LLDPE Liner and Drainage net;
3. Erosion Control Devices;
4. 24" Erosive layer;
5. Seeding and Mulching;
6. Mobilization/Demobilization;
7. Labor Costs; and
8. Stone for methane gas collection.
9. Geotextile for methane gas collection.
10. Vent pipes for methane gas collection.
11. Engineering Costs and QA/QC of the Composite liner and certification of closure.

Estimate of Probable Costs:

1. 18" of $1x10^{-5}$ cm/sec. soil cover for 20 acres:

   Total yardage + 15% = 55,660 yd^3 @ a cost of $6.90/$yd^3$
   ∴ Cost = $384,054

2. 40 Mil LLDPE Liner and Drainage net for 20 acres

   Total Footage + 15% = 1,001,880 ft^2 @ a cost of $0.85/$ft^2$
   ∴ Cost = $851,598

3. Erosion Control devices

   Estimated costs @ $75,000
   ∴ Cost = $75,000

4. 24" Erosive soil layer for 20 acres.

   Total yardage + 15% = 74,213 yd^3 @ a cost of $4.05/$yd^3$
   ∴ Cost = $300,563

5. Seeding and Mulching for 20 acres.

   Estimated cost of $2,000/acre
   ∴ Cost = $40,000

6. Mobilization/Demobilization.

   Estimated cost of $175,000

7. Labor Costs.

   Estimated cost of $200,000

8. Stone for methane gas collection.

Total estimated linear feet = 1,952 ft.
Total estimated volume for a 2'x1' trench = 3,904 ft^3
with a density of 120 lbs/ft^3 total weight =235 tons @ a cost of $18.00/ton
∴ Cost = $4,230

9. Geotextile for methane gas collection.

Total estimated linear feet = 1,952 ft.
Total estimated perimeter for a 2'x1' trench = (1,952 ft × 6 ft)@ a cost of $0.20/ ft^2
∴ Cost = $2,343

10. Vent pipes for methane gas collection.

Estimated cost @ $600.00 each (11).
∴ Cost = $6,600

11. Engineering Costs and QA/QC of the Composite liner and certification of closure.

Estimated cost = $200,000
∴ Cost = $200,000

Total of Estimated Phase 1and 2 Closure Costs:

	1.	$ 384,054
	2.	$ 851,598
	3.	$ 75,000
	4.	$ 300,563
	5.	$ 40,000
	6.	$ 175,000
	7.	$ 200,000
	8.	$ 4,230
	9.	$ 2,343
	10.	$ 6,600
	11.	$ 200,000
Total:		$ 2,239,388

SECTION 7.0

POST-CLOSURE PLAN

7.1 Introduction

CONTACTS:

Name:	Michael W. Jarman
Title:	County Manager
Phone No.:	(252) 559-6450
Address:	130 South Queen Street Kinston, NC 27502

DESCRIPTION OF USE:

The County has no future use planned for their landfill at this time.

DESCRIPTION OF MAINTENANCE ACTIVITIES:

The County will be monitored quarterly for evidence of settlement, subsidence and ponding in the cap system. The entire site will be monitored quarterly for evidence and effects of erosion. The erosion control plan will be preserved. Annually in the Spring, the vegetative cover will be monitored to assure a good stand of vegetation, and where needed, it will be reseeded. These maintenance activities will take place over the entire post closure period of thirty years.

The leachate collection system will be monitored annually and flushed out if necessary. Leachate will be collected and treated until the generation of leachate has stopped due to capping.

DESCRIPTION OF MONITORING ACTIVITIES:

The County will monitor and analyze ground and surface water semi-annually for (Subtitle D Appendix I) constituents for a period of thirty years. The County will also monitor methane gas at landfill structures and the boundary quarterly for the thirty-year period.

COMPLETION OF POST-CLOSURE CARE

Following completion of the post-closure care period for each MSWLF unit, the owner or operator will notify the Division of Solid Waste that a certification, signed by a registered professional engineer, verifying that post-closure care has been completed in accordance with the post-closure plan, has been placed in the operating record.

CLOSURE OF LEACHATE STORAGE FACILITIES

The County will close the leachate lagoon within 180 days after liquid collection has ceased.

All solid waste will be removed from the leachate lagoon, connecting sewer lines, and manholes. All solid waste removed will be properly handled and disposed of according to federal and State requirements. All connecting lines will be disconnected and securely capped or plugged.

All waste residues, contaminated system components (composite liner system), contaminated subsoils, structures and equipment contaminated with waste will be removed and appropriately disposed. If the groundwater surrounding the impoundment is contaminated, other corrective actions to remediate a contaminant plume may be required by the Department. If the groundwater surrounding the lagoon is found not to be contaminated, the liner system may remain in place if drained, cleaned to remove all traces of waste, and both liners punctured so that drainage is allowed. The lagoon is to be backfilled and regraded to the surrounding topography.

7.2 Post Closure Costs

The largest closed area to be monitored within the post closure life will be Phase 1and 2 (20 Ac.).

Post Closure Costs:

Methane gas, ground water and surface water will be monitored for 30 years after closure. The cap will also have to be monitored for the 30 year period. All costs include reports, data analysis, and certifications.

1. Ground and Surface Water monitoring semiannually for 30 years for appendix I constituents and statistical analysis.
   Estimated cost/sample = $840.00/sample
   Total annual samples = 2(9 wells + 3 surface) = 24 samples/year
   Estimated cost = 30 years x 24 samples/year x $840.00/sample

   ∴ Cost = $604,800

2. Methane Gas monitoring quarterly for 30 years.
   Estimate $600.00/quarter = $2,400.00/year
   Estimated cost = 30 year x $2,400.00

   ∴ Cost = $72,000.00

3. Cap Monitoring and repairing any problems.
   Estimate $100,000 for the 30 years.

   ∴ Cost = $100,000

4. Closure of sedimentation and erosion control devices.
   Estimate $24,000.00 for closure

   ∴ Cost = $24,000

5. Leachate Management.
   Estimate $300,000.00 for the 30 years.

   ∴ Cost = $300,000

6. Closure of leachate lagoon.
   Estimate $30,000 for Closure.

7. Maintenance of gas vents, monitoring wells, etc.
   Estimate $60,000

Total of Estimated Phase 1and 2 Post Closure Costs:

	1. $ 604,800
	2. $ 72,000
	3. $ 100,000
	4. $ 24,000
	5. $ 300,000
	6. $ 30,000
	7. $ 60,000
Total:	$ 1,190,800

SECTION 8.0

FINANCIAL ASSURANCES

TO BE SUBMITTED AT A LATER DATE